MOTOR-OPERATED VALVE PERFORMANCE TESTING AND CONDITION MONITORING USING DATA FROM THE MOTOR CONTROL CENTER

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ABSTRACT

Much progress has been made over the past 20 years at CANDU® nuclear stations to understand and improve Motor-Operated Valve (MOV) performance and reliability. If set up properly, most MOVs show very repeatable and predictable results when tested during outages. In fact, it is believed that, to some extent, a few of the encountered MOV failures stem from repeated maintenance operations and intrusive test methods.

In this context, the potential for assessing MOV performance and monitoring their condition using electrical data acquired at the Motor Control Center (MCC) has generated considerable interest over the past few years. The overall approach consists of acquiring current and voltage signals at the MCC to derive motor power and motor torque traces. A correlation between the output parameters typically measured at the valve and the derived motor data is usually established through initial baseline tests. Following subsequent tests at the MCC, several valve performance indicators are derived using the original baseline data and the newly acquired MCC data to assess the valve performance and monitor its condition.

The potential benefits from acquiring data at the MCC are the increased trending/monitoring capability and also the cost savings associated with the potential identification of MOVs that may not need "at-the-valve" testing as initially scheduled. This would help reduce maintenance costs and radiation exposure to personnel.

At CANDU stations, MOV testing is currently performed almost exclusively at the valve. Voltage and current are occasionally measured at the MCC to generate motor power traces, but not with the intent of performing extensive MCC-based valve diagnostics since most CANDU stations have yet to acquire the tools required for this type of analysis. In this context, a COG (CANDU Owners Group) R&D program was launched to assess the potential and reliability of the various methods/systems used for MCC valve diagnostic testing.

This paper summarizes the results of investigations conducted to validate the methodology, recommends the best practices, and helps the stations implement maintenance programs that can take advantage of this diagnostic approach.

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INTRODUCTION

In 2005, the Valve User Working Group (VUWG) recommended that a CANDU Owners Group (COG) R&D program be initiated to assess the potential and reliability of various methods/systems that can be used for valve diagnostic testing performed from the Motor Control Center (MCC).

A preliminary study was launched at Atomic Energy of Canada Limited (AECL) to gain a better understanding of what methods and techniques were generally available for assessing valve performance and for monitoring valve condition from the MCC. Following this initial review phase, work focused on surveying the commercially available tools, reviewing what was being done in other countries, and discussing the potential for future implementation at CANDU stations.

In 2007/08, several preliminary validation tests were performed at AECL Chalk River using a fully instrumented Motor-Operated Valve (MOV) test rig and an MCC data acquisition system to assess the reliability of this diagnostic technique. Thrusts measured at the valve were compared with thrusts derived from the acquired electrical data, and known defects and degradations were artificially implanted to check the sensitivity of the diagnostic tool. A strategy was also defined for the future implementation of MCC-based MOV diagnostics at the CANDU stations.

The outcome of the initial review, testing, and validation work performed at AECL over the past two years is summarized in the following sections of this paper.

MOV OVERVIEW

Operating Principles

A motor, an actuator and a valve body are the main components of a motor-operated valve. The motor torque output is used to drive the actuator via a pinion gear and a gear train, which in turn drives a worm splined onto the opposite end of a worm shaft. The worm moves axially along the splined shaft. During this phase, the worm drives a worm gear that rotates a drive sleeve/stem nut assembly. The worm also compresses a spring pack that is used to de-energize the motor via a torque switch. The stem nut drives the valve stem up and down. Typically, the torque switch is preset to restrict the amount of thrust exerted by the actuator to shut the valve properly. A limit-switch drive gear is used to stop the valve at the end of the close-to-open stroke. Packing material stuffed around the stem is used for sealing the valve.

Key Parameters and Events

Upon discussion with the station valve users, it appeared that rising-stem motor-operated gate valves would initially be targeted for the potential use of MCC diagnostics. Therefore, for this investigation, the description of key parameters and typical events will be limited to this type of component.

When the signal to close a rising-stem gate valve is sent, the motor starts moving and the spring pack force is relieved in the actuator. At this time, the only load on the motor comes from turning the gears inside the actuator (also called Hotel Load). When the worm gear lugs engage the drive sleeve lugs (Hammer Blow), the stem nut starts moving, its tension is relieved, and the thread reversal phase starts (zero stem load area) until the stem nut starts pushing on the stem. Once the stem/disc clearance is picked up, the disc starts moving as well. For static conditions (no differential pressure (ΔP) from the fluid), the stem load observed during this stem movement corresponds to the packing friction load (also called Running Load). This load remains fairly constant until the disc contacts the seat. At that point, the load rapidly increases (Seating Load) until the torque switch trips, the motor shuts down, and the motor inertial effects stop. For dynamic conditions (presence of ΔP from fluid) there is an additional stem load present due to the line fluid pushing on the stem (piston effect/stem rejection). As the disc starts throttling the flow (ΔP load), the load starts increasing gradually. Once the disc contacts the seat, the load increases rapidly up to the trip point, as previously described for the static case. The load at torque switch trip is one of the key parameters monitored.

When the signal to open a rising-stem gate valve is sent, the motor starts moving and the spring pack force is relieved in the actuator. Following Hammer Blow, the stem nut starts moving and the large stem compression is relieved. At thread reversal the stem/stem nut clearance is picked up (zero load condition). Once the stem/disc clearance is picked up, the stem starts pulling the disc for unseating. For the no-flow condition, this corresponds to a thrust peak followed by a return to the packing friction load until the limit switch trips and the motor shuts down. For the dynamic condition, the unseating thrust peak is followed by a slower return to the running load level as the pipe opening starts to uncover. In both cases, the unseating thrust peak is a parameter commonly monitored for opening cycles.

Typical Modes of Failure and Reported Component Degradation

Six typical modes of MOV failure are usually encountered: failure to open, failure to close, failure to operate as required, plugging (failure to remain open), internal leakage, and external leakage [1]. Many components can potentially degrade and lead to decreased performance and/or failure.

Corrosion and/or wear of the valve seat or degradation of the guides can affect valve performance and result in valve leakage.

Changes in packing load and/or degradation of the packing can result in leaks and/or hour-glassing of valve stems and can also affect valve margin.

The properties of the grease used at the stem/stem nut location can change over time and affect the transformation of actuator torque to stem thrust. Excessive stem nut wear may also degrade the lubricant properties. The lubricants used in the actuator can affect its efficiency if they degrade (gear box and limit switch box).

A screw or locknut that becomes loose can affect the valve set-up and performance (loosened stem-nut locknut or loosened torque switch setting screw). This is often caused by excessive vibration. Other reported degradation potentially caused by vibration includes the wearing/corrosion of limit switch contacts.

In the actuator, excessive spring pack relaxation may affect the thrust developed at torque switch trip. Other components in the actuator may degrade and have an impact on actuator efficiency and valve performance. Degraded actuator parts reportedly replaced at CANDU nuclear stations in the past include the motor, the motor pinion gear, the worm shaft gear, the worm gear, and bearings.

Other problems may also stem from more drastic deteriorations, such as a bent stem or a cracked yoke.

REVIEW OF OVERALL METHODOLOGY FOR MCC-BASED MOV DIAGNOSTICS

Motor Power Monitoring (MPM) Method

The MPM method is based on the correlation of motor power and stem thrust [2]. It consists of acquiring a thrust trace at the valve and concurrent motor power trace at the MCC to determine the thrust at torque switch trip for the selected MOVs.

The thrust trace is analysed to determine the amount of time between the point indicating hard seat contact and the torque switch trip point. The corresponding thrust/time relationship is derived, as well as the average running load (packing load) prior to hard seat contact [2].

During a subsequent performance test, motor power data acquired at the MCC are analysed to determine the amount of time between hard seat contact and the torque switch trip point. The thrust/time relationship is then used to determine the new thrust at torque switch trip. Therefore, this method can be used to trend the amount of thrust developed at torque switch trip without having to go back to the valve. The comparison of actual and reference thrust data is used as the basis for valve diagnostics.

Motor Torque Method

The Motor Torque Method is based on the use of upper and lower motor torque set points converted from the existing stem thrust and stem torque initial set points. The conversion factor is based on the overall actuator gear ratio and on representative values of actuator efficiency and stem factor (actuator torque/actuator thrust). The stem factor and actuator efficiency are obtained through direct measurement (at-the-valve) for a few selected MOVs to determine conservative values to be used for the conversion [2].

The relationship between stem thrust and motor torque is described by the following equations [2]:

$$ActuatorTorque = MotorTorque \times Ratio \times Efficiency$$

$$Thrust = \frac{ActuatorTorque}{StemFactor}$$

$$or$$

$$Thrust = MotorTorque \times Ratio \times \frac{Efficiency}{StemFactor}$$

During a performance test at the MCC, the motor torque data are estimated based on electrical measurements (input motor power, motor current and other nameplate and motor curve data) and are compared to the lower and upper motor torque set points to ensure that positive margin exists. The performance tests include an assessment of motor torque during running, seating and unseating of the valve. The motor torque at actuator torque switch trip is also analysed to confirm that the motor has sufficient power to trip the torque switch. The performance test accuracy can be improved if previous at-the-valve data are available to estimate the expected thrust overshoot due to motor inertia. Additional motor capability tests may be performed during valve operation under degraded voltage conditions to confirm that positive margin exists [2].

Correlated Thrust Method

For the Motor Torque Method described above, the motor torque upper and lower set points are calculated directly from the stem thrust and stem torque set points. For the Correlation Method, the overall relationship between actuator output thrust and motor torque is based on an initial at-the-valve and MCC test. Data from this test are used to create a linear curve fit of the relationship between actuator output torque and /or stem thrust and the estimated motor torque. A representative correlation factor is developed. During a subsequent performance test, motor torque data are acquired from the MCC and the available correlation coefficient is used to derive stem thrust and stem torque. As for the Motor Torque Method described above, when determining thrust at actuator torque switch trip, the correlation can be refined if previous at-the-valve data are available to estimate the expected thrust overshoot due to motor inertia [2]. The upper and lower set points are usually adjusted to take into account the additional uncertainties from the MCC-based analysis process (uncertainty of correlation method, uncertainty due to potential variations of stem factor and actuator efficiency over time). At subsequent MCC measurements, the derived correlated thrust is checked against the adjusted thrust set points to assess valve margin. As well, the estimated motor torque at torque switch trip is checked against the reduced voltage motor torque. At subsequent outages, it is useful to perform a new parallel test and establish a new correlation. The correlation factor can then be adjusted to account for expected changes over time.

Discussion

For MCC-based MOV performance testing, it appears that motor torque signature is more reliable than motor power or motor current signature. The current signature may not always properly track the valve loading variations [3]. Furthermore, the torque signature generally seems to be less noisy and shows higher sensitivity to valve load changes. Another advantage of the motor torque measurement is that it is less sensitive than the motor power signature to changes in load on the motor. As a result, the linearity of the relationship between the MCC-derived parameter and valve loading is less affected by motor load changes when using motor torque [3]. The motor torque signature is also much less affected by potential changes in input voltage [3]. Changes in power level could, therefore, be attributed to several factors other than changes in valve loading conditions. This is a limiting factor to widespread use of motor power for MOV condition monitoring.

The reliability of the Motor Torque Method is tied to the accuracy of the parameters measured at the MCC and to the awareness of how the two main coefficients used for the direct thrust calculations (i.e., the actuator efficiency and the stem factor) may vary over time or as a function of increased duty. The accuracy of the predicted thrust can also be improved through adequate knowledge of the rate of loading characteristics for the type of stem tested, of the expected thrust overshoot due to motor inertia, and of the typical variations expected in the torque switch trip value.

When using the Correlated Thrust Method, sufficient margin must be allocated to account for the correlation method uncertainties and for uncertainties related to potential variations of actuator efficiency and stem factor. The upper and lower acceptable motor torque limits are usually adjusted to account for these uncertainties. This automatically results in tighter motor torque limits compared to the thrust limits used for direct assessment of the thrust at the valve. When the limits are more restrictive, it is easier to fall outside. In the case of MCC-based data, the results can certainly be deemed conclusive if the data lie within the imposed limits. However, if the data were found outside the limits, it would be hard to draw conclusions since the real thrust data may still be within the acceptable thrust limits.

RESULTS OF PRELIMINARY LABORATORY VALIDATION TESTS

The objectives of this section are to summarize the preliminary results of tests performed to assess the CRANE Nuclear MCC-based diagnostic system in the AECL MOV test rig. The experimental set-up consists of an 8-inch VELAN gate valve, a Limitorque SMB-0 actuator, a CRANE MOVATS torque/thrust cell connected to a VIPER 20 CRANE Nuclear acquisition system. A photograph of this test rig set-up for the acquisition of torque, thrust, and electrical data is shown in Figure 1 below.

For the first phase of the validation process, the focus was on assessing the repeatability of MCC data, and checking what aspects of the valve condition could be identified/detected using the estimated motor torque signature. This included the implantation of known defects and degradations to check the sensitivity of the diagnostic system (loose stem nut locknut, changes in packing gland stress, and changes in stem/stem nut lubricant).

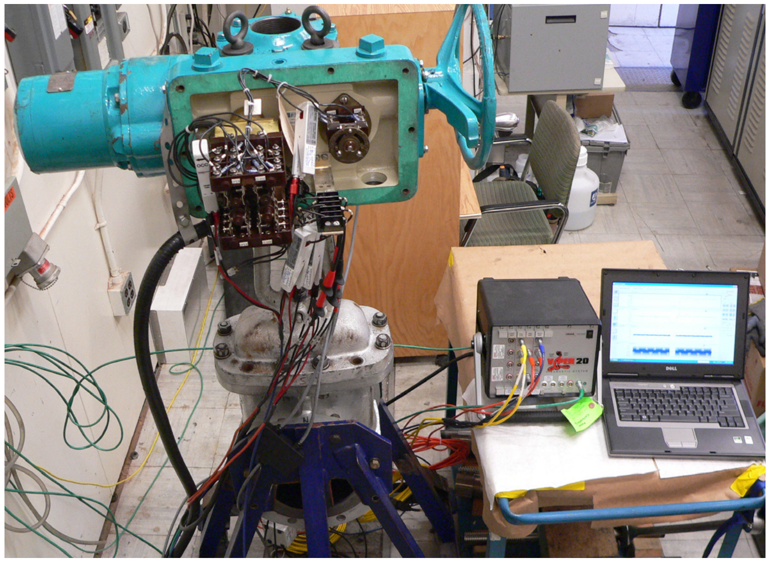

Figure 1 Photograph of the AECL Test Rig Used for the Preliminary Validation Work

Determination of Actuator Efficiency

One of the key features of the CRANE Nuclear MCC-based MOV diagnostic system is the generation of estimated motor torque signatures. This means that, with knowledge of the overall actuator ratio, and assuming that the Torque Swich Trip (TST) actuator torque can be measured at the valve, MCC data can be used to derive the corresponding TST motor torque and calculate the actuator efficiency.

Parallel electrical, stem thrust, and actuator torque data were acquired at AECL using the MOV test rig. The estimated motor torque signature was generated using the electrical data and the CRANE Nuclear software. The actuator efficiency is shown in Figure 2 for the end of the running load and for the seating portions of the closing stroke. Based on this graph, the actuator efficiency derived during the seating portion ranged from 0.35 to 0.40. Therefore, MCC data can be used to monitor actuator efficiency over time.

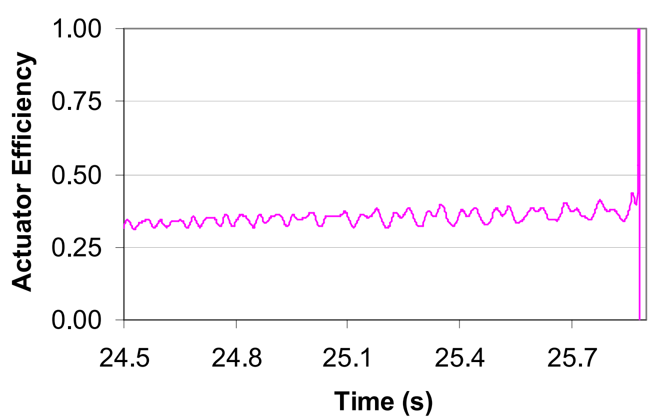

Figure 2 Derived Actuator Efficiency for the Seating Portion of a Closing Stroke

Repeatability of MCC Data

The objective was to compare the estimated motor torque data for cycles showing very repeatable thrust and actuator torque signatures. The estimated motor torque traces were generated for three consecutive cycles. An overlay graph is shown in Figure 3. The results show good repeatability for this parameter.

Comparison of Static and Dynamic Test Results

The MOV test rig was used to generate two successive cycles: one for no-load conditions (static cycle) and one using a side loading system to simulate the presence of a ΔP from a fluid. This method to simulate the ΔP effects was developed as part of a previous stem/nut grease qualification test program [4]. The estimated motor torque signatures were generated for the two different types of cycle. An overlay graph is shown in Figure 4. This graph clearly shows that MCC data can be used to perform a qualitative assessment of valve performance under flow conditions (determination of presence or absence of flow, assessment of proportion of ΔP load and seating load prior to reaching the torque switch point, etc.).

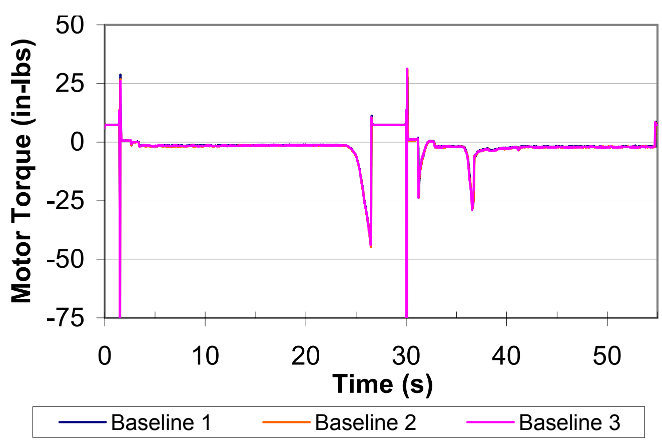

Figure 3 Estimated Motor Torque Signatures Overlaid for Three Consecutive Cycles

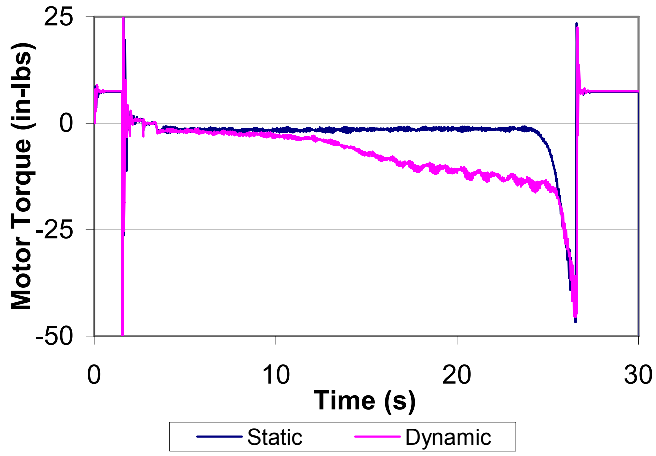

Figure 4 Overlaid Static and Dynamic Estimated Motor Torque Signatures

Correlated Thrust Method Applied to Two Consecutive Cycles

A correlation was derived between the estimated motor torque and the measured stem thrust using signals from a first cycle. This was done using a CRANE software routine applied to the end of running load and the full seating portion of the closing stroke. A predicted correlated thrust signature was then derived for the next cycle using the estimated motor torque obtained for that cycle and the correlation previously established for the first cycle. The correlated thrust and measured thrust signature are shown for the second cycle in Figure 5. The predicted thrust at TST for the second cycle was 80.6 kN (18,150 lbs). The actual measured thrust at TST for the second cycle was 81.5 kN (18,341 lbs). Therefore, there was approximately a 1% difference between the predicted and the measured TST stem thrusts. Of course, this is an ideal case where the cycles compared were consecutive, acquired within a very short period of time, and were very similar. Therefore, a good match of predicted and measured thrusts was expected in this case.

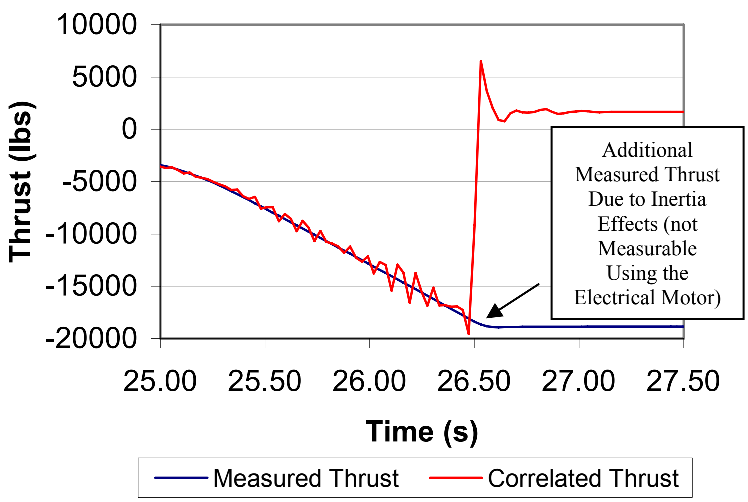

Figure 5 Correlated and Measured Thrust Signatures for the Second Cycle

Correlated Thrust Method Applied to Two Non-Consecutive Cycles

An MOV test program performed at AECL to characterize the performance of stem/stem-nut greases was used to validate the correlated thrust method for non-consecutive MOV cycles. For these tests, 47 cycles were performed between the pre-test (when the baseline data was acquired and the correlation established) and the post-test (when the thrust was predicted using the MCC data). The actuator and valve body were unchanged throughout this test program but a variety of stem geometries were used (various stem diameters, stem pitches, and various numbers of starts).

The comparison of predicted versus measured stem thrusts is shown in Table 1 for five of these MOV stem/stem-nut lubrication tests along with the ideal case described above for two consecutive cycles (Test 1).

Table 1
Comparison of Predicted and Measured Thrusts

Pre Test		Post Test			
Measured Thrust (lbs)	**Number of Valve Cycles Between Pre-Test and Post-Test**	**Predicted Thrust (lbs)**	**Measured Thrust (lbs)**	**Absolute Error (lbs)**	**Relative Error (%)**
18226	**Test 1** (2 Cycles)	18150	18341	-191	-1.0
19288	**Test 2** (47 Cycles)	18693	19920	-1227	-6.2
13622	**Test 3 (47 Cycles)**	13231	13726	-495	-3.6
17679	**Test 4 (47 Cycles)**	17742	17655	86	0.5
19749	**Test 5 (47 Cycles)**	19828	20504	-676	-3.3
21745	**Test 6 (47 Cycles)**	21251	21964	-712	-3.2

After each 47-cycle test, the stem thrust predicted using the MCC-derived motor torque and the pre-established correlation was in good agreement with the corresponding stem thrust measured at the valve. The average discrepancy of results between the predicted and measured values was 3.4% and discrepancies ranged from 0.5 to 6.2%.

Simulated Degradation and Implanted Defects

The objective of this evaluation was to check what type of valve degradation or defects could be adequately identified/detected using the estimated motor torque signature derived from MCC data.

The first defect implanted was the loosening of the stem-nut locknut. The estimated motor torque signatures for the baseline and as-left conditions are compared in Figure 6. The trace obtained after loosening the locknut clearly shows increasing thread reversal duration (both for the closing and opening sequence). This large increase is typical of this type of defect and can be easily detected using MCC data. If a smaller increase is detected and the locknut is tight, then the increased duration could result from increasing stem nut wear.

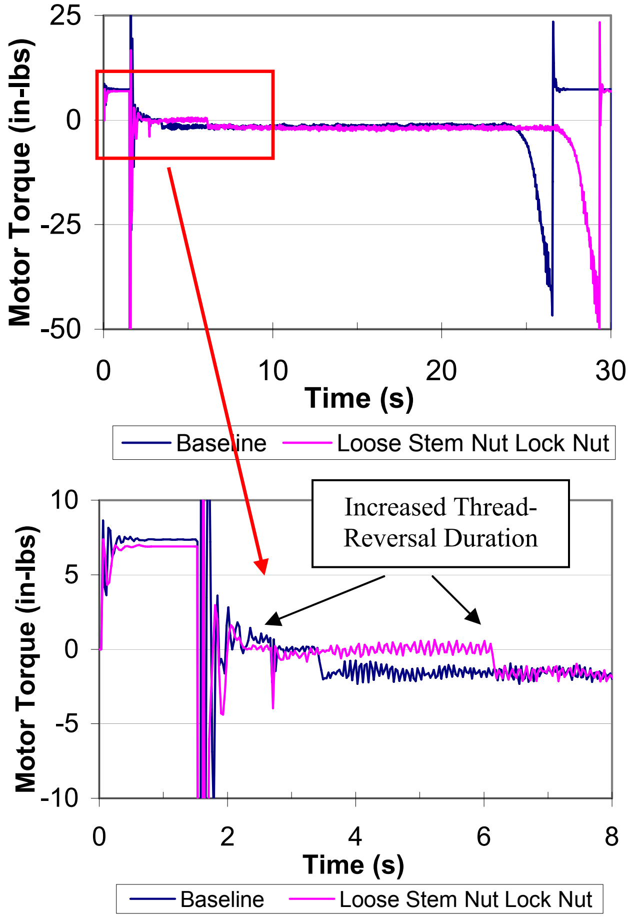

Figure 6 Detection of a Loose Stem-Nut Locknut Using the Estimated Motor Torque Signature Derived from the Electrical Data

The next simulated degradation was a change of packing friction. This was achieved by purposely loosening or tightening the packing gland nuts to lower or increase the packing gland stress and simulate packing friction changes that may occur over time. The reference packing friction force, F, was approximately equal to 1200 lbs. The first simulated case was for a packing friction divided by a factor of two from the reference load. The second case was simulated to show the effect of increasing the packing friction by a factor of two from the reference load.

The three thrust signatures (focusing on the running load portion of the closing stroke) are shown in Figure 7. The average thrust values are directly affected by the change in packing gland stress. Since the stem/stem-nut coefficient of friction is unchanged throughout this test, the actuator torque signatures would show similar variations, and, therefore, the motor torques should also be affected by these packing friction load changes.

The three estimated motor torque signatures were then generated and overlaid as shown in Figure 7. The trend is similar to what was observed for the thrust signatures. The graph clearly shows that a significant change in packing friction can be identified using the estimated motor signature derived from the MCC electrical parameters.

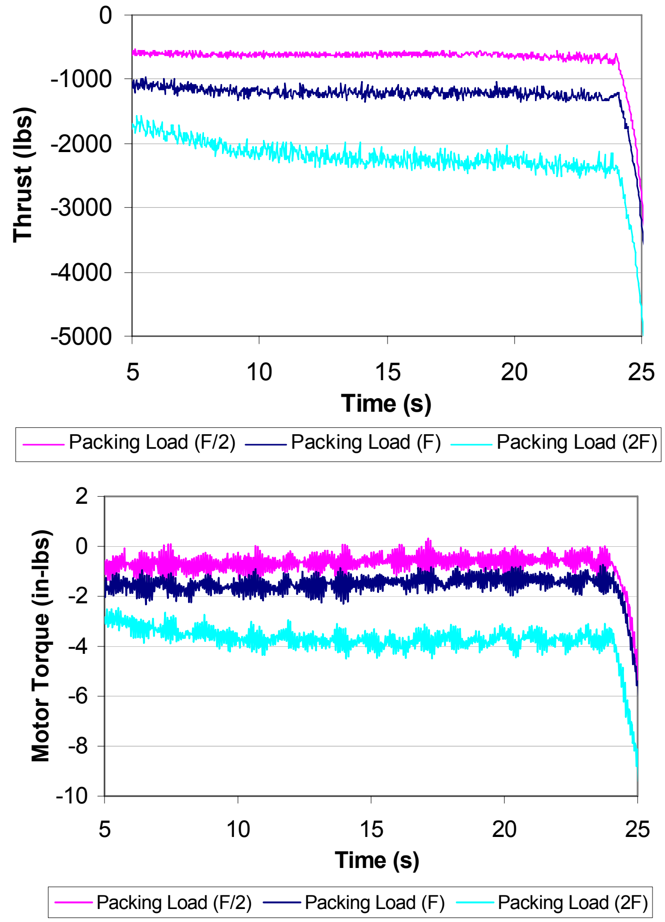

Figure 7 Effect of Changes in Packing Load on the Average Running Thrust and Estimated Motor Torque

The last modification to the original set-up was an induced degradation of the stem/stem-nut lubrication characteristics. This was achieved by adding some grease solvent at the stem/stem-nut interface. The end result was an increase in stem/stem nut friction coefficient from the original set-up (32% increase in the running portion of the stroke and 50% increase near TST). The increase in friction coefficient in the running portion is shown in Figure 8. Since the thrust resulting from the packing friction load generated during the running load portion of the stroke remains constant whether the stem/stem-nut grease degrades or not, the grease degradation will cause an added demand on the torque required to overcome this packing thrust. Therefore, this increase should be observed when looking at the motor torque signatures.

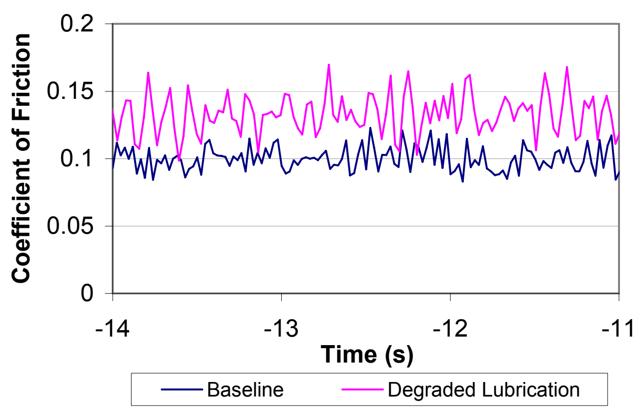

Figure 8 Increase in Stem/Stem Nut Friction Coefficient Resulting from Degraded Lubricant

An estimated motor torque signature was generated for each of the two above conditions. The overlaid signatures are shown in Figure 9. As expected, the change in motor torque due to the degraded grease can be clearly identified in the running load portion of the closing stroke (increase in average motor torque of 37%).

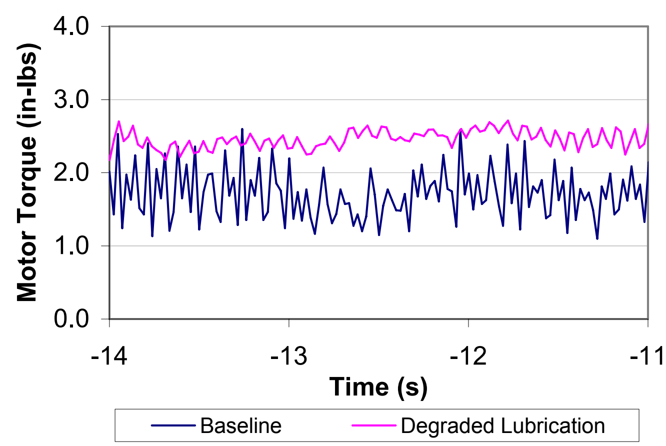

Figure 9 Effect of Degraded Stem/Stem Nut Lubricant on the Average Motor Torque Estimated During the Running Load Portion of the Stroke

STRATEGY FOR IMPLEMENTATION AT CANDU STATIONS

Current Practices

At CANDU stations, MOV performance testing is currently performed almost exclusively at the valve. Most stations are equipped with valve diagnostic tools initially developed for at-the-valve testing. These tools include hardware used to acquire electrical data at the actuator or from the MCC. At the stations, voltage and current are occasionally acquired from the MCC to generate motor power traces, but not necessarily with the intent of performing extensive MCC-based valve diagnostics.

Thrust measurement at the valve is difficult, time consuming, and expensive. It involves time to erect and disassemble scaffolding and/or shielding and time to do the set-up and perform the test. In the end, the cost to perform a test can be up to 25 times less when using MCC-based measurements [5].

Selection of Valve Candidates

The criteria for selecting appropriate groups of valves on which to implement this type of diagnostic program were based on discussions with valve users and MCC diagnostic tool vendors.

The first criterion stems from the basic need for monitoring valves. In that respect, safety-related valves are prime candidates since additional effort to monitor their performance and the condition of their components could be easily justified. For safety-related valves, subjected to regularly scheduled preventive maintenance, field data tend to show that MOVs do not undergo significant changes between subsequent at-the-valve performance tests [6]. This finding provides a possible justification for increasing at-the-valve test intervals and scheduling MCC-based tests in between [7].

Secondly, it would be preferable to choose a group for which at-the-valve testing is difficult/costly (for example, because of access problems or relatively high radiation fields). Focusing on these valves would be the best way to demonstrate the cost benefit associated with the introduction of MCC testing. Beyond the cost benefits associated with this type of maintenance approach, there may also be some technical benefits. Feedback from stations seems to indicate that repeated at-the-valve testing at relatively short intervals on the most critical valves may increase the risk of introducing damage or set-up changes (human factor risks) that can actually increase the overall risk of equipment unavailability [6].

Thirdly, it would be best to concentrate on valves that show reasonably high margin (above 20% at first) because of the added uncertainties associated with measurements taken at the MCC.

Finally, it is important to target a group of valves that are stroked frequently (for example several times a month) and visited/tested at the valve relatively frequently (for example every outage). A large amount of data would then be available to validate the approach and do proper trending of both valve performance and component health. Also, wearing components would more likely be detected on a group of valves that are stroked often.

The authors approached MOV specialists from several CANDU stations to identify groups of valves that meet some of the criteria outlined above. MOVs used in the maintenance cooling system would be good candidates because they are located in a fairly high-dose environment and are stroked once a month on average. They typically show fairly high margin and are routinely visited for at-the-valve performance testing. Another targeted group of valves would be from the Emergency Cooling Injection (ECI) System. These valves are stroked on average twice a month. Their typical margin is 35 to 40% and the cost of at-the-valve testing is relatively high in this case. Generally, most MOVs installed in access-controlled areas would be of interest for this type of diagnostic program.

Recommended Approach for Implementation of a Pilot Study

The first step would consist of continuing the analysis of available MCC data to further validate the methodology and provide additional evidence that predicted thrusts usually are in good agreement with the corresponding measured thrusts.

Once the preliminary validation work are completed and once the targeted groups of valves are selected, some pilot valves would be equipped with torque and thrust measurement systems and baseline data would be generated simultaneously at the valve and at the MCC. Using this data, a correlation would be established between the motor torque measured at MCC and the thrust measured at the valve. At that time the actuator efficiency and the stem factor would also be derived and entered into a database.

During the interval between two outages, data would be acquired from the MCC on a regular basis when the valves are stroked to monitor performance and condition. The correlation established earlier using the baseline data would then be used to derive a predicted stem thrust. The predicted value would be checked against thrust set points previously adjusted (narrowed) to take into account the added uncertainty inherent to acquiring data from the MCC. The motor torque signature would also be analysed to detect changes relative to actuator efficiency, packing friction, stem/nut friction, wear or loosening of parts, etc.

During the next outage, as-found data would be acquired simultaneously at the valve and from the MCC. The electrical data would be used to predict the thrust using the baseline data and the correlation from the previous outage. The predicted thrust would then be compared to the as-found measured thrust to assess the validity of the correlation method. Once the valve is overhauled and any maintenance work is completed, new as-left baseline data would be acquired simultaneously from the MCC and at the valve, and a new correlation would be established.

At the end of the pilot study, a comparison of predicted versus measured thrust would serve as the basis for deciding whether a wider-scale implementation of this methodology is warranted.

CONCLUSIONS

An R&D program was launched at AECL to assess the potential and reliability of various methods/systems that can be used for MOV diagnostic testing performed from the MCC.

A review of methodology showed that, for MCC-based MOV performance testing, motor torque data are more reliable than motor power or motor current data.

Preliminary tests on an MOV test rig demonstrated that data acquired from the MCC are repeatable and reliable. Stem thrusts predicted using the MCC-derived motor torque and a pre-established correlation were in good agreement with the corresponding stem thrusts measured at the valve. The discrepancy of results was found to be around 3.4% on average.

The preliminary tests also confirmed that MCC data can be used to successfully identify valve problems, such as the loosening of a stem-nut locknut, stem nut wear, a change in packing friction, or the degradation of the stem/stem-nut lubricant. MCC data can also be used to assess the effect of flow ΔP on valve loading.

A phased approach to increased MCC-based MOV diagnostics is recommended. It would consist of a further validation of the methodology using available laboratory and plant data followed by the implementation of a pilot study on a selected group of valves.

ACKNOWLEDGMENTS

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