The Study on Residual Stress Improvement with 29 inch pipe by MeSIA

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1. Introduction

The commercial nuclear power plants around the world have been performing mitigation and repairs to deal with primary water corrosion cracking in pressurized water reactors. MeSIA [1] is one of the mitigation technologies removing tensile residual stress contributing to some cracks such as intergranular stress corrosion cracking and primary water corrosion cracking in nuclear industry. The concept of this technology is to change tensile stress to compressive stress by plastic deformation generated by mechanical pressure.[1]

This paper addresses the study on making favorable residual stress on interesting regions with 29 inch pipes. Both experiment and finite element analysis were performed to measure stress and to predict stress. This study will be done at the end of this year. Therefore, the results shown in this paper is subject to adding data.

2. The experiment method

2.1 MeSIA Tool

MeSIA installed on outside diameter of pipe squeezes 29 inch pipe by means of hydraulic power shown in Fig. 1. The dimension is a little bit different between inside diameter of MeSIA split rings and outside diameter of pipe.

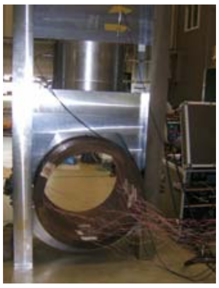

Fig. 1 29inch MeSIA

2.2 Mechanical properties of the pipe

Material of pipe is SS400 which is a rolled pipe. Outside and inside diameter are each 880 mm and 730 mm. The length is 700 mm. Material properties is shown in table 1.

Table 1 Material property

YS(ksi)	Young mo(ksi)	Poisson’s	E.L(200mm)
36.3	29e3	0.26	20%

2.3 Mechanical loads and measuring

The mechanical loads were applied with between 1000 kN and 5000 kN while strain was measured by tee rosette strain gages attached to the inner wall of pipe at 0°, 90°, 180° and 270 in two rows shown in Fig. 1.

Strain gages couldn’t attach the same locations in length direction due to poor surface conditions.

3. Finite element analysis

The finite element analysis was performed with ANSYS 13 APDL. The boundary condition was found to have minimal effect on the mechanical loads. Three dimensional analysis was performed with two half rings shown in Fig. 2 because actual mechanical loads of MeSIA are not symmetric.[2] Degree of freedom fixed all directions at one node of pipe. Solid 185 element that is 1st order was used because this is highly nonlinear analysis.[3] Material property and loading were same as experiment.

The pipe is rolled and welded pipe. So pipe was modeled with bead shape.

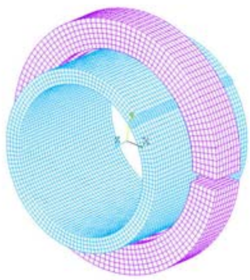

Fig. 2 Mesh

4. Discussion of the results

4.1 The results of experiment

Fig. 3 shows plastic strain depending on loads at 4 inch distance from pipe center where mechanical loads were applied. 0 degree is the bottom of the pipe. Degree direction is counter clock. Residual compressive stresses were generated at 0 and 180 degree in axial direction. Residual tensile stresses were generated at 90 and 270 degree in hoop direction.

[1] **Me**chanical **S**tress **I**mprovement **A**pparatus

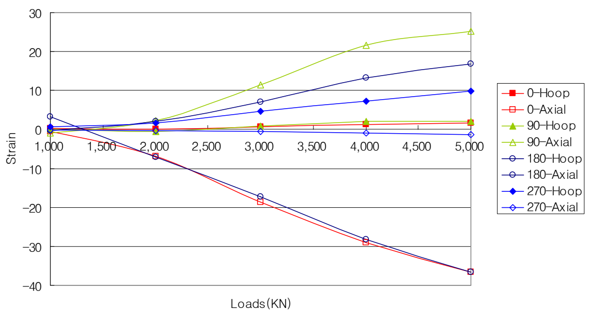

Fig. 3 Strain at 4 inch distance from pipe center

Fig. 4 shows plastic strain at 7.8 inch distance from pipe center. Residual compressive stresses were generated at 0 and 270 degree in hoop direction. Weld beads were located between 0 and 270 degree. Residual tensile stresses were generated at 0 and 270 degree in axial direction.

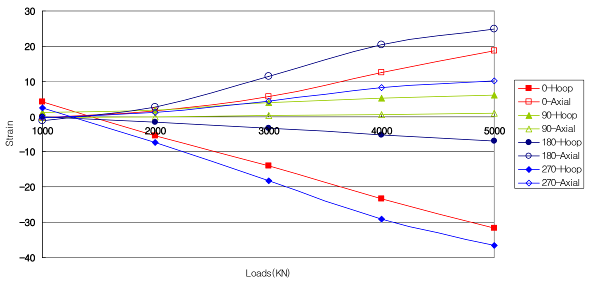

Fig. 4 Strain 7.8 inch distance from pipe center

4.2 The results of finite element analysis

Fig. 5 shows axial stress distribution. Compressive stresses were generated at almost all locations. Compressive stresses were generated at inner surface from pipe center to pipe end except hoop stress shown in Fig. 6.

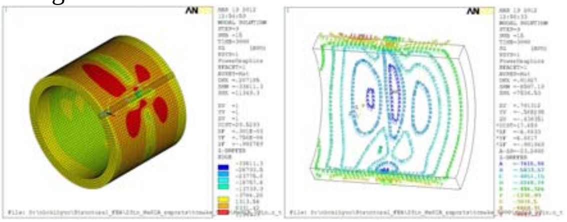

Fig. 5 Axial stress distribution

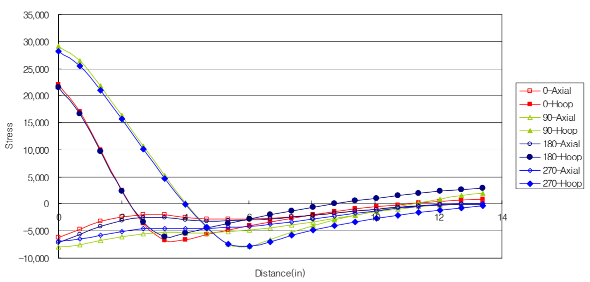

Fig. 6 Inner Surface Stress after MeSIA

4.2 Comparison with results of test and FEA

The comparison with results of experiment and FEA is shown in table 2 based on locations where compressive stresses were generated in experiment because the results of experiment and FEA are different.

Table 2 Comparison with results

Loc	Deg	Experiment(psi)	FEA(psi)
4 in	0	-1,059(Axial)	-2,488(Axial)
	180	-1,058(Hoop)	-5,405(Hoop)
7.8 in	0	-915(Hoop)	-1,996(Hoop)
	270	-1,058(Hoop)	-4,882(Hoop)

5. Conclusions

In case of 6 inch pipe, the results of experiment and FEA were similar but the results of 29 inch pipe are not. The reasons should be as below

1. The pipe which was made by rolling and welding has already residual stress and shape problems owing to welding beads.
2. The dimension between inside diameter of half split rings and outside diameter of pipe is different.
3. Strain gages couldn't be attached at the same locations in length direction because of inappropriate inner surface conditions.
4. 29 inch pipe and MeSIA are too heavy to locate it correct position.

Although the results are inappropriate, we can see the possibility of MeSIA to make favorable stresses at all locations and directions. Based on this experience, Additional experiment and FEA are going to be performed.

REFERENCES

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[3] Materials Reliability Program : Welding Residual Stress Dissimilar Metal Butt-Weld Finite Element Modeling Handbook(MRP-317), EPRI, Palo Alto, CA:2011. 1022862