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The relationship between residual stresses and transverse weld cracks in the plate

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ABSTRACT The transverse crack, a type of cold crack, occurs perpendicular to the axis of the weld interface, longitudinal residual stresses (σx direction) are more important in transverse crack occurrence from my own experience. Specimens were fabricated and welded under actual construction conditions, and then residual stresses of longitudinal stresses were measured for different welding conditions with SAW and FCAW process.

The residual stress values for the specimen welded interpass temperature below 30℃was higher than the specimen welded interpass temperature of 100~120℃. And also the residual stress values for a specimen measured at weld surface, as welded condition, was higher than that of longitudinal residual stresses that was measured from a small test piece, due to the residual stress was relieved in the process of the cutting and machining. Transverse weld cracks were detected in the area of the maximum residual stresses both SAW and FCAW process.

1. Introduction

Residual stresses are developed in the vicinity of a weld joint during arc welding. A weldment is locally heated by most welding processes, therefore, the temperature distribution in the weldment is not uniform, and metallurgical changes take place as welding progresses along welding joint.

Therefore, the welding residual stress is sometimes called the restraint stress(Refs. 4-5).Transverse weld cracks were detected in the specimen welded with preheating and interpass temperature below 30℃ with FCAW process, cracks were detected at a distance of 9.5-10mm away from the top of the welded surface, between layers 5-8. While in the specimen welded with preheating 70℃, interpass temperature below 30℃ of SAW process, cracks occurred at a distance of 9.5-14mm away from the top of the welded surface(before turnover the test panel). (Refs. 1-3). The transverse crack, a type of cold crack, occurs perpendicular to the axis of the weld interface. Therefore, longitudinal residual stresses are more important in transverse crack. Up until now, few investigations of measuring residual stresses in the actual structure have been undertaken. In this study, therefore, specimens were fabricated and welded like the actual construction conditions, and then longitudinal residual stresses were measured for different welding conditions with SAW and FCAW process.

2. Experimental Procedure of Residual Stresses

The residual stresses were measured using the Rosette gauge hole-drilling method per ASTM E837-01(Ref. 9).

The surface residual stresses of FCAW along

the weld metal centerline(σx direction) were measured as welding conditions after the specimen was cooled completely. To measure the longitudinal residual stresses as function of depth in the joint, the specimens were machined to expose the longitudinal center line. And the specimens were taken from the center of the test panel. Longitudinal residual stresses were measured both SAW and FCAW process. In the specimen welded SAW, the Rosette gauges are attached 3mm, 8mm, 15mm, 20mm, 25mm, 30mm, 5mm, 42mm and 47mm from the weld surface. And also welded FCAW, the Rosette gauges are attached 3mm, 10mm, 20mm, 30mm and 45mm from the weld surface.

3. Results and Discussion

3.1 Residual Stresses

Figure 1 shows the longitudinal surface residual stresses for FCAW. The residual stresses measured at the surface of a deposited metal in a longitudinal direction of weld interface. In all measured points, the residual stress values for a specimen welded preheating and interpass temperatures below 30℃(86°F)was higher than the preheating and interpass temperatures of 100~120℃(212-248°F).

Figure 2 shows the residual stresses of longitudinal stresses as function of depth in the joint for SAW. The residual stresses measured at the longitudinal direction of a deposited metal. Most of measured points, the residual stress values for a specimen welded preheating 70℃(158°F), interpass temperatures below 30℃(86°F) was higher than the preheating 70℃(158°F), interpass temperatures of 100~120℃(212-248°F). The same method, residual stresses measured at the longitudinal direction of a deposited metal for FCAW as shown in Fig. 3. Most of measured points, the residual stress values for a specimen welded preheating and interpass temperatures below 30℃(86°F) was higher than the preheating and interpass temperatures of 100~120℃(212-248°F). By the way, slightly higher residual stresses was measured in welds with lower preheat and interpass temperature. But the deviation of residual stresses measured as welded conditions may be higher than that of residual stresses measured in a small machined test piece.

The residual stress values for a specimen measured at weld surface, as welded condition, was higher than that of longitudinal residual stresses that was measured from a small test piece at the same position. The residual stress values were about five times higher as shown in Fig. 1 and Fig. 3. It is meant that the residual stress was relieved in the process of the machining before residual stress measurement. But, the tendency of residual stress agreed with other research papers(Refs. 12-13). In multipass welds, residual stress is distributed non-uniformly.

Gunnert(Ref. 12), have shown that distribution of residual stress in the directions in the weld metal of a butt joint 1 in. thick,(25mm) low-carbon steel plates. Welding was sequenced alternately on both sides so that angular distortion would be minimized. High longitudinal tensile residual stresses were found in the areas near surface of the weld.

Especially, the transverse cracks were detected in area of the maximum residual stresses both SAW and FCAW process. The residual stresses and hydrogen accumulation may be at a maxi- mum in the locations(Ref. 14).

It is believed that they were directly affected transverse crack occurrence.

4. Conclusions

The relationship between residual stresses of longitudinal stresses and transverse weld cracks was studied for EH32 TMCP 50mm thick plate welded with SAW and FCAW process. The results of this study can be summarized as follow:

1) The formation of transverse weld cracks did not follow the grain boundary ferrite; rather, they propagated across the grains. From fracture morphology, it is noted that transverse cracks occur in high stresses

2) The residual stress values for a specimen measured at weld surface, as welded condition, was higher than that of longitudinal residual stresses that was measured from a small test piece, due to the residual stress was relieved in the process of the cutting and machining.

3) The residual stress values for the specimen welded interpass temperature below 30℃ was higher than the specimen welded interpass temperature of 100~120℃. Transverse weld cracks were detected in the area of the maximum residual stresses for both SAW and FCAW process

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