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AUTOMOTIVE DRIVETRAINS
INTELLIGENT
ELECTRIFIED

INNOVATIVE SENSOR TECHNOLOGY REVOLUTIONIZES LUBRICATION SYSTEM ANALYSIS IN TRANSMISSIONS

9 – 12 December 2019, Berlin, Germany

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OVERVIEW

- Introduction into lubrication system analysis
- State of the art & challenges
- Requirements & concept for a new system
- Comparison to traditional methods
- Fields of application
- Outlook

INTRODUCTION

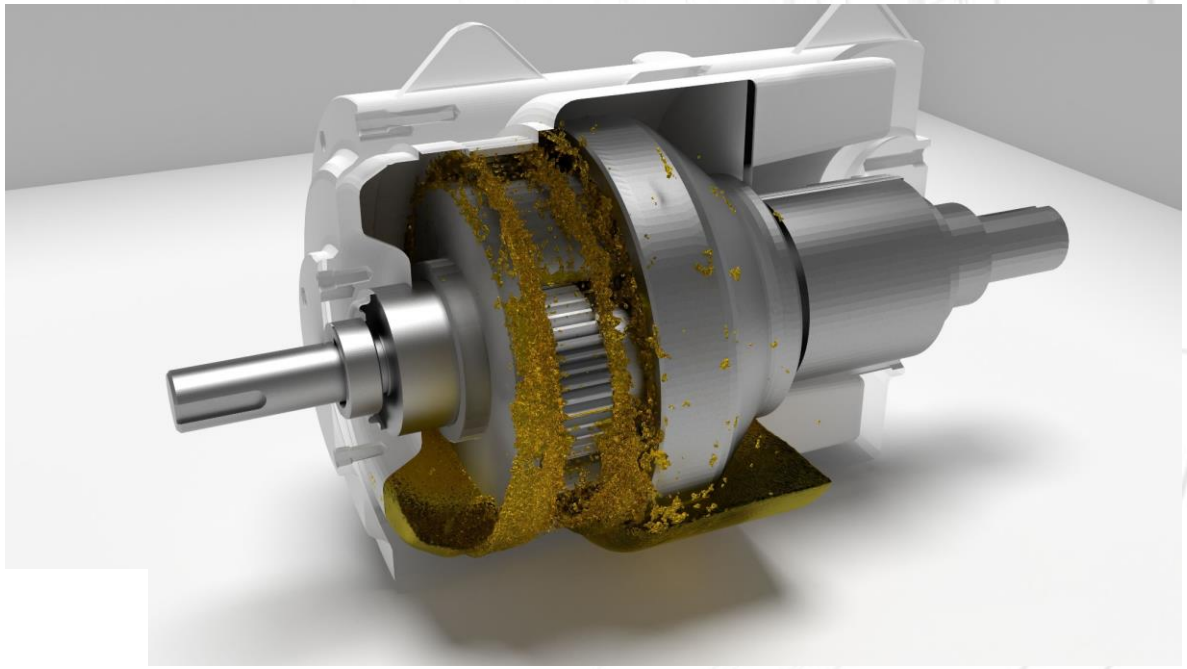
- Graz University of Technology
  - Institute of Machine Components and Methods of Development

- AVL-TU Graz Transmission Center
  - Research Center
  - Cooperation with AVL List GmbH

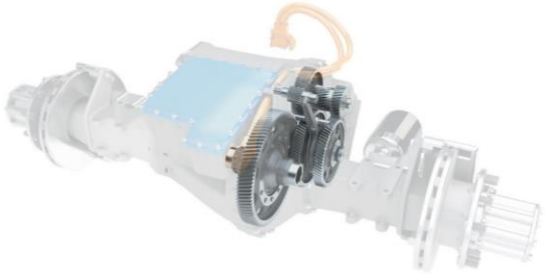
- One research focus: Tribology
  - Friction
  - Wear
  - **Lubrication systems for transmissions & e-axles**

CURRENT PROCEDURE

- Experience based design of lubrication systems for transmissions
- Simulation approach
- Prototype development
- Experimental verification



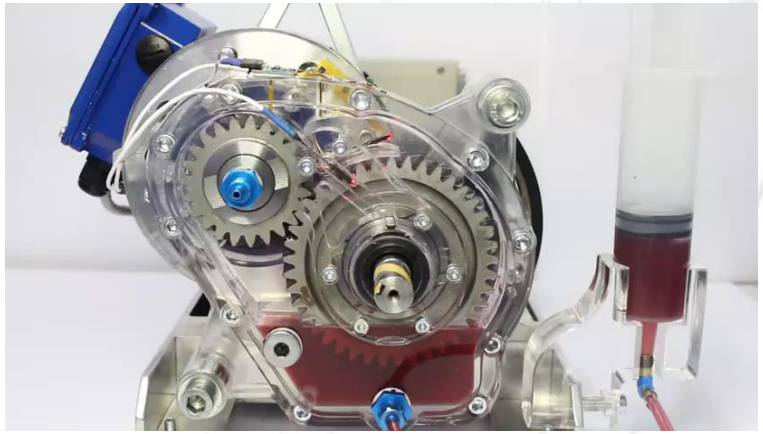
- Trends
  - Increasing rotational speed (e-drives)
  - Geometrical constraints
  - Higher power density
  - New design concepts



Sources:
https://www.nextflow-software.com/gearbox-lubrication/

CHALLENGES

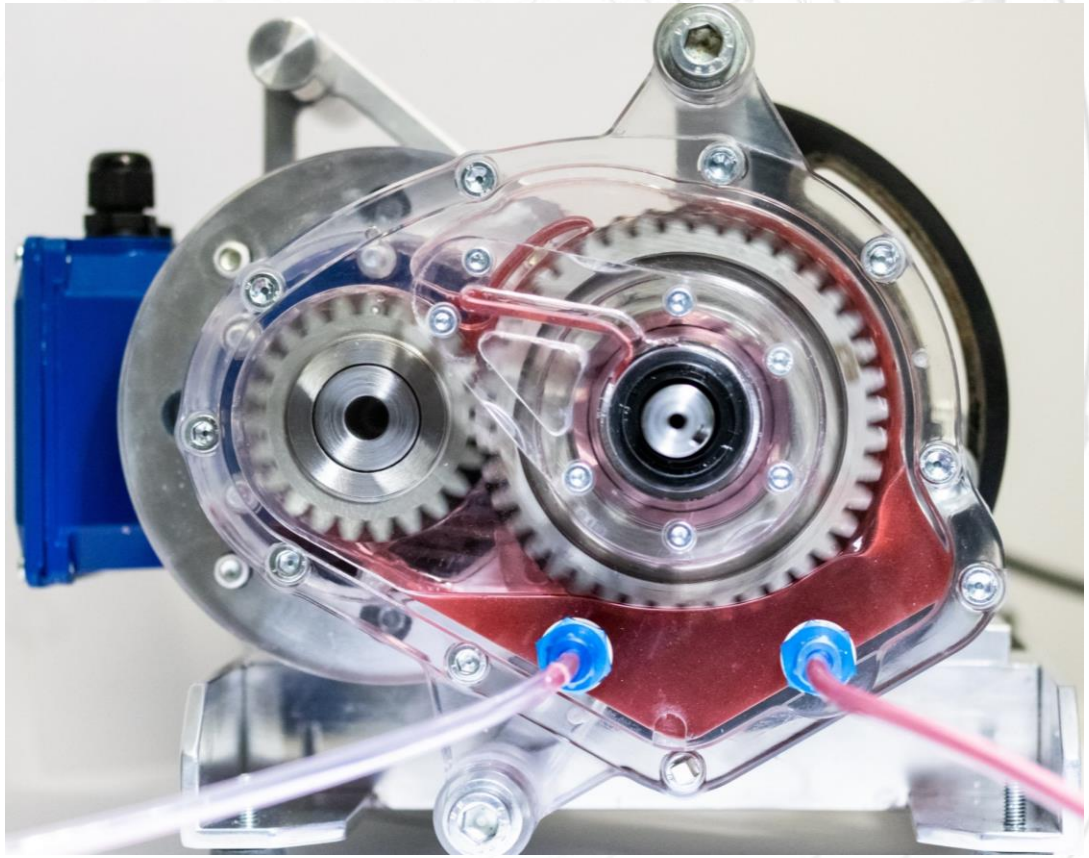
- Current verification methods reach their limitations
  - Tilt rig
    - Only approximation of real conditions
  - Visual analysis: transparent structures (housings, bypass tubes)
    - Limited optical accessibility, high speeds
  - Dye tests with luminescent additives
    - Not reproducible behavior over time
  - Thermal component measurement
    - Indirect measurement parameter
    - Over- or underlubrication cannot be distinguished
- **Not fully known product behavior remains**
  in terms of lubrication system performance



Sources:
AVL List GmbH

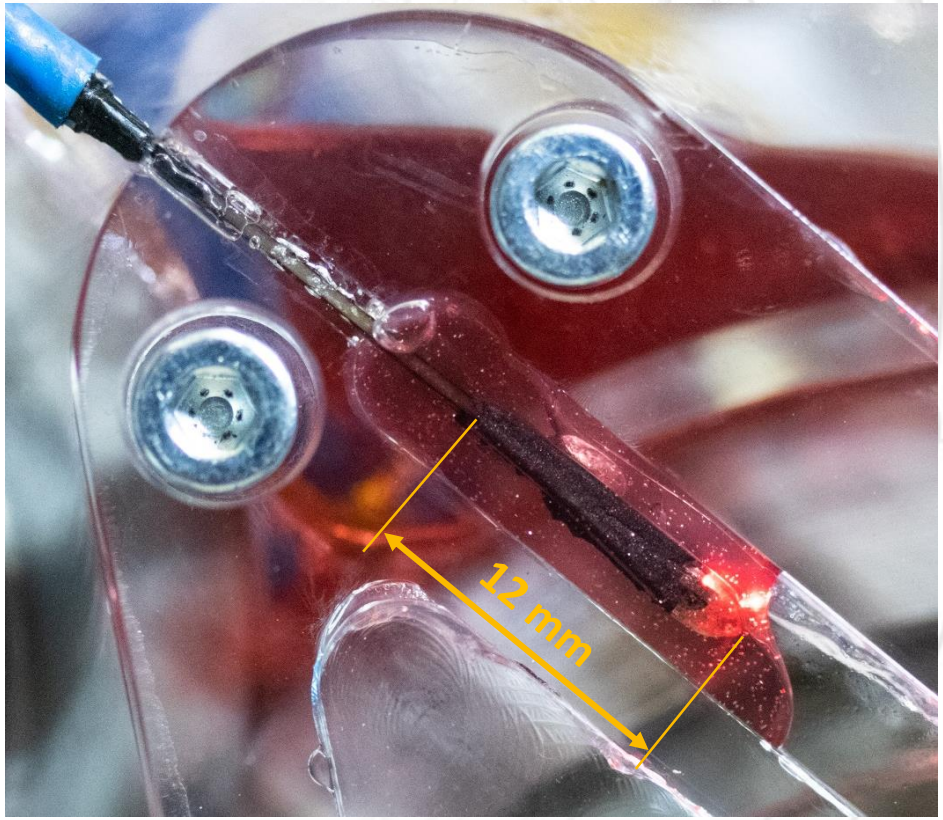
REQUIREMENTS

- Lubrication system measurement targets
  - Flow characteristics
    - Velocity
    - Volumetric rate
  - Lubrication condition
    - Oil
    - Oil-air-mixture
    - Air
- Design of the measurement system
  - Minimally invasive
  - Compact size
  - Resistant against harsh environment



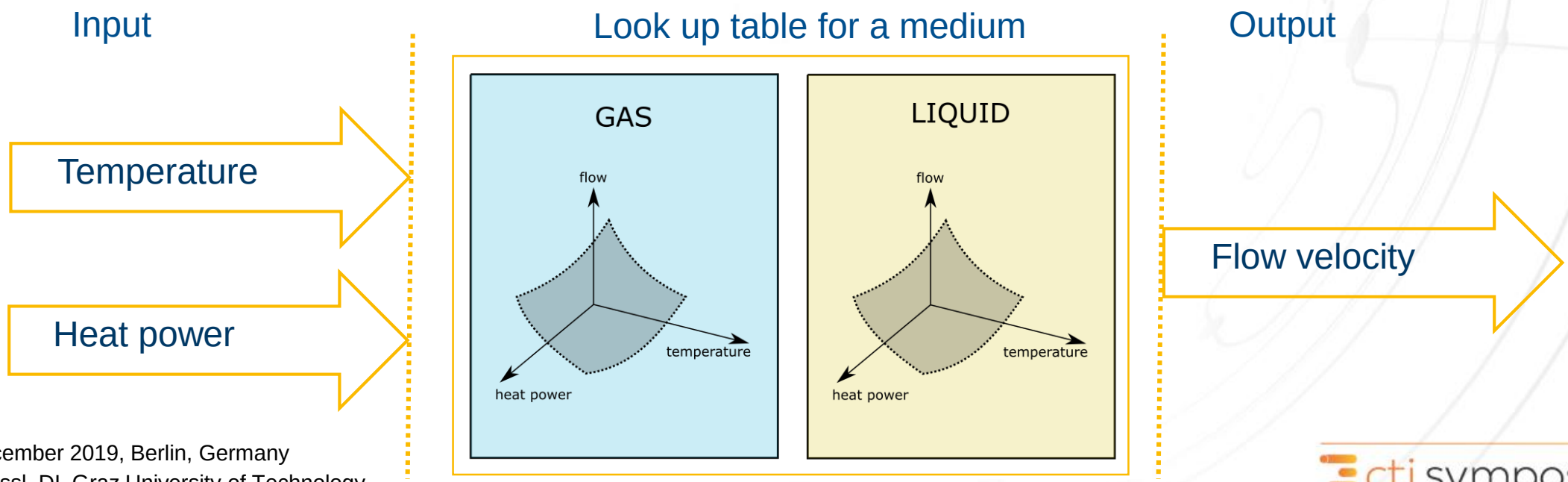
NEW MEASUREMENT SYSTEM

- Combination of two measurement principles
  - Calorimetric flow meter
  - Optical gas/liquid detection
- Size of a match stick
  - Cross-section: 2.5 x 2.5 mm
  - Length: 12 mm
- Output signals: raw data
  - Temperature of the fluid
  - Heat power of the calorimeter
  - Signal from the gas/liquid detector
- Internationally patented

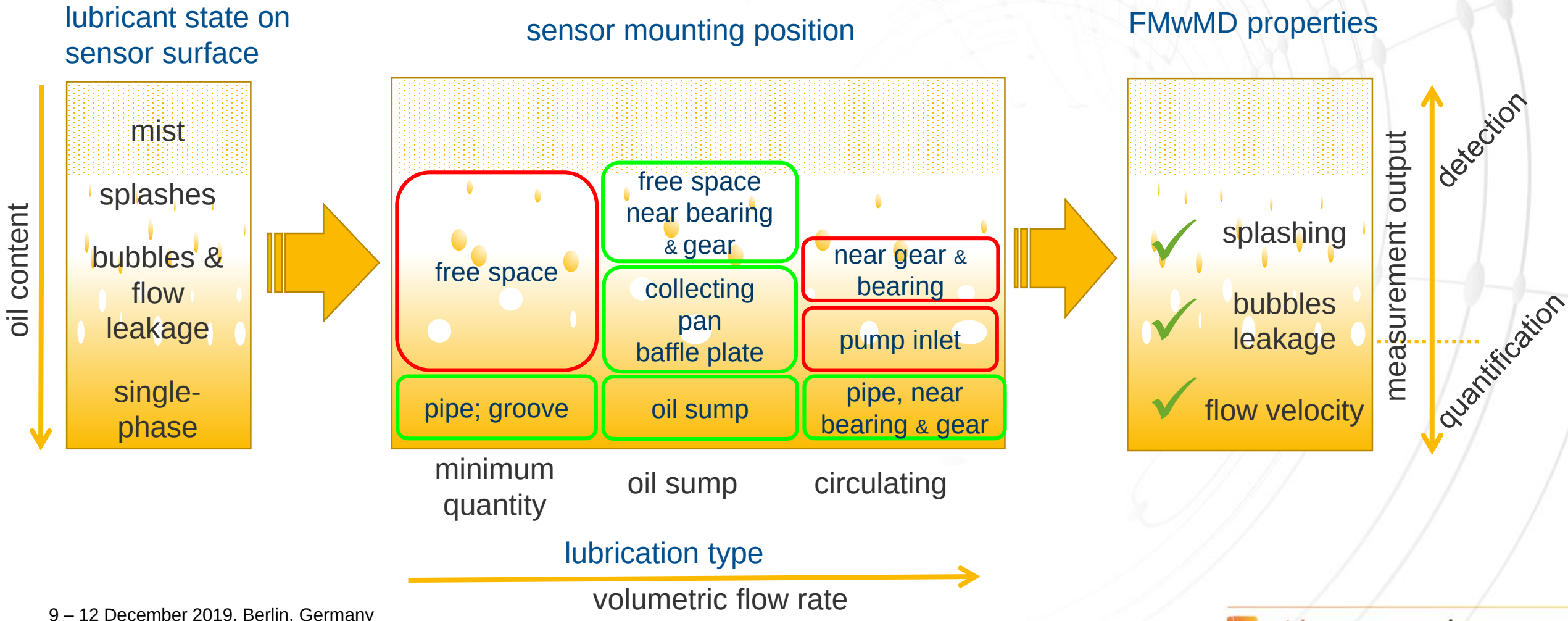


CALIBRATION DATA

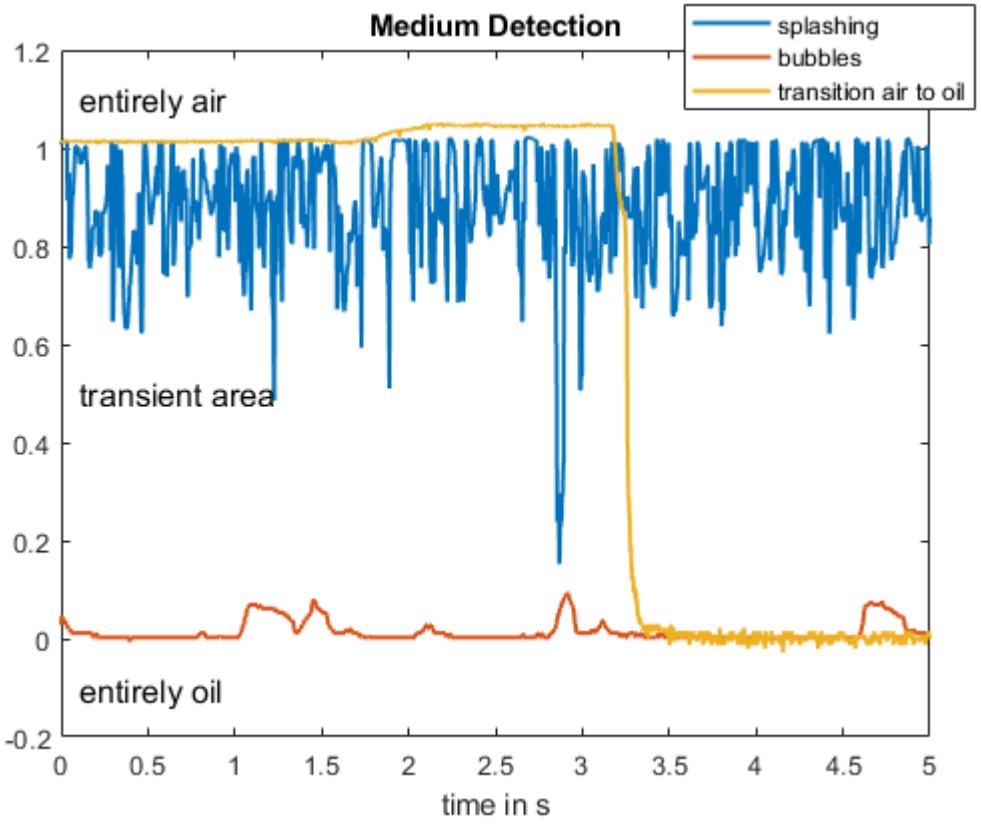
- Calibration for each oil type
  - Temperature of the fluid → compensation of component deviations
  - Heat power of the calorimeter → conversion to flow velocity
  - Signal from the gas/liquid detector → compensation of component deviations

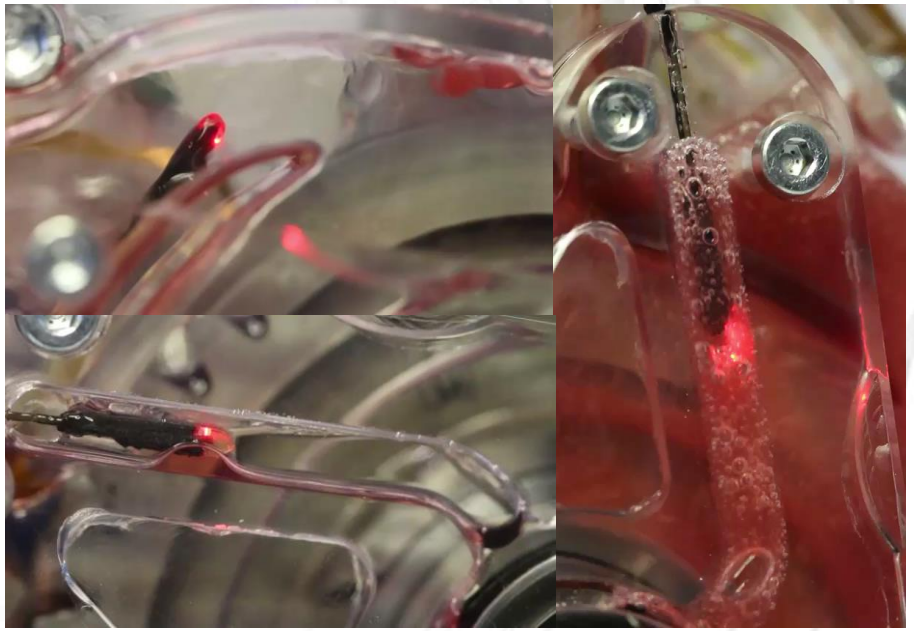


SENSOR MOUNTING POSITION



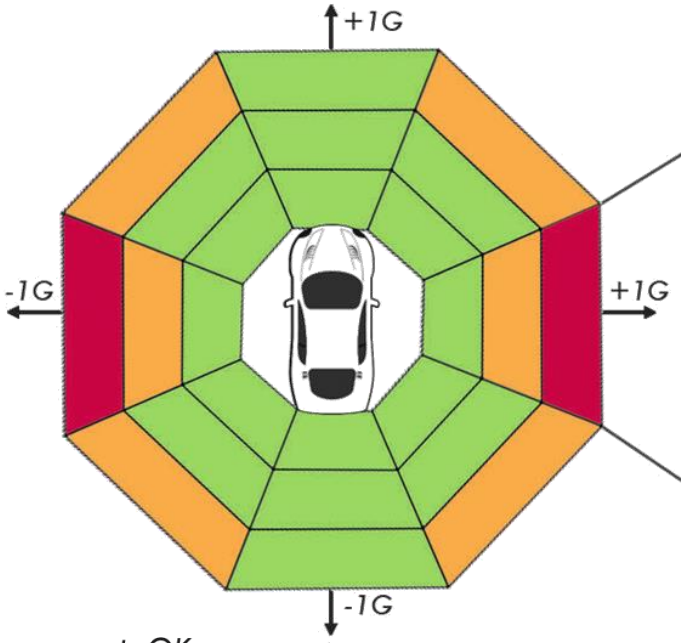
EXAMPLE MEASUREMENT RESULTS



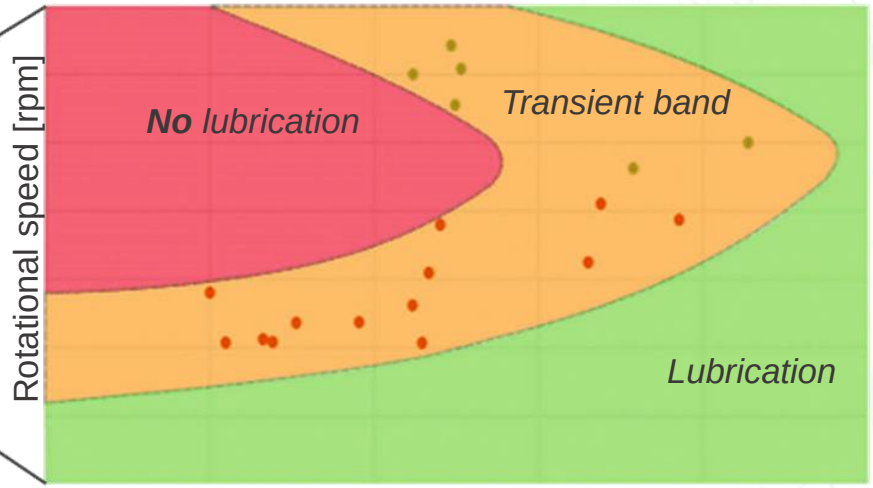


LUBRICATION ANALYSIS MAP

Lubrication map of a transmission



Lubrication map of a component



Lubrication of all components OK
Occurence of oil outages at certain components
No lubrication at certain components

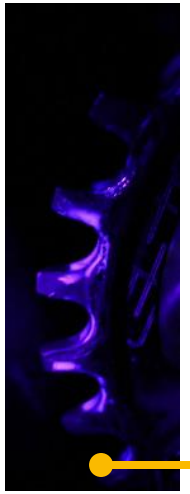
- FMwMD-Sensor already used in several projects
- **Lubrication failures in electrified powertrains identified**

Sources:
www.netclipart.com

COMPARISON

Visual analysis

Dye test



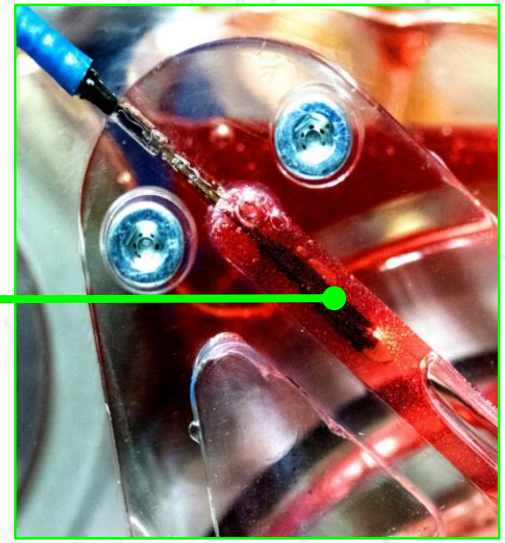
Endurance test

Thermal component measurement

	traditional methods					sensors alternatives		
	visual analysis transparent housing; riser, tubes	**dye test** with luminescent additive	**endurance tests**	**temperature measurement**	new FMwMD	**thermal flow sensors**	**ultrasonic flow measurement**	**capacitive measurement of fluid phase**
competence level × high ≈ medium ✓ low	×	×	≈	×	✓	✓	✓	✓
real time measurement & detection	×	×	×	✓	✓	✓	✓	✓
detection of bubbles; splashes; single phase flow	≈	×	×	×	✓	×	×	✓
flow measurement at single phase	×	×	×	×	✓	≈	✓	×
minimally invasive	×	✓	✓	✓	✓	✓	×	✓
system view × poor ≈ limited ✓ good	✓	≈	✓	×	✓	×	×	×

FMwMD

Flow **M**eter
with
Medium **D**etection

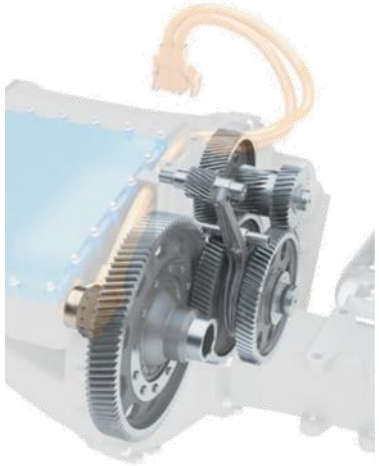


Sources:
AVL List GmbH
www.reichelt.at

FIELDS OF APPLICATION

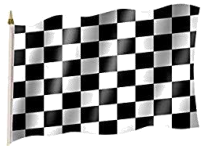
- Tool for
  - Automotive transmission development
  - Condition monitoring (prototyping & series application)

- Focus area
  - Lubrication systems: transmission, clutch, engine, …
  - Coolant systems: battery & fuel cell, …



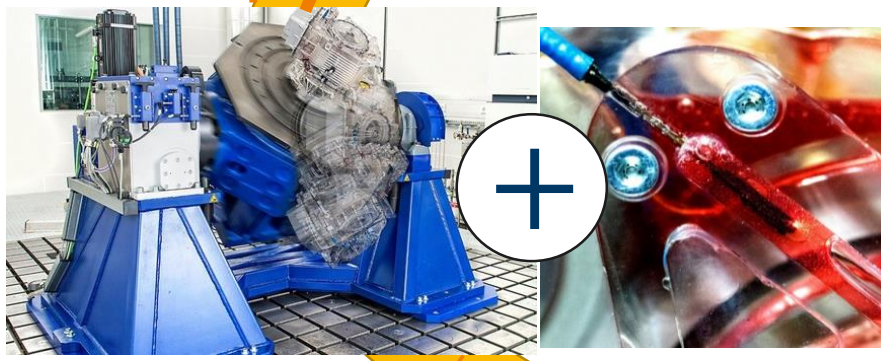
Sources:
www.fastwrx.com
www.smart.com
www.indiamart.com

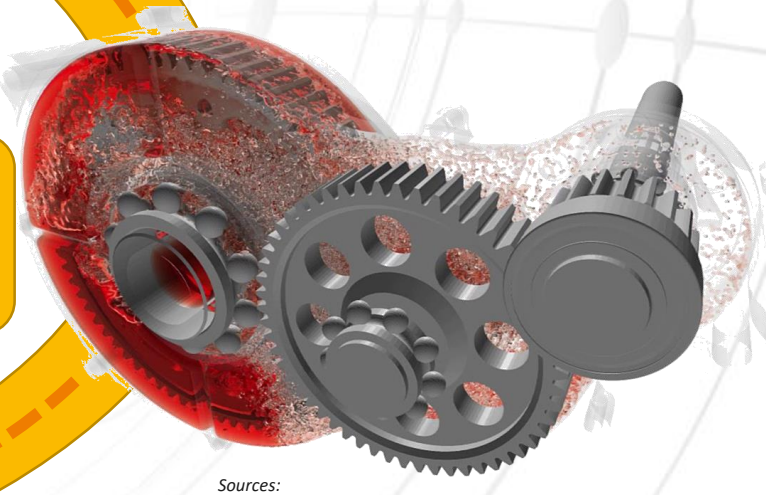
FUTURE LUBRICATION DEVELOPMENT



Verification with FMwMD

Experience based design





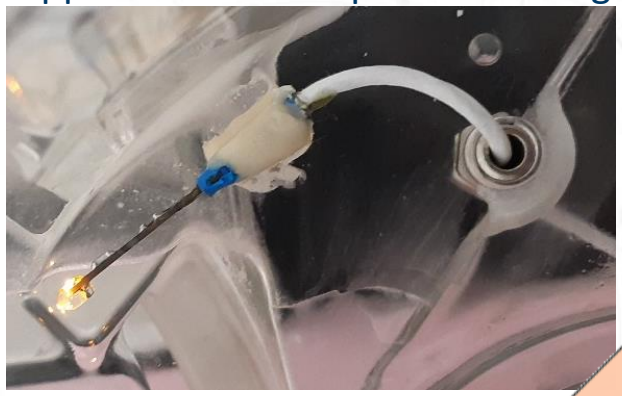
Simulation approach

Sources:
AVL List GmbH
CADblog.pl

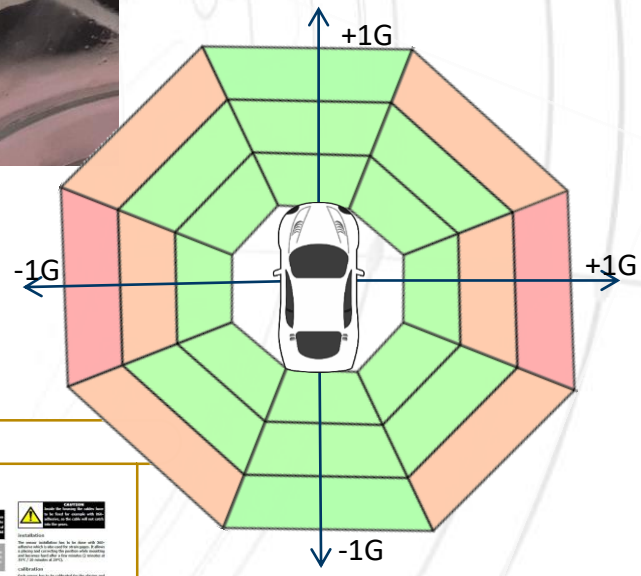
CURRENT STATUS

- FMwMD sensor is **ready for operation** in a **short time frame**
- Existing know-how in **application and evaluation**
- Completed projects with **proofed technology**
- **Defined method** for lubrication system analysis

Application in transparent housing



Data evaluation



Procedure

OUTLOOK

- Next generation of FMwMD: **Flexible foil sensor**
  - Better adaption to analysis area (holes, drillings)
  - Thinner design
    - Measurement elements integrated in foil design
  - Low power consumption
    - Battery powered
    - Inductive coupling

- Planned features
  - Integrated bus-system (CAN)
  - Wireless data transfer

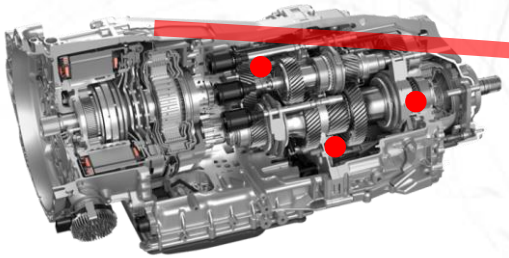
Flexible foil sensor

Wireless & battery powered sensor node
One week continuous operation

SUMMARY

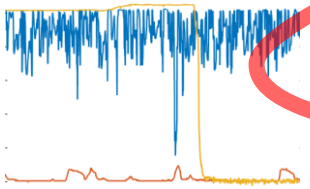
- Challenges in transmission lubrication systems require new measurement methods
- Patented sensor innovation: FMwMD
  - Ready for operation
  - Proofed technology
  - Know-how for practical use
- Additional sensor in lubrication system analysis:

Definition of measurement point

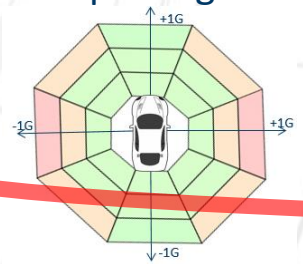


Installation of the sensor

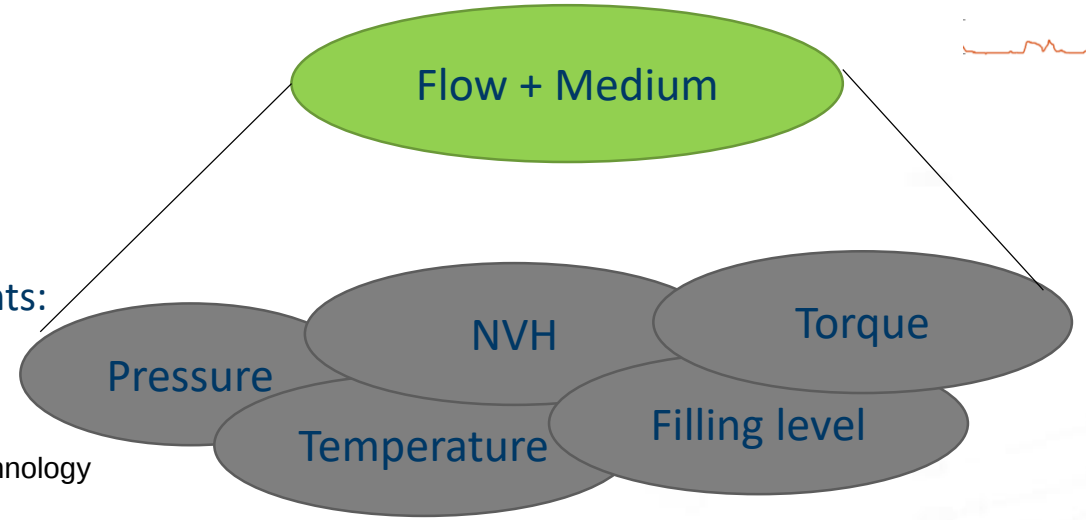
Data evaluation



Reporting



Traditional measurements:



Sources:
https://www.zf.com/products/en/cars/products_46338.html

MANY THANKS TO

Prof. Dipl.-Ing. Dr.techn. Robert Fischer

Univ.-Prof. Dipl.-Ing. Dr.techn. Hannes Hick

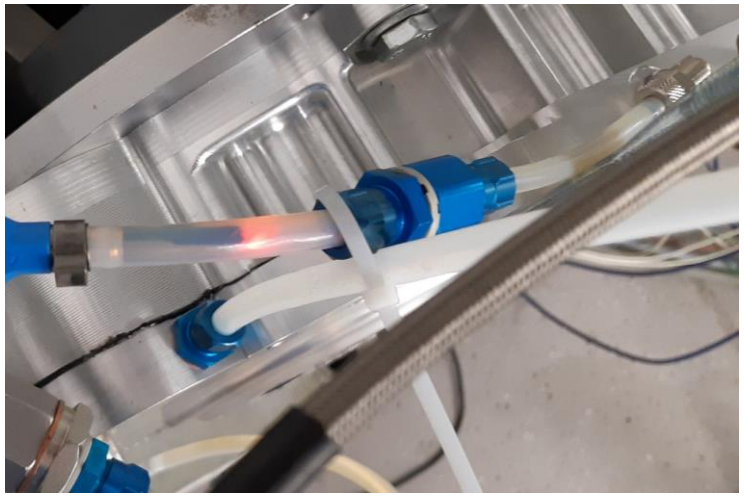
Prof. Dr.-Ing. Karsten Stahl

Questions & Answers

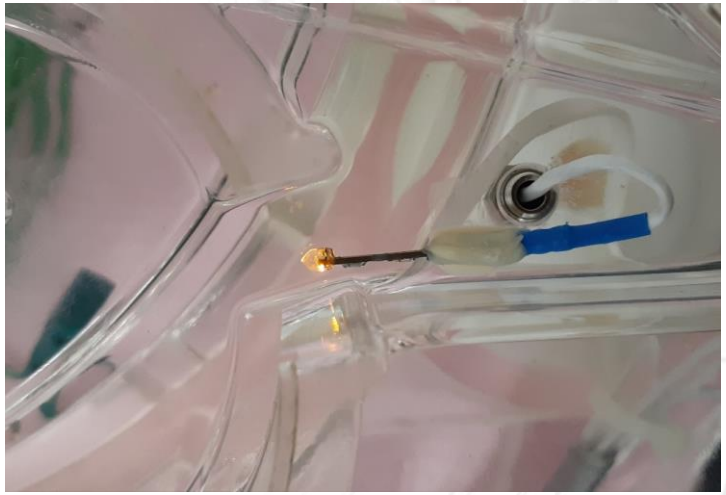
Decide now – switch between sessions or stay here

APPLICATION EXAMPLES

battery powered liquid/gas sensor
on rotating gear



probe sensor in bypass



probe sensor in transparent housing
in oil supply line