American Journal of Biomedical Science & Research

www.biomedgrid.com

ISSN: 2642-1747

Review Article

Numerical Simulation of Fluid Flows in Rotating Discs: A Review

Dragan Mandić

Belgrade Power Plant, Savski nasip 11, Belgrade, Serbia

***Corresponding author:** Dragan Mandić, Belgrade Power Plant, Savski nasip 11, Belgrade, Serbia.

***To Cite This Article:** Dragan Mandić. Numerical Simulation of Fluid Flows in Rotating Discs: A Review. Am J Biomed Sci & Res. 2025 28(6) AJBSR.MS.ID.003739,* **DOI:** 10.34297/AJBSR.2025.28.003739

Received: October 01, 2025; **Published:** October 28, 2025

Abstract

This paper presents a numerical analysis of fluid flow velocity parameters in four distinct physical models of pipe flows with rotating bodies. A key factor influencing velocity is the role of frictional forces between the contact surfaces of the rotating discs and the surrounding fluid. For each physical model, specific relationships between flow rates and fluid pressures were observed at an identical theoretical pipe cross-section. The study suggests that the interdependence of these variables can be applied in the design of pump impellers for external cardiovascular circulation—an area of critical importance. Motivated by this potential, the work aims to contribute to the continued development of impeller modeling. Flow velocity distributions are presented for selected positions of the rotating discs within the pipeline, serving as illustrative confirmation of the findings.

Keywords: Fluid, Rotating disc, Impeller, Translational flow, Friction

Nomenclature: Pa, N/m^2: Pascal; B,m: Width; b,m: Distance between plates; L,m: Length; β,° : Angle; δ, m: Thickness; ∇p, Pa: Pressure drop due to friction; τ: Shear stress or sub-grid scale molecular stress tensor; ρ, kg/m^3: Density; ϕ, kg/m·s: Additional variable (non-reacting scalar); V, m^3: Control Volume; Gϕ, kg/m·s: Dynamic Diffusivity of additional variable; A, m^2: Surface Area; Sϕ, kg/m^3·s: Mass Source Term; U, m/s: Velocity Magnitude

Abbreviations: Ref: Reference; Static: Static; Abs: Absolute

Introduction

Numerical simulations using ANSYS software aim to reproduce, with high fidelity, the complex motion of fluids in systems with varying geometrical configurations and hydraulic conditions. Particular attention is given to the initial boundary conditions, including flow regimes, pressures, and fluid-structure interactions on selected geometrical surfaces. These simulations provide insights into the dynamic behavior of fluid flows in the presence of rotating discs, highlighting both the challenges and opportunities for accurate modelling [1,2].

Problem Statement

Geometric Models of Rotating Bodies

For the geometric models of rotating bodies (Figures 1 and 3), a rotational speed of 4 rad/s was assumed for the discs.

Mathematical Flow Models

The general conservation (transport) equations for mass, momentum, energy, and scalar quantities were solved over a set of control volumes [1]:

$$\frac{\delta}{\delta t}\int_{v}\rho\phi dV+\oint_{A}\rho\phi V.dA=\oint_{A}\Gamma_{\phi}\nabla\phi.dA+\int_{V}S_{\phi}.dV, \quad (1)$$

where:

ρ, kg/m^3 - density

ϕ, kg/m·s - additional variable (non-reacting scalar)

V, m^3 - control volume

A, m^2 - surface area

Γϕ, kg/m·s - dynamic diffusivity of the additional variable

Sϕ, kg/m^3·s - mass source term

The individual terms of Equation (1) represent:

$$\partial t/\partial\int v\rho\phi dV$$

-unsteadiness due to local fluctuations (1.1)

$$\oint A\rho\phi V.dA$$

- convection (1.2)

$$\oint A\Gamma\phi\nabla\phi.dA$$

- diffusion (1.3)

$$\int vS\phi dV$$

- generation (1.4)

Results of Numerical Simulations on Elementary Discs

Elementary Discs with External Fluid Supply

The following figures illustrate the variations of fluid velocity vectors between rotating discs (Figures 1-4).

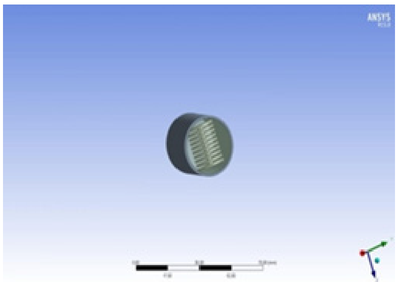

Figure 1: Transverse cylindrical rotating discs in a fluid flow within a cylindrical tube.

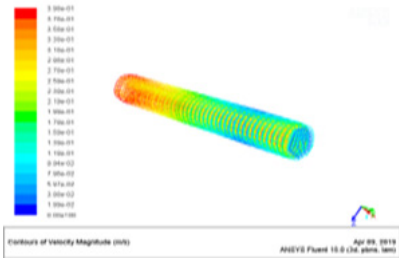

Figure 2: Diagram showing the increase in fluid velocity due to a rotating body in a longitudinal fluid flow.

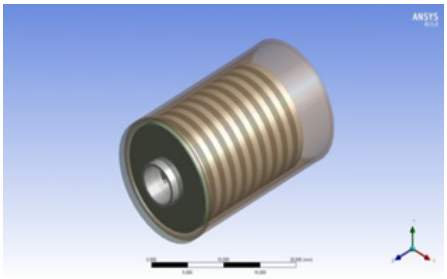

Figure 3: Longitudinal cylindrical rotating discs with an internal opening in a translational fluid flow within a cylindrical tube.

Figure 4: Diagram of fluid velocity changes along a pipeline.

Analysis of Results

Along the pipeline, increases in collective fluid velocities were observed, with intensities proportional to the distance from the rotating discs (Figures 2 and 4). Simultaneously, turbulence zones were detected, with intensities directly dependent on flow velocity [3,4]. Maximum fluid flow velocities were found in regions immediately adjacent to the exit sections between circulation rings. When complex flow velocities were considered (combining rotational and translational motion), the observed speed increments were significantly higher than those with translational motion alone.

Conclusion

Numerical simulations of fluid velocities in pipelines with rotating discs provide a reliable method for identifying flow regimes and fluid pressures pre-conditioned for specific technological processes. These simulations establish the necessary conditions for accurate process execution and can serve as a foundation for selecting optimized technological procedures [5].

Acknowledgments

None.

Declaration of Interest

None.

References

1. ANSYS (2006) Introduction to CFD Analysis, Introductory FLUENT Notes, FLUENT 6(3).
2. Tesla N (1913) Fluid Propulsion U.S. Patent 1, 061,142.
3. Mandić D, CFD Modeling of Turbulence in Channels of Plate Heat Exchangers, 5th International Conference of Fluid Flow, Heat and Mass Transfer (FFHMT'18), Niagara Falls.
4. Mandić D (2017) CFD Modeling of Hydrodynamic Phenomena and Heat Transfer in Channels of Plate Heat Exchangers, 4th International Conference of Fluid Flow, Heat and Mass Transfer (FFHMT'17), Toronto, Canada, 22-23.
5. Lukic B (2018) A Passively-Suspended Tesla Pump Left Ventricular Assist, The Pennsylvania State University, US National Library of Medicine - National Institutes of Health, Nov 2010, Canada.