Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 29-30, 2015

Analysis of Mechanical Stress Improvement Process (MSIP) on the welding between Reactor Vessel Inlet/Outlet and Reactor Coolant System (RCS) Piping

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1. Introduction

Reactor Vessel (RV) Inlets and Outlets are connected with Reactor Coolant System (RCS) Piping by welding. The materials for RV's Inlets and Outlets ,Welding and RCS Piping are low-alloyed steel A508, Inconel 182 and stainless steel Type 316 respectively. Due to welding process and different material characteristics, welding areas at the inner diameter (ID) of the Pipe experiences tensile stress.

Over certain period of operation, this areas encounter circumferential and longitudinal cracks due to Primary Water Stress Corrosion Crack (PWSCC).

To reduce the crack in this areas, one of the method is to apply the Mechanical Stress Improvement Process (MSIP). This paper will study the effects that optimize the method of MSIP.

2. Concept and operation

In this section, MSIP's concept and its contributing factors are described.

2.1 The concept of MSIP

Two clamps are placed on top and bottom or side-way of pipe. The Clamps are located behind the welding area. The two clamps are pushed down toward each other (as figure 2.2) and squeezed the RCS Pipe. The squeeze will cause RCS Pipe to deform slightly (0-0.01% of Diameter of Pipe). After deformation, the two clamps are released from the Pipe.

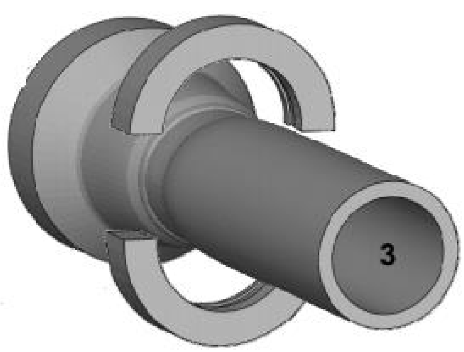

Figure 2.1. Clamping of RCS Pipe

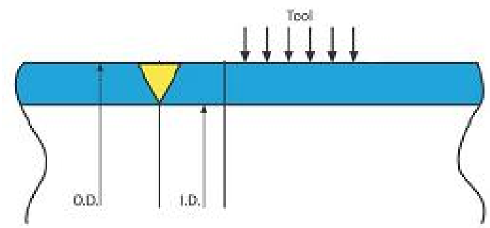

Figure 2.2. Placement of Clamping on RCS Pipe

Due to deformation of the RCS Pipe, the tensile stress on the weld at the ID of the Pipe (from now is referred as "in weld") is converted to compressive stress. This compressive force will arrest cracks, if any, to initiate or grow in the weld.

2.2 Factors affect MSIP

The factors that affect MSIP are distance "a" to place the clamp after the welding area, the width of the clamp "b" and the pressured applied "P" to the Pipe.

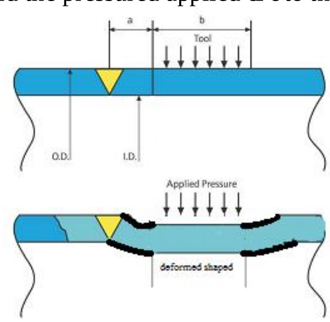

Figure 2.3. Factors that affect MSIP

2.3. Simulation setup

To understand these factors, the following steps are conducted

1. A model which represent RV Inlet, welding area and RCS Piping and the two Clamps are constructed using ANSYS software.
2. The welding area is pre-stressed at 23106 psi.
3. A known clamp width "b" is applied
4. A known condition of pressure applied "P" is applied.
5. The distance "a" is varied.

6. Repeat step 3 with different value of ôbô of 3, 4, 5 inch
7. Repeat step 4 with different value of ôPô of 300 000, 400000, 500000 psi
8. The resulted stress at the weld is recorded.

The data is collected as the table below

Width ôbô (inch)	Applied Pressure ôPô (psi)	Distance ôaô (inch)	Stress at Weld (psi)
(3-5)	300000 - 500000	0.5	Ansys results
		1.5	Ansys results
		2.5	Ansys results
		3.5	Ansys results
		4.5	Ansys results
		5.5	Ansys results

3. Result of MSIP Analysis

In this section, data from the test model are plotted in graph.

3.1 Clamp width of 3 inch with varying ‘a’ and ‘P’

The stress resulted from the squeeze of the two Clamps to the Pipe is recorded. The distance ôaô from the welding area is varied from 0.5-5.5 inch. The Pressure applied ôPô on the Clamp width of 3 inch is also varied. Figure 3.1 shows the graph of stress in weld over location of the clamp on the Pipe.

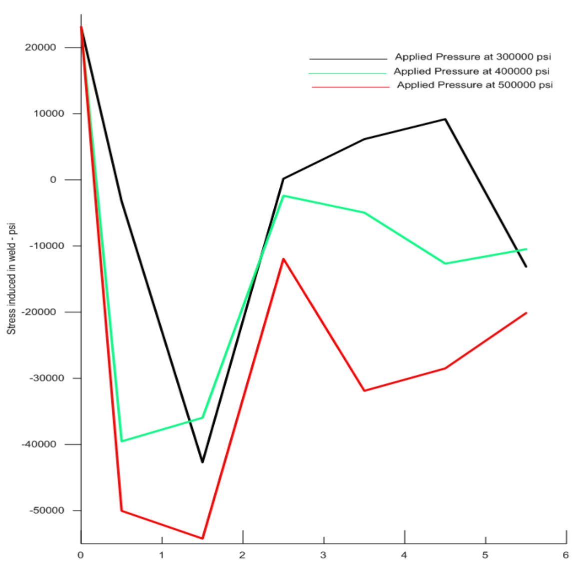

Fig. 3.1.Stress in weld for 3 inch width Clamp

3.2 Clamp width of 4 inch with varying ‘a’ and ‘P’

The width of the two Clamps is changed to 4 inch. Other conditions such as Pressure applied ôPô on the Clamps and distance ôaô on Clamps to the Pipe are similar to the condition in 3 inch width Clamp.

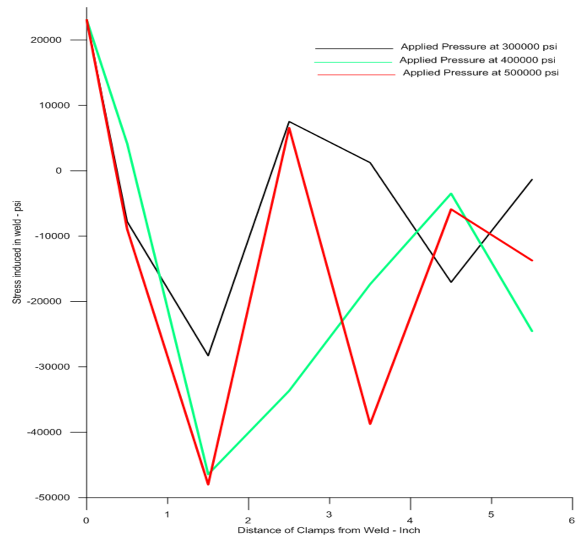

Fig. 3.2.Stress in weld for 4 inch width Clamp

3.3 Clamp width of 5 inch with varying ‘a’ and ‘P’

The width of the two Clamps is changed to 5 inch. Other conditions such as Pressure applied ôPô on the Clamps and distance ôaô on Clamps to the Pipe are similar to the condition in 3 inch width Clamp.

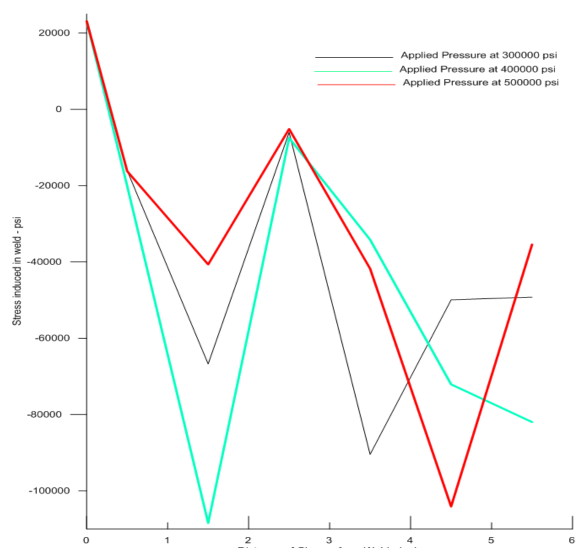

Fig. 3.3.Stress in weld of Pipe for 5 inch width Clamp

4. Conclusions

4.1 Conclusion for individual graph

For the individual graph of 3 inch width thickness, we can make the conclusions

Higher applied pressure óPô at the same distance óaô will induced higher compressive stress in weld.

The optimal distance óaô is 1.5 inch away from the weld.

At distance óaô equals 2.5 inch, the compressive stress induced to weld is much smaller than other position.

4.2. Conclusion for 3 graphs

For the 3 graphs for different width óbô of the Clamps, we can make the conclusions

For a higher applied pressure óPô, the tensile stress in weld will be converted to a higher compressive stress.

For any distance óaô of the Clamp, after the MSIP, the tensile stress in weld will be reduced greatly.

For Clamp with larger width óbô, the conversion from tensile to compressive stress is more uniform in the welding area related to surrounding area.

For Clamp with larger width óbô, compressive force induced in weld is higher for the same pressure applied.

ACKNOWLEDGEMENTS

This research was supported by the 2015 Research Fund of the KEPCO International Nuclear Graduate School (KINGS), Republic of Korea.

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