Integrated Maintenance Technology of 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. The creep damage also occurs in welded portions at aged super critical power plants that have been operated for more than 200,000 hours. Then, to run the plants without trouble is an important issue in the maintenance section of the thermal power generation division, referring to damage assessment results of structural components.

In this project, we aim to improve our non-destructive inspection technology and analytical damage prediction technology, which have been developed to prevent damage and loss caused by accidents at the power plants. We also aim to develop a monitoring technology of damage in service. Further, integrating those technologies, we will construct a new system of the maintenance technologies for the power stations.

Main results

1. Development of ultrasonic inspection technique applicable to surfaces with complex geometry

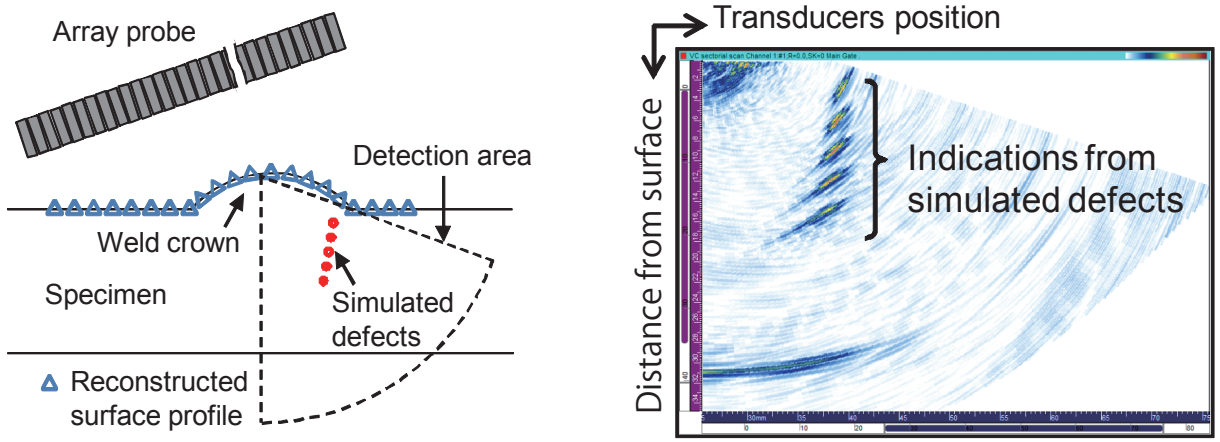
Ultrasonic testing is widely used for the detection of internal defects. However, it is difficult to apply ultrasonic testing to components with a complex geometry such as weld-reinforced pipes and nozzles with intricate weld geometry. To develop an ultrasonic inspection technique applicable to surfaces with a complex geometry, we developed a method for reconstructing surface profiles by means of signal processing [Q10021]. In conjunction with this reconstruction method, the phased array ultrasonic inspection technique developed in an earlier study was applied to specimens with weld reinforcement shape. The results show that the proposed method can accurately detect internal defects in components with intricate geometry, which are difficult to detect by conventional ultrasonic testing.

2. Detection of local wall-thinning defects using high-frequency guided waves

To detect local wall-thinning defects in pipes, for example, liquid droplet impingement erosion, a measurement technique using guided waves with a higher frequency than conventional guided waves, has been established. Simultaneously, a measuring system with high detectability has also been developed [Q10011]. This technique was applied to small-diameter pipes and elbow pipes with poor long-range propagation due to the effect of curvature (Fig. 2). Detectability limits were examined on the basis of the applied results. Moreover, measurement results show that it is possible to determine the depth of wall-thinning defects from the dependence of the defect echo intensity on the refraction angle.

3. Acceleration of plumbing stress analysis program

The calculation algorithm of an already developed analysis program for USC boiler plumbing systems was modified so as to rapidly estimate stress states even for a massive plumbing models consisting of 3D solid elements. The method of solving simultaneous equations, which occupied major part of the calculation time, was changed from a direct method to an iterative method. Consequently, it was shown that the calculation speed of the modified program was approximately 20 times that of the previously developed program (Fig. 3) [Q09005].



(a) Specimen with weld crown and reconstructed results of surface profile

(b) Inspection result obtained by the present method

Fig. 1 Inspection results of specimen with weld crown by ultrasonic testing

Reconstruction of surface profile by means of signal processing enables inspection taking into account of complex geometry surface. As a result, the presented method could detect internal defects, which are difficult to detect by conventional ultrasonic testing, in the specimen with weld crown accurately.

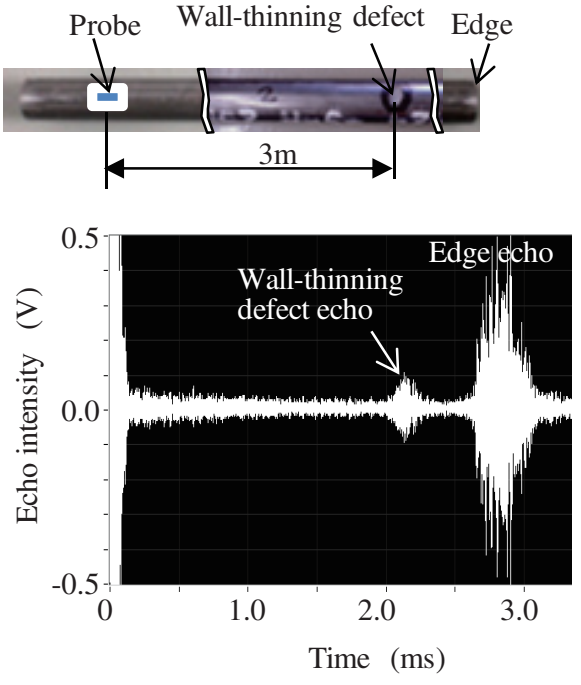


Fig. 2 Measurement result for wall-thinning defect in small-diameter pipe (diameter = 34 mm, thickness = 6 mm) using high frequency guided waves

A wall-thinning defect whose depth is approximately equal to 20% of the pipe thickness was detected at a distance of 3 m from the defect using high-frequency guided waves. It is also possible to determine the defect depth from the dependence of the defect echo intensity on the refraction angle.

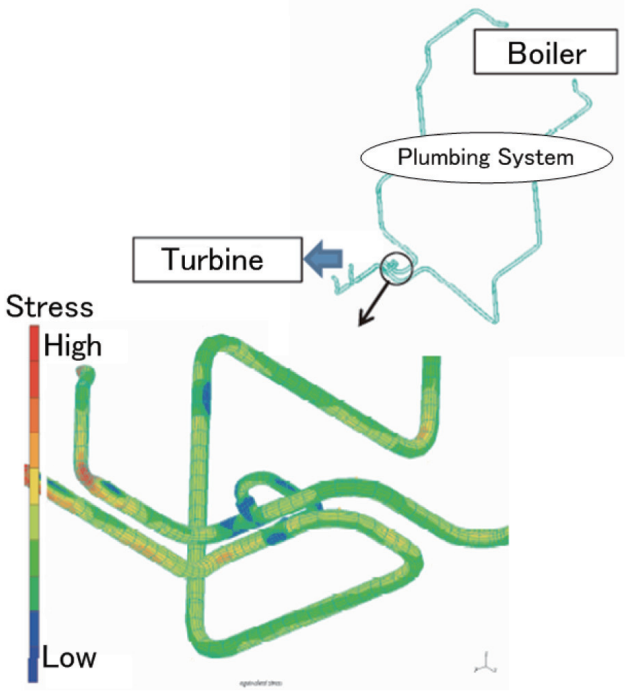


Fig. 3 Example of 3D large-scale stress analysis for the plumbing system of a USC plant

The calculation algorithm of the analysis program for USC boiler plumbing systems was modified so as to rapidly estimate stress states even for a massive plumbing model consisting of 3D solid elements.