Wear Properties of the Surface AlloYed AISI 1020 Steel with Fe\((15-x)\)Mo\(_x\)B\(_5\) by TIG Welding Technique

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Surface alloying caused the improvement in the mechanical/chemical properties of near surface regions of the steels. In the present study, surface alloying treatment with boron, molybdenum, and iron on the AISI 1020 steel was realized by the technique of TIG welding. Ferrous boron, ferrous molybdenum, and Armco iron were used for surface alloying treatment. Before the treatment, ferrous alloys were ground and sieved to be smaller than 45 \(\mu\)m. The powders were mixed to be composed of Fe\((15-x)\)Mo\(_x\)B\(_5\), where \(x = 1, 3, \) and 5 (by at.%). Prepared powders were pressed on the steel substrate and melted by TIG welding for surface alloying. Wear tests of the surface alloyed AISI 1020 steels were realized against WC-Co ball using a ball-on-disk method under the loads of 2.5, 5, and 10 N at the sliding speeds of 0.1 m/s for 250 m sliding distance. Friction coefficient and wear rates of the surface alloyed steel with Fe\((15-x)\)Mo\(_x\)B\(_5\) alloy powder are changing between 0.30 and 0.80 and 5.86 \(\times\) \(10^{-5}\) mm\(^3\)/m to 2.52 \(\times\) \(10^{-3}\) mm\(^3\)/m depending on applied load and alloy composition, respectively.

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1. Introduction

Modern industrial applications require parts with special surface properties such as high corrosion and wear resistance and hardness. Alloys possessing these properties are usually very expensive and their utilization drastically increases the cost of the parts. The most effective and economical approach to improve surface ability of machine parts and components to withstand harsh environments and high surface stresses is by creating surface layers that would possess a high level of corrosion and wear resistance. In this way unique service characteristics can be obtained such as a combination of high surface hardness with high impact strength of the bulk. This approach can be also effectively applied to refurbishing worn machine parts [1].

The hard facing alloys obtained using high-energy density sources such as electron beam welding, plasma arc and laser have been widely applied to enhance the wear and corrosion resistance of material surface [2-5]. The high melting temperature, hardness and wear resistance like Zr, Ti, and Cr borides [9, 10]. There is not enough study about the Fe-Mo-B alloys used for surface alloying treatments.

In this investigation, TIG process is used as a high energy density beam to form a high molybdenum Fe-Mo-B hard surface above the AISI 1020 steel with a powder mixtures consisting of ferrous molybdenum, ferrous boron, and iron. Main objective of the study is wear properties of the surface alloyed steels with Fe\((15-x)\)Mo\(_x\)B\(_5\), where \(x = 1, 3, \) and 5 (by at.%) alloy against WC-Co.

2. Experimental procedure

The substrate material for the welding surface was prepared from AISI 1020 steel plates. Before welding, these specimens were ground and cleaned with acetone to remove any oxide and grease and then dried with compressed air. The nominal composition of ferrous molybdenum alloys used in the study (wt\%) was as follows: 62% Mo, 0.3% Cu, 0.09% C, 0.98% Si, 0.03% P, and balance Fe. Ferrous boron and molybdenum were grounded by ring grinder and sieved to be 45 \(\mu\)m particle size. Ball-on-disk arrangement was used for friction and wear test. The WC-Co ball, 10 mm in diameter, was used in the wear test. The WC-Co ball has mirror like surface finish. Most of the materials are encountered with ambient temperature and humidity in the industrial applications. Therefore, the friction and wear tests were carried out at room temperature (21 \(\pm\) 3°C), relative humidity being 64 \(\pm\) 5 conditions. Wear tests were carried out under the loads of 2.5, 5, and 10 at 0.1 m/s sliding speed for 250 m distance. Mean Hertzian contact pressures [11] calculated for WC-Co ball under the loads of

\[\text{FeMo}_2\text{B}_2, \text{FeMo}_5\text{B}_{11}, \text{etc.} \quad [7-10]. \]

These compounds have high melting temperature, hardness and wear resistance like Zr, Ti, and Cr borides [9, 10].
higher the friction coefficient for the alloy compositions of \( x = 1 \) and \( x = 3 \); friction coefficients of the alloy composition of \( x = 5 \) are nearly equal to each other for all applied loads.

![Figure 2a](image)

![Figure 2b](image)

Figure 2a shows the variation of friction coefficients as a function of applied load with different alloyed layers \((x = 1, 3, 5)\) against WC–Co ball at the sliding speed of 0.1 m/s for 250 m sliding distance. It is clear from this figure that the friction coefficient is changing between 0.48 and 0.81 according to alloy composition and applied load. While the higher the applied load caused to, the
cess of the metals in industry. The wear mechanism was abrasive-oxidative.

4. Conclusions

1. It has been proven that surface alloying treatment of AISI 1020 steel using \( \text{Fe}^{(15-x)}\text{Mo}_x\text{B}_5 \) alloys for \( x = 1, 3, \) and 5 wear realized by TIG welding.

2. Hard faced layers of the steel consist of \( \text{Fe}_2\text{B}, \text{Fe}_{13}\text{Mo}_2\text{B}_5, \text{Mo}_2\text{FeB}_4, \) and iron phases.

3. Increase of the molybdenum content in the alloy composition caused the increase of boride phases formed in the alloyed layers.

4. The friction coefficient is changing between 0.48 and 0.81 according to alloy composition and applied load. While the higher the applied load caused the higher friction coefficient for the alloy compositions of \( x = 1 \) and \( x = 3, \) friction coefficients of the alloy composition of \( x = 5 \) are nearly equal to each other for all applied loads.

5. Increase in applied load caused the increase of wear rate for all alloy compositions. But increase of molybdenum content in the alloy composition caused the decrease of wear rate for all applied loads.

6. Wear mechanism of the surface alloyed AISI 1020 steel with \( \text{Fe}^{(15-x)}\text{Mo}_x\text{B}_5 \) alloys for \( x = 1, 3, \) and 5 alloys was changing with molybdenum content increment from the severe abrasive wear to mild abrasive wear.

References