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Comparative study of oxidation influences on mechanical properties and weldability on different welding processes

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1. INTRODUCTION

Given the diverse applications of metals in the industry, steels are subjected to various exposure conditions that can lead to material degradation. This process of material deterioration is commonly referred to as corrosion. The onset of oxidation can have significant ramifications, potentially affecting the company in various ways, including the loss of mechanical strength, reduced efficiency, compromising employee safety, and a decline in material properties, among other consequences.

From an economic and industrial production standpoint, having an understanding of the corrosive processes affecting steels becomes valuable, making it worthwhile to conduct qualitative assessments of welded joints to detect potential anomalies in the weld bead resulting from corrosive influences

2. METHODOLOGY

To obtain hardness results, the average values of the indentations performed on the plates were calculated. These indentations were made on both sides of the welded bead, with three lines: one indentation line at the center of the plate, one indentation line located 10 mm above the plate's center, and one indentation line positioned 10 mm below the plate's center.

Within each line, indentations were performed at three distinct points, perpendicular to the welded bead. The first indentation was made at an approximate distance of 1 mm from the welded bead, with the subsequent two indentations placed every 3 mm. This approach resulted in three lines and three columns on each side of the welded bead, as depicted in Figure 1.

In Figure 2, we have the presentation of the qualitative and non-destructive liquid penetrant test, aimed at analyzing potential defects and cracks in the weld bead.

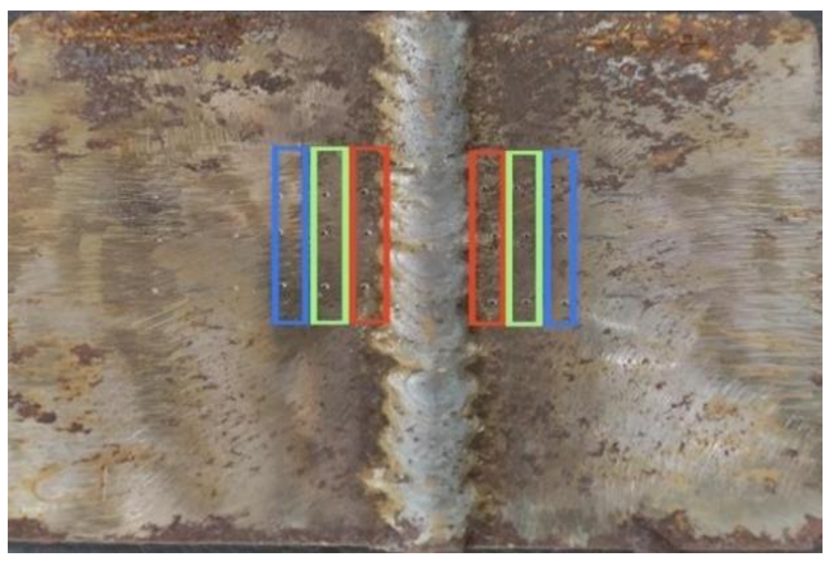

Figure 1. Highlighted columns on both sides of the welded bead

Figure 2. Non-destructive liquid penetrant test

In order to analyze the influences on the welded joint resulting from the mechanism of steel corrosion, test specimens were exposed to a corrosive environment for a specified duration. In this manner, the influence of the corrosion rate of ASTM A36 steel on both shielded metal arc welding (SMAW) and gas metal arc welding (GMAW) processes was assessed. Additionally, the impact caused by the welding process in relation to a new oxidative environment was evaluated while maintaining a new oxidation rate.

Furthermore, the hardness of the samples, spatter formation, and sensitivity arising from the welding process were examined, thereby qualifying the liquid penetrant inspection process following the welding operation.

3. RESULTS AND DISCUSSION

The prolonged exposure of samples to more aggressive environments led to an expected pattern of increased spatter occurrences and progressive mass reduction. This trend was consistent in both welding methods, and spatter quantification followed the procedure outlined in Figure 3.

As the corrosion phenomenon advanced during the welding of metal plates using both techniques, a heightened level of difficulty was evident. This was confirmed by the fact that plates exposed during the first week demonstrated satisfactory weldability, producing favorable results in terms of weld bead quality, liquid penetrant testing, and hardness evaluations. The application of a developer (Figure 4) to the liquid penetrant revealed defects from the process. In contrast, samples subjected to prolonged exposure displayed decreased performance.

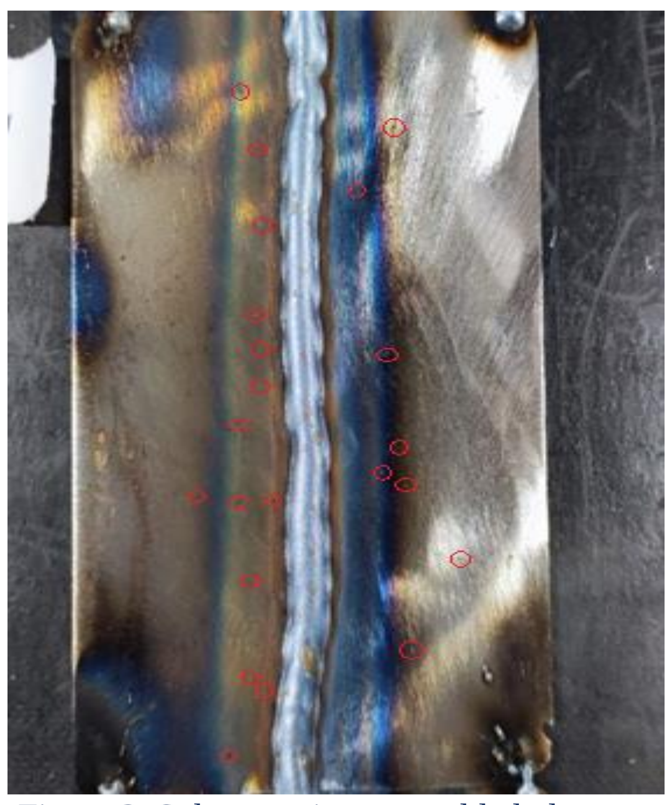

Figure 3. Splatter points on welded plate

Figure 4. Application of penetrating post-liquid developer

4. CONCLUSIONS

Based on the obtained results, several noteworthy conclusions can be drawn:

As anticipated, weldability was significantly affected by the increasing corrosion rates, with the samples from the 4th week facing more substantial welding challenges. The samples from the 1st week consistently delivered positive results, irrespective of exposure conditions, exhibiting favorable outcomes concerning visual appearance, liquid penetrant tests, and mechanical properties evaluated through hardness tests. Distinct discontinuities beneath the weld bead, identified via liquid penetrant testing, were already evident in the samples from the 2nd week. Notably, samples subjected to different storage conditions (water and air) displayed significant variations in results.

Regarding the recorded number of spatters on the samples, it is worth highlighting their distribution, with spatters being more prevalent on plates immersed in the corrosive environment, primarily on the left side of the weld bead in all samples. This phenomenon is primarily attributed to the direction of the welding bead. The hardness test results were consistent with expectations, revealing a direct correlation between hardness values and corrosion rates. Essentially, as the exposure time increased, along with the severity of environmental conditions and subsequently higher corrosion rates, hardness values decreased proportionally.

Furthermore, the hardness results exhibited a noticeable trend concerning the distance from the weld bead, with values diminishing as the indentations approached the weld bead. These findings undeniably signify the direct influence of corrosive attributes on the welding process, impacting weldability, weld joint quality, and the mechanical properties of the metal.

5. REFERENCES

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