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Experimental and Computational Fluid Dynamic Modeling of a Progressing Cavity Pump Handling Newtonian Fluids

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Abstract : Progressing Cavity Pump (PCP) is a type of positive displacement pump that is being awarded greater importance as capable artificial lift equipment in the heavy oil field. The most commonly PCP used is driven single lobe pump that consists of a single external helical rotor turning eccentrically inside a double internal helical stator. This type of pump was analyzed by the experimental and Computational Fluid Dynamic (CFD) approach from the DCAB031 model located in a closed-loop arrangement. Experimental measurements were taken to determine the pressure rise and flow rate with a flow control valve installed at the outlet of the pump. The flowrate handled was measured by a FLOMEC-OM025 oval gear flowmeter. For each flowrate considered, the pump's rotational speed and power input were controlled using an Invertek Optidrive E3 frequency driver. Once a steady-state operation was attained, pressure rise measurements were taken with a Sper Scientific wide range digital pressure meter. In this study, water and three Newtonian oils of different viscosities were tested at different rotational speeds. The CFD model implementation was developed on Star- CCM+ using an Overset Mesh that includes the relative motion between rotor and stator, which is one of the main contributions of the present work. The simulations are capable of providing detailed information about the pressure and velocity fields inside the device in laminar and unsteady regimens. The simulations have a good agreement with the experimental data due to Mean Squared Error (MSE) in under 21%, and the Grid Convergence Index (GCI) was calculated for the validation of the mesh, obtaining a value of 2.5%. In this case, three different rotational speeds were evaluated (200, 300, 400 rpm), and it is possible to show a directly proportional relationship between the rotational speed of the rotor and the flow rate calculated. The maximum production rates for the different speeds for water were 3.8 GPM, 4.3 GPM, and 6.1 GPM; also, for the oil tested were 1.8 GPM, 2.5 GPM, 3.8 GPM, respectively. Likewise, an inversely proportional relationship between the viscosity of the fluid and pump performance was observed, since the viscous oils showed the lowest pressure increase and the lowest volumetric flow pumped, with a degradation around of 30% of the pressure rise, between performance curves. Finally, the Productivity Index (PI) remained approximately constant for the different speeds evaluated; however, between fluids exist a diminution due to the viscosity.

Keywords : computational fluid dynamic, CFD, Newtonian fluids, overset mesh, PCP pressure rise
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