1. Introduction

A question often asked is how well does a simulation model represent reality?

This paper describes verification of simulation models with the help of real-life test results. The verifications were made by IRIS (International Research Institute of Stavanger) and Agito in connection with modifications to a subsea XT compensator circuit on a field operated by Statoil.

A by-pass line between the compensator circuit and system return was to be installed to prevent the compensator circuit from running empty and in worst case prevent the closing of the gate valves.

The modification was to be performed on the already installed XT's subsea by using a special tool called Cannula Tool. The tool was specifically designed to be installed by use of an ROV subsea. This is a non-reversible operation since the tool will puncture a tube in the compensator circuit.

It was therefore important that the modification gave the desired effects. To verify the system behavior after the modification, a simulation model was set up in SimulationX®. The simulation model was verified against real test results from a test performed at IRIS.

2. Cannula Tool Model

The model of the Cannula Tool is based on two simple restrictions as shown in Figure 1.

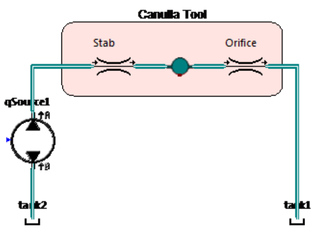

Figure 1 Verification model of Cannula Tool

The two restrictions are set up with a flow capacity as measured in the laboratory on the real tool. The plot below shows the test results from the IRIS laboratory.

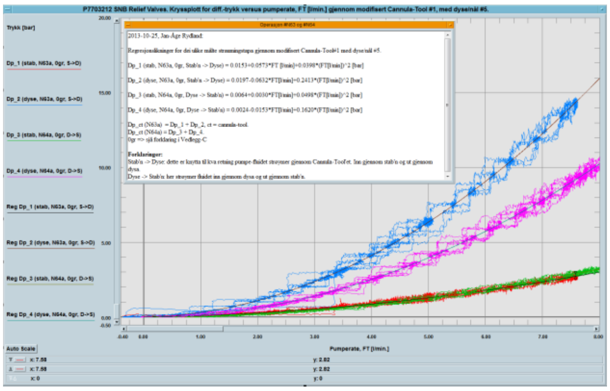

Figure 2 Tested flow capacity in Cannula Tool

It turned out that the flow capacity of the Cannula Tool was different depending on which way the liquid flowed. Therefore, the model was set up with the flow direction from the return system to the compensator circuit. This is the flow direction in the real system when closing the XT gate valves.

The plot below shows the flow capacity of the two restrictions from the model.

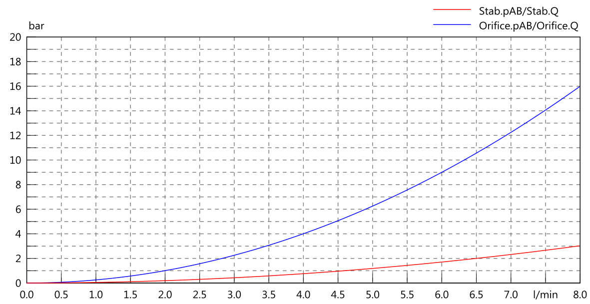

Figure 3 Simulated flow capacity in Cannula Tool model

3. Model of Test Set-up

A detailed model of the test set-up was built. Figure 4 below shows the SimulationX® model for the test set-up without Cannula Tool.

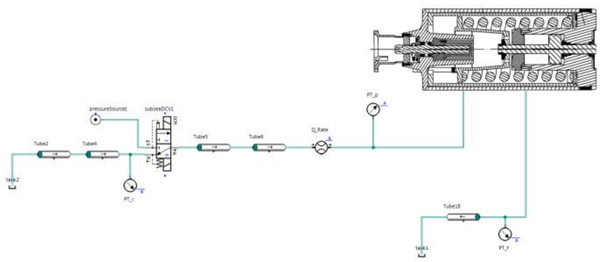

Figure 4 SimulationX model of test set-up without Cannula Tool

The gate valve is built as a user compound and used along with items from the standard library in the model. The gate valve user compound is set up with the geometric values and theoretical friction numbers provided by the manufacturer. The rest of the model is set up with measured values from the test setup.

Figure 5 below shows the same model with the Cannula Tool included.

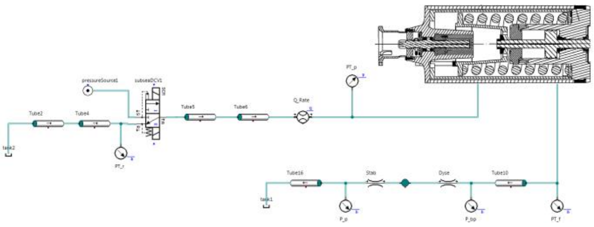

Figure 5 SimulationX model of test set-up with Cannula Tool

4. Comparing Results

Four separate tests and simulations were performed to compare the results before the simulation model was used in a complete system.

The comparison was made on the closing sequence and there were three measurement parameters that were compared;

- Start to Close Pressure
- Fully Closed Pressure
- Closing Time

The plot below shows where on the pressure transient these values can be found.

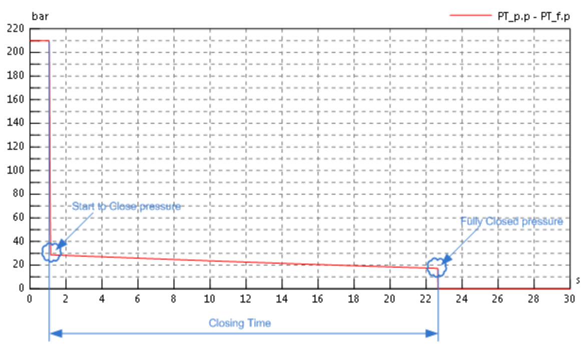

Figure 6 Pressure trend when closing the gate valve

Start two Close Pressure is the pressure when the actuator piston starts to move. This value is dependent on the static friction, restrictions in the hydraulic lines and the mass to be accelerated.

Fully Closed Pressure is the pressure when the actuator piston reaches its end stops. This pressure is dependent on the actuator dynamic friction, mass and spring force.

Closing Time is the time the actuator uses to close. Closing Time is dependent on the static and dynamic friction, mass, spring force and restrictions in the hydraulic lines.

These measurements provide good answers to whether the model represents reality or not. They can also provide a good indication of what is wrong if the discrepancy is large.

Test 1

The first run was with the valve actuator without Cannula Tool installed and with the return and the compensator line to the ambient pressure (0 bar). The results are compared in Table 1:

Results from:	Start to Close	Fully Closed	Closing Time
IRIS Test	29.5 [bar]	17.8 [bar]	21.1 [sec.]
SimulationX	28.7 [bar]	17.2 [bar]	21.6 [sec.]
Deviation	-2.8 %	-3.5 %	+2.4%

Table 1 The results show a maximum discrepancy between the test and simulation of 3.5%

Test 2

The second run was with the valve actuator and the Cannula Tool. The return and compensator line is vented to the ambient pressure (0 bar). The results are compared in Table 2:

Results from:	Start to Close	Fully Closed	Closing Time
IRIS Test	29.6 [bar]	18.1 [bar]	21.2 [sec.]
SimulationX	29.0 [bar]	17.4 [bar]	22.0 [sec.]
Deviation	-2.1 %	-4.0 %	+3.8%

Table 2 The results show a maximum discrepancy between the test and simulation of 4%

Test 3

The third run was with the valve actuator without the Cannula Tool installed and with the return and the compensator line to the ambient as it was for the Statoil operated subsea installation (35 bars). The results are compared in Table 3:

Results from:	Start to Close	Fully Closed	Closing Time
IRIS Test	24.1 [bar]	13.8 [bar]	23.4 [sec.]
SimulationX	25.3 [bar]	13.9 [bar]	23.5 [sec.]
Deviation	+4.9 %	+0.7 %	+0.4%

Table 3 The results show a maximum discrepancy between the test and simulation of 4.9%

Test 4

The fourth run was with the valve actuator and the Cannula Tool. The return and compensator line is vented to the ambient as it was for the Statoil operated subsea installation (35 bars). The results are compared in Table 4:

Results from:	Start to Close	Fully Closed	Closing Time
IRIS Test	27.3 [bar]	14.8 [bar]	38.3 [sec.]
SimulationX	25.8 [bar]	14.8 [bar]	40.0 [sec.]
Deviation	-5.8 %	0 %	+4.4%

Table 4 The results show a maximum discrepancy between the test and simulation of 5.8%

5. Summary

These four simple tests show that a simulation model in SimulationX® will represent a real system with only minor deviations. The model will be able to provide users with valuable information about the system functions.

It is important to emphasize that all four tests were completed with same model. I.e. no changes were modelled between the tests. It is one model representing four different scenarios.

Hence, optimizing a simulation model will give reliable results for the same system in a different situation. Such as, when it is installed subsea. If one develops and verifies the simulation model as part of the system design, the engineers will in the end have reliable models for detailed system tests. Then it is possible to define reliable system limits and test the emergency functions in extreme situations that are impossible to test on real-life systems. For instance a shut-down of a BOP at extreme conditions or a drill string breakage at maximum load on a drilling rig.

The results shown here are just a few of the outputs available in a simulation model. There are a lot of possibilities with a good simulation model. SimulationX® provides opportunities to connect the control system to the model and test the software in advance before commissioning. This will result in large economic gains in terms of saved hours later. Another possibility is to export the model to a Real Time application and build training simulators that can improve operators' skills and response in emergency situations.

It is also of great value to have a good simulation model available when operators offshore need assistance from the experts located onshore, or when systems start to behave strange as was the situation at Statoil operated subsea installation where this example was taken from.

It is important to remember that a simulation tool does not contain any magic formula. The good old expression "garbage in, garbage out" still applies. In effect; the output can never be better than the input.

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