

Study on Welding Technology and Microstructure and Properties of Ultra-high Strength Dual-phase Steel for Automobile

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Abstract. In the background of energy saving and environmental protection, the lightweight of automobile is the goal of its development. The use of ultra-high strength steel as the structural parts and safety parts of car body is to ensure the lightweight of automobile under the premise of ensuring the safety of the car. In order to improve the vehicle safety and save the cost, the welding process of ultra-high strength steel should be optimized continuously. As ultra-high strength steel, DP steel is in common use for bodywork. When they are welded by spot welding, laser welding, MAG and CMT welding, the heat input and welding speed should be controlled so as to prevent the occurrence of burn through and incomplete welding. DP steel reduced the generation of tempered martensite while welding, they will be able to obtain the welding joints with good hardness and strength. CMT welding technology of DP steel is the development trend of automotive sheet welding.

Introduction

With the development of economy and the strengthening of environmental protection consciousness, the application of lightweight technology is an important development target of automobile manufacturing industry, so the use of ultra-high strength steel is inevitable. According to the annual sales of China's automobiles of Jia Jin et al., [1], since 2009, China surpassed the United States to become the world's largest automobile producer, which means that the demand for cars has been largely increased. So cars should meet the new requirements of safety, environmental protection, energy saving while reducing the cost of expenditure.

As the demand of people for cars increases, the improvement of the essential needs of automobiles, the strengthening of the competitiveness of automobiles to ensure both safety and comfort of automobiles and the requirements of energy-saving, the promotion of the use of ultra-high strength steel is one of the effective ways to reduce the thickness of materials and reduce the deadweight of the construction machinery [2]. Ultra-high strength steel is flourishing in this background, and it is applied to structural parts and safety parts of automobile body. DP Steel is favored for its low cost and special dual-phase structure, which has high strength and plasticity and good impact performance [3].

Welding Process of DP Steel and Analysis of Its Microstructure and Properties

Spot Welding of DP Steel. DP Steel is a new type of steel with homogeneous distribution of ferrite, without yield extension, without room temperature aging, low ratio, high working hardening exponent and high baking hardening value [4-5].

Xu Shihai et al., studied the performance of DP590GA hot-dip galvanized dual-phase steel using resistance spot welding, founded that under the same welding category, the strength of the welded joint of the two-phase steel was lower than that of the hot-dip galvanizing by 10%~40% [6]. The reason analysis of DP590GA spot welding joint strength is shown in table 1.

Table 1 The reason of joint strength decrease with different current in DP590GA by spot welding

Current	The reason of the strength decrease of joint
Small current phase	The residual zinc content is larger in the fusion zone
Medium Current phase	The presence of the zinc layer in the welding process reduces the contact resistance and the current, resulting in a decrease in the core diameter.
Large current phase	DP590GA produces splash

Wang Xiaobei et al., carried out spot welding tests of DP780 hot-dip galvanized duplex steel standard samples, founded that in the case of 11.0 kA hardness of 430HV, in the range of 7.8kA~11.2 kA, solder joints of the maximum tensile strength of was 165kN [7].

In conclusion, galvanized biphasic steel is better than ordinary phase steel for welding with larger current in order to acquire a better spot welding, in the test process to control the spot welding of the current, you can get better hardness and tensile strength.

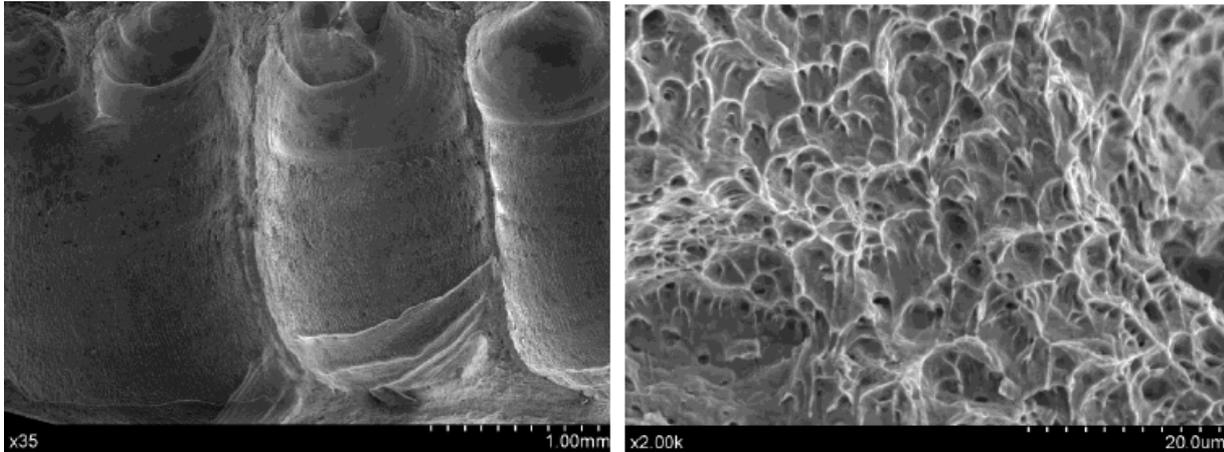
MAG Welding of DP Steel. Huangpengfei et al., used MAG welding to DP780 high-strength steel lap joints of the microstructure and tensile shear performance analysis, founded that when the heat input was in the range of 93 J/mm ~205J/mm, the intensity increased with the increase of heat input [8]. Nie Lipingim proved the MAG with the spoke steel DP600 and rim steel SPFH540 and RCL540 lap welding process, when determining the reasonable parameters, it was founded that there was a phenomenon of recovery and recrystallization under the action of thermal cycling, and the high temperature tempering would precipitate the martensite at 600°C when the heat is produced. The formation of tempered martensite is the cause of softening in the heat-affected zone [9].

In conclusion, in order to get better hardness of the specimen when the MAG welding was used in the DP steel, we should make absolute control in the temperature to avoid the formation of tempered martensite.

Laser Welding of DP Steel. Yang Lijun et al., used YAG solid-state laser butt welding of DP980 ultra-high strength steel, it was founded that the metal zone and the microstructure of the complete phase transition zone were very high in hardness, there was a softening phenomenon in the incomplete phase transition zone and tempering zone, and the martensite in the incomplete phase change region became austenite. During the cooling process, the martensite and ferrite were formed, the ferrite content increased, and the welded joints produced tempered martensite [10]. Xia Mingsheng et al., studied the DP980-grade zinc-plated duplex steel in laser welding and founded that the decomposition of martensite is the main cause of softening [11].

CMT Welding of DP Steel. Hu Chao [12] conducted a lot of experiments, founded that when the welding speed was 6mm/s, the number of weld pores in 82%Ar+18%CO₂ as protection gas were relatively less than that of 90%Ar+10% CO₂, when the protection gas was 100% CO₂, it was easier

to produce dense bar pores. It was founded that CO₂ was not the main cause of stomata, zinc was the main cause of air pores, in a reasonable range of increase in the proportion of CO₂, with the



increase in the amount of heat input, the time of zinc bubble overflowed increased, so that the weld pores became less, which was shown as Fig.1.

(a) Section stomata

(b) Morphology of ductile fracture area

Fig. 1 Morphology of section

Zhao Jingqimade welding tests on DP780 galvanized steel and aluminum, due to the differences of the melting point of aluminum and steel. When in the same state, aluminum melted but molten steel did not, this would use CMT fusion-brazing welding. It was found that the performance of the aluminum/steel joint was the best when the current was 80A and the welding speed was 600mm/min. Welded joints are composed of melting zone, interface zone and zinc-rich zone [13], which was shown as Fig.2.

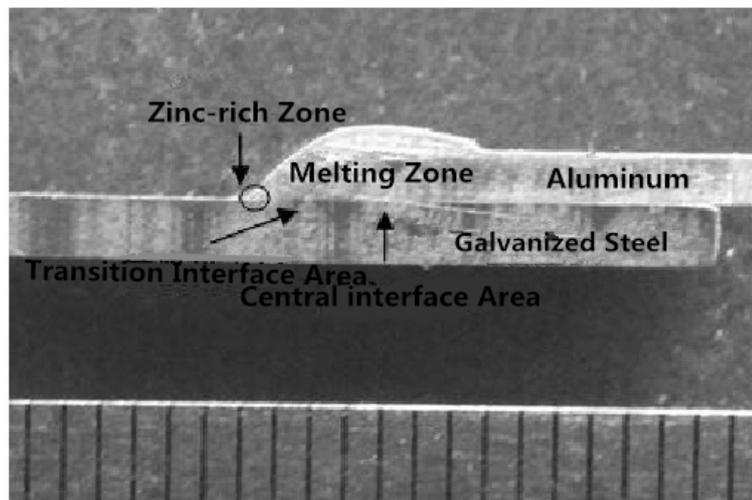


Fig. 2 The cross sectional morphology of DP780 galvanized steel / aluminum welded joint

Because of the high arc temperature and low edge temperature, the thickness distribution of the interface center compound layer of aluminum and galvanized steel plate was uneven and the center thickness was thin.

It boiled down to the CMT welding speed and welding current on the weld surface molding had a certain effect, especially galvanized duplex steel, to control the heat input and CO₂ ratio, the hole reduced the increase in the bearing area, thus avoided welding or weld uneven phenomenon.

Conclusions

Since 21st century, under the condition of energy saving and environmental protection, and the increase of people's use of automobiles, the use of ultra-high strength duplex steel is the inevitable choice in the current time, which means that we should constantly explore more energy-saving, more exert the quality of steel plate welding process and welding equipment. In this paper, the welding process and the microstructure and properties of ultra high strength duplex steel used in automobiles are summarized and analyzed, and the following conclusions are obtained:

(1) DP Steel is composed of martensite and ferrite matrix two-phase structure, so in the DP steel welding, we should control the welding temperature on the impact of the plate, reduce temper martensite generation, in order to make better control of the hardness.

(2) CMT as a new welding technology, due to its no splash, small heat input characteristics, more and more applies in the automotive welding. DP Steel as a common steam body steel, the combination of CMT welding technology and DP Steel is the development trend. Therefore, CMT welding of DP Steel should pay attention to the welding current and welding speed on the effect of weld forming and control the heat input and CO₂ ratio, in order to reduce the formation of pores at the same time to prevent the occurrence of biting edge and incomplete fusion.

Acknowledgments

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