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Effect of buttering and hardfacing on ballistic performance of shielded metal arc welded armour steel joints

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ABSTRACT

Quenched and tempered (Q & T) steel closely confirming to AISI 4340 is well known for its superior ballistic performance and hence used in the fabrication of armour vehicles. These steels are traditionally welded by austenitic stainless steel (ASS) fillers to prevent hydrogen induced cracking. Due to weld thermal cycles and under matching fillers, the armour steel joints show poor ballistic performance compared to the base metal. Attempts were made to deposit hardfaced interlayer between ASS weld metals. Though this method yielded marginal improvements in ballistic performance, cracks were observed in between base metal and hardfaced layers. In this investigation an attempt has been made to eliminate these cracks by depositing a soft buttering layer using ASS consumable in between base metal and hardfaced layer. This paper reveals the effect of buttering and hardfacing on ballistic performance of shielded metal arc welded armour steel joints.

1. Introduction

Steel is the world's most versatile material with a wide range of attractive properties and comparatively less production cost. Armour grade quenched and tempered (Q & T) steel is used for protection of military and nonmilitary vehicles, because of their high energy absorbing properties. The ballistic requirement of Q & T steels used for armour application requires high strength, greater notch toughness and high hardness [1–3]. These low alloy steels are having fine acicular tempered martensitic structure produced by quenching and tempering treatment. The microstructure of the base plate is altered significantly by the heat involved in the welding process, especially those associated with high heat input. Previous studies have explored the weldability of Q & T steels. The effect of different consumables on weld quality, the effect of different welding processes and different combination of layered structures were studied. However most of the work has concentrated on the tendency of hydrogen induced cracking (HIC) [4–7], heat affected zone (HAZ) softening [8–11], the ceramic front layer and metallic back layer composite and or fiber encapsulated composite [12]. It was reported that the ballistic immunity can be improved by depositing hardfacing alloy in between austenitic stainless steel (ASS) welds [10,13]. Welds with complete hardfacing was shattered under ballistic impact. An overlay of hardfacing alloy over ASS welds was also disintegrated, due to extensive cracking in the hardfacing layer. Sandwiched hardfacing alloy weld between ASS welds, resulted in the occurrence of cracks in the interface between hardfaced layer and the base metal. This is due to the brittle nature of the interface.

This paper reports the influence of ASS buttering layer between armour plate (base metal) and weld metal/hardfaced metal. Welding of armour steel plates was carried out by shielded metal arc welding (SMAW) process using ASS and low hydrogen ferritic steel (LHF) electrodes. The ballistic test results were correlated with the interface microstructure, and hardness distribution across different weld combinations.

2. Experimental work

The base metal (BM) used in this exploration was 18 mm thick high strength, low alloy, Q & T steel closely confirming to AISI 4340 specification. The heat treatment applied was exposing the base metal to austenising temperature at 900 °C followed by oil quenching and subsequent tempering at 250 °C. This heat treatment is responsible for high hardness, higher strength and good toughness value for this base metal. The chemical composition of base metal and filler metal are presented in Table 1.

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