Conjugate Heat Transfer of Cooling Channels

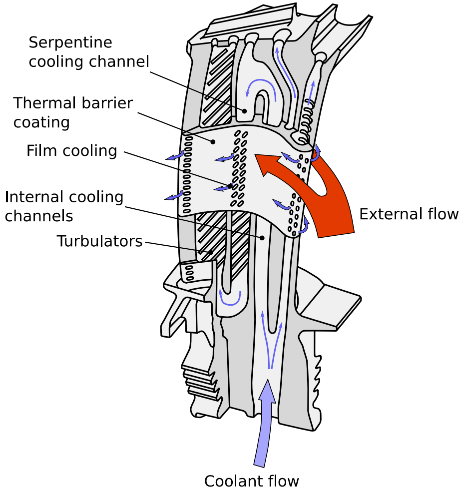
Sebastian Scholl
Supervisor: Professor Tom Verstraete

von Karman Institute for Fluid Dynamics

COPA-GT project meeting, January 7, 2013
Doctoral Presentation

Section Outline

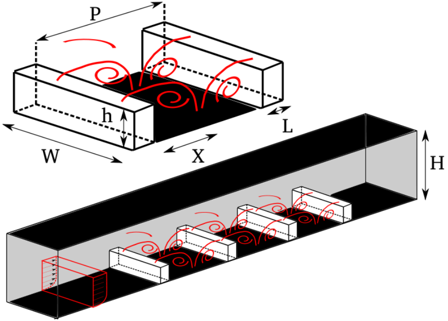
Turbomachinery Cooling



Goal of the PhD project

- Conjugate Heat Transfer of cooling channels in a turbine blade using LES
- Why Conjugate Heat Transfer ?
- Why LES ?

Turbomachinery Cooling



Goal of the PhD project

- Conjugate Heat Transfer of cooling channels in a turbine blade using LES
- Why Conjugate Heat Transfer ?
- Why LES ?

Section Outline

Solver

Coolfluid 3

A Collaborative Simulation Environment

other methods

Plugins

Finite Element

Fluid solver

Finite Difference

Coolfluid 3 Kernel

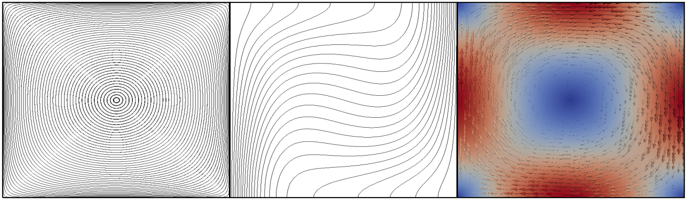
Meshreader

Parallelisation

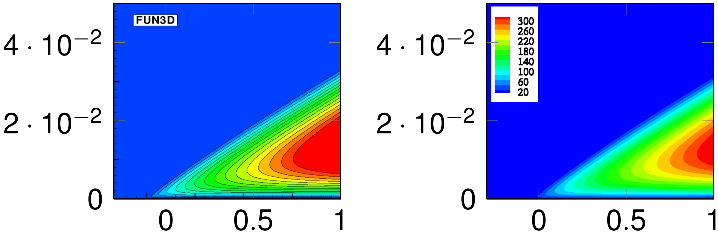
python user interface

Conduction solver

Implementation of energy equation



Implementation of turbulence model



Section Outline

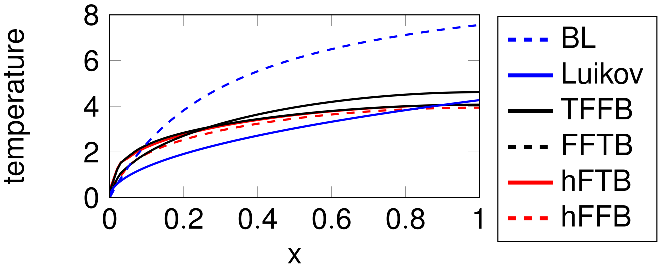
Conjugate Heat Transfer

Coupling methods

$$\boxed{fluid} \underset{T}{\overset{q_{wall}}{\rightleftarrows}} \boxed{solid} \qquad \boxed{fluid} \underset{T}{\overset{h,\ T_{fluid}}{\rightleftarrows}} \boxed{solid}$$

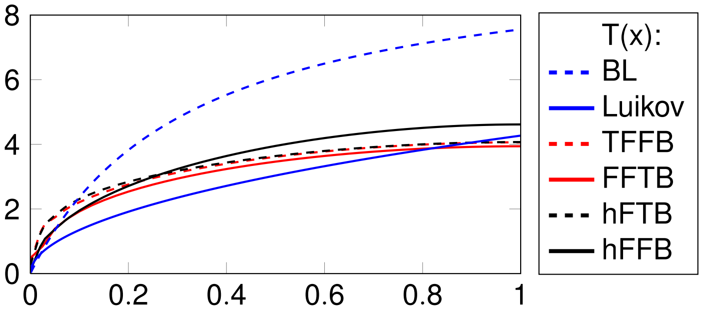
$$\boxed{fluid} \underset{q_{wall}}{\overset{T}{\rightleftarrows}} \boxed{solid} \qquad \boxed{fluid} \underset{q_{wall}}{\overset{h,\ T_{fluid}}{\rightleftarrows}} \boxed{solid}$$

Coupling procedures



parameter	value
T_∞	0
$T_{solidwall}$	10

Coupling procedures



parameter	value
T_∞	0
$T_{solidwall}$	10

Section Outline

Inlet conditions

Section Outline

Training Sessions

- VKI-LS: Introduction to CFD
- VKI-LS: Introduction to LES
- VKI-LS: Optimization
- VKI-RM: 2D Boundary Layers
- VKI: Internal Seminar and PhD Symposium
- Turbomeca: Maintenance Course on Helicopter Engines
- Chalmers University: Unsteady Simulations (LES)
- Udacity: Introduction to Computer Science
- Udacity: Programming Languages
- Coursera: Heterogeneous Parallel Programming
- Stanford University - Coursera: Scientific English
- French Course, Level B1 (09/2012 - 06/2013)

Section Outline

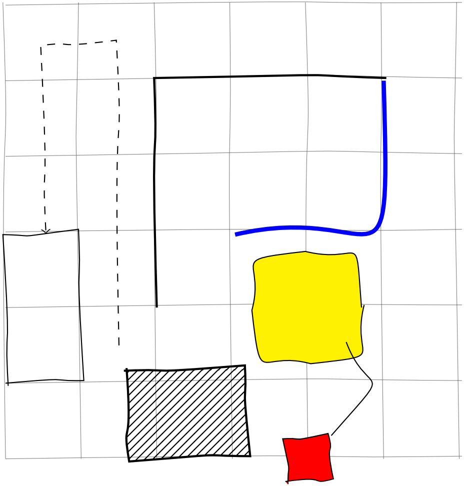
Achievements

What did we do ?

- Familarization with to COOLFluiD 3
- Implementation of energy equation
- Implementation of turbulence model
- Implementation and investigation of coupling procedures
- Created inlet conditions for LES

What are the next steps ?

- LES
- Comparison of the results with existing VKI experiments



Timeline

- Familarization with Coolfluid 3
- Implementation of enegy equation
- Implementation of turbulence model
- Implementation of coupling strategies for CHT
- Creation of inlet conditions for LES

- Further investigations of coupling procedures
- LES of the channel
- Secondment

- Optimization
- Finalize thesis

References

1 T. Banyai et. al. *A Fast Fully-Coupled Solution Algorithm For The Unsteady Incompressible Navier-Stokes Equations.* CMFF, 2006

2 B. Janssens et. al. *Discretization of the Incompressible Navier-Stokes Equations using a Domain Specific Embedded Language.* 9th National Congress on Theoretical and Applied Mechanics, 2012

3 T. Verstraete. *Multidisciplinary Turbomachinery Component Optimization Considering Performance, Stress, and Internal Heat Transfer.* Universiteit Gent, PhD Thesis, 2008