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Present Situation and Development of Condition Monitoring Technologies†

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Abstract:

Main equipment installed in steel works of JFE Steel have passed 30–40 years since its operation. Inspection activities of cracks and corrosion have been strengthen to prevent equipment failure due to aging. In addition, high operating rate and stable operation have been required to improve equipment efficiency. The development and introduction of higher efficient equipment monitoring technology is needed and JFE Steel has developed technologies such as remote control diagnosis device to measure cracks and steel thickness without building a foothold, new diagnosis system for low speed rotating machines and journal bearings, diagnosis technology for large-sized motors and generators without stopping the motor. These new monitoring technologies have contributed to production improvement and establishment of "Safe Safety" operations.

1. Introduction

The main equipment of the steel works of JFE Steel has now been in operation for 30–40 years since startup. For this reason, inspections of cracks and corrosion have been strengthened to prevent equipment failure due to aging. On the other hand, more efficient diagnosis of equipment deterioration and to repair it at the appropriate time are now necessary in order to respond to demands for high operation rate in recent years.

This paper describes the transition in condition monitoring technologies and the development of condition monitoring technologies corresponding to equipment deterioration modes.

2. Transition of Condition Monitoring Equipment at Steel Works

2.1 Expansion of Online Monitoring Sensors

Figure 1 shows the transition in online conditioning monitoring sensors installed permanently on steel works equipment. Compared to the 1995 baseline, installation of these sensors had increased by approximately 25 times by 2009. The number of vibration sensors for medium- and high-speed rotating machines of approximately 600 min^{-1} class[1)] has increased, and use of condition monitoring devices such as thermometers, flowmeters, and pressure gauges has also expanded. Also taking in the information of ammeters and operating conditions, etc., JFE Steel also monitors the changes of equipment load conditions. These devices have been adopted in hot strip mills and other plants to achieve stable equipment

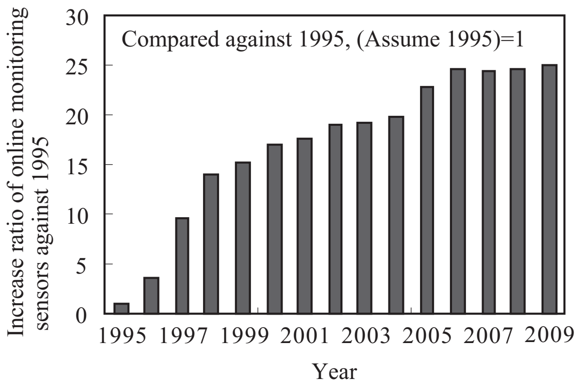

Fig. 1 Transition of online monitoring sensor

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operation.

2.2 Equipment Inspection and Detailed Diagnosis Efforts

In addition to adoption of monitoring sensors, various types of inspections and detailed diagnosis, as shown in **Fig. 2**, are now carried out to know accurate the conditions of the equipment. Crack diagnosis such as ultrasonic testing, magnetic particle testing, and phased array ultrasonic testing makes up more than half of the works. Others are detailed diagnosis by frequency analysis and self-correlation processing based on vibration waveforms of equipment which showed abnormal data by online monitoring sensors, JFE Steel also diagnosis the displacement, stress, and torque diagnosis, and ferrography (oil analysis) [2], etc.

Using JFE Steel's "Scan-WALKER™" [3] to identify the location of local corrosion of byproduct gas piping efficiently, the company also has minimized the replacement area.

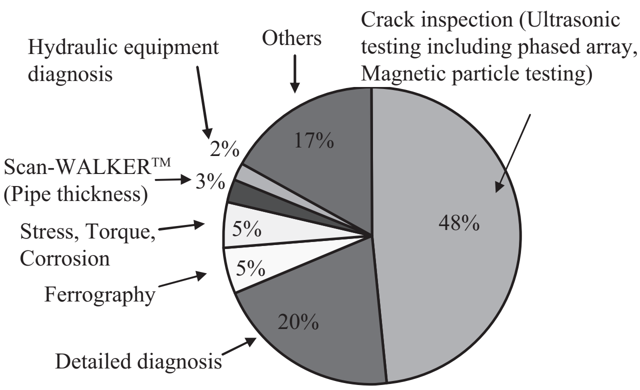

Fig. 2 Items of diagnosis works

3. Status of Development of Condition Monitoring Technologies

The condition monitoring technologies included in this special issue are technologies were developed to correspond the deterioration modes of equipment shown in **Table 1** to applicate for non opening inspection, remote control, high accuracy, simplified judgment of abnormalities, and other features, thereby expanding the applications of these technologies. More specifically, remote control crack diagnosis technology using the high temperature time of flight diffraction (TOFD) method for inspection of the welding lines of the steel shell of blast furnace hot stoves and various types of measurement technologies utilizing high accuracy infrared thermography were developed and have been applied practically to diagnosis without construction of scaffolding or opening of the equipment. Non opening ultrasonic flaw detection diagnosis technology has also been applied practically to gas pipeline supports. In the area of vibration analysis, early abnormality detection was realized for low speed rotating machinery, journal bearings, and other equipment which had been difficult to diagnosis with conventional techniques. Among other technologies, an online diagnosis technology for large-scale motors using partial electric discharge and shaft voltage waveform diagnoses, a diagnosis technology using high frequency wave amplitude attenuation, an insulation degradation diagnosis technology using acoustic emission (AE), a high accuracy earthquake

Table 1 Developed technology and application area

Degradation mode	Development technology	Application area
Crack	Remote control diagnosis using high temperature time of flight diffraction (TOFD)	Hot stove (Blast furnace)
	High accurate infrared camera	Neck portion of roll crane structure
	Geo-acoustic tomography (Pseudorandom wave)	Crane garter of housing structure
	Phased array ultrasonic testing	Driving device, steel structure
Vibration	High accurate vibration waveform analysis	Low-speed rotary machines journal bearing reciprocating motion
	High function monitor device	
Corrossion	Scan-WALKER™(Thickness)	Overhead piping
	Pipe thickness measurement using ultrasonic testing for the saddle shape support area	Pipe area of saddle shape support
	Internal camera robot for pipe	Pipeline
Abrasion	Realtime Fe (Ferrum) concentration analysis in grease	Bearing
The others	Partial electric discharge axis-voltage wave diagnosis	Large-sized motor and generator
	Insulation diagnosis equipment using acoustic emission (AE)	Electrical installations
	High accurate infrared camera	Stress, Temperature, Fatigue
	High accurate earthquake damage prediction technology	Overall

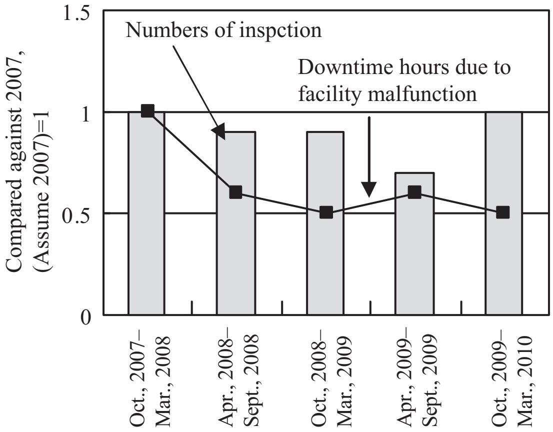

Fig. 3 Transition of inspection and downtime hours

damage prediction technology, and others have been developed and are in use with actual equipment, contributing to equipment stabilization.

4. Results of Condition Monitoring

Figure 3 shows the number of inspections, including the number of monitoring sensors, and the trend in the ratio of downtime hours using the second half of FY2007 as the baseline. Downtime has been reduced by approximately one-half by the development and expanded use of condition monitoring technologies and control of normal values of equipment using those devices.

5. Conclusion

This special issue introduces condition monitoring equipment which has been applied to actual equipment by JFE Steel, its group companies, and companies involved in joint development. As it is necessary to respond to many kind of deterioration modes in steel works, development will be continued. JFE Steel Group will also work to apply and these condition monitoring technologies for other areas.

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