Maha Fluid Power Research Center

Intensive Mini-Course on HYDROSTATIC PUMPS AND MOTORS

Contact Information

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Dates

March 27th – 31st, 2023
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

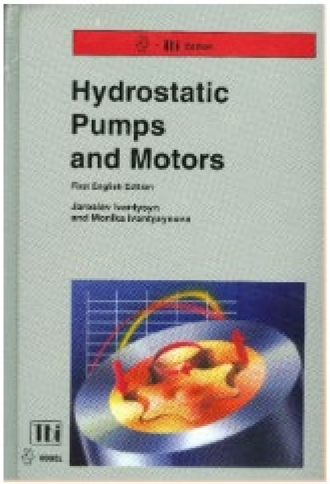
Course Description

The design and optimization of positive displacement pumps and motors are one of the interests of the Maha industrial members. This is an intensive course designed to help professionals from Maha industrial members who have an engineering background gain fundamental knowledge and skills on hydrostatic machines. The five-day course covers a) the essential physics that helps to understand the operation of performance of hydraulic machines, b) the working principles of common types of hydrostatic pumps and motors, c) an in-depth study into piston and gear machines, and d) introduction and hands-on experience of using the computer simulation in assisting design and optimization of pumps and motors.

The course includes class lectures, in-class practices, simulation demonstrations, and hands-on pump simulation. Simulation software Simcenter Amesim and Simerics MP+ will be used during the demonstration and hands-on experience. No additional fee will be charged to the course participants for using the software over the duration of the course.

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

Textbook



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

Reprints are available at the
Follett's Purdue Bookstore
1400 W State Street
West Lafayette, IN 47906
(765)743-9642
0303txt@follett.com

Learning Objectives

1. Understand the common type of hydrostatic pumps and motors's working principles and advantages/disadvantages.
2. The dynamics and kinematics of axial piston machines and gear machines
3. Identify common sources of power losses and their analytical expression with proper assumptions.
4. Conduct hydrostatic pump steady state performance test
5. Develop a piston pump lumped parameter simulation in Amesim
6. Practice simulation of a piston pump in Simerics and predicts the flow limitation due to cavitation

Tentative Schedule

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

Day	Topic

Monday
Lecture
	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
	• Overview of the characteristics and common application of different types of hydrostatic machines
	    o Piston types – axial and radial
	    o Gear types – external and internal

	○ Gerotor ○ Vane ○ Screw • Working principle and application of the above-mentioned common types of positive displacement machine
Monday Lab	Hydrostatic machine steady state performance test • Introduction to the hydraulic circuit and DAQ system • Conduct steady-state test • Interpolate the measurement results
Tuesday Lecture	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 • Compression loss • Common way to mitigate the challenge due to compressibility
Tuesday Lab	Lumped parameter model I: • Introduction to Amesim simulation • Settings of fluid properties • Components – hydraulic cylinder, orifice • Develop a single-piston plunger pump • Post-process simulation results
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) 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 Swashplate control system • Schematics of a displacement control system • Schematics of a pressure compensation system
Wednesday Lab	Lumped parameter model II: • Develop a swashplate-type piston pump lumped parameter model • Calculate flow ripples and swashplate forces and moments
Thursday Lecture	Cavitation and Aeration • Density/pressure relationship considering static cavitation • Impact of cavitation in pumps and motors 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) • 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
Thursday 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 …)
Friday Lecture	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)

Attendance

The minicourse will open to in-person participants at Purdue University: max 20 participants

Cost

Free registration for:

- 1 participant from Maha Fluid Power Research Center Basic Members
- 2 participants from new Maha Fluid Power Research Center Basic Members (joining the center in 2023)
- 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.