Precision Cooling for CO_2 Reduction

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CHALMERS

Focus of the Automotive Industry

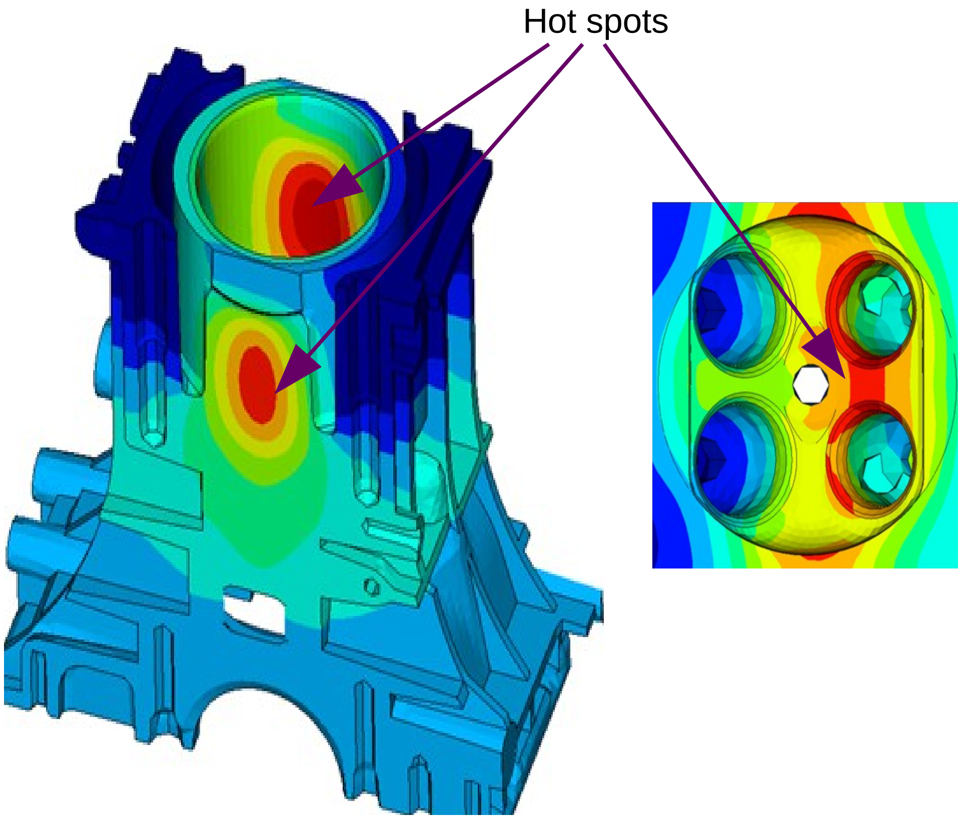
- Hybridization of vehicles
- Increasing transport requirements → Smaller engines with higher power
- Fuel economy and efficiency

Research Focus

Development of simulation methodologies for an *improved Cooling Strategy* in the coolant jacket of gasoline and diesel powered internal combustion engines.

Measures for improved cooling

1. Precision cooling – Concentrated cooling of hot spots and avoid over cooling non-critical regions.

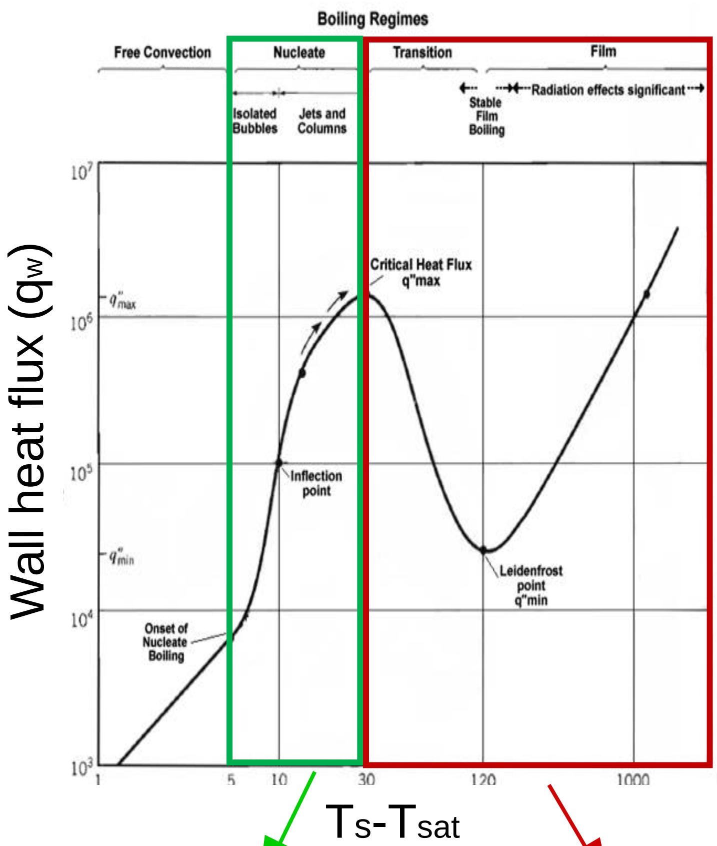


Typical temperature distribution in the cylinder block (left) and cylinder head (right) of an intermediate cylinder in a 4 valve gasoline engine

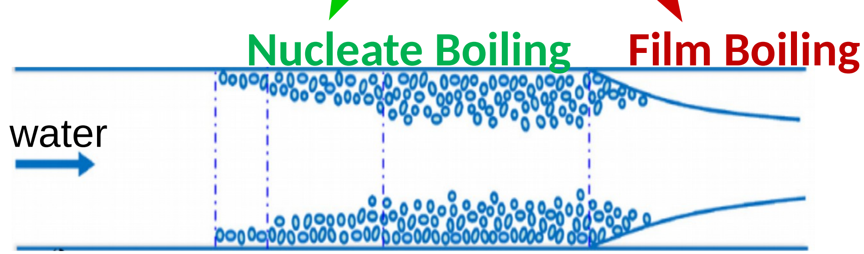
2. Local subcooled flow boiling – potential for enhanced heat transfer

Boiling Curve for water at 1 atm

The *nucleate boiling* region - potential for removing more heat from the engine cylinder compared to the forced convection region.



Film boiling - causes sudden increase in engine wall temperature due to the low heat transfer through the vapor layer and lead to material failure. Entering region is to be avoided.

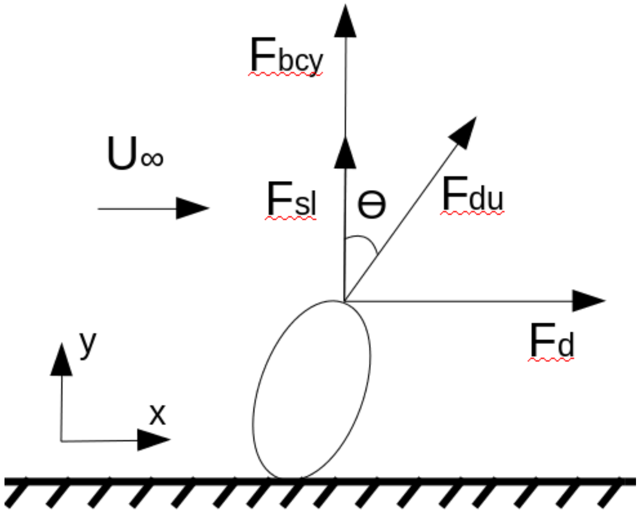


3. Surface structure modification (such as golf ball surface)–
known to enhance heat transfer.

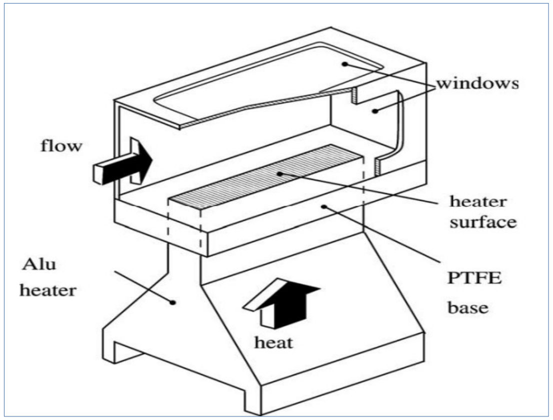
Boiling model – based on vapor bubble dynamics

The **Boiling Departure Lift-off (BDL)** model proposed by Steiner et al [1], based on forces acting on individual bubbles is being evaluated.

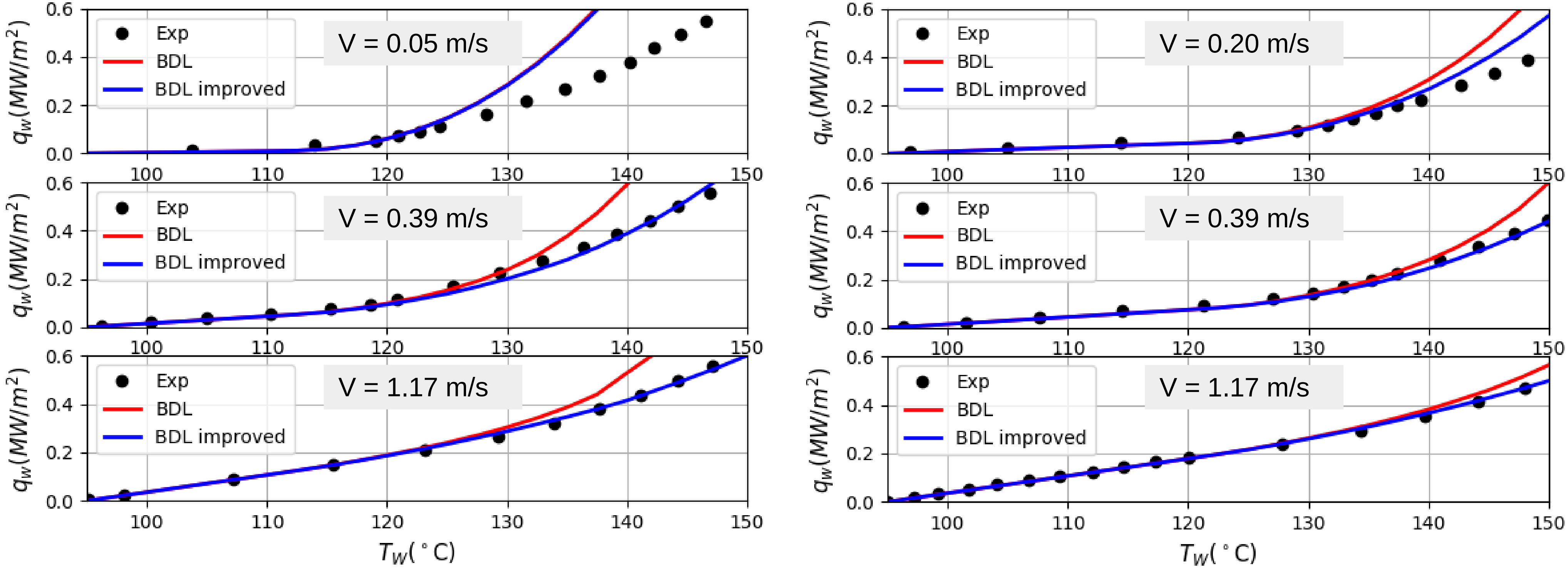
F_d – Drag force
F_{sl} – Lift force
F_{bcy} – Force due to buoyancy
F_{du} – Force due to bubble growth



Results in brief



Test section - Experimental facility of Steiner et al [1]



Boiling curves for water : P = 1.5 bar (left) and P = 2.0 bar (right) with varying bulk velocities. Experimental data points from Steiner et al [1].

[1] Steiner, H., Kobor, A. and Gebhard, L., 2005. A wall heat transfer model for subcooled boiling flow. International Journal of Heat and Mass Transfer, 48(19-20), pp.4161-4173.

Potential Benefits

- Engine operates at higher temperature
  - Improved thermodynamic efficiency and reduced chances of incomplete combustion
  - Reduced warm up time
  - Potential fuel consumption benefits
- Large reduction in coolant flow rate
  - Smaller cooling system and resulting weight reduction
  - Reduced parasitic load on the engine (of cooling fan and coolant pump)
- Access to coolant at higher temperature - Improved performance of cab heaters
- The methodology can be implemented in other applications like batteries and electric motors.