

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?

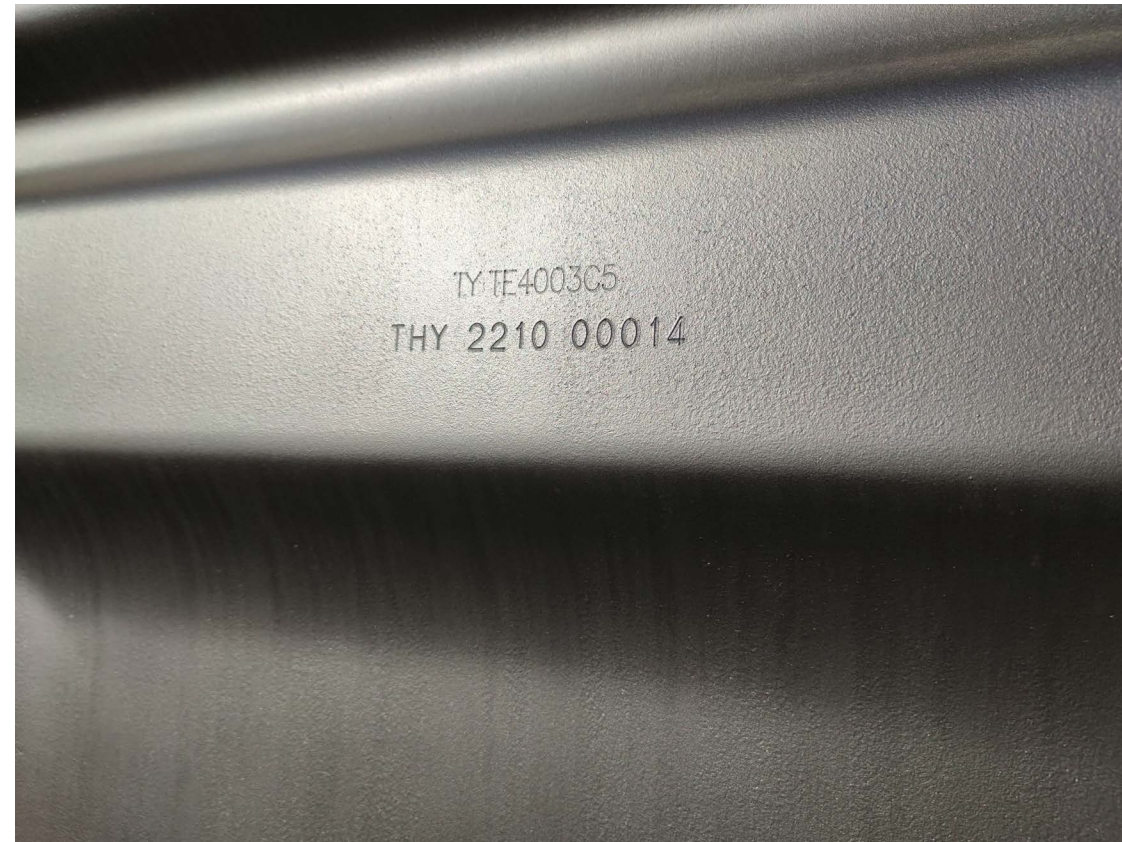
TISCO has been engaged in the research and development and promotion application of stainless steel and high-strength carbon steel for long time, and is the most competitive stainless steel enterprise in the world, with more than 8 million tons of stainless steel and more than 6 million tons of high-strength 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





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 $\geq 500\text{MPa}$, tensile strength $\geq 600\text{MPa}$, shear strength $\geq 350\text{MPa}$, the results of the 72-hour cyclic infiltration test of the compound stainless steel achieved excellent results of $\leq 5\%$. New materials



by downstream vehicle manufacturers welding, forming inspection, welding tensile strength $\geq 620\text{MPa}$, 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.

