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The Study for Application of Residual Stress Improvement on 6inch Pipe Butt Weld By MeSIA®[1]

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1. Introduction

The welding procedure generates residual tensile stress at the inner region of pipe which is one of the factors contributing to some cracks such as Intergranular Stress Corrosion Cracking and Primary Water Corrosion Cracking in nuclear industry. There are some accidents in nuclear power plants due to those kinds of cracks. Nuclear power plants in Korea have also experience of PWSCC making big issue to have nuclear integrity. There are some technologies to mitigate or repair dissimilar metal weld related to Alloy600. MeSIA is one of the mitigation technologies changing residual tensile stress to residual compressive stress in the weldment and heat-affected zone at the inner region of the pipe butt welds. The concept of this technology is to eliminate tensile stress by plastic deformation generated by mechanical pressure[1]. To have optimum compressive stress, some major parameter combinations, distance, pressure width and loads, were found in which were mentioned at spring paper this year.

This paper addresses the study for application of residual stress improvement. Two kinds of pipe, carbon seamless pipe and welded seamless pipe with carbon steel and stainless steel, were used to see the possibility. And finite element analysis was also performed. This study will be complete in 2012 when 29inch mock-up test is completed. Therefore, the information shown in this paper is subject to adding data.

2. The Experiment Method

MeSIA installed on outside diameter of pipe squeezes the pipe to make plastic deformation. To demonstrate how much and what kind of stress is generated, tee rosette strain gages were attached to the inner wall of pipes at 0°, 90°, 180° and 270. Figure 1 shows MeSIA and attached strain gages.

Figure 1. 6inch MeSIA

Table 1 shows the mechanical properties of pipes used for test

Table 1. Mechanical properties

Material	E	Yield	Tensile
A106 GrB Sch120	28.3e6psi	35ksi	60ksi
A312 TP304	28.3e6psi	30ksi	75ksi

In case of only pipe, 500kN force was applied five times to see hardening effect. Because strain gages couldn't install on the pipe in the real field, we couldn't know how much big stress should be generated. To know stress status, outside diameter where MeSIA was installed was measured. If enough plastic deformation wouldn't be made, the force is applied until required outside diameter was reduced.

500kN force was applied just one times for welded seamless pipe.

3. Finite Element Analysis

To make simple, two types of FEA were performed. Firstly two dimensional axi-symmeteric models were used to calculate the weld residual stresses and to evaluate MeSIA effects in comparison with before and after MeSIA. In this analysis, assume that uniform force was applied at circumferential direction. Secondly simple 3D models were used to calculate residual stresses for the carbon seamless pipe. Figure 2 shows two models of FEA.

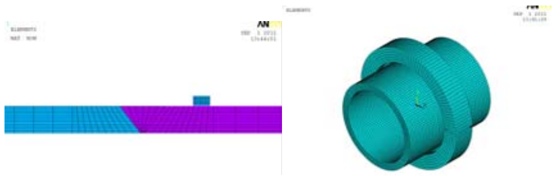

Figure 2. 2D and 3D Models

Nonlinear analysis of material and contact was performed.

4. Discussion of the results

4.1 The Results of The Carbon Seamless Pipe and FEA

Figure 3 shows strain when 500kN was applied first time for about 300 seconds. Residual compressive stresses were generated at all location with hoop and axial directions. Figure 4 shows strain with five MeSIA squeezes. Strain at axial and hoop direction was average value having bigger than before squeeze.

[1] MeSIA is a registered trademark of KPS

Hardening effect was seen obviously. Second squeeze has the biggest hardening effect.

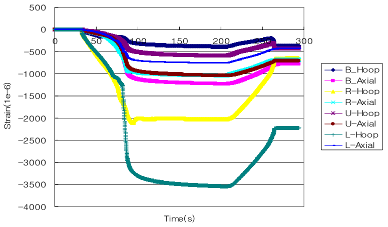

Figure 3. The strain at 1st Loads

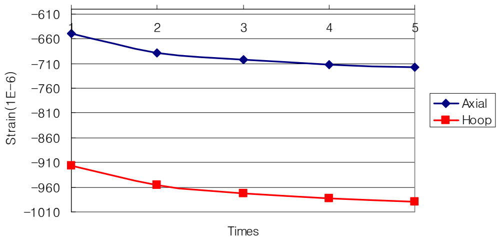

Figure 4. Strain at five squeezes

Figure 5 shows axial stress distribution of FEA results. Compressive stress was generated at all direction. Red color means tensile stress and blue color means compressive stress

Figure 6 shows results of FEA and test. Two points are test results and lines are results of FEA. In comparison between FEA and test results, Axial stress was similar but hoop stress was a little bit different.

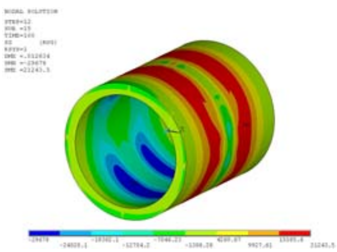

Figure 5. Axial Stress distribution with 3D Model

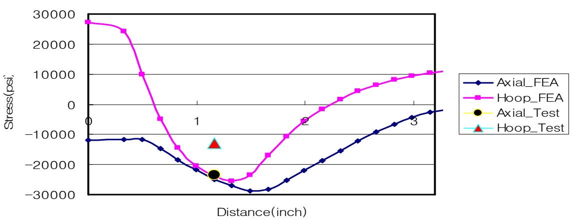

Figure 6. Test Results vs FEA Results

4.2 The Results of The Welded Seamless Pipe and FEA

After welding pipe with carbon and stainless steel, MeSIA was applied. Figure 7 shows stress distribution at axial direction with before and after MeSIA.

Test results are average stress at hoop and axial direction. Tensile stress generated by welding procedure was changed to compressive stress at all directions. In comparison between FEA and test results, Axial stress was similar but hoop stress was a little bit different.

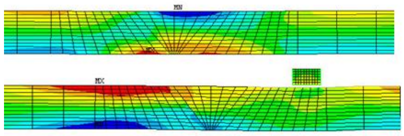

Figure 7. Stress before and after MeSIA

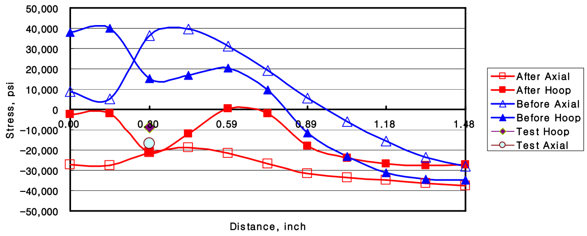

Figure 8. Test Results vs FEA Results

3. Conclusions

Residual compressive stresses were generated by MeSIA with Both carbon seamless pipe and mock pipe welded between carbon and stainless steel pipe. In comparison with the results of test and FEA, Axial stress is similar but hoop stress is not. The trend of stress is almost same.

Through this test, we can see the possibility of MeSIA Application in the field.

29inch MeSIA shown as figure 9 has been already made. Experiment and FEA of 29inch MeSIA are going to be performed.

Figure 9. 29inch MeSIA

REFERENCES

[1] Materials Reliability Program : Mechanical Stress Improvement Process(MSIP) Implementation and performance Experience for PWR Application(MRP-121), EPRI, Palo Alto, CA:2004