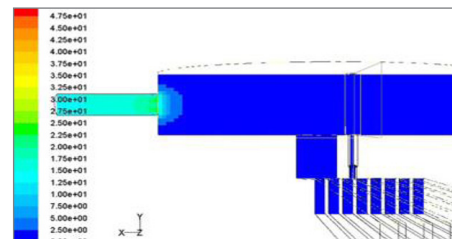
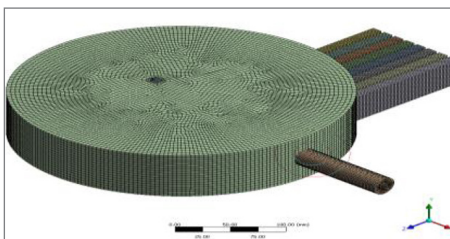


OPTIMISING HVAC COMPRESSORS: DANFOSS

The Background



Founded in Denmark in 1933, Danfoss is now a global trendsetter in the climate and energy industry, pushing the boundaries within fields such as refrigeration and A/C controls, commercial compressors, heating solutions, district energy and power electronics. The global group is a leader within research, development and production, sales and service of mechanical and electronic components for several industries, and seeks to reach its goals with a minimal consumption of raw materials and energy, the least possible impact on its surroundings and the most efficient use of resources.

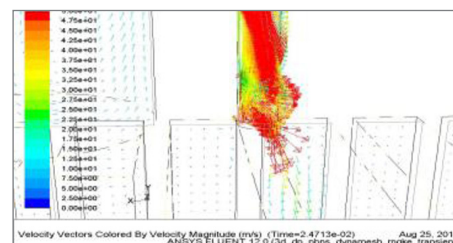
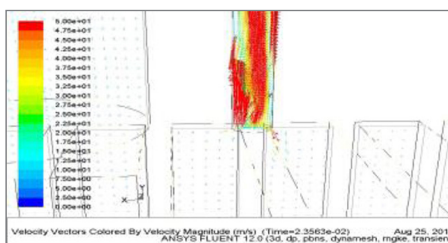
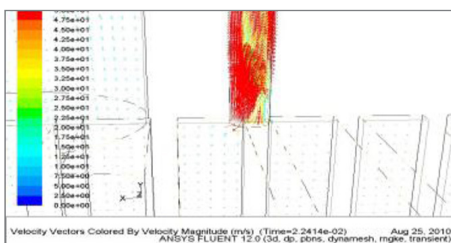
The Danfoss Commercial Compressors division develops and manufactures reciprocating and scroll compressors for commercial refrigeration and air conditioning applications. The company continuously invests in research, development & testing activities - about a tenth of all employees are dedicated to R&D.

As part of their ongoing improvements, Danfoss wanted to develop a simplified model of scroll compressor to look at different IPD (intermediary discharge port) canal configurations.

“This project required a new approach to CFD. That’s why we chose Renuda – I was confident that their knowledge and expertise could optimise the solution.”

*Pierre Ginies Technology Manager
Danfoss Commercial*

The Challenge



A scroll compressor is designed to deliver a certain pressure rise according to a given specification; the pressure rise is fixed for the given rotational speed of the compressor. The performance of the compressor is dependent on external weather conditions and the condensation pressure - if the compressor delivery pressure is greater than that of the condensation pressure, the compressor will consume excess electricity for no economic benefit.

To avoid this waste of energy, a pressure relief valve can be used to reduce the pressure inside the scroll compressor such that the compressor delivery pressure is equal to the condensation pressure. The performance of the relief valve is, however, unknown with respect to the pressure drop across the valve, and interaction with the gas on the HP side in the discharge volume.

Experimental tests have been carried out that demonstrate the process but Danfoss still needs to be able to assess the performance of such a relief valve for different compressors with varying condensation pressures. Danfoss decided to simulate the process using Computational Fluid Dynamics (CFD).

CFD has already been used to simulate the flow and compression process in a scroll compressor, but this numerical model is considered to be too complex for this problem, which, if simulated using CFD, would cost unreasonable amounts of time and money (licensing fees). Hence a simpler numerical model had to be developed.

The Solution

Danfoss commissioned Renuda® to build a simplified generic model of a scroll compressor that can be used to test different IDP canal configurations. In close collaboration with Danfoss, Renuda built up a modelling methodology by testing various approaches in various steps and then combining them. This saved time in the long run because if an approach didn't work it could be discarded quickly and an alternative tested. The multi-step approach involved:

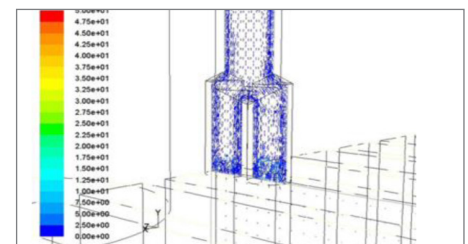
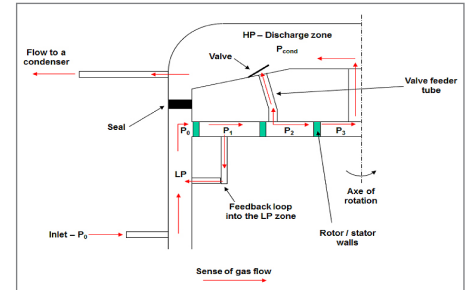
- Testing a simplified model for mesh deformation process i.e. gas compression.
- Testing a simplified model for sliding mesh and interfacing between a compressor gas pocket and the IDP canal.
- Testing the method for valve opening and closing using a 1 DOF approach.
- Combined testing of steps 1, 2 and 3 using a simplified model.

The final generic model of the scroll compressor involved modelling:

- Testing a simplified model for mesh deformation process i.e. gas compression.
- Testing a simplified model for sliding mesh and interfacing between a compressor gas pocket and the IDP canal.
- Testing the method for valve opening and closing using a 1 DOF approach.
- Combined testing of steps 1, 2 and 3 using a simplified model.

Upon completion of the last step, the generic scroll compressor model was built and an unsteady calculation was run in parallel using a current IDP canal configuration. Results were then compared with a OD model which showed good agreement.

Physical Model



How Danfoss Benefited

- Danfoss will be able to reduce energy waste by more accurately calculating the compressor delivery pressure under differing conditions.
- Renuda's model has enabled Danfoss to save time by defining a methodology for future simulations of pressure relief valves in scroll compressors.
- Danfoss can now quantify the amount of mass going through the pressure relief valve and how much goes through the adjacent pocket.
- Danfoss now has a 3D model for predicting pressure and temperature rise which is in reasonably good agreement with the OD model. The 3D model can be used to optimise the OD model.

Why did Danfoss choose Renuda?

- **Quality of Work** – Danfoss was confident in Renuda's ability to do this project successfully because of their previous work for Danfoss on internal flows on scroll compressors –the flow in motors for cooling electric motors; uniform mass flow in compressor delivery pipes.
- **Relevant Experience** – Renuda has done a lot of user coding influence for controlling moving and deforming mesh, and moving mesh with one degree of freedom.
- **Specialist Knowledge** - Renuda has a good understanding of the CFD software that Danfoss uses.

“ I am impressed by Renuda's work. They are very professional; I have confidence in them. Their expertise in CFD modelling has provided Danfoss with a more accurate view.”

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