11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

THE INFLUENCE OF MODIFIED THOM ROTORS TO THE BOUNDARY LAYER

Markus Rütten*[1], Robert Ritz[2,4] and Thomas Schomberg[3,4]

German Aerospace Center, Bunsenstrasse 10, 37073 Göttingen, Germany
[1] markus.ruetten@dlr.de, [2] robert.ritz@dlr.de, [3] thomas.schomberg@dlr.de
[4] University of Kassel, Institute of Mechanics, Mönchebergstrasse 7, 34125 Kassel, Germany

Key words: *Magnus effect, Thom rotor, vortical flow, boundary layer, surface structure, FVM*

Due to the high cost pressure in the field of aviation, the increase in efficiency is in focus of development. Nowadays the airfoils are highly developed and optimized. A new approach of geometry has to be explored to reduce the resistance and increase the buoyancy. The focus on these considerations is the Magnus effect, in which rotating cylinders generate a lift force. This has already been investigated in the past. In 1924 the pioneer A. Flettner developed the Flettner rotor. He presented the performance of the rotor with the first Magnus effect driven ship "Buckau". His construction crossed the atlantic ocean driven by two rotating cylinders in May 1926. Especially in the following years the Magnus effect was subject of research. Important elements in this case were different surface roughnesses, rotor geometries, ratios of circumferential speed velocity to free stream velocity, and the effect of end plates. The scottish engineer A. Thom reached a significant increase of the performance by adding so called Thom discs coaxial and equidistantly arranged to the symmetry axis of the cylinder [5].

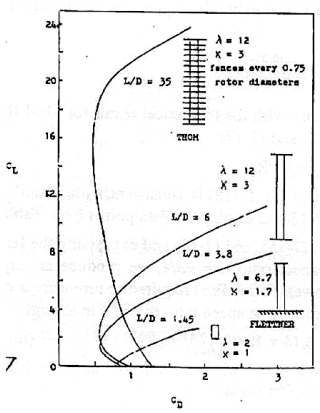

Figure 1: C_l over C_d [4]

The promising properties has led to numerous attempts to use Flettner rotors in the fledgling aviation. However, only existing aircraft geometries were used by replacing the conventional airfoils with such rotors. Considering the gyroscopic forces, this seems not to be effective. Rather, these forces may just be used to develop novel airplane geometries. Such an aircraft does not possess the agility of a conventional one, but projects like the "Citizen-Friendly-Airplane" are conceivable to improve the take-off properties [2]. The first prototypes achieved an even nowadays amazing lift-to-drag ratio (Figure 1).

Furthermore the NASA tested the influence of hybrid airfoils in high lift aerodynamics by adding a rotating cylinder at the leading edge of a Fowler flap. In the 1970s the prototype YOV-10A proved the capability of Flettner rotors by performing steep approaches and short landings but also revealed the weakness in handling due to gyroscopic forces [3]. Modern material combined by lightweight construction could remedy

this problem so the potential of the Flettner rotor can be used.
In this numerical flow simulation study we are focusing on the interaction between the surface structure and the boundary layer, especially the generated vortices at the Thom discs will be analyzed. Moreover the influence of different fluid properties appearing at high altitude will be investigated. In the first part of the work we will validate the experimental data to generate a reference rotor. After studying the occurring effects we will apply particular surface structures in order to affect the C_l/C_d ratio positively. Presuming a use of further developed rotors in civil aviation we are going to optimize the rotors for hight altitude conditions as a second step.
Before going into details the underlying grid generation, the used CFD code (TAU) and the relevant CFD simulation setup will be explained. Additionally, the design concept of Thom rotors will be briefly introduced. Special attention will be given to the design methodology, before the flow characteristics around a specified Thom rotor will be exemplarily explained. In a short main manner main aspects of the flow field will be presented. Based on the CFD results the analysis will concentrate on the vortex at Thom discs. Thereafter, the interaction between the surface structure and the boundary layer will be discussed. Finally, some design varieties of the surface structure will be given.

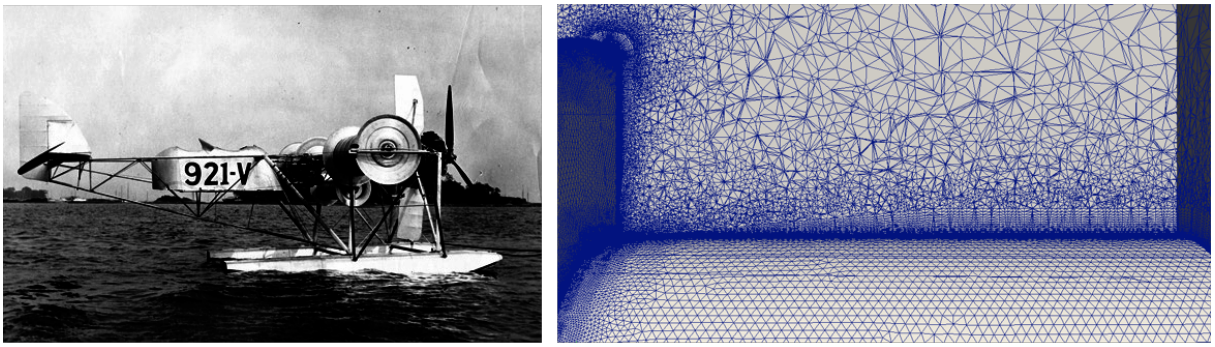

Figure 2: One of the first aircrafts with Flettner rotors and the generated grid.

REFERENCES

[1] E.R. Gowree, and S.A. Prince: A computational study of the aerodynamics of a spinning cylinder in a crossflow of higher Reynolds number. Proceedings of the 28th ICAS International Congress of the Aeronautical Sciences, 2012.

[2] L. Müller, D. Kozulovic, M. Hepperle, and R. Radespiel: The influence of the propeller position on the aerodynamics of a channel wing. 2012

[3] J. Seifert: A review of the Magnus effect in aeronautics. 2012

[4] D.M. Schulz-Hoos: Der Thom-Rotor-Flügel,
http://www.sunny-boxwing.de/rotorfluegel.htm, last checked 20.12.2013.

[5] A. Thom: Effect of discs on the air forces on a rotating cylinder. Aeronautical Research Committee, Reports and Memoranda. 1934