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Numerical simulation of the flow inside a scroll compressor equipped with Intermediate Discharge Valves

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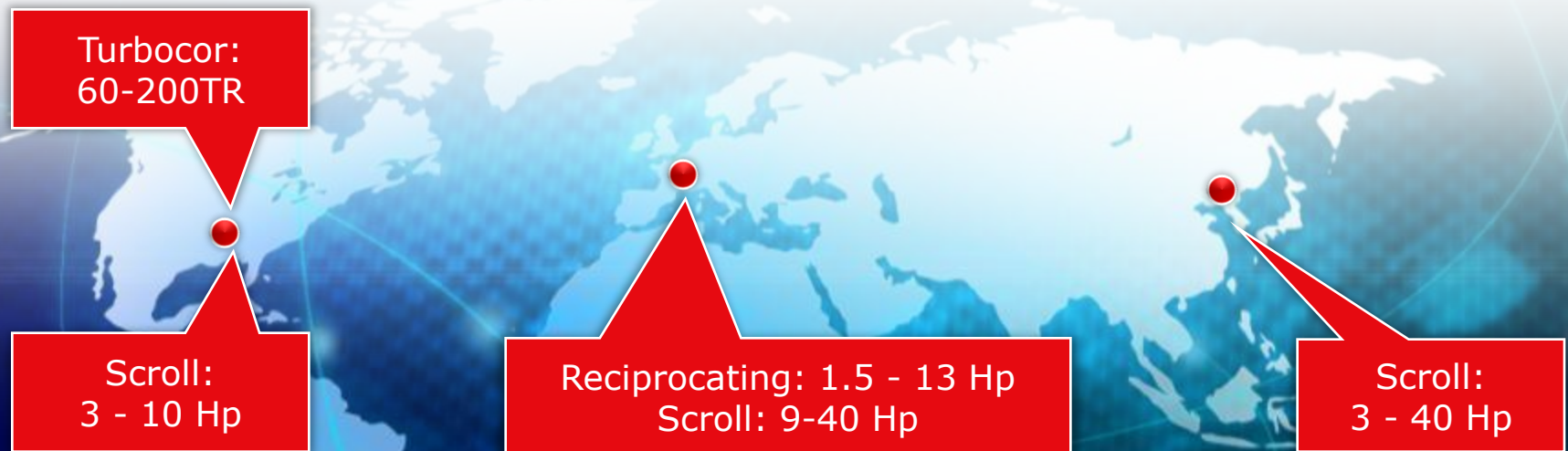
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Danfoss Commercial Compressors

- Leading compressor R&D and manufacturing for commercial air conditioning, heating and refrigeration applications since 1971
- Manufacturing in Europe, USA, China
- Leading the market in commercial inverter scrolls with prequalified drives
- Pioneers of Danfoss Turbocor Compressors with oil-free, magnetic bearing technology



- CFD is an essential part of the scroll compressor design process at Danfoss (internal gas circulation, head losses, oil lift...).
- CFD has been used for modelling the scroll compression process with a good degree of accuracy.
- Focus can now be put on the details of a design such as gaps, IDVs, spiral leading edge profiles, dummy ports.

Numerical model

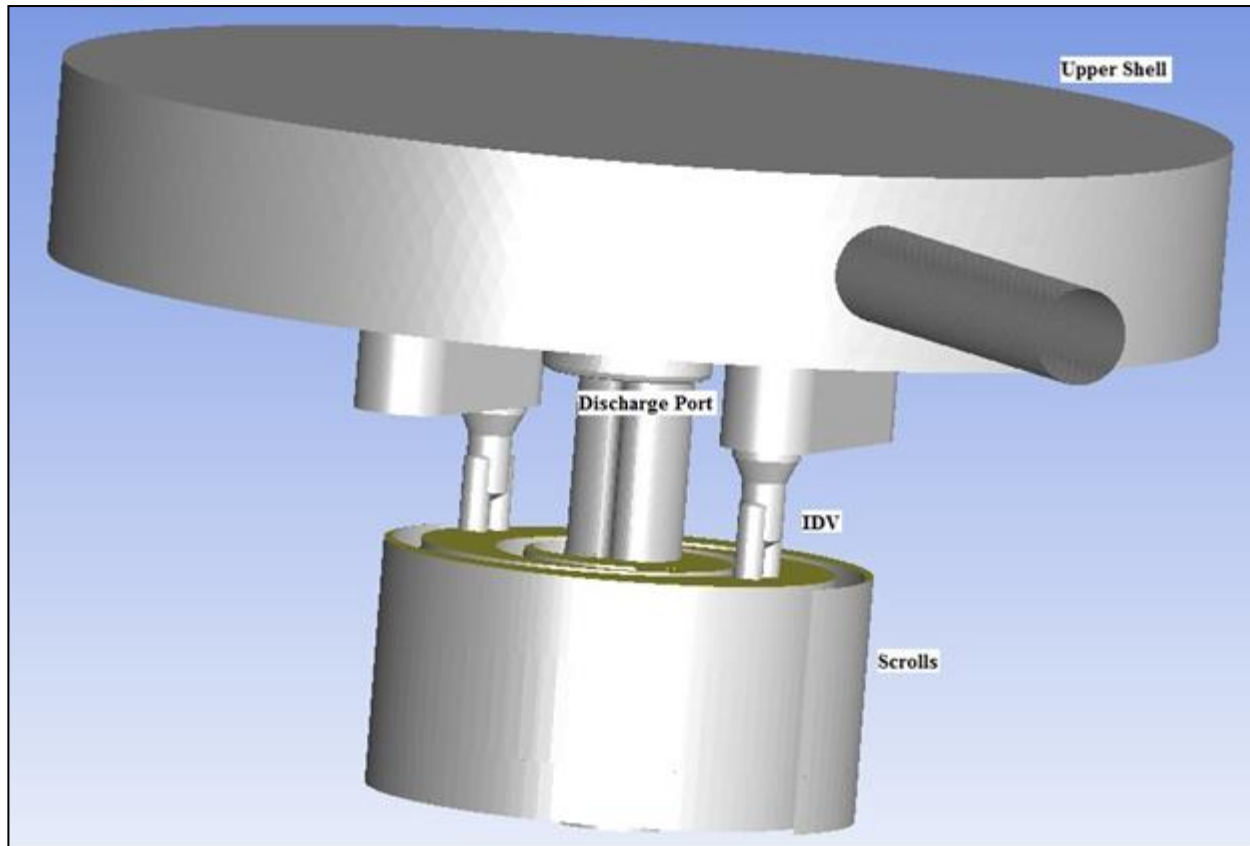


- FLUENT CFD solver.
- 3D, unsteady, turbulent compressible flow.
- Computational domain : final gas pocket, discharge port, 2 IDVs and the high pressure zone of a 25 tons - 2.4 volume ratio machine.
- Motion of the scroll implies a deforming mesh with smoothing or remeshing of the grid at every time step.

Computation domain



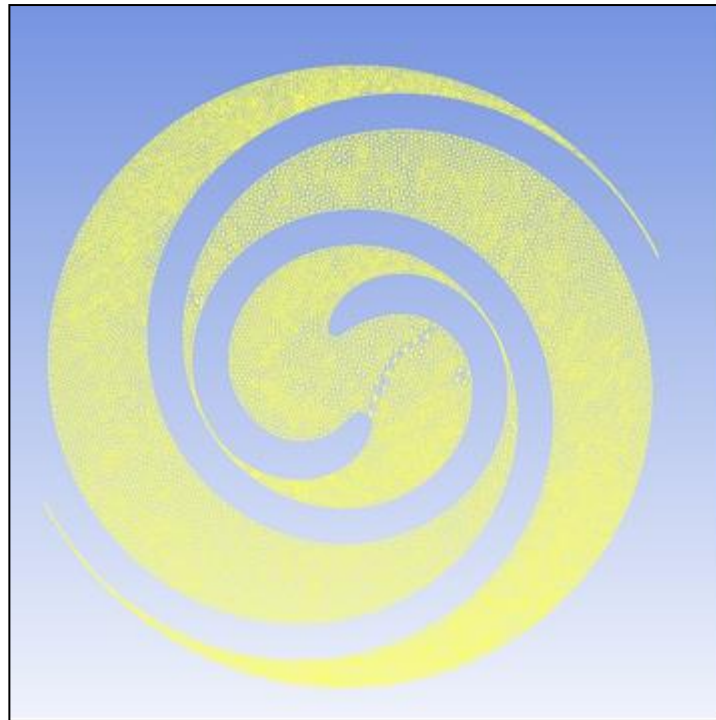
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Initial mesh of the gas pocket



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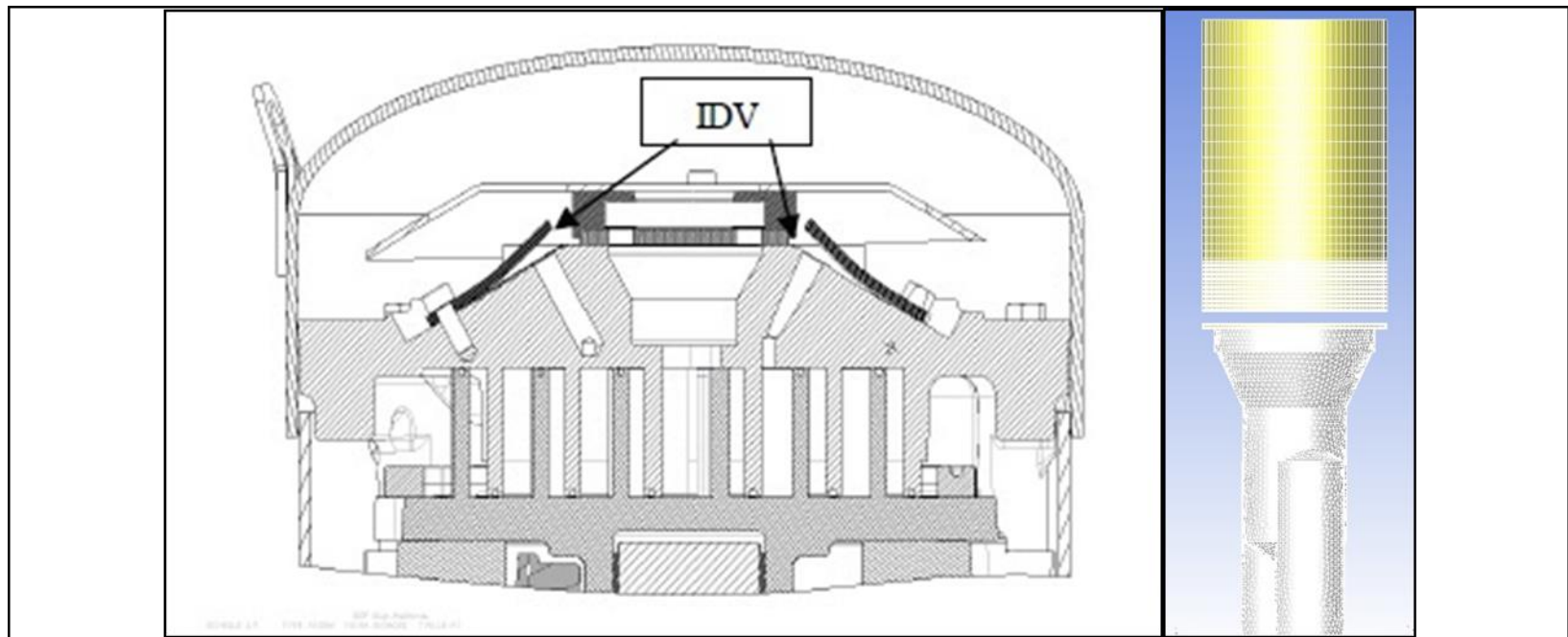


Mesh of the IDVs



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The IDVs are modelled as a solid round disc submitted to gas pressure of the pocket and the upper shell.
Its motion is controlled by a « User Defined Function ».

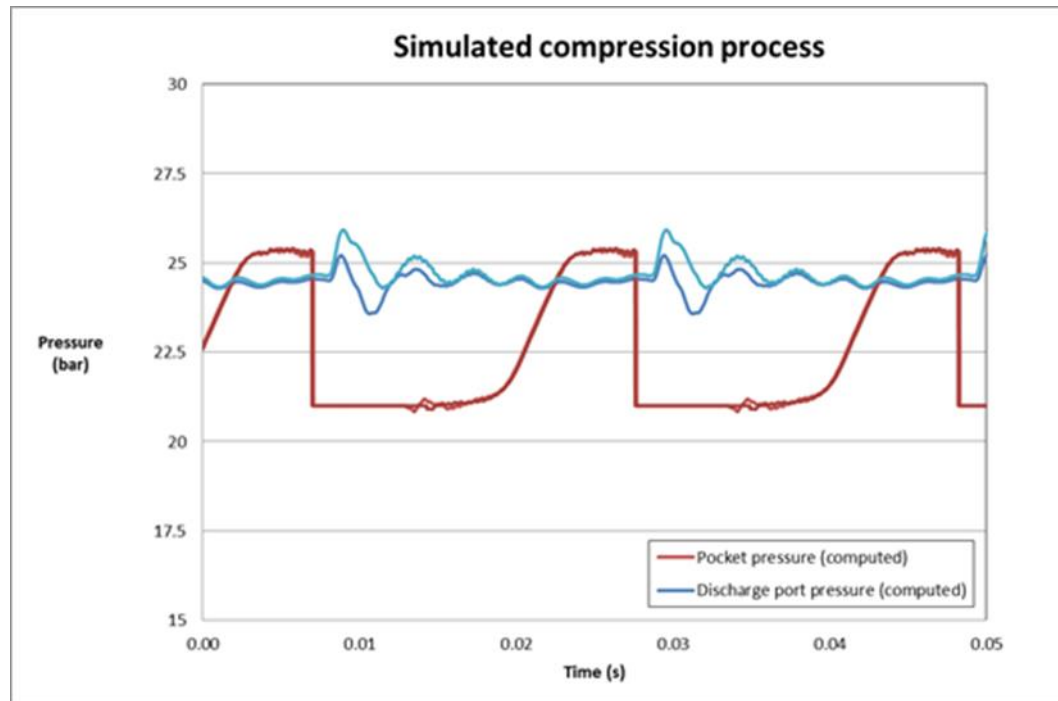


- Refrigerant : R410A.
- Rotational speed : 2900 rpm.
- Operating point :
 - evaporation temperature 10°C (50 F)
 - condensing temperature 40°C (104 F)Pressure ratio 2.23, ensuring opening of the IDVs.

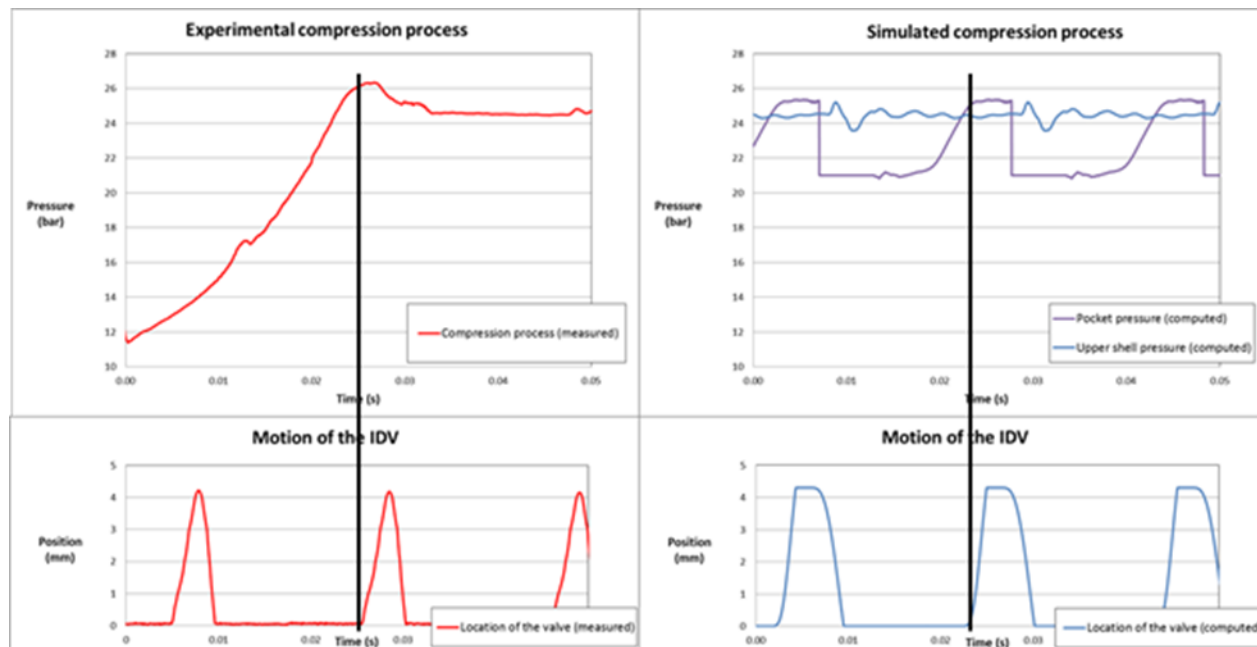
Results

- Unsteady CFD provides a significant quantity of time dependent data to be analysed.
- However information is available at any point in the computation domain.
- Possibility to analyse flow fields with contour and vector plots.
- Probes in the flow domain allow to draw time dependent curves for all types of data.

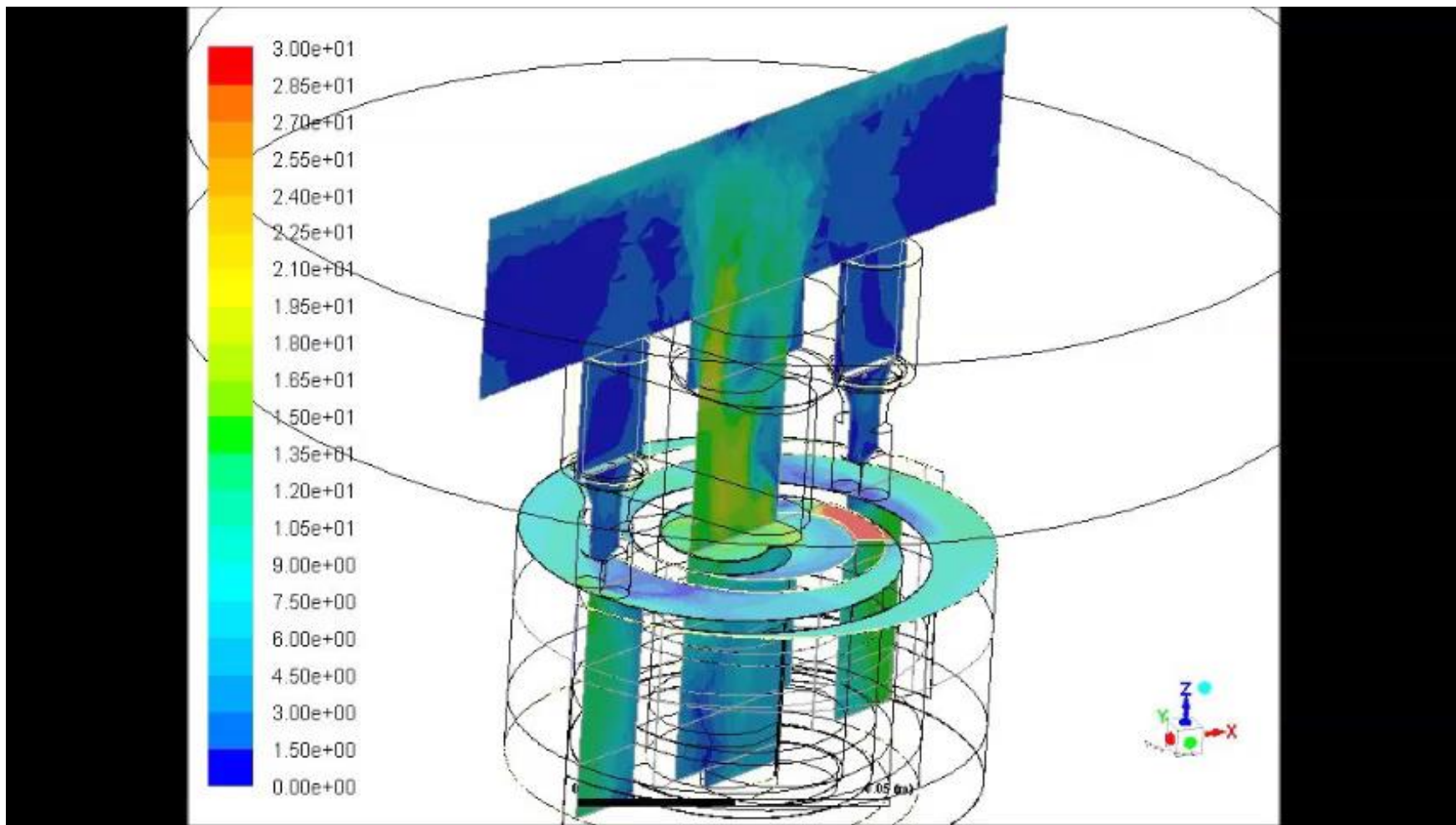
Pressure distribution in the pockets and in the discharge port. The IDVs efficiently limit the over pressure.



A comparison between test results and computations show the necessity to improve the tuning of the IDV model.



Analysis of flow field



- The various steps of the compression process can be clearly seen.
- The IDVs open at the end of the compression process.
- However, the IDVs must not interfere with the opening of the discharge port.
- The velocity magnitude in the tip gap at the end of the wrap may be important.
- The direct and indirect pockets don't bleed off simultaneously.

Conclusion

- The scroll compression process can be modelled in a reliable way, taking in account various details.
- The analysis can bring a lot of information and help in the understanding of the phenomena occurring during the compression or the discharge process.
- CFD can be used during the scroll compressors design process.