The wireless diagnostic system for motor operated valves

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Abstract: To aim at maintenance optimization, a motor operated valve (MOV) diagnostic system called "MOVDAS" has been developed by using new sensor technologies incorporating torque sensor into the MOV. It has been introduced into nuclear power plants operated by Japan Atomic Power Company (JAPC) for the support of Condition Based Maintenance (CBM). This system, directly checking the torque behavior of the MOV, accurately diagnoses the condition of the MOV during plant operation. Further for the ease of data collection and manpower saving, the wireless diagnostic system based on MOVDAS utilizing Personal Handyphone System (PHS) has been recently introduced into nuclear power plants in JAPC.
Keyword: Condition-Based Maintenance, MOVDAS, build-in torque sensor, wireless diagnostic system

1 Introduction

Motor operated valves (MOVs) are widely used in nuclear power plants for safety injection and isolation, playing safety roles of "Scram", "Cool" and "Containment".

These safety-related MOVs are usually inspected for their healthiness by disassembly. But disassembling the healthy valves may bring about troubles caused by inadvertent human action (setting error, damage of parts, etc.). Analysis of 570 cases of malfunctions since 1988 which were detected prior to failures shows that 70 % of them were due to poor torque control during maintenance outages. The conventional diagnostic devices for MOVs have been partly used for maintenance activity during outage in Japan since late 1980s. However, it was necessary to attach many sensors to MOV drive unit by disassembling. Due to poor work performance, only two MOVs per day could be diagnosed. And they could not be used in surveillance test during plant operation.

In 1998, JAPC decided to develop an in-situ diagnostic system called "MOVDAS" that could accurately detect transitional torque behavior by upgrading the torque sensing technology with the strain gauges. JAPC has been gathering diagnostic data by MOVDAS during operation at Tokai 2 and Tsuruga Nuclear Power Station where 80 to 100 torque sensors have been installed. In 2007, in order to mitigate the burden of maintenance people in charge of diagnosis of MOVs, JAPC developed a remote diagnostic system MOVDAS with wireless and personal computer technique for practical use[1, 2].

2 Development of new diagnostic system

2.1 Points and features

MOVDAS consists of built-in torque sensors and PC based diagnostic system. The developed breakthrough is a new replaceable torque sensors built into torque spring assembly in the existing MOV drive unit. The torque spring assembly equipped on the MOV drive unit (LIMITORQUE type) as shown in Fig. 1 moves toward right and left in proportion to driving torque loaded on a valve stem on valve open-close direction. We developed the new built-in torque sensor composed of 4 strain-gages, mounted inside the torque spring cartridge which directly received the valve load. Accuracy of torque sensor is within ±0.5% of FS (full scale) satisfying IEEE 382 standard[3].

MOVDAS can monitor the valve's health condition and performance at surveillance test during power operation based on actual torque data. Fig. 1 shows torque spring mechanism of Limitorque type MOVs.

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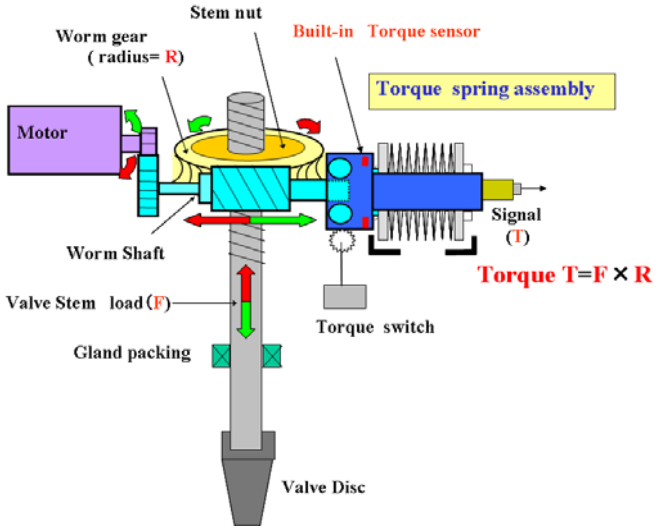

Fig. 1 MOV hardware configuration.

2.2 Outline of diagnostic method

The diagnosis of MOV is performed by tracking the degree of degradation by comparing the torque value and timing of torque waveform with the original healthy base data.

Figure 2 shows a typical torque waveform when a gate valve is moved from full close to full open position. The first half of torque waveform gives much hint about the degradation of the gear transmission mechanism, and the second half tells much about the degradation of valve stem and disc.

If the transmission gear becomes worn, the required time (play away time) between the hammer blow and the valve pulling out would be longer. And if a foreign material causes hang up on the valve disc, the waveform of pulling out torque would be higher.

2.3 Mock-up test results

Figure 3 shows the diagnosis items provided from mock-up test of degradation and failure modes. The test indicated that MOVDAS can diagnose almost all the basic items of both the driving unit and the valve unit through the analysis of the torque waveform.

Figure 4 shows the torque waveform in case of stem nut worn-out. The time difference, $\Delta T1 - \Delta T2$, backlash times between the normal and the worn-out conditions, can estimate amount of abrasion between stem nut thread and stem screw.

2.4 Confirmation of design base performance

As for the reactor safety, safety related MOVs must guarantee design base performance at the condition of maximum differential pressure on the valve in case

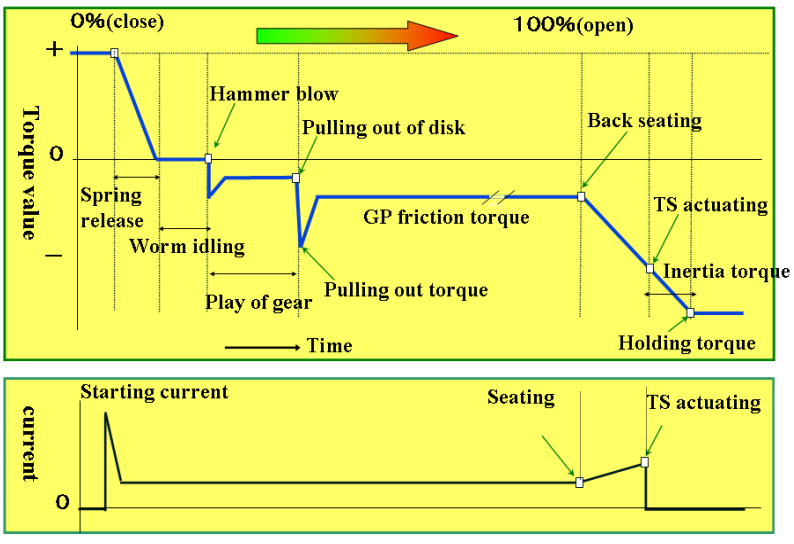

Fig. 2 Typical torque curve of gate valves by MOVDAS.

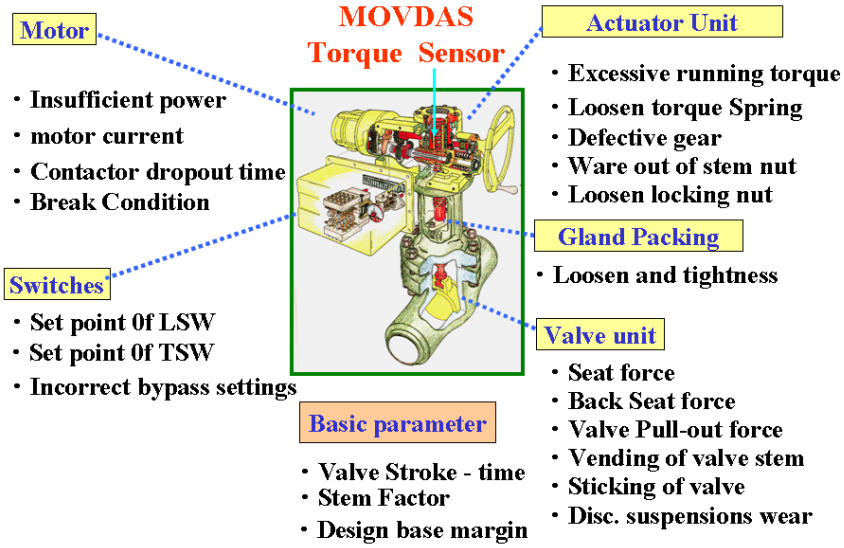

Fig. 3 Diagnosis items.

of plant emergency condition. This system meets the requirements of Generic Letter (GL) 89-10 “Motor-Operated Valve Testing and Surveillance” and GL 96-05 "Periodic Verification of the Design-Basis Capability of Safety-Related Motor Operated Valves", issued by USNRC.

3 Development of wireless remote diagnostic system

3.1 Background of the development

To analyze MOV data, MOVDAS uses vibration signal and motor magnetic signal in addition to the torque signal at the MOV. The prototype MOVDAS was a portable equipment requiring some manpower to gather certain data on site. When MOV was actuated, it was difficult to obtain data at the high radiation area, and was necessary to develop remote diagnostic system.

3.2 Outline of wireless remote diagnostic system

Figure 5 shows the wireless remote diagnostic system.

As JAPC already has PHS phone network system with almost 200 antenna units stretched over each site, it was advantageous to apply it to MOVDAS data transmission. It has been verified so as not to generate noise to influence the nuclear instrumentation system.

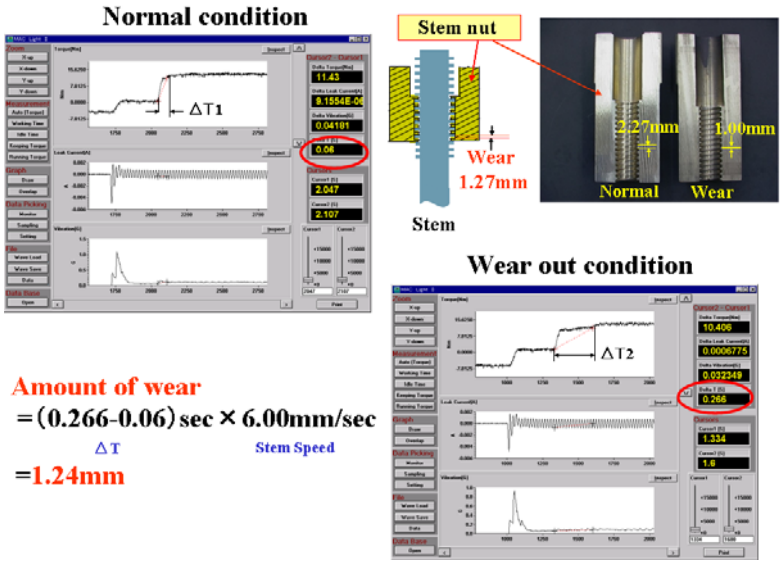

Fig. 4 How to check wear of Stem Nut.

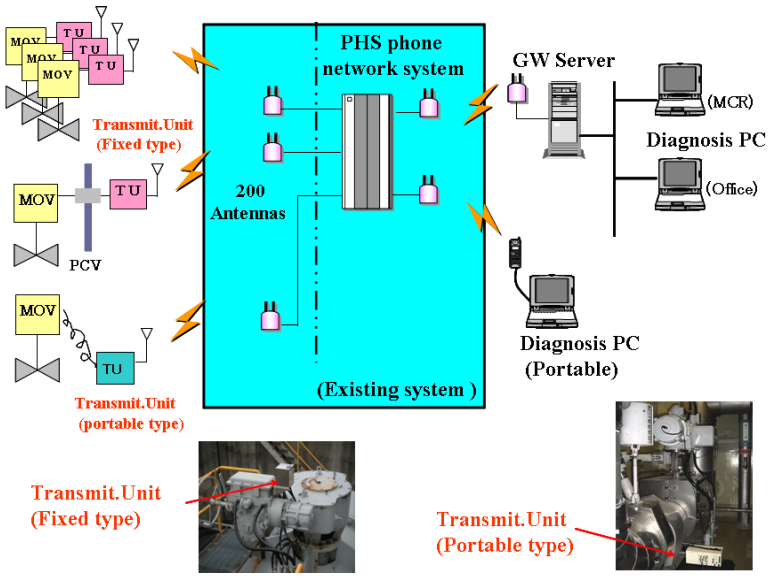

Fig.5 Example of MOV wireless remote diagnostic system.

The remote diagnostic system has automatic health monitoring functions based on sensor signal data such as driving torque, motor current(motor magnetic) and vibration of each MOVs. We can use two types of transmission unit, fixed type and portable one.

When the monitored MOV is actuated to move, it automatically starts to collect data and sends them to the gateway server with ID number of the MOV. The diagnostic PC connected to LAN analyzes the data for the trending of degradation of MOVs. This system makes diagnostic report automatically (Fig. 6).

4 Conclusions

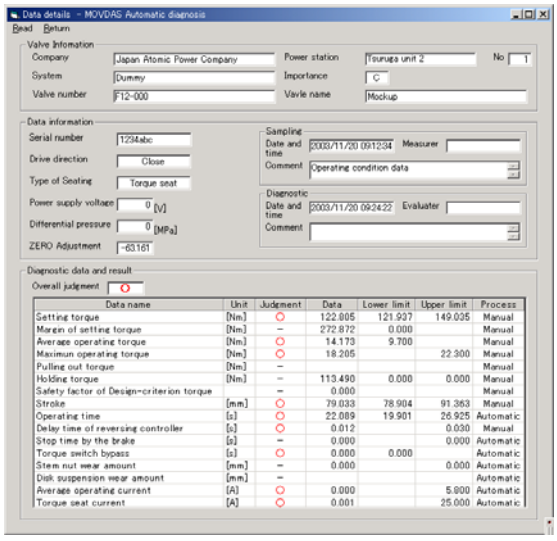

Fig. 6 Example of diagnostic report.

MOVDAS can measure, even during plant operation, the driving torque by the torque sensor installed on the MOV. This is the key reason for the success of MOVDAS. The measured torque waveform makes it possible to diagnose the valve drive unit and valve unit in totality. By this sensing technology and computing technology, it will be possible to visualize the invisible situation, especially the inside condition and degradation of valve unit and to achieve the optimizations of disassembling inspection frequency of MOVs.

MOVDAS can detect various failures and can diagnose degradations. And it will be possible to know the performance of the safety related MOVs under design basis conditions by the surveillance test during operation.

With rapid progress of wireless technology and IT, we expect that the intelligent valve combined with sensing technology and IT would be realized making it possible to reduce the MOV's cost by down-sizing of valve drive unit.

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