Faculty Engineering Technology
Program Mechanical Engineering

UNIVERSITY OF TWENTE.

COLLOQUIUM

Group: **Engineering Fluid Dynamics**

As part of his MSc thesis assignment

E.J. Grift

will give a presentation, entitled:

Computational Method for Ice Crystal Trajectories in a Turbofan Compressor

Date: Friday May 9, 2014

Time: 14:00

Room: **Horstgebouw C.101**

Summary:
The past decades about 10 events per year have been reported of large aircraft with jet engine power-loss events at altitudes above 22,000 feet. It is suspected that these events are caused by in-engine icing while flying in atmospheric conditions above extensive regions with highly convective clouds, involving massive amounts of high-altitude ice crystals (haic). In-engine icing is the phenomenon that a large number of atmospheric ice crystals during their in-engine trajectory partially melt and subsequently accrete inside the compressor of the turbofan engine. To investigate this phenomenon an EU research project called HAIC has started involving 34 partners worldwide. In the present research, within the framework of the HAIC project, a computational method is developed to provide insight in the trajectories of the ice crystal while travelling through the first stage of a turbofan compressor. Of special interest are the particle characteristics at impact on the compressor blades.

The first stage of the turbofan compressor, a stator-rotor-stator combination, is represented by a rotating annularly cascaded flow domain, using mixing-plane boundary conditions at the stator-rotor interfaces. The ice crystal trajectories are computed employing a known steady inviscid flow field solution. Ice crystals are modeled as rigid spherical particles and are assumed not to affect the flow field or one another. The trajectories are calculated based on a drag model developed by Clift et al. using a Lagrangian method and the classical fourth-order Runge-Kutta time-integration scheme. The change of particle mass due to evaporation and sublimation is accounted for, as well as particle heating due to convection and phase transition using an ice-core water-film model. To simulate trajectories crossing the mixing-plane between rotor and stator the trajectory of a large number of randomly released particles is simulated such that with enough particles a realistic solution is obtained.

To be able to simulate a large number of particles the computation should be sufficiently efficient. The bottle-neck in the calculations is the inverse-interpolation to retrieve the flow field variables from the specified solution at grid points. Computational performance is boosted by using pre-selection based on bounding boxes stored in an Alternating Digital Tree. The impact locations on the rotor and stator are calculated from the trajectories to obtain a β-catch efficiency for each compressor blade.
Trajectory calculations have been carried out for several conditions. It is found that under normal cruising conditions ice particles with a diameter in the range of 20 to 500 µm have no time to melt during their flight through the first compressor stage and thus upon impact consist of pure ice.

Assessment committee:
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