Preliminary Study for Development of Welds Integrity Verification Equipment for the Small Bore Piping

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1. Introduction

For a number of years the power producers' market has been experiencing far-reaching changes worldwide. As the operational time increases of nuclear power plant, people have raised the issue for the safety of nuclear power generation, hoping to safely operate a nuclear power plant. Therefore, there is necessary to develop a maintenance technique for maintaining the components of a nuclear power plants.

From the early 1970s, damage accident of socket welds have been frequently reported. It has been reported leakage accident of small-bore piping in Korea. Leakage accident of small-bore pipes are those that will increase due to the aging of the nuclear power plant. And if leakage of the pipe is repaired by using the clamping device when it occur accident, it is economically benefits. The clamping device is a fastening device used to hold or secure objects tightly together to prevent movement or separation through the application of inward pressure. However, when the accident occurs, it can't immediately respond because maintenance and repairing technology are not institutionalized in KEPIC. Thus it appears an economic loss. The technology for corresponding thereto is necessary for the safety of the operation of nuclear power plants.

The purpose of this research is to develop an online repairing technology of socket welded pipe and vibration monitoring system of small-bore pipe in the nuclear power plant.

Specifically, detailed studies are as follows :

- Development of weld overlay method of safety class socket welded connections
- Development of Mechanical Clamping Devices for Safety Class 2, 3 small-bore pipe
- Development of online monitoring system of small-bore piping
- Development of demonstration test of the device
- Review and modification of KEPIC conformity assessment system

For a while to introduce Korea Electric Power Industry Code (KEPIC), a set of integrated standards applicable to the design, construction and operation of electric power facilities including nuclear power plants, has been developed on the basis of referring to the prevailing U.S. codes and standards which had been applied to the electric power facilities in Korea.

Although the technical requirements of KEPIC related to design and inspections for pressure vessels have been developed on the basis of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC), Korea Electric Association (KEA) that is KEPIC maintenance organization is trying to find and improve unreasonable requirements based on the acquired experiences for the continuous construction and operation of NPPs.

In the administrative requirements, KEPIC, unlike ASME, adopted not only mechanical field but also electrical field related to NPPs. Furthermore, the qualifying system for services such as Nondestructive Examination, Heat Treatment, Design and Equipment Qualification Organization was adopted to improve safety and reliability for NPPs.

2. Development of welds integrity verification equipment for the small-bore piping

This research has been performing betterment study to solve problems during the Repair & Replacement step of nuclear power plants.

Failures of small-bore piping connections continue to occur frequently in nuclear power plants, resulting in degraded plant systems and unscheduled plant downtime. Fatigue related failures are generally detected as small cracks or leaks before major pressure boundary ruptures occur. However, in many cases, the leak locations are not isolable from the reactor pressure vessel and result in forced plant outages. Because socket welds are used extensively for small-bore piping and fittings(less than 2 in.) in nuclear power plants, this study was undertaken to improve socket weld integrity.

Korea does not possess the overlay technique of socket welded connection, it is dependent the technology in abroad. This is the economic loss by the

absence of maintenance technology for the socket welded connection of safety class.

The majority of fatigue failures are caused by vibration of socket welds. It was discovered that approximately 80% of the fatigue failures in the nuclear power plant industry have been associated with high-cycle vibration fatigue of socket-welded connections in small bore-piping.

The socket weld leg size configuration can have an important effect on its high cycle fatigue resistance, with longer legs along the pipe side of the weld greatly increasing its predicted fatigue resistance. Other potentially important factors influencing fatigue life include residual stress, weld root and toe condition, pipe size, axial and radial gaps, and materials of construction. The purpose of this project is to perform high cycle testing of socket weld of various designs in order to quantify the effects of these factors upon fatigue strength. Overlay repairs of leaking socket welds were also included in the high cycle fatigue testing.

On-line repair welds would provide and extended life, allowing replacement of the repaired connection to be scheduled during a routine outage reducing the costs associated with the common failures.

Korea has not performed testing data of high-cycle fatigue life and analysis of fatigue failure up to date. Therefore test and analysis will be performed that include comparisons of the various socket weld designs with socket welds requirements of KEPIC and recent test data form ASME. Table 1 is selection item of fatigue failure testing. The item considered cause failures from operation experience, type, materials, size of pipe and vibration.

Non-contact vibration monitoring systems will be developed which are based on the analysis of vibration signals. Higher demands with regard to the safety and reliability of pipes require methods to get an idea of the mechanical state of the plant at any time during operation and to recognize failures already in their developing phase.

Table 1. High risk Group of Socket Welded Connection

No.	Tag.No	Type	Material	Size
1	212-3-BB-BB103_001-FW01	CAN	STS	¾, sch.160
2	212-3-BB-BB105_001-FW01	CAN	STS	¾, sch.160
3	212-3-BB-BBF08_001-FW01	CAN	STS	¾, sch.160
4	212-3-BB-BBF09_001-FW01	CAN	STS	¾, sch.160
5	212-3-BB-BBF10_001-FW01	CAN	STS	¾, sch.160

3. Conclusions

The purpose of this study is to develop an online repairing technology of socket welded pipe and vibration monitoring system of small-bore pipe, resulting in degraded plant systems. And it is necessary to institutionalize the technology. The fatigue crack testing of socket welded overlay will be performed and fatigue life evaluation method will be developed in second year. Also prototype fabrication of mechanical clamping device will be completed.

Base on final goal, the intent is to propose practical evaluation tools, design and fabrication methods for socket welded connection integrity. And result of this study is to development of KEPIC code case approved technology for on-line repairing system of socket welded connection and fabrication of mechanical clamping device.

ACKNOWLEDGMENTS

This paper was supported by the energy efficiency of the Korea Institute of Energy Technology Evaluation and Planning(KETEP) grant funded by the Korea government Ministry of Trade, Industry and Energy.(No. 20161510200340)

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