About the cooling of power components in automotive electric drive trains

M. Schmidt, P. Stücke, H. Eichert, S. Hauschwitz

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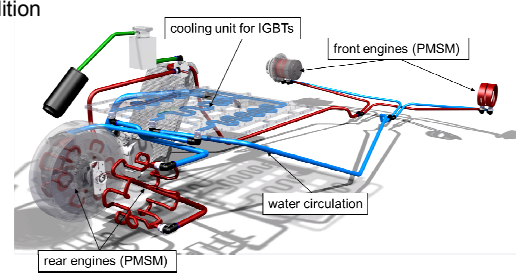
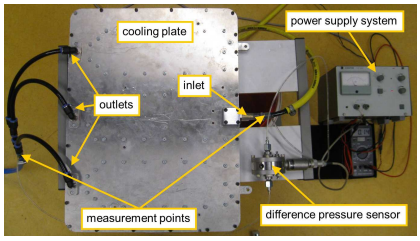
Introduction

- Complex cooling circuits for 4-wheel electric drive train
- Permanent magnet synchronous machine (PMSM) controlled by frequency converter with insulated gate bipolar transistors (IGBT)
- Keeping the power components in a temperature range for all ambient operating condition

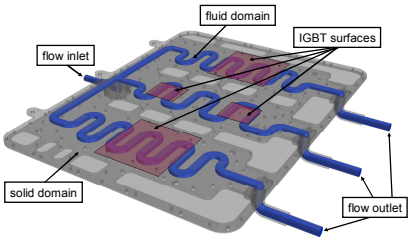


Experimental and Numerical Setup

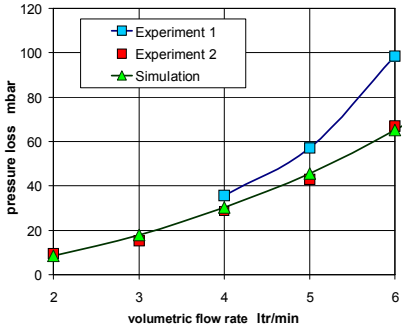
- Measurement of pressure loss vs. volumetric flow rate for validation of the numerical simulation

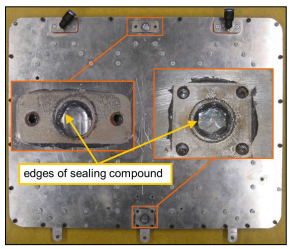


- Three-dimensional flow model must represent the experiment precisely
- CFD-Code StarCCM+ based on Finite Volume Method
- Solving set of equations :
  Continuity, steady incompressible Navier-Stokes and Energy
- Turbulence Model: k-ε
- Fluid- and Solid domain connected via interface
- Dimensionless wall distance y+ < 1 for resolving velocity profile near wall



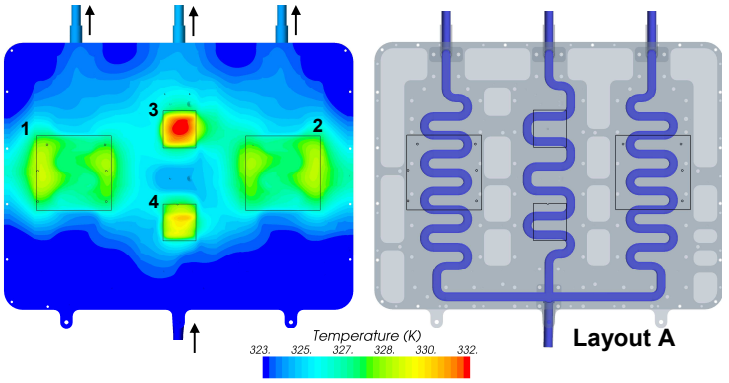
- Disagreement of experiment (no.1) and simulation require closer analysis
- Disassembled experiment shows the excessive usage of sealing compound which reduces the effective cross section and increases the pressure loss
- After removing the sealing compound the simulation predicts very well the experimental curve (no.2)





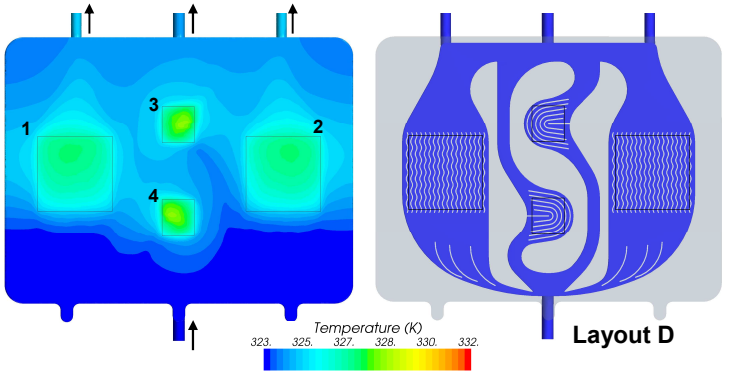
Results

- Thermo-Fluid Simulation with powered IGBTs for existing cooling plate
- Non-uniform temperature distribution and overheating of IGBT No. 3

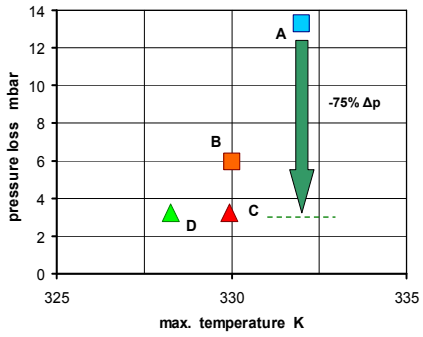


Optimization

- Homogenous temperature distribution
- Reduced pressure loss
- Individual channels per IGBT
- Symmetric mass flow distribution
- Reduced mean flow velocity
- Bigger active surface area



- Total reduction of pressure loss by 75 % compared to existing layout
- Decreasing the maximum temperature by 4 K
- Symmetric temperature distribution across the cooling plate



Conclusion

- Validation of the numerical model with experimental measurement
- Systematic optimization of pressure loss and transferred heat
- Significant reduction of pressure loss together with an homogenous temperature distribution
- More efficient of electric system and extended driving range

Contact:

Prof. Dr.-Ing. Peter Stücke
West Saxon University
Department of Automotive Engineering

Dr.-Friedrichs-Ring 2a
08056 Zwickau GERMANY

peter.stuecke@fh-zwickau.de

Prof. Dr.-Ing. Helmut Eichert
helmut.eichert@fh-zwickau.de

M.Sc. Dipl.-Ing.(FH) Marcus Schmidt
marcus.schmidt.1@fh-zwickau.de

Dipl.-Ing (FH) Sebastian Hauschwitz
sebastian.hauschwitz@fh-zwickau.de