Collaborazioni efficaci fra eccellenze universitarie e PMI per accelerare gli sviluppi dei prodotti



IDEE E STRUMENTI PER L'IMPRESA MANIFATTURIERA

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# FPRL at a glance

#### **Didactics**

- 1<sup>st</sup> course of Fluid Power in Italy (1979)
- 1979 2017: about 9500 students
- From 2014: 2 courses in English at M.Sc.
- More than 100 M.Sc. theses

#### Research

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- About **100** scientific papers
- Development of simulation models of
- positive displacement machines and valves

#### www.fprl.polito.it



## Laboratory

- 1985: construction of the 1st Lab
- 2005: completion of the new Lab



# **Test facilities**

#### LUBRICATING PUMPS TEST RIG



LOAD SENSING TEST RIG with steering unit and hydraulic winch



#### PUMPS AND MOTORS TEST RIG



DIDACTIC TEST RIGS







#### SERVOVALVES TEST RIG









# **Industrial research collaborations**

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# Aims and types of simulations

#### **Prediction of the component/system behaviour for:**

- Reduction of the number of prototypes and of experimental tests
- Optimization of the performances (increment of the efficiencies)
- Finding solutions for possible malfunctions

#### **Type of domain**

- Fluid (flow rate, pressure, temperature and so on)
- Solid (contact stress, wear and so on)

#### Simulation models (fluid)

- Lumped parameters (0D)
- Distributed parameters (1D, 2D, 3D)  $\rightarrow$  Computational Fluid Dynamics

#### **Fluid-bodies interaction**

- Simulation of micro-movements (due to clearances)
- Deformations



# The simulation of positive displacement pumps



Variable volume chambers

- 1 variable chamber = 1 control volume (homogeneous fluid properties)
  - control volumes connected by resistive hydraulic components (flow areas in portplate, leakage passageways)

#### **1D3D** The entire domain is discretized in elementary cells (mesh)



**0D** 



# Lumped parameter models



Internal gear pump (gerotor)

- Hydraulic volume: continuity equation
- Hydraulic resistance: flow equation



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Pressures, flow rates



Evaluation of the geometric quantities





# **CFD models**





# **Example of CFD simulations**

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# **Fluid-bodies interaction**

#### Small movements of mechanical parts $\rightarrow$ influence on leakages

Contact vane-stator in a vane pump (detachment analysis)





Force equilibrium on each vane:

If contact  $\rightarrow$  evaluation of contact force on the stator  $\rightarrow$  contribution to the stator equilibrium

If detachment  $\rightarrow$  evaluation of the leakage on vane tip  $\rightarrow$  influence on the chamber pressures





# Synthesis of models capabilities

#### Lumped parameter (0D):

- Leakages evaluation  $\rightarrow$  clearances optimization
- Chamber pressure history  $\rightarrow$  optimization of the port plate
- Contact forces
- Power consumption analysis

# **1D:**

- Pressure ripple
- $\rightarrow$  fluid-borne noise
- Wave propagation

## **2D:**

- Detailed analysis of:
  - Leakages through complex geometries
  - Axial forces on rotors and balance plates

#### **3D:**

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- Detailed analysis of internal pressure drops
  - $\rightarrow$  evaluation of the operating conditions of incipient cavitation
  - $\rightarrow$  tuning of 0D models





#### **DUPLOMATIC GROUP**



## **DUPLOMATIC GROUP IS GROWING MORE AND MORE**

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#### WIDE RANGE OF HYDRAULIC COMPONENTS





# New product development – Starting from a draft? Existing Product (1/3)



#### Pump type: PVX-20

- Model code: PVX-20B30-RF-P-5S17-A
- Maximum displacement: 48.856 cm<sup>3</sup>/rev
- Maximum continuous pressure: 210 bar
- Displacement control: dual stage absolute pressure limiter
- Pressure limiter setting range: 24 - 210 bar
- Speed range: 1150 - 1800 rpm





# New product development – Starting from a draft? Existing Product (2/3)





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# <u>New product development – Starting from a draft? Existing Product (3/3)</u>







# Simulation as a tool for deep investigations









# **Modeling tuning/validation**

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# Wear due to high contact stress









#### **Pressure ring wear improvement**

#### **CURRENT PRODUCTION 210 bar**



- 1 hr deadhead
- 0 hr peak power
- Ok cycles

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#### NEW PUMP 250 bar



- 3 hr deadhead
- 24 hr peak power
- 20k cycles





# New product development – Lesson learned

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#### **PQR - Variable Displacement Vane Pump**





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Size	Unit	010	018	028	032	045	071	080	100	140	180
Displacement	cc/rev	10	18	28	32	47,3	71	82,3	100	140	180
Frame		SAE A 2 bolt	SAE A 2 bolt	SAE B 2 bolt	SAE B 2 bolt	SAE B 2 bolt	SAE C 2/4 bolt	SAE C 2/4 bolt	SAE C 2/4 bolt	SAE D 4 bolt	SAE D 4 bolt
Rated Pressure	bar		250								
Intermittent Pressure	bar						320				

- Increased rated pressure from 210 to 250 bar
- Added new displacements (10 and 180 cc/rev)



# **Intensive testing**



• 10 test benches for parallel runs

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- Most powerful 250 kW full qualification test bench
- Time for qualification: 2 to 3 months based on official test specification



## Improved performances of PQR Variable Displacement Vane pump







## **AP1V – Variable Displacement Piston Pump**





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Size	Unit	015	021	035	045	065		
Displacement	cc/rev	14.9	20.9	35.3	45.2	65.9		
Frame		SAE A 2 bolt	SAE B 2 bolt	SAE B 2 bolt	SAE C 2 bolt	SAE C 2 bolt		
Rated Pressure	bar	280						
Intermittent Pressure	bar			350				

• Increased rated pressure from 240 to 280 bar



# GRAZIE PER L'ATTENZIONE

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