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Analysis of the Effect of Viscosity in an Electric Submersible Pump (Esp) Through A CFD Approach

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Extended Abstract

Electrical Submersible Pumping (ESP) is one of the main artificial lifting methods used in oil extraction processes. This method consists in the use of a multi-stage centrifugal pump, characterized by its high production flow rates and the flexibility in its installation [1]. However, the performance degradation of an ESP is associated with fluids viscosities. For instance, emulsions of different viscosities appear while operating an ESP in heavy oil fields with high water fractions. Due to system complexity, there is an opportunity to understand its behavior through computational fluid dynamics (CFD) together with knowledge in transport phenomena to identify favorable operating conditions. Therefore, the general objective of the study is to build the head and efficiency curves of an ESP, operating with a range of fluid viscosities through CFD to determine points of better efficiency and maximum head. To accomplish the main objective, the generation of an appropriate computational domain of the pump is imperative, aiming to run the simulations in a stable state using the STAR-CCM+ software. So, an evaluation of the performance degradation can be run by analyzing the effect of viscosity on the head and flow rate. Afterward, the results are compared and validated with experimental data.

Therefore, to meet the objectives, the research scope involves a literature review at the beginning to fully understand the problem and state of the art. After, the formulation of a mathematical model is required to evaluate the principles of conservation of mass and momentum within the control volume. On the other hand, a one-stage configuration is used to reduce problem complexity and simulation times. With the previous definition, it is required to extract the internal volume of the pump using STAR-CCM+, defining relevant regions (input, impeller, diffuser, and boundaries). The input and output are extruded to assure a developed flow. Subsequent, the treatment of the mesh is critical to obtain high-quality cells using different settings through a convergence analysis. Then, for the simulation, the physical models and initial conditions are defined to obtain relevant head and efficiency reports as well as speed and pressure field scenes. This will lead to the construction of head and efficiency curves for fluids with different viscosities to analyze pump performance and conclude about the objectives.

Finally, it is important to mention that the literature review is finished, finding in the research of [1] a guideline. On the other hand, the author of [2] presents the experimental data needed for the validation of the numerical model. Results of this research show a reduction of the pressure head with the changes of viscosities at 3500-rpm rotational speed. The performance of the mixed-flow pump deteriorates continuously with viscosity, which is caused by an increase of the friction losses in the hydraulic channels [1]. In addition, for viscosities of 1 and 50 cP, a saddle point is observed at approximately 0.7 times the desired flow rate. For the 200 cP curve, the same effect is on 0.3 times the desired flow. This phenomenon is related to the separation flow pattern inside the pump channels at part-load operation, especially prominent for diffuser pumps [1].

References

[1] E. M. Ofuchi, H. Stel, T. Sirino, T. Vieira, F. J. Ponce, S. Chiva y R. Morales, "Numerical investigation of the effect of viscosity in a multistage electric submersible pump," *Engineering applications of Computational Fluid Mechanics*, vol. 11, nº 1, pp. 258 - 272, 2017.

[2] G. Amaral, V. Estevam, SPE, Petrobras and F. Franca, "On the Influence of Viscosity on ESP Performance," *SPE Production & Operations*, no. 24, pp. 303-311, 2009.