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An innovative approach for the numerical simulation of oil cooling systems

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Abstract. Aeronautics engine cooling is one of the biggest problems that engineers have tried to solve since the beginning of human flight. Systems like radiators should solve this purpose and they have been studied extensively and various solutions have been found to aid the heat dissipation in the engine zone. Special interest has been given to air coolers in order to guide the air flow on engine and lower the high temperatures achieved by the engine in flow conditions. The aircraft companies need faster and faster tools to design their solutions so the development of tools that allow to quickly assess the effectiveness of an cooling system is appreciated. This paper tries to develop a methodology capable of providing such support to companies by means of some application examples. In this work the development of a new methodology for the analysis and the design of oil cooling systems for aerospace applications is presented. The aim is to speed up the simulation of the oil cooling devices in different operative conditions in order to establish the effectiveness and the critical aspects of these devices. Steady turbulent flow simulations are carried out considering the air as ideal-gas with a constant-averaged specific heat. The heat exchanger is simulated using porous media models. The numerical model is first tested on Piaggio P180 considering the pressure losses and temperature increases within the heat exchanger in the several operative data available for this device. In particular, thermal power transferred to cooling air is assumed equal to that nominal of real heat exchanger and the pressure losses are reproduced setting the viscous and internal resistance coefficients of the porous media numerical model. To account for turbulence, the k-ω SST model is considered with Low-Re correction enabled. Some applications are then shown for this methodology while final results are shown in terms of pressure, temperature contours and streamlines.

Keywords: CFD simulation; aerodynamics; oil cooling; flow field; numerical simulation; porous media

1. Introduction

The present work deals with a new numerical methodology and flow fields analyses of oil cooling duct systems for aerospace applications. This research effort has been conducted in the framework of the European project ESPOSA (Efficient Systems and PrOpulsion for Small Aircraft) of 4th call VII FP, A. Carozza, G. Mingione, (2013), ESPOSA Grant Agreement, PART B: Agreement N 284859. The project develops and integrates novel design and manufacture technologies for a range of small gas turbine engines to provide aircraft manufacturers with modern propulsion units, thus improving efficiency, safety and pilot workload reduction. In

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