Stainless Steel Industry Awards 2023

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Introduction

All companies supplying case studies for the application awards had to answer the following questions:

The Challenge

What problem were you trying to solve or what feature were you trying to develop?

Why?

Why did you decide it was necessary to address this challenge?

Needed Action

What action(s) did you take to solve the problem or undertake the development?

Action Review

Were the action(s) taken SMART? Specific, Measurable, Achievable, Realistic and Time-bound

Target Beneficiaries from the Action

Who are the people, organisations and/or communities who have benefited from the outcome of the above action? (e.g.; host company, employees, contractors, local community, regional community, customers, global community, etc.)

Horizontal Expansion Capability

Can the actions or approach taken be expanded for use elsewhere within your company and/or applied within other member companies?

Outcome

What benefits have you observed and quantified since you took the action? Please also explain the value of each of the stated benefits to employee health and well-being, job satisfaction, leading indicators (KPIs) and lagging indicators (KPIs).

We hope the case studies will give inspiration to other member companies worldwide.

The worldstainless Team

Duplex stainless steel wire rope cable solution

Member company

Australian Stainless Steel Development Association

Challenge

ASSDA Member and Accredited Fabricator Arcus Wire Group delivered an innovative duplex stainless steel wire rope cable solution for a hydropower project in the Middle East.

The 344MW Kokhav Hayarden pumped storage hydropower plant is located 120km northeast of Tel Aviv. The project is the first and largest of its kind in Israel, as well as the lowest of its kind globally. The powerhouse lies 275m below sea level and features two 3.1 million m3 reservoirs at different heights. Expected to be operational in the first half of 2023, the hydropower station is designed to provide flexible backup power and stability to the national electricity grid of Israel.

Arcus Wire Group was engaged by GE Renewable Energy to manufacture and supply the cables to form part of a guiding system for the draft tube gates and stop logs for the lower surge shaft of the power station.

Why?

The original project brief specified eight identical wire ropes approximately 110m in length with a diameter of 35mm constructed of a half-locked coil with an internal core of large diameter wire, capable of a permanently applied load of 100kN in an underwater application. A long working life was a critical requirement as maintenance of the cables was not an option once in place.

The initial consideration of materials in order of preference was carbon steel (heavy zinc coating), austenitic stainless steel, and duplex stainless steel. The water baseline data for the application during operating conditions was:

- pH value: Min 6.50 pH, max 9.00 pH
- Temperature: Min 2°C, max 33°C
- Total Dissolved Solids (TDS): Max 2,200mg/L
- Hardness: CaCO3 Max 960mg/L
- Alkalinity: CaCO3 Max 436mg/L
- Iron concentration: Max 320µg/L
- Chloride (Cl-)) concentration: Max 1,000mg/L
- Sodium (Na+)) concentration: Max 504mg/L
- Magnesium (Mg2+)) concentration: Max 144mg/L
- Silica and other hard particles with hardness >5 Mhos:

- Particle diameter >_ 50µm: Maximum concentration = 20mg/L
- Particle diameter >_ 1.5µm: Maximum concentration = 50mg/l

The cable guiding system required one part of the wire rope to be attached to an anchor embedded in concrete and permanently submerged in water exposed to highly corrosive conditions. The top part of the cable is connected to a post-tensioned wire located above ground and exposed to air, with temperatures at a maximum of 45 degrees Celsius and humidity of up to 75%. Post-installation, the wire rope cables will not be accessible for maintenance for up to 30 years.

Needed action

ASSDA was consulted during the design phase, and as the specification evolved, the client identified stainless steel as a more suitable and sustainable option than carbon steel wire ropes for the submerged application. Considering the maximum temperature and minimum pH level, grade 316 stainless steel would be at its limits, particularly with the crevices

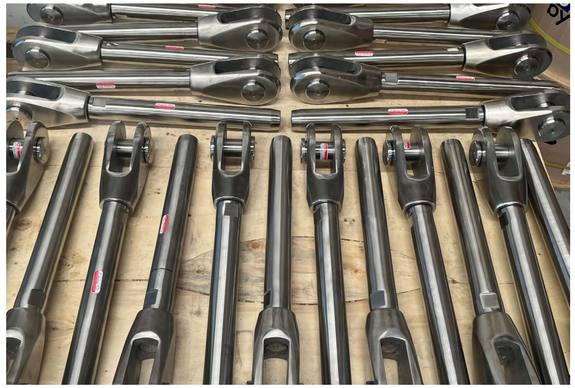
that are characteristic of wire rope. 2205 duplex stainless steel was recommended and ultimately chosen as the material of construction to reduce the risk of pitting and crevice corrosion, in addition to its tensile strength, longevity and life-cycle cost-effectiveness.

The final design specification delivered alloy grades 1.4362, 1.4462 and 1.4501 duplex stainless steel wire rope cables, half-locked coil with an internal core of large diameter wires and a 30-year lifetime warranty.

The terminations proposed and subsequently selected for use were grade 2205 duplex stainless steel swage forks. They were designed specifically by the Arcus Wire Group team for the 26mm wire rope and a pin diameter of 40mm to allow connection for the anchor at the bottom of the post-tensioning system at the top.

Action review

Specific: Arcus Wire Group worked with its mill and manufacturing partners to produce and fabricate 970m of 26mm diameter 6x19 SL and IWRC construction 2205 duplex stainless steel wire rope and



20 units of 2205 duplex stainless steel fittings. Seale construction (SL) is a wire rope construction that offers excellent breaking load characteristics. It is used in a wide variety of applications and is resistant to wear and abrasion due to its larger outer wires. An independent wire rope core (IWRC) adds strength to the total length of the rope and reduced the amount of stretch during service.

Measurable: Material testing was performed on the wire rope cables. This included destruction testing of a 3m sample cable to measure the breaking strain (breaking at 456.061kN as tested on a horizontal tensile testing machine calibrated to AS 2193: Calibration and classification of force-measuring systems), 10 rounds of cyclic loading up to 100kN and unloading to 1kN of an 11m sample cable and locading up to 1.8 times the maximum working load of 180kN to determine elongation under the various conditions. All cables delivered conformed to EN 12 385-4: Steel wire rope; EN 13411-8 Terminations for steel wire ropes – Safety – Part 8: Swage terminals and swaging; and EN 10088-3: Stainless steels – Part 3: Technical delivery conditions for semi-finished products, bars, rods, wire, section and bright products of corrosion resisting steels for general purposes.

Achievable: Achieved! Carbon steel was the preferred material of choice, but ultimately, duplex stainless steel was chosen to deliver the exacting demands of the project specification. Delivery of technical information and expertise was critical to the outcome, and all parties involved in executing the final product. This will open doors for new applications where stainless steel, and specifically duplex stainless steel wire rope cables may not have previously been considered. In this particular project, maintenance is not an option and is an excellent life-cycle costing example.

Realistic: Collaboration is key. The execution and successful outcome of this project would not have been possible without the expertise and contribution of all stakeholders involved. Arcus Wire Group worked closely with its client to understand their requirements and deliver the ultimate materials solution with design and technical support provided by ASSDA. They also worked closely with mill and manufacturing partners to develop the final products specifically designed and produced for the project.

Time-bound: The duplex stainless steel wire cables were assembled, swaged, tested and quality certified at Arcus Wire Group's facility on the Gold Coast, Queensland, Australia, and shipped over 14,000km to the project site in Israel. The final delivery included 8 x hamma® 26mm diameter 2205 duplex stainless steel wire cables measuring 111.4m and weighing over 325kg each. Due to strict timelines enforced for the project air freight was necessary. The heavy weight (more than 2.5 tonnes overall) and reduced availability of flights caused by COVID-19,

made scheduling the delivery logistically challenging, however, the project timelines were achieved and delivered on time.

Horizontal Expansion Capability

Yes – there has been a lot of interest in this project and application as one of the first examples globally of a duplex stainless steel wire rope cable solution. Stainless steel delivers a sustainable material solution for applications in aggressive environments, and this particular solution has already been considered to support another project application here in Australia (construction of 30m high 'wind fences' in Port Hedland to reduce dust emissions and withstand cyclonic weather). In a world that is working towards a sustainable future and a circular economy, we need to promote these types of projects and solutions to grow the market and the use of stainless steel. It also highlights the emergence of duplex stainless steel in new applications.

Other comments

This project was the 2022 winner of ASSDA's Australian Industry Stainless Steel Fabricator Awards in the Architecture, Building and Construction category. Arcus Wire Group delivered Australian stainless steel innovation and service delivery at its best with the supply of its wire rope cable solution meeting the exacting demands, life-cycle and performance expectations of Israel's new hydropower station.

Arcus Wire Group was also invited to speak about this project at the following events:

- Stainless Steel World Asia Expo & Conference 2022 (Singapore, 26-27 October 2022)
- Stainless Steel World Duplex Seminar & Summit 2022 (Rotterdam, 1-2 November 2022)

Fish-friendly screen replacement project for the Rangitata Diversion Race

Member company

Australian Stainless Steel Development Association

The Challenge

For the past six years ASSDA Member and Accredited Fabricator AWMA Water Control Solutions has partnered with New Zealand's Rangitata Diversion Race Management Ltd (RDRML) to successfully deliver one of the world's largest fish-friendly water extraction facilities.

The Rangitata Diversion Race (RDR) extracts water from the New Zealand South Island's Rangitata River, 365 days of the year. The 'race' is a 67 km long channel that diverts water from the river for irrigation, stock water and hydropower generation. It was crucial to the RDRML that this process no longer came at a cost to the environment, primarily, native fish populations.

The new facility was required to capture flows at a rate exceeding 30 cubic metres per second. AWMA were awarded the design and construct contract to supply an environmentally sustainable diversion screen solution, that will deliver the required flows whilst excluding sporting fish (primarily salmon and trout) and a variety of native fish, so they can return, unharmed, back into the river system.

Why?

AWMA bought to the RDR project high level engineering capabilities, internationally recognised best practice technology, in-house expertise and local manufacture capabilities.

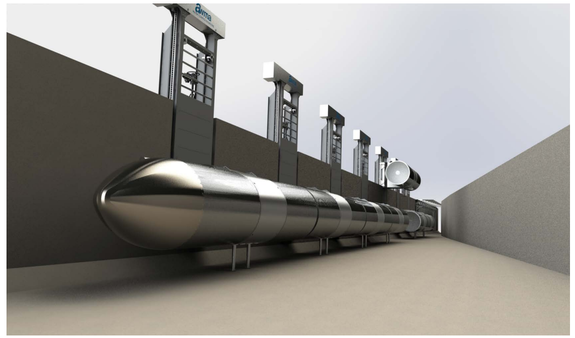
Theoretically, AWMA was awarded the RDR contract for the design and construction of this significant screening structure on the following grounds;

- Ability to offer world-leading proven design and performance screen technology within the region
- AWMA were the first contractor engaged on the project (early contractor involvement) to participate in the detailed design phase with input into the civil and structural design of the works
- AWMA completed extensive CFD modelling to confirm that the overall design and site hydraulics would meet all the project fish protection compliance criteria
- Ability to offer in-house, extensive and experienced engineering expertise including FEA and CFD analysis
- Flexible design integration leading to

AWMA Flat Panel Screens

affordable capital cost of project in relation to other options

- Low cost of ownership
- Low maintenance robust design
- Ability to maintain defined screen tolerances over the life of the screen
- Less moving components than alternative designs
- Long asset life (50 plus years)
- Defined orifice size, no maintenance, continuity of conformance to specification for life of the asset
- Reduced civil infrastructure costs to other solutions
- Proven performance of screen design 20 plus years in service
- Compliance to Aust/NZ Best Practice Fish Exclusion Guidelines
- Australian made with local presence and support during design, manufacture and ongoing operation



Design

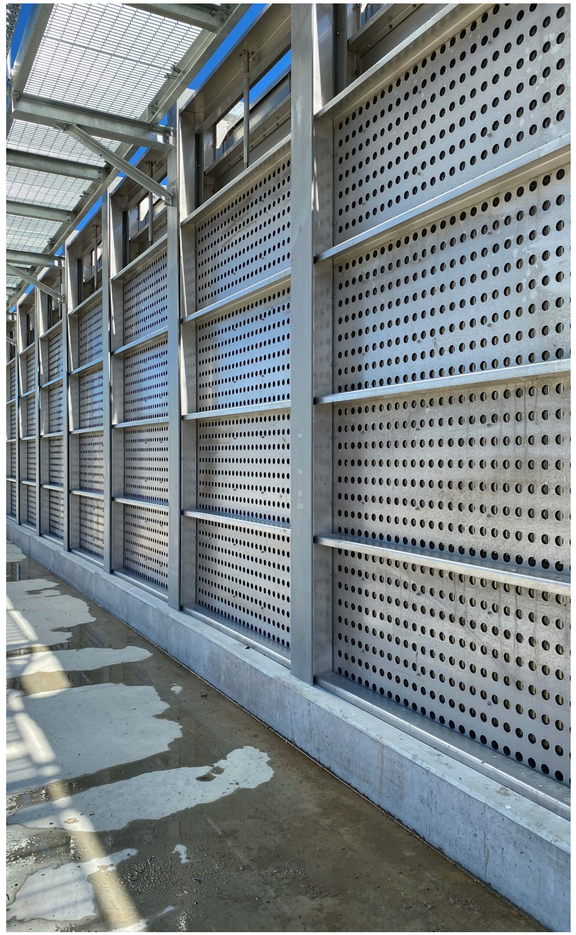
Manufacture

Install

Needed action

Over a 5 year period, RDRML in collaboration with consultants, ecologists, ECan Compliance Authority and various other stakeholders conducted extensive research to determine the best and most viable screen solution available in the world today. This involved overseas visits to explore and view operational screening facilities and speak firsthand with water regulators, scientific specialists, operators and equipment manufacturers to better understand the world's long established, well proven screening practices. The experience and knowledge acquired during these tours demonstrated that the best screening practice was achieved through the use of positive physical exclusion screens, with proven design and performance characteristics. The materials and design were required to meet client specifications, as well as compliance with USEPA 316(b) and the NIWA Fish Screening: good practice guidelines for Canterbury. The final decisions were based on decades of successfully documented performance results with reliability backed by independent scientific, consulting engineers and regulatory authorities. The result for RDRML was the selection of physical, self-cleaning, wedge-wire screening systems.

The environmentally sustainable solution



AWMA’s complete RDR Screen Solution - Back

AWMA designed for the RDR project features a stainless steel screening structure that is self-cleaning, fish-friendly, has a low whole of life cost, is compliant with fish screening guidelines, meets client requirements and sets a new standard for the design of intake screen technology.

Fish protection was the project’s primary objective. The materials and design chosen for the physical screens were therefore of utmost importance.

There are three main design characteristics of fish protection screens.

1. Aperture size: Intake screens are available in a variety of aperture sizes. The size required is site specific based on the aquatic life present (including fish species and breeding patterns). Aperture size will be dictated by local specifications.
2. Approach velocity: The velocity of the water approaching and passing through the screen should be as low as possible. This prevents entrainment and impingement of both debris and fish. The velocity must be evenly distributed across the entire screen area. Low approach velocities also reduce head loss.

AWMA’s complete RDR Screen Solution - Front

3. Self-cleaning functionality: Traditional intake screens require regular manual cleaning with significant operational and safety risks. Advances in intake

screen technologies include innovative cleaning systems, with internal and external brush cleaning mechanisms. A self-cleaning screen ensures efficient operation, with fish protection, without comprising flow. Additionally, a sustainably clean screen improves pump efficiency reducing energy consumption.

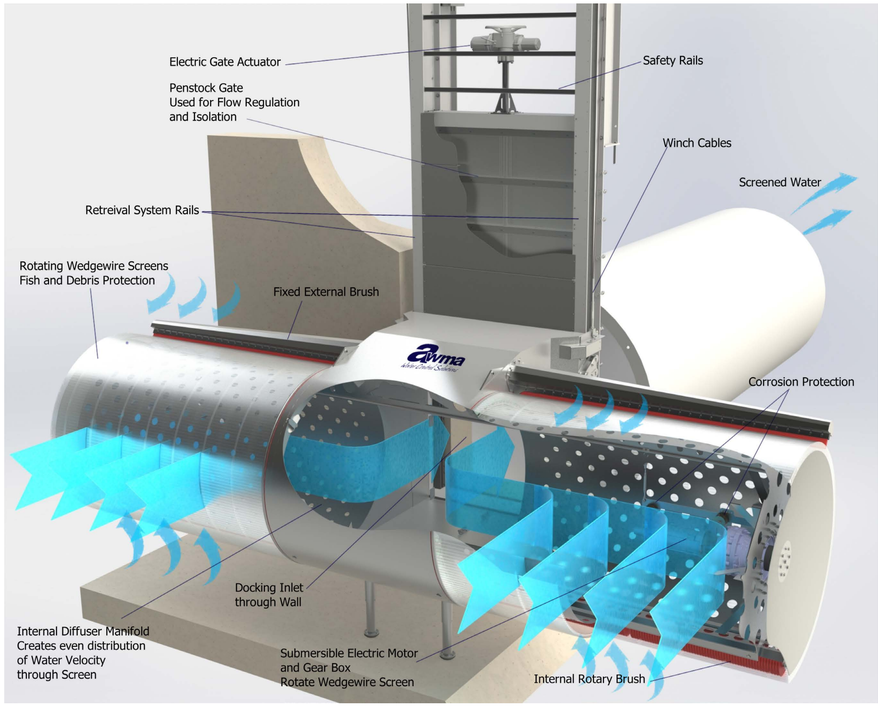
The RDR structure's strong, well proven stainless steel wedge wire screen medium protects fish and aquatic life, whilst delivering high quality water. The innovative self-cleaning mechanisms use internal and external brushes to clean the screen surfaces, ensuring they remain clear of debris, algae and weed.

In order to accommodate large irrigation flows, the AWMA design required seven Cylindrical T-Screens (for maximum surface area), as well as Flat Panel Screens along the fish bypass channel (where space was restricted).

The seven Cylindrical T-Screens are all 2.1m in diameter, 8m in length and with the retrieval systems were 8.75m high. The Flat Panel Screen is 3.5m high and 30m in length. This presents a total screen area of 475m2 over 86m, weighing in excess of 100 tonnes, to extract flows of approximately 30m3/sec.

Wedge wire is a superior medium for self-cleaning and mechanical cleaning capability. It is a robust medium, with a smooth outer surface and a self-cleaning triangular profile. Wedge wire can be manufactured in cylinders or flat sheet. The slot dimensions are precise and will not alter over the nominated life of the asset, when used in applications such as fish protection screens.

Wedge wire is a welded construction of triangular profile wires that are resistance welded onto support rods in a very precise position. The distance in between the triangular wires (slots) determines the filtration rate. It is also the aperture (slot size), set by local specialists, for site specific fish protection.



AWMA choose to utilise Australian made stainless steel wedge wire as the screen medium. Wedge wire can be made from 304, 316 and duplex stainless steels. It is the premium product of choice, providing a robust maintenance-free structure that

has a 50-year asset life expectancy in fresh water, has a smooth easy to clean outer surface that is suited to brush cleaning, has a self-cleaning profile and will retain slot size accuracy over the life of the asset.

Wedge wire is a welded material manufactured using specialised CNC controlled resistance welding machines and mandrels. Profiled wires are resistance welded onto support rods. Each resistance weld is the result of an electrical current, plus pressure, forming a very strong bond between each profile wire and the support rod, subsequently creating a very strong structure.

Wedge wire cleaning characteristics include:

- Anti-Clogging Slot: Wedge wire forms V-shaped openings with a narrow opening outside and wide opening inside. Therefore, large particles are kept outside the screen and small particles pass through the narrow opening and enter the screen.
- Easily cleaned surface: The smooth exterior surface allows for easy and complete mechanical brush cleaning, without any detrimental effects to the wedge wire. The brushed cleaned wedge wire screen incorporates internal and external cleaning brushes to mechanically remove biofouling from both sides of the wedge wire.
- The characteristics of high-quality, stainless steel materials combined with innovative infrastructure design has resulted in an environmental solution that has unparalleled outcomes for native fish protection, high-quality water output, reduced energy consumption and reliable flow delivery.

Custom designed tooling was manufactured to enable efficient handling of the screen elements whilst they were processed through the factory. A large screen rotator was designed to safely secure and rotate the T-screens for fabrication, fit out, testing and inspection. A number of cradles were also manufactured to safely secure and transport the screen sections.

This project consumed 6300 labour hours from in-house AWMA staff.

Quantity of stainless steel used

- Screens:
  - 14 x 2100mm diameter, 3000mm long, grade 304 stainless steel wedge wire screens
  - 140 metres of grade 316,16mm Wire Rope with stainless Turnbuckles and fittings
  - Grade 316 stainless steel drive shafts, 110 mm in diameter x 7 headstocks
  - Grade 304 stainless steel headstock covers for the retrieval systems x 7
  - Each T-Screen mass 6.56t
  - Total Weight: 46 tonnes of stainless steel
- Flat Screen:
  - 30m x 3.5m (105 square metres) of Flat Wedge Wire Panel
  - 8 tonnes of stainless steel in total
- LayFlat Water Control Gate:
  - 1.8tonne grade 304 stainless steel

Total: Over 55 tonnes of stainless steel

Stainless steel grade/s and surface finish used

- 2B finish on grade 304 stainless steel
- Grade 316 with mill finish

AWMA team onsite for site inspection

Horizontal Expansion Capability

This project may not substantiate a significant quantity of stainless steel nor does it highlight specific grades or finishes, but rather showcases the material's composition, characteristics and applications that promote it as one of the most valuable and environmentally sustainable resources for today's world-leading innovators.

Wedge wire is a product used globally with applications across water filtration, mineral processing, pulp and paper manufacturing, food processing, oil extraction, mining, architecture, and now world-leading, environmentally sustainable water delivery systems.

Outcome

This project demonstrates Australian innovation, quality and expertise at its best with AWMA's ability to compete at a global level. Trusted to deliver high-quality products, environmentally sustainable technologies, reliable water delivery solutions and valued long-term relationships that support national supply chains, local employment and valued economy, resulting in the delivery of leading-edge technologies, suitable for world-wide adoption.

Other comments

This is a world-class project that showcases the quality and diversity of Australia's stainless steel materials and manufacturing capability. It is a win for Australian export opportunities and an international step forward for worldwide environmentally sustainable water management techniques.

Supporting Australian companies, suppliers of this project who are also ASSDA Members include:

- Vulcan
- Arcus Wire Group
- Akras Industries
- Midway Metals

Reducing the weight of car transporter trailer by duplex stainless steel

Member company

NIPPON STEEL Stainless Steel Corporation

The Challenge

In most cases, the pillars of car transporter trailers have been made from carbon steel. By switching over to high-strength duplex stainless steel, its thickness can be reduced and the weight of car transporter trailer becomes lighter. By saving weight we aimed to increase the weight capacity of the car transporter as well as to improve energy efficiency. In addition, stainless steel pillars are more corrosion-resistant, which helps reduce maintenance costs.

Why?

As hybrid and electric vehicles become more common, automobiles are getting heavier, which reduces a trailer's carrying capacity. That means more transporters would be needed to carry a similar number of vehicles, resulting in shortages of drivers. In addition, improving the energy efficiency is important in helping to preserve the environment. We believe that saving the car carrier weight can contribute towards tackling all these issues.

Needed action

The challenge was lightening the pillar material without compromising on strength. NSSC and Hamana Works Company Limited, the trailer manufacturer, decided to use NSSC2120 high-strength duplex stainless steel, and succeeded in reducing the thickness of the material. The thinner material required changes to the design and to the welding techniques, but as a result of these efforts, we were able to introduce a weight saving car transporter on the market.

Action Review

Specific: We developed the lightened car transporter trailer. In order to reduce the weight, we could reduce the pillar thickness by using high-strength duplex stainless steel. With the goal of achieving the same pillar strength as the carbon steel pillars, we modified the design of pillar structure.

Measurable: During two-years running tests of the prototype transporter, we inspected any damage and rusting.

Achievable: No problem was found during testing.

Realistic: After checking the data from the running tests, we concluded that we were able to go ahead with production and sales.

The seismic retrofitting of the Kamihirai Flood Gate

Member company

NIPPON STEEL Stainless Steel Corporation

The Challenge

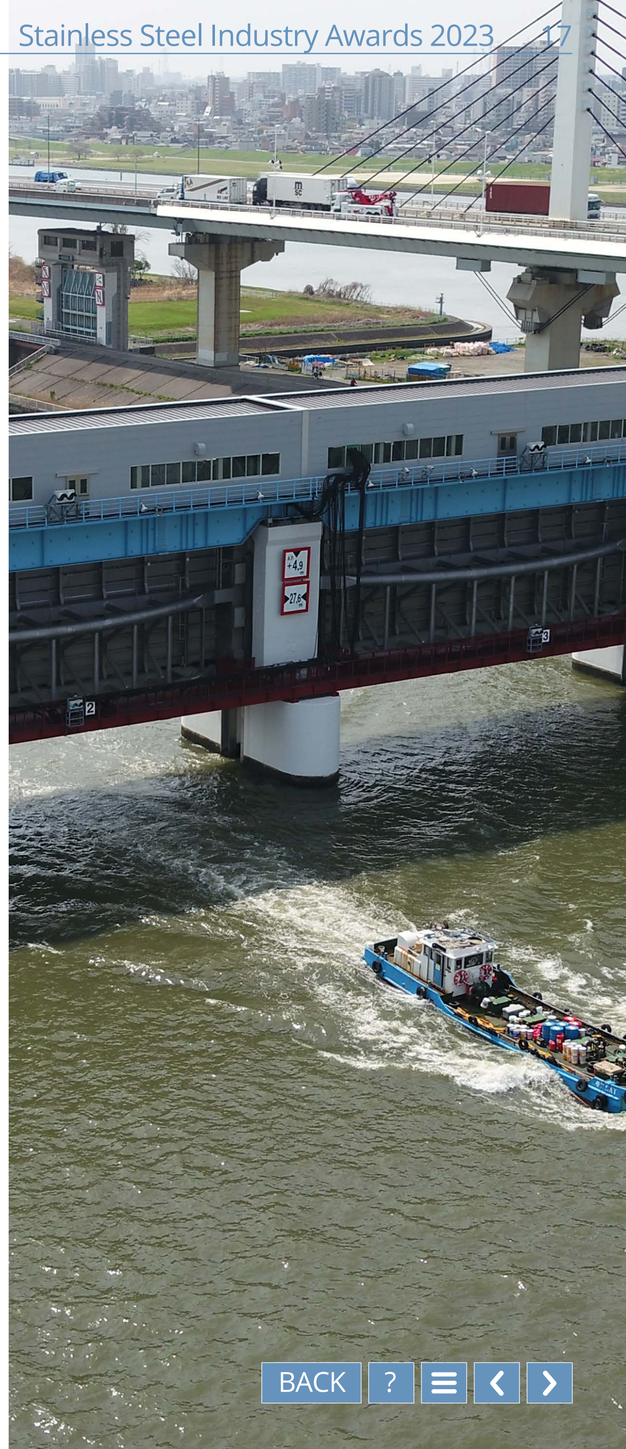
1. In recent years, natural disasters have occurred more frequently and more severely, which causes great damage to people's lives.
2. In preparation for Tokyo Inland Earthquake, the Tokyo metropolitan government is proceeding with seismic retrofitting of flood gates installed for tsunamis and storm surges. The Kamihirai Flood Gate is 30m wide and 9m high, making it one of the largest of them.
3. Since the Kamihirai Flood Gate is located in a residential area, it is particularly difficult to coordinate the repainting of the gate leaf. Therefore, the Tokyo metropolitan government decided to renew the gate leaf to all-stainless steel to meet the latest standards.
4. However, when conventional stainless steel such as SUS316L is used, the weight increases significantly, resulting in insufficient strength of the flood gate post. For this reason, it was initially considered difficult to make the Kamihirai Flood Gate entirely stainless steel.

Why?

1. There are many flood gates in Japan for tsunami or storm surge, including the Kamihirai Flood Gate. Since most of the large flood gates are made of carbon steel, regular repainting maintenance work is required.
2. However, in Japan, the working population is rapidly declining, and the number of young people who want to work in the construction industry is decreasing. There is a serious shortage of workers for repainting maintenance of steel structures.
3. Making the gate leaf entirely stainless steel provides a radical solution to these problems. Switching the material of large scale steel structures to stainless steel was rare and technically difficult. However, if this challenge could be overcome, we believe it would be possible to contribute to the national resilience of Japan, and at the same time, it would lead to the creation of a large demand for stainless steel plates.

Needed action

1. In order to ensure the seismic performance of the flood gate post, an increase in the weight of the gate was



Kamihirai Flood Gate (Tenmporary assembly at fabrication plant)

not allowed. In addition, the stainless steel used for the gate leaf needed to be of high strength to comply with the latest stringent seismic standards

2. For meeting these requirements, it was decided to use duplex stainless steel as the material. The Kamihirai Flood Gate was particularly difficult to manufacture because it is the only structure in Japan that uses a Vierendeel structure with large diameter pipes.

3. Therefore, a welding technique was developed for Uranami welding of large-diameter duplex stainless steel pipes, especially a high-level technique that enables the production of high-quality welded joints by on-site welding.

Action Review

Specific: 1. In order to comply with the latest seismic standards, it was necessary to avoid increasing the weight of the gate leaf, and materials with high strength and high corrosion resistance were required. For that reason, duplex stainless steel was adopted for the entire gate leaf.

2. In examining the adoption of duplex stainless steel, we developed an Uranami welding technique for large-diameter pipes with a diameter of 1 meter, and confirmed that the required corrosion resistance, strength, toughness, and appearance could be secured.

Measurable: The gate leaf became larger and lighter; The weight of the gate leaf before the renewal was 210 tons. Even after the renewal with duplex stainless steel, the weight was kept at 210 tons, despite the fact that the area of the gate leaf was increased by about 22%.

Achievable: 1. By adopting high-strength duplex stainless steel, the weight of the gate leaf was not increased. Therefore, it was able to meet the latest seismic standards.

2. The use of highly corrosion-resistant duplex stainless steel eliminates the need for repainting maintenance and reduces future maintenance costs.

3. The Kamihirai Flood Gate is the only flood gate in the world with an elegant appearance of the pipe Vierendeel structure made of duplex stainless steel. It is popular with residents as a local landmark.

Realistic: 1. In order to produce high-quality welded joints, we optimized the groove shape of the welded part, selected the optimum welding material, the composition of the shielding gas, and controlled the amount of welding heat.

2. Established Uranami welding technology for duplex stainless steel large diameter pipes.

Time-bound: The renewal work of the Kamihirai Flood Gate was completed within the original deadline as the main construction work, excluding related work.

Horizontal Expansion Capability

Through the renewal of the Kamihirai Flood Gate, the manufacturing technology and construction technology for structures using duplex stainless steel have improved. These technologies can be used horizontally on a global scale as measures to improve the LCC of river structures that are becoming larger scale.

Outcome

The success of the Kamihirai Flood Gate renewal project has demonstrated that duplex stainless steel is suitable as a material for large-scale steel structures and has great potential as a structural steel. Duplex stainless steel is becoming the standard material for river structures in Japan. Through this project, we are proud to have contributed to the national resilience of Japan by working together with the people involved in the project.

Other comments

1. It is worthy of praise that the Kamihirai Floodgate has been renewed for five years without losing its function as a tidal gate and protecting the local residents.
2. As the flood gate became larger, the opening of the gate was widened, which contributes to the improvement of the safety of ships passing under the flood gate.

Kamihirai Flood Gate (Full view of flood gate(from upper stream side)

Development of low cost and high strength stainless steel and its application on coal belt conveyor

Member company

China Baowu Steel Group Corporation - TISCO

The Challenge

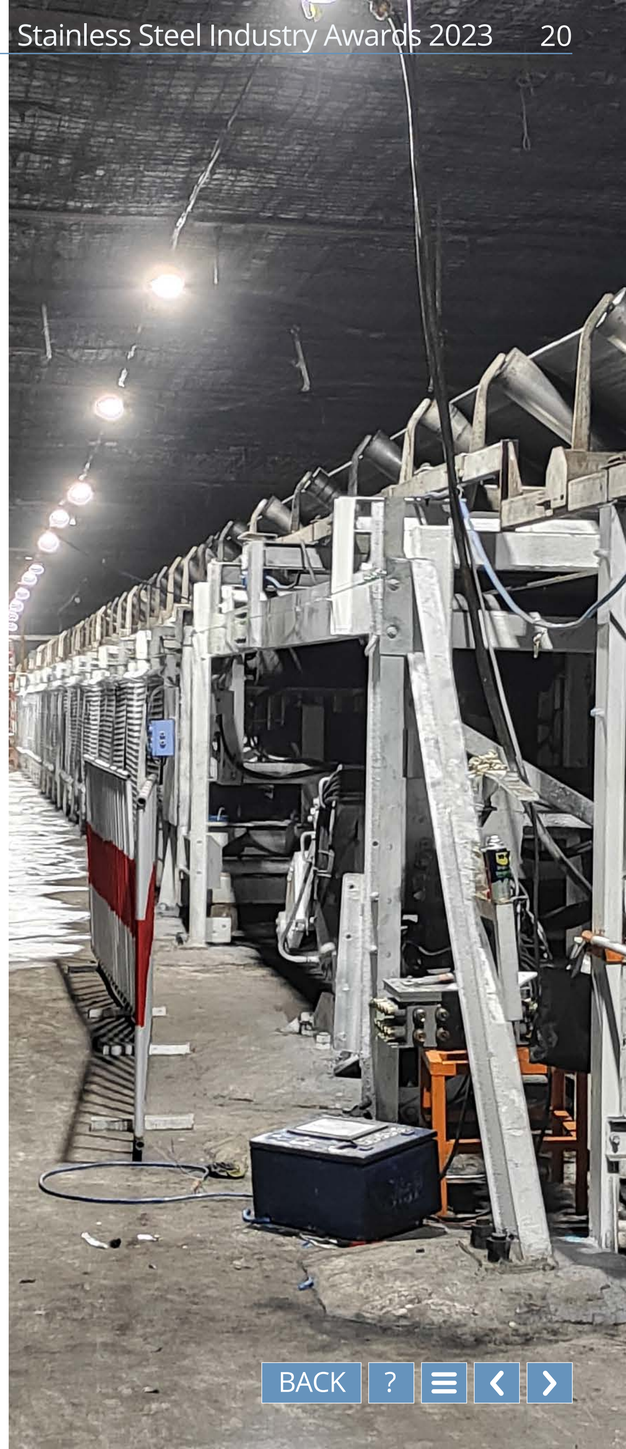
Belt conveyor is a key equipment in the production of coal industry, playing an important role in the efficient transportation of coal materials. The rollers of this equipment are the most core rotating parts,which account for more than 30% of the total cost and run serially, the quality performance of the rollers has a great impact on the belt conveyor work efficiency and cost reduction. Due to the working environment of dense coal dust, high humidity and influence of acid, etc., it leads to the problems of corrosion of the roller cylinders(made of carbon steel), increase of surface roughness and coal dust bonding, deterioration of roundness, increase of running resistance, increase of energy consumption and short service life (≤30,000h on average) etc. In addition, the bracket used for load-bearing is also made of carbon steel with poor corrosion resistance, and its safe service life is less than 10 years even with galvanized treatment and regular maintenance by painting. Because of the low strength (yield strength level of 350MPa), thick cross-section of the workpiece, big weight (a single bracket weighs about 40kg), and the hard load of assembly and disassembly work. The annual stainless steel consumption of roller and bracket are about about 200,000 tons in the Chinese coal industry.To solve these problems the coal industry is pushed to develop a long-life, economical and green products in order to achieve the upgrading and replacing of products.

Why?

Stainless steel is a material of excellent corrosion resistance and good mechanical properties, long service life, low maintenance cost, and its scrap is 100% recyclable If a low-cost, high-strength stainless steel can be developed to replace the traditional carbon steel used for belt conveyor rollers and supports, it can achieve lower energy consumption, resource conservation and environmental friendliness throughout the life cycle of this equipment and meet the demand for low-carbon, green and sustainable development in the field of belt transportation in the coal industry.

Needed action

Cr12 type is a resource-saving ferritic stainless steel with the lowest alloy content, which has good corrosion



resistance in atmospheric and weakly corrosive environments, and is an ideal material to replace carbon steel in environments with high requirements for stress and corrosion resistance.

The working environment of coal belt conveyor is a weakly corrosive environment, adapting Cr12 type stainless steel instead of carbon steel is the most economical way to solve the corrosion problem. However, the yield strength of this type of steel is low, about 300MPa, which does not have an advantage compared with carbon steel. Considering the demand for weight reduction and cost reduction in application, the yield strength of the material needs to be increased to more than 460 MPa.

On the basis of basically no cost increase, how to achieve industrial production through material design and process innovation, to achieve a significant increase in the strength of Cr12 type stainless steel, but also has good plastic toughness, which will be a huge challenge; The welding of coal belt conveyor roller cylinder and bracket during processing is also a key factor, how to solve the brittleness problem after welding for Cr12 type stainless steel during processing is also the key technical problems to achieve massive application.

After years of unremitting research, through a unique composition design and annealing process innovation, we have developed a low-cost high-strength stainless steel with duplex organization of ferrite and martensite on the basis of conventional Cr12 type ferritic stainless steel. The yield strength of the product reaches more than 460MPa (about 500MPa on average for finished products),

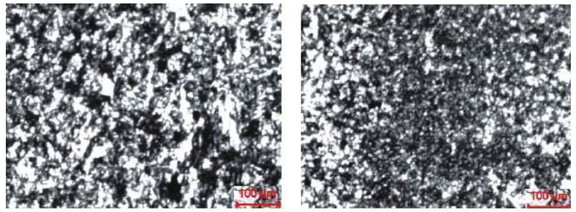


Figure 1: High-frequency induction welding steel pipe with fine welding tissue

elongation after break ≥20% (about 24% on average for finished products), DBTT (toughness and brittleness transition temperature) ≤-20°C, and has good bending and other processing properties.

According to the product form and use characteristics of coal belt conveyor rollers, adapting low heat input high-frequency induction welding and induction heat treatment of the weld seam online and cold rolling process, we have successfully developed a high-precision stainless steel pipe for rollers with good weld quality

Figure 2: Stainless steel rollers for coal belt conveyor (Newly developed stainless steel)

(Figure 1) and straightness ≤ 0.5mm/m and out-of-roundness ≤ 0.2mm, achieving a wall thickness reduction of more than 20% of the rollers; The service life of the roller made by it has exceeded 50,000h (designed service life of 70,000h), and the energy consumption of belt machine operation has been reduced by more than 20%, and the operation efficiency has been

significantly improved (Figure 2, 3).

Figure 3: Stainless steel rollers in service with a bright surface

By adapting molten electrode gas shielded welding and suitable commercial welding materials a high-strength stainless steel bracket is successfully produced a (Figure 4), which achieves a weight reduction of more than 30% of the structure,

Figure 4: Stainless steel rollers and supports for coal belt conveyors (Newly developed stainless steel)

significantly reduces the intensity of work during installation and disassembly; The use of the process of maintenance without painting avoids the impact of carbon steel painting on the human body and the environment; Now the working brackets are in good condition, the longest service one among them has been working for 6 years (Figure 5),and the service life is expected to be 30 years, which will significantly reduce the operating cost of users.

Figure 5: Stainless steel rollers and supports for coal belt conveyors (Newly developed stainless steel)

Action review

Specific: Problems that tend to arise under the current status of using common materials.

1. The rollers have serious rust and corrosion, short service life and large running resistance.
2. The bracket is heavier and more difficult to carry.
3. Rust and corrosion cannot be detected and the damage rate is high. The failure of rollers and supports may bring about production interruptions and downtime for maintenance.

In order to solve the above problems, we upgrade the material of rollers and brackets from ordinary carbon steel to stainless steel, and develop Cr12 type high strength stainless steel with yield strength over 460MPa with ferrite and martensite duplex organization, and the precision rollers and brackets of long life and light weight are made for coal belt conveyor from such stainless steel.

Measurable:

1. With the reducing of cylinder wall thickness of Stainless steel roller ,lowering operation energy consumption, and extending service

life from the original 15-20,000 hours to 50,000 hours; The stainless steel cylinder thickness of the rollers is reduced by 30% leading to 20% energy-saving ;A breakthrough in the length of the belt machine is achieved, a single-point drive belt machine can replace the original two belt machines, which substantially reduces the workload and costs in installation, maintenance, the site workers are also reduced by half; The damage rate is reduced to 3% of the original.

2. 40% weight reduction of the belt conveyor support unit significantly reduces the work intensity and operation and maintenance costs during installation and disassembly.

Achievable: Goal: Mass production and application of products to achieve line upgrade and low carbon operation of conveying systems in the coal mining field.

Our stainless steel have manufactured more than 1,000,000 rollers, which are used in the intelligent mines in China. 20% power saving is achieved in belt conveyor operation.

Realistic: The customer recognition is achieved in the application , and we continue to develop the market, Nearly 20,000 tons of stainless steel products has been applied in the coal industry, which has a good result of product performance.

Time-bound: In 2012 we began to understand the needs of the coal industry and intervened in the development of this field in accordance with the development plan.In 2014 stainless steel for rollers was applied massively.In 2016 stainless steel for supports was applied massively. All of them were developed and completed according to the planned time.

Horizontal Expansion Capability

The developed stainless steel has the properties of high strength, good plastic and toughness,and weldability. It can be produced through conventional stainless steel equipment and processes with high efficiency and low cost. The product can replace carbon steel, weathering steel, coated steel, etc. in atmospheric and weakly corrosive environments where the force and corrosion resistance are requested, and the industrial promotion can be easily done. Now It has been successfully applied to coal belt conveyor and started to be promoted in iron ore belt conveying, power station, yard terminal conveying, etc. The future market potential is extremely huge. At present, for the metallurgical enterprises the iron-making, sintering, coking, mining and port etc. systems fulfil the conditions to use stainless steel for rollers and supports.

Outcome

Based on the bottleneck breakthrough of the low strength for traditional Cr12 type ferritic stainless steel, the new stainless steel of 460MPa level is developed ,which behaves the ferrite and martensite duplex organization and properties of low-cost high-strength.By the cooperation with the welded pipe factory and bracket factory downstream processing manufacturing enterprises, It solves the material welding process technology problems□achieves the mass production of stainless steel rollers and brackets and eliminates the pain points of the coal industry belt conveyor, which not only brings good benefits for the company, but also helps to strengthen the

competitiveness of coal enterprises low-carbon green operation and industry. It mainly achieves the following results:

1. The weight of stainless steel roller is reduced by more than 20% and the service life extends by 3 times, which significantly reduces coal belt conveyor operation and maintenance time and costs.
2. The weight of stainless steel brackets is reduced by more than 40%, which significantly reduces the labor intensity of workers during disassembling and assembling; and the life span is increased by two times, which reduces the times of disassembling and assembling during the production of coal belt conveyors and shortens the working time of workers in harsh environments.
3. Belt conveyors made of stainless steel rollers and brackets have an overall power saving of more than 20% and a productivity increase of more than 10%, with life-cycle costs of rollers and brackets reduced by more than 38% and a significant reduction in spare parts inventory.

High strength and high corrosion resistant stainless steel cladding material of TE4003C5 for railroad vehicles

Member company

China Baowu Steel Group Corporation - TISCO

The Challenge

China's railroad wagon holdings of 966,000, of which about 95% of the wagon body using 350-450MPa grade weathering steel. Weathering steel wagons require more than three workshop repairs during the whole life cycle, which cannot meet the 25-year service requirements of the whole vehicle. The railroad wagons made of T4003 stainless steel have good corrosion resistance and a predicted life of more than 100 years, but the price is three times that of weathering steel, and the strength level is only 350MPa. The problem of mismatch between corrosion resistance and design life in existing carriage material is difficult to adapt to the development direction of light weight and heavy load of railroad wagons, so this project intends to develop a new material with high strength, high corrosion resistance and economy to meet the needs of railroad wagon industry.

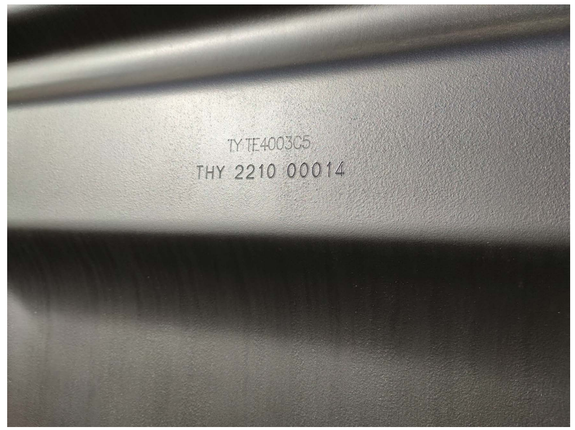
Why?

TISCO has been engaged in the research and development and promotion application of stainless steel and high-strength carbon steel for long time, and is the most competitive stainless steel enterprise in the world, with more than 8 million tons of stainless steel and more than 6 million tons of high-strength carbon steel manufacturing capacity, rich varieties and complete specifications. Stainless steel covers the full range of austenitic, ferritic, martensitic and duplex stainless steels, and high-strength carbon steel is of stable quality, achieving stable production of 235-2000 MPa grade carbon steel in batches. In the field of railroad wagons, the market share of Q345-Q500MPa grade weathering steel reaches more than 50% in China, the market share of T4003 stainless steel reaches more than 90%, and there is a profound research and inspection basis in the corrosion of coal on steel materials. TISCO has advanced 2250mm width hot rolling production line and 4300mm width plate production line, with rich experience in clad plate preparation, and has the ability to cladding preparation of high strength carbon steel with high corrosion resistant stainless steel.

Needed action

1. TISCO is the first one In the international proposed stainless steel T4003 and high strength weathering

BACK ?



steel Q450NQR1 rolled composite preparation of high strength and high corrosion resistance stainless steel cladding material, and named it as “TE4003C5”. The corrosion resistance design of the new material is comparable to T4003 and more than 5 times higher than Q450NQR1. The corrosion rate under the corrosive environment of coal was studied to determine the optimum thickness ratio of base layer and cladding layer to meet the requirements of railroad wagons service for more than 25 years, achieving the perfect compatibility of the best corrosion resistance and the highest strength of steel for railroad wagons in service.

2. Development of the length of 8m dissimilar steel welding Assembling key process technology. Innovative bevel design form, using the 316 stainless steel wire to achieve the ferritic stainless steel and high strength weathering steel direct welding , to solve the problem of Weld cracking caused by the welding stress of dissimilar steel, to break through the technology bottleneck for the large size of the raw material surface roughness, flatness caused by poor local sealing area pseudo-vacuum , to achieve a high efficiency encapsulation billet, the 8m length of 400 series Stainless steel and high-strength weathering steel direct welding Assembling billet process route for the first time in China.

3. Adopting asymmetric direct rolling technology of hot continuous rolling and dissimilar steel welded Assembling billets for cladding steel coil production. On the basis of the large long dissimilar steel welded billet technology, it breaks through the technical problems of dissimilar steel rolling and uneven deformation of post-rolling cooling, forming a new technology of “dissimilar steel asymmetric welded billet + hot strip rolling + cross-cutting”. Compared with the traditional process, this technology omits the intermediate billet opening and coil tearing process, reduces investment costs, shortens the manufacturing cycle, improves surface quality and thickness accuracy, and has more obvious advantages in production efficiency and material yield.

Action review

Specific: With the rapid development of China’s economy, China’s railroad wagon ownership continues to grow, the demand for steel materials is huge. At present, 95% of the car body using 350-450MPa grade weathering steel, due to general corrosion resistance, weathering steel truck needs multiple repairs in the whole life cycle, can not meet the 25 years of service requirements; T4003 stainless steel has good corrosion resistance, but the price is high, limiting its promotion and application. Therefore, there is an urgent need to develop new materials with high

strength, high corrosion resistance and high cost performance to meet market demand.

Firstly, we visit the end-users of railroad wagons to understand the corrosion resistance of existing materials and the parts most prone to corrosion, the manufacturing and maintenance costs during the whole life cycle of the vehicle and the user's demand of how to balance high strength and high corrosion resistance, and select the best base and cladding materials. Secondly, according to the vehicle model, use parts and corrosion data, design the thickness of base layer and cladding layer required for full thickness material. Thirdly, choose the best welding billet and rolling process to complete the preparation of the rolled compound material, test the properties, and require the mechanical properties to meet the standard requirements of the base layer and the corrosion resistance to meet the standard requirements of the cladding layer. And assess whether its weldability and molding properties meet the vehicle preparation requirements. The fourth carry out the test vehicle preparation, delivered to the user.

Measurable: According to the railroad wagon in-service materials and its high-temperature deformation behavior research, determine the base layer using Q450NQR1 material, stainless steel using T4003 material. After dissimilar steel billet welding Assembling and rolling, the new material named TE4003C5, yield strength ≥ 500MPa, tensile strength ≥ 600MPa, shear strength ≥ 350MPa, the results of the 72-hour cyclic infiltration test of the compound stainless steel achieved excellent results of ≤ 5%. New materials

by downstream vehicle manufacturers welding, forming inspection, welding tensile strength ≥620MPa, the performance is excellent, to meet the test vehicle preparation requirements.

Achievable: The project aims to develop high strength and high corrosion resistance stainless steel cladding materials for railroad wagons, through the production of stainless steel plates and high strength carbon steel continuous casting billets directly welded and continuously rolled, the properties of the new material prepared to meet the original target requirements, and by the downstream vehicle manufacturers processing and production of 22 70-ton special open wagons for coal transport, to achieve a high strength and high corrosion resistance stainless steel cladding materials in the railroad wagon The world premiere of high strength and high corrosion resistance stainless steel cladding material in the field of railway wagons.

Realistic: The project carries out relevant tests, production, inspection and evaluation in accordance with the set objectives, and all the tasks set have been realized with good results. The new materials developed have been

successfully applied in batch on the special open wagons for railroad coal transportation, and according to the projection of corrosion, it can achieve more than 30 years without cutting and changing simple maintenance.

Time-bound: This project has been implemented since March 2021, and the expected completion time is the end of 2022. Under the close cooperation of various departments of TISCO, the first test roll was successfully completed off the line in January 2022, and the comprehensive quality was assessed by inspection to meet the standard requirements. A new vehicle manufacturing contract was signed with downstream vehicle client and 22 70-ton special open wagons for coal transportation were manufactured and delivered to users in November 2022, successfully completing all tasks within the project requirement time.

Horizontal Expansion Capability

High strength and high corrosion resistance stainless steel cladding material TE4003C5 for railroad vehicles, produced by hot rolling direct rolling of dissimilar steel welded composite billets, has mechanical properties that meet the standard requirements of high strength weathering steel and corrosion resistance that meet the standard requirements of stainless steel, realizing the perfect compatibility of high strength and high corrosion resistance, and has been processed by downstream users to complete the preparation and delivery of 22 special open wagons of 70 tons for coal transportation, realizing the preparation and application of stainless steel cladding materials for railroad vehicles is a double first.

The manufacturing technology has good promotion and application value, using this preparation technology TISCO produced 304+Q235B rolled cladding materials for construction steel formwork, and will continue to improve, and will be promoted in the future in the rolled clad material of high-strength carbon steel with austenitic, ferritic, martensitic and duplex stainless steel above 600 MPa grade.

Outcome

The successful development of TE4003C5, a high strength and high corrosion resistant stainless steel cladding material for railroad vehicles, opens up a new path for the development and promotion of TISCO's new materials. The future TISCO cladding material production capacity can reach more than 100,000 tons, the annual output value of 1 billion RMB, with considerable economic benefits. According to China's railroad wagon retaining 30% of the vehicle using stainless steel cladding material preparation to estimates, the cumulative use of steel up to 1.45 million tons.

High strength and high corrosion resistance stainless steel cladding material TE4003C5 has been applied in batch in 22 new 70-ton coal transport special open wagons, which is significant to the development of downstream industries. (1) Heavy-duty railroad wagons: Through lightweight design, each wagon can achieve an extra 2 tons of load with the same axle weight to meet the heavy-duty needs of railroad wagons. (2) railroad wagon long life: can realize wagon body simple maintenance without cutting and changing in 3 workshop repair periods ,

the whole wagon life increased to more than 30 years. (3) Efficient operation of railroad wagons: compared with weathering steel Q450NQR1, it can realize no cut-off replacement, significantly shorten the workshop repair time, improve the operating time of the vehicle in transit, reduce the labor intensity of workers, significantly improve the operating environment, and save maintenance cost of 20,000 RMB per wagon to meet the demand for high efficiency of railroad wagons. (4) In line with the development trend of low consumption and low carbon: each wagon saves 2 tons of steel, according to the national vehicles are using composite materials, can save 1.932 million tons of steel production, reduce carbon emissions 4.521 million tons.

Custom beds for pick up trucks

Member company

North American Stainless

The Challenge

Develop a product that would mix wood with stainless steel for a unique look.

Why?

The design required a metal to combine with wood that would provide a clean look that would last.

Needed action

Stainless strips of T304 were selected as the best alternative.

Action review

Specific: The design required a metal that had to have a high resistance to corrosion as the metal strips would have to maintain the clean bright look in an outdoors setting. NAS stainless steel was the

solution in order to achieve the modern aesthetic look as well as the required corrosion resistance.

Measurable: Grade T304 has measurable corrosion resistance and with adequate care has proven to be the correct solution.

Achievable: Objective to produce a custom bed with a unique look that will last was achieved with the use of NAS T304 stainless steel.

Realistic: Fabrication of custom truck beds was possible to execute and the objective was achieved with the use of NAS T304 strips.

Time-bound: Custom beds were fabricated on time without problems.

Horizontal expansion capability

Other companies within the group can supply similar grade for same type of application.

Outcome

Customer will observe the benefits provided by the corrosion resistance of NAS T304 grade so that customers buying the custom truck beds will value the benefits of combining wood with stainless steel as opposed to other metals.

Other comments

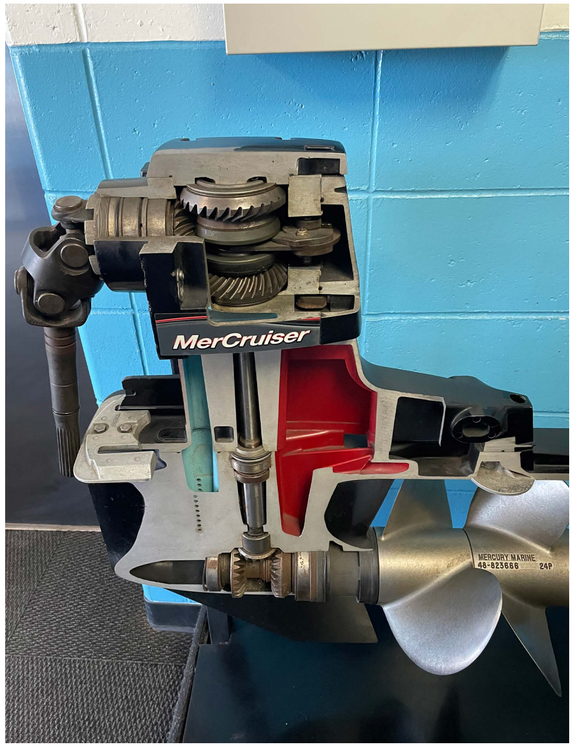
These custom truck beds combine both the unique look of wood and stainless in a product that traditionally did not include stainless steel.

Pictures courtesy of Rolled Metal Products

Stainless Steel Shaft for Outboard Engine

Member company

North American Stainless



The Challenge

The marine outboard engine needed a corrosion resistant internal shaft.

Why?

Due to the marine environment where outboard engines are used, corrosion resistance is needed in vital components like the internal shaft.

Needed action

The use of NAS grade 17-4 was selected for the internal shaft as the best option for corrosion resistance and strength needed by the component.

Action review

Specific: NAS 17-4 stainless steel grade was selected after studying the corrosion resistance of several materials.

Measurable: The resistance to corrosion in a marine environment is measurable over the life span of the engine.

Achievable: Objectives to use a component that when cared properly would supply the required corrosion resistance was achieved.

Realistic: Results required were achieved.

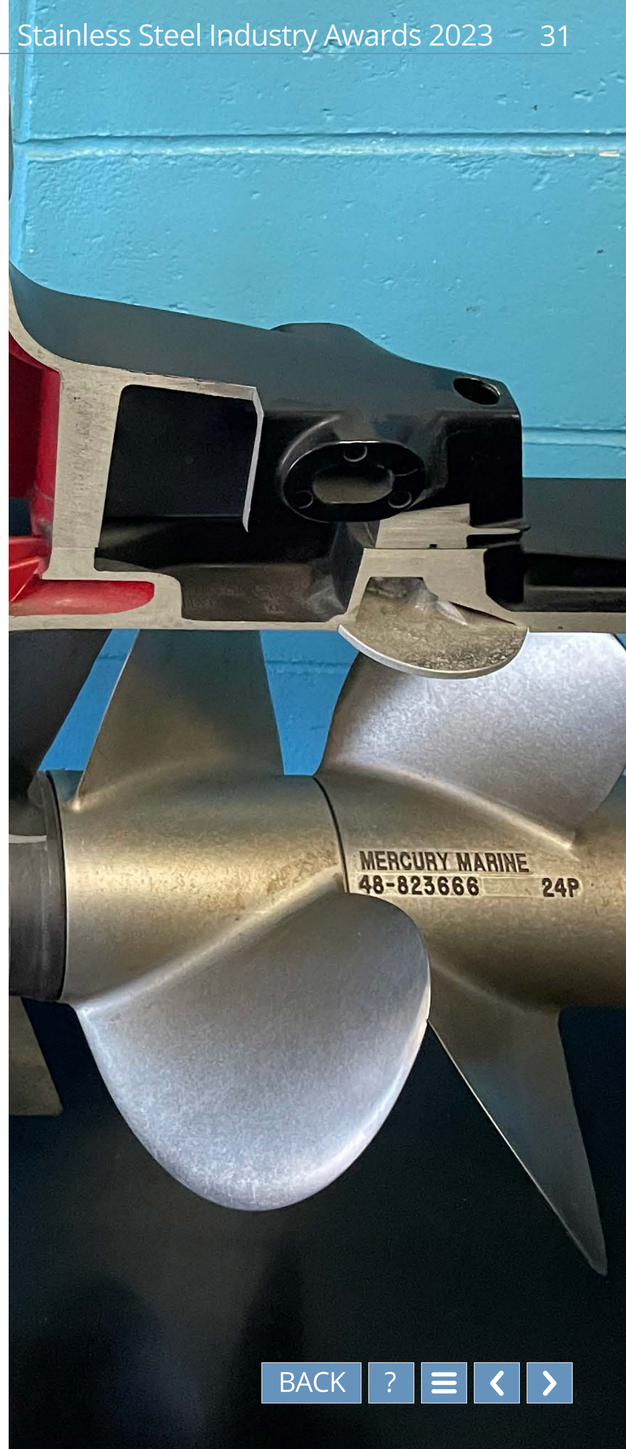
Time-bound: Actions were achieved within the timeframe required.

Horizontal Expansion Capability

Use of grade 17-4 from the Acerinox group companies can be used for similar applications.

Outcome

Benefit supplied by NAS 17-4 grade in this application corresponds to ongoing sales of material for marine board engines.



Picture courtesy of Jason Wheeler

Stainless Steel/Copper tanks for production of Tequila

Member company

North American Stainless

The Challenge

The customer wanted to use tanks for the production of tequila that were fabricated with copper and stainless steel.

Why?

The customer required tanks to be made out of food grade stainless steel for the benefits of corrosion resistance but also wanted to include the use of copper in the tank fabrication in order to give the tequila a specific flavour.

Needed action

NAS T304 was selected as the best alternative for the stainless steel portion of the tank as it provides the necessary corrosion resistance needed as well as easy of coupling with copper components of the tanks.

Action review

Specific: Customer experimented with different types of stainless steel and found that NAS T304 was the best alternative for both corrosion resistance in the tequila production process as well as easy of joint with the copper components.

Measurable: The benefits of using NAS T304 are measurable in that corrosion resistance can be measured over the life span of the tanks.

Achievable: Initial objectives to fabricate stainless steel/copper tanks that would couple the objectives of corrosion resistance sanitary benefits with the specific taste of copper given to the tequila were achieved.

Realistic: The objective was realistically achieved.

Time-bound: Fabrication and use were achieved within the required time frame.

Horizontal Expansion Capability

T304 grade steel from other companies within the Acerinox Group can be used for similar applications.

Outcome

The customer is very pleased with the goal achieved and thus will be looking to fabricate more unis in the future.

Wood/Stainless Steel Barrels for Tequila

Member company

North American Stainless

The Challenge

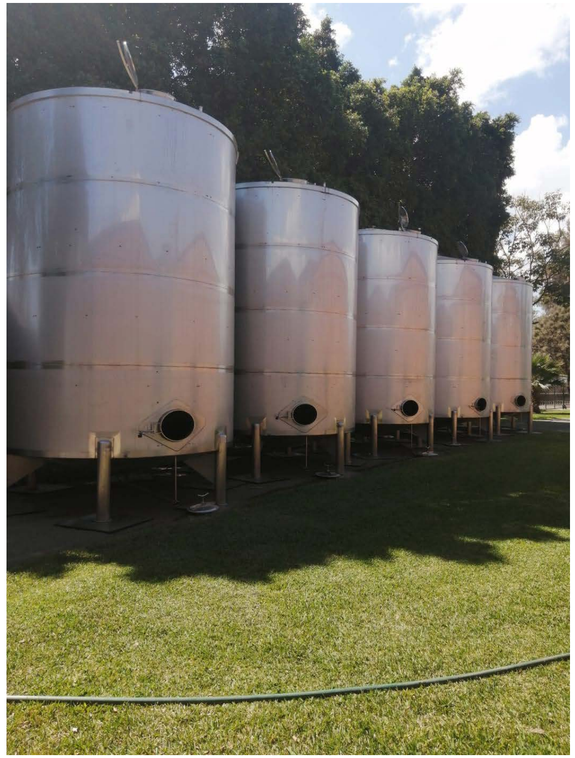
Replacing the need for multiple tequila storage tanks with large tanks made out of a combination of wood and stainless steel.

Why?

Wooden barrels are normally used for the storage of tequila, in order to improve better efficiency a larger tank was needed but still had to be internally lined with wood in order to preserve the traditional method of storing.

Needed action

Large tanks of up to 500,000 liters were designed in order to replace the need for multiple tanks. In order to be able to



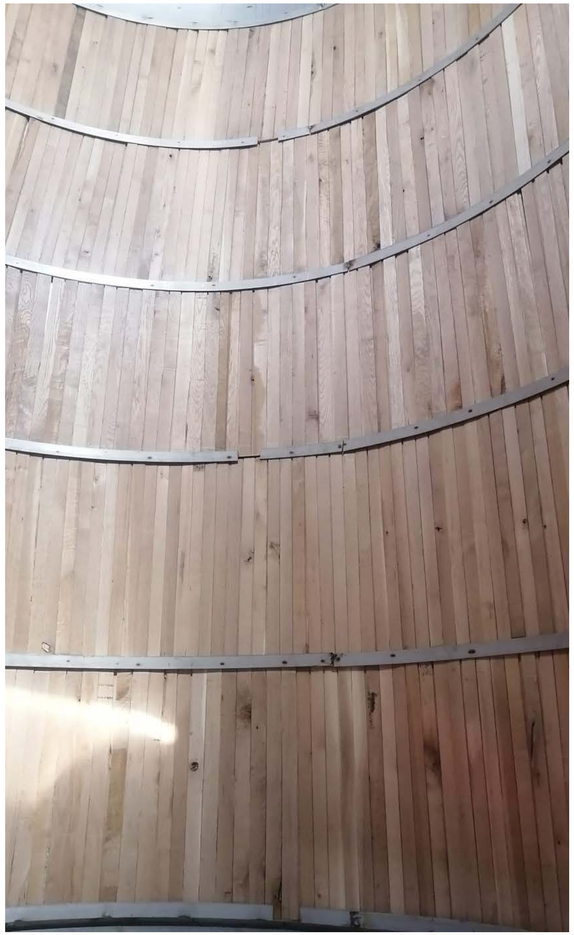
contain such large quantities NAS T304 stainless steel was used as the material to fabricate the tank and the inside was lined with wood. This solved both the need to maintain the wood in contact with the Tequila and at the same time provided a tank that was both sanitary with food grade stainless and has good corrosion resistance.

Action review

Specific: NAS T304 stainless steel was selected as the best material for the tank due to its proven use for food grade applications as well as the corrosion resistance and ease of fabrication.

Measurable: The corrosion resistance of T304 grade is measurable and as such the coupling with the wood lining is maintained free of corrosion that could lead to internal breaks in the coupling.

Achievable: Objectives to fabricate large volume tanks for tequila storage that



would have the same benefits as smaller wooden barrels with the benefits of corrosion resistance were achieved.

Realistic: Fabrication was achieved thus solution was deemed to be realistic.

Time-bound: Fabrication and measurable benefits were achieved within the required time frame.

Horizontal Expansion Capability

Similar use of T304 stainles steel in combination with wood can be achieved with same grade from other companies within the Acerinox group.

Outcome

Customer is very pleased with the benefits achieved with the combination of NAS T304 stainless steel and wood lining in order to produce larger tanks for tequila storage that enables the customer to use less number of wooden barrels.

Stainless Steel Tipper Trucks and Trailers

Member company

Aperam South America

Challenge

We are addressing the issue of excessive wear on tippers transporting corrosive products.

Why?

Because we believe that there are many situations where corrosion and abrasion processes act simultaneously in the wear of parts and components, and the high strength stainless steel sheets, ENDUR 300, are an economically viable solution for this application.

Needed action

To carry out this development, we created ENDUR 300 stainless steel sheets with 300 HB hardness, 800MPa yield strength and 11% Chromium. Endur plates are the perfect union between AHSS and stainless steel.

Action review

Specific: The vast majority of tippers in Brazil are manufactured with common carbon steel plates or advanced high-strength steels (AHSS). When manufactured from advanced high-strength steels, their service life is increased and/or weight reduced, but they still suffer the corrosive effect of aggressive and wet loads. As the abrasive effect of transported products does not allow protection by painting or galvanizing, the stainless steel solution is the best way.

From the launch of the ENDUR 300 in 2019, a stainless steel supplied with high hardness and mechanical resistance, we started the first tests with tipper trailers.

Measurable: In this period of about 3 years, more than 500 tippers have been manufactured in ENDUR 300 for the transport of mineral coal, table salt, ores with high humidity and organic waste in general and others with excellent results. For example, there is a tipper transporting coal that started operating with 3.00 mm thick plates and after 2.5 years of use and more than 90,000t of mineral coal transported, it is 2.92 mm thick at the point of greater wear.

Achievable: In 2022 we had sales of around 500t for the production of tippers. Two important tipper manufacturers in Brazil officially presented their ENDUR 300 products to the market.

Realistic: The main actions involved in this development were:

- identification of operating conditions where common steels fail due to corrosion;
- Approaching end customers to propose tests with stainless steel;
- product development in stainless steel together with manufacturers;
- follow-up of prototype results;

Time-bound: In 2023 we intend to expand sales for tippers to more than 1000t of ENDUR sheets;

Horizontal Expansion Capability

We believe that the high strength stainless steel solution can be used by all global tipper manufacturers, especially for the transport of corrosive products.

Outcome

The ENDUR 300 is produced by Aperam South America using pig iron produced from charcoal with zero CO_2 emissions.

Additional filtration system to improve caster segment reliability

Member company

Columbus Stainless

The Challenge

The initiative was addressing the high number of continuous caster segments that were suffering bearing and roll failure as a result of insufficient cooling. The reduced cooling efficiency was as a result of debris accumulation in the cooling circuit incoming with the water.

This debris was accumulating in all the cooling water supply pipes causing them to block, resulting in restricted or omitted cooling to the bearing and rolls. This resulted in bearing failures, roll damage etc.

This in turn resulted in a significant increase in the number of segment changes that needed to be performed during 2021 as can be seen below.

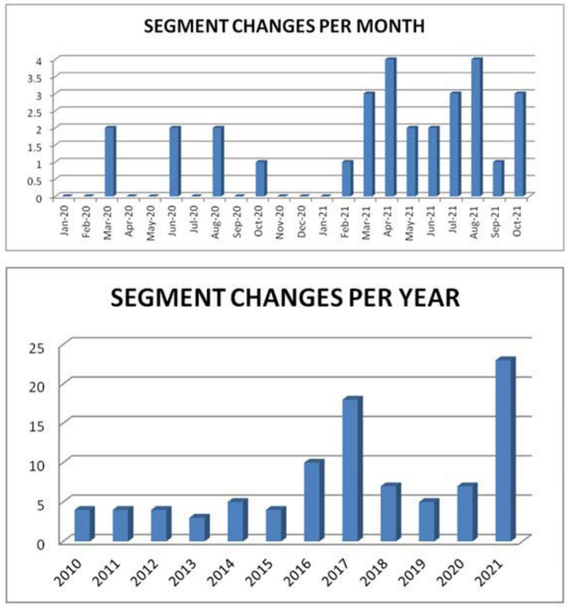


Figure 1. Segment replacement history.

Why?

We have experienced a series of premature equipment (Segments) failures which triggered a need to conduct a Root Cause and Failure Analysis (RCFA). On analysing the failure we discovered that the root cause of the failure was due to segment bearing overheating i.e. the bearings were not being cooled as they were supposed to as the water passageways were restricted by the

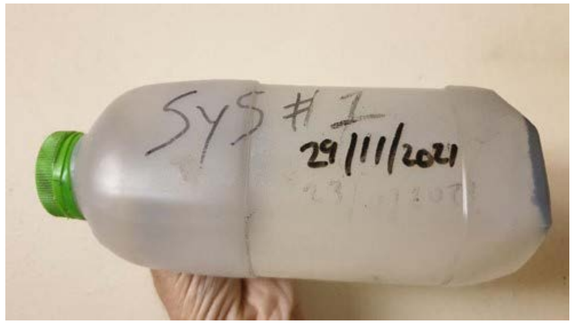


Figure 2. Segment cooling water indicating the debris accumulated at the bottom of the bottle.

accumulation of foreign debris.

Needed action

Although there is a filtration system at the Central Water Plant (CWP), the filtration system was unable to filter all the debris elements and therefore needed a solution to address this identified flaws.

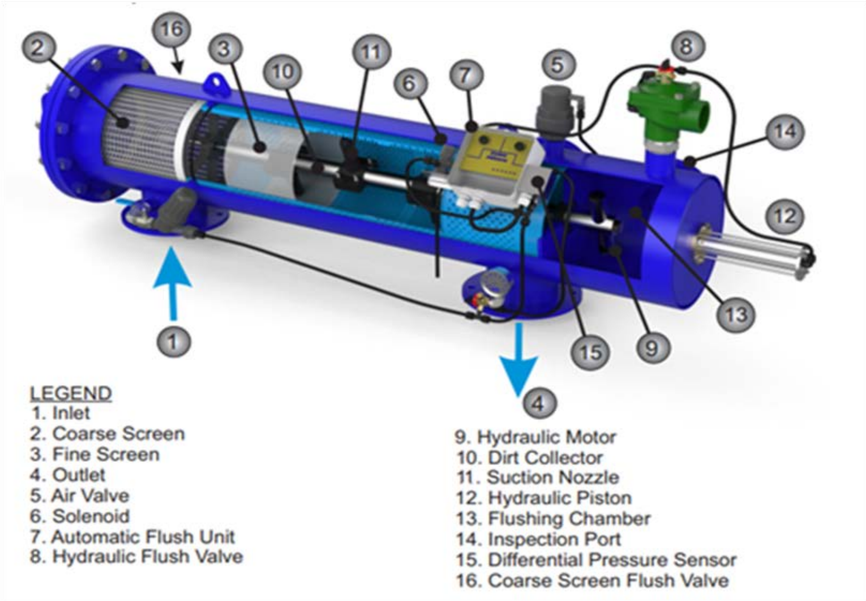


Figure 3. Cubic filtration system to remove debris in cooling water supply system.

We therefore resorted to install an additional Cubic Filtration System (CFS - figure 3) and a Magnetic Filtration System (MFS – figure 4) in series i.e. the water from the CWP will be further filtered through the Cubic filtration system and further fine filtered by the magnetic filtration system before reaching the equipment (Segment).

Figure 4. Magnetic Filter System.

The magnetic filtration system installation and the fine magnetic debris that was removed with the filter can be seen in figure 4 and 5.

Figure 5. Magnetic debris removed on magnetic poles.

Action review

Specific:

- The solution was custom built to specifically address the water contamination problem that affected the performance of the segments.
- Although the normal filtration through screen is a normal practice, the double filtration combining the traditional screening together with the magnetic filtration system was a key and a breakthrough in addressing this challenge. Finer screens would work perfectly in trapping the finer debris but would significantly result in significant waterflow loss which would again be detrimental in the cooling of the equipment. The magnetic system traps the debris with negligible water flow losses as the system reaches a certain saturation point and allows the water through.

Measurable:

- Based on the water flow requirements calculated to satisfy the cooling of the equipment, three units of the Cubic Filtration System were installed. Further each supply line feeding the segments was fitted with a magnetic filter connected in series which makes up nine of them in total suffice to address the problem.
- The effect of this solution can be measured by comparing the segments exchange rate of 27 exchanges in the year 2021 to 7 exchanges in the year 2022 which is a 74% reduction.

Achievable: The objective to reduce the segment failure rate through the installation of the combined filtration system was achieved in that the failure rate was significantly reduced by 74% which is quite significant.

Realistic:

- The proposed solution was hypothesized and upon a thorough analysis and deliberation a decision was made to actually put it into practice.
- To date the system is in operation and the benefits are evident.

Time-bound: From conception to implementation, the project took three months to install the first phase (The Cubic filtration System) and the second phase (Magnetic Filtration System) was projected to be completed by the end of the year as the magnetic filters had to be custom made to fit into our system. This was achieved.

Horizontal Expansion Capability

The filtration system can be successfully used anywhere in the organization provided that the fluid to be conveyed is within the chemistry specification specified by the Original Equipment Manufacturer (OEM). The only requirements is that it has to be designed for that specific system as systems are not identically the same hence the need for custom design to fit the need and purpose of that entity.

Outcome

The most outstanding outcome is the reduction of the equipment failure rate i.e. the reduction of the segments exchange rate by 74% in 2022. This has

also improved the business efficiency as the plant availability has improved thus increasing the throughput through unplanned downtime reduction. Maintenance cost and other related costs such as opportunistic cost has also improved as a result. Failed segments rollers had an immediate and direct impact on product (slabs) quality (surface scratches) which acted as a bottleneck to subsequent processes. This quality issue has been alleviated as well through this initiative. Finally this has led to job satisfaction to both the equipment user, the equipment repairer and the product user respectively proving this solution to be a great success.

Other comments

Some preliminary study and some depiction of the problem and envisaged solution are added on a separate document for further insight.

In House Optimisation of Breakout Protection System

Member company

Columbus Stainless

The Challenge

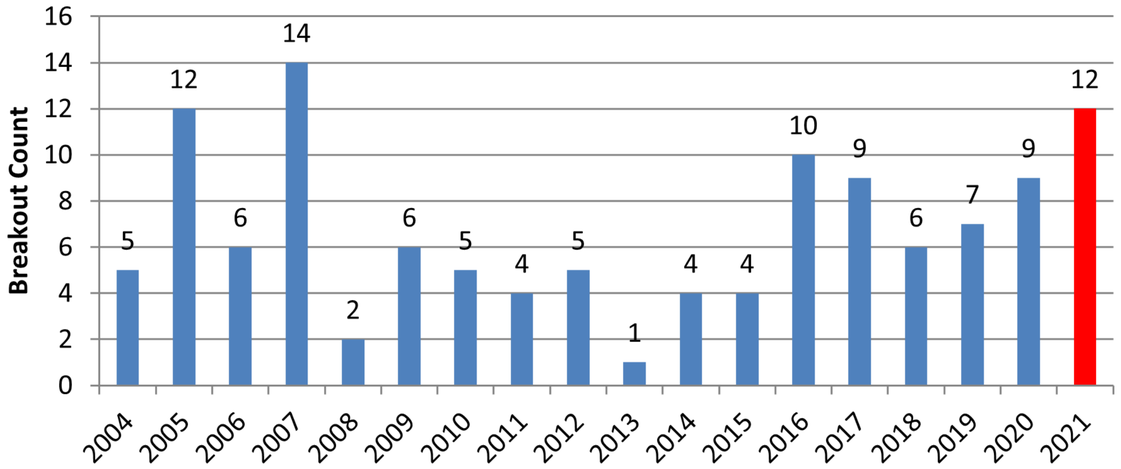
The occurrence of breakouts during the continuous casting of slabs poses a significant safety and production risk to the melt shop and its personnel. During a breakout an uncontrolled spillage of steel from within the steel strand being cast occurs, which ignites all flammable material inside the casting bow, can cause steam explosions and damages the casting equipment severely. It also results in excessive downtime and lost production opportunity and leads to significant additional cost to rework heats in the Argon Oxygen Decarburization (AOD) process.

A breakout is typically identified by the personnel that are present on the casting deck as an eruption of flames emanating from below the mould and oscillator covers, this also results in the personnel being put in a hazardous situation which could potentially result in burn injuries being sustained.

Why?

Breakouts are events that do occur on occasion and have been something part of the operational dynamic of the continuous caster for as long as records have been kept.

During the 2021 production year there had been 12 breakouts that occurred (see figure). During the post mortem investigation into these events it had been identified that 6 of these were as a result of thin shell events (steel shell rupture upon mould exit), 3 were due to stickers where the shell got stuck to the mould and tore open, 2 were due to equipment failure, 1 was due operator mould packing error.



The estimated impact to cost and production during the occurrence of a breakout and the subsequent time required to repair the machine and get it operational again is approximately 12 hours of downtime and roughly R3.5 million. This equated to roughly 144 hours of lost production time and R42 million of additional production cost to recover from the breakouts of 2021.

It was deemed necessary to improve our detection and warning system for breakouts in such a way that the stickers and thin shell events, need to be identified, alarm made and the operator be put into a

position to take decisive action to prevent a breakout from occurring.

Needed action

In order to address the two main sources of breakouts i.e. stickers and thin shell occurrences it was essential to understand the mechanism of thin shell breakouts and also shell tear propagation during sticking scenarios.

Sticker Breakouts:

From the inspections of numerous sticker breakouts shells it was very evident that there is a diagonal type tear that occurs in the shell as a portion of the shell gets stuck and the rest of the strand continues to move down relative to the static piece of shell. This relative movement of the remainder of the shell causes the tearing of the shell in a diagonal upwards pattern as indicated in the picture below.

This also correlates well with what is described in literature regarding the propagation of the tear in a V-type pattern as can be seen in the picture below.

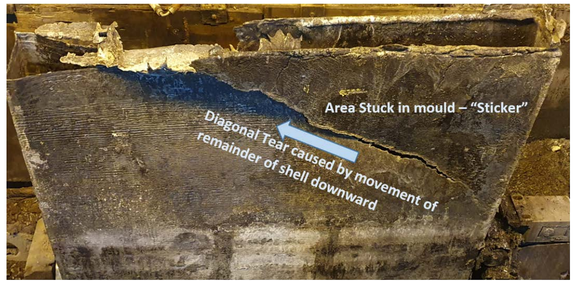


Figure 2. Sticker breakout showing the clear diagonal tear propagating towards the top of the strand.

This also correlates to the patterns that were detected on the Breakout Prevention System (BOPS) that Columbus has developed – this system utilises thermocouple readings in the mould to detect the extent of the rate of change in temperature. The challenge was however that the severity of these tears were often insufficient to trigger the current alarms and were subsequently missed – the initial BOPS system was too robust and did not react.

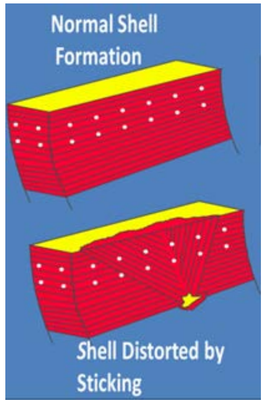


Figure 3. Depiction of normal shell vs. shell development during sticking (Intechopen).

The BOPS' intelligence then had to be upgraded in order to check for a developed diagonal pattern and not simply to react on two thermocouple's indicating a rise in temperature in succession as this creates a large amount of nuisance alarms.

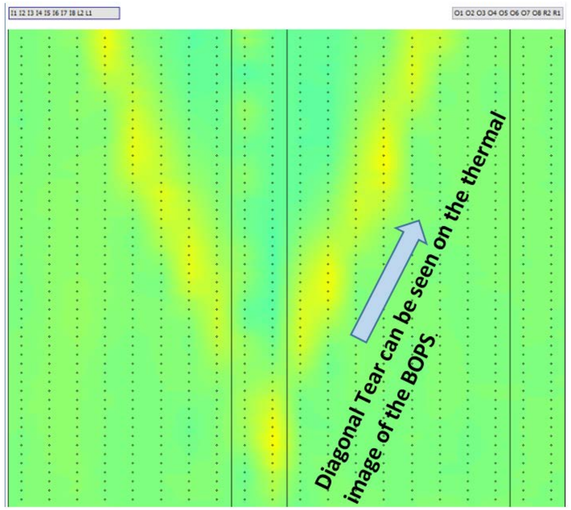


Figure 4. Actual Columbus BOPS depiction of sticking on the BOPS (Breakout Prevention System)

The system was updated to monitor until it gets a diagonal pattern that spans four thermocouples before triggering an

alarm. This also created the possibility of making the system more sensitive on the thermocouple value on which it would trigger as the period over which it monitors to confirm a tear is longer. This significantly reduced the nuisance tearing alarms. To summarize a new alarm was introduced to recognize the sticker pattern and not only look at the rate of temperature change of adjacent thermocouples.

Thin Shell Breakouts:

Figure 5. Thin Shell Breakout

During a thin shell breakout the produced shell is too thin to withstand the ferrostatic pressure exerted by the steel column in the mould and subsequently the shell ruptures upon mould exit as can be seen in figure 5.

During the investigations of thin shell breakage it was determined that a simple heat removal calculation related to a steel input into the mould could be used to simulate the shell thickness that is achieved. It was also established that for most steel types a shell thickness of 15 mm on the wide faces and 20 mm on the narrow faces was the safety limit for sufficiently thick shells to prevent shell rupture.

Based on this, an online heat removal calculator was built to continually display the amount of heat removed per ton of steel that is added to the mould. This calculator had limits programmed for each steel type based on a heat removal balance which utilises the average heat capacity and heats of fusion of the major constituting elements of the grade. The calculator was based on the assumption that the mass of steel required to produce the specified shell thickness on the wide and narrow side had to have all its superheat removed and also be cooled to below solidus (heat of fusion for all constituents had to be removed).

The resultant calculation spreadsheet can be seen below (the example used is for a 310 grade SS cast).

All of these modifications were incorporated into the BOPS system by mid 2022.

31085 Composition

Ni	19.5 %
Cr	24.5 %
Fe	56.0 %

Fe

Heat Capacity	0.45 kJ/kg°C
Heat of Fusion	247.09 kJ/mol
Molecular Mass	55.85

Cr

Heat Capacity	0.45 kJ/kg°C
Heat of Fusion	394.23 kJ/mol
Molecular Mass	52

Ni

Heat Capacity	0.44 kJ/kg°C
Heat of Fusion	297.67 kJ/mol
Molecular Mass	58.69

Energy removal Scenario

Mould Width	1060.00 mm
Cast Speed	0.85 m/min
Superheat	35.00 °C
Shell Wide	15 mm
Shell Narrow	20 mm
Solidified mass per second	4.5 kg/s

Minimum Total Energy Required	**1.51 MW**
Removal per ton cast	**64.62 MW/t steel cast**
With Safety 10% Safety	**71.09 MW/t steel cast**

Calculated Heat Removal Required for sufficient shell thickness.

Figure 6. Minimum Energy removal calculator for prevention of thin shell breakouts.

Action review

Specific:

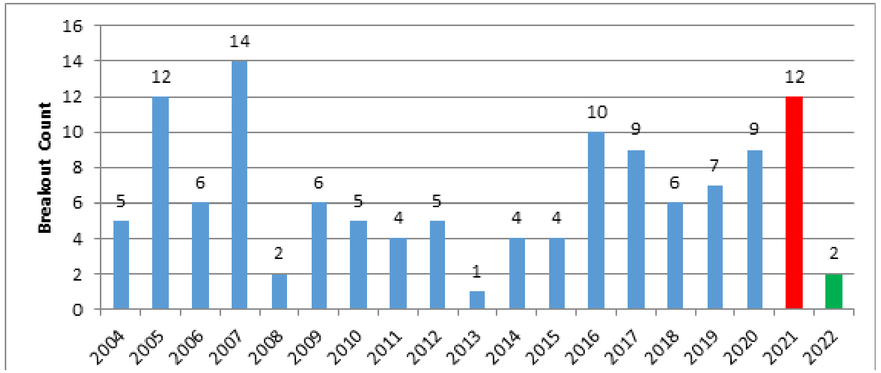
Sticker Breakout Detection:

1. Investigation into the cause of sticker breakouts.
2. Investigation into the manifestation of this alarm on the Breakout Protection System displays.
3. Developing an algorithm that detects the diagonal tearing phenomenon that is characteristic of a shell tear.
4. Optimising the algorithm in terms of sensitivity and accuracy of identifying a sticking scenario / shell tear.

For Thin Shell Breakout Prevention:

1. Investigate the mechanism of thin shell breakouts.
2. Implement a preventative system to indicate that the shell on mould exit will be insufficient.

Measurable: Since the implementation of the improved sticker alarm (Tearing alarm)



the number of breakouts decreased to only 2 in 2022. Both of these incidents were not related to stickers – 1 was due to a thin shell breakout and the second was due to a mould packing failure. The reduction achieved can be seen in the graph.

Achievable:

Sticker breakouts:

The initial objective was to reduce sticker breakouts by 50 %. This was achieved as there have been zero sticker breakouts since the implementation of the system in 2022.

Thin Shell Breakouts:

Since the implementation of the thin shell heat removal tracking system there have been zero thin shell breakouts in 2022. The one thin shell breakout in 2022 occurred before implementation of the heat removal indicator.

Realistic: The actions that were taken were realistic as the production team and the software development team of the CCM were involved in idea generation, implementation and optimisation of the system.

Time-bound: The objective was to have the system operational within the first quarter of 2022 which was achieved.

Horizontal Expansion Capability

This system can be rolled out to other casting departments within our organisation as a customisable solution to breakout detection.

Outcome

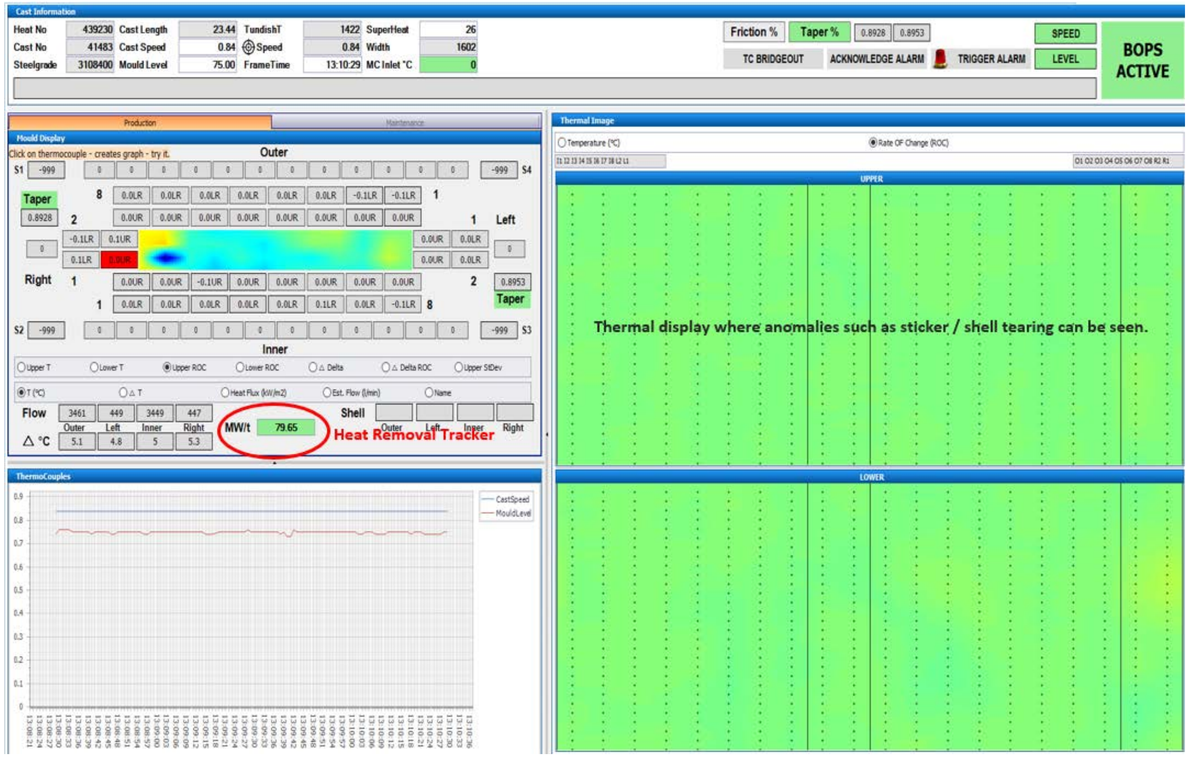
Since the implementation of modification to the Breakout protection system, with the updated Tearing alarm to detect stickers and the mould heat removal tracking the amount of breakouts experienced in 2022, there were only 2.

Health and Well-being: As discussed earlier, strand breakouts can be very dangerous and has the potential to lead to serious injury. By reducing their occurrence, the risk is reduced and a safer environment is created. In any melt shop there is very few morale breakers like a strand breakout. Besides being very difficult to recover from, the environment to work in is a very harsh one with exposure to heat and fumes. In addition, these incidents can happen any time of the day and the time spent on site by management as a result puts strain on their families and overall wellbeing. By reducing these incidents overall well-being was promoted.

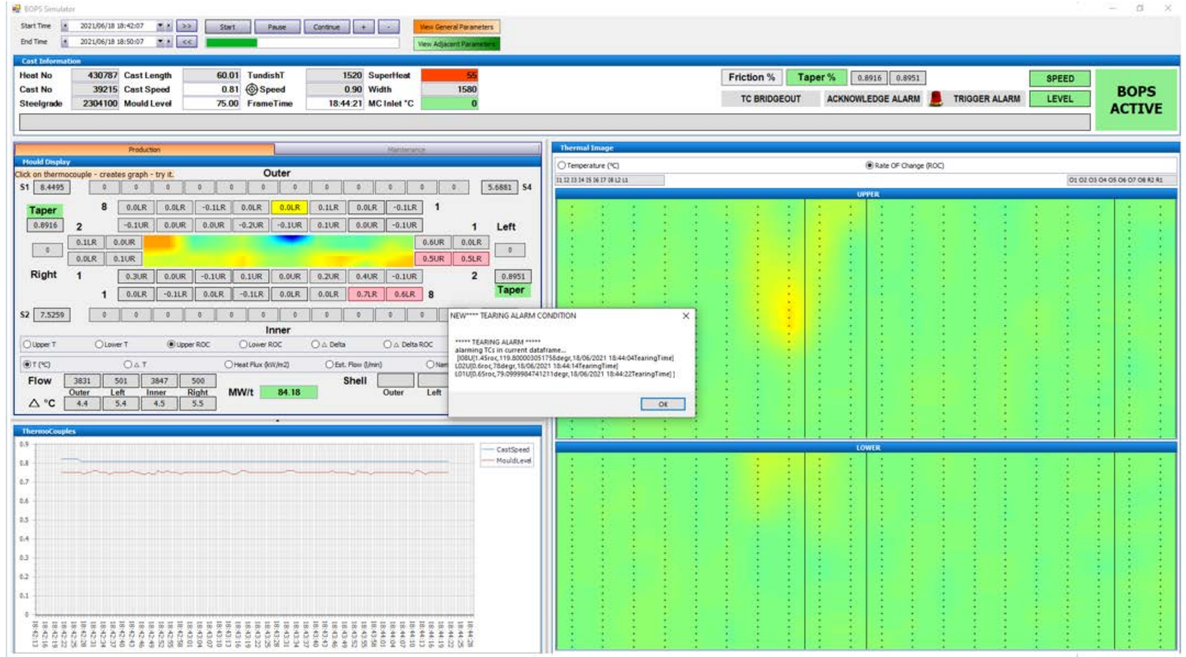
Job Satisfaction: The challenge to the team was zero breakouts in 2022. Although we did not achieve it, an 83% reduction is an achievement that generates immense pride among the team which improved overall job satisfaction.

Business Efficiency and Sales: In a time when market demand was high, this initiative allowed the business to take advantage of the demand by an 11% improvement in overall production achieved in the melt shop.

Cost: If compared to the total cost of repair of the previous year (144 hours of lost production time and R42 million) the downtime resulting from 2 breakouts in 2022 was 18 hours lost and approximately R7 million in repairs. This equates to a saving of R35M just in terms of reduced rework cost, and does not include the regained lost opportunity cost which will add to this value.



Overall BOPS Display.



Sticker/Tearing Alarm catching a possible breakout.

Off-line EAF Electrode Cooling

Member company

Columbus Stainless

The Challenge

Electrode joining is a critical part to the EAF process, there are 2 options on how this can be done.

1. Join the electrode in-line, while in position on top of the EAF.
2. Join the electrode off-line.

From previous experience, it was found that there are a lot of risks involved when joining electrodes in-line; these are typically bad joints, electrode nipples getting bumped, debris entrapment on the contact surfaces, etc. Therefore, a practice was adopted to join electrodes off-line as much more care can be taken to ensure a proper joint between the electrode pieces.

However, this had the negative impact that hot electrodes were showing signs of excessive oxidation for which no value adding was given.

Why?

Due to the sharp increase in electrode prices, these oxidation losses started to become significantly more expensive and any saving on electrode consumption was seen as a major cost benefit.

Needed action

In order to determine the best solution, a few options were considered. The following 2 were found to be the most viable:

1. Coat electrodes in a protective layer.
2. Cool electrodes as soon as they are removed from the EAF.

All the electrode suppliers were contacted to enquire about possible solutions they might have for a protective coating. A few did have some options but all of these options had a significant cost implication and the process of coating the electrodes was very difficult. Therefore option 2 was explored further.

Initially it was difficult to get a proper prototype in position and operational since the resources to manufacture the equipment in house were limited. However, it was approved that a boilermaker from an external company coulc be hired in to come and assist. Under the guidance and management of the EAF Production Technician, it was possible to get the equipment installed during a 2 day shutdown. Since the final solution was not very complex, the majority of work needed was some water piping and spray bars that had to be welded in position.

Action review

Specific: Some planning was needed to manufacture as much as possible off-line until some downtime was available to finish the installation. An external boilermaker was hired in to be a dedicated resource to this project. The main aim of this project was to lower the electrode losses due to oxidation.

Measurable: The amount of losses is closely monitored on a regular basis and compared to consumption figures from before the off-line electrode cooling installation.

Achievable: It was already determined beforehand that cooling the electrodes will have an impact on the degree of oxidation it was accepted that this will definitely

show an improvement. To implement the actual equipment was not an issue as the EAF Production Technician already did the required planning and design.

Realistic: The installation of the equipment was planned to be done during a shutdown, all of the equipment could be installed and the system was fully operational after the shutdown.

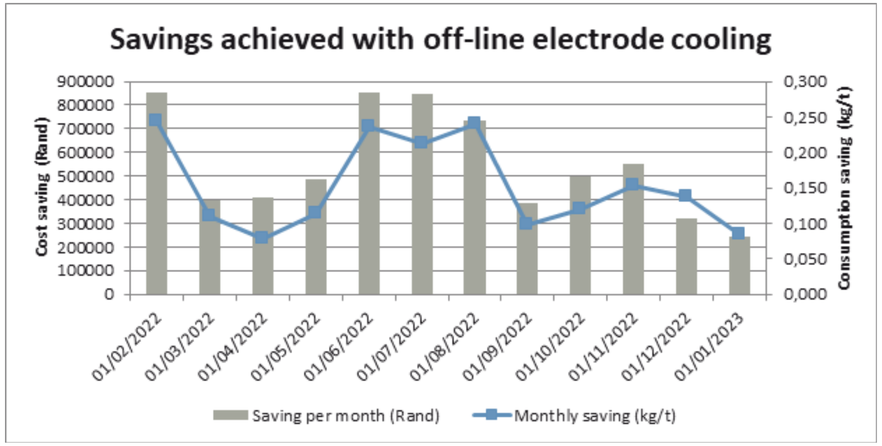
Time-bound: There were no issues on this once the dedicated resources were allocated.

Horizontal Expansion Capability

EAF electrode cooling is very specific to the EAF process so direct application elsewhere than is in Columbus is not viable but the principles can be applied at numerous areas and on other plants in the group.

Outcome

Since the implementation of this project a noticeable improvement has been seen on the EAF electrode consumption. On average the electrode consumption has dropped by 6% when compared to before the cooling was in position. The graph below shows the saving per month in Rand as well as electrode mass per ton, since the off-line cooling was installed.



Other comments

The actual solution was very simple and very easy to understand. It was also found to be very low on maintenance needed to keep it operational. This was only possible through some creative in-house problem solving done by the EAF team. Below is a picture that shows the spray bar in operation.

Cooling water that is sprayed onto the electrode

The roof of Japan National Stadium

Member company

NIPPON STEEL Stainless Steel Corporation

The Challenge

The Japan National Stadium was the main venue for an international sports event held in 2021. This stadium was intended to be in harmony with the forest adjacent to the stadium (Jingu no Mori), and to remain high-quality and durable for a hundred and more years in the future.

In addition, the stadium was designed to make use of the wind, instead of air conditioners, to control rising temperatures. We needed to work closely with the roof designer and builders to identify the optimum stainless steel grade and to develop the surface finish needed to achieve their design goals.

Why?

While stainless steel had been used for roofs, the Japan National Stadium was intended to be an iconic structure based on the concept of sustainability. Therefore, we believed that this was a good opportunity to promote the features of stainless steel, and to develop new application for the pre-coated stainless steel sheet.

Needed action

We needed to select the best material that would meet the requirements, so together with the roof designer and builder, we selected SUS445J2. SUS445J2 is a high-purity ferritic stainless steel. This is a resource saving stainless steel grade with high corrosion resistance, and its linear expansion coefficient is low as that of carbon steel.

In order to mitigate the temperature rise of the surface by solar radiation, we achieved the highest level of whiteness for a pre-coated steel sheets with highly durable (fluorine) coating material.

We produced samples of the material for the builders, who tested and verified its workability.

Action review

Specific: We confirmed the optimum steel grade and stability of coating film with the data that we have already collected through previous applications, samples, and through exposure and lab tests.

Measurable: Color stability limits were assessed and confirmed by analyzing the brightness and color difference of the coating film.

Achievable: We used SUS445J2 and highly

durable fluorine coating material. Because of this, we achieved goals of providing durable and heat mitigating material.

Realistic: We were able to complete the production in a reasonable process and period, because we had a lot of experiences of supplying ferritic stainless steel for roofs since 1989.

Time-bound: Construction was completed as planned for the international sports event scheduled for 2020 (actually held in 2021).

Horizontal Expansion Capability

We believe that more stainless steel roofs are used for future construction projects where harmonizing with the environment and reducing CO2 emissions are important goals.

Outcome

Extending the life of structures became a more important issue worldwide, as well as harmonizing structures with the environment. We are proud to be able to contribute these challenges by providing our product.

Roofs are not just installed in new buildings. We expect the potential needs of renovation of roofs in order to improve existing structures. We believe that stainless steel with its excellent surface finish increases energy efficiency and durability of structures.

Non-magnetic and High Strength Austenitic Stainless Steel with High Nitrogen for Mobile Devices

Member company

POSCO

The Challenge

As the smartphone equipped with an enhancement of camera performance and addition of various sensors, becomes more functional, it sometimes occurred malfunctions due to the influence the of electromagnetic waves. In particular, the integration of various components has made it important to shield the effect of electromagnetic waves between each component. Moreover, to reduce the weight of the mobile devices, it is necessary to use the thin gauge of material with high strength.

However, the existing austenitic stainless steels have faced with a problem that becomes having more magnetic properties when they are hardened by cold rolling, since they have experienced the mechanical phase transformation from austenite to deformation induced martensite. That is why austenitic stainless steels are limited in their use for electromagnetic shielding.

Why?

The goal was to develop a non-magnetic austenitic stainless steel with high strength by designing the alloy composition and process optimization to stabilizing the austenitic phase.

Needed action

1. Competitive alloy design and process development (using Nitrogen for stabilising the austenitic phase)
2. Optimization of hot-rolling as well as cold manufacturing conditions for improving the strength and suppressing the martensitic transformation under stress or strain condition.

Action review

Specific: In order to prevent the magnetization, it is important to suppress the transformation of the austenitic phase to martensite during work hardening through the austenite stabilization. Thus, we considered the Ni, Mn, and N known as austenite stabilizing element, and more focused on an addition of element N because of the alloy element price and the corrosion resistance. Except for hindering the magnetization by stabilizing austenitic phase, N is an effective element for increasing strength, and thus, easily obtained the high strength by adding N.

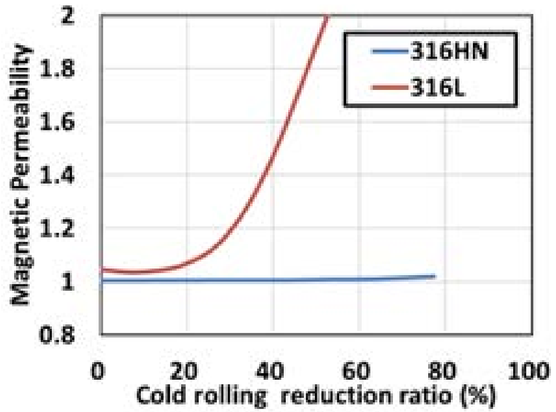
Moreover, it is also important that galvanic corrosion problems may occur due to the induced current by interacting the various electronic components operated inside the smartphone. Therefore, it is necessary to use a material with having a high corrosion resistance to maintain the device performance. Thus, we begin to study the base of 316L alloy, and then consider the addition of N from the viewpoint of enhancing the corrosion resistance and hardening the solid solution.

Measurable: 316L with 10% Ni exhibits a relatively high permeability over 2.0 at 60% of work hardening when measured by ASTM A324 method D, making it unusable for the precision electronics. It was found that more than 14% of Ni addition was required to stabilize the austenite. However, in the case of 316L with N addition (hereafter called 316HN),

the increase in permeability during work hardening was considerably suppressed while maintaining 10% of Ni content.

Achievable: Generally, austenitic stainless steels are strengthened by the formation of martensitic phase during work hardening. Thus, it is difficult to obtain high strength by suppressing the formation of martensitic phase. 316HN alloy overcomes this limitation by adding N, a solution hardening element, to achieve the goal of high strength and non-magnetism at the same time.

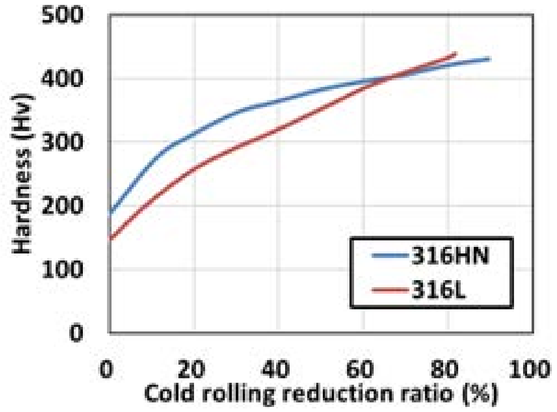
Realistic: 3: 316HN was developed for the casing of smartphone components such as cameras that requires non-magnetic properties. Recently, it has been adopted in high-end smartphones with enhanced camera features using electromagnetic waves, such as a function of autofocus and image stabilization. In particular, it has been used as a screen reinforcement



Variation of magnetic permeability with cold reduction

plate for foldable phones. Screen reinforcement plate plays an important role in maintaining the durability against repeated folding.

Time-bound: TThe smartphone market is a very fast-moving market that demands the innovation by every year. We have successfully launched our product with the non-magnetic properties that meet our customers' demand, and expected it to be



Variations of hardness with cold reduction

adopted continuously.

Horizontal Expansion Capability

316HN is used in smartphone cameras with the functions of autofocus and image stabilization, as well as in foldable phones with the reinforcing materials to protect the display screens.

It is also expected to be used as an electromagnetic shielding component in future electric vehicles.

	CPT(°C)
316HN	50
316L	24

Compared of CPT with alloys

Outcome

The non-magnetic austenitic stainless steel has been continuously expanding its usage in the mobile device markets such as smartphones. Electronics companies are utilizing the non-magnetic and high strength 316HN to improve the camera performance and make the more durable foldable phones.

Other comments

316HN is a high-value steel grade for the precision electronics market, such as

smartphones. It exhibits similar properties but better corrosion resistance of those of 316L, so it is expected to be applied to a wide range of products in the future.

Development of Low-Cost Brazing Filler Metal for Stainless Steel

Member company

POSCO

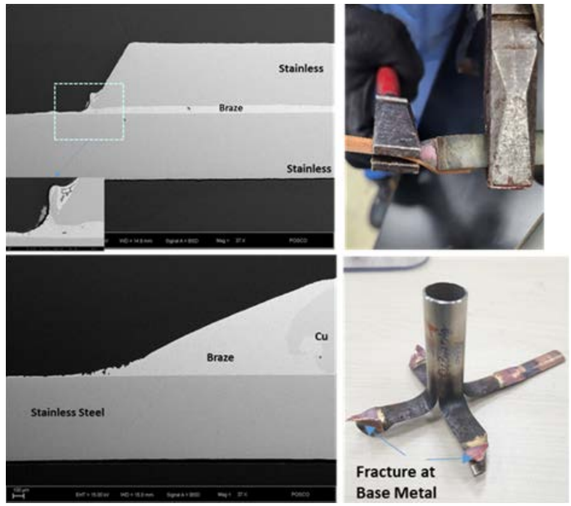
The Challenge

In order to replace the expensive copper tube which is used as an air conditioner's refrigerant pipe, with the stainless steel tube, POSCO had developed a highly-formable stainless steel, 304J1. However, to use it as an air conditioner parts such as refrigerant and heat exchanger pipes, it is necessary to join both of the stainless steel and the copper tubes by brazing method. In the brazing, the brazing filler metal (BAg : Brazing filler metal contained above 30% of Ag) for stainless steel is very expensive compared to that (BCuP : Brazing filler metal contained Cu and P) for copper, thus the brazing cost is remarkably increased. To commercially widespread use the brazing both of stainless steel and copper,

POSCO has developed a new low-cost and good quality brazing filler metal, which is 5~6 times cheaper than that of BAg. It will effectively cut down the manufacturing cost of customers who want to use stainless steel by replacing copper tube, and join the both of tubes by brazing process.

Why?

The customer who wants to replace copper with stainless steel tube asked for the development of low-cost brazing filler metal. It is not easy to widely use the stainless steel for an air conditioner's refrigerant pipe without the cost-down of brazing filler metal.



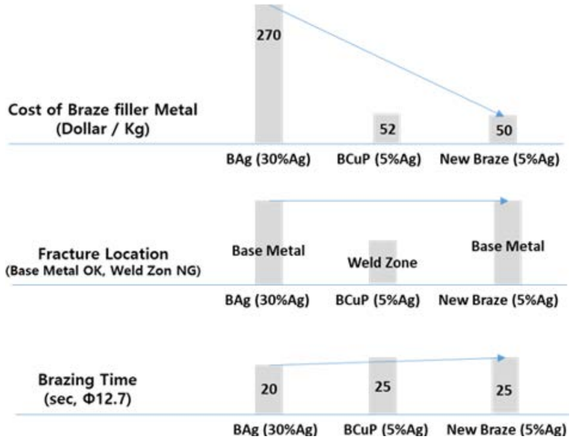
Microstructures and mechanical tests

Needed action

POSCO has developed the cost-effective brazing filler metal by designing the usage of competitive alloys. A newly designed brazing filler metal was mainly based on the Brass (Cu, Zn) alloy system, and added a small amount of Ag, Al, Ni, and Mn.

To lower the melting point and improve the wettability, a small amount of Ag was added since Ag is very expensive element, about 910 $/kg, thus the amount of Ag should be restricted within 3~5%. Moreover, less than 1% of Al was added to supplement the wettability, and also less than 1% of Ni and Mn were added to improve the workability, bonding strength, and corrosion resistance.

P is known as an effective element which can reduce the melting point, thus it normally added to 5% or more. However, in the case of stainless steel brazing filler metal, P content should be extremely limited because it easily reacted with Fe in stainless steel, which resulted in the formation of brittle intermetallic compound (Fe_2P, Fe_3P). The formed intermetallic compound deteriorated the interface strength of brazed joint both of



Quality positions

stainless steel and copper, and then easily caused to fracture under the shear stress condition.

Action review

Specific: Tube of air conditioner's refrigerant and heat exchanger, and 'frame' of stainless steel bicycle

Measurable: Fracture location, Brazing time (sec), Product price ($/kg) and

Torch brazing process

Wettability

Achievable: Satisfying the brazing properties between stainless steel and copper tubes, and promoting the sales quantity of POSCO's highly formable Stainless Steel

Realistic: Electronic, Boiler and Bicycle companies in Korea and China have been testing the newly developed brazing filler metal, and will be using it in their manufacturing process.

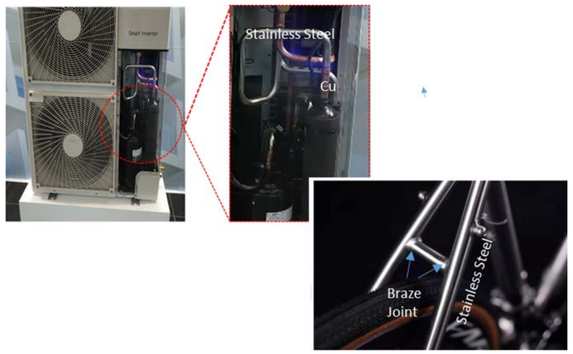
Time-bound: From 2022, newly developed brazing filler metal has been produced at the co-worked company DAECHANG, and successfully met with the requirements of customer's.

Horizontal Expansion Capability

First of all, it can be applied to all industries that want to replace copper tube with stainless steel. The newly developed brazing filler metal can be used to reduce the brazing cost of a company that uses stainless steel tube at the air conditioner fields.

Outcome

In the case of using a brazing filler metal containing more than 30% of Ag, the price of filler metal is about 270 $/kg, but in the newly developed filler metal, the price was lowered to about 50 $/kg level. Therefore, customers who want to use the stainless steel instead of copper tube, can achieve a manufacturing cost reduction by approximately more than 5 times. Also, for POSCO it is possible to increase the sales amount of stainless steel, 304J1.



Applications of air conditioner and bicycle

High-Strength 430 Stainless Steel for Large-Scaled Premium Home Appliances

Member company

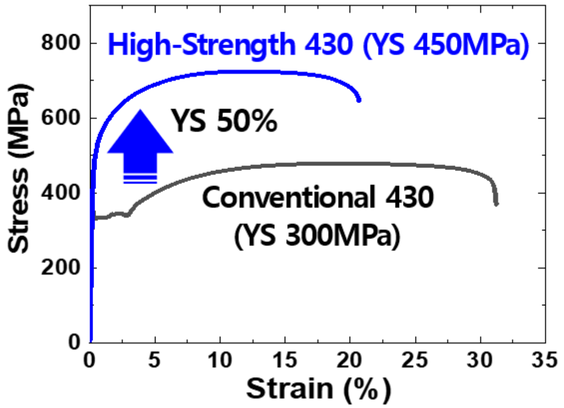
POSCO

The Challenge

Recently, global home appliance companies such as Samsung Electronics etc, require the high strength of material to cut-down the total material cost in large premium home appliances by using thinner one.

Ferritic stainless steels which are usually applied to home appliances have a level of yield strength about 300MPa. Thus, to meet the customers' requirement of high yield strength, it is generally used to work hardening by cold rolling or solid solution hardening by adding Si, Mo and so on. However, these methods result in increasing the manufacturing cost.

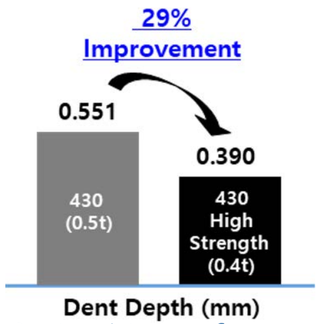
In this development, the yield strength is improved by using the phase transformation technology of conventional 430 stainless steel without changing its composition.



Stress-strain curves of high-strength and conventional 430

Why?

By utilizing the martensitic transformation of the conventional 430 stainless steel, it is possible to obtain the high strength,



Dent resistance of high-strength and conventional 430

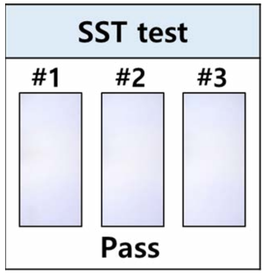
Needed action

To develop the high-strength 430 with about 450MPa yield strength

1. Establishment of CAP (cold rolling and annealing process) conditions to secure the suitable fraction range of martensite in conventional 430 steel
2. Optimization of Tension-levelling conditions to adjust the wave of the

and achieve the thinner thickness of exterior material with excellent dent resistance.

BACK ?



Salt spray test result of high-strength 430

high strength coil.

Action review

Specific: High-strength 430 stainless can be applied to the refrigerator door for the premium home appliances

Measurable: Yield strength (MPa), Dent resistance (measured by dent depth, mm @200N load), Steel thickness (mm)

Achievable: An increment by about 50% (300 → 450MPa) in the yield strength of developed technology compared with that of conventionally produced 430

Realistic: An increment by about 29% in dent resistance due to increasing the yield strength, and also reducing the thickness by 20% at the same level of dent depth.

Time-bound: From 2021 to 2022, POSCO successfully developed the strengthening technology to meet the requirements of global home appliance companies.

Examples of refrigerator & dishwasher door

Horizontal Expansion Capability

It can be applied as a refrigerator or dishwasher door, and other exterior materials for large home appliances required a high strength.

Outcome

High-strength 430 stainless steel is successfully developed by utilizing the martensitic phase transformation of conventional 430 without deteriorating the corrosion resistance.

In addition, the thickness reduction is contributed to cut-down the material cost for home appliance companies.

POSCO plans to apply high strength 430 stainless steel for refrigerator doors in collaboration with Samsung Electronics.

Technology and product development of wide ultra thin stainless precision foil

Member company

China Baowu Steel Group Corporation - TISCO

The Challenge

The wide ultra-thin stainless precision strip steel is the pearl on the stainless steel crown, which is still blank in the world. The production of precision foil with a width of more than 600mm has been a worldwide problem. The production of wide and ultra-thin strip steel is in the international blank, and its technology is difficult, and there is no mature experience to learn from, which is mainly manifested in: (1) the requirements for steel purity are high, and poor inclusions are easy to cause rolling perforation and surface quality defects; (2) The rolling thickness accuracy is high, and the shape control is difficult; (3) High temperature annealing is easy to break the strip, draw the strip and collapse the coil; (4) It is difficult to realize continuous production due to lack of basic and applied research on ultrafine grain and fatigue life in China; (5) The production process is complex and there is no complete equipment integration

Why?

Wide ultra thin stainless steel precision foil represents the important development direction iron and steel industry. It is the key material in high-end manufacturing field, Which is widely used in aerospace, electronic information, new energy, precision manufacturing and other industries. It is the key basic material in high-end manufacturing field. Emerging fields have an urgent demand for ultra-thin tape materials with wide width. In recent three years, the annual growth rate of ultra-thin tape demand has maintained at more than 50%, and the future demand will reach more than 150,000 tons per year.

Needed action

1. The research reveals the evolution law of inclusions during precision strip rolling:Hard inclusions are difficult to deform during cold rolling, which is the main reason for defects; Plastic inclusions are easy to deform and extend. The control technology of low oxygen content and inclusion plasticity was developed for the first time, and the two-way control of low oxygen content and inclusion plasticity was realized. After the implementation of the process, the total oxygen content of the billet decreased by 65%, and the proportion of plastic inclusions increased from less than 30% to more than 95%; Inclusion size in ultra-thin strip steel is less than 1 μ m.
2. Aiming at the problem of rolling accuracy, a high accuracy calculation model for wide ultra-thin strip rolling was established for the first time. Research and development of Ti-Fe alloy roll material with high strength and excellent toughness, compound multi-curve roll shape of intermediate roll, establishment of roll system configuration principle of wide ultra-thin strip steel, forming 0.015 × 600mm optimal roll system configuration;The rolling process of multi-pass small reduction, variable tension and temperature control in the final rolling process of wide ultra-thin strip has been developed to realize high-

precision and stable rolling of wide ultra-thin strip.

Action review

Specific: Centering on the wide ultra-thin precision stainless steel foil urgently needed in the cutting-edge fields such as aerospace, nuclear power, high-end electronics, new energy, etc., taking advantage of the advantages of the product development and precision strip equipment of TISCO, aiming at the characteristics of the high quality requirements of the wide ultra-thin precision stainless steel strip, such as thickness accuracy, plate shape, surface, etc., it has broken through the bottleneck problems of bad plate shape, strip extraction, broken strip, and surface in the production process, forming the smelting Rolling and other key technologies of wide ultra-thin strip with independent intellectual property rights.

Measurable: The total oxygen content of the slab is reduced by 65%, and the proportion of plastic inclusions is increased from less than 30% to more than 95%. The types of inclusions are all low melting point silicate, and the quantity and size are significantly reduced. Inclusions in 0.02mm ultra-thin strip break along the rolling direction.Point distribution, inclusion size up to 1 μ m.

The thickness of ultra-thin stainless steel foil is reduced from 0.02 to 0.015, and the width is increased from 420mm to 600mm.

Achievable: The mass production of wide stainless steel foil with thickness of 0.015mm and width of more than 600mm has been realized for the first time, with thickness accuracy of ± 0.001mm, forming three categories and 21 varieties of products, with hardness of 620HV and fatigue life of 200000 times

Realistic: High purity plastic inclusion control technology, including AOD steel slag composition control technology, LF low alkalinity and low oxidation refining slag system control technology, LF deep deoxidation technology and other three technologies. The two-way control of low oxygen and inclusion plasticity is realized [O] The inclusion size reaches 1 μ m when it is controlled below 20 ppm.

Coupled with the deformation of roll system and the plastic forming characteristics of metal, a special rolling model for wide ultra-thin strip was developed. Based on the special rolling model for wide ultra-thin strip, a complete set of rolling technology with the core of roll system configuration, roll material selection and multi-pass shape dynamic control has been developed, realizing the limit specification of 0.015 × High-precision rolling of 600 mm stainless steel foil.

Time-bound: From January 2012 to June 2017, ultra-thin strip rolling model development, thickness accuracy and shape control

A rolling model based on boundary integral algorithm is developed, which improves the calculation accuracy and efficiency of the rolling model, especially the edge shape of steel strip is effectively controlled. Based on the rolling model, the roll system configuration, roll material parameter selection and other technologies are developed, which lays the foundation for the shape control of wide ultra-thin strip. Through scanning the strip shape after each rolling pass, the rolling parameters are dynamically adjusted to

ensure the quality of the strip shape.

From June 2013 to December 2016, steel purity control

AOD slag composition control technology can reduce Al and Mg entering molten steel to form hard inclusions by strengthening slag removal treatment in smelting process and controlling the use of slag containing Al and Mg. The alkalinity of LF refining slag is reduced from 1.9~2.1 to 1.6~1.8, and the content of slag (FeO+MnO+Cr2O3) is controlled below 1.5%, which changes hard inclusion into plastic inclusion. Si-Ca-Ba alloy is added for deep deoxidation to reduce the amount of inclusions in steel.

Horizontal Expansion Capability

The project has led the development direction of ultra-thin stainless steel strip in the world, represented the cutting-edge manufacturing level of the steel industry, and promoted the expansion of cold-rolled stainless steel products to a thinner and wider direction. The developed inclusion control technology has been extended to other stainless steel and steel smelting processes, and the developed ultra-thin rolling process provides technical reference for other steel cold rolling processes. The development and application of new materials have led to new technological breakthroughs in related industries such as vacuum sputtering coating, electrochemical deposition coating, micropore processing, banknote printing template forming, film coating, foil composite, surface passivation, coating treatment, 5G low magnetism, etc.

Outcome

Wide ultra-thin stainless steel foil products fill many international gaps, and the overall technology has reached the international leading level, leading other similar products in terms of thickness accuracy, performance, coil weight, delivery cycle, etc

Continuous Casting: “Towards 0 in accidents” - Alerts for overhead cranes

Member company

ACERINOX EUROPA S.A.U.

Challenge

ACERINOX EUROPA is immersed in the global reduction of risks for workers. A very important chapter in this regard takes place in the Continuous Casting Section. With the participation of the workers themselves, who have designed the measures, a series of projects have been launched. In this document we are going to expose our new overhead crane positioning system.

Why?

ACERINOX EUROPA, strongly committed to risk reduction, detected years ago the importance of the workers themselves in defining those risks. For this, the factory implemented an internal award to encourage participation...

Needed action

“Alerts for approaching overhead cranes in corridors with poor visibility”. As will be seen, this project does not replace the established security protocols but rather complement those protocols.

Action review

Specific: ACERINOX EUROPA has established a global security risk detection strategy. And all the sections are specifically analyzed. What is shown in this document is an analysis carried out by the workers to reduce the risk between the Continuous Casting and Grinding Sections facilities.

Alerts for approaching overhead cranes in corridors with poor visibility.

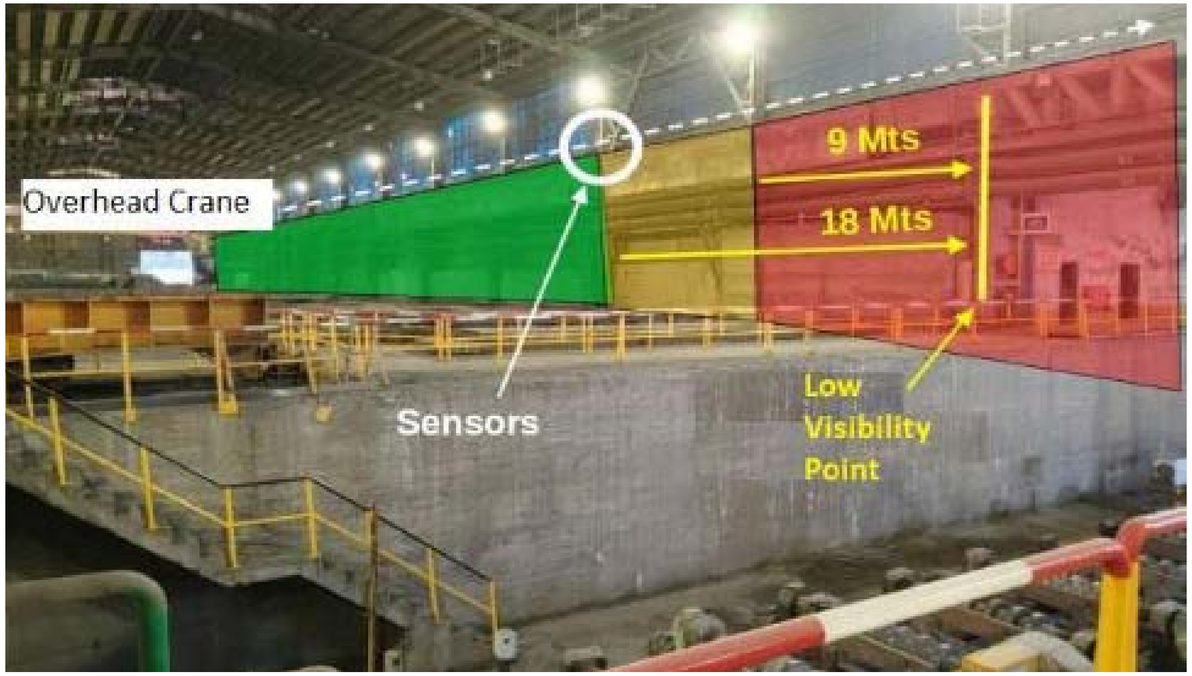


Figure 1: detectors that make the traffic ligths work

One problem, common to all factories, is the route of the overhead cranes through pedestrian areas. Even if all safety requirements are met, the pedestrian crossing requires: a) that the crane be far

Figure 2: traffic light

enough away; b) the crane operator has to see the presence to authorize the crossing. But, it is a fact, there are corridors with poor visibility.

The project consists of a set of position detectors that make a traffic light work (see figure 1). This traffic light (see figure 2) warns the pedestrian of the proximity of the crane: Red (Crane in work area -do not pass-); Orange (Crane approaching -do not pass-); Green (can pass).

Measurable: The project explained is recent, and has already been tested with good results. The objective has been verified by the operators themselves and safety team.

Achievable: The initially proposed objective: to provide safety in the operation and reduce the risk was widely achieved.

Realistic: The project is already in operation.

Time-bound: The project had a fundamental quality: common sense. This meant that there was no problem in meeting the established times. The project was carried out by the operators themselves the first time.

Horizontal Expansion Capability

The project has been designed to be able to be extended to any similar area of the factory itself and any other.

Outcome

The project has been already tested. The new measure, together with the previous ones, reduced the sensation of risk and the possibility of accidents. The fact that the project was designed by the workers is considered of great importance. It is a great satisfaction for themselves, but also for the Management of the factory for the degree of awareness achieved that is shown.

In addition to safety, the project implies a reduction in waiting times.

Other comments

Highlight once again that the most important thing for the organization has been to verify the degree of awareness of the workers, and the fact that they themselves provide solutions to the risks they detect.

Continuous Casting: “Towards 0 in accidents” - Safety in the assembly of segments

Member company

ACERINOX EUROPA S.A.U.

Challenge

ACERINOX EUROPA is immersed in the global reduction of risks for workers. A very important chapter in this regard takes place in the Continuous Casting Section. With the participation of the workers themselves, who have designed the measures, a series of projects have been launched. In this document we are going to expose our new platforms for the assembly of the Continuous Casting segments.

Why?

ACERINOX EUROPA, strongly committed to risk reduction, detected years ago the importance of the workers themselves in defining those risks. For this, the factory implemented an internal award to encourage participation...

Needed action

"Increase the Safety in the assembly of segments in Continuous Casting”. This project does not replace the established safety protocols but rather complement those protocols.

Action review

Specific: ACERINOX EUROPA has established a global safety risk detection strategy. And all the sections are specifically analyzed. What is shown in this document is an analysis carried out by the workers in the Continuous Casting Section.

“Safety in the assembly of segments”

Figure 1: operator on the continuous casting segment

Figure 2: operators on the continuous casting segment

One of the biggest risks in a steel mill is the change of continuous casting segments. Before the proposed change, two operators had to climb through the segments to hook that segment (see figure 1). Although all safety measures were met, the operation continued to have a degree of risk (see figure 2) that has been eliminated: a work platform (for each segment) has been adapted to eliminate the risk of falling. In figures 3 and 4 an operator can be seen working on the new work platform.

Note: Figures 1 and 2 show the work before this invention.

Measurable: The project explained is recent, but has already been tested with

Figure 3: operator on the new platform

good results. The objective has been verified by the operators themselves, and safety team.

Achievable: The initially proposed objective: to provide safety in the operation and reduce the risk was widely achieved.

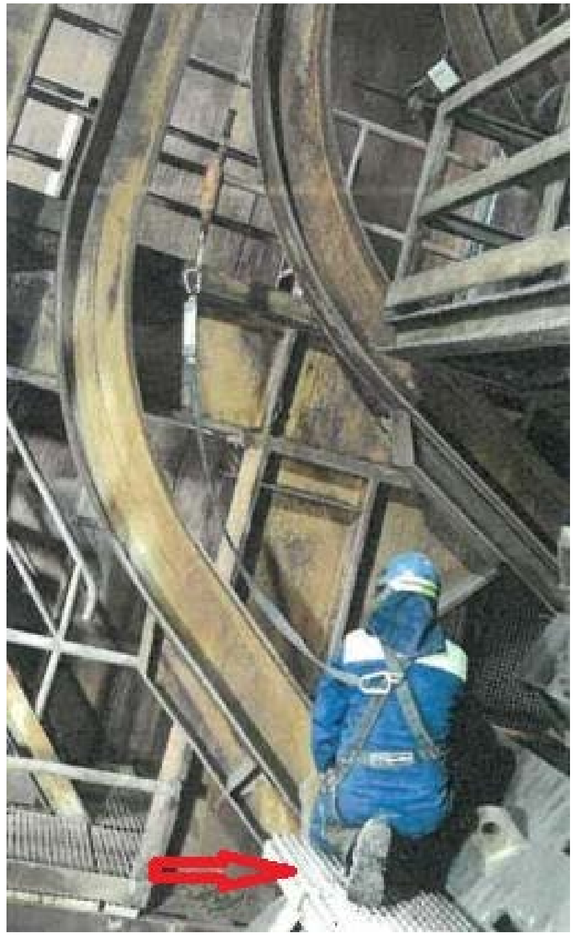


Figure 4: operator on the new platform

Realistic: The project is already in operation.

Time-bound: The project had a fundamental quality: common sense. This meant that there was no problem in meeting the established times. The project was carried out by the operators themselves the first time.

Horizontal Expansion Capability

The project has been designed to be extended to any similar facility.

Outcome

The project has been already tested. The new measure, together with the previous ones, reduced the sensation of risk and the possibility of accidents. The fact that the project was designed by the workers is considered of great importance. It is a great satisfaction for themselves, but also for the Management of the factory for the degree of awareness achieved that is shown. In addition to safety, the project implies a reduction in waiting times.

Other comments

Highlight once again that the most important thing for the organization has been to verify the degree of awareness of the workers, and the fact that they themselves provide solutions to the risks they detect.

Employee Assistance Plan

Member company

ACERINOX EUROPA S.A.U.

Challenge

The affectation of psychosocial problems at work.

Why?

Due to a decrease in effective working hours, materialized by the increase in work disabilities due to psychological and psychiatric causes, since it is among the top three causes of IT.

Needed action

1. Protect the mental health of workers.
2. Early detection of pathologies.
3. Improve the emotional well-being of the workforce.
4. Help them, accompany them and guide them to solve problems.

Action review

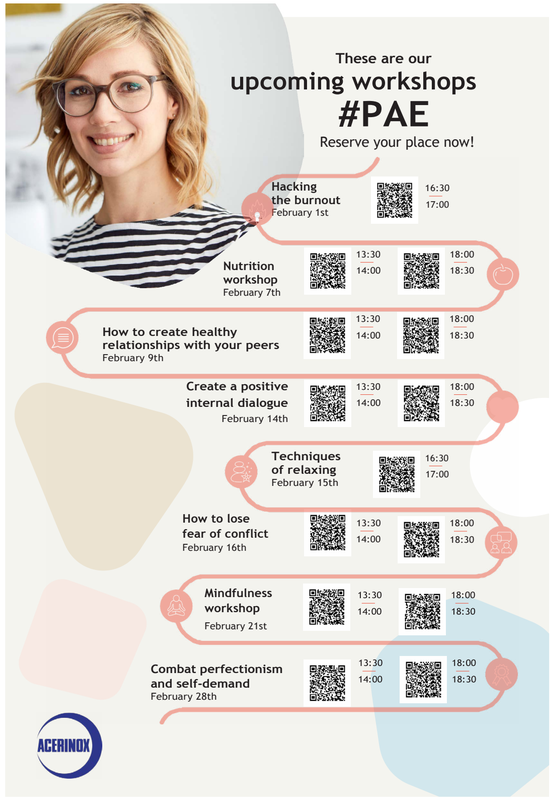
Specific: Acerinox Europe has developed a telepsychology service 24 hours a day with a local partner, 7 days a week, preparing training workshops to teach self-help tools. To access to these workshops, our workers must scan a QR code.

Measurable: We quantify the reduction of temporary disabilities due to psychological problems, according to the temporary disability management system.

Achievable: During the first six months the number of casualties must be reduced. Prevent psychological/psychiatric problems from being in the Top 3 largest causes of disability in the company.

Realistic: It due to psychological/psychiatric causes has been reduced by 0.6% compared to the previous year. In economic terms by the reduction of absenteeism in an annual R.O.I. of 40,000 euros. Cost of the investment: 10,000 euros.

Time-bound: The first challenge has been achieved, reducing temporary disabilities due to psychiatric/psychological causes, so that in order to continue a positive projection during the year 2023 and these kind of causes can eliminate it from the Top 3, Acerinox Europa will continue with the project and will expand it to all job centers.



Horizontal Expansion Capability

Since psychological/psychiatric problems spread faster and faster throughout the world, generating problems for workers around the world and with it, security problems in all companies, it is very interesting to apply psychological health measures such as the one we have proposed, both in the companies of the Acerinox group and in the companies that make up the world stainless association.

Outcome

Workers who have already used the psychology service are happier in their day-to-day activities and have increased their productivity.

The company has found a way to save costs for casualties.

Other comments

We attach a calendar of activities planned for February 2023, promotional flyer and an illustrative example.

Smart Safety Zone

Member company

Bahru Stainless Sdn. Bhd.

The Challenge

By solving the issue of human error in observing employees' whereabouts, to reduce injuries and accidents in busy production environments like operating production machines and packing lines.

The presence of rotation machinery can make busy industrial areas, such as operating production machines and packing lines, difficult to monitor and control. Keeping track of everyone's activities and locations can be challenging, which can cause mishaps that result in serious injuries or fatalities. Employees who cross the aisle where the rotating machinery is operating run the risk of being struck by the operator, who may have missed them. This may result in costly legal actions, reduced output, and a detrimental effect on staff morale.

Why?

To solve the issue of human error that can result in accidents, severe injuries, or fatalities when tracking the whereabouts of employees in certain contexts. To boost morale among workers, productivity, and workplace safety. To avoid expensive legal battles and monetary damages for the business caused by mishaps and injuries. To reduce downtime brought on by accidents in order to increase the production process' overall efficiency.

Needed action

The detection of people's presence using smart sensor barrier system technology and sophisticated algorithms, followed by the immediate disabling of the machine operations.

Action review

Specific: Sensor barrier system and wide angle sensor used to recognize, identify and respond to human presence .

The picture indicates the smart safety zone coverage after the implementation at the machine.

Measurable: Decreasing accident-related downtime and injuries.

Achievable: The production rate increased due to workers to be more productive as their workplace became safer.

Realistic: Easily incorporated onto current machines design and adjusted to each unique machine requirements.

Time-bound: Implementation can be done in a specific time frame.

Horizontal Expansion Capability

These steps and installation can be easily adopted and expanded for usage in more facilities.

The picture indicates the smart safety zone coverage after the implementation at the machine.

Outcome

Increased worker safety: The Smart Sensor Barrier works to reduce accidents and injuries by detecting and reacting to human presence.

Productivity gains: The Smart Sensor Barrier can boost productivity by reducing accident-related downtime and enhancing the overall effectiveness of the production process.

Improved workplace trust and confidence as a result of the Smart Sensor Barrier's implementation.

Reduced risk of costly lawsuits: The Smart Sensor Barrier can lower the risk of expensive lawsuits by preventing accidents and injuries.

Cost savings: The Smart Sensor Barrier can help business to save money by reducing accidents and downtime.

Employee morale can be raised by using the Smart Sensor Barrier to provide a safer working environment and show that employers care about their welfare.

The picture indicates the smart safety zone coverage after the implementation at the machine.

Alarm system to reduce the risks associated with wet scrap charge on the Electric Arc Furnace.

Member company

Columbus Stainless

The Challenge

Explosion at Electric Arc Furnace during basket charging resulting in slag and steel splashing, caused by wet scrap and Lost Time Injury to an employee. See attached notification.

Why?

Serious safety risk to any individual in the surrounding area when basket is being charged with possibility of reaction between wet scrap and molten material. Scrap is stored outside and exposed to the elements and improved protection was therefore required to limit the risk.

Needed action

1. Improved shielding around the furnace was built and installed.
2. Installing warning alarm before basket charging that warns anyone in the area to get to a safe position before the basket is charged. Updating of the basket charging procedure.
3. Memorandum was drafted to communicate to all employees about the preventative measure implemented. See memorandum attached.

Action review

Specific: Addressing the risk caused by wet scrap being charged by clearing the area via a warning alarm prior to basket charging.

Measurable: Updating procedure and newly installed alarm has to date prevented any occurance.

Achievable: After implementation no further injuries occurred related to basket charging.

Realistic: Yes, the solutions were implemented within a short timeframe.

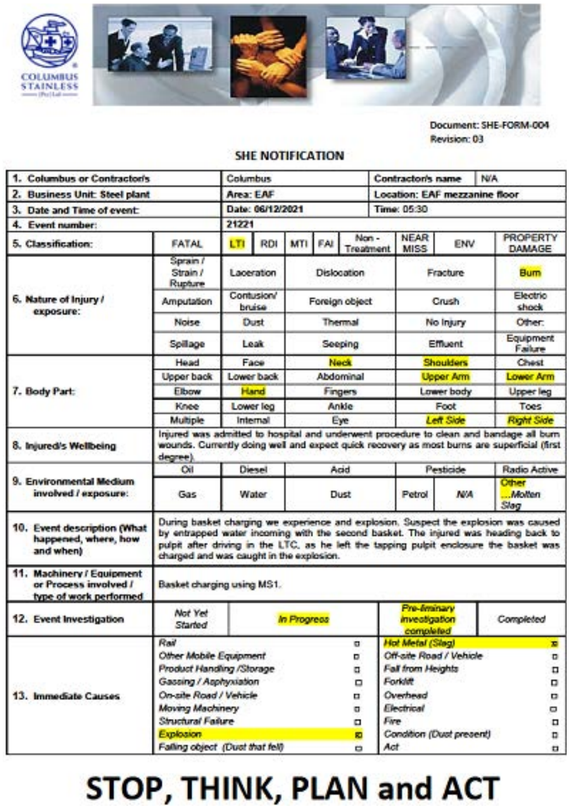
Time-bound: Yes, the actions were completed and implemented within 2 weeks following the LTI.

Horizontal Expansion Capability

Yes, procedure with alarm for basket charging can be adopted elsewhere in other member companies.

Outcome

Improved safety of the melt shop employees during basket charging was achieved with no similar injuries in the 8 month period following implementation. In addition the prompt response to install and implement corrective action contributed to increased morale and overall well being.



COLUMBUS STAINLESS

Document: SHE-FORM-004
Revision: 03

SHE NOTIFICATION

1. Columbus or Contractor/s		Columbus				Contractor/s name		N/A	
2. Business Unit: Steel plant		Area: EAF				Location: EAF mezzanine floor			
3. Date and Time of event:		Date: 06/12/2021				Time: 05:30			
4. Event number:		21221							
5. Classification:	FATAL	LTI	RDI	MTI	FAI	Non - Treatment	NEAR MISS	ENV	PROPERTY DAMAGE
6. Nature of Injury / exposure:	Sprain / Strain / Rupture	Laceration		Dislocation			Fracture		Burn
	Amputation	Contusion/ bruise		Foreign object			Crush		Electric shock
	Noise	Dust		Thermal			No Injury		Other:
	Spillage	Leak		Seeping			Effluent		Equipment Failure
7. Body Part:	Head	Face		Neck			Shoulders		Chest
	Upper back	Lower back		Abdominal			Upper Arm		Lower Arm
	Elbow	Hand		Fingers			Lower body		Upper leg
	Knee	Lower leg		Ankle			Foot		Toes
	Multiple	Internal		Eye			Left Side		Right Side
8. Injured/s Wellbeing	Injured was admitted to hospital and underwent procedure to clean and bandage all burn wounds. Currently doing well and expect quick recovery as most burns are superficial (first degree).								
9. Environmental Medium involved / exposure:	Oil	Diesel		Acid			Pesticide		Radio Active
	Gas	Water		Dust			Petrol	N/A	Other ...Molten Slag
10. Event description (What happened, where, how and when)	During basket charging we experience and explosion. Suspect the explosion was caused by entrapped water incoming with the second basket. The injured was heading back to pulpit after driving in the LTC, as he left the tapping pulpit enclosure the basket was charged and was caught in the explosion.								
11. Machinery / Equipment or Process involved / type of work performed	Basket charging using MS1.								
12. Event Investigation	Not Yet Started	In Progress					Pre-liminary investigation completed		Completed
13. Immediate Causes	Rail ☐						Hot Metal (Slag) ☒		
	Other Mobile Equipment ☐						Off-site Road / Vehicle ☐		
	Product Handling /Storage ☐						Fall from Heights ☐		
	Gassing / Asphyxiation ☐						Forklift ☐		
	On-site Road / Vehicle ☐						Overhead ☐		
	Moving Machinery ☐						Electrical ☐		
	Structural Failure ☐						Fire ☐		
	Explosion ☒						Condition (Dust present) ☐		
	Falling object (Dust that fell) ☐						Act ☐		

STOP, THINK, PLAN and ACT

Broken Hot Mill back up roll cover

Member company

Columbus Stainless

The Challenge

On 28 Feb 2022, the finishing mill back up roll (BUR) had a roll failure (a surface and subsurface broke where the material breaks away from the core of the roll) while rolling the last pass of a hot strip and causing a scrap. The roll was taken out of the mill and several people took photos for inspections and inspected the roll after that. In the morning of 1 March 2022, at 7:00, the roll was cool to the touch. In the afternoon of 1 March at approximately 15:00, approximately 18 hours after the spall, the roll spontaneously started to break and shattered or burst apart in little pieces. One of these pieces hit and broke a truck window 30 meters away. This is

Roll cover from safe distance

obviously a risk to personnel working in the area.

Why?

The shattering is most probably caused by internal stresses in the roll, created by the forging process during manufacturing. Since it is impossible to tell if there are

Roll cover lowering

internal stresses remaining in a spalled roll, a method to cover the rolls will be used to prevent the pieces that may break off spontaneously from flying around and cause damage or injuries.

Needed action

Since it can't be predicted when a roll that failed can start bursting apart, a method had to be devised where personnel would

Roll cover fully lowered

have to be far away from the broken roll and out of the line of fire from roll pieces breaking off. It had to be a simple and relatively low cost design as it would not be used more than once every one to three years. This spontaneous bursting apart is the first occurrence in 10 years or more.

The team brain stormed a few ideas and a

Roll covered chocks removed

concept design was drawn on 3D software.

A conveyor belt was used as covering material as it would absorb the impact of the bursting roll pieces best and would allow pieces that shattered and break off to fall harmlessly to the ground. Since no-one would be allowed near the roll, the use of tag lines to open the conveyor over the roll was to be eliminated. A lifting bar with spreader beams is used to manoeuvre the conveyor belt by crane through the spacer beams on the BUR chocks. Hooking and unhooking the covering device should be easy and have to be done from a safe distance. The concept should be easily adapted to fit on work rolls in either mill too.

Action review

Specific: Since it can't be predicted when a spalled roll can start bursting apart, a method had to be devised where personnel would have to be far away from the broken roll and out of the line of fire from roll pieces breaking off. It had to be simple and relatively low cost design as it is not something that happens often or would be used regularly.

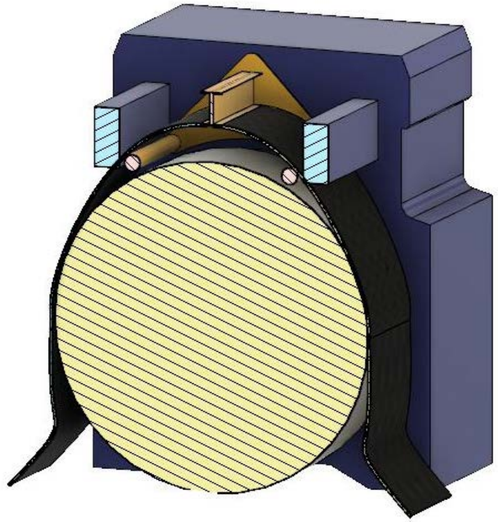
It would have to work on both Rougher mill and Steckel mill back up rolls, and would have to cater for scenarios where either the top or the bottom roll is broken, since the risks and configuration on rolls and chock sare a bit different.

It would need to go onto the broken roll as soon as it is out of the mill window and stay on the broken roll until it is safely removed from the roll change tunnels in the roll shop. It would have to fit roll sizes from new to scrap size rolls, and have to be guided through the two spacer beams at the top of the top BUR.

Measurable: This type of incident doesn't happen often and it happens less than once a year. The bursting apart has not happened in 10 years. It has not happened again since the cover was manufactured.

Achievable: The project achieved all of the requirements, with the main target to eradicate the risk of direct and indirect personal injury and equipment damage.

Functional design criteria included:



- Low cost.
- Simple design and easy to store.
- The height should be such that the crane can lift it over stacked back up rolls.
- Has to work on Rougher and Steckel

(finishing) mill back up rolls.

- Concept can easily be adapted to fit other mills and or work rolls.
- Has to work on both top and bottom back up rolls.
- Has to be manipulated from a safe distance.
- It should accommodate roll size from new to scrap size rolls.
- Would not need tag lines to operate.
- Once the cover is over the roll it should be safe to remove the chocks from the roll.

Realistic: The roll cover concept was designed by one team member in his free time in less than a month. The concept design was given to a manufacturer that made it in less than 2 months. Old conveyor belts, that were in the shop were used, so that there was no cost to the company and the steel frame cost R9000 (±€472) to manufacture.

Time-bound: The roll cover was designed and manufactured in 3 months. It was tested in October 2022 to see if everything worked as planned. The roll cover could be put on a test top back up roll by a crane operator with little experience in less than 10 minutes from 20 meters away without any assistance from anyone near the roll.

Horizontal Expansion Capability

Yes, the concept can be adapted to fit any of the back-up rolls or work roll in the Hot Mill of any plant.

Outcome

It would be safe to work with a broken forged back up roll and one would not have to fear internal stresses causing the roll to explode and possibly hit or kill someone with broken roll pieces.

Overhead Hot Metal Crane Warning System for Ladle Preparation

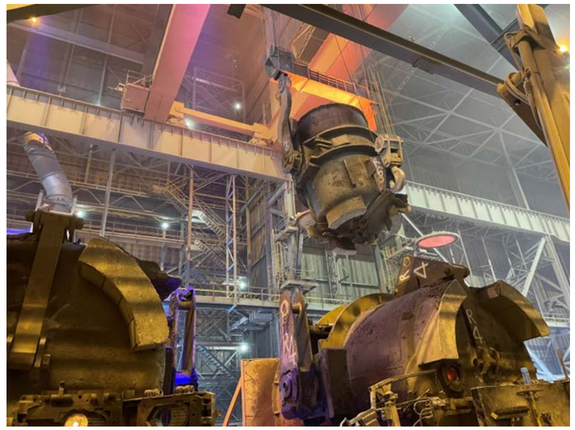
Member company

Columbus Stainless

The Challenge

During the preparation of ladles there is constant movement of ladles in close proximity or overhead of the ladlemen. During the preparation process, especially lancing of the plugs and slidegates they are not able to remain constantly vigilant and as a result, regularly found ladles over them or being surprised when a ladle passes by. This posed a serious risk of injury due to unforeseen / unplanned steel spillage whilst teeming ladle is in transit or being bumped with a ladle as well as resulting in personnel working under suspended load.

The purpose was therefore to develop an early detection and warning system to



alert the ladlemen of approaching cranes and ladles.

Why?

The area where the ladlemen work - 200 tons bay - is an extreme high risk area where liquid steel transfers between electric arc furnace (EAF), argon oxygen decarburisers (AOD's), ladle furnace (LMF) and continuous casting machine occurs continually. This results in ladles passing by and liquid steel coming in close proximity to the area where ladle preparation work is being conducted by workers on ground level.

Needed action

The situation was remedied through the installation of an alarm system, which is activated via limit switches situated on the crane gantries. As the crane approaches the ladle preparation area, the limits are made and the alarm is activated. The alarm is generated by a siren and strobe lights which ensure that the warning is both audible and visual (see picture).

Action review

Specific: Original purple light fixtures attached to overhead crane found to be insufficient in alerting the personnel performing ladle preparation – especially during lancing operations that light cannot be easily discernible.

The siren and strobe light option was chosen as it was found to be more observable / noticeable by workers in the direct vicinity. Although it might not eliminate the risk entirely it does introduce significant mitigation.

Measurable: No previous recorded

accidents. However it is noticeable that workers are more attentive to their surroundings and aware of looming dangers. Workers are quite responsive when the alarm is activated.

Achievable: Yes, early detection has been successfully installed and adopted by workers in the immediate high risk area.

Realistic: Yes they were. All products used are freely available on the market and only requires positioning and installation.

Time-bound: The system was implemented within the envisioned 4 months set out.

Horizontal Expansion Capability

Absolutely yes. Anywhere where there is overhead crane movement in a high risk environment and workers permanently active in the direct vicinity.

Outcome

It is clear that a more safety conscious employee has been created through the actions put in place. Employees are also more noticeably looking out for each others' safety and well-being. Employees also feel more assured that the company is concerned about their working environment and thus in return creates a sense of increased job satisfaction.

Other comments

The general safety notification board with the details on the siren system can be seen on the right.

Figure 3. General ladle preparation safety notification board with the siren system indicated.

Portable Lifelines for truck loading and securing

Member company

Columbus Stainless

The Challenge

In 2021, Columbus experienced a serious incident whereby a truck driver slipped and fell off a truck while securing a load. This resulted in an open wound on his lower right leg. The trailer height of trucks used to transport Columbus cargo is at a maximum of 1.6 m above the ground. The challenge faced was to ensure all truck drivers and operators are able to safely load and secure truck loads while standing/walking on the truck trailer.

Why?

It became necessary to ensure that all truck drivers and operators climbing onto to truck trailer to direct the loading of material or to secure a load, are protected from falling to the ground and injuring themselves.

The introduction of the portable lifelines will ensure that we safeguard the truck drivers and operators from potential falls and injuries and support the business value, "**Safety as a way of life**"

Needed action

In order to provide a safer working environment for the truck drivers and operators, Columbus installed retractable lifelines with a harness in all loading warehouses. We were however constrained to install lifelines in open air loading areas without a roofing structure to support the lifeline.

Together with our current logistics service provider C.Steinweg Logistics, various options were explored and tested. In 2022 a portable lifeline was designed for use in loading areas in Columbus Stainless without a roofing structure.

Action review

Specific: We identified a lack of fall protection in open air areas. A number of options were explored but none were readily available or developed in the markets.

Development of the portable lifeline took a few trial and error attempts but in the end, the current design proved as most successful to meet the required needs.

Measurable: Reduction / Elimination of injuries due to falling off a truck trailer bed.

Achievable: The initial objective was to find a way to use retractable lifelines in open air areas. The design achieves this objective

Realistic: The portable lifeline consisted of the following:

- A 22.5 meter lifeline as per the required lifting standards.
- A retractable fall arrest block which is suitable to carry SWL of 125 kg. The fall arrest is to allow truck drivers and operators to work on the truck beds ranging from 1.4 meters up to 1.6 meters high with a truck bed width of 2.4 meters wide.
- A safety harness (SWL 125 kg) with a retractable lanyard. The harness comes with a trauma loop (Clip on type).
- Steel carriers to move freely over the anchor points.
- Test certificates per lifeline authorized by the lift testing authority.

Time-bound: The initial market research, development & design took ±1 year.

Horizontal Expansion Capability

This design can be used in all open areas that do not have a roofing structure and requires the use of fall arrest lifelines.

Outcome

The main benefit of this portable lifeline design is that the risk of falls and injuries while loading and securing cargo on a truck is lowered significantly which directly improves employees / contractors safety, health and well-being.

In terms of job satisfaction, it enables truck drivers and operators peace of mind and assurance of safety measures in place.

This design gives the business a real world tool to prevent any injuries while loading and securing a truck load.

Other comments

One of Columbus' core values "**Safety as a way of life**" is embedded in this project as we strive to provide but also ensure that the truck drivers and operators are safeguarded against fall risks in all areas of Columbus.

Safe Access to Structures

Member company

Columbus Stainless

The Challenge

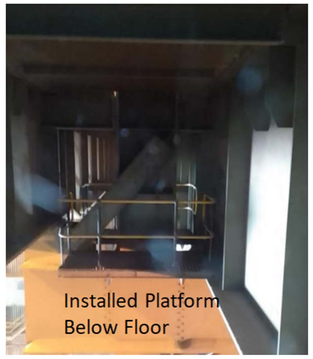
Structural Statutory Maintenance problematic due to production time constraints. Safe access to maintain structures was required without affecting production throughput.

Why?

Access to inspect steel girders and columns would have to be executed either with scaffolding of rope access and this would only be possible on long shutdowns.

Needed action

It was decided to access the structural bolts from the top by cutting a hole in the floor and installing a platform with a cat ladder. The bolts can now be inspected and complete maintenance is now possible on the girders and columns, even during production times.



Action review

Specific: Safety was addressed

Measurable: Time to carry out inspections reduced and dates when work was carried out is not dependent on plant shutdowns anymore.

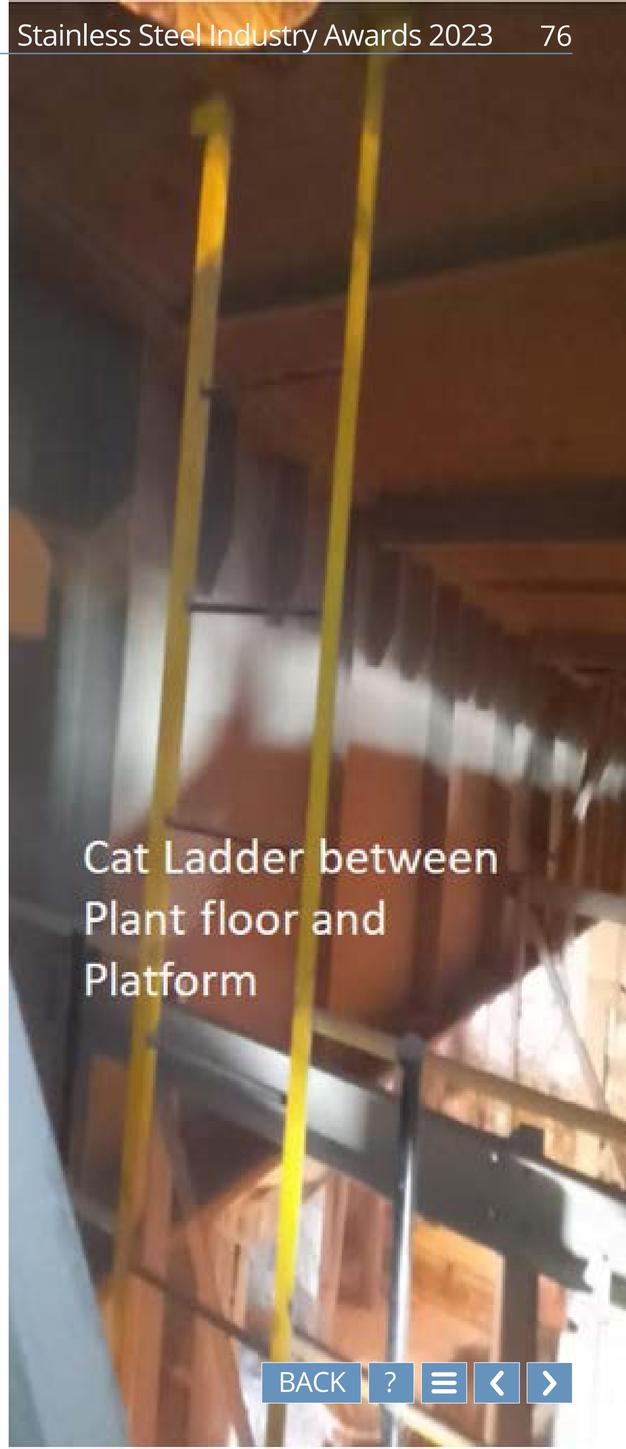
Achievable: Annual Statutory inspections can be planned outside plant shutdowns and staff members reallocated to other shutdown work when plant stops for maintenance.

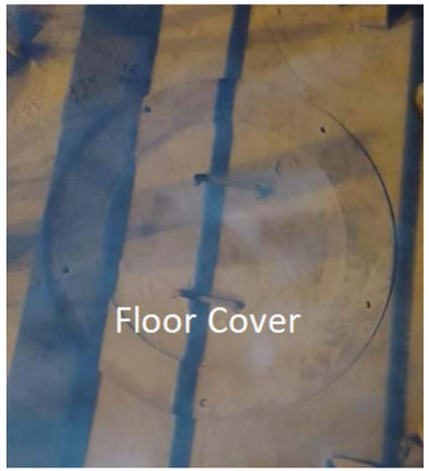
Realistic: All inspections are carried out as planned and no constraints prevent or delay this.

Time-bound: Planned work was carried out and achieved. Inspection time and scaffold erection time would take 2 weeks. Currently 6 hours.

Horizontal Expansion Capability

All companies with a girder arrangement as shown in the attached drawing can implement this.





Outcome

Safety is the main benefit as there are 6 cranes in the bays. All work that is now carried out, takes place within the girders away from any crane movement. Production is not affected and tasks can be planned to suit the maintenance department carrying out the task.

Other comments

The access area is entered via a cat ladder and the work is carried out on a fixed platform with handrails.

Shapemeter roll polisher

Member company

Columbus Stainless

The Challenge

Reocurring problems with dirt building up on the shapemeter roll after the Skin Pass Mill at the AP2 was becoming a problematic situation. The buildup would cause pickups that made unacceptable dents in the steel strip surface. These defects would appear randomly on the roll and press random dents into the strip. The position where the roll is situated makes it very difficult to find access to clean the roll. Space is constrained and contact with the roll meant that someone would have to put themselves in harms way. It soon became a conflicting situation of quality versus safety.

Why?

We needed to preserve the quality of the steel but at the same time find a practical and safe means to clean the roll while the line is running. Long meters affected with pickups and also the drive to reduce unnecessary stopovers required intervention to eliminate the problem.

Needed action

Designed and build a polisher that is pressing with its own weight against the roll continuously while the line is in operation. This means that there would be no human intervention required to clean the roll surface. Basically this device is self maintaining the roll surface.

Action review

Specific: Needed to preserve quality and safety – eliminating the quality defects (pickups) and reducing stopovers to stop and clean roll. Also protect the safety of personnel by ensuring no wild chance and no contact is made with the roll in a confined space.

Measurable:

- Pickups – meters affected.
- Stopover Ratio.
- Safety – There was a serious accident in the past where the arm of an operator was caught performing roll cleaning tasks.

Achievable: Yes – the polishing tool as above indicated eliminated the safety risk completely as it operates on its own without any human intervention.

The problem with pickups was also addressed to the extend that pickups from this area are very rare. Due to the implementation of this tool, the stopover ratio of the AP2 also improved.

Realistic: Very practical and cost effective solution to eliminate more than one problem (Quality and Safety). The polisher also forms part of quick change over technology as it takes less than a minute to change with no compromise to either quality nor safety.

Time-bound: Yes – polisher was designed, built and installed within one month.

Horizontal Expansion Capability

Yes, definitely. Especially in the case of confined, hidden spaces and where rolls pose the danger of nip points.

Outcome

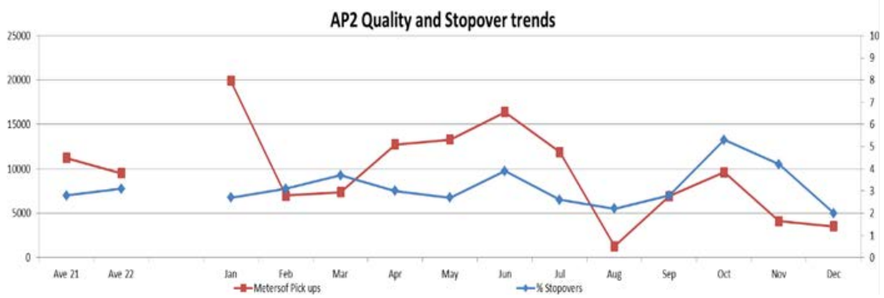


Image 1: Indicates the decline in both meters booked for pickups over the AP2 and the decline in the stopover ratio.

Image 2: New polisher pressing against roll while line is in operation. From the picture one can see the space is very restricted and that it would be very difficult form someone to clean the roll.

Image 3: Enlarged picture of the new polisher cleaning the roll on its own.

Steering Camera Cleaning Tool

Member company

Columbus Stainless

The Challenge

The steering cameras on the Hot Mill Finishing Mill are critical for the operators to be able to steer the strip inside the mill. The cameras are located on the entry and exit sides of the mill, facing the mill on the coiler boxes. They need to be cleaned on a regular basis because of the steam and steel dust that collect on the camera box lenses during the rolling process. The lenses need to be cleaned twice per 8 hours shift to allow a clear camera picture in the control room so the operators can apply the correct real-time steering response. To clean, the operator must step off the safe platform and climb on a narrow ledge to reach the cameras.

Why?

Previously, before cleaning the cameras, the operators would have signed a permit, followed the relevant lock-out procedure and wear a safety harness which is hooked onto the hot coiler box surface. The operator would then step off the platform onto a ledge to reach the camera. Even with the safety harness, there was a risk of the operator falling or being burnt due to the proximity to the coiler furnaces. There was also exposure to heat stress while cleaning the cameras.

Needed action

1. Firstly a risk assessment was done.
2. From the risk assessment, possible options to mitigate or eliminate the risks were discussed.
3. From the discussion, the target was to clean the cameras, entry and exit, without stepping from the platform. Additional targets were to remove the need for wearing additional PPE (a harness) and reduce heat exposure.

Action review

Specific: The material used included a modified PVC pipe and plastic welds to make a T-shaped tool. A wet and a dry cloth were then secured on the arm-ends of the 'T-tool' for washing and drying of the cameras. This method did not require stopping the plant or waiting for a roll change opportunity.

Measurable: Harnesses are no longer required as the operator does not need to climb on the coiler boxes or step off the safe platform to clean the cameras. The risk of the operator falling, being burnt or injured has been eradicated.

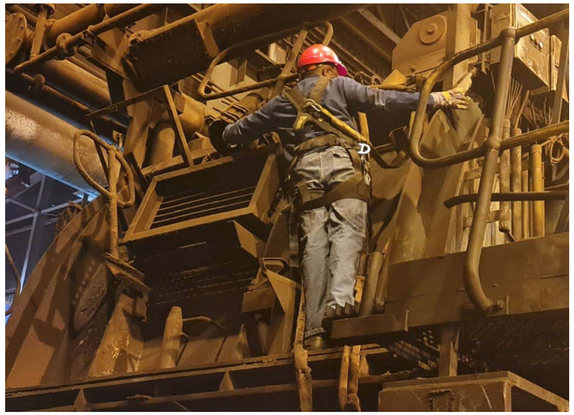
Risk Assessment Results (before and after implementation):

	Risk	Probability	Severity	Score
Before	Risk: Burning, Heat stroke (PPE worn)	3	4	12
	Risk: Burning, heat stroke (Hot surfaces)	3	5	15
	Injury: Falling from hooked harness	2	5	10
	Injury: Slipping and falling from narrow platform	3	5	15
Total				52
After	Risk: Burning, Heat stroke (PPE worn)	2	4	8
	Risk: Burning, heat stroke (Hot surfaces)	2	4	8
	Injury: Falling from hooked harness	0	0	0
	Injury: Slipping and falling from narrow platform	0	0	0
Total				16

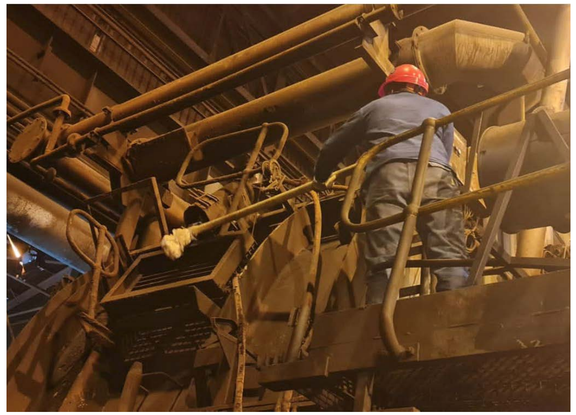
Reduction	Risk	41%
	Injury	100%

Achievable: The project achieved all of the safety outcomes as highlighted from the risk assessment, in particular:

- eliminate the potential of falling while cleaning the cameras and
- reduce the risk of heat stress and burning during the cleaning process.



Picture 1 - Old method (harness and stepping off safe platform)



Picture 2 - New method with tool (standing on safe platform)

Picture 3 - Picture of new camera cleaning tool with handle, including a wet and a dry cloth

Functional design criteria included:

- low cost,
- simple design which is easy to use,
- quick implementation, and
- solution should be sustainable.

Realistic:

- The camera cleaning T-tool was designed on shift by the operators.
- The concept design was given to a manufacturer that made it in less than a week.
- The T-tool was tested as soon as it arrived on-site and made standard practice as it mitigated the risks previously associated with the cleaning of the camera lenses.

Time-bound: The cleaning of the camera lenses can now be done in less than 5 minutes compared to it previously taking 20 minutes.

The steering camera cleaning tool was designed and built within the initial time-frame and was implemented in February 2022.

Horizontal Expansion Capability

Yes, the T-tool is used to clean other difficult to reach cameras in the Hot Mill area. The same methodology could also be applied to various other manufacturing plants.

Outcome

The steering camera cleaning tool has been in operation since February 2022. Employees complete the cleaning task quicker with less exposure to heat stress, no additional PPE requirements (like a harness) and significant lower risk, which has improved employee well-being and job satisfaction. The cleaning of cameras is done more frequently as it can be done while processing of material. With the new T-tool, there is no longer a need to wait for a delay or occasionally make a delay to clean the camera lenses.

Shot Hoppers

Member company

North American Stainless

The Challenge

A safer means to add reclaim shot to our Hot Anneal Pickle line.

Why?

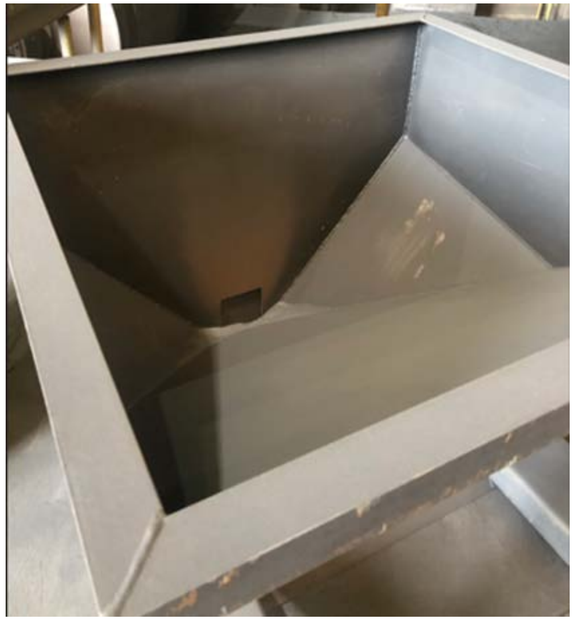
Historically, NAS would hang from a fork lift large bags of reclaim shot (2000 pounds) from woven straps on the top of shot bags. This method involved hanging a heavy mass looped around forks suspended 8 ft in the air. This method was a safety concern for our operators ranging from a potential crush/swing hazard to ergonomic concerns when breaking open the bag to load the shot into the shot blasters.

Needed action

NAS devised a different method to add reclaim shot. We designed shot hoppers to engineer out the hazards associated with the previous method of shot addition.

The hoppers incorporate several safety improvements:

1. Elimination of suspended load by installing fork channels at the bottom of the hoppers.
2. Slide gate at the bottom front of the hopper to allow for easy in shot addition.
3. Sloped internal shot containment. Gravity feed shot addtion.
4. Cleaner work space. Less housekeeping issues due to the streamlined design that allows for ease and efficient shot addition to the system.



Action review

Specific: Design and fabrication of the shot hoppers along with implementation of the new standard work in order to mitigate the safety concern.

Measurable: Safety: We eliminated suspending reclaim shot and the associated safety risks. We add reclaim shot approximately six times in a 24 hour period; hence, we eliminated the old/less safe standard work, which was done many times throughout the day.

Achievable: Objectives were met. We achieved a safer way to conduct a necessary operation of reclaim shot addition to shot blasters.

Realistic: This project was realistic and achievable. Actions were all completed as intended.

Time-bound: The design and fabrication took several months, but overall this project was completed within the necessary time constraints.

Horizontal Expansion Capability

Yes. NAS is under the umbrella of Acerinox. The company has several hot anneal and pickle lines; hence, horizontal expansion is relevant and can be explored at our sister companies.

Outcome

We are observing elevated employee buy-in since we made a standard practice easier and safer for the employee. A reduction of near miss hazards related to shot addition to the system. The practice of adding shot with the shot hopper innovation has improved ergonomics for the operators relating to the task of adding reclaim shot.

Implementation of Ergonomic Assists for Heavy Lifting

Member company

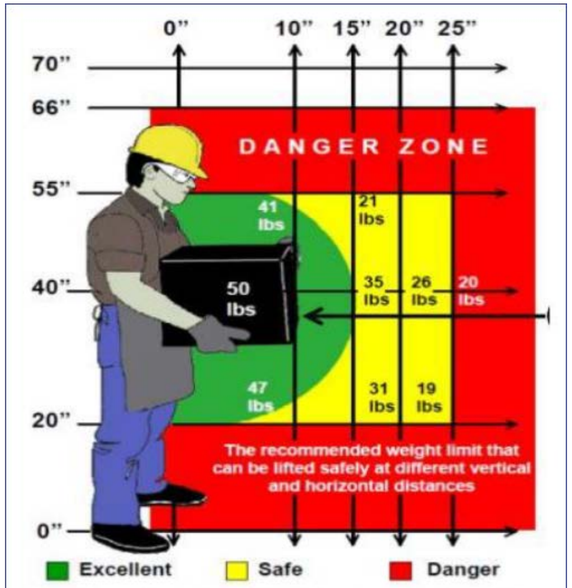
North American Stainless

The Challenge

Our Melt Shop had many areas where employees have to manually lift objects that are equal to or greater than 50 lbs or they were required to lift 25 lbs or less frequently. This presented an ergonomic hazard to employees that in the past resulted in back, shoulder and abdominal strains.

Why?

Due to the potential of increased injuries from ergonomic issues and the need to reduce the amount of weight employees were required to handle, we wanted to identify a way to either reduce the weight or find a more ergonomic way to ensure



The figure above shows the different zones when lifting an object. As your reach increases, the recommended weight limit decreases. This is because as we move the object further from our body, we have less control.

that the weight employees were lifting was in the "green zone".

Needed action

First an assessment was completed of the tasks that required lifting heavy objects (anything over 25 lbs). Once this list was generated, the melt shop team worked with a vendor who specialized in material handling equipment. In addition, some areas were not able to use off the shelf equipment and those lifting tasks required the team to work with different designers and fabricators to redesign our material handling equipment to make it lighter. The MS team also worked with engineers to design a piece of equipment to make ladle shroud changes safer for the operators performing the tasks.

Action review

Specific: Identify task were employees were exposed to ergonomic hazards due to lifting heavy objects. Once the list is identified, risk ranks the task that has the most exposure.

Measurable: Evaluate the reduction in the amount of weight the employees are required to lift when performing at task, should result in a lower amount of back, shoulder and abdominal strain injuries. (All items have a weight listed-purchased weight; items addressed were to focus on green zone lifting with pallet lifters or tool balancers to reduce the lifting by 90%).

Achievable: The objective was to focus on reduce floor to shoulder lifting.

Realistic: Action items were realistic in such that most were able to be purchased such as the lift tables, tool balancers and carts. Expanded the slab caster storage area to provide more work area and to accommodate the lift tables. Lift/dump tables are being utilized to transport and

add materials to the AOD chutes. The powder trays were redesigned using a lighter material, this change reduced the weight of the trays by 20 lbs. Tool balancers were added to reduce the weight of the cylinders employees must lift from 60 lbs to ~10 lbs push down force since they are hanging now; lifting from pallet lifters have bags of power or product always in the green zone.

Time-bound: 8 months for the above projects to be completed. Additional projects are planned for 2023 and 2024.

Horizontal Expansion Capability

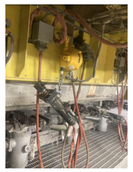
This equipment can be used in all mills and areas to assist employees in minimizing bending and lifting heavy objects.

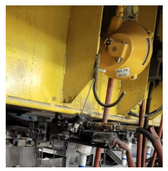
Outcome

Since implementing some of these material handling tools, we have been able to reduce the number of strain and sprains in our Melt Shop area. We have made the material easier to access, lighter and reduced fatigue from the need to continuously bend over and lift heavy bags from the floor.

Tool Balancers

Tool balancers installed. Operators no longer lift the 60 lb cylinders. The tool balancers redacted the weight from 60 lbs to ~10 lbs push down force since they are hanging low.





Pallet Lifters and Lift/Dump Tables

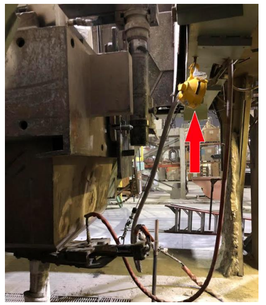
The pallet lifters and lift/dump tables help to keep material at waist level. Minimizing lifting from below the waist and keep heavier items in the green zone.

Redesigned Powder Trays

New Al powder trays came in today. old trays had a weight of 30 lbs each. the new trays only weigh 10 lbs each

Winch

Added a winch to pull the chop block into place. Reducing the need to manually put the block into place.



Fair Culture. Acknowledgments and Consequence Management

Member company

ROLDAN, S.A., Acerinox Group

The Challenge

People make mistakes that, as a general rule, we don't usually recognize, and yet many of these mistakes cause accidents. The challenge is to facilitate the early detection of unsafe conditions, the transparent communication of safety information and the effective prevention of accidents.

Why?

To create a climate of trust that encourages the communication of essential information related to security, establishing the line between acceptable and unacceptable behaviors. To promote an attitude of questioning, resistant to complacency, seeking permanent improvement, demanding individual and corporate responsibility, through the organizational commitment to safety.

Needed action

Creation of the Fair Culture procedure.

Acknowledgments and consequence management.

Dissemination to own personnel and subcontractors.

Pillars of just culture:

- Recognition and exemplarity of good security practices.
- Report and transparent information in a climate of trust.
- Independence of the study team and analysis of risks and events.
- The right to error of the workers of the organization is admitted.
- Equitable disapproval of unacceptable behaviors.

Action review

Specific: Procedure that describes how to apply the concept and how the result is measured through rewards and sanctions.

Measurable: Through the system of rewards and management of consequences, the Security Commitment Level (NSC) of own personnel and subcontractors is valued, increasing proactivity and reducing incidents.

Achievable: The procedure has to bear fruit over time with an increase in the level of commitment and a reduction in accidents.

Realistic: It is an already existing procedure in other sectors such as the aeronautical sector.

Time-bound: Full implementation is estimated at 1 year.

Horizontal Expansion Capability

This procedure can be used and implemented in other group companies and in any company in the sector.

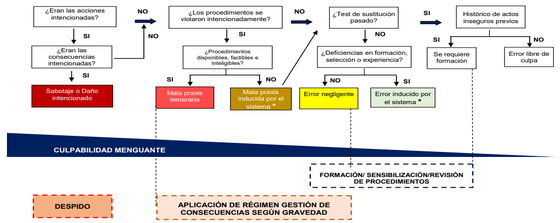
Outcome

Before the procedure:

- Subjective reward and punishment system.
- Poorly defined contract commitment.
- Lack of transparency.
- Late detection of unsafe conditions due to lack of communication.

After the procedure:

- Reward system defined and known by all parties.
- Punishment system, within the agreement but applied in a totally objective way.
- Defining the contractor's commitment to safety.
- Increased transparency in communication.
- Increased safety by detecting unsafe conditions.



FAIR CULTURE: MAIN ELEMENTS	
ELEMENTS TO ENHANCE	**ELEMENTS TO ELIMINATE**
Guarantee workers who report incidents or deviations that they can do so anonymously, separating management and investigation processes from the notifications of the productive areas of the organization.	Save data of people who report incidents or identify them in some accessible medium.
Promote notification as something normalized and desirable to improve problems and prevent events.	Censor notification of negative events. Act in a coercive or punitive manner using notifications as evidence.
Reinforce the responsibility of all the workers of Roldán, S.A. through its support and the provision of adequate means to work safely.	Allowing unsafe work or with inadequate means for the correct development of activities, be they human or technical means.
Increase sincerity in relations with Management, so that responsibility is inherent in the communication of events and acceptance and transparency are reinforced in the communication of incidents.	Inaction in the face of willful or malicious conduct, both in the report and in conduct of manifest hostility towards the company, such as sabotage, boycott, etc.
Increase the capacity of workers through training, information, communication, in such a way that they can do their job correctly and are equipped with the necessary means to do so.	Carry out activities with a lack of knowledge, means or sufficient and adequate experience for it, in such a way that situations of conflict and risk are generated.
Analyze the work processes to detect if the sequence and operations to be carried out imply that the workers have to improvise or skip the rules. In the event that this occurs, the procedure must be changed so that it contemplates the safe execution of the processes.	Maintain procedures or modus operandi that are manifestly insecure, especially if they have previously produced failures or errors.
Disseminate knowledge, good practices, safe work procedures, standards, as well as knowledge obtained from error management, as a means of prevention.	Denying, hiding or minimizing mistakes or their consequences as a way of avoiding punishment.
Accept that errors will appear as a normal part of the performance of the activity, there being some margin to have the right to make mistakes.	Considering the production of an error something so negative that it encourages its concealment or denial by the components of the organization.

NSC Calculation Form

NCS = A + B-C

A= A1 + A2 - A3

A1: Compliance with regulations relating to critical risks: this index will take into account compliance with work permits, LOTO and specific security plans.

A2: Compliance with other safety regulations: compliance with general factory regulations will be evaluated, such as the provision and correct use of PPE, the state of order and cleanliness of the work area, signage, participation in meetings of ORP coordination, the correct management of the platform for the coordination of business activities (Achilles)...

A3: Number of reprimands imposed on the contractor once the Cultura Justa de Roldán, S.A. procedure has been applied.

B: Contractor safety observations: This indicator is intended to assess the proactive nature of the contract, considering for this the communications made regarding risk situations, improvements or incidents without material or personal damage. Suggestions, good practices or risk communications made through the communication channels established by Roldán, S.A. will be considered in the calculation: Coordination Meetings, Preventive Observations, Gemba Walks, Cross Audits, Drills... In any case, these communications must be validated by Roldán's technicians to be taken into account in the calculation of the indicator.

C: Accidents: With this index the accident rate of the contract will be penalized provided that in the investigation of the accident it is determined that the cause of the

NCS	CATEGORY	RESULT
NCS≥20	**A**	The safety performance of the contract is adequate.
20>NCS≥10	**B**	The contractor's safety performance requires improvement actions and an action plan should be required.
NCS<10	**C**	The level of security performance of the contract is not accepted and an improvement plan associated with the withholding of 2% of the four-month billing is required.

Procedure for fixing support post framing

Member company

ROLDAN, S.A., Acerinox Group

The Challenge

To avoid carrying out work in the vicinity of suspended loads during the tightening control operation of the fastening screws of the P-624 headframes to the support post.

Why?

The headframe, once assembled, slides with the help of the overhead crane over the guides of the support post and adjusts to them. At this point, the cylinders are in a horizontal position. This operation is carried out in the support post turner.

Using the turner and with the help of the crane, the support post and headframe assembly is rotated, leaving the cylinders in a vertical position. At this time, the screws are placed to fix it, joining two of the legs of the headframe itself to the support post.

After this operation, the assembly is placed back on the support post turner and at a 45º inclination and with the crane supporting part of the weight of the assembly, they check the tightening of the screws from below.

Needed action

Establishing a procedure to check the fastening of the headframe to the post using gauges:

1. Once the frame has been slid onto the support post and the cleanliness between surfaces has been verified, the distance between reference points will be measured using gauges on both legs.
2. After turning the assembly over and fixing the frame to the support post through the screws, the reference distance will be checked again. In this way it will be detected if the headframe has become loose, since in this case, this last measurement will be greater than the first.

Action review

Specific: Procedure for checking the fixing of the frame to the support post, avoiding intervention in the suspended assembly.

Measurable: Elimination of risks associated with interventions in the vicinity of suspended loads.

Achievable: The procedure is simple and allows a systematic verification.

Realistic: The procedure is easy to understand and carry out.

Time-bound: The implementation of this system is immediate.

Horizontal Expansion Capability

This procedure can be applied to other similar jobs or to other Group facilities.

Outcome

Before the improvement:

- Greater number of steps in the intervention (it was required to raise the load) .
- The verification of the measurement was made with the load suspended (risk of impact or entrapment).

After the improvement:

- Easier operation.
- The check is made with the assembly correctly positioned, completely eliminating the risk.

Platform for axial adjustment of rolling stands P-815-20

Member company

ROLDAN, S.A., Acerinox Group

The Challenge

Improving access to the upper part of the block and protecting against falling to the same and different levels during the manual operation of axial adjustment in the “even” units B2 to B10 of the block.

Why?

Currently, a manual ladder is used to access the adjoining “odd” unit, using it as a step, and from this step to the “even” unit that has to be adjusted. Both during access and during adjustment there are risks of falling at the same and different levels. There are no collective protections in the work area. In addition, the entire area is wet and therefore slippery, increasing the risk.

Needed action

Design, build and provide a ladder with a work platform with collective protection to carry out these works, so as to allow safer access to the work area as well as work on the platform without the risk of falling.

Action review

Specific: Ladder design with work platform after consultation and participation of the workers. Detailed explanation of the executions taken relevant to this entry.

Measurable: Suggestions from workers to improve working conditions and avoid accidents.

Achievable: Good preventive observation of workers to improve safety at work. Having this means for access and positioning during the adjustment must guarantee long-term security measures.

Realistic: The need is analyzed with the workers and the equipment is designed with the intervention of the section, maintenance and PRL with the aim of making it the most practical and safe design at the same time.

Time-bound: In a month and a half it is expected that the equipment will be available to the workers.

Horizontal Expansion Capability

Based on this design, others can be developed with the measures adapted to the area of application, both within Roldán and in other companies.

Outcome

During the design: Satisfaction of the employees when having their opinion and participation.

In the long term and once they have the equipment, greater job satisfaction is expected by having equipment to carry out the work more safely.

Safety, respect, equality and well-being at work!

Member company

Aperam

The Challenge

Showing importance to sanitary facilities such as toilets and changing/shower rooms is more than a simple hygiene and safety concern. It is a way of showing importance to the people working on our sites.

With this project, Aperam wanted to provide adequate facilities to ensure the well-being of its employees at any workplace and demonstrate the importance that the company attaches to the quality of health and welfare facilities.

Why?

Aperam attaches great importance to the quality of health and welfare facilities as they are fundamental to the quality of working life. Qualitative, clean, easily accessible sanitary facilities (washing accommodations, toilets and changing rooms), must be provided for all people working on or visiting our sites.

Due to the age of some of our sites' infrastructures and the dirtiness inherent to some production processes, the condition of a number of changing rooms and bathrooms has deteriorated in the past years.

Some of the main issues were:

- The sanitary facilities were originally made for a strictly male population, and can thus be inadequate for the growing female staff in production.
- Sanitary rooms in old buildings can have ventilation problems that could cause mould, we can have air draughts, lack of privacy, as well as risks of slipping and injury.

Needed action

To solve the above-mentioned issues, Aperam defined a common standard for Sanitary facilities:

- Definition of a standard for Sanitary facilities, in consultation with the recently created Aperam Global Health Expert Circle (organ composed of mill doctors and other external health experts, Health & Safety Team, HR, and workers representatives, working together on Health topics on a global level)

This standard was validated by the Health & Safety Strategic Committee (organ composed of Mill managers and the Global Health & Safety team).

This document defines minimal standards for showers, restrooms (toilets) and dressing rooms.

Following aspects were taken into consideration:

- General design requirements for sanitary rooms
- Water (temperature etc.)
- Washing accommodations (hand washing and shower facilities)
- Toilets
- Changing rooms
- Hygiene general requirements

Particular attention was paid to the following points: definition of male/female zones, privacy, access to physically disabled people, special care for truck drivers coming to our sites, employees from external companies and visitors, hygiene plan.

- Creation of an audit grid linked to the standard, translated into 10 languages
- Setting up of audits on each site

Audits were conducted on each Aperam site with members of the local health circles (which includes staff representatives and site management) to evaluate the current situation compared to the new Aperam Standard.

The local audits gave an overview of the number of non-conformities detected per site and allowed us to establish a first budget estimation to close all gaps.

- Definition of a local action plan to solve all issues over maximum 3 years and solve at least 15% in 2022.
- Definition and validation of Multi-year capex plans for all sites

And as from now:

- Local planning of an annual budget available for regular maintenance to ensure that this standard is maintained.
- Processing of complaints about cleanliness or defective items, issues henceforth treated as a priority by the site management.

Action review

Specific: Distribution of a clear standard for all Aperam sites worldwide, as well as an evaluation grid translated in all needed languages.

The document defines minimal standards for showers, restrooms (toilets) and dressing rooms.

Any deviation from this standard will need to be approved by the divisional CEO.

Measurable:

- Overview of the number of non-compliance to the standard per topic and per site.
- Local action plans to solve all issues over maximum 3 years and solve at least 15% in 2022.

Achievable: To make sure our action plan is achievable, Aperam anticipated:

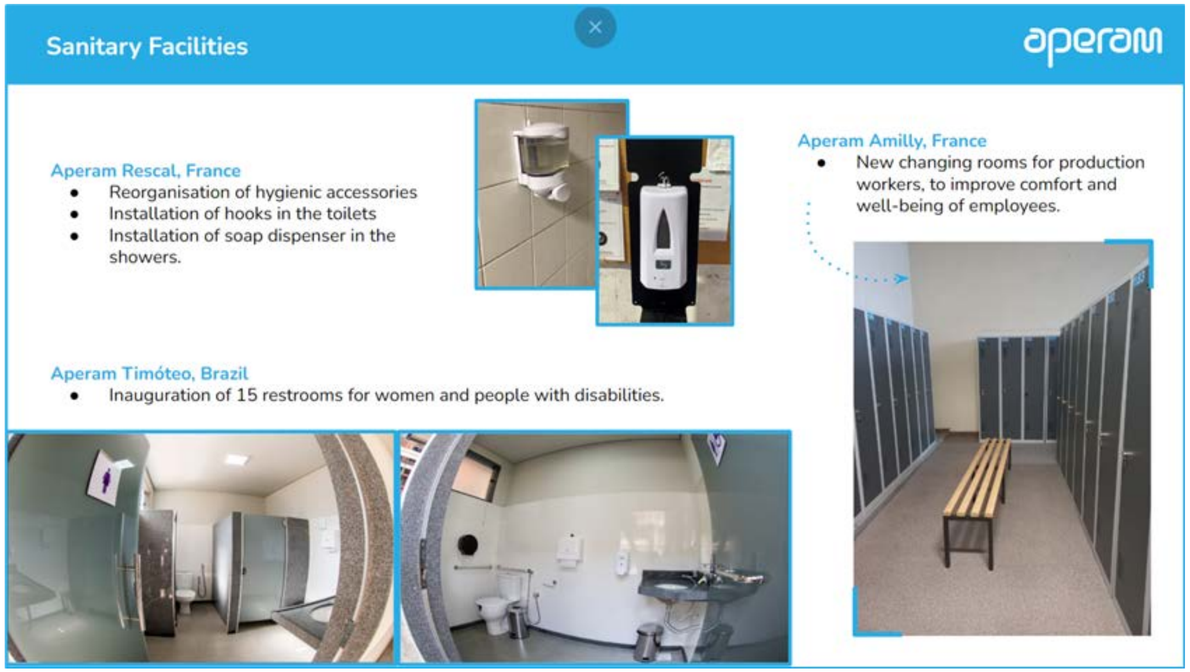
- A list of actions planned/done per site
- A priority list, to prioritize the required in initiatives
- A provisional budget estimation.

Realistic: As we had clear specifications and clear audit grids, the actions to implement were very clear.

Aperam sites will, as a minimum, follow the prevailing local regulations for showers, restrooms and dressing rooms. But where this Aperam standard is more demanding, then it will apply.

Here some concrete examples:

- Separate sanitary rooms shall be provided for female and male employees.
- Furnishings or structural installations in sanitary rooms must not endanger the safety and health of workers (e.g. through cutting or bumping edges or through the possibility of the accumulation of pathogens)
- In washrooms and changing rooms, effective ventilation must be ensured depending on the use. The ventilation of sanitary rooms must be arranged in such a way that no draughts occur.
- Lighting in sanitary rooms shall have a minimum luminance of 250 lx
- Floors must be slip-resistant even when wet.
- In sanitary rooms an air temperature of at least +20 °C must prevail during the period of use;
- The risk of legionella must be assessed (risk assessment) and the showers controlled accordingly.
- Water sources that are not drinkable should be clearly marked on taps.
- A least one shower and one hair drier for every 5 workers who may use the place simultaneously (end of shift) must be available
- There should be the possibility to use an individual and lockable shower and cubicle.
- Each shower needs to be provided with clean hot and cold water and individual



non-irritating soap (preferably in soap dispenser)
- There should be separated areas for keeping clean and soiled protective clothing.
- For work wear and protective clothing that has become damp during the activity, it must be possible to dry them until the next time they are used, if necessary also outside the changing room, e.g. in an adequately ventilated drying room or with drying room or with electrically operated drying cabinets.
- It must be ensured that truck drivers, contractor employees or visitors have safe and quick access to clean toilets and washing facilities at any time (internal or provided by the external company)
- We recommend that at least one shower be provided for truck drivers.
- ...

Time-bound: The first target was to close all actions within one year.

Taking into consideration the different projects and the current economic situation, it has been decided to prolong the delay of realisation to 3 years (until 2024). Today we see the first improvements made on all sites.

Horizontal Expansion Capability

Yes definitely! Showing importance to the toilets and changing/shower rooms is showing importance to the people working on your sites. It is more than only hygiene and safety; it is also about universal issues such as well-being and respect.

The action plan and methodology we have followed can be easily imitated by other member companies who share the same issues

Outcome

The overall appearance of our sanitary facilities greatly improved, which makes them more attractive for our workers, while offering them more comfort and privacy.

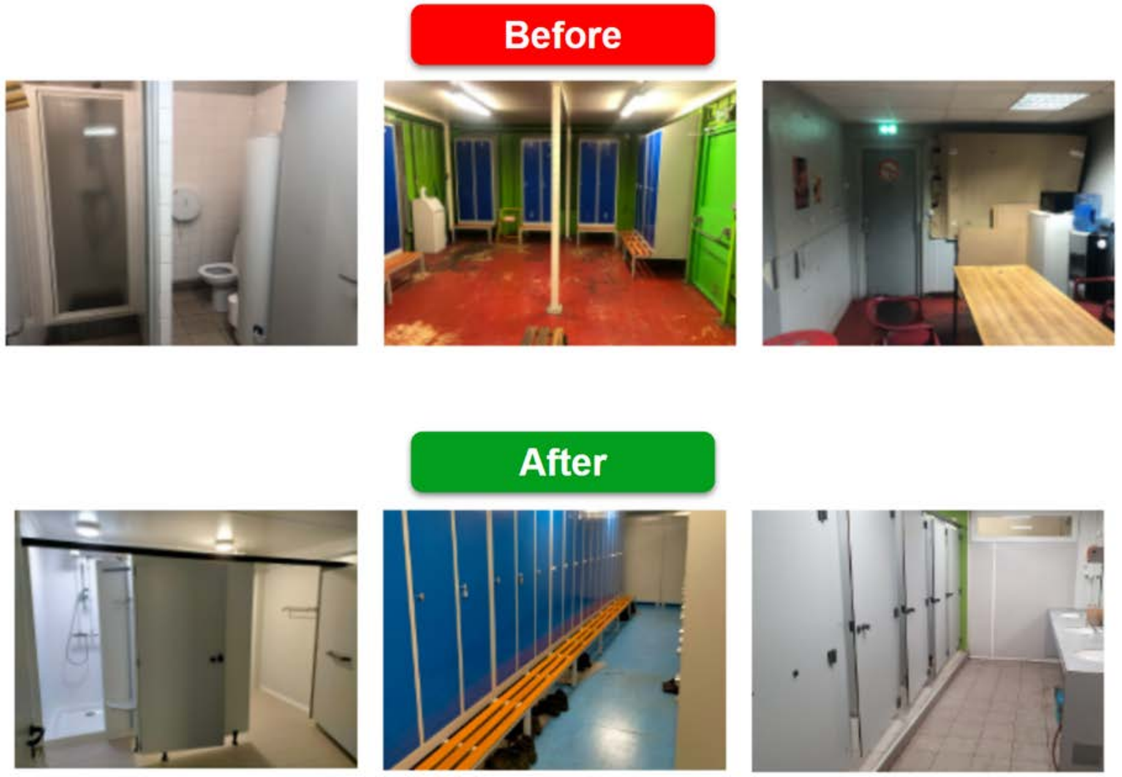
The modernised sanitary facilities offer more space for women, so the employment of more women in production is not constrained.

In addition, with the right equipment and premises, the risk of injury caused by slipping and falling is reduced, as the risk of catching cold (due to draughts, etc.).

The motivation of our people has increased, and Aperam genuinely believes that as we all know, motivated people are very important assets in a competitive market.

Other comments

Here are concrete, illustrated examples of initiatives taken by our sites, as part of the new Standard for sanitary facilities. To inspire our teams and share good practices that can be reproduced on other sites, Aperam actively communicates those sanitary facilities improvements at the corporate level throughout the year.



Focus on one of our sites: Recyco, France

- New women's toilets, to improve our employees' well-being
- New men's changing room: separation of clean from dirty changing rooms for workers exposed to lead.

Prevention of a fire in Continuous Casting

Member company

Nippon Yakin Kogyo Co. Ltd.

The Challenge

The continuous casting (CC) machine is used for producing slabs of stainless steels. In this process, argon gas blowing is conducted to stir the molten steel before casting. This is effective in preventing the formation of low temperature layer in the molten steel and removing harmful inclusions. However, there is a risk of causing a fire hazard due to splashes from the molten steel. Therefore, on-site checks by the operators should be carried out on areas in the blind spots of the monitoring cameras to ensure that combustible materials have not ignited.

Why?

There was a potential to improve the working environment by finding safer and more efficient ways of checking for outbreaks of a fire.

Needed action

3s were installed so that the operators could check from the monitoring cameras.

Action review

Specific: The installation of convex mirrors eliminated blind spots for the monitoring cameras. The operators can check for outbreaks of a fire in a timely manner with the monitoring cameras from the control room.

The example of the convex mirror installed in the gas blowing station of CC.

Measurable: This measure can eliminate the danger of on-site checking and also improve the work efficiency. A fire has been successfully prevented.

Achievable: This measure has been successfully achieved.

Realistic: We easily installed the mirrors in positions that could be seen by the monitoring cameras.

Time-bound: We have achieved according to our original plan (within several months).

Horizontal Expansion Capability

We are planning to expand for other fire risk areas.

Outcome

The operators can check for outbreak of a fire in a timely manner with the monitoring cameras from the control room. We can now prevent a fire without on-site checking.

Digitization of Equipment Inspections

Member company

Nippon Yakin Kogyo Co. Ltd.

The Challenge

Our daily inspections of the plant equipment are important tasks to maintain high levels of safety and productivity. We used to prepare reports from handwritten inspection sheets and refer to printed reports to carry out repairs. Therefore, it was taking a long time from the moment inspections were carried out until the instructions were issued to the site, which caused problems in sharing information and speeding up repairs.

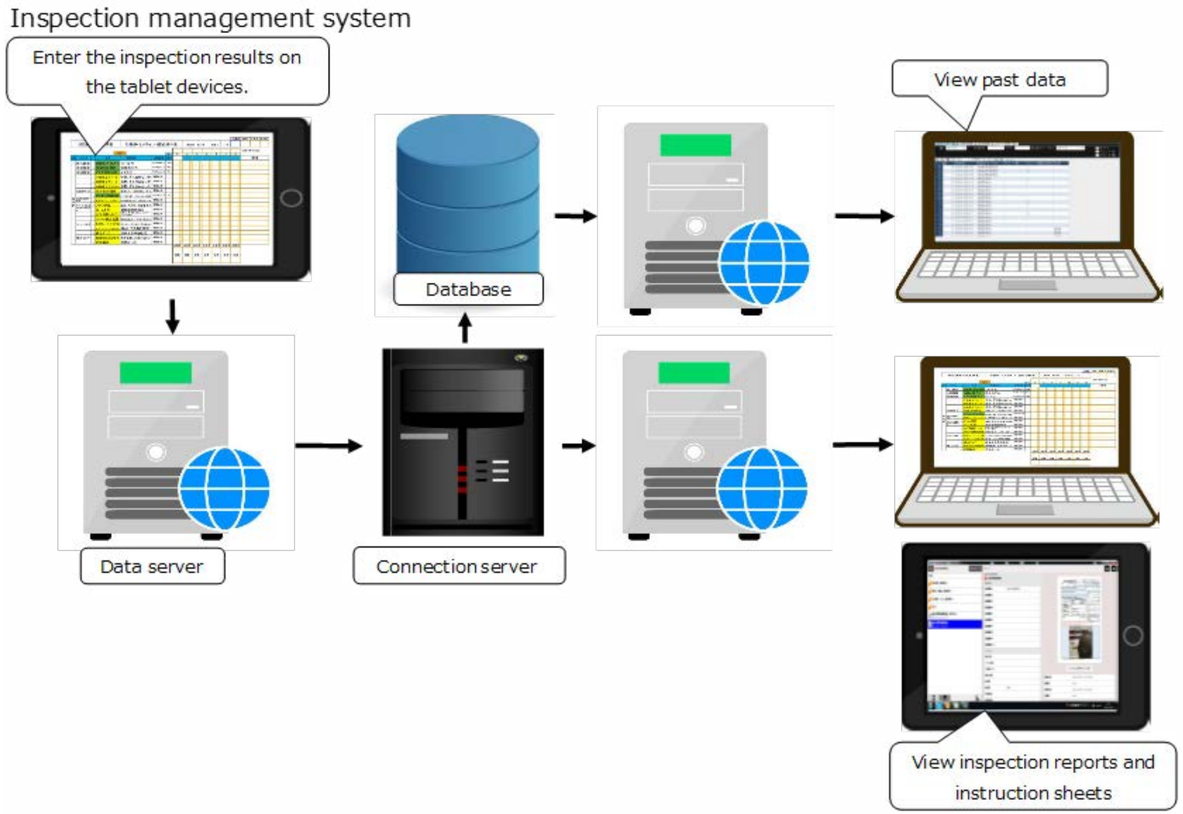
Why?

The paper-based ways of sharing and providing information prevented rapid repair actions. Therefore, the digitization technologies were focused to solve this problem.

Needed action

The digitization of the inspection records and the instructions have been conducted as follows.

1. The inspection results have been entered on the tablet devices.
2. The entered data have been stored on the data server.
3. The data stored on these servers can be used to check inspection records and view past data from the PC / tablets.
4. Alert notifications can be delivered to the PC for any anomalies found during inspections.
5. The inspection reports and the



instruction sheets can be made with the tablets and attached photos directly to them.

Action review

Specific: The tablet devices and the data server have been prepared and the management system has been constructed.

Measurable: The time between inspection and instruction has been reduced from seven to three days at the earliest.

Achievable: The installation of the facilities and the system construction have been successfully achieved.

Realistic: The system can be constructed with commercially available tablets and data servers.

Time-bound: We have achieved according to our original plan.

Horizontal Expansion Capability

This system can be horizontally expanded to the other plants if necessary.

Outcome

The time between inspection and instruction has been reduced from seven to three days at the earliest. Inspection work has become more efficient.

1. The inspection management system using the tablets and the data server was constructed.
2. The inspection data, reports and instructions can be viewed at any time.
3. The information sharing and provision has speeded up.

Program of Sustainable Social Actions – 12 Months = 12 Actions (12M:12A)

Member company

ACERINOX EUROPA S.A.U.

The Challenge

Acerinox Europa is fully committed to Sustainability and the importance of its implementation in the facilities.

The Sustainability Section from Acerinox Europa planned to increase the number of sustainable actions in the year, looking for the implication of organization and the society surround us. The target is setting a plan, not only for Acerinox Europa staff, but also its volunteers team and the neighboring community.

For this reason, it was launched the program called 12 Months = 12 Actions (12M:12A). Each activity deals with a sustainable topic (social, environmental and economical issues) and with the achievement of the Sustainable Development Goals (SDG) approved by the United Nations Organization.

Why?

Acerinox Europa strongly believes that the social awareness and consciousness is a key point to achieve the correct sustainability development. Until now, the actions were done without Sustainable Development Goals (SDG) associated and the 100% employees commitment and knowledge.

Participation of Acerinox Europa Employees in employment workshop focused on socially excluded groups with Alternatives Association - January 2022

The program described before is considered a great way to:

- Bringing sustainability closer to employees (creation of a volunteers team) and the neighboring community.
- Promoting and disseminating our commitment to sustainability.
- Reaching the Sustainable Development Goals (SDG).

Needed action

The elaboration of the mentioned program implied the need to create a working group (Human Resources and Sustainability Sections) which ensured the correct planification of the different sustainable actions to be held during 2022. Therefore, this planification has to be aligned with the different sustainable themes and the achievement of the Sustainable Development Goals (SDG).

In addition, initiating a communication campaign to inform about the actions, the registration of the volunteers and the

results and conclusions of each action.

Action review

Specific:

- Working team: Human Resources and Sustainability sections.
- Planification of the actions: Sustainable topics (social, environmental and economical issues) and Sustainable Development Goals (SDG) associated.
- Elaboration of the program 12 Months = 12 Actions (12M:12A).
- Communication strategy: confirmation of communications channels (information boards, screens, informative emails, volunteers registration email, etc), dissemination of closure of actions, ...
- Collection of the results for each activity.

Measurable:

- Number of actions per month.
- Number employees as volunteers.
- Number of volunteer hours.
- Sustainable Development Goals (SDG) associated.
- Communication registrations.

Achievable:

- Human Resources and Sustainability Working Team.
- Approved Economic Budget.
- Planification of actions (taking into account the need or not of volunteers).
- Activation of Communication Strategy.
- Final version of the Program 12M:12A.

Realistic:

- Working Team Meetings.

Acerinox Europa Volunteers Team - Solidarity Race - March 2022

- Communication Campaign (information distribution, press releases, etc).
- Quantification of the results (measurable data).
- Conclusions and improvement proposal.

Time-bound:
Actions were completed within the original time frame but:

- in some cases the planification was longer than expected,
- no actions in holiday periods (August and December).

Horizontal Expansion Capability

Acerinox Europa is fully convinced that this sustainable measure could be replicated in member companies to reinforce the implantation of the Sustainability and

guaranteeing the awareness both inside and outside the organization.

Outcome

Acerinox Europa finally planned and carried out a total of 16 actions during the year 2022.

These actions have covered all the sustainable topics (environment, economy, culture, safety, health, etc) and most Sustainable Development Goals (SDG).

Highlight the Acerinox Europa volunteers team involved in the actions: 27 employee volunteers and 288 volunteer hours.

In addition, the number of Sustainable Development Goals (SDG) that were worked with the program 12M:12A were a total of seven.

Finally, there were 14 press releases (website, newspaper, social networks,...) to inform the society about the actions that were promoted, financed and executed by Acerinox Europa.

In the conclusions final meeting of HHRR and Sustainability work team, the most relevant points and proposals for improvement were detected to continue advancing in this program alternative.

Thanks to this project, Acerinox Europa has reinforced its commitment to Sustainability, improved and increased the awareness and consciousness of employees and neighboring community and organized a volunteers team.

Acerinox Europa proposes to continue carrying out sustainable social actions during 2023 to demonstrate that in this way adds to the development of society and companies.

Other comments

In the following table, the total of actions of the program 12M: 12A are shown and the Sustainable Development Goals (SDG) associated to these actions and some links with information about them:

January	1. Participation in employment workshop focused on socially excluded groups with Alternativas Association (San Roque)		https://www.europasur.es/san_roque/Acerinox-Europa-talleres-empleo-coordinadora-alternativas_0_1653735011.html
February	2. Cultural Days (Los Barrios City Hall) + Volunteering		https://www.guiadecadiz.com/es/agenda/febrero/2022/ix-jornadas-culturales-andaluzas-2022-villa-barrios#
March	3. International Women´s Day 4. "Women of Steel" – UNESID		https://www.europasur.es/los_barrios/Dia-Mujer-8M-talleres-musica-ruta_0_1659135255.html
	5. Solidary Race (Palmones) + Volunteering		https://unesid.org/blog/category/mujeres-de-acero/ http://www.carrerasolidariapalmones.es/galeria-2022/

April	6. Safety Week (Acerinox Europa) + Volunteering		https://www.europasur.es/los_barrios/Acerinox-Europa-simulacros-Semana-seguridad_0_1679832608.html
May	7. Reforestation - II Phase (Palmones) + Volunteering		https://www.acerinox.com/expcrt/sites/acerinox/.content/galerias/galeria-descargas/ENG_Memoria_2021.pdf
June	8. Donation of COVID-19 tests to a nursing home (Los Barrios) 9. Participation in employment workshop organized by Algeciras Trade Agency.		https://www.europasur.es/campo-de-gibraltar/empleo-empresas-comarca-puestos-trabajo-Camara-Comercio_0_1696631971.html
July	10. Donation equipment for beach users (Palmones)		https://www.rtvsol.es/noticias/local/alconchel-supervisa-el-dispositivo-de-socorrismo-y-vigilancia-puesto-en-marcha-en-la-playa-de-palmones-202207041442

September	11. Awareness European Mobility Week 12. Participation in Stainless Steel Worls Conference & Exhibition (Maastricht).		https://mail.google.com/mail/u/0/?tab=rm&ogbl#search/sema/FMfcgzGqQcsLpqFgPsCCMbwgPXfmDxfj https://stainless-steel-world-event.com/files/pdf/ssw/ssw2022_acp.pdf
October	13. Presentation of 25N Campaign- Intenational Day for the eradication of gender violence (Los Barrios) 14. Assistance to Job Search Networking (INNOVA JOB Project)		https://www.diarioarea.com/2022/10/17/acerinox-se-suma-en-los-barrios-a-la-campana-contra-la-violencia-de-genero/
November	15. Intenational Day for the eradication of gender violence 16. Participation in employment workshop organized by Cádiz University		https://losbarrios.es/campana-25n/

Waste water re-use

Member company

ACERINOX EUROPA S.A.U.

The Challenge

Overexploitation of scarce resources. Specifically, ACERINOX EUROPA wants to help combat the desvastating effects of drought.

Why?

Acerinox Europa is a great reference in the industrial sector in Campo de Gibraltar and, in turn, a model company in the European framework in environmental matters. Respect for the environment is one of its priorities, making it an example of a sustainable industry committed to the fight against climate change and overexploitation of scarce resources. One of the problems in the South of Spain is the water scarcity done to decrease in rainfall.

For this reason, the Environmental Section from ACERINOX EUROPA, has made a significant effort searching ways to become better water stewards and reduce our 'water footprint'.

Needed action

To use waste water as process water and auxiliary processes, such as:

1. Cleaning streets. At the same time, this action will also reduce diffuse emissions from material transport. **IMPLEMENTED**.
2. Industrial cleaning with suction-blow pump trucks. **IMPLEMENTED**.
3. Watering gardens. **IN PROGRESS**.

Image 1. Wasted water is refilled to a tanker truck with own pump from gutter.

Image 2. Tanker truck watering lanes with wasted water.

Action review

Specific: To improve the environment making productive use of scarce resources.

Measurable:

- Decreasing consumption in water intake. Measured by water meter.
- Reducing the 'blue water footprint'.

Achievable: At this time, the discharged water after the neutralitation process is being used to watering lanes and yards to avoid dust, cleaning streets and industrial cleanning, saving 400 m³ per week.

Realistic: Water manhole, stage of the irrigation system, PVC and polyethylene valves, accesories, tubes and water manhole are to be installed.

Image 3. Tanker truck industrial cleaning.


Image 4. Tanker truck industrial cleaning.

Time-bound: ACERINOX EUROPA considered starting this process with a first phase watering lanes and yards to avoid dust, cleaning streets and industrial cleanning in August 2022.
As a consequence of the good results, ACERINOX EUROPA will use this water for watering gardens too. In progress.

Horizontal Expansion Capability

ACERINOX EUROPA will communicate it to all associated companies and to the competent authority for the matter.

Outcome

- Water consumption has been reduced (-400 m³ per week, approximately)
- Diffuse emissions from traffic, waste produced by handling and pre-treatment of raw materials have been reduced.

Annealing Furnace Revamping for Gas Saving

Member company

BAHRU STAINLESS SDN BHD

The Challenge

Gas consumption at Annealing Furnace 2 higher comparing to the designed specification.

Why?

To reduce heat loss via improving energy (natural gas consumption) efficiency.

Needed action

To carry out the annealing furnace exit section revamping, by replacing with the modified enclosed system to prevent excessive heat loss.

Action review

Specific: The gas consumption was higher than the design specification and we suspected there was a big opening gap at the furnace's existing lifting roll section that had caused unnecessary heat loss in the annealing process.
The revamping proposal is to replace the lifting roll chamber section, with the modified enclosed system, that allows the exit opening to be adjustable in order to minimise the furnace heat loss.

New furnace Exit lifting structure in position

Position of Carousel Roll

Measurable: Natural gas specific consumption after the revamping modification is measured and made comparison to the previous gas consumption trend to indicate the efficiency of gas consumption had been achieved.

Achievable: Annealing for the steel's after the revamping indicates the reduction of gas consumption at 6% where it is equivalent to the 2.25% of the GHG emission reduction (based on 100,000 AP2 ton). See attachment for details.

Realistic: The gas saving from the revamping project is significant in terms of energy intensity & cost. The gas reduction also directly contributes to the Scope 1 GHG emission reduction measures.

Time-bound: The revamping work started in Oct 2022 and the trial runs on Nov-Dec 2022 showed the gas saving achievable at 6%.

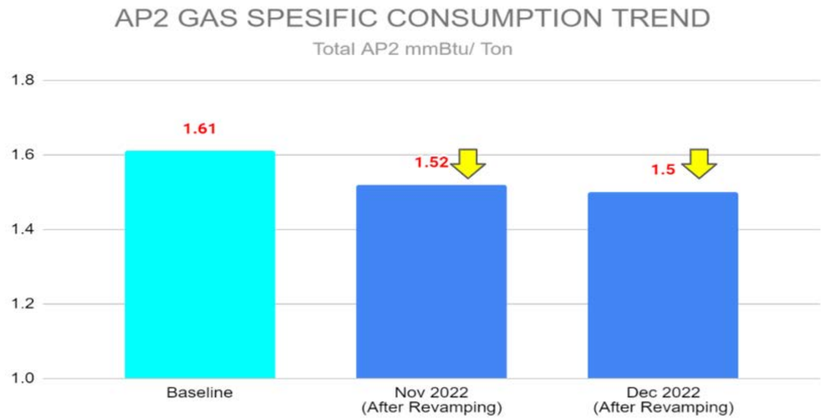
Horizontal Expansion Capability

Yes. The same concept of revamping at the furnace chamber could be taken as gas reduction measures for similar furnace design as improvement.

Outcome

Annealing is an energy intensive process. With the elevated high cost of energy, the gas consumption reduction initiative is an important measure to obtain lower energy operation cost and improve the energy intensity. The gas consumption reduction not only has direct savings in terms of energy cost, but also contributes to the correlated Scope 1 GHG emission reduction that aligns with the climate change mitigation action and the ESG commitments.

New furnace exit connects to hot cooling section after revamping



Base line	AP2 Ton	AP2 mmBTu	Total AP2 mmBtu/ton	Gas Saving			CO2 Reduction
	101,621	163,468	1.61	Ratio %	mmBtu	GJ	Ton
After Revamp	November		1.52	5.26%	632	667	33
	December		1.50	6.54%	905	955	48
	2022 Avg Saving		1.51	5.95%	1543	1628	82

Improving Mixing in Sump Pit Using Agitator

Member company

BAHRU STAINLESS SDN BHD

The Challenge

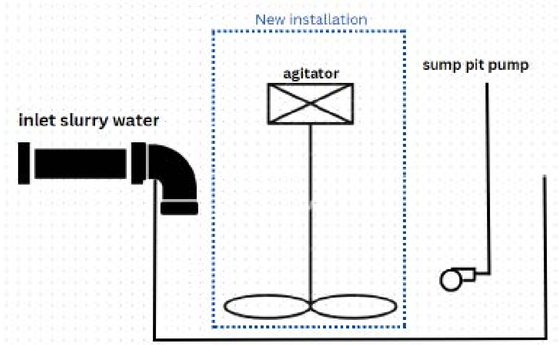
The sump pit 7 at Neutralization Plant is operated as a pit to collect water and slurry from draining pipe of the filter press, previously compressed air to blower.

Why?

The compressed air is blown using a pipe to the floor of the sump pit, only one point that has a mixing and sludge keeps accumulating at another point.

Needed action

Changing the compressed air piping to agitator to provide a good mixing so sludge will not accumulate inside the sump pit.



Action review

Specific: Using compressed air piping to blow the sump pit water causing sludge accumulation at the sump pit floor. We replaced compressed air piping to the agitator to have a homogenous liquid.

Measurable: Checking on sludge level inside sump pit and pump performance.

Achievable: The production team will visually ensure no sludge accumulates on the floor inside the sump pit and forms homogenous water.

Realistic: Improving the sump pit operation to a minimum disruption.

Time-bound: After installation, the sludge level is decreased and no accumulation was on the floor of the sump pit.

Horizontal Expansion Capability

Installation of agitators can be implemented to all sump pits.

Outcome

- Result in energy saving due to a minimum power consumption that is required to create a homogenous liquid.
- No adjustment of compressed air required, providing ergonomics to the personnel during handling.
- Pump operationals are kept to a minimum disruption and reduce costs for repair work of the dry running pump.

Picture of the Agitator at sump pit 7

- Good control of mixing inside the sump pit decreases the sludge level and increases efficiency of the plant operation.

Improving Quality of Stormwater

Member company

North American Stainless

The Challenge

The pH-value in the stormwater is elevated.

Why?

Large rain events cause very high solids and elevated pH in the stormwater discharge. NAS was holding ponds to reduce TSS as stormwater and adding sulfuric acid to reduce pH. During high rain events, there was an issue of adequate control.

Needed action

NAS installed rock checks to reduce flow velocity multiple stormwater collection ditches to reduce velocity of the stormwater prior to the holding ponds to allow for additional settling. In addition NAS installed a CO2 system in the last holding pond to control pH on a consistent basis and discontinued the use of sulfuric acid as a control.

Action review

Specific: To improve solids removal, a series of rock checks were created approximately 20 feet apart. The rock for the base of the rock checks are made from with smaller rock placed on the downstream side to improve filtration.

To reduce the pH, a CO_2 tank was installed with a feed system that would release CO_2 based on pH readings taken in the last pond. The CO_2 is fed into the water through a small pipe with holes. The automatic feedback from the pH probes keeps the final pH in range.

Measurable: pH is readily checked and evidence of solids settling out in rock checks.

Achievable: Systems were installed without issue. Results have been repeatable.

Realistic: Rocks were easily installed via an excavator. The areas between the rock checks are periodically cleaned to remove solids that have settled out.

The CO_2 system was installed without any issues and requires just periodic pH checks on the probes to verify that they are calibrated, and the transfer of CO_2 into the large storage tank.

Time-bound: Time to install equipment was a few months.

Horizontal Expansion Capability

Yes. This approach was used to control stormwater from melt and cold mill areas, but will be expanded for controls in the remaining portions of the property.

Outcome

The outcome was immediately apparent with each of the polls behind the rock checks becoming laden with lime build-up. The discharge water is less opaque. The pH of the stormwater is consistently between 8 and 8.5 instead of ranging from 7.5 to 10.

Reducing Waste with Oil Water Separation

Member company

North American Stainless

The Challenge

NAS shipped off site 1.25 million gallons of oily water (mixture of oils, oily water, and emulsions) for off site treatment and oil recovery.

Why?

Reducing the quantity of waste that had to be treated off site and generating clean water for reuse.

Needed action

NAS conducted a trial with a third party that is able to remove the oil and oily emulsion (without the addition of chemicals) by using a rope skimmer, ultra filtration, and reverse osmosis (RO). This treatment does not require special waste treatment permitting from the Environmental Agency for this treatment and can be used onsite.

Action review

Specific: A small system was installed to conduct the oil water separation trial. The equipment consisted of a stainless steel tank with oil skimmer, a ultrafiltration feed tank (100 gallon), a ultrafiltration membrane, a ultrafiltration filtrate/reverse osmosis feed tank (100 gallon), a reverse osmosis membrane and final RO filtrate tank. Samples were collected and analyzed at each step to verify the oil concentration efficiency of each step. This trial occurred for 6 days over a two month period to make sure that the different types of oily water/oil emulsion could be treated.

Measurable: Oil concentrations were measured in the waste, after the use of oil skimmer, after ultrafiltration, and after the RO. The permeates of the ultrafiltration and reverse osmosis were tested for conductivity, TSS, and alkalinity.

Achievable: The trial demonstrated that the oily water and emulsions could be separated to produce 3 side streams (1) oil for shipment to oil purification/reuse, (2) RO concentrate that could be treated through waste water treatment, and (3) RO filtrate that is water for reuse.

Realistic: The trial demonstrated that a full size unit can be developed to treat 15,000 gallons per day. The labor required to operate the equipment will be approximately the same as the labor needed to load oily water onto trucks for shipment. The quality of the water increased with each phase of treatment.

Time-bound: NAS completed the trial within 2 months.

Horizontal Expansion Capability

This approach can be used elsewhere with the purchase of the additional equipment.

Outcome

The trial demonstrated that a full size unit can be developed to continually treat the oily waste. Based on the trial, the following streams will be generated: 78% clean RO water for reuse; 20% oil free wastewater that can be treated through wastewater treatment plant; and 2% oil and oily solids. This quantity of oil and oily waste to be shipped off site will be significantly reduced.

Energy utilization of CO2 in converter smelting

Member company

China Baowu Steel Group Corporation - TISCO

The Challenge

CO_2 recycling in the steelmaking process, CO_2 converter bottom-blowing technology, converter top-blowing CO_2 energization technology.

Why?

China Baowu TISCO Group is the largest joint producer of stainless steel and carbon steel in China, the recycling of CO2 is of great significance for TISCO Group to complete the task of energy saving and emission reduction. In addition, because stainless steel production requires the consumption of large amounts of argon, the price of argon is 2-3 times the price of CO2, the use of CO2 to replace argon is an effective way to reduce the cost of steelmaking production.

Needed action

1. Carbon steel converter top blowing CO_2, increase gas recovery, to prevent the explosion of the electric dedusting

After CO_2 is blown into the converter top gun, the C in the iron water reacts with CO_2 to produce CO twice as much as that produced by the reaction with oxygen, which can rapidly increase the CO content in the exhaust gas and advance the node of gas recovery, and the CO content in the recovered gas is higher than that of all top-blown oxygen (see Figure 1). Through production data statistics, the relevant furnace times with and without CO_2 in the top gun are compared separately.

1. The gas recovery can be increased by 6.57Nm3/t. The average amount of extra pure CO recovered per furnace is 674Nm3, which is 59Nm3 more than the CO_2 consumed, indicating that all the blown-in CO_2 is converted into CO.
2. The total gas recovery time is increased by 53s/furnace and the start of recovery time is advanced by 68s, which indicates that the gas recovery time can be effectively improved when top blowing CO_2.
3. From the above theoretical analysis and field practical verification, the converter smelting process can convert all CO_2 into CO and realize the purpose of CO_2 energy recycling.

2. Carbon steel converter bottom-blowing CO_2 instead of argon

In order to improve the bottom-blow stirring intensity of the converter, improve the proportion of CO_2 instead of argon while reducing the end oxygen content of the converter, steel and auxiliary material consumption, and the converter bottom-blow system was optimized, the bottom-blow element was changed from a gas permeable brick to a metal ring tube, and the number and location of the bottom-blow holes were optimized, and the bottom-blow control system and stirring process were developed (see Figure 2), which was effective in reducing the argon consumption, the end oxygen content of the molten steel and TFe content in the slag. As the implementation of the bottom-blowing CO_2 process aggravates the bottom erosion, shortens the lining life and affects the overall advancement of the top-bottom re-blowing CO_2 process, the converter online thermal bottom replacement technology was developed

to completely solve the problem of rapid bottom erosion. From the first bottom replacement on October 9, 2021 to the end of 2022, the bottom was successfully replaced four times, with an average time of 17 hours per bottom replacement, and the longest number of times the small bottom was used after replacement was 4271 and the shortest was 3631, which solved the problem of promoting the CO process in the converter.2

After our theoretical study on the application of CO_2 to replace argon in stainless steel converter, we carried out tests under different smelting stages and gas distribution process conditions, and conducted a comprehensive comparison in terms of temperature, consumption, resistant material erosion and reduction, respectively, to determine that CO_2 can be used in the stainless steel smelting process. But in the current process conditions of iron + alloy smelting process heat is insufficient, and the use of CO_2 heat absorption exacerbates the problem. From economic considerations, CO_2 can only partially replace argon in the current stainless steel smelting process, and the proportion of ultra-pure ferritic stainless steel CO_2 replacing Ar is stabilized at about 25% (about 5 Nm^3/t).

Action review

Specific: The converter production needs to consume a large amount of argon gas, the price of argon gas is 2-3 times the price of CO_2, using CO_2 to replace argon gas can reduce the cost of steel production, while the converter top blowing CO_2 can increase the amount of converter gas recovery.

Measurable: From June 2020-October 2022, it will replace only the use of argon gas by about 13,000 tons. Reduce 2,700 tons of ferro-silicon used for controlling the electric dust discharge explosion and increase gas recovery by 17 million m3, which has achieved significant effect of reducing argon consumption, increasing gas recovery and reducing CO_2 emission.

Achievable: By comparing the analysis before and after use, without considering the reduction of steel and deoxidizer consumption, from June 2020 to October 2022, the cost saving of using CO_2 alone is 35.23 million RMB.

Realistic: The project realizes the resource and energy utilization of CO_2 in the smelting process of stainless steel and carbon steel, reduces CO_2 emissions, and is of great significance to the energy saving and emission reduction and green development of the steel industry.

Time-bound: The project was completed on schedule and achieved the desired results.

Horizontal Expansion Capability

The company has overcome a series of technical problems in the use of CO_2 around the energy saving and emission reduction and green development of the industry, and developed a number of international leading process technologies such as online thermal bottom replacement of the converter, top blowing CO_2 control of the electric de-dusting explosion in the converter and the use of CO_2 in the stainless steel converter. The industrial application of CO_2 in TISCO's steelmaking process cannot only reduce production costs, but also store CO_2 in the form of converter gas to realize the energy utilization of CO_2 and reduce

carbon emissions. This technology can be promoted in the industry to drive energy saving and emission reduction in the steel industry.

Outcome

Since June 2020, the use of CO_2 to replace argon gas to form a large-scale application. By the end of 2022, the cumulative use of carbon dioxide gas is about 31,000 tons, replacing about 13,000 tons of purchased argon gas, reducing 2,700 tons of ferro-silicon used for controlling electric dedusting and increasing gas recovery by 17 million m^3 , which has achieved a significant effect of reducing argon gas consumption, increasing gas recovery and reducing carbon dioxide emission. Only the use of CO_2 a cost savings of 35.23 million yuan.

Other comments

At present, TISCO's CO_2 is sourced from external sources, and the usage quantity and cost are limited. After the completion of TISCO's CO_2 internal capture project in 2023, the annual output is expected to reach 50,000-60,000 tons, and in order to maximize the internal recycling of CO_2, the usage field and scale of CO_2 need to be further expanded, and the use of CO_2 as a protective gas for continuous casting and ladle stirring gas instead of Ar needs to be further studied, and the use of CO_2 in the treatment of slag needs to be promoted. The use of CO_2 in the process of steel slag treatment should be promoted, and the use of CO should be increased and its emission reduced.

Sustainable developments in the Sanitation industry – product modification

Member company

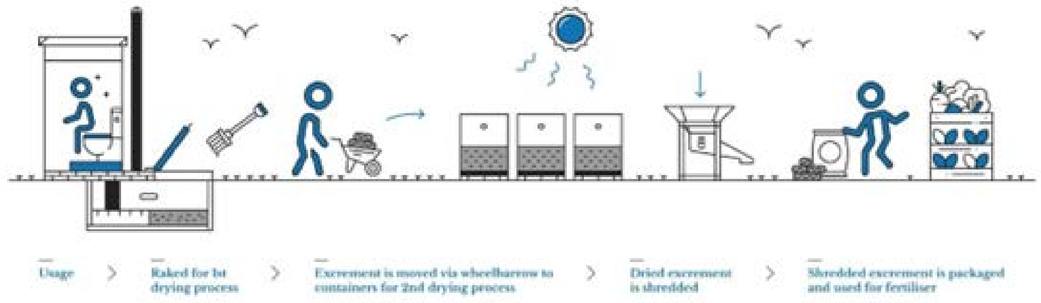
Betram (worldstainless Member: Columbus Stainless)

The Challenge

Sanitation issues are a global concern, especially in rural or under developed countries. Betram introduced the Amalooloo product as a sustainable, dignified solution which addresses issues most find unattractive to discuss. The submission made in 2021 (Sanitation System) details the dry sanitation system. In summary, Amalooloo has been running pilot projects for several years and continue to do so to ensure the sustainability of our technology. By making use of the Amalooloo Dry or Low Flush Sanitation Technology, we could safely and easily manage dry human organic waste and process it into a useable by product such as fertiliser on-site. The Amalooloo Sanitation System is specifically designed to function without any water and is only dependent on natural environmental conditions. We improve the dignity, health and hygiene of the community and reduce or eliminate sanitation related diseases with on-site treatment. The dry human organic waste can be removed on an annual basis by a service provider at a very affordable rate, or by the household themselves at no cost. The dry human organic waste can be used as a fertiliser as a method of nutrient recovery. Note: Noticeable difference in the growth patterns and health of the crops can be seen using this type organic matter on vegetation. (see O&M video)

With the new design:

The biggest challenge in the world regarding rural sanitation, based on our experience and extensive research over the past 20 years, is the inability of current technologies to treat faecal sludge or human organic waste on-site in a safe and eco-friendly manner. Another key aspect of this challenge was the lack of communication between the supplier of the technology and the end user for sustainability – to reap the full benefits of the sustainable sanitation system. We soon realised that we could not only manufacture a technology but had to provide a holistic sanitation solution that covers all aspects that contribute to a sustainable sanitation system namely; Design, Manufacturing, Transportation, Installation, Education, Communication, and Maintenance.



Design changes:

Key design features include the unique separator design in accordance with the new ISO 30500 standards.

The new pedestal design has a unique patented flap that serves multiple purposes. The flap is located at the outlet of the pedestal. This new system is made out of high, durable plastic pedestal – with the unique safety features afforded by high quality grade stainless steel springs, to ensure durability of the mechanisms during use.

- The flap automatically opens when the user takes a seat on the pedestal and automatically closes when the user stands up – ensuring no visibility of human waste during usage. This not only reduces odours, but also reduces exposure to harmful bacteria carried by flies into traditional sanitary systems.
- The flap can also be manually operated by foot to dispose of incidentals and/or other sanitation related products or for use by children or as a urinal for men. As a urinal, the urine is diverted to the back of the pedestal into the separator and through the ecological pipe into the soil via a drip irrigation method.

The new seat design ensures child-friendly placement, with the backrest moving closer for their comfort and safety.

Safety locking mechanism has also been designed into the system to ensure the user cannot be locked in whilst using the toilet.

Rain water can be harvested in the system by the use of a combination of stainless steel gutters and polyethylene water storage tanks. This addresses water shortages that are prevalent worldwide.

The system is very durable; it can accommodate high usage per day as it is not dependent on any mechanical or biological processes. The system has been tested for up to 10 uses per household without any negative results.

The Myloo on-site dry sanitation technology comprises:

- Aesthetically designed super structure.
- Torsion stainless steel door (3CR12).
- Stainless steel springs – enhances durability of the operating mechanisms.
- Foot peg for opening the door without using your hands.
- Secondary drying process embedded in the design.
- MyLoo pedestal with complete urine diversion system (UDS) - Polyethylene.
- Water storage system – consisting of stainless steel gutters and polyethylene storage tanks.

- Handwashing technology.
- Sanitation starter pack technology (APP included).

Amalooloo has been running pilot projects for several years and continues to do so to ensure the sustainability of our technology. By making use of the Amalooloo Dry or Low Flush Sanitation Technology, we could safely and easily manage dry human organic waste and process it into a usable by-product such as fertiliser on-site. The Amalooloo Sanitation System is specifically designed to function without any water and is only dependent on natural environmental conditions. We improve the dignity, health and hygiene of the community and reduce or eliminate sanitation related diseases with on-site treatment. Establish communication between the supplier and the end-user as well as a service within the community to attend to maintenance requests and ongoing health and hygiene training.

This full system is indeed the world solution to sanitation problems.

Why?

Currently, UNICEF and WHO estimate that 1.1 billion people lack access to improved water supplies and 2.6 billion people lack adequate sanitation. Providing safe water and basic sanitation to meet the MDGs will require substantial economic resources, sustainable technological solutions and courageous political will. We review five major challenges to providing safe water and sanitation on a global basis:

1. contamination of water in distribution systems,
2. growing water scarcity and the potential for water reuse and conservation,
3. implementing innovative low-cost sanitation systems,
4. providing sustainable water supplies and sanitation for megacities, and
5. reducing global and regional disparities in access to water and sanitation and developing financially sustainable water and sanitation services.

Continuous development of this product to meet the ever changing needs of the community remains the main objective.

Needed action

Amalooloo designed (developed and patented by Betram (Pty) Ltd) a unique sanitation system for both waterborne and dry (ventilated improved pit) structures. This affordable, superior product does not compromise on quality or style and includes the safe management, collection, storage, treatment and disposal of human excreta.

The scientific principle behind the technology is aerobic, natural composting of human excreta that is separated at source. This technology is only dependent on natural, environmental conditions resulting in ecologically friendly results. It also does not require water to function (but we recommend it for health hygiene reasons).

Amalooloo has a built-in hand wash basin for added health and hygiene benefits, and a built-in child safety seat, making it safe and user-friendly for people of all ages and genders, including disabled users. Rain water can also be harvested from their units by paring the system with storage tanks. Therefore eliminating the need for additional water to be fed into the system.

The door made of stainless steel has a child-friendly locking device that prevents someone from locking you in from the outside. Health, hygiene and AIDS awareness educational material is displayed on the inside, and the design provides privacy and safety, and prevents dirt, insects, rodents and snakes from coming in. The child safe seat adjustments make it safe for children to use this sanitary system. In the recent past, this has been a devastating threat in African regions where pit latrines have traditionally been used – where children accidentally fall into the pit toilets. This new design gives users peace of mind.

Our unique Urine Diversion System (UDS) is one of the key components and a world breakthrough in closing the sanitation loop.

Action review

Specific:

- The main aim of this development is to create a fully sustainable, affordable and safe sanitation system.
- Amalooloo engaged in the design and development of a unique sanitation system for both waterborne and dry structures for 5 years. There continues to be development on this front as technology advances.
- Amalooloo engaged in the design and development of built-in hand wash basin and a built-in child safety seat for 2 years following the commercialisation of its first products. This is to promote hygiene – further enhancing safety aspects of this product. Rain water harvesting gutters and tanks have now been designed into the system – addressing the global water shortage concerns.
- Amalooloo engaged in the design and development of door's child-friendly locking devices for 1 year following the commercialisation of its first products.
- Amalooloo aimed to display health, hygiene, and AIDS awareness educational material in all its toilets by 2015.

Measurable: Number of units per year. Amalooloo has seen an increase in inventory levels as the demand has sharply risen over the past decades – In 2022, inventory levels have doubled from 2010 inventory levels.

Achievable: Yes, ongoing successful implementation of the product since 2003

Realistic: Sales: Up to date, Amalooloo has sold 700 000 units (this includes schools and municipalities).

Time-bound: Original growth milestones have been achieved on time. Ongoing growth projections underway.

Horizontal Expansion Capability

Our organisational culture is based on continuous improvement and outreach for new opportunities as well as challenges. The above mentioned actions can be used to widen our sanitation technology footprint across the world, ending high-risk sanitation practices, moving low income populations up the sanitation ladder, and urban sanitation systems. As previously mentioned, our technology is only subject to natural conditions and our research and development (R&D) function possesses the financial and intellectual capacity to meet the requirements of any climate zone around the globe. Amalooloo engaged in the design and development of a unique sanitation system for both waterborne and dry structures for 5 years – Amalooloo has seen the following benefits:

- Efficiency: Amalooloo currently operates at an efficiency of 85%.
- Cost: In 2022, Amalooloo achieved a profit margin of 50%.
- Material Quality: Amalooloo's Supplier Evaluation, allowed to gauge our Suppliers and source materials from only reliable high quality supplier – In 2022, the scrap rate due to low quality materials was at 0.5%.
- Inventory levels: Amalooloo has seen an increase in inventory levels as the demand has sharply risen over the past decades – In 2022, inventory levels have doubled from 2010 inventory levels.
- Sales: Up to date, Amalooloo has sold 700 000 units (this includes schools and municipalities).

Outcome

Satisfied community - due to the efficiency of this system and the fact that the system is designed to meet their evolving needs; communities continue to demand this cost-effective solution from the relevant government authorities. The ripple effect is increased product sales.

Other comments

Although the technology is now here to stay, continued improvements are being made to ensure the product evolves to solve a global sanitation problem.

- Safety of the user - taking into account the new pedestal flap, child-safe seat design and anti-locking system from outside the unit (preventing users from being locked in).
- Harvesting rainwater (to be reused in the system or to water the adjacent vegetable garden and many more uses).
- Reduction in water usage (Dry and low-water systems).
- Improved hygiene/health due to this efficient sanitation system.
- Eco-friendly byproducts used to further sustain community crops.

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About worldstainless

worldstainless is a not-for-profit research and development association which was founded in 1996 as the International Stainless Steel Forum.

Its primary roles are to undertake stainless steel industry beneficial tasks that are better coordinated centrally in the fields of

- Promoting industry and material sustainability benefits
- Conserving resources and promoting the circular economy
- Providing economic and industry-leading statistics
- Support industry health & safety needs and developments
- Outlining market development and expansion opportunities
- Maintaining brand reputational positioning
- Materials education

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