Study on the signatures for a Magazine

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1. Introduction

In this paper, diagnostic algorithms are developed to be utilized to monitor the condition of and to diagnose defects in the magazine of a fuelling machine installed in CANDU plants. The magazine plays a role in storing fuels, plugs and tools. Since the magazine operates in the high radiation area, it is impossible to give direct access to it for measuring the signals. Therefore, inlet and outlet pressures of a hydraulic motor, which can be acquired remotely, were selected as the measuring variables. The measured signals are further processed to extract the diagnostic signatures. They were examined and validated in the various experiments with the magazine mock-up.

2. Mock-up of the magazine assembly

To study the gradual degradation and defects occurring in the magazine assembly, a half-size mock-up was designed and built in the laboratory. The magazine assembly is driven by hydraulic power and consists of a hydraulic motor, a worm reducer, a ferguson indexing driver, a rotor, 12 stations, a spider assembly and housings. The stations store new and spent fuels, plugs, and tools for the purpose of refueling[1]. The channels can align easily within the dwell period. The dwell indicates when the rotor assembly doesn't move during the rotation of the motor. Figure 1 shows the side-view picture of the magazine mock-up.

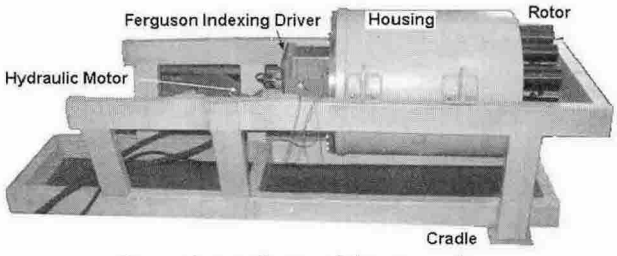

figure 1. mock-up of the magazine

3. Diagnostic signature

In order to diagnose the fuelling machine, it is necessary to monitor the change of the load on the drive trains. The motor torque is a very useful physical quantity to look into the conditions of the magazine. Since no access is allowed during operation, the torque as a diagnostic signature should be obtained non-invasively and remotely. The torque(T) of hydraulic motor can be obtained by the following general equation (1).

$$T = \eta_m \frac{DP \cdot q_m}{2\pi} \quad (1)$$

Where DP is the differential pressure served with the motor and η_m is the mechanical efficiency. q_m is the displacement.

Since the efficiency and the displacement of motor hardly vary in the working range, the differential pressure can be considered as the diagnostic signature. The DP(Differential Pressure) signature is processed to diagnose the magazine effectively using the developed method.

4. Experiments

The experiments were carried out with the mock-up of the magazine assembly in the various conditions including defective conditions. The several sensors were attached to measure pressure, acceleration, displacement, rotation and so on. The pressure sensors were installed in the manifold of hydraulic power pack and encoders were installed in the indexing cam shaft and the rotor. Several accelerometers were attached outside of the gear boxes and housing. The measured signals such as displacements, rotations and accelerations are used to verify the validity of the developed diagnostic algorithms using motor torque signature. Following chapter discusses the experimental conditions and the results.

5. Results and analyses

5.1. Effect of lubrication

The loading conditions are controlled by the housing pressure and weight distribution of the channels. As the load increases, so does the difference of the DP as shown in Figure. 2. However, the DP indwell region does not increase as the load does. Since the loading does not affect the rotational torque in the dwell region. The DP in dwell region is good signature to indicate the rotating torque for the free loading condition whatever the loading conditions are. Therefore the level of the DP signature in dwell region is a good indication of the condition of lubrication

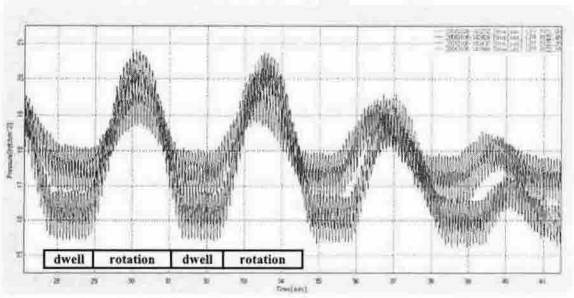

figure 2. DP signatures when the magazine rotates

5.2. Monitoring the pressure margin

The motor torque is generated by the pressure difference between the inlet and the outlet. Therefore for the same loading condition, the outlet pressure decreases as the inlet pressure decrease to generate the same torque. However, there is limitation in the outlet pressure to operate properly. Figure 3 shows the outlet pressures according to 5 evenly decreasing inlet pressures. For the low inlet pressure, outlet pressures do not decrease as the inlet pressure. Instead they require more time to rotate the full cycle. This indicates the limitation of inlet and outlet pressure which should be maintained. From these limitation pressure margin can be monitored.

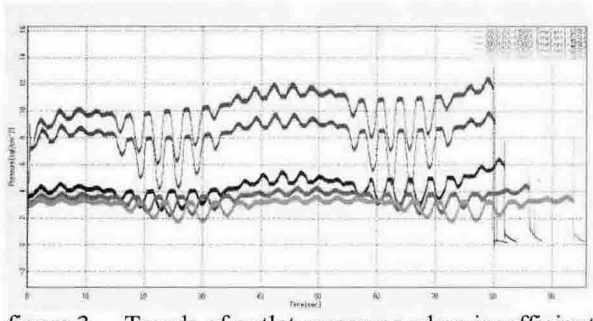

figure 3. Trends of outlet pressures when insufficient inlet pressures are served

5.3. The alignment of the channels

The magazine is controlled to align between channels during dwell by the operating computer. Before the long-time operation, the magazine is calibrated to stop in the middle point of the dwell interval. But, the adjusted and aligned system can be changed by the environment as time goes by. The upper arrow in the dwell part of figure 4 indicates the exact middle point of the rotation of the motor in the dwell. The breakpoint should be monitored to be located near the mid-point by the periodical check-up.

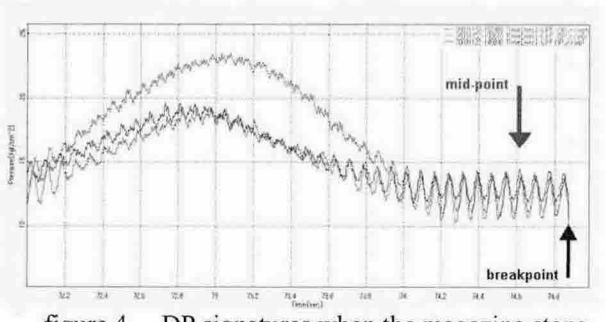

figure 4. DP signatures when the magazine stops

6. Conclusion

The DP signature is used to diagnose diagnosing the magazine assembly remotely and non-invasively. Several degraded or defected conditions are considered and the diagnostic signatures are obtained for the defective cases which are simulated in the mock-up. This study discusses how to analyze the diagnostic signatures which is necessary to develop a diagnostic system of fuelling machines. The diagnostic system will lead to the efficient maintenances, which results in the enhancement of plant safety and maintenance cost.

7. Acknowledgements

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