1d gas network solver

Bachelor, Master, Internship

MTU AERO ENGINES AG*

in 2023

Background MTU Aero Engines AG is one of the leading manufacturers of aero engines. In this project we calculate the effect of internal and external turbine blade cooling systems (Fig. 1a) with a one dimensional gas network (1b) solver. In particular, we are looking at optimization problems constrained by ordinary differential state equations (odes):

$$\min J(u) \text{ s.t. } F(u) = 0 \tag{1}$$

where the cost functional J is a weighted sum of balance errors and F the operator defined by the ode boundary value problem on the network domain Ω with initial conditions u_o

$$u := (t, p), \quad u' = f(u)\, \forall x \in \Omega, \quad u = u_0\, \forall x \in \partial\Omega \tag{2}$$

with states temperature $t(x)$ and pressure $p(x)$ and right hand side $f : \mathbb{R}^2 \to \mathbb{R}^2$.

Topic Several avenues are open for theoretical and practical explorations:

- conditions for existence of optimal solutions (depending on the cost functional J, the boundary conditions, the right hand side f) and the network form (closed loops, forks).
- different formulations of the optimal problem (1) for instance discretize first or optimize first
- convergence studies of our solver
- implementation of alternative algorithms
- studies to the stiffness of the state equation

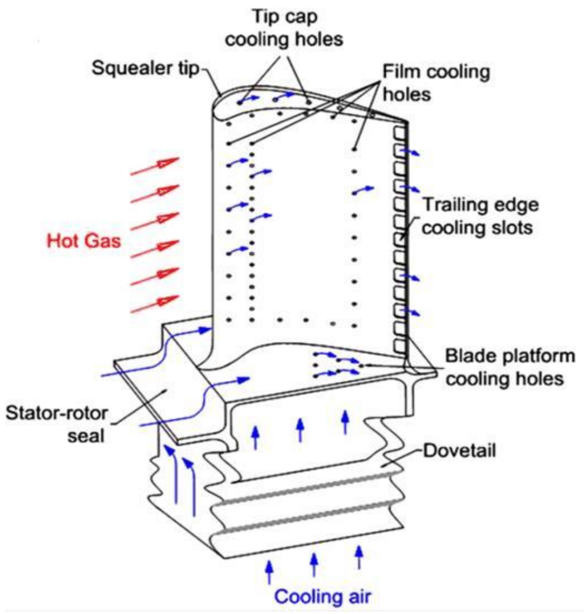
Profile Interested students (mathematics/engineering/physics) should bring a strong understanding of numerics of ordinary differential equations and ideally optimization methods. Knowledge of a programming language is mandatory, `C++` is an asset.

Benefits Joining our software development team will give the candidate an opportunity to work on industrial-sized applications and experience modern development practises from continuous integration to software versioning at one of the main engineering companies of Germany.

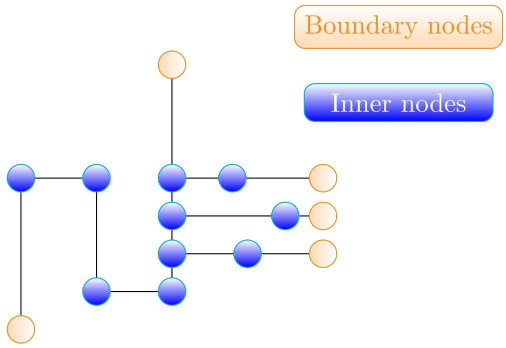
Remote working is possible but a major part must be spent at MTU Munich.

Application If you are interested in joining our team please send your application directly to Daniela Fusseder* (letter of application, CV, certificates, university performance record).

*Contact: `www.mtu.de`, CAE Engineering Systems and Software, FIEA, Dr. Daniela Fußeder, Dachauer Str. 665, daniela.fusseder@mtu.de



(a) Schematic gas turbine blade cooling [1]



(b) A 1d gas network example

Figure 1: Turbine blade cooling

References

[1] Djamel Cherrared. Numerical simulation of film cooling a turbine blade through a row of holes. *Journal of Thermal Engineering*, 3:1110–1110, 04 2017.