Development of a low heat-input welding technique for armor steel joints to enhance high cycle fatigue behavior by suppressing softening of the heat-affected zone

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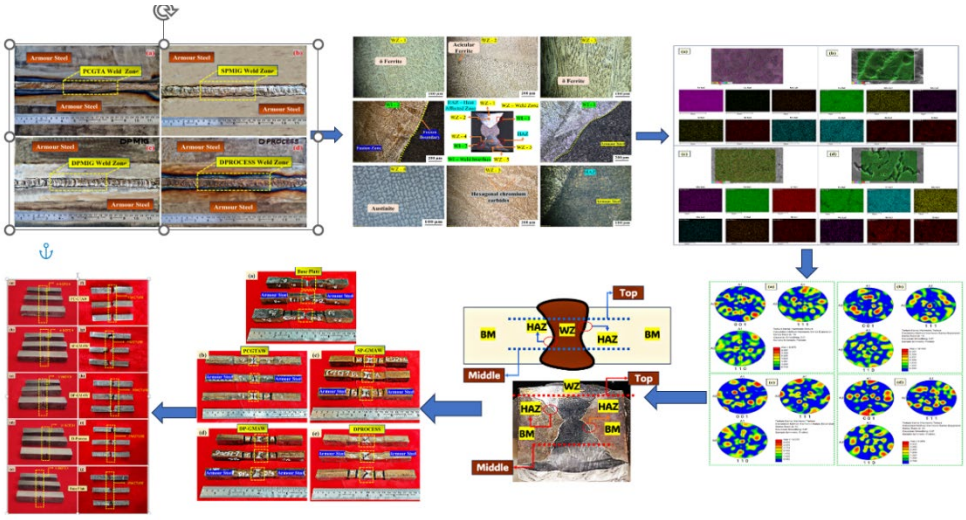
Graphical Abstract/ Lavout



Project Description:

Armor steels are recognized for their exceptional high hardness, high strength-to-weight ratio, and excellent toughness. This unique combination of mechanical characteristics has made it a popular contender for crucial military applications. These steels are well-suited for the construction of combat vehicles, which involves welding as the most important manufacturing process.

In various applications, arc welding has gained increased attention from a welding perspective. But the formation of the softening zone in HAZ is the main issue with welding armor steel. It has been noted that it loses toughness, strength, and hardness, which leads to poor mechanical and metallurgical properties. The zone undergoes recrystallization, and grain growth during welding leads to softening, known as softening zone. It is well known that the growth of precipitate size helps in reducing the strength. This softening mechanism is mainly because of the additional heating generated by the successive weld passes, which initially re- crystallizes the grains and finally leads to grain growth. The HAZ softening could also be related to the microstructural evolution during the weld thermal cycle. It was reported that the acicular martensitic structure of the base metal is changed into low carbon martensite (tempered martensite) and carbides in addition to a product like reverted austenite. The retained austenite in the base metal would transform into a bainite structure. All the above-mentioned microstructural transformations in the HAZ region could be the reason for this softening effect in this zone.

Armor steel is complicated to weld due to its high carbon content, leading to it being prone to cold cracking. Cracks appear in the fusion line due to the high hardness and presence of hydrogen in this zone. The large content of austenite stabilizer, manganese, and nickel can lead to hot cracking due to the segregation of impurity elements that have poor solubility in austenite. Cracks can appear in base metal as a result of mistakes during steel production, in the fusion line because of hydrogen presence, or in the weld metal during a welding process. During military operations, for the sake of traversed on gravel terrain types, armored vehicles are exposed to impact and fatigue loading. As a result, cracks created in the weld joint can easily propagate, affecting the structural integrity of military armored vehicles.