Experimental Parameter Study for Residual Stress Improvement on 6inch Pipe Butt Weld By MeSIA®[1]

Hong Seok Cho, Ki Hyun Cho, Min Hwan Mo
Korea Plant Service and Engineering Co., Technology Research & Development Institute
196, Geumgok-dong, Bundang-gu, Seongnam-si, Gyeonggi-do, 463-726 Korea, chs@kps.co.kr

1. Introduction

Primary Water Corrosion Cracking(PWSCC) is worldwide issue recently. Some nuclear power plants in Korea had also the leakage at the steam generator drain line and the reactor vent line due to PWSCC. So the regulatory institution and utilities have a lot of concerns for material aging. There are some technologies to mitigate or to repair DMW locations with alloy600. MeSIA®(Mechanical Stress Improvement Apparatus) changing residual tension stress to residual compressive stress in the weldment and heat-affected zone at the inner region of the pipe butt welds has being developed by KPS. The concept of this technology is to eliminate tensile stress which is one of three conditions contributing PWSCC[1]. This study will be complete in 2012 when 29inch mock-up test is complete. Therefore, the information shown in this paper is subject to adding data.

This paper addresses the results of experimental parameter study to demonstrate that residual compressive stresses are generated at the inner wall of 6inch pipe and to qualify the finite element analysis

2. The results of experimental parameter study

There are many kinds of tools to change mechanically residual stresses at the inner wall. All tools have to be installed on outside diameter of pipe which makes space limitation. The space of the sand boxes which are the way to access Reactor nozzles is actually too small to install MeSIA®. So clamp type of MeSIA® was chosen. This type of MeSIA® has challenge to make uniform stresses. To make sure that residual compressive stresses are generated at all location, experimental parameter studies were performed by measuring 2 axis strain with four tee rosette strain gages located at 0°, 90°, 180° and 270° at the inner wall of the pipe. To have optimum residual stress, there are three of major parameters which are the position MeSIA®, loading width and applied force. Firstly in this experiment the position of MeSIA® was fixed at 25mm from MeSIA® edge to the center of the strain gage. And loading width was 9mm, 25mm and 40mm. applied force was applied from 200KN to 500KN

The pipe material type was seamless pipe of A106 GrB Sch 120 whose yield stress and tensile stress are 44.9ksi and 68.4ksi on the inspection certificate. Finite element analysis was also performed to validate FEA results by comparing with test results.

Figure 1 shows 6inch MeSIA® to perform experimental parameter studies with strain gages on 6inch pipe. Experiment will perform with 6inch DMW mock-up and with 29inch pipes. And FEA will be validated by comparing the result of those mock-tests

Figure 1. 6inch MeSIA

In this section, the results of experimental parameter studies are shown.

2.1 9mm of loading width

Figure 1 shows strain due to pressurization and decompression with 9mm loading width. On the graph U, D, R and L mean the position of strain gage such as upper, down, right and left. 200KN force couldn't make plastic deformation. Applied force between 400 and 500KN generated much bigger residual compressive stresses. But radial located at the bottom were much bigger than others. This reason should be the installation of strain gage because to install axis of strain gage coincide with axis of pipe in inside of pipe was difficult.

Parameter combination with 25mm of distance, 9mm loading width and bigger 300KN made residual compressive stresses at all directions

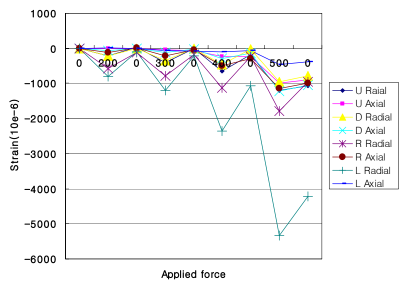

Figure 2. Strain with 9mm loading width

---

[1] MeSIA is a registered trademark of KPS

2.2 25mm of loading width

Figure 2 shows that big residual compressive stresses were generated at right and left side with hoop direction and residual tension stresses were generated at upper and bottom side with hoop direction until 400KN. Finally over 500KN compressive stresses were generated at all locations

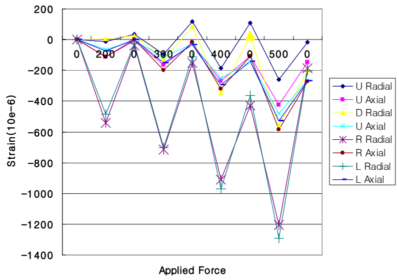

Figure 3. Strain with 25mm loading width

2.3 40mm loading width

Figure 3 shows that residual tension stresses at both upper and bottom side were generated at hoop direction and big residual compressive stress were generated at both right and left side.

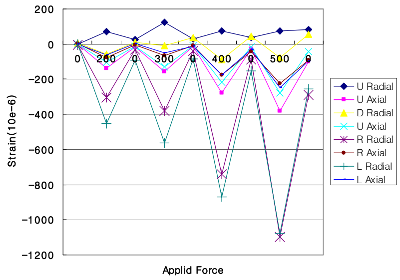

Figure 4. Strain with 40mm loading width

2.4 Qualification of FEA

FEA was performed by simple 2D model of the axis symmetry. In this analysis, assume that uniform force was applied at circumferential direction. Nonlinear analysis of material and contact was performed. Figure 4 shows the results of FEA. Residual compressive stresses at hoop and axial direction were generated.

Figure 5 shows that stress distribution at vertical line form ID installed strain gages in experiment to OD. compressive stresses at axial direction were generated until about 50% of wall thickness. And compressive stresses at hoop direction were generated until over 70% of wall thickness.

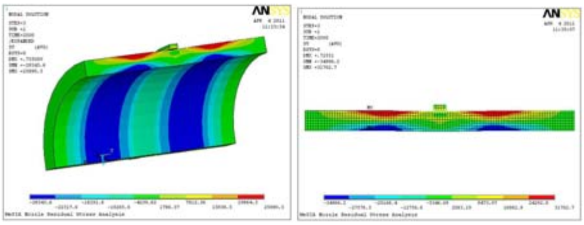

Figure 5.Axial stress distribution

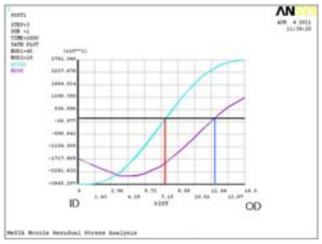

Figure 6. Stress distribution at vertical line

Table 1 shows comparison between FEA and experiment based on the point installed strain gages in experiment. Axial stresses were almost similar but hoop stresses were a little bit different. The more FEA analysis will be performed with 2D and 3D model

Table 1. Comparison between FEA and experiment

Direction	FEA	Experiment	Error
Axial stress	-28.45ksi	-27.83ksi	2.23%
Hoop stress	-17.17ksi	-26.59ksi	35%

3. Conclusions

The bigger loading width was used, the less residual stresses were generated and residual tension stresses at hoop direction in both upper and bottom side were generated.

In 500KN applied force and 25mm distance, table 1 shows residual stress depend on loading width.

Table 2.Summary of the residual stresses

Location	Loading Width		
	9mm	25mm	40mm
Upper Radial	-30.29	-0.43	2.35
Upper Axial	-25.47	-4.11	-2.83
Bottom Radial	-22.31	-5.60	1.54
Bottom Axial	-29.87	-7.42	-1.16
Right Radial	-26.87	-5.24	-8.14
Right Axial	-28.16	-7.73	-2.63
Left Radial	-119.59	-5.80	-7.21
Left Axial	-10.98	-7.62	-2.71

Through this experimental parameter studies, the smaller loading width was used, the bigger compressive stresses were generated and residual tension stresses were generated at upper and bottom side when loading width was bigger

In those experiment, parameter combination with 25mm distance, 9mm loading width and between 400KN and 500KN applied force makes enough residual compressive stresses at inner wall with all direction

REFERENCES

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