Modeling And Simulation Of Subsea Chemical Distribution System

agito technical dynamics

Visualize the solution – Remove the risk

1. Introduction

There is frequently a need for injection of different types of chemicals in subsea production systems.

Examples of chemicals:

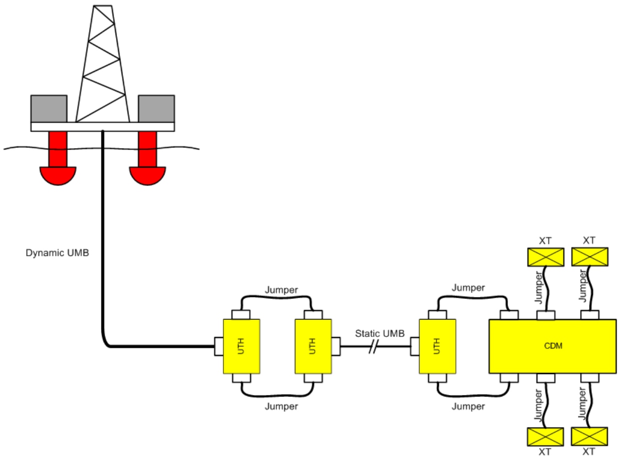
Methanol, corrosion inhibitors, and scale inhibitors. It is highly important, from the viewpoints of both technology and costs, to have control at all times of how much and at which points the various chemicals are injected into the different production lines. The traditional method uses a dedicated line from the surface to inject directly into each Xmas tree (XT). However, the increasing trend of multiple wells per umbilical makes this impractical. Therefore solutions using common supply lines with distribution on the seabed, in the same way as the hydraulic systems, are desirable. Here too it is important to know that the correct amount is injected into each production line, so there is no overconsumption of chemicals that later have to be removed from the produced oil/gas.

This article describes how, using modern tools such as SimulationX®, models of chemicals injection in subsea systems can be set up and used to verify the system's functions and dynamic properties against one or several requirements specifications.

2. System description

Figur 1 presents a typical system for subsea chemical distribution. The chemicals are pumped from the surface vessel to the installations on the seabed via common lines in the umbilical and jumpers, in the same way as in the hydraulic distribution system.

The Chemical Distribution Module (CDM) which distributes chemicals out to the Xmas trees (XT) is similar to our Hydraulic Distribution Module (HDM). A valve mounted on each XT controls the injection flow. This enables individual injection rates even with a common supply line.



Figur 1 Subsea control system for oil and gas production

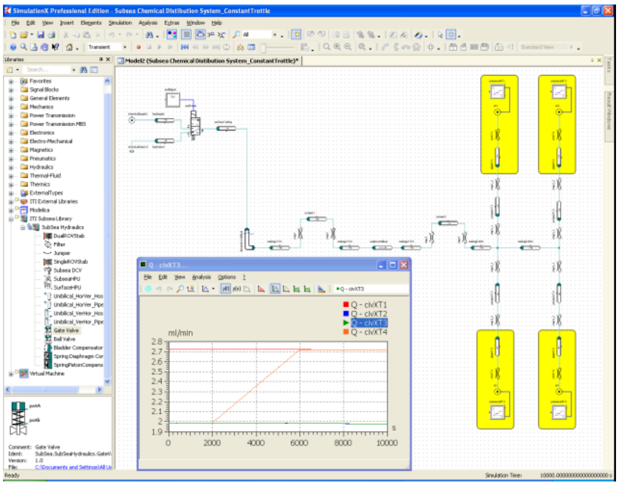
Often, the challenge lies in selecting the correct type of valve to control the chemical injection rate. Today, there are two main types on the market. One fixed throttle valve and one variable throttle valve. The main difference between these two is that with the fixed throttle valve the injection rate will vary with varying differential pressure through the valve, while with a variable throttle valve the injection rate remains constant regardless of a differential pressure if it is within the valve's working range – Constant flow valve.

Which of these two types of valve is most suited for this type of system is open to discussion and will not be examined here, but we will show that using software such as SimulationX® it is possible to model the systems with a high degree of accuracy and to observe how the various solutions behave under different pressure conditions.

3. System model in SimulationX®

SimulationX® contains a library with generic models for components which makes it easy to set up a model and to generate results quickly. There is a graphic user interface which provides the user with an improved overview of the individual elements interdependence and effects throughout the entire system. The graphic user interface also facilitates easier understanding of the model, and simplifies documentation for models which can be used by multiple users.

Figur 2 Presents a "screen dump" from SimulationX® with the system model for this scenario. The model comprises elements from the SimulationX® library that is dedicated to subsea systems – hydraulics, in conjunction with elements from the standard libraries.



Figur 2 SimulationX® model of an injection system

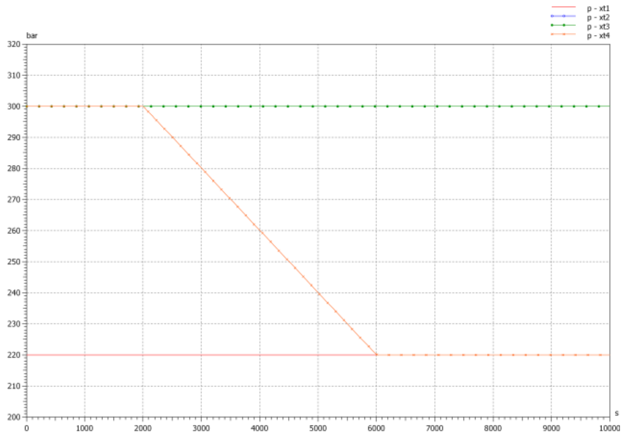
The special elements have been developed from many years' experience with subsea systems. The individual elements have been designed such that parameters from standard technical data sheets should be sufficient documentation to enable set up of a system model and generation of reliable results.

If special fluids which are not included in SimulationX® are needed, a dedicated tool to define new fluids called "Fluid Designer" has been developed by ITI. New fluids can be entered in the fluid library as "user fluids" and can be reused in other systems/applications in the same way as the standard fluid library that is integral to SimulationX®.

4. Results generated by SimulationX®

The example includes 4 wells of which 3 have a well pressure of 300 bar while the fourth has a well pressure of only 220 bar. The injection valves are preset to the same injection rate.

After a given time (at t=2000 seconds), the pressure in well 4 (XT4) drops to 220 bar as shown in Figur 3. What is interesting is the effect on the injection rates.



Figur 3 Pressure variation in XT1 to XT4

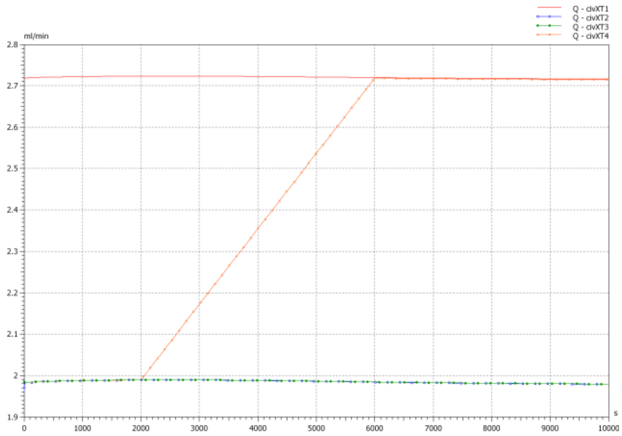
Fixed throttle valve:

A fixed throttle valve changes the injection rate when the differential pressure over the valve varies. In practice, the size of this change varies with the design of the valve, but it will always be a function of the differential pressure over the valve.

In the following example we included a fixed throttle valve that is set at about 1.95 ml at a differential pressure of 200 bar. The differential pressure for the injection valve for XT2, 3 and 4 is initially just above 200 bar while the injection rate for XT1 is just above 280 bar.

From 2000 to 6000 seconds the differential pressure changes above the injection valve on XT 4 from ~200 to ~280 bar with the result that the injection rate changes from almost 2 ml/min to just above 2.7 ml/min as shown in Figur 4.

This is an increase of 35% in the preset injection rate.

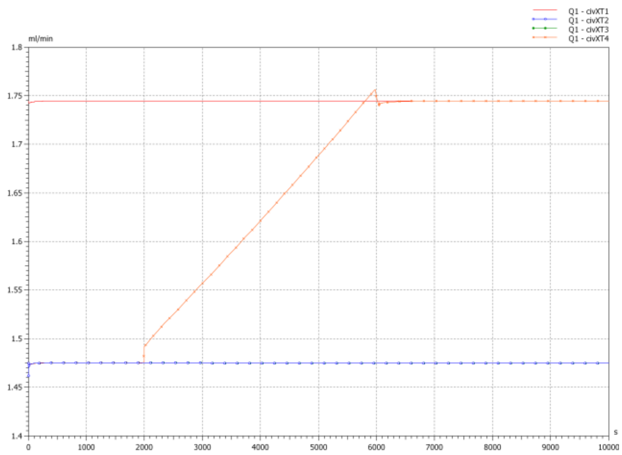


Figur 4 Change in the injection rate with a fixed throttle valve

Variable throttle valve:

Using a variable throttle valve, the injection rate will be more stable because the valve's internal "regulator" will continually attempt to maintain a constant injection rate through the valve regardless of the pressure difference. In other words, the valve is self-regulating.

In Figur 5 we can see that the injection rate with a variable throttle valve changes from 1.47 to 1.74 ml/min. This is an increase of 18% in the preset injection rate.



Figur 5 Change in the injection rate with a variable throttle valve

5. Summary

This example demonstrates the importance of conducting verification of design in an early phase of the project enabling a better overview of the system's performance and variations. It is also important to run simulations at different process pressures in order to ensure that the system can provide the correct injection of chemicals in the future when the natural overpressure in the well has dropped, and the need for injection of chemicals changes due to water production, etc. It is important to note that the system requirements do, in fact, apply throughout the lifetime of the field.

Variable throttle valves are often used only in parts of the valve's working range, resulting in unnecessarily large variations in the injection rate. Using a simulation tool such as SimulationX®, the valve's internal area between the regulating piston and the seat/poppet can be optimized for the range in which the valve is intended to work.

Injection of chemicals in connection with subsea oil production is expensive but, using simple techniques and modern tools, injection can be optimized generating economic and environmental benefits.

Svein Myhra and Rune Lien

Agito AS

www.agito.no