Prof. Dr.-Ing. Jürgen Weber
Chair of Fluid-Mechatronic Systems

Profile and Key Activities

GFPS Webinar
Dresden | March 3rd, 2025

Profile and Key Activities
of the Chair of Fluid-Mechatronic Systems

Outline

1. Structure
2. Research
3. Academics

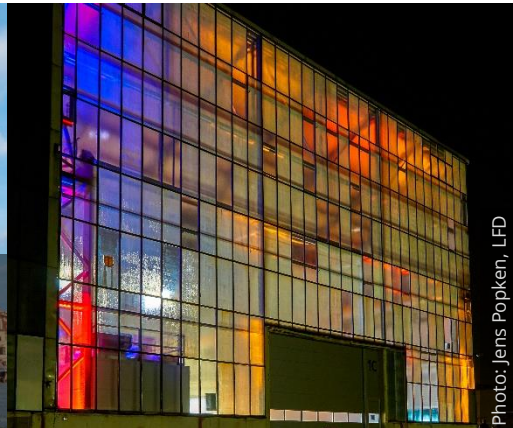

Photo: TU Dresden

Photo: André Wirsig
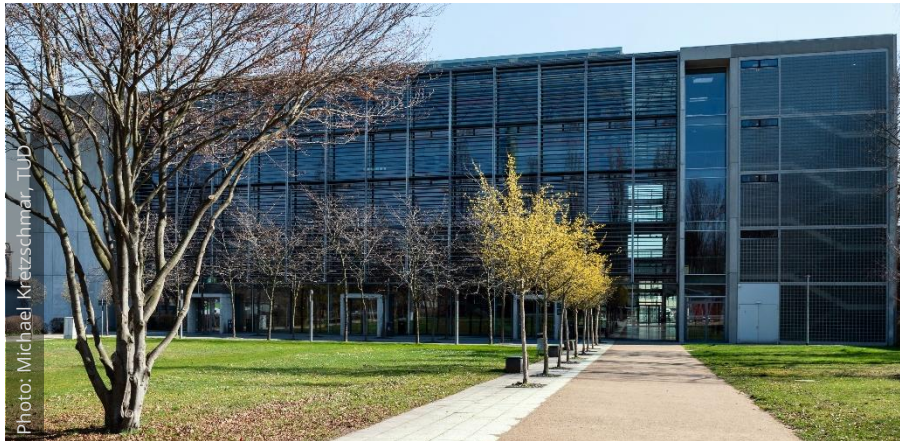
Photo: TU Dresden

Photo: Jens Popken, LFD

Photo: Jens Popken, LFD

TECHNISCHE UNIVERSITÄT DRESDEN

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Dresden | March 3rd, 2025

Slide 2

FLUID-MECHATRONISCHE SYSTEMTECHNIK DRESDEN

DRESDEN concept

1. Structure
General Overview

GFPS Webinar
Chair of Fluid-Mechatronic Systems
Dresden | March 3rd, 2025

TECHNISCHE UNIVERSITÄT DRESDEN

FLUID-MECHATRONISCHE SYSTEMTECHNIK DRESDEN

DRESDEN concept

Photo: Juliane Weber

Technische Universität Dresden
Facts and Figures

Technische Bildungsanstalt an der Brühlschen Terrasse (1828)

Hörsaalzentrum TU Dresden

- approx. 30,600 students[1]
- approx. 8,750 full-time employees[2]

Five Schools with 17 Faculties

- School of Science with the Faculties of Mathematics, Biology, Chemistry and Food Chemistry, Physics, and Psychology
- School of Humanities and Social Sciences with the Faculties of Education; Arts, Humanities and Social Science; and Linguistics, Literature and Cultural Studies
- School of Engineering with the Faculties of Mechanical Engineering, Electrical and Computer Engineering, and Computer Science
- School of Civil and Environmental Engineering with the Faculties of Civil Engineering, Architecture, Transport and Traffic Sciences "Friedrich List", Environmental Sciences, Business and Economics
- School of Medicine with Faculty of Medicine and University Hospital "Carl Gustav Carus"

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Slide 4

FLUID-MECHATRONISCHE SYSTEMTECHNIK DRESDEN

DRESDEN concept

Faculty of Mechanical Science and Engineering

Institutes

- Institute of Power Engineering
- Institute of Manufacturing Science and Engineering
- Institute of Solid Mechanics
- Institute of Lightweight Engineering and Polymer Technology
- Institute of Aerospace Engineering
- Institute of Machine Elements and Machine Design
- **Institute of Mechatronic Engineering**
- Institute of Natural Materials Technology
- Institute of Fluid Mechanics
- Institute of Material Handling and Industrial Engineering
- Institute of Textile Machinery and High Performance Material Technology
- Institute of Process Engineering and Environmental Technology
- Institute of Materials Science

- ☐ about 5,000 students
- ☐ approx. 50 professors
- ☐ approx. 1,000 employees
- ☐ ~€60 Mio. third-party funds annually

Zeuner-Bau TU Dresden

Institute of Mechatronic Engineering
Overview

INSTITUTE OF
MECHATRONIC ENGINEERING
Institute's Director : Prof. Dr.-Ing. Jürgen Weber

The Chairs

CHAIR OF FLUID-MECHATRONIC SYSTEMS	CHAIR OF MACHINE TOOLS DEVELOPMENT AND ADAPTIVE CONTROLS	CHAIR OF MAGNETO-FLUID DYNAMICS, MEASUREMENT AND AUTOMATION TECHNOLOGY	CHAIR OF CONSTRUCTION MACHINES
Prof. Dr.-Ing. Jürgen Weber	Prof. Dr.-Ing. Steffen Ihlenfeldt	Prof. Dr. rer. nat. habil. Stefan Odenbach	Prof. Dr.-Ing. Frank Will

approximately 100 research fellows

Institute of Mechatronic Engineering

Synergies and Cooperation Possibilities

Research Objectives

Key Topics

Key Topics	Functionality and Performance	Energy Efficiency	Robustness and Availability	Networking and Intelligence
Virtual Development Methods	🟠 🔴 🔵	🟠 🔴 🔵	🟠 🔴 🔵	🟠 🔴 🔵
Machine and Process Analysis	🟠 🔴 ⚫ 🔵	🟠 🔴 ⚫	🟠 🔴 ⚫ 🔵	🟠
System Integration	🟠 🔴 ⚫ 🔵	🔴	🔴	🟠 ⚫ 🔵
Test Rig Development	🟠 🔴 ⚫ 🔵	🟠 🔴 ⚫ 🔵	🟠 🔴 ⚫ 🔵	🟠 🔴 🔵
Alternative Materials	🟠 🔴 ⚫ 🔵	🔴 🔵	🟠 🔴	
Imaging Measurement Methods	🟠 ⚫ 🔵	🟠 ⚫	⚫ 🔵	🟠 ⚫
Fundamental Experiments	🟠 🔴 ⚫ 🔵	⚫	🟠 🔴 ⚫ 🔵	
Control System Development	🟠 🔴 ⚫ 🔵	🟠 🔴	🟠 🔴 🔵	🟠 🔴 🔵

🟠 Construction machinery   🔴 Fluid-Mechatronic Systems   ⚫ Measurement and Automation Technology   🔵 Machine Tools Development and Adaptive Controls

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FLUID-MECHATRONISCHE SYSTEMTECHNIK DRESDEN

DRESDEN concept

Institute of Mechatronic Engineering
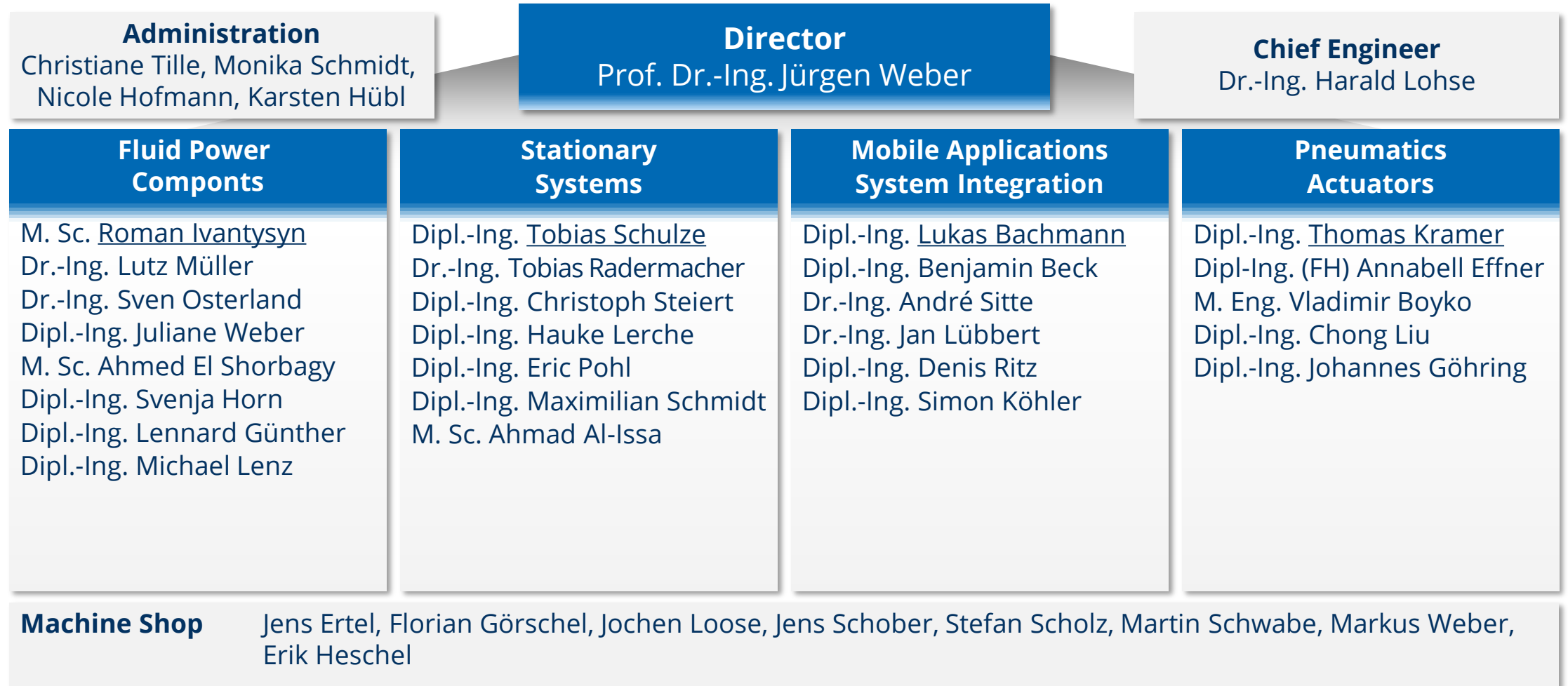## Facts and Figures

- **Holistic mechatronic approach** in the research of machines and processes as connecting element
- **120** employees, including **100** research fellows
- Laboratory (test rigs & field tests) and Machine Shops with more than **3.700 m²** plus and additional 1.100 m² of available research space
- **Approx. 6 Mio. EUR** third-party funds annually
- **Extensive equipment** for experiments and measurements under laboratory and field conditions
- Know-how, experience and software in all major **simulation methods/tools** (FEM, MKS, CFD, DEM, HiL, SiL, ...)

Photo: Crispin-Iven Mokry

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TECHNISCHE UNIVERSITÄT DRESDEN

FLUID-MECHATRONISCHE SYSTEMTECHNIK DRESDEN

DRESDEN concept

Chair of Fluid-Mechatronic Systems

Our Team

Administration	Director	Chief Engineer
Christiane Tille, Monika Schmidt, Nicole Hofmann, Karsten Hübl	**Prof. Dr.-Ing. Jürgen Weber**	Dr.-Ing. Harald Lohse

Fluid Power Componts	Stationary Systems	Mobile Applications System Integration	Pneumatics Actuators
M. Sc. Roman Ivantysyn	Dipl.-Ing. Tobias Schulze	Dipl.-Ing. Lukas Bachmann	Dipl.-Ing. Thomas Kramer
Dr.-Ing. Lutz Müller	Dr.-Ing. Tobias Radermacher	Dipl.-Ing. Benjamin Beck	Dipl-Ing. (FH) Annabell Effner
Dr.-Ing. Sven Osterland	Dipl.-Ing. Christoph Steiert	Dr.-Ing. André Sitte	M. Eng. Vladimir Boyko
Dipl.-Ing. Juliane Weber	Dipl.-Ing. Hauke Lerche	Dr.-Ing. Jan Lübbert	Dipl.-Ing. Chong Liu
M. Sc. Ahmed El Shorbagy	Dipl.-Ing. Eric Pohl	Dipl.-Ing. Denis Ritz	Dipl.-Ing. Johannes Göhring
Dipl.-Ing. Svenja Horn	Dipl.-Ing. Maximilian Schmidt	Dipl.-Ing. Simon Köhler	
Dipl.-Ing. Lennard Günther	M. Sc. Ahmad Al-Issa		
Dipl.-Ing. Michael Lenz			

Machine Shop   Jens Ertel, Florian Görschel, Jochen Loose, Jens Schober, Stefan Scholz, Martin Schwabe, Markus Weber, Erik Heschel

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FLUID-MECHATRONISCHE SYSTEMTECHNIK DRESDEN

DRESDEN concept

Our team is looking forward to meeting you!

General Contact:

Chair of Fluid-Mechatronic Systems, Kutzbach-Bau, Helmholtzstraße 7a,

Director: Prof. Dr.-Ing. J. Weber

Person to Contact

- Research (general): Dr.-Ing. Harald Lohse (harald.lohse@tu-dresden.de)
- Academics: Dr.-Ing. Lutz Müller (lutz.mueller@tu-dresden.de)

Photo: Juliane Weber, IFD

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FLUID-MECHATRONISCHE SYSTEMTECHNIK DRESDEN

DRESDEN concept

2. Research
Overview

Research Focus
Overview
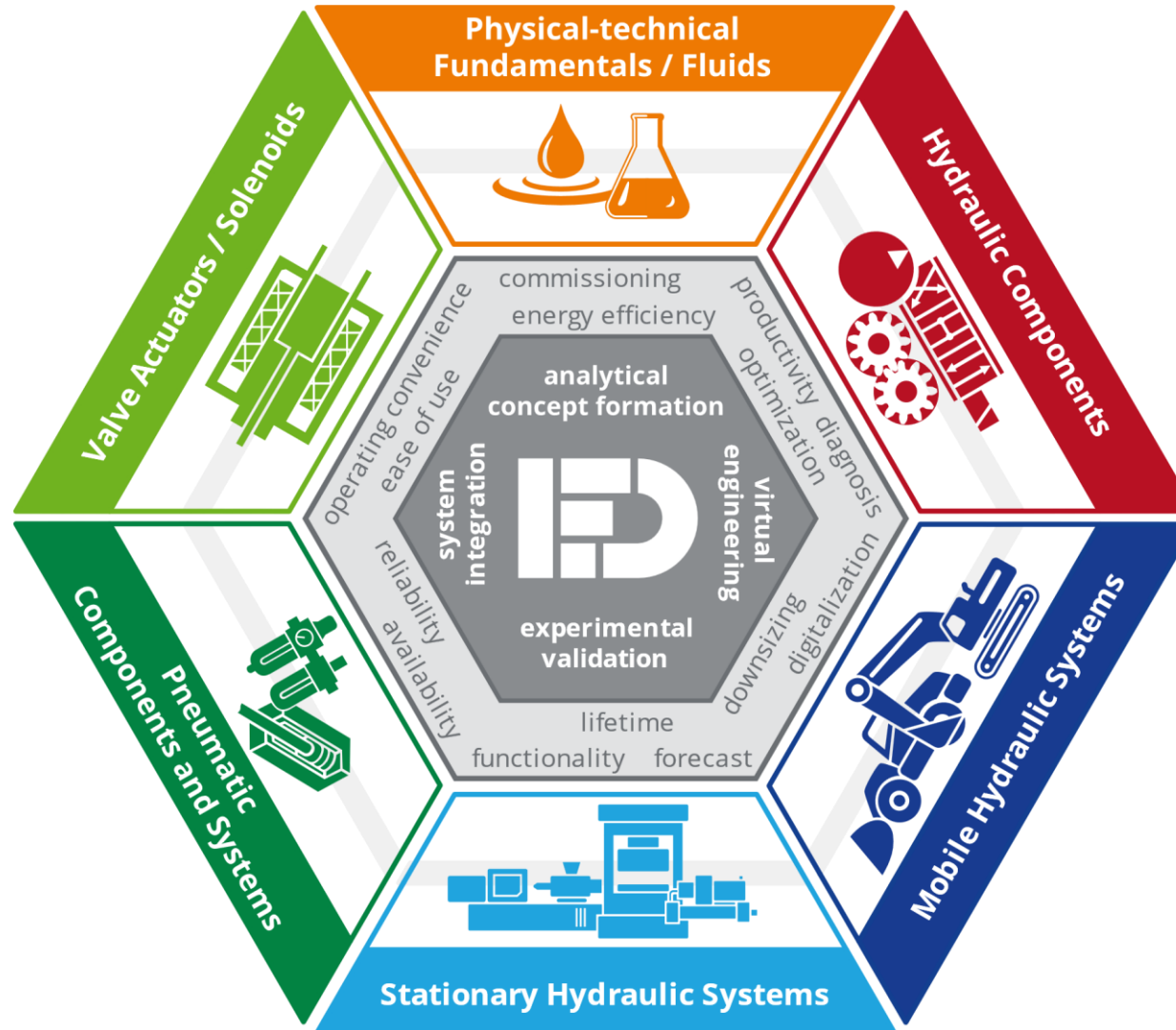
Fluid Power Components | Basics
Selected Research Topics

Motion Coupled Analysis of the Internal Flow of Hydraulic Valves

Sensor arrangement

FSI model: tilting of the slider
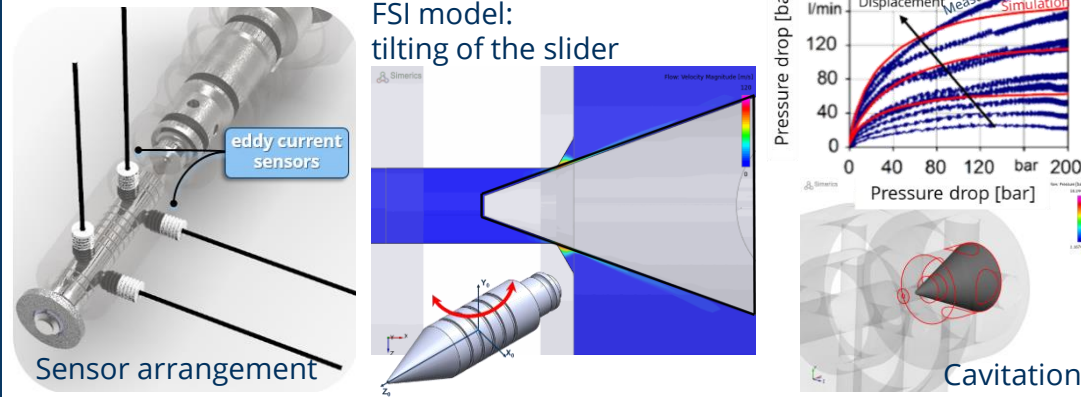
Cavitation

Tribology Optimization of Pump Systems through Production-Oriented Insertion of Mesostructures

≤1 μm Abrieb
Structure after 500h load test

Measured overall efficiency
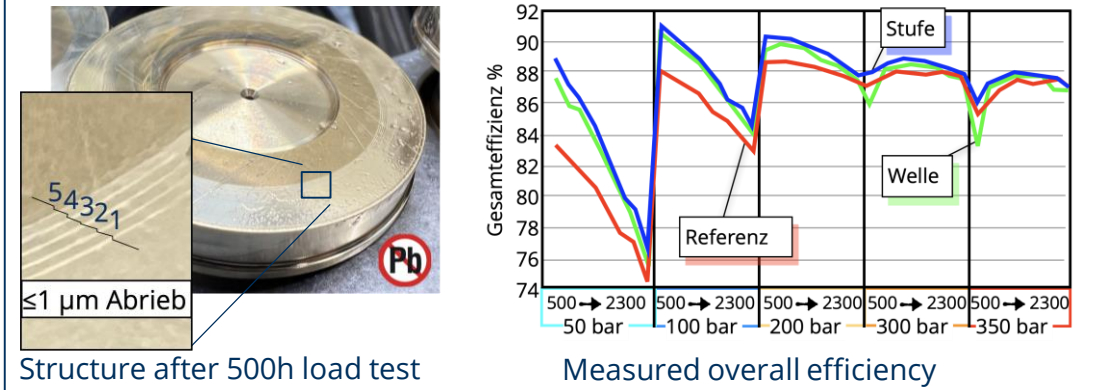
Wireless Measurement of Temperatures in the Cylinder Block of an Axial Piston Pump

Block Outer Surface Max Temperature
Temperature as an indicator of efficiency

Cavitation Erosion in Hydraulics

Copper sample
Out
Cavitation zone
In
„Valve spool"

luftfrei $\Delta m = 24{,}2 mg$
gesättigt $\Delta m = 5{,}5 mg$
0,31mm 0,61mm
0,12mm

TECHNISCHE UNIVERSITÄT DRESDEN

FLUID-MECHATRONISCHE SYSTEMTECHNIK DRESDEN

DRESDEN concept
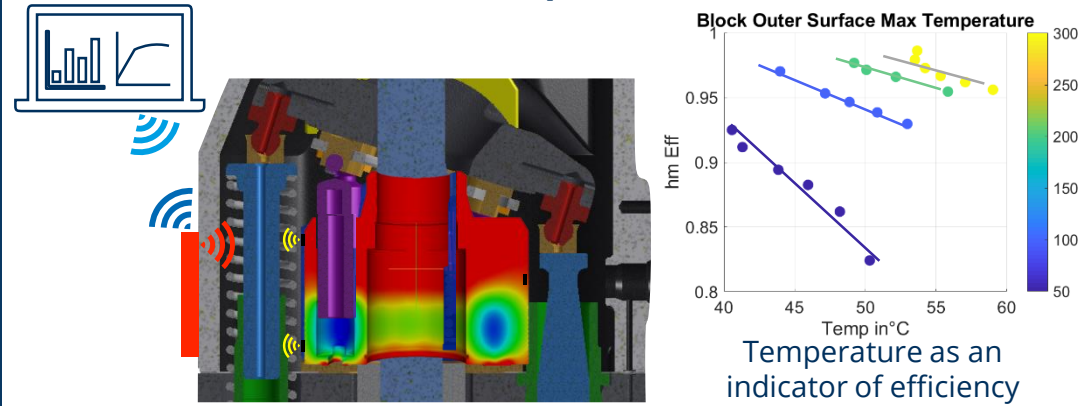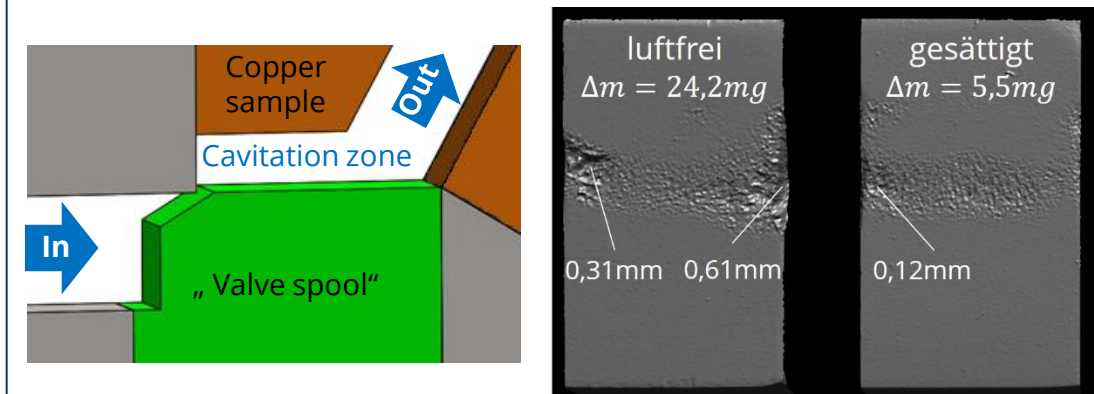
Stationary Systems

Selected Research Topics

Thermo-energetic Description of Fluid Systems in Machine Tools

Transition to demand-oriented cooling

Cooling system integration into the overall machine
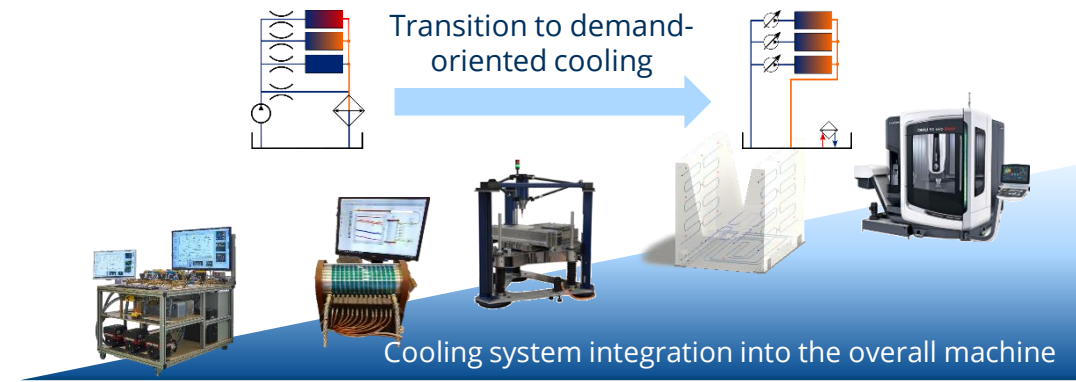
Thermal Management of Compact Drives

Model based analysis cooling structures

Modeling and simulation

MOR-FEM

Co-Simulation

Parameter extraction

Netzwerk-simulation

Electro-hydraulic and -mechanical compact drives

Experimental analysis

Thermo-energet. behavior

Differentiated modeling for design/operational phase
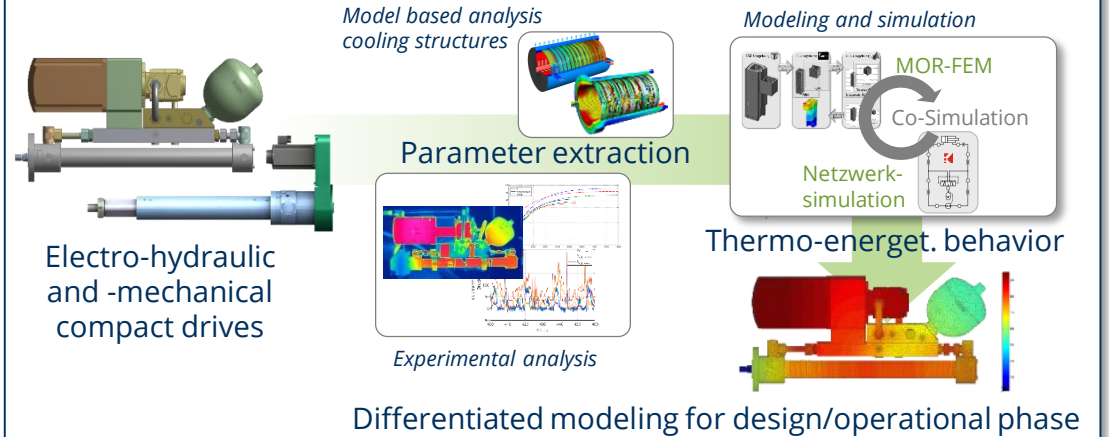
Automated Commissioning of Variable-Speed Linear Drives in a Closed Loop System

Parameteridentifikation

Reglerparametrierung

Feedforward control

$D = \det$

w — Controller System x

Theoretical model

Adjusted model

Error

Reglernachführung
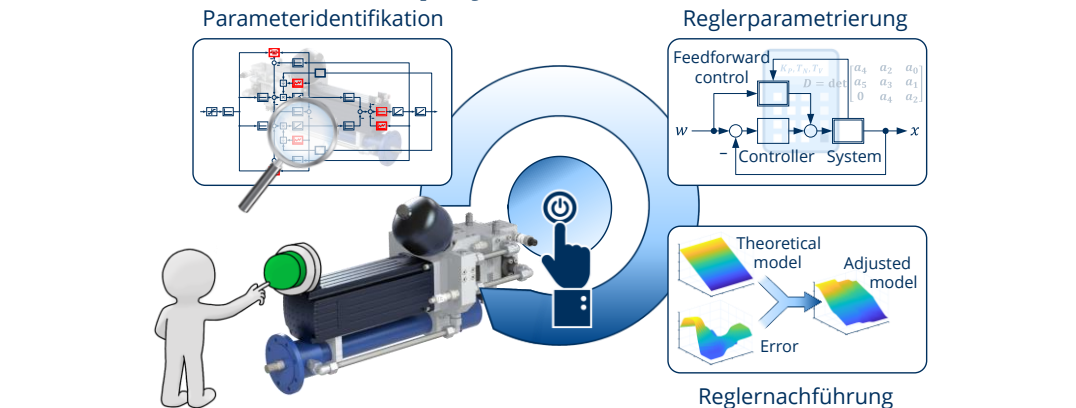
Cost-efficient Electro-hydraulic Compact Drives through Plastic Components

$v_{max} = 0{,}3...0{,}4$ m/s
$p_{max} = 40$ bar
$F_{max} = 5$ kN

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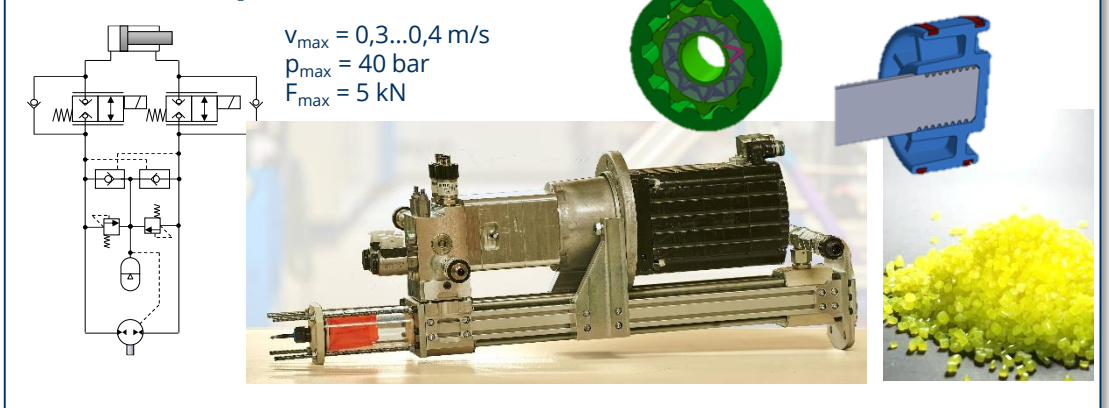
Mobile Applications | System Integration

Selected Research Topics

CONSTRUCTION 4.0

Local data server- construction site control system

Uplink public Network (www)
S2C = Server to Cloud
M2C = Machine to Cloud

OPC UA AGGREGATING SERVER

OPC UA CLIENT

Storage

Simulation

Tracing

C/UI

M2S

M2M

M2C

excavator - Information source on site

OPC UA SERVER

- M2S = Machine to Server
- M2M = Machine to Machine
- C/UI = Client App/ User Interface

Adaptive Model-based Fault Detection

Process → Sensors

Model

| Stat. behavior | Dyn. behavior | Oil | Solver |

ODE System & Solver

Error response

Info ← Diagnosis ← Detection ← Features

Analysis of the Thermal Interactions of Drive Systems of Mobile Machinery

Thermal model

Validation

Experiment

Model-based and experimental analysis

Digitization-compatible Mobile Hydraulics

Input **Model** **Output**

y

x

v [mm/s]

t[s]

Inventory → Impact Analysis → Optimization

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FLUID-MECHATRONISCHE SYSTEMTECHNIK DRESDEN

DRESDEN concept

Investigation of Damping Processes with Pneumatic End-Position Damping

Parameterization, simulation and validation

F_{Fr}

p v

$Q(c)$

Robust end position damping

Robust optimization, implementation, test

$RMS(y_1)$

y_i

$RMS(y_2)$

Original design   Optimal design

Sensitivity analysis

Energy Reduction in Vacuum Handling by Reducing Dead Volumes Using Bionic Active Principles

iWF   BGF

SCHMALZ

Optimierung

Parameter   Gestalt   Topologie

d_M

η

p_1 p_3

SmartMicroFluidicActuator

smart³ materials solutions growth

Material advancement

Modeling and simulation

Fluid assembly

A—A

MSM

B—B

System development and test application

Adjustment sawing process

Electromagnetic pump drive

Scalability pump

HNP Mikrosysteme   ETO GRUPPE JOINTLY INNOVATIVE   Fraunhofer THM   DST   RoweMed Medical 4 Life

Multi-stable Electro-Magneto-Mechanical Actuator Structures

Position δ

B

H

Magnetize

H

t

$$F_m = \frac{B^2 A}{2\mu_0}$$ $$F_F = F_0 - c\delta = F_m$$

Multi-stable flux $\Rightarrow$ Multi-stable magnetic force $\Rightarrow$ Multi-stable position

Semi-hard-magnetic material (e.g. AlNiCo)

δ

F_m Anchor

F_F Spring

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FLUID-MECHATRONISCHE SYSTEMTECHNIK DRESDEN

DRESDEN concept

Photo: Juliane Weber, LFD

Photo: Jens Popken, LFD

Experimental facilities and laboratories with a total area of 3700 m² plus 1100 m² free experimental field area (IMD)

■ Modern test field with 600 m² hall area
  □ Hydraulic and pneumatic section
  □ Anechoic sound measurement room with possibility for sound measurements acc. to accuracy class 1 (ISO 3745 bzw. DIN 45635)
  □ Reverberation chamber with 13 m³ for stationary noise investigations
■ 1150 m² machine hall with another 250 m² outdoor area

Pneumatic and hydraulic pressure supply

■ water-cooled central unit (520 l/min, 350 bar, 180 kW) with the possibility of pressure, flow and power regulation
■ Hydraulic unit (200 l/min, 260 bar, 43 kW) for mobile hydraulic tests
■ Hydraulic unit for the supply of the sound measuring rooms
■ Hydraulic unit (120 l/min, 150 bar, 30 kW) for supplying the reverberation chamber or the optical measuring section

FLUID-MECHATRONISCHE SYSTEMTECHNIK DRESDEN

DRESDEN concept

Research
Infrastructure and Technical Equipment

Metrological equipment
- Real-time simulation and controller hardware
- Dynamic power meters 50 kW / 80 kW
- high speed cameras
- Sound and vibration measurement systems
- Laser triangulation systems
- Laser vibrometer
- Thermography system
- Viscometers, refractometers, pycnometers
- Oxygen sensors
- Measuring microscope, precision balances

Software Equipment
- Numerical flow calculations (incl. CHT, FSI): ANSYS (CFX, Fluent, Workbench), CASPAR FSTI, PumpLinx®
- Magnetic field calculation/FEM: ANSYS (Maxwell, LS-DYNA, Mechanical)
- System simulations: SimulationX, Matlab/Simulink
- Simulation coupling (z. B. OPC-UA, TCP/IP)
- Measurement date acquisition und evaluation: LabView, DIADEM, MATLAB, IRBIS® 3 plus
- Further software tools: SolidWorks, ProEngineer, MathCAD, CorelDRAW, MS Office
- Own developments for component calculations

Photo: Juliane Weber, LFD
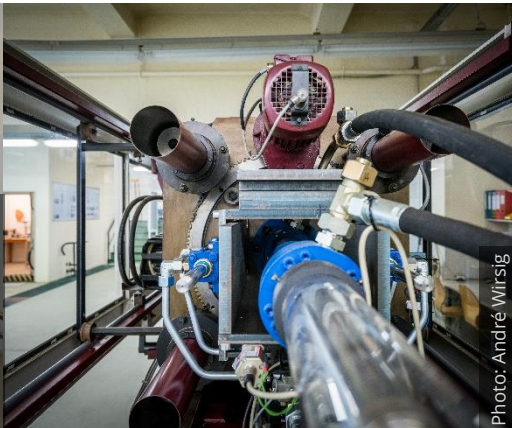
Photo: André Wirsig
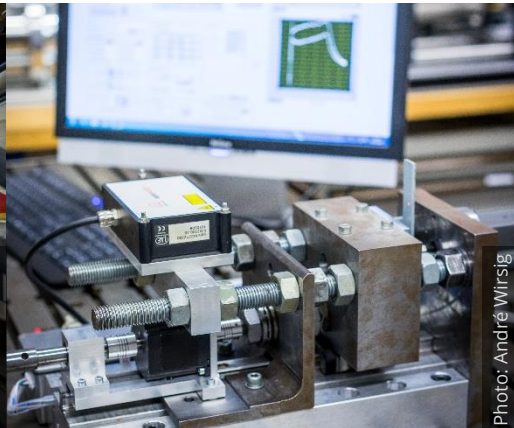
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FLUID-MECHATRONISCHE SYSTEMTECHNIK DRESDEN

DRESDEN concept
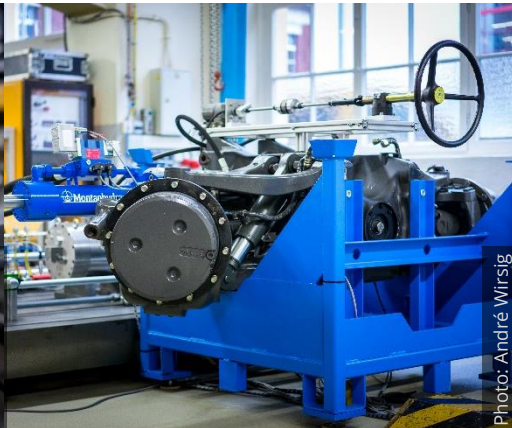
Research
Infrastructure and Technical Equipment

Hydraulic Test Facilities
- Deep drawing press 250 t
- 160 t injection molding machine
- Electro-hydraulic load axis
- Working hydraul. of excavator kinematics
- Electro-hydraul. active steering systems
- 24 t wheel loader
- Test rigs for hydraulic valves
- Hydraulic torque test rig for displacement units
- Cavitation/erosion investigation
- Fluid analysis: tensile, shear test
- Flow visualization
- Automotive component test rigs
- Hydraulics educational test rig

Pneumatic Test Facilities
- Flow measuring section according to DIN 6358
- Laser refraction test for air flow visualization
- Test rig for characteristic value measurement of pneumatic vacuum ejectors
- Magnetic force test rig for pneumatic/hydraulic valves
- Pneumatic cylinder test rig
- Pneumatic handling system
- Blow-out test rig for bulk solids
- Pneumatics educational test rig

Software-/Hardware-in-the-Loop
- Real-time-simulation: Core i5-2500K, 4 GB RAM
- Signal conditioning:
  - Sensor emulation 4 - 20 mA, +/- 10 V, TTL
  - Electric switch measurement 0 - 5 A, 0 - 24 V, CAN
- Imprinting of electrical faults: 68 channels
- Software and coupling:
  - Simulation: SimulationX, Matlab/Simulink
  - Programming: CodeSys, MATLAB, C/C++
- CAN monitoring

TECHNISCHE UNIVERSITÄT DRESDEN

FLUID-MECHATRONISCHE SYSTEMTECHNIK DRESDEN

DRESDEN concept

Research Networking

Overview

3. Academics
Overview

Lectures
Overview

Fundamental Lectures
- Fundamentals of fluid power drives and controls
- Actuators

Specialized Lectures
- Fluid power components and systems
- Sealing technology
- Electro-hydraulic drive technology in industrial applications
- Pneumatic control systems
- Practical course fluid power in industrial applications
- Mobile hydraulics
- Control systems, software development and safety in mobile applications
- Practical course fluid power in mobile applications
- Modeling and simulation of fluid power systems
- Modeling and simulation of fluid power components
- Aircraft hydraulic systems

Student Works
- Undergraduate projects
- Diploma, bachelor and master theses

Photo: LFD

Photo: Juliane Weber, LFD

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FLUID-MECHATRONISCHE SYSTEMTECHNIK DRESDEN

DRESDEN concept

Lectures
Mechanical Engineering

MW-MB-AKM-02: Fundamentals of Drive Systems

- Fundamentals of fluid power drives and control (2/1/0)
- Electrical drives (2/1/0)

MW-MB-AKM-07: Hydraulic Components and Systems

- Hydraulic Components and Systems (2/1/0)
- Sealing technology (2/0/0)

MW-MB-AKM-15: Fluid-Mechatronics in Industrial Applications

- Electro-hydraulic drives in industrial applications (1/1/0)
- Control systems of pneumatic drives (1/1/0)
- Practical training in fluid power and industrial applications (0/0/1)

MW-MB-AKM-23: Fluid-Mechatronics in Mobile Applications

- Mobile hydraulic systems (2/1/0)
- Control, software development and safety in mobile applications (1/0/0)
- Practical training in mobile hydraulic applications (0/0/1)

MW-MB-AKM-24: Computational Engineering in der Fluidtechnik

- Modelling and simulation of fluid power systems (lumped parameters) (1/2/0)
- Modelling and simulation of fluid power components (CFD, FEM) (1/1/0)

Bachelor ——————————→ Master ——————————→

Dipl.-Ing. ——————————————————————————————→

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FLUID-MECHATRONISCHE SYSTEMTECHNIK DRESDEN

DRESDEN concept

Construction Future Lab – CFLab gGmbH

THE centre for application research in digital construction

Cooperation with the construction industry

CF LAB

Paving the way for innovative work processes

CF LAB

TECHNISCHE UNIVERSITÄT DRESDEN

Chair of Fluid-Mechatronic Systems

Chair of Construction Machinery

Chair of Construction Management

Chair of Industrial Design Engineering

Chair of Industrial Communications
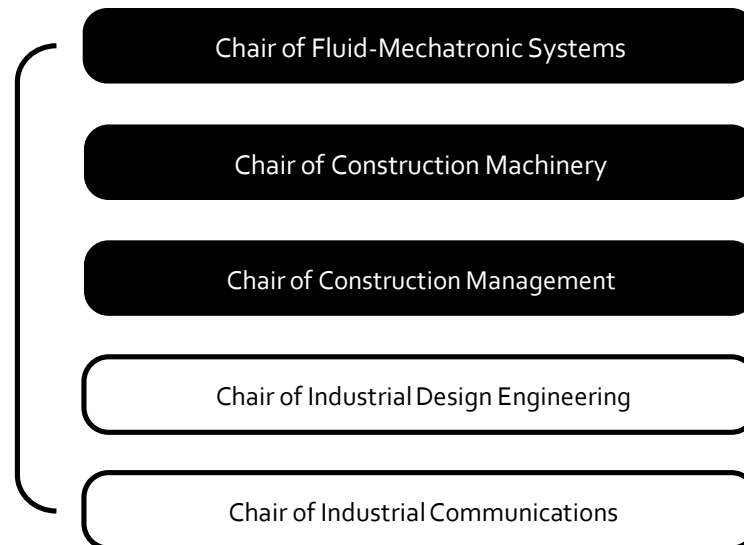
Prof. Dr.-Ing. Jürgen Weber
Chair of
Fluid-Mechatronic Systems

Prof. Dr.-Ing. Frank Will
Chair of
Construction Machinery

Prof. Dr.-Ing. Dipl.-Wirt.-Ing. Jens Otto
Chair of
Construction Management

SACHSEN

Interdisciplinary

CFLab-Team

André Sitte

Benjamin Beck

Nicole Hofmann

Julian Taesch

Felix Schmitt

Janik Mischke

Lisa Schlund

Volker Waurich

Johannes Stockbauer

Jan Lübbert

Jianbin Liu

Florian Storch

Max Brandt

Veit Klopfer

Some selected CFLab projects

Simulation-based efficiency evaluation of systems architecture for hybrid & electric contruction machines
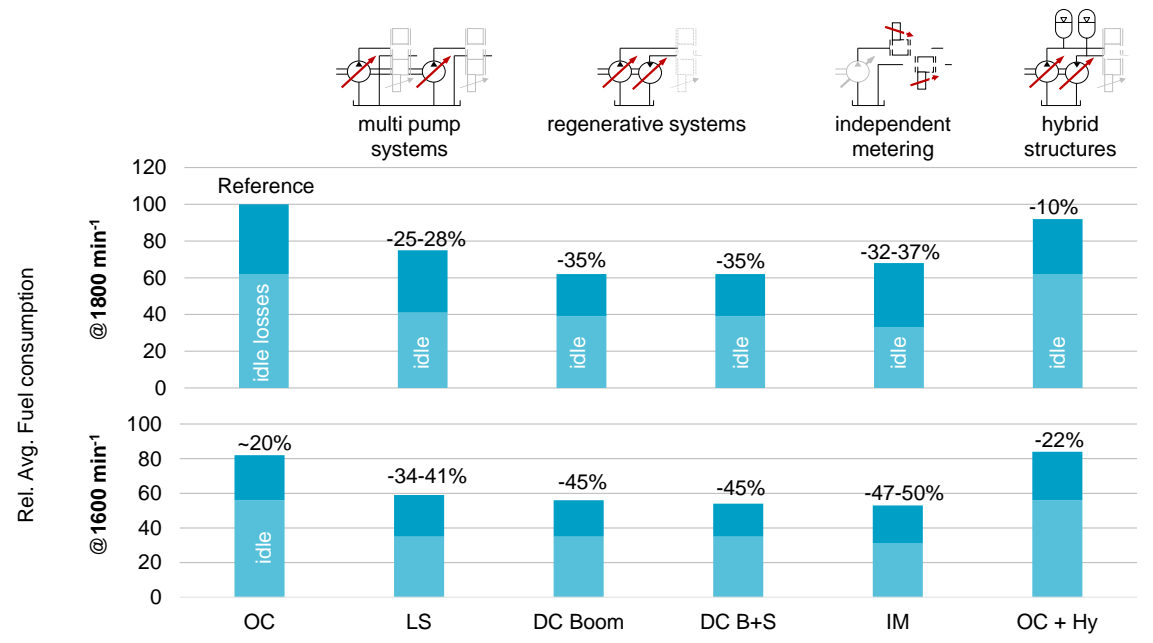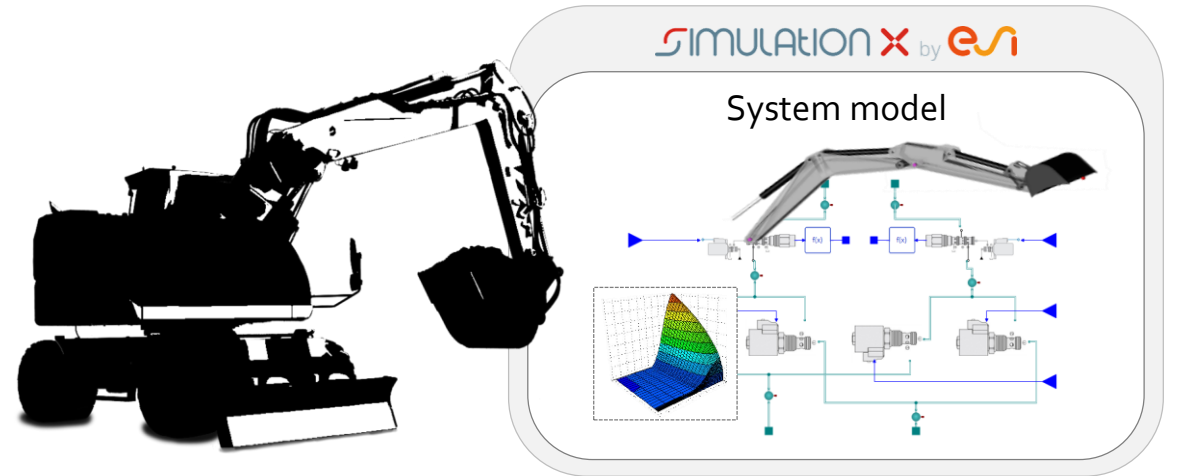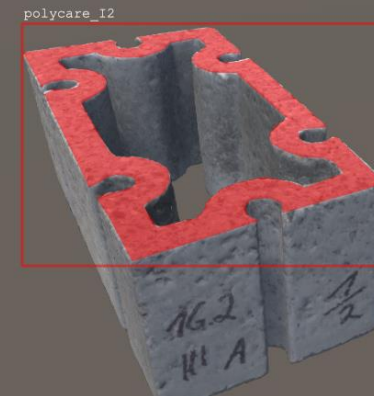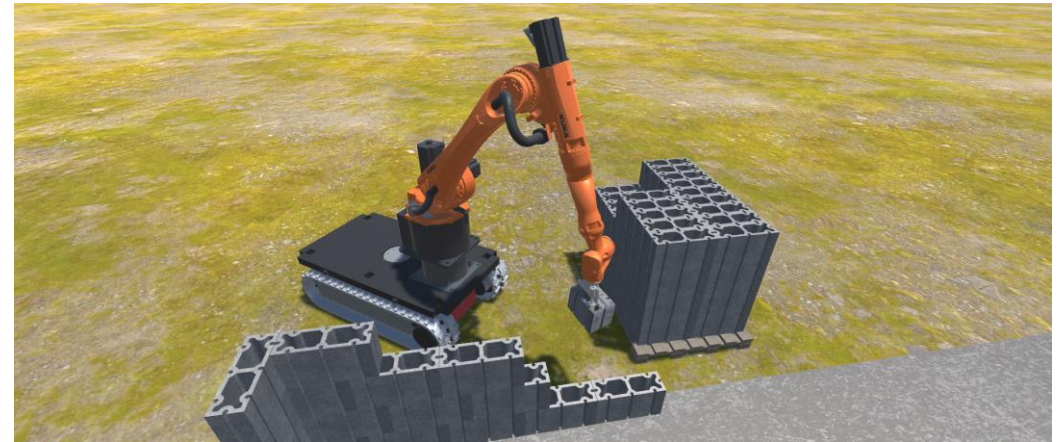
Automation of machine functions

certification of standardized interfaces & connectivity

interoperability of mixed fleets

- Development and test of automated machine functions for earthmoving machinery
- Integration, test and certification of standardized interfaces
- Focus on interoperability due to mixed fleets of construction companies

Construction Robotics – Walling, drilling, spraying

- Virtual Prototyping

- Computer Vision for Handling and Planning
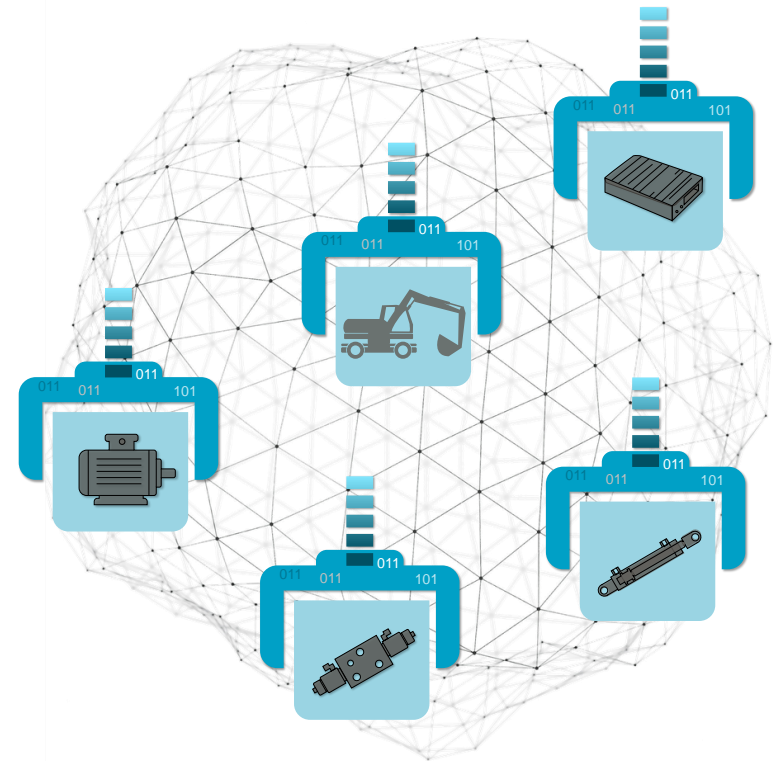
- Demonstrators on the basis of 6-axis industrial robot

Increasing the reliability of people detection on construction sites through AI-based technologies

- Use of YOLO model and generation of construction site typical image data

- Publication at **10th Symposium Construction Machinery** on September 26th and 27th, 2024 in Dresden

Fluid 4.0 –

Implementation
of the digitalisation
for fluid power 4.0
in the cross-industry and
cross-manufacturer data room using
asset administration shells,
submodels and demonstrators

– Joint research project with nearly every player within the fluid power community

Thank you for your attention!
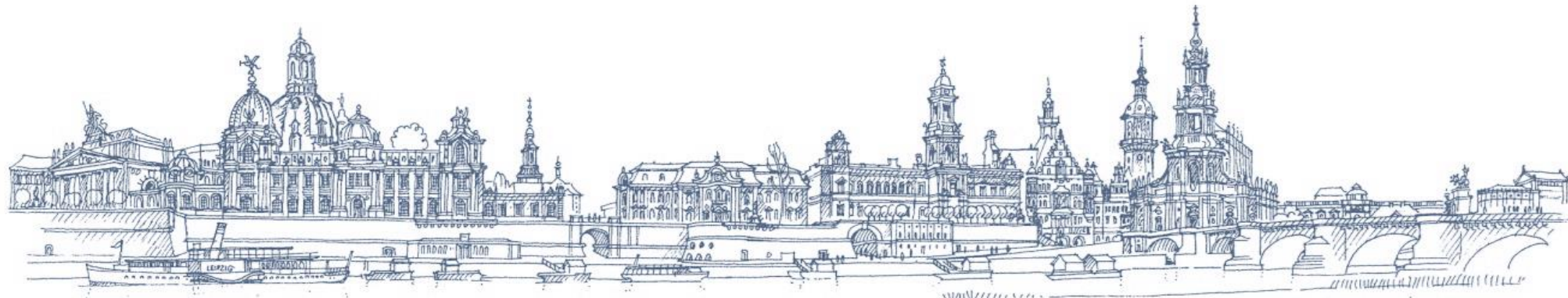
Technische Universität Dresden | Institute of Mechatronic Engineering
Chair of Fluid-Mechatronic Systems

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https://tu-dresden.de/mw/fluidtronik | Twitter | LinkedIn