Diagnostic Technology of Performance of Power Plants Using Laser Torque Sensor

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1. Introduction

Both combined cycle power plants (Fig.1) and nuclear power plants have assumed the leading role in electricity supply in recent years. It is important to identify which kinds of turbine deteriorate the performance in the plants when the plant performance is reduced so that fuel conservation can be achieved especially in combined cycle power plants. The heat input-output method is conventionally used to diagnose the performance of turbine, which is the main machinery of power plants. However, the accuracy of the method is not sufficient to diagnose the performance as the accuracy is estimated to be approximately 10%, because the method requires difficult measurement of flow rate and temperature of high temperature fluid. Accordingly, we hypothesized that the diagnostic accuracy could be greatly improved if the output of each turbine in the plant could be measured by a torque sensor. Thus, a diagnostic method using a torque sensor was studied. However, it is difficult to apply conventional types of torque sensors such as strain gauge or electromagnetic pick-up to the measurement of turbine output at power stations. The reason is related to the fact that (1) it is necessary to modify the equipment to set the sensor, (2) accuracy of the sensors is insufficient, and (3) it is difficult to apply the sensor to torque measurement of rapid rotary machinery.

2. Technology

A new type of laser torque sensor was devised to solve these difficulties fundamentally (Fig.2). The sensor measures axial distortion caused by power transmission using laser beams focused on small stainless steel reflectors having bar-code patterns attached to the surface of the rotating shaft. However, the actual distortion angle of the rotating shaft at the thermal station is too small for accurate measurement. Accordingly, the new method uses a technique of signal processing featuring a high frequency of 100 nano sec to calculate the distortion angle, namely the delay time between output signals by the correlation (Fig.3). As a result, it was confirmed that the accuracy of the sensor is within 0.5% in the experiment using apparatus driven by a motor. However, we discovered some error factors, which affected the measurement results due to infinitesimal measurement, such as influence of center shift of the rotating shaft in experiments at commercial plants. These error factors were eliminated by improvements of the sensor on the basis of the countermeasures attained by trial and error.

The whole turbine output was measured to test the performance of the torque sensor at the nuclear power plant (Fig.4). The values agree with the values obtained by existing instruments of the power station, namely the electrical outputs. Therefore, it is considered that the sensor performance attained a level of practical use.

3. Conclusion

This technology succeeded in attaining the level of practical use at both combined cycle power plants and nuclear power plants. Thus, the application area of the sensor is spreading in the electrical power industry at present. The optical torque sensor is expected to be useful for torque measurement in not only the electrical power industry, but also the automobile and motor industry in the future.

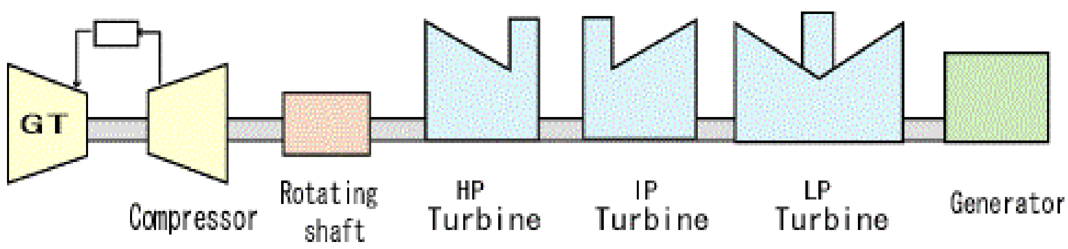

Fig.1 Configuration of the ACC

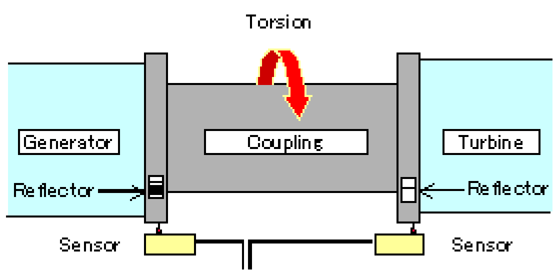

Fig. 2 Laser torque sensor

Time (7.2 μ s/div.)

Fig. 3 Output signal on the turbine and output signal on the generator

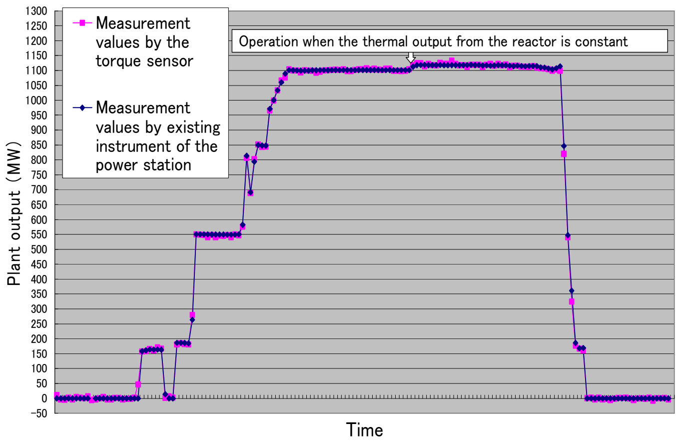

Fig. 4 Whole turbine output measured by the torque sensor at a nuclear power plant