Maha Fluid Power Research Center

Intensive Mini-Course on HYDROSTATIC PUMPS AND MOTORS

Contact Information

Lizhi Shang: shangl@purdue.edu
Andrea Vacca: avacca@purdue.edu

How to Register

Please reach out to any of the above contact persons for the registration link and discount code if applicable.

Dates

Oct 13th – 17th, 2025
Monday – Thursday whole days and Friday morning

Target audience

This course is designed for industry professionals who have

- Engineering degrees or equivalent
- Basic understanding of the positive displacement machine principle

Course Description

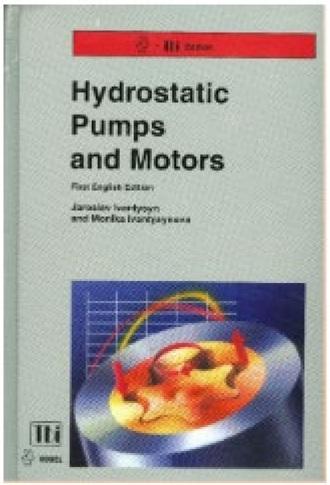
Designed for professionals with an engineering background from Maha industrial members, this intensive five-day course focuses on the design and optimization of positive displacement pumps and motors – a key interest for Maha's industrial partners. Participants will gain fundamental knowledge and practical skills in hydrostatic machines, covering:

a) Essential physics for understanding hydraulic machine operation and performance.
b) Working principles of common hydrostatic pump and motor types.
c) In-depth study of piston and gear machines.
d) Introduction to computer simulation for design and optimization.
e) A hands-on experience in pump noise measurement within Maha's Semi-anechoic chamber.

The course provides a comprehensive learning experience through class lectures, in-class practices, and hands-on laboratory sessions. Participants will gain practical skills through numerical simulations using industry-standard software such as Simcenter Amesim and Simerics MP+, as well as Maha's in-house developed Multics. A unique highlight is the hands-on experience in pump noise measurement. All software/lab usage during the course is included at no additional fee.

At the end of day 5, all participants who completed the course will be granted a Maha intensive course completion certificate.

Textbook



Hydrostatic pumps and motors
Jaroslav Ivantysyn and Monika Ivantysynova
2001 Akademia Books International

Reprints (Spiral binding) are available at the
Follett's Purdue Bookstore
1265 W. State Street
West Lafayette, IN 47906
(765)743-9642
purdue@bkstr.com

Learning Objectives

Upon completion of this course, participants will be able to:

1. **Analyze** the working principles, advantages, and disadvantages of common types of hydrostatic pumps and motors.
2. **Explain** the dynamics and kinematics specific to axial piston machines and gear machines.
3. **Identify** common sources of power losses in hydrostatic machines and their analytical expressions, based on appropriate assumptions.
4. **Conduct** hydrostatic pump noise measurement.
5. **Experience** the latest simulation tool for hydrostatic machines.

Online Option

While the optimal learning experience for this course is achieved through in-person participation at Purdue University, recognizing travel constraints, we are pleased to offer an online option starting this year.

This online format provides access to the live lecture sessions, conducted Monday through Friday mornings, and includes a daily assessment to be completed asynchronously. Unfortunately, online participants will not be able to participate in the afternoon lab sessions.

Tentative Schedule

The table below provides the schedule for the minicourse, which will occur from Monday to Thursday and Friday morning.

<table>
<tr><th>Day</th><th>Topic</th></tr>
<tr><td>Monday
Lecture</td><td>Refresh the working principle of the positive displacement machine
• Displacement volume
• Theoretical flow rate and torque of pumps and motors
• Volumetric, hydromechanical, and total efficiency of pumps and motors
• Steady-state measurement of hydrostatic pumps and motors
Overview of different types of pumps and motors and their working principle (Part 1)
• Overview of the characteristics and common application of different types of hydrostatic machines
  ○ Piston types – axial and radial
  ○ Gear types – external and internal
• Working principle and application of the above-mentioned common types of positive displacement machine</td></tr>
<tr><td>Monday
Lab</td><td>Lumped parameter model:
• Introduction to Amesim simulation
• Settings of fluid properties
• Components – hydraulic cylinder, orifice
• Develop a single-piston plunger pump
• Post-process simulation results
• Develop a swashplate-type piston pump lumped parameter model
• Calculate flow ripples and swashplate forces and moments</td></tr>
<tr><td>Tuesday
Lecture</td><td>Overview of different types of pumps and motors and their working principle (Part 2)
• Overview of the characteristics and common application of different types of hydrostatic machines
  ○ Gerotor
  ○ Vane
  ○ Screw
• Working principle and application of the above-mentioned common types of positive displacement machine
Definition of common fluid properties
• Viscosity
• Bulk modulus
• Density
Laminar flow in gap analytical calculations
• Calculation of viscous friction between two parallel surfaces
• Friction (viscous stress) on the surface and leakage flow
• How to reduce (balance) friction and leakage in lubricating gaps
Compressibility of the fluid and its effects on pumps and motors' performance
• P-V diagram considering compressible fluid
• Calculation of the volumetric flow rate considering compressibility</td></tr>
</table>

	• Compression loss • Common way to mitigate the challenge due to compressibility
Tuesday Lab	Lubricating Interface model: • Introduction to Mutlics • Numerical simulation of piston/cylinder lubricating interface • Visualization of simulation results • Post-process of the power loss distribution in hydrostatic machines
Wednesday Lecture	Piston machine kinematics and dynamics • Piston stroke and velocity • Pressure and flow in a single displacement chamber • Kinematic flow ripple • Swashplate forces and moments • Piston forces and moments (piston free body diagram) • Cylinder block forces and moments (cylinder block free body diagram) Cavitation and Aeration • Density/pressure relationship considering static cavitation • Impact of cavitation in pumps and motors
Wednesday Lab	CFD simulation: • Creating mesh of an existing piston pump geometry • Conduct CFD simulation and interpolate convergence criteria • Conduct CFD simulation at multiple operating points and map the performance curve • Visualizing simulation result (pressure distribution, flow velocity, gas fraction …)
Thursday Lecture	Piston machine design parameters and their associated performance impact • Piston/cylinder interface friction and leakage calculation • Cylinder block/valve plate interface friction and leakage calculation • Slipper/swashplate interface friction and leakage calculation Piston machine common designs • Common design part A: valve plate groove, filled/hollow piston, offset and gamma angle • Common design part B: male/female piston, piston groove, multi-land slipper, step slipper vs orifice, spherical cylinder block, cylinder block balance land, slipperless design Gear machine kinematics and dynamics • Involute gear profile (external and internal) • Gerotor gear profile • Definition of the displacement and the displacement volume over time (external, internal, and gerotor) • Leakage paths in gear machines (external, internal, and gerotor)

<table>
<tr><td></td><td>Kinematic flow ripple (external, internal, and gerotor)
Forces and moments on driving gear and driven gear (external)
Forces and moments on journal bearing bushing (external)
Gear machine design parameters and their associated performance impact
Number of gears
Width of gears
Gear geometry
Meshing groove and high-speed groove
Gear machine common designs
Journal bearing bushing/balance plate
Consideration of gear motors</td></tr>
<tr><td>Thursday
Lab</td><td>Hydrostatic machine noise test
Introduction to the hydraulic circuit and DAQ system
Conduct noise test
Interpolate the measurement results
Lab tour</td></tr>
<tr><td>Friday
Lecture</td><td>Swashplate control system
Schematics of a displacement control system
Schematics of a pressure compensation system
Discussion of hydrodynamic effects and deformation effects on pump performance
Definition and challenge of EHL
Pressure distribution of a sliding bearing
Pressure distribution of a journal bearing
Demonstrate a Multics simulation result of journal bearing with and without elastic deformation
Demonstrate the deformation magnitude of critical components in piston pumps and gear machines using Multics
Discussion of thermal effects on pump performance
Concept of T-EHL
Demonstrate Multics simulation result with and without consideration of fluid domain heat transfer (piston pump)
Demonstrate the thermal deformation magnitude (piston pump)</td></tr>
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Attendance

The minicourse will open to in-person participants at Purdue University. Number of participants is limited to the classroom/lab capacity.

Cost

Free registration for:

- 1 participant from Maha Fluid Power Research Center Basic Members

- 3 participants from Maha Fluid Power Research Center Executive Members

$1,500 / additional participants from members (*)

$3,500 / participant for non-members (*)

(*) registration priority goes to members benefitting from free registration as detailed above

Registration includes all course material (book is not included), lunches, and coffee breaks.

No dinner/hotel accommodation provided.