Technische Universität Braunschweig

Institut für mobile Maschinen und Nutzfahrzeuge

Efficiency studies on double pump supply units

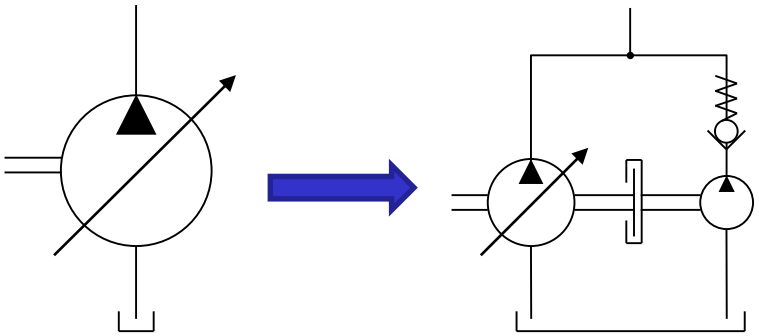
Kerstin Ritters, Lennart Roos, Prof. Ludger Frerichs

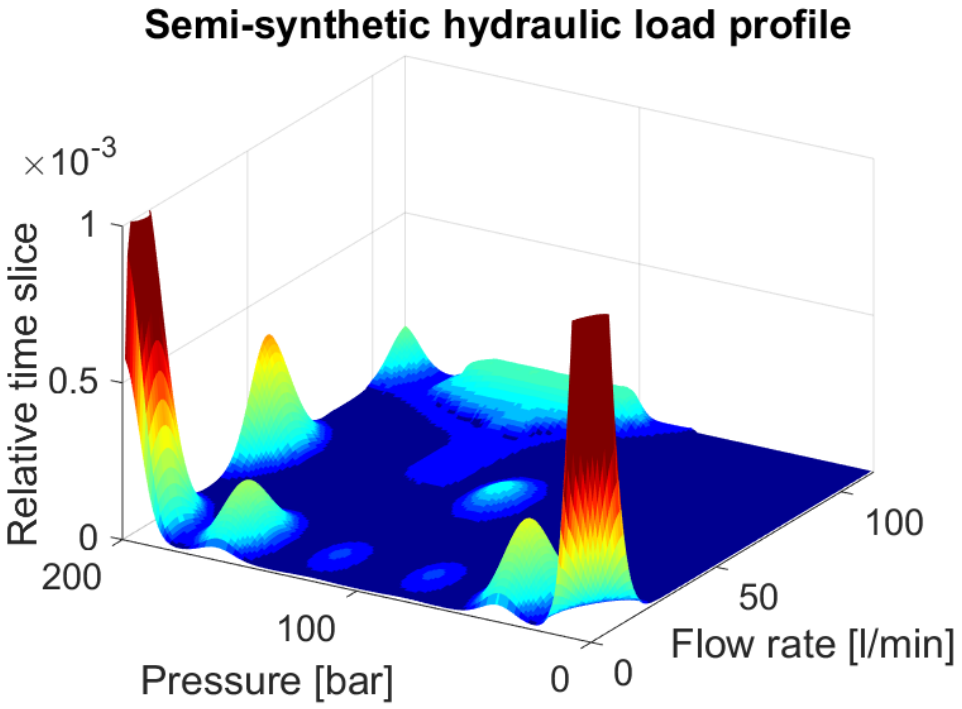
19.03.2018

Motivation

- Peak power of pumps is required rarely (e.g. tractor hydraulics)
- Efficiency in operating points with small power demand is low

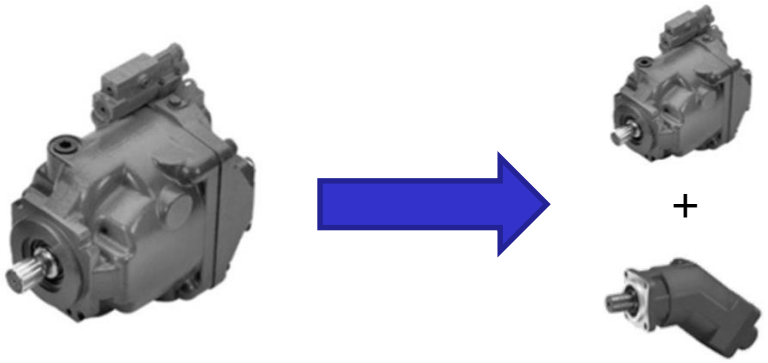
→ Use of two pumps for higher efficiencies in operating points with small power demands





Agenda

1. Exemplary application
2. Concepts of double pump systems
3. Simulation of double pump systems
4. Bench tests
5. Conclusion



1 Exemplary application

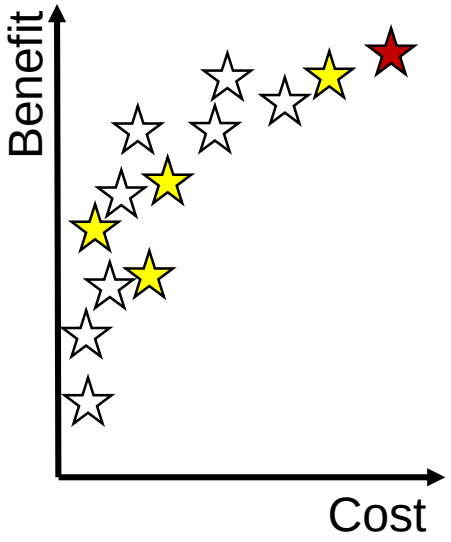
Exemplary application:

- 100 kW tractor
- 30 kW hydraulic peak power (200 bar, 90 l/min)
- Annual working period: 1000 h

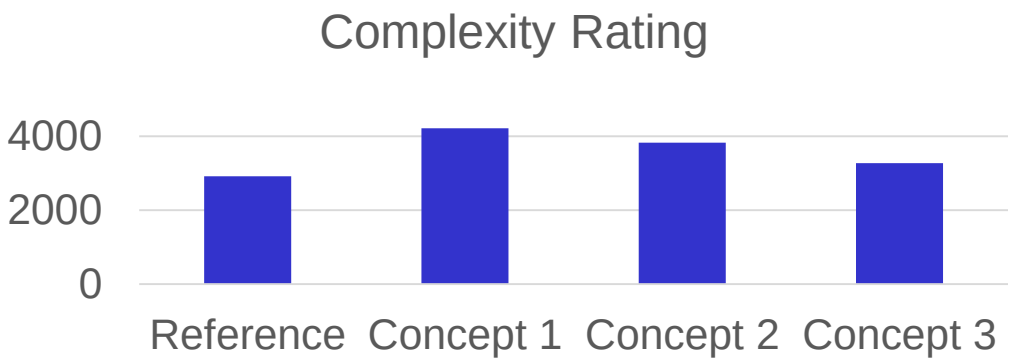
Source: Fendt

2 Concepts of double pump systems

- Wide variety of pump combinations:
  - Pumps with constant or variable displacement
  - Different sizes
  - Fixed coupling or connection via clutch
  - Shared or individual drives
- Use of off-the-shelf components for the test bench
- Aim: Find concepts with best cost-benefit ratio



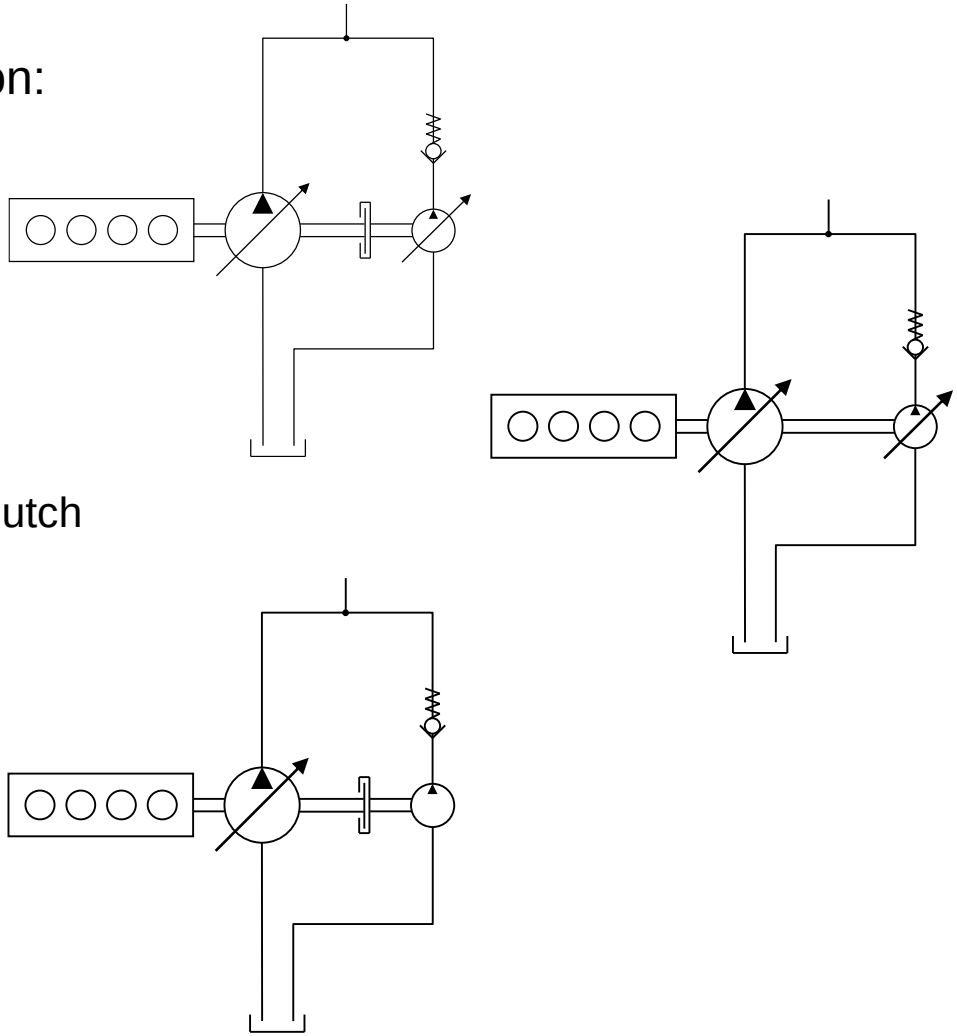
- Rating system for complexity of supply units
  - Complexity of components
  - Complexity of interfaces



2 Concepts of double pump systems

Three concepts under investigation:

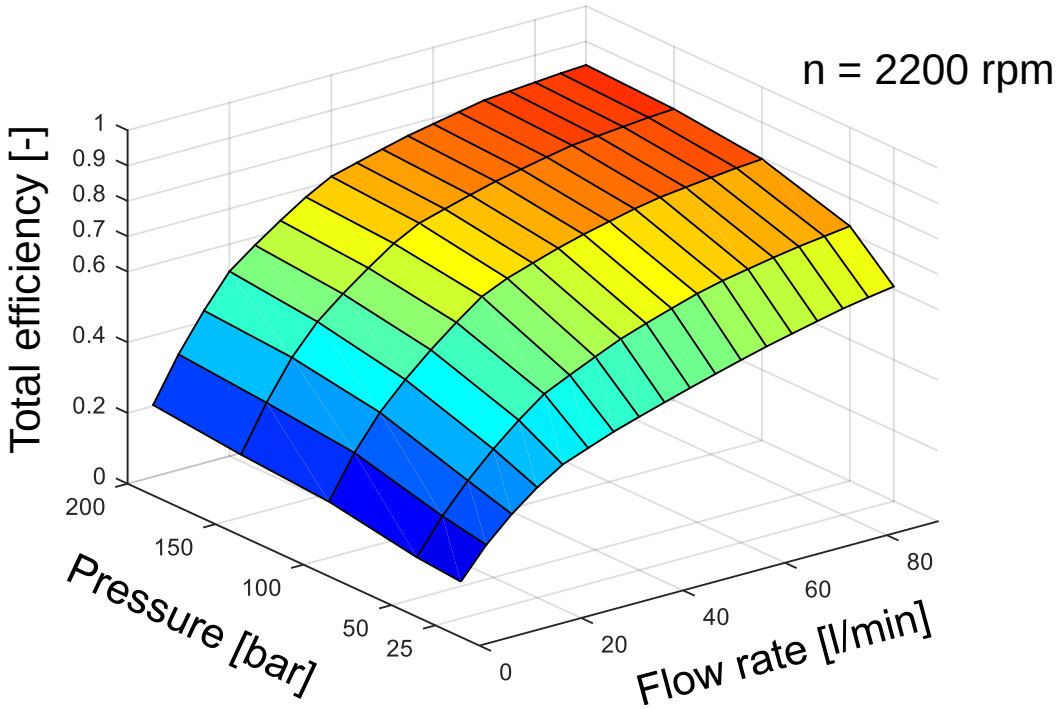
- Concept 1
  - Two variable pumps
  - $V_{P1} > V_{P2}$
  - Connected via clutch
- Concept 2
  - Same as concept 1, without clutch
- Concept 3
  - Variable and constant pump
  - $V_{P1} > V_{P2}$
  - Connected via clutch



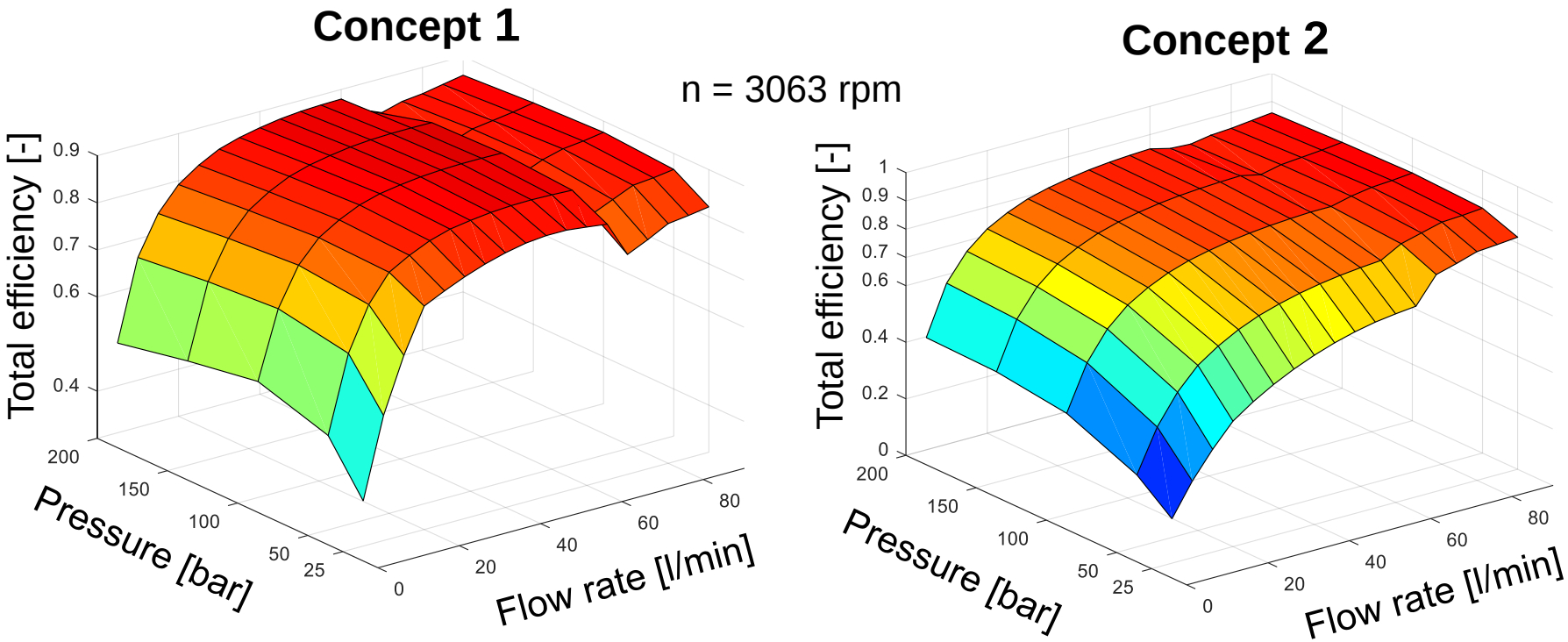
3 Simulation of double pump systems

- Simulation with LMS Amesim
- Generic efficiency diagrams for pumps
- Pressure-dependent losses for pump controller

- Reference pump:



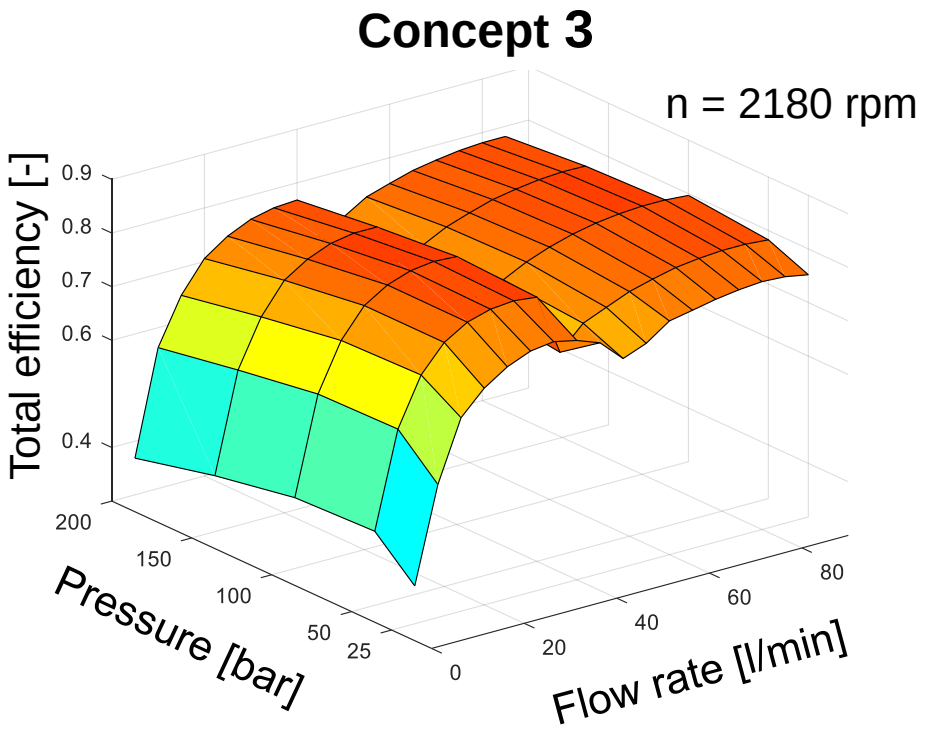
3 Simulation of double pump systems



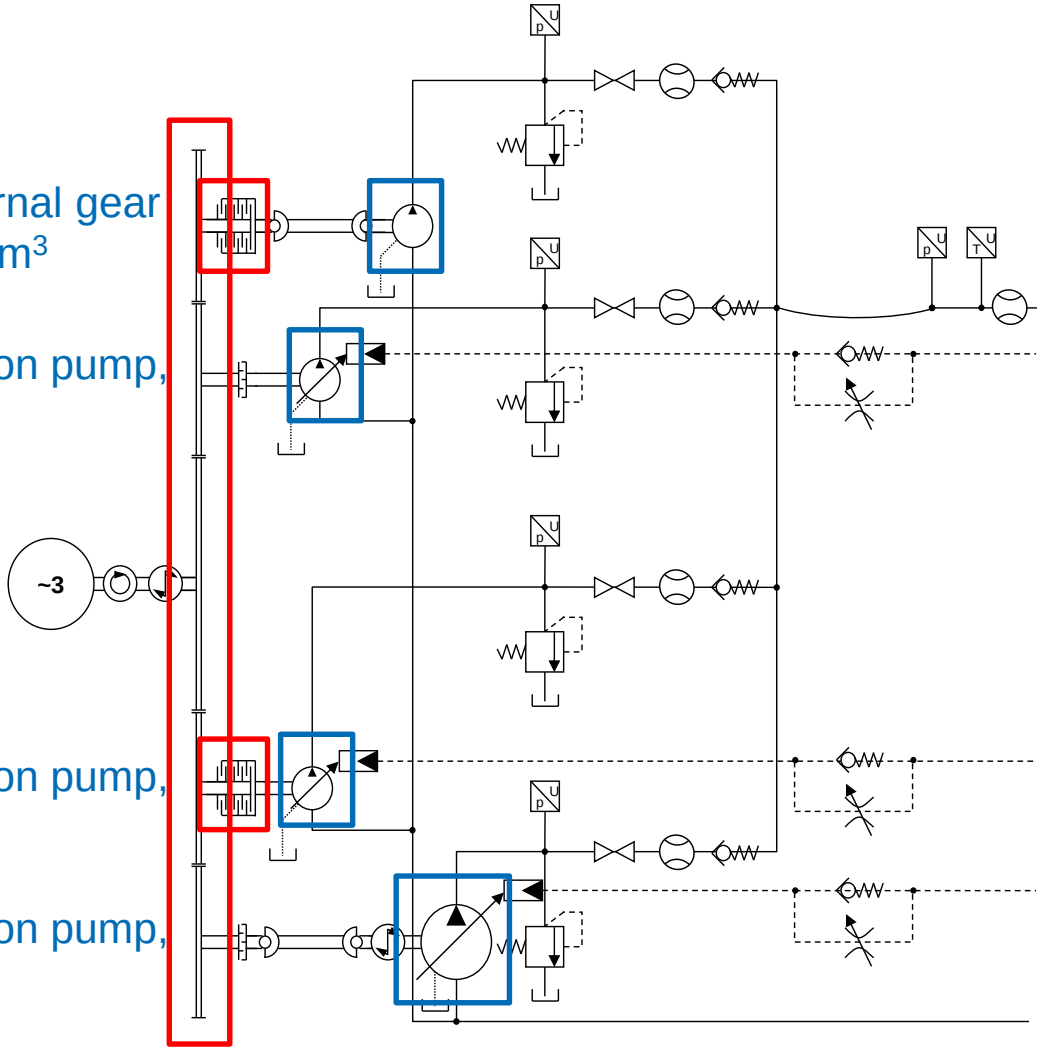
- Decline of the efficiency when maximum flow rate of the first pump is reached
- Both concepts show higher efficiencies in comparison with the reference pump
- Drag losses of the secondary pump in concept 2 lower the efficiency for small flow rates

3 Simulation of double pump systems

- Stronger decline of efficiency
- Efficiency of secondary pump (gear pump) is smaller than of piston pumps
- Savings at small flow rates
- Higher losses than the reference system for high flow rates and pressures

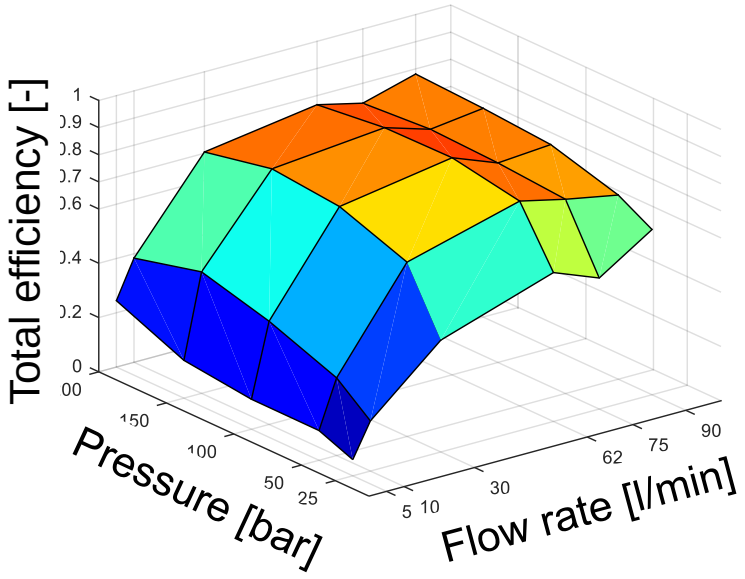


4 Bench tests



4 Bench tests – Concept 2

n = 3063 rpm



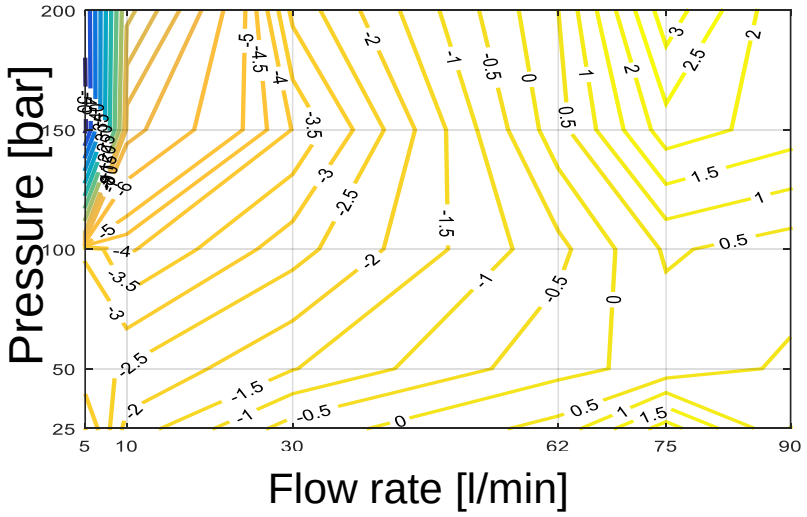
Comparison to simulation:

- Same characteristics of efficiency as in the simulation
- Differences: 5 - 18 %

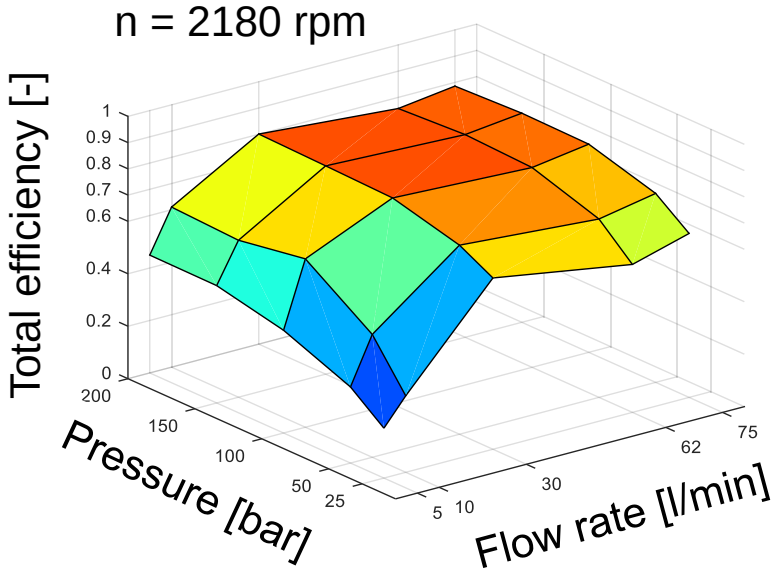
Comparison to reference pump:

- Reduction of losses for small flow rates
- Higher losses for operation with both pumps

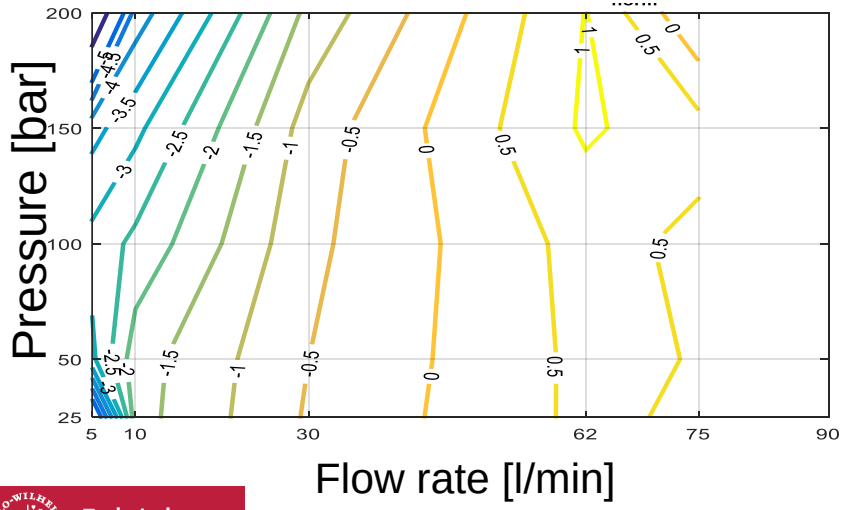
Difference of power losses [kW] ($n=n_{max}$)



4 Bench tests – Concept 3



Difference of power losses [kW] (n=n_{max})



<u>Comparison to simulation:</u>

- Characteristic drop of efficiency cannot be seen (missing measurement)

<u>Comparison to reference pump:</u>

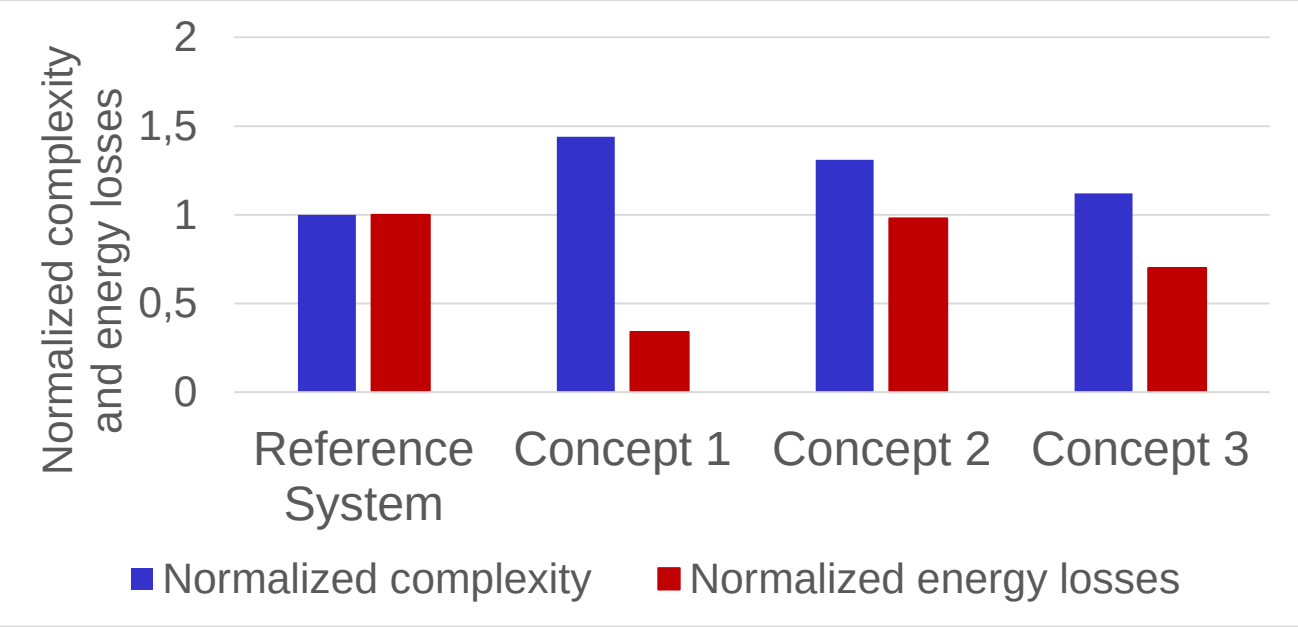
- Reduction of losses for very small flow rates
- Higher losses for operation with both pumps

5 Conclusion

- Merging the efficiency studies and the load profile

  → Annual energy losses of the supply systems

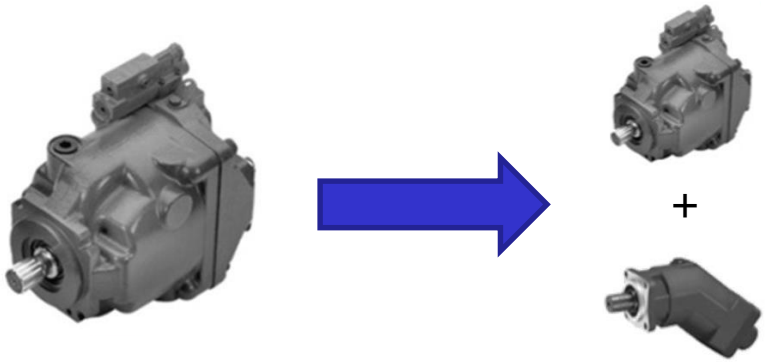
- Evaluation of results based on energy losses and complexity



- More complex systems provide higher saving potentials

5 Conclusion – Summary

- Choosing of an exemplary application
- Development of concepts for double pump supply units
- Rating of the complexity of the systems
- Simulation of three concepts
- Investigation of three concepts at the test bench
- Conclusion: Higher saving potentials for more complex systems possible



Funded by:
Forschungsfonds Fluidtechnik
VDMA

Thank you for your attention!

Test rig tractor hydraulics

Kerstin Ritters
Technische Universität Braunschweig
Institute of Mobile Machines and Commercial Vehicles
Langer Kamp 19a
DE - 38106 Braunschweig

Phone: +49 531 391-7120
Fax: +49 531 391-5951
imn@tu-braunschweig.de
www.tu-braunschweig.de/imn