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A PARAMETRIC-CFD STUDY FOR HEAT TRANSFER AND FLUID FLOW IN A ROTOR-STATOR SYSTEM

Alireza Rasekh[1*], Jan Vierendeels[1] and Peter Sergeant[2,3]

[1]Department of Flow, Heat and Combustion Mechanics, Faculty of Engineering and Architecture, Ghent University, Ghent, Belgium. Email: Alireza.Rasekh@UGent.be, Jan.Vierendeels@UGent.be
[2]Department of Electrical energy, systems and automation, Ghent University, Ghent, Belgium.
[3]Department of Industrial Technology & Construction, Ghent University, Ghent, Belgium.
Email: Peter.Sergeant@UGent.be

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Over the past few decades, considerable attention has been paid to investigate the heat transfer in axial rotor-stator disk systems that are mostly crucial in disk type electrical machines [1]. It is very important to improve cooling in order to maintain both a long life time and high reliability of such machines. In particular the magnets should be sufficiently below the critical temperature (150°C) to avoid demagnetization. Numerical simulation of turbulent flow in an open rotor-stator system was performed by Yuan et al. [2]. The results revealed that there exists an optimum rotor–stator distance for a given Reynolds number, at which the average heat transfer on the stator reaches a maximum.

This paper describes the numerical study of the turbulent flow and heat transfer in the air-gap of an enclosed rotor-stator system with prescribed surface temperature. The configuration of the problem under investigation has been illustrated in the fig. 1 where the left disk represents the rotor and the right one is stator. The turbulence was treated with a SST k-ω model and the boundary layers around the solid walls were designed to obtain a y^+ value below 5. Furthermore, the air density variation due to temperature differences was considered.

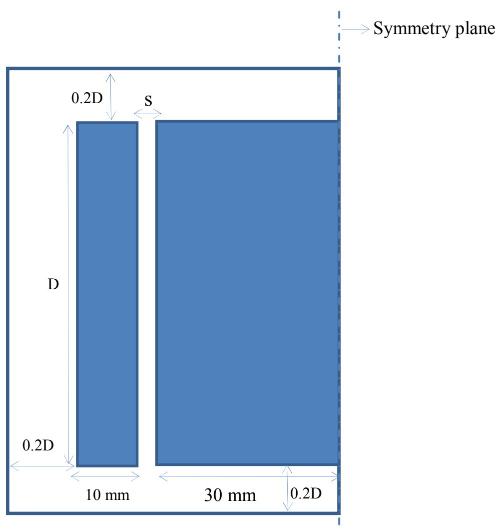

Fig.1. Problem configuration where $D = 2R$ is the disk radius.

No study has been reported in the literature regarding putting holes in the rotor disk. Thus, the main objective of this study was to evaluate the thermal performance of the discoidal system in the presence of holes. To handle the rotor motion, multiple reference frame and sliding mesh techniques have been employed as the latter case takes into account the effect of the position of the holes during rotation. In the range of rotational Reynolds number ($Re = \Omega R^2 / \upsilon$) 5.13×10^4 to 5.13×10^5 and air gap ratio ($G = s/R$) from 0.00667 to 0.02667, the heat transfer rate and the flow characteristic in the gap between the disks are calculated. Here, s and R are defined in fig. 1, Ω is the rotational speed in rad/s and ν is the kinematic viscosity of air. Fig. 2 represents the temperature distribution inside the enclosed rotor-stator system while the surface temperature of rotor, stator and cover are kept at 100, 120 and 50 °C respectively. The results, according to tab.1, reveal that the addition of the holes in the rotor is advantageous for the heat transfer as air is allowed to enter into the air gap through the holes, resulting in a net radial flow in the gap region between the rotor and stator.

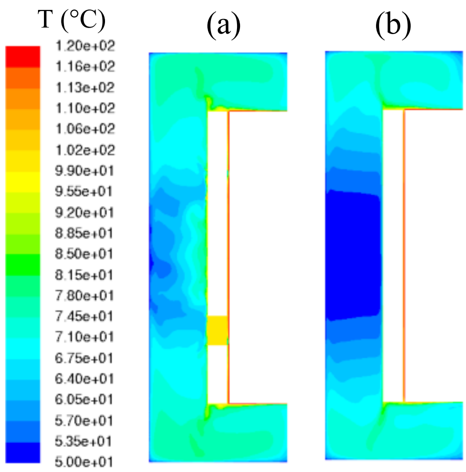

Fig.2. temperature contour in the enclosed rotor-stator system (a) with holes (b) without holes for Re = 1.54×10^5 and G =0.0133.

Table 1. Effect of holes in rotor on the heat transfer rate (W) for Re = 1.54×10^5 and G =0.0133.

	without holes	with holes
rotor wall	27.5	33.2
stator wall	42.3	56.9
cover wall	-69.8	-90.1

REFERENCES

[1] D.A. Howey,A.S. Holmes and K.R. Pullen, Radially resolved measurement of stator heat transfer in a rotor–stator disc system. *International Journal of Heat and Mass Transfer*., Vol. 53, pp. 491–501, 2010.

[2] Z.X. Yuan, N. Saniei and X.T. Yan, Turbulent heat transfer on the stationary disk in a rotor–stator system. *International Journal of Heat and Mass Transfer*., Vol. **46**,pp. 2207–2218, 2003.