JFE TECHNICAL REPORT
No. 17 (Apr. 2012)

Multi-Function Online Monitoring System "Condition-Eye"†

1. Introduction

The multi-function online monitoring system "Condition-Eye" (**Photo 1**) is a system which enables online condition monitoring of all types of mechanical equipment, not limited to general rotation machines, but also including various types that had been difficult to monitor with conventional technologies, for example, low-speed rotation machines, rotation machines with sliding bearings, reciprocation machines, press machines, etc. The following describes the features and functions of Condition-Eye and presents example of machine diagnosis.

2. System Outline

This multi-function online monitoring system performs high speed computations on signals from various types of sensors (vibration, temperature, pressure, etc.) by a dedicated monitor, accumulates the results in a server, and enables graphic display and various diagnoses/analyses on an upper-level client PC. An example of the system configuration is shown in **Fig. 1**. It may also be noted that use in simple monitoring when responding to unexpected trouble is also possible by combining the monitor and a personal computer as shown in Photo 1.

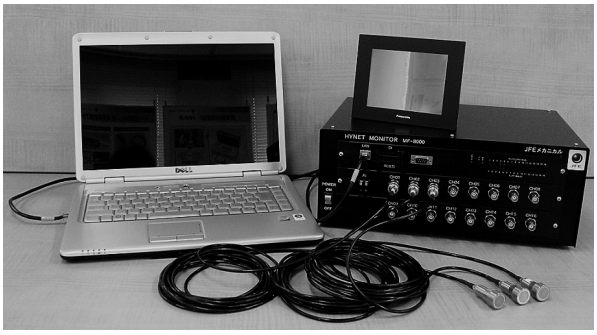


Photo 1 Equipments of online monitor

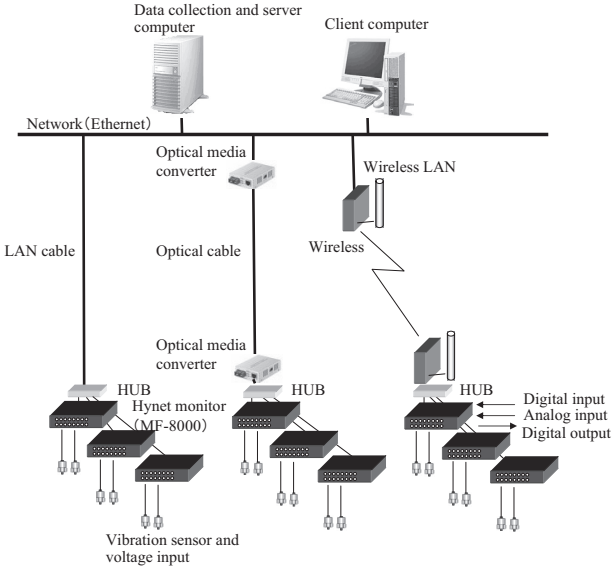


Fig. 1 System configuration

3. Main Features

The main features of this multi-function online monitoring system are described below.

(1) Early detection of abnormalities by the integrated parameter judgment method,* and diagnosis of low-speed rotation machines and rotation machines with sliding bearings is possible: Judgment of pass/fail by one value integrating multiple parameters such as frequency components and kurtosis calculated from vibration waveforms.

(2) Abnormality diagnosis of valves of compressors, etc. by the Kullback-Leibler divergence method is possible: Quantification of waveform changes as Kullback information and pass/fail judgment using that value.

(3) Diagnosis of 1-cycle operation equipment such as press machines, etc. by a pattern monitoring technique is possible: Recognition of the normal operating pattern of the machine (measured data), comparison of that normal pattern with the pattern during ordinary operation, and pass/fail judgment.

(4) Lissajous figure (shaft center track) by simultaneous sampling and operating deflection shapes (animation of machine motion) are possible.

(5) Evaluation by coherence function analysis (confir-

† Originally published in *JFE GIHO* No. 27 (Feb. 2011), p. 58−60

* A patent for "Diagnosis method for rotation machines and its program" has been granted jointly to 3 companies, JFE Steel Corporation, The Tokyo Electric Power Co., Inc. (TEPCO), and Mentec Kiko Corp. (now JFE Mechanical Co., Ltd.) (Japanese Patent No. 4312477).

Table 1 Example of usage

	Level judgment method	Integrated parameter judgment method	Kullback-Leibler divergence method	Pattern judgment method
Rotating machine (Rolling bearing)	◎			
Rotating machine (Sliding bearing)		◎		
Rotating machine (Low speed)		◎		
Reciprocating machine			◎	
Pressing machine				◎
Wide-range changeable velocity				◎

◎：Effective diagnosis technique

mation of coherence of vibration propagation) is possible.

(6) Auto-setting of relative judgment reference values based on data of normal state is possible.

(7) Auto precision diagnosis and analysis: Automatic precision judgment and analysis are possible when an alarm is generated by abnormality cause judgment logic.

(8) Statistical calculation/setting of optimum prediction equation, including autoregressive integrated moving average (ARIMA) model using accumulated data, and prediction of the date on which the limit will be reached is possible.

Examples of application of the optimum diagnostic technique by equipment are shown in **Table 1**.

4. Diagnosis Examples

As results of application to press machines, reciprocating pumps, etc. using the above-mentioned technologies, detection of the following deterioration abnormalities has now become possible.

4.1 Detection of Ball Screw Bending Damage in Press Machine Transfer Unit

Abnormal peak vibration was detected in the vibration waveform measured in a ball screw bearing of the transfer unit shown in **Fig. 2**. Because this occurred during ball screw operation, the existence of an abnormality in the ball screw was diagnosed and a dismantled inspection was performed. As a result, it was found that the ball screw had suffered bending damage, causing heavy movement of the ball screw. When the vibration data were checked again after exchanging the ball screw, the velocity and acceleration values after exchange were 1/8 and 1/20, respectively, of those before exchange (**Fig. 3**).

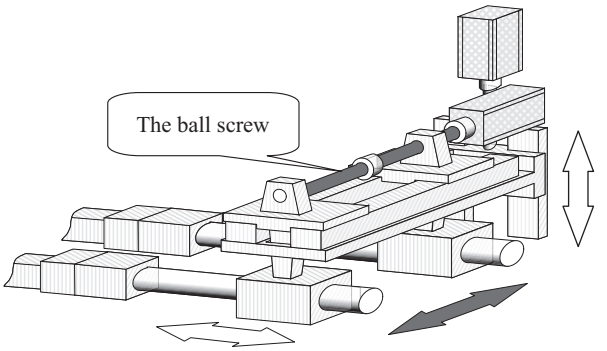


Fig. 2 Transfer device

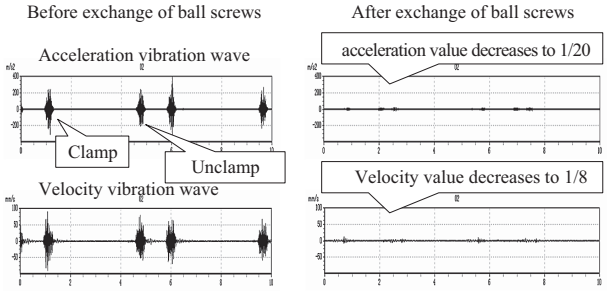


Fig. 3 Before and after the ball screw exchange

4.2 Detection of Metal Abnormality in Press Machine Eccentric Shaft

Figure 4 shows an example of impact vibration caused by backlash between a shaft and the bearing metal caused by wear-out of the bearing metal. The waveforms on the left side of Fig. 4 are acceleration waveforms during the abnormality. The top part shows vibration of the metal casing part. As impact vibration occurred during vertical movement of the shaft, this problem was caused by shaft backlash caused by wear-out of the metal. The lower waveforms show vibration of the clutch bearing during rotation. It can be understood that much impact vibration occurred during one rotation.

The waveforms at the right show the condition after exchange of the metal and bearing. Occurrence of

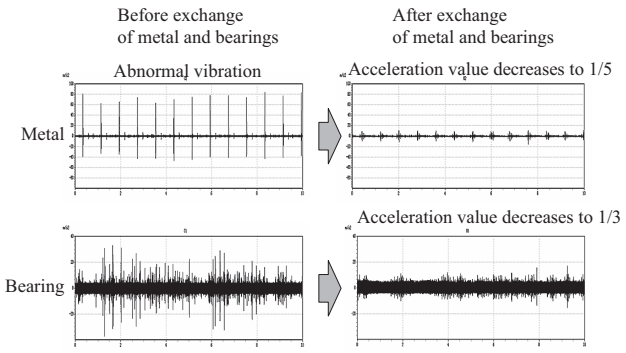
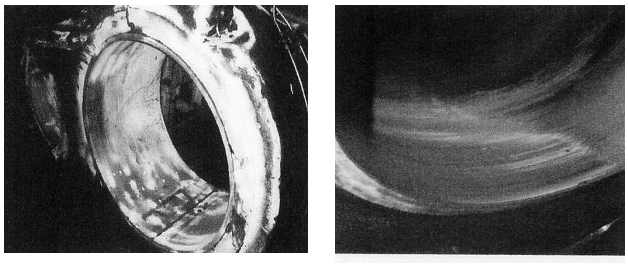


Fig. 4 Before and after the bearing exchange



Metal crack　　Metal wear-out

Photo 2　Wear-out and crack of bearing

impact vibration is slight, and the acceleration values have decreased to 1/5 and 1/3, respectively. As results of the dismantled inspection, uneven wear and crack had occurred in the metal (**Photo 2**), and damage/wear-out and backlash of the outer ring and inner ring track surfaces had occurred in the clutch bearing.

5. Conclusion

The multi-function online monitoring system “Condition-Eye” enables online condition monitoring of all types of mechanical equipment, including condition monitoring of low-speed rotation machines and rotation machines with sliding bearings, which had been difficult to diagnose with conventional technology, and equipment with instantaneous, intermittent, or 1-cycle operation. This system can make an important contribution to stable equipment operation by comprehensively supporting equipment diagnosis technologies.

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