FLOWNEX®
SIMULATION ENVIRONMENT

TURBINE PROTECTION – TWO PHASE FLOW REGIMES

The main challenge explored in this case study is root cause analysis of dynamically hazardous movements in the distillate lines to a plant deaerator. Flownex's simulation optimisation tool was used to determine the preferred two phase flow regime. By using Flownex to identify the cause it was possible to mitigate a commercial impact on the project, maintain the planned commissioning schedule and improve the existing plant design thereby also removing the safety risk of unwanted dynamic line movements.

Eskom

POWER GENERATION

CHALLENGE:

The main challenge explored in this case study was to reduce dynamic movements (caused by unwanted two phase flow) in the distillate lines to the deaerator by designing modifications into the existing system.

BENEFITS:

This case study will demonstrate the construction of a basic flow model in Flownex to effectively calculate the specific parameters necessary to determine the two phase flow regime. The optimized parameters will improve unwanted flow and prevent future system failure if implemented.

SOLUTION:

By applying modifications to the Flownex model, the ideal two phase flow regime needed in the distributor pipe could be determined. These modifications had the desired effect of moving the regime away from the slug flow area thereby eliminating the unwanted dynamically hazardous movements in the lines.

"The optimized parameters will improve unwanted flow and prevent future system failure if implemented."

"Flownex assisted in solving a complex and potentially dangerous problem during commissioning of the unit. It ensured that this specific problem did not cause any delays in the commissioning process."

Nicolaas Hallatt (Pr.Eng.), Turbine Plant Engineer

INTRODUCTION

During the commissioning of an Eskom Power Station Unit, severe dynamic movement occurred on both lines to the deaerator. The identified lines were taken out of service and the cause was investigated.
After initial investigations it was concluded that the lines were too flexible. The CAESAR[1] model was revisited and additional supports were installed. This, however, did not solve the problem. The problem thus had to be process-related.

SYSTEM DESCRIPTION

The HP-heaters are shell and tube heat exchangers that act as pre-heaters in the Rankine cycle. The heaters extract steam from the turbine to heat the feed water before it goes to the boiler. The condensate/distillate that forms during the condensation process is then cascaded to the previous heater.

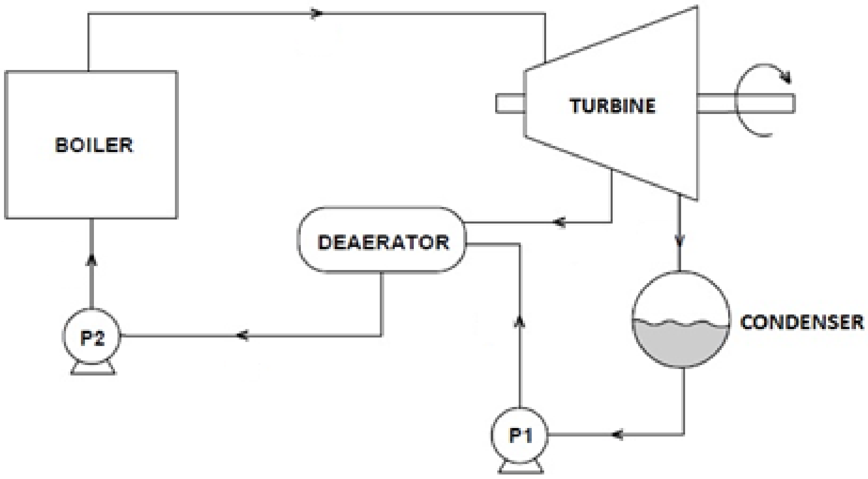

Figure 1: Rankine cycle with extraction to deaerator

This specific line is used to transport the condensate/distillate from HP-heater 2 to the deaerator storage tank. It is fitted with a control valve, isolation valve and a number of small maintenance drains. At the deaerator a distributor is fitted to ensure the flow into the tank is distributed evenly.

Flownex can effectively assist the CAESAR software in determining structural responses and stresses by using the Flownex simulation outputs. These outputs include internal pipe pressure, transient forces and forces due to temperature change.

[1] Intergraph CAESAR-software evaluates the structural responses and stresses of piping systems to international codes and standards.

OBJECTIVE OF SIMULATION

The objective of the simulation was to calculate the parameters for the initial problematic two phase flow regime. The next step was to simulate different distributor flow size areas and then to assess the pressure profiles to determine the desired optimum flow conditions in the pipe lines.

FLOWNEX MODEL

The Flownex model of the system is shown in Figure 2.

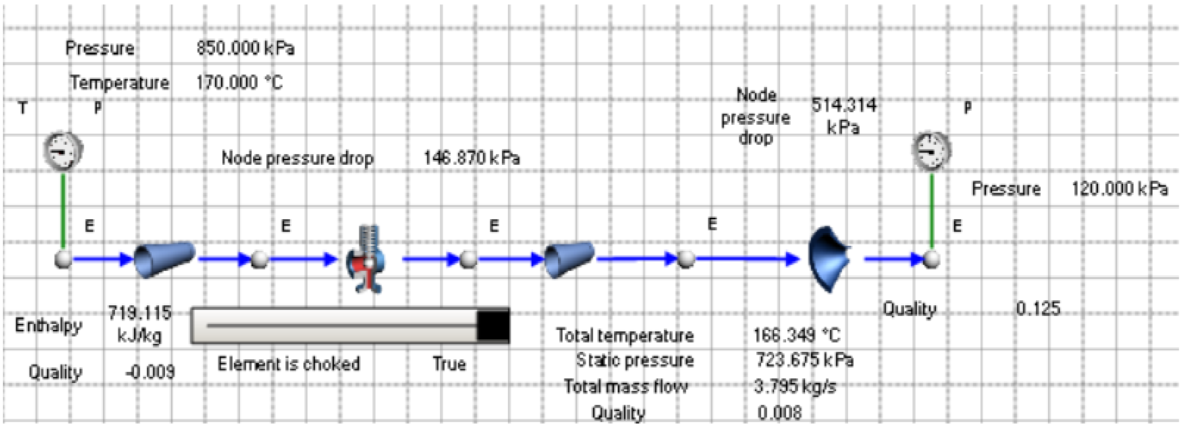

Figure 2: Flownex simulation of the deaerator system.

DESCRIPTION OF SIMULATION

The main elements of this system consist mainly of piping, one control valve and a flow restrictor.

When the flow size area for the distributor is changed in the model and a simulation is run, the flow and pressure results for each component in the model will change. The flow area of the distributor can be adjusted and optimised to deliver the desired flow results. The data is then finally analysed for the best solution.

"The objective of the simulation is to calculate the parameters for the initial problematic two phase flow regime."

RESULTS

After running the simulation, the model showed that the pressure drop through the distributor was significantly higher than expected when the model was set up in a manner that represented the system as installed. The reason for this occurrence was the flashing across the control valve being much less than designed for, resulting in two phase slug flow in sections of the line, causing unacceptable dynamic line movement.

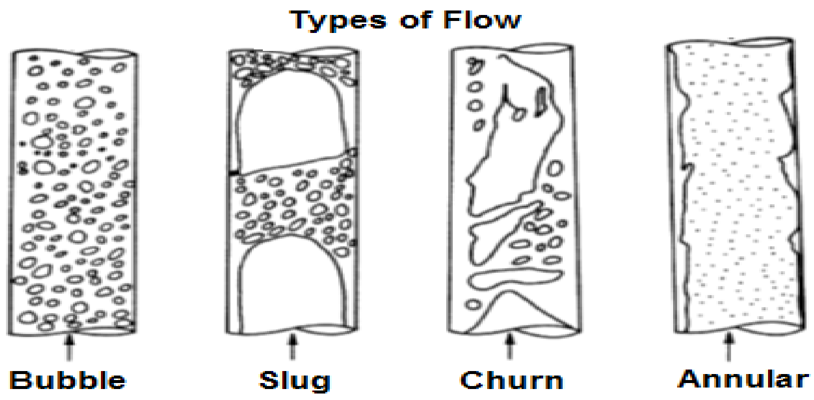

Figure 3: Flow patterns.

The two phase slug flow regime was characteristic of the flow problem in the system. Some parameters in the model were changed and the simulation was run again. The decision was made to modify the distributor pipe by increasing its flow area. This resulted in a reduction in pressure drop across the distributor and thus the overall back pressure on the line. The resultant pressure drop caused more flashing across the control valve and moved the flow regime away from the slug flow area as can be seen in Figure 4 below.

"The resultant pressure drop caused more flashing across the control valve and moved the flow regime away from the slug flow area"

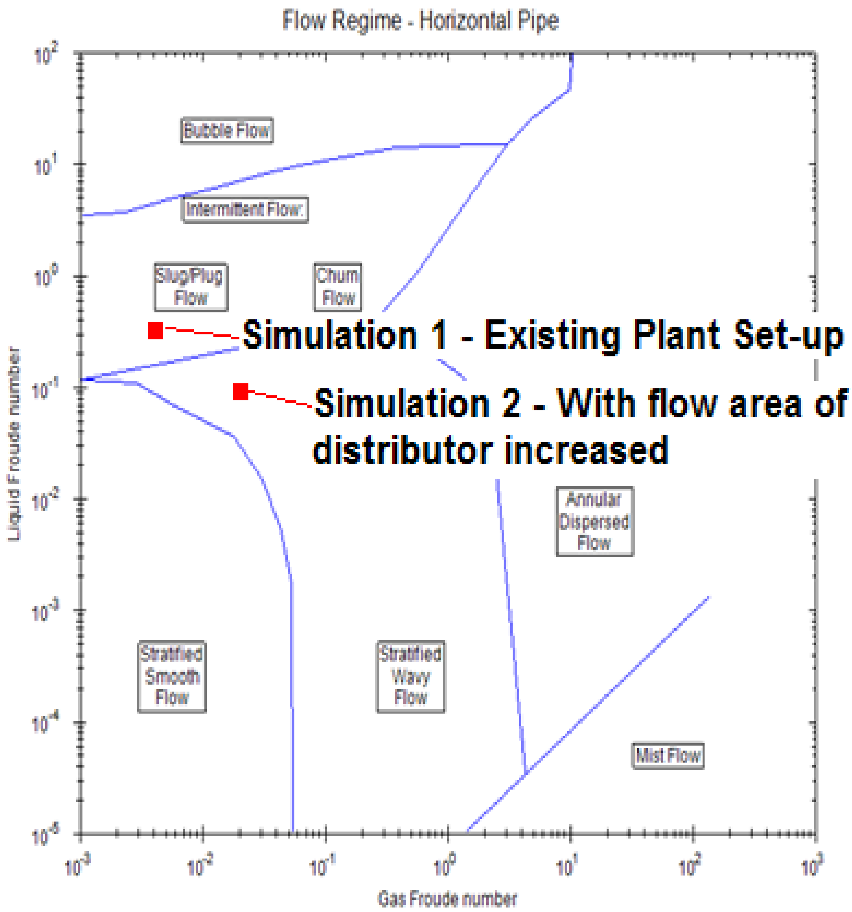

Figure 4: Simulation flow type results of the existing plant model versus the modified model.

CONCLUSION

Benefits for the Flownex situation model are as follows:

- It was confirmed that the two phase flow regime was not evaluated for all possible conditions during the design of the plant.
- The distributor was sized using EPRI CS 2251[2], evaluation of pressure drop across the distributor was not a requirement in this guideline.
- By running the simulation the model results confirmed that the behaviour was not in line with the original design. Upon investigation it was discovered that sub-cooling components had been removed from the heaters in the 1980's causing a heat imbalance in the system, which was the root cause of the problem. Using the simulation model to optimise the existing plant setup with minimum physical modifications, it was calculated that, by increasing the distributor flow area, it was possible to compensate completely for the lack of sub-cooling components and re-balance the system.

The most important achievement on this project was using the Flownex simulation optimisation tool to determine the preferred two phase flow regime. It was possible to mitigate a commercial impact on the project, maintain the planned commissioning schedule and improve the existing plant design thereby also removing the safety risk of unwanted dynamic line movements.

TESTIMONIAL

Testimonial provided by Nicolaas Hallatt (Pr.Eng.), Turbine Plant Engineer:

"Flownex assisted in solving a complex and potentially dangerous problem during commissioning of the unit. It ensured that this specific problem did not cause any delays in the commissioning process."

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[2] EPRI CS 2251 is the recommended guideline for the admission of high energy fluid to steam surface condensers.