[2D06]: COMPUTATIONAL FLUID DYNAMIC STUDY OF A HIGH PRESSURE EXTERNAL GEAR PUMP

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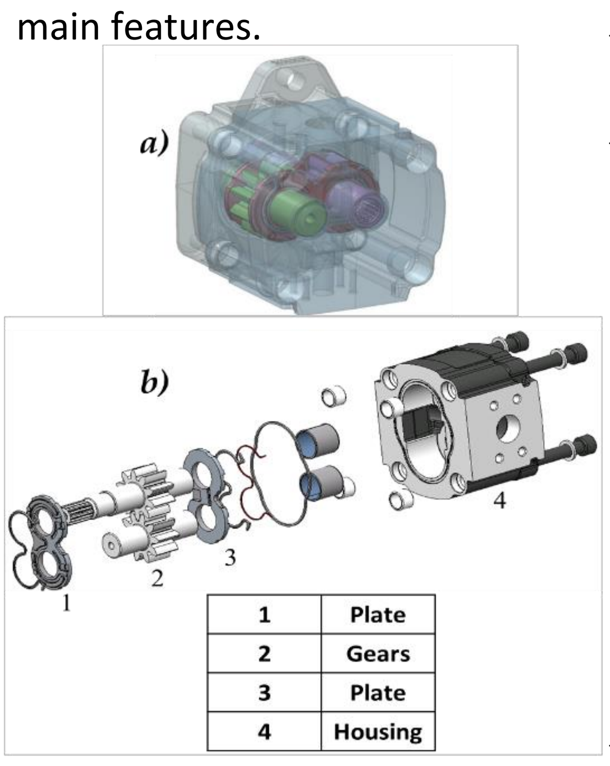
Introduction & Motivation

- As known, the high-pressure external gear pump are widely used in the Fluid Power field.
- The optimization the performance of these components can be done though modeling approach.
- In particular the study of the internal fluid-dynamic of the EGP is important in to estimate the volumetric efficiency of the pump by modifying the internal leakages.
- By using a modeling technique it is possible to evaluate the effects on the pump performance of clearances in the meshing area.
- The methodology can be also applied in order to investigate cavitation especially in meshing fluid volume of the pump.

Casappa KP30 Description

A The pump under investigation is the Casappa KP30 (Casappa S.p.A., Parma, Italy). The pump geometry is shown in the exploded vision in Figure 1(b). In the table reported by following there are listed the pump main features.



Pump Main Features	Value
Nominal displacement	44 cm^3
Inlet pressure range	0.7–3 bar
Max. continuous pressure	P1 = 250 bar
Max. intermitted pressure	P2 = 270 bar
Max. peak pressure	P3 = 290 bar
Rotational speed	Min = 350 min^{-1} Max = 3000 min^{-1}

Figure 1. (a) Casappa KP30, (b) exploded vision of the pump drawing.

Numerical Model Description

The three-dimensional CFD model of the pump has been built up stating from the geometry already shown in figure 1. Each part of the pump has been extracted and then included in the final model.

Fluid Volume Extraction

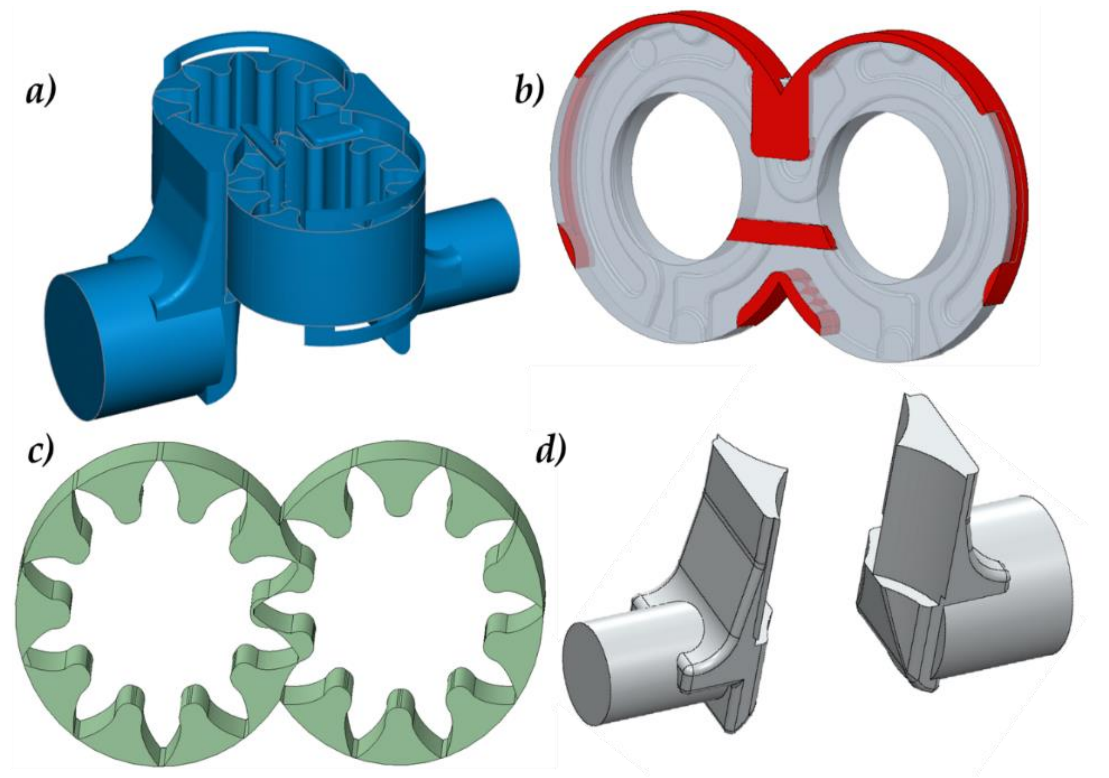


Figure 2. Extracted fluid volume of the external gear pump, (a) entire fluid volume, (b) fluid volume of the plate, (c) fluid volume in rotation, (d) fluid volume of the ports.

The fluid volume has been meshed using a body-fitted binary tree approach. The grid generated with a body-fitted binary tree approach is accurate and efficient because the parent-child tree architecture allows for an expandable data structure with reduced memory storage. The entire mesh of the pump is shown in figure 3.

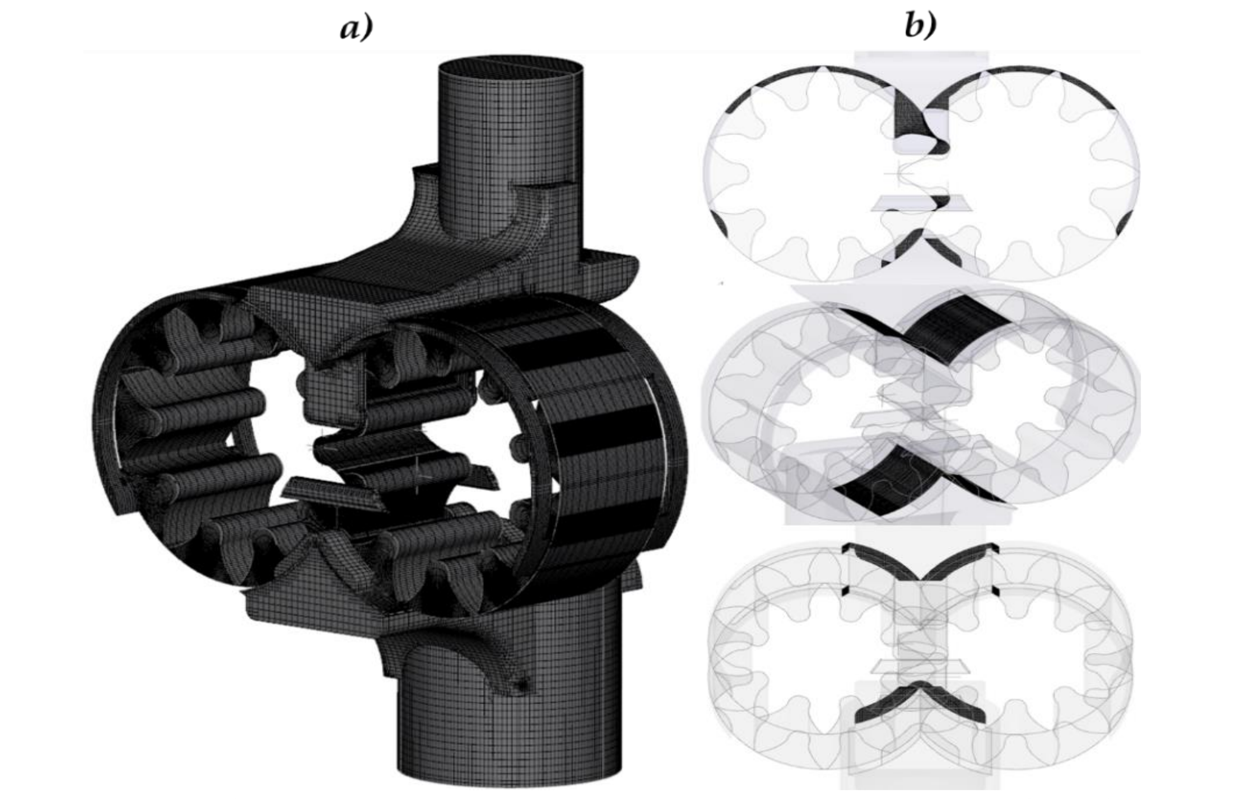


Figure 3. (a) Binary tree mesh, (b) mismatched grid interface (MGI) between volumes

Leakages

An analysis on the sizing of the gaps between teeth has been carried out. This study, in fact, becomes crucial to correctly predict the performance of an external gear pump. Therefore, it has been done a study by modifying the clearances between teeth of gears. Figure 4 shows the final gap given as input to the model.

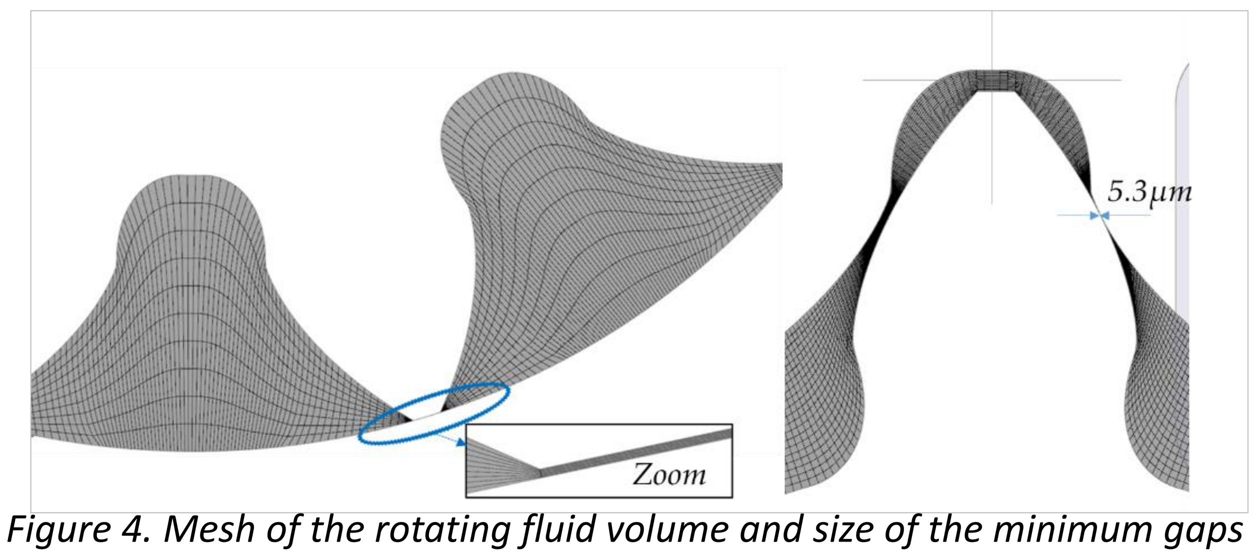


Figure 4. Mesh of the rotating fluid volume and size of the minimum gaps

Experimental Test Set-Up

The pump has been tested on a dedicated test bench at Casappa S.p.A. The test bench is shown in Figure 5. Simulations have been run under the same conditions tested in the lab with pump speeds of 1000, 1500 and 2500 rpm, oil temperatures of 50 and 80 ° C and delivery pressures of 50, 150 and 250 bar.

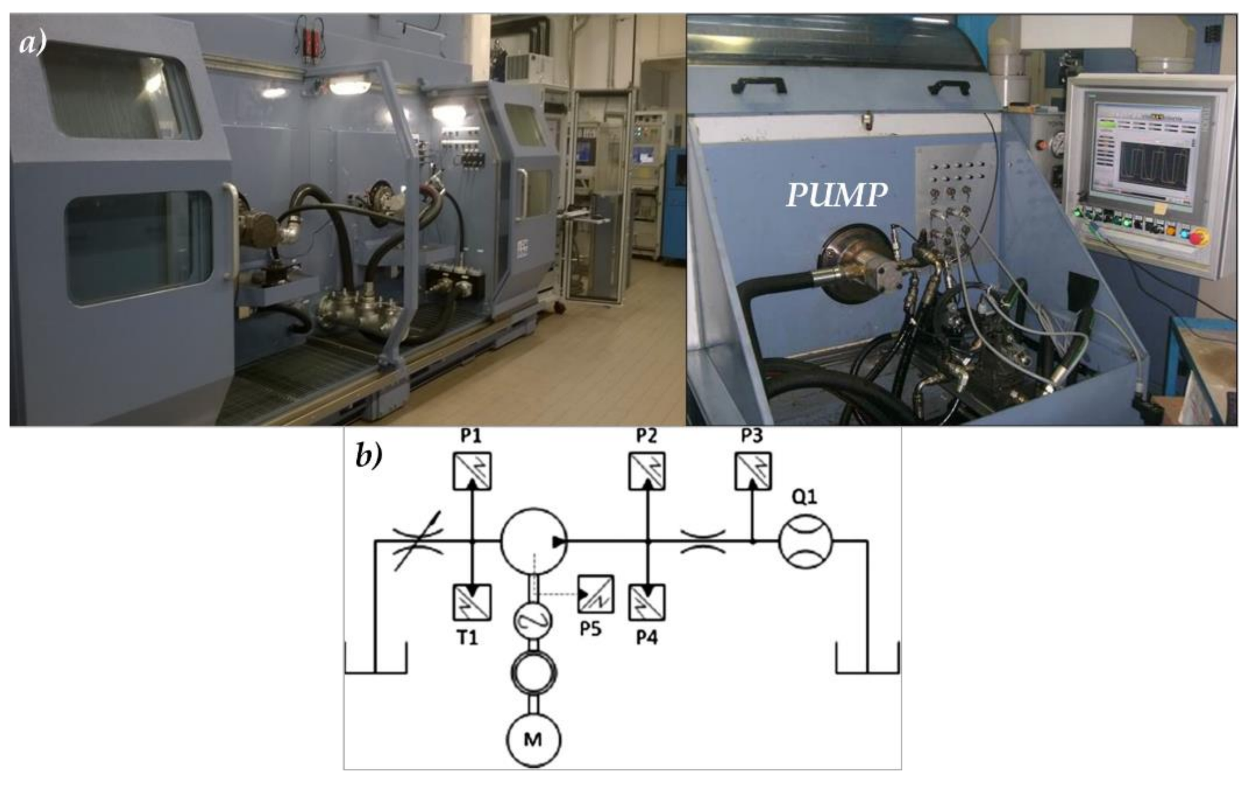


Figure 5. (a) Test bench of Casappa S.p.A., (b) test bench layout

Model Validation & Results

Model validation has been done also comparing at the delivery flow-rate varying the delivery pressure. This comparison is shown in Figure 6a) with the oil temperatures of 50 ° C and at pump speed of 1500rpm. In figure 6b) the pressure ripple at 1500rpm and 50° C and 50bar is presented.

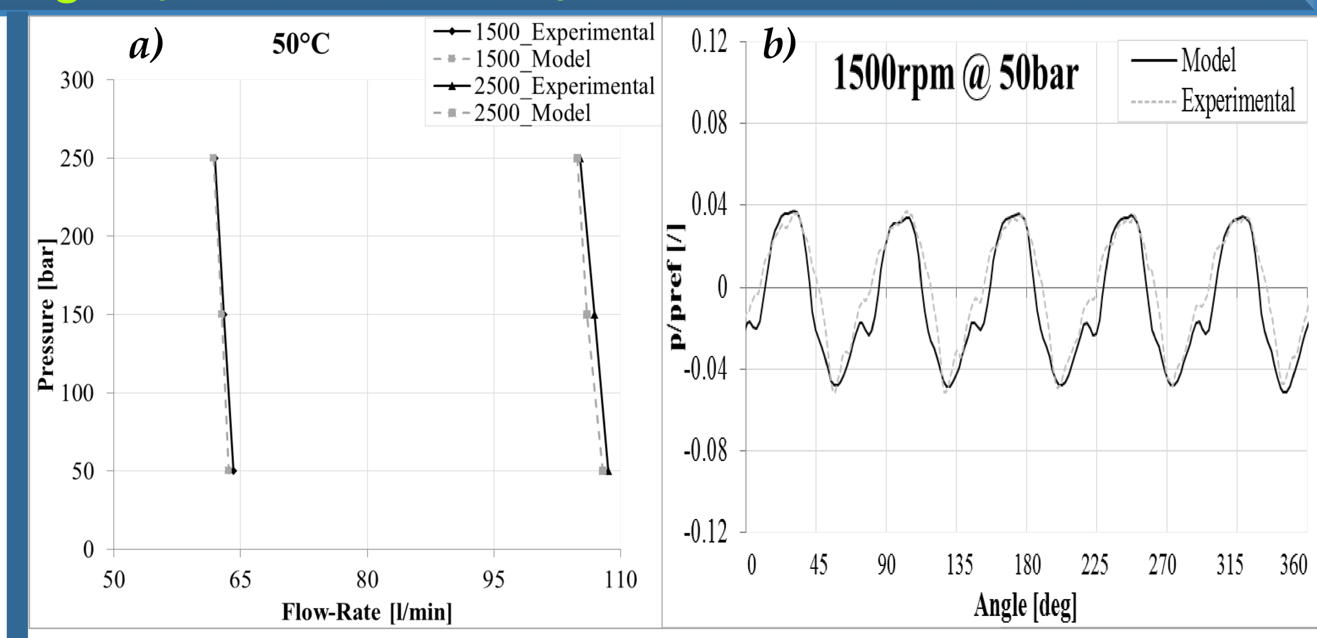


Figure 6. (a) Pressure vs. delivery flow-rate comparison at 50, (b) Pressure ripple at 50 bar@1500 rpm@50 °C

The validated model has been analyzed in order to study the pump in depth. Figure 7 shows a first result of the numerical model with the velocity magnitude countering through the leakages between gears and the static body. The area under investigation in the pictures is shown in particular in Figure 7c. In fact figures refer to the leakages between the first pressurized chamber and the last chamber at low pressure.

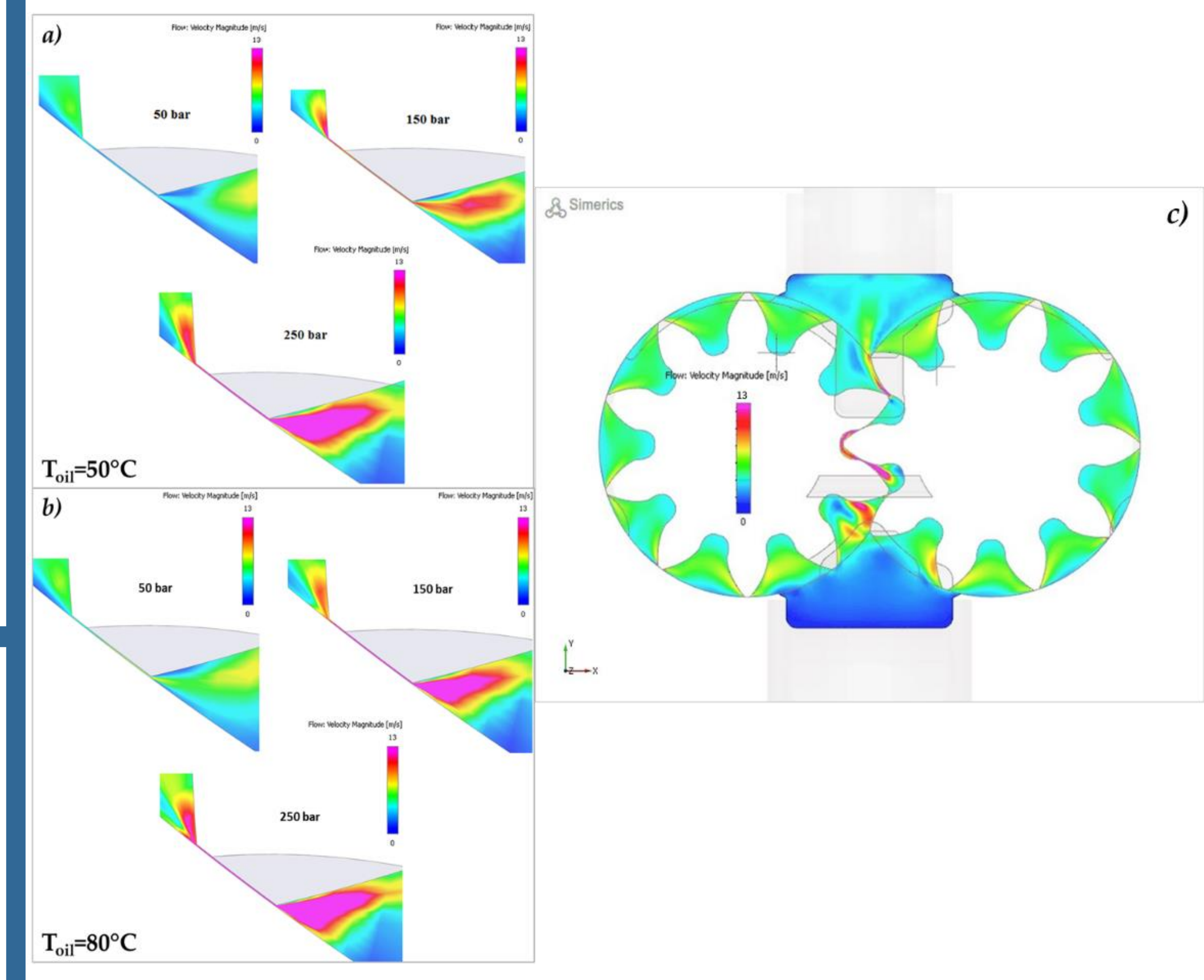


Figure 4. Velocity magnitude at (a) 50 ° C, (b) 80 ° C and (c) zoomed area

Conclusions & Future Work

Conclusions

- A three-dimensional CFD study a high-pressure EGP has been built up on a geometry of a pump manufactured by Casappa S.p.A.
- Leakages have been taken into account in order to correctly estimate the volumetric efficiency of the pump. The final model has demonstrated to achieve an accuracy close to 1%.
- Model results have been validated with experimental data obtained by the pump manufacture on the described test bench.
- Simulations have found that at the higher pressure and speeds the pump has a tendency to cavitate. For this reason, monitoring points have been located inside the chamber volumes of both gears.
- This study summarized a methodology able to completely describe the operation of pumps such as external gear pumps.

Future Work

- The described methodology will be applied for designing of more efficient new pumps.

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