Project Subjects

Integrated Maintenance Technology for Inspection, Prediction and Monitoring

Background and Objective

It is recently reported that creep damage preferentially accumulates in welded portions of high chromium steels at ultra super critical thermal power plants, which are in service for less than 100,000 hours. Creep damage also occurs in welded portions at aged super critical power plants which are operated for more than 200,000 hrs. Therefore, trouble free operation of the plants is an important issue for the maintenance section of the thermal power generation division, referring to damage assessment result of structural components.

In this project, to prevent damage and loss which are caused by accidents at power plants, we developed advanced non-destructive inspection technology, analytical damage prediction technology and monitoring technology of damage in service. Furthermore, by integrating these technologies, we constructed a new system of the maintenance technologies for power stations, which we call the "Maintenance Triangle".

Main results

1. Damage assessment system for welded joint based on stress analysis of boiler piping

We developed a finite element program which is able to analyze the stress generated in the entire piping system, and constructed a damage assessment system for welded joints (Fig. 1) by combining the FE program with a void growth simulation program developed in previous work. Since the entire piping between boilers and turbines is modeled in an FE mesh, system load can be evaluated in the FE analysis. Inner pressure was also able to be considered owing to using three dimensional elements. Conducting the stress analysis and void growth simulation, we were able to predict creep damage to welded portions of the boiler piping with high accuracy [Q09005].

2. Advanced non-destructive inspection technology for welded joint of boiler piping

In order to detect damage inside materials of piping with sound precision, we have developed an advanced ultrasonic phased array nondestructive inspection (NDI) system. Optimizing inspection conditions based on an ultrasonic wave propagation simulation, it was demonstrated that the system was able to detect a state of damage where the creep void was overcrowded in the heat-affected zone of welded joints (Fig. 2). By introducing signal processing technology to the NDI system, we could apply the modified inspection system to welded components with complex surface geometry, which were hard to do with conventional ultrasonic NDI systems [Q09016].

3. Damage monitoring technology with optical fiber acoustic emission sensors

A monitoring system with optical fiber acoustic emission (AE) sensor was developed to examine damage of structural materials at high temperatures under service conditions, which was difficult for existing systems so far. We were able to detect AE signals caused by the propagation of creep cracks and fatigue cracks in the laboratory using the developed monitoring system. Further, it was installed to a high temperature equipment of an actual boiler to monitor the propagation of thermal fatigue cracks (Fig. 3). It was confirmed that the system works under a real operation environment.

Other reports [H09003], [H09004], [H09012], [Q09011]

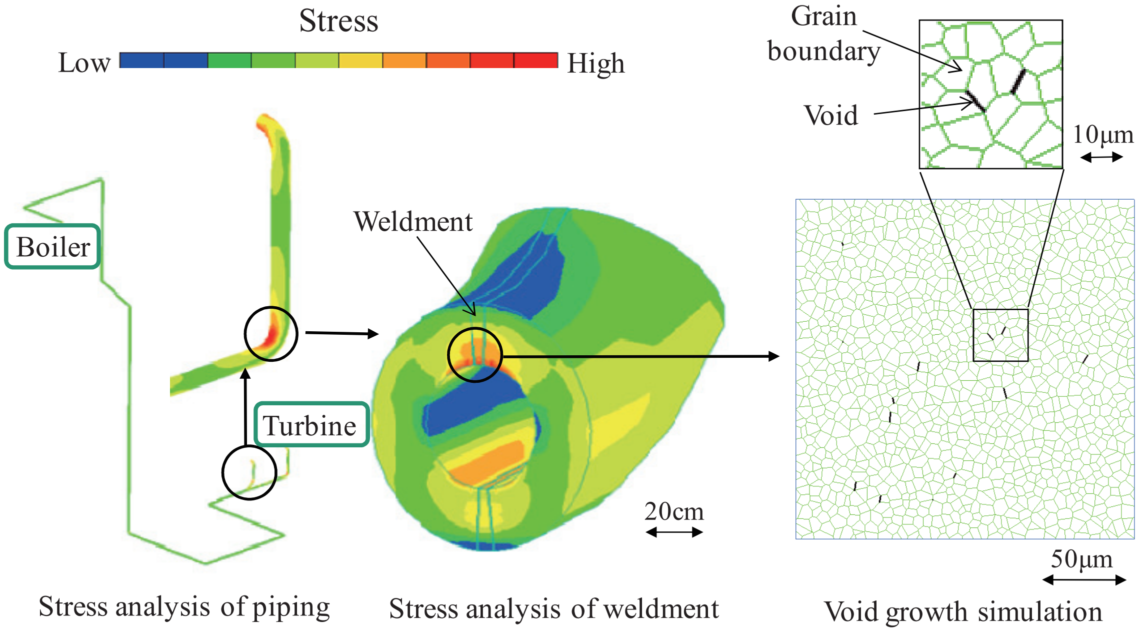

Fig. 1 Flow of damage evaluation in welded joints of piping

It became possible to evaluate system load accurately by analyzing entire piping system, and to consider inner pressure with steam in piping by using three dimensional elements.

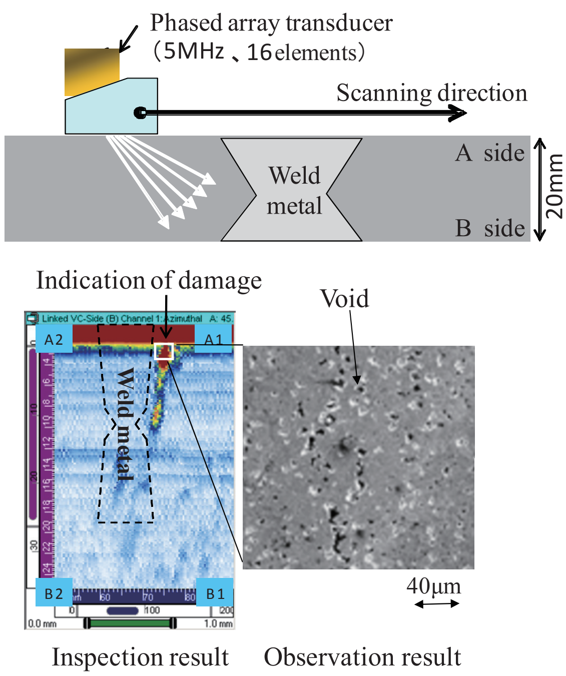

Fig. 2 Inspection result of creep damage

It was demonstrated that the NDI system was able to detect creep damage prior to the small cracks stage in the welded joints specimen.

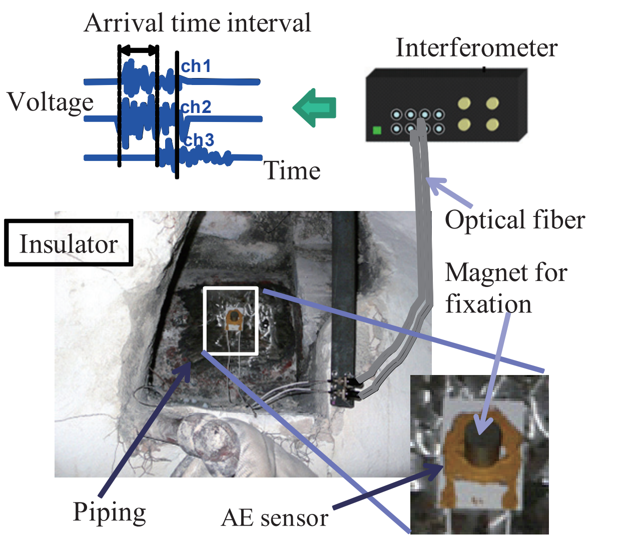

Fig. 3 Installation of AE sensor to real piping

An online monitor became possible with the optical fiber AE sensor for high temperature equipment.