BLOW-OFF TEST VALVE ANALYSIS

A blow-off test to determine compressor performance during part load conditions is required at a newly built compressor plant. The test requires controlled flow variation in order to test the compressor's performance within the specified range. For this, a pipe header with 1½" and 1" solenoid valves needs to be designed. The flow rate should be incrementally variable between 30 Nm^3/min and 160 Nm^3/min.

POWER INDUSTRY

CHALLENGE:

The client requires the total number of valves (standard valves available on site) as well as the blow-off valve header configuration which will enable variation of required flow rates by means of fully opening and closing the individual valves. The client is also interested in the valve throat static temperatures during blow-off as well as the flow rate through each of the valves. The client additionally requested flow velocities in certain sections of the existing pipe network.

BENEFITS:

With Flownex®, the correct number of valves as well as their sizes can be selected to allow the minimum and maximum flow rates to be achieved incrementally. Flownex® allows the blow-off valve header configuration to be designed and optimised. The behaviour of the existing system can also be analysed in terms of outlet temperatures, pipe flow velocities and flow rates, to ensure that the system operates within reasonable boundaries.

SOLUTION:

The results indicated that one 1″ valve and five 1½″ valves should be used. By opening and closing different configurations and numbers of valves, the flow could be varied incrementally between the specified minimum and maximum flow rates. Furthermore, client requirements such as the maximum flow velocities in various sections of the existing pipeline as well as the valve outlet temperatures could be determined by using Flownex®.

"Flownex® provided an efficient and convenient way of predicting the thermo-hydraulic behaviour of the existing compressed air system as well as the valves and pipe header. This enabled us to determine the sizes and number of valves required to obtain a number of different flow rates within the minimum and maximum range within a short period of time." – Faan Oelofse (M-Tech Engineer)

BLOW-OFF TEST VALVE FLOW ANALYSIS

INTRODUCTION

A commissioning test blow-off valve header needs to be designed for a newly built compressor plant. The configuration should allow flow control during compressor performance testing within a specified flow range, with controlled flow variations. For this configuration a pipe header with open/close solenoid valves will be used to achieve an incremental flow variation between 30 Nm^3/min and 160 Nm^3/min.

The objective of this project was to determine:

- If the required flow range can be achieved with the existing system configuration (pipework, filters, flow restrictors etc.).
- The number and sizes of the solenoid valves required to achieve the specified flow range.
- The expected static temperatures at the outlet of the blow-off valves.
- The expected flow velocities in the piping upstream of the blow-off valves.
- The expected flow rates with varying number of valves open.

“Piping data could be obtained from the built-in pipe schedule tables. This ensured that less time was spent on setting up the model and more time was available to evaluate and improve the design and optimisation of the blow-off valve header.”

FLOWNEX MODEL

The system downstream of the compressor mainly consists of a pipe network including secondary losses (valves, elbows and T-junctions), compressed air filters, a desiccant dryer as well as a sonic nozzle to protect the desiccant dryer from excessive flow.

All pipe sections were modelled using the pipe element based on information obtained from the client drawings, which included length, diameters and secondary losses (valves, elbows, etc.).

The impact of the desiccant dryer and filter on the network was simulated as a pressure drop that varies with the flow rate. The Flownex® general empirical element was used to model this pressure drop.

The sonic nozzle, located downstream of the dryer, protects the desiccant material (in the dryer) from excessive flow by means of achieving sonic velocity (choking) in the nozzle throat during excessive flow conditions. Static pressure recovery is achieved in the section downstream of the nozzle throat. The nozzle was modelled using the Restrictor with Loss Coefficient element. The diameter, contraction coefficient and loss coefficient of the element were determined based on the geometry of the nozzle and compressible gas theory.

The Flownex ANSI control valve component was used to simulate the solenoid valves. The valve flow coefficient (Cv), as indicated on the valve manufacturer's data sheet, was used in conjunction with the valve pressure differential ratio (valve X_T) to determine the flow rate through the valves at choked flow conditions.

SOLUTION

The simulation results indicated that five 1½" solenoid valves with one 1" solenoid valve will enable the commissioning personnel to test the compressor control at 11 flow rate set points within the required range of 30 – 160 Nm^3/min. By means of a parametric study, the flow uncertainty as a result of uncertainties in input parameters (pipe roughness, sonic nozzle pressure recovery and solenoid valve X_T) could be determined. The expected static temperatures at the outlet of the blow-off valves and the expected flow velocities in the piping upstream of the blow-off valves could be determined at all the flow rate set points.

> "Results for the flow rates and temperatures could also be graphically represented for easier interpretation."

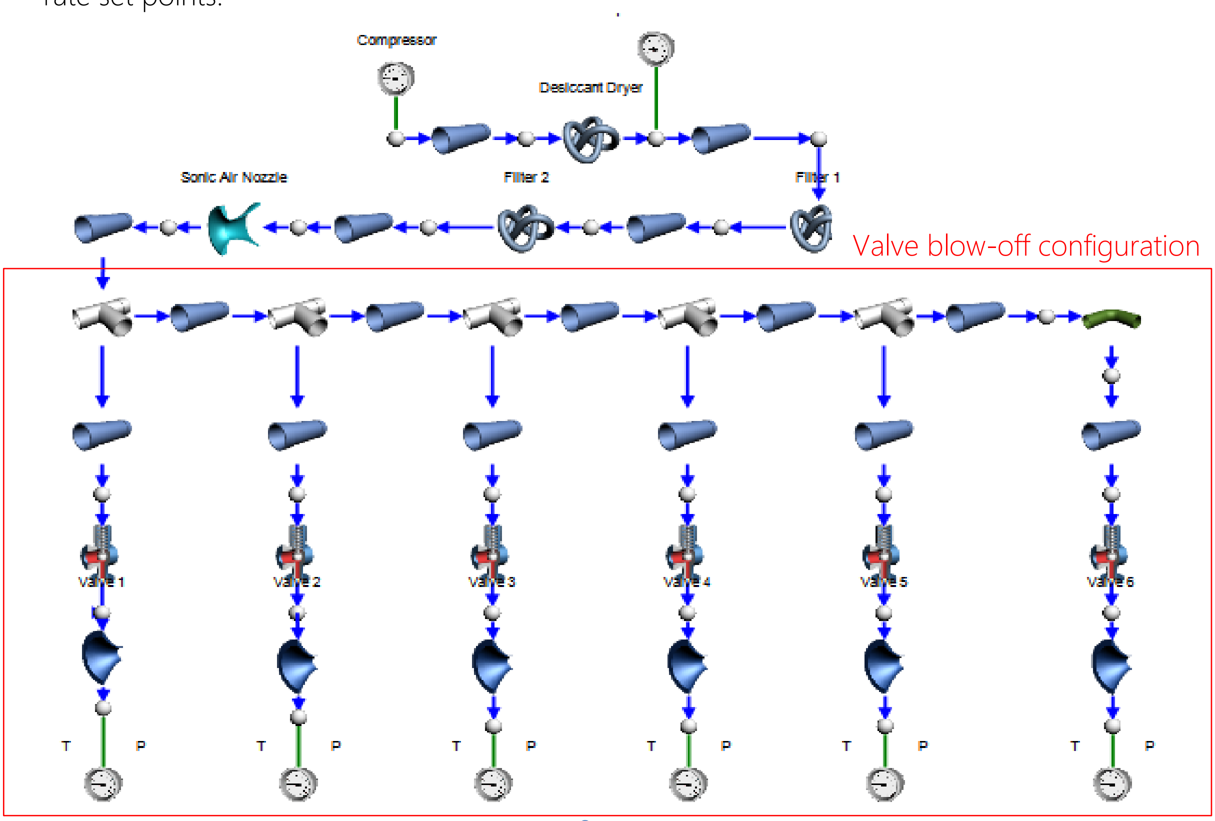

Figure 1: Flownex® Blow-off configuration.

SUMMARY

Using Flownex, the design and valve selection for the compressor flow control commissioning header can be easily performed and at a fraction of the time when compared to conventional methods. The ability to perform numerous simulations within a short time span, gives the user the ability to perform parametric studies, thereby quantifying the uncertainty of unknown input parameters. Furthermore, results such as outlet air temperatures, flow velocities etc. can easily be obtained from the network.