**Concept ELV² - Development of an Electric Drive Axle for Heavy Commercial Vehicles**

**International Congress - ELV**

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**Motivation**

**Problem**
- Growing demand for electric cars and trucks
- Faster development of powertrains required
- Due to the characteristics of electric machines, new powertrain topologies emerge

**Solution**
- Holistic design approach
- Evaluation on different stages of simulation
- Optimization of existing transmissions

**ika’s Approach**

1: Transmission Synthesis
2: Transmission Concept
3: Efficiency Evaluation and Optimization
4: Thermal Evaluation
5: Optimized and Evaluated Transmission Model

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**Transmission Synthesis, Design and Evaluation**

**Brief description of model**
- Automated transmission topology synthesis
- Design gear design based on standards
- Two-staged evaluation (1st after synthesis, 2nd within genetic algorithm)
- Evaluation weights may be chosen for different vehicle types (e.g., trucks and cars)

**Exemplary solutions for a truck transmission**
- Quality Pareto-optimum
- > 300 different topologies à ~105 different gear variants

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**Efficiency Evaluation**

**Iterative efficiency calculation**
- Force, torque and speed model of the full transmission
- Iterative analysis of torque and power losses as a function of the direction of power flow
- Loss calculation according to state of the art and research for gear pair, roller bearings and seals

**Evaluation of total efficiency and individual losses**
- Static loss and efficiency analysis
- Dynamic energy demand assessment for specific operating points or reference driving cycles
- Evaluation of individual sub-component losses for efficiency optimization

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**E-Axle Schematic Diagram**

**E-Axle Concept**

**Properties**
- Two speeds
- Detachable sides to reduce losses
- Main side: Drives truck up to 26t
- Boost side: Drives empty truck (up to 15 t)
- Combined: Maximum weight of 41 t

**Next Steps**
- Finalize build-up
- Efficiency measurement
- Validation of presented models

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**References**

  https://doi.org/10.1007/s41321-019-8126-3
  https://doi.org/10.1007/s41321-021-00420-6

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**Thermal Evaluation**

**Definition of boundary conditions**
- While housing data is automatically generated
- Systemic boundary conditions are supplemented by the properties of the lubricant
- Ambient temperatures and local loads are included

**Thermal network model**
- Gearbox components are modeled in 3D to derive their thermal properties
- Thermal nodes can be determined (heat capacity, thermal conductivity)
- Properties are integrated into a time-independent transfer matrix

**Calculation of component temperatures**
- Load-dependent transfer coefficients are calculated
- Oil distribution is considered using SPH-based distribution simulations
- Coefficients are transferred into a conductance matrix
- Time-step based solution in performed

**Verification via measured data**
- After calculation, a comparison with the measured and simulated component temperatures is performed
- Measurement of rotating gearbox elements is complex, hence a telemetry unit is required
See you soon!

Save the date

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