# Computational Fluid Dynamic model of a Gear Pump leakages by using a Dynamic Mesh

**Serena Morselli [1], Cristian Ferrari [1]**

[1] CNR – IMAMOTER. Istituto per le Macchine Agricole e Movimento Terra — National Research Council of Italy
Via Canal Bianco, 28 - 44124 Ferrara

## Introduction

Gear pumps represent the majority of the fixed displacement machines used for flow generation in fluid power systems. The internal conformation of this system contains many undetermined variables, due to both the manufacturing techniques and the breaking-in pressure, that strongly affect the pump performance..

The 3D CFD model of this type of products is particularly difficult to develop and is presented in this work, which main purpose is a sensitivity analysis on key operating parameters of a gear pump studied with both numerical and experimental techniques.

### CFD difficulties for gear pumps simulations

- **Moving gear contact point** – Impossible to easily simulate using most of the 3D CFD commercial code
- **Changing fluid domain** – Deforming meshes are compulsory
- **Interference coupling between gears and casing** – Experimental geometry different from simulated geometry (breaking-in procedure)
- **Great differences of mesh length** – Volume in between gears modifies rapidly

**High computational cost**

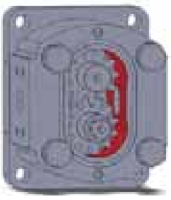
- **Dynamic mesh**
- **Numerical leakage** – Creation of a layer of mesh between the gears in order to better adapt the mesh deformation
- **Time dependent simulation**

## Method

### 1 Geometry

Leakage paths considered for the aim:

- Clearances between gear and case (25 μm)
- Clearences between gears (numerical leakage)



### 2 Fluid domain extrapolation

- Lengthen of the suction and discharge pipes (increase stability at the boundaries)
- Boolean operation of subtraction of the fluid from the geometry
- Lateral gaps excluded from the model

### 3 Boundary Conditions & methods

| | |
|---|---|
| Rotational speed [rpm] | 1000 - 2000 |
| Δp [bar] | 8 -140 |
| Turbulence model | 2-eq k-ω SST |
| Convergence criteria | $10^{-4}$ |
| p-v coupling scheme | PISO |
| Resolution scheme | Second order |

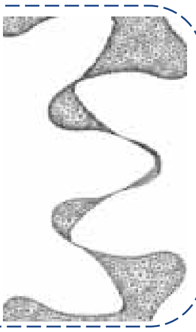
### 4 Dynamic Mesh

ANSYS FLUENT

Deforming mesh in the in-meshing fluid thanks to the use of two algorithms:

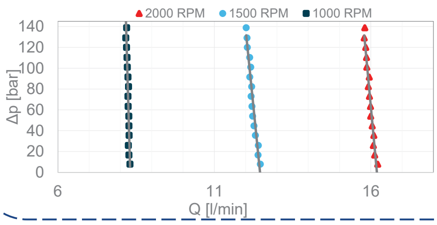
- Smoothing (Spring Analogy)
- Remeshing (2.5 D Mesh Motion)

Mesh updated at each time step of $10^{-7}$ s



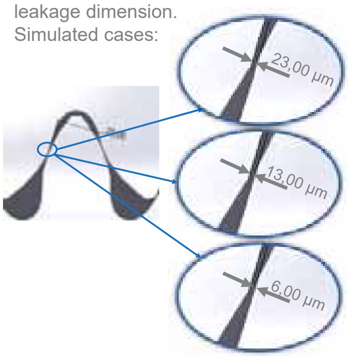
### 5 Validation

Characteristic curve data acquisition at the test bench




### Leakage variation

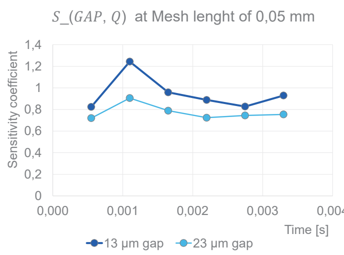
Repetition of the method at different leakage dimension.
Simulated cases:




### Sensitivity analysis

Partial derivatives method

$$S_{GAP,Q(t)} = \left|\frac{\partial Q}{\partial GAP_i}\right|_{GAP^0=6\,\mu m}$$

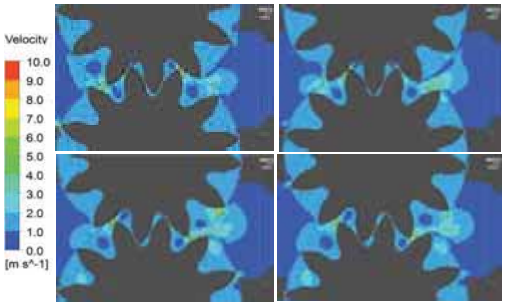



High variation of the flow rate in function of the leakage dimension

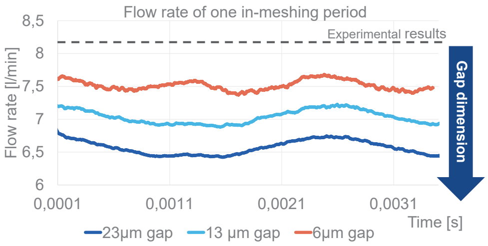
### 6 Results

Results for a rotational speed of 1000 rpm at a differential pressure of 45 bar.

Velocity gradient during the functioning:

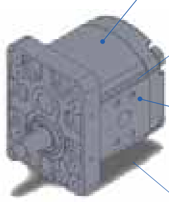



The results obtained are a time dependent comparison of the flow rate trend in function of the gap variation. Is possible to observe that the accuracy of the simulation increases with the leakage reduction and the computational cost.




The numerical leakage is the key parameter for the CFD analysis of a gear pump and by estimating the discretization error is possible to re-design the pump without the construction of prototypes.

### 7 Future prospectives



- Low computational cost prediction of the entire curve of functioning
- Creation of the fluid-structural model
- Vibrational-noise prediction
- Light-weight design

**Contact address:**
*s.morselli@imamoter.cnr.it*

**References:**

- [1] S. Mancò, N. Nervegna, "Simulation on an external gear pump and experimental verification" In *Proceedings of the JHPS International Symposium on Fluid Power*, 139-152, (Tokio, Japan,1989).
- [2] R. Castilla, P. J. Gamez-Montero, N. Erturk, et Al., "*Numerical simulation of turbulent flow in the suction chamber of a gearpump using deforming mesh and mesh replacement*," International Journal of Mechanical Sciences 52, 1334-1342 (2010).
- [3] S. Dhar, A. Vacca, *"A fluid structure interaction – EHD model of the lubricating gaps in external gear machines:Formulation and validation"*, Tribology International 62, 78-80 (2013).