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

TWO DIFFERENT METHODS FOR DETERMINATION OF BLOOD FLOW STAGNATION REGIONS IN THE PVAD – COMPARATIVE STUDIES

Damian Obidowski[1], Piotr Reorowicz[2], Przemyslaw Klosinski[3] and Krzysztof Jozwik[4]

[1] Institute of Turbomachinery, Lodz University of Technology, 90-924 Lodz, Wolczanska Str. 219/223, Poland, damian.obidowski@p.lodz.pl, www.imp.p.lodz.pl
[2] Institute of Turbomachinery, Lodz University of Technology, 90-924 Lodz, Wolczanska Str. 219/223, Poland, piotr.reorowicz@p.lodz.pl, www.imp.p.lodz.pl
[3] Institute of Turbomachinery, Lodz University of Technology, 90-924 Lodz, Wolczanska Str. 219/223, Poland, przemyslaw.klosinski@p.lodz.pl, www.imp.p.lodz.pl
[4] Institute of Turbomachinery, Lodz University of Technology, 90-924 Lodz, Wolczanska Str. 219/223, Poland, krzysztof.jozwik@p.lodz.pl, www.imp.p.lodz.pl

Key Words: *PVAD, CFD, Blood Flow Stagnation, Immersed Body Technique*

Pneumatic Ventricle Assist Devices (PVADs) are devices which enable a bridge for the heart recovery or a bridge to transplant in numerous cases. Their proper operation exerts a direct influence on the patient's life. One of the basic requirements to be fulfilled during their designing process is to eliminate the places in which very low blood flow velocities occur or blood even does not move, which means that they are not flown through during the ventricle operation cycle. An application of numerical simulations allows for verification of a large number of design variants without building prototypes and conducting investigations which employ blood, thus reducing costs and shortening the time for preparing a new device.

The results attained during modelling of a blood flow in the PVAD with two methods that allow for a qualitative and quantative comparative evaluation of various geometrical models of PVADs will be discussed. The first method consists in determination of the space within which the velocity values are lower than 0.01 m/s (excluding the wall conditions) during the whole cycle of the ventricle operation. The second method assumes employment of the two-phase flow in which it is possible to observe the process of replacement of the "old" liquid by the new one of identical properties during blood pumping through the PVAD. It allows one to determine the stagnation regions of the "old" liquid after a certain number of operation cycles of the ventricle supplied with the new "liquid" only. A comparative analysis of the results and methods in which the model developed at the Institute of Turbomachinery, TUL, in which the flow is enforced by a motion of the membrane, will be presented. Additionally, in this model, the disk heart valves modelled with the immersed solid technique move depending on the pressure and flow conditions, as it takes place in the real ventricle assist device.

REFERENCES

[1] Ansys CFX Reference book, Release 12.1.

[2] B. Johnston, P. Johnson, S. Corney, D. Kilpatrick, *NonNewtonian Blood Flow in Human Right Coronary Arteries: Steady State Simulation*, Journal of Biomechanics, Vol. 37, pp. 709-720, 2004.

[3] K. Jozwik, *Modelling of Blood Flows*, A series of monographs, No. 2063, Lodz University of Technology, Lodz, 2013.

[4] K. Jozwik, D. Obidowski D., *Numerical simulations of the blood flow through vertebral arteries*, Journal of Biomechanics, Volume 43, Issue 2, pp.177-185, 2010.

[5] D. Obidowski, K. Jozwik, P. Klosinski, P. Reorowicz, *Comparison of the Flow Pattern and Stagnation Areas Developement in the VAD under Transient and Steady State Conditions*, Journal Of Artificial Organs, Vol. 36, p.556, 2013.

[6] D. Obidowski, P. Klosinski, P. Reorowicz, K. Jozwik, *Influence of an Artificial Valve Type on the Flow in the Ventricular Assist Device*, IFMBE Proc. Vol. 29, Medicon, Greece, pp. 410–413, 2010.

[7] P. Reorowicz, D. Obidowski, P. Klosinski, K. Jozwik, *Flow Modelling in the Pneumatic Ventricular Assist Device with Mesh Deformation and Immersed Body Techniques – Investigations of Stagnation Zones*, IFMBE Proc., Budapest, Hungary, 2011.

[8] S.J. Sonntag, T.A.S. Kaufmann, M.R. Bussen, F. Graf, M. Laumen, T. Linde, U. Steinseifer, *Numerical Washout Study of a Pulsatile Total Artificial Heart*, Journal Of Artificial Organs, Vol. 36, p. 557, 2013.

[9] S. Sterkowicz, *Fifty years later. Artificial heart – yesterday, today and tomorrow*, Kardiochirugia i Torakochirurgia Polska, vol. 5 (2), pp. 216-221, 2008 (in Polish).