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PERFORMANCE OF THE WATER/GLYCERINE SEPARATION BY HYDROCYCLONE

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ABSTRACT

The petroleum industry has traditionally relied on conventional gravity based vessels, that bulky, heavy and expensive, to separate multiphase flow. The growth of the offshore oil industry, where platform costs to accommodate these separations facilities are critical, has provided the incentive for the development of compact separation technology. Hydrocyclones have emerged for the development of compact alternative for separate water/oil, for example. A hydrocyclone is a static device that applies centrifugal force to a liquid mixture so as to promote the separation of heavy and light components. Heavy components move outward toward the wall of the cylinder where they agglomerate and spiral down the wall to the outlet at the bottom of the vessel. Light components move toward the axis of the hydrocyclone where they move up toward the outlet at the top of the vessel.

The exact physics necessary to describe the swirling multiphase flow is only partially understood. In recent years, some works [1; 2; 3] about hydrocyclone simulation using the Computational Fluid Dynamics (CFD) has reported this technique is appropriate to understand the fluid flow in a hydrocyclone. The objective this study is to describe the performance of a hydrocyclone to remove dispersed water from a glycerine continuous stream. The governing equations for the velocity, pressure and volume fraction fields in a multiphase flow can be written as in Eqs. (1) and (2). A RNG k-ε turbulent model have been used because is more accurate and reliable to describe the flow than the standard k–ε turbulent model [4]. The numerical solutions to Eqs. (1) and (2) was obtained by software CFX using the following boundary conditions: (a) uniform velocity at the inlet (6 m/s); (b) uniform pressure at the underflow and overflow (101325 Pa); (c) no slip at fluid/solid interface and (d) wall roughness height equal 0.045 mm. The density of the glycerine is 1200 kg/m^3 and the water 998 kg/m^3 at 25ºC. The computational grid used for simulation is presented in Figure 1a.

$$\frac{\delta}{\delta t}\left(r_\alpha \rho_\alpha\right) + \nabla \cdot \left(r_\alpha \rho_\alpha U_\alpha\right) = S_{MS\alpha} + \sum_{\beta=1}^{N_p} \Gamma_{\alpha\beta} \qquad (1)$$

$$\frac{\delta}{\delta t}\left(r_\alpha \rho_\alpha U_\alpha\right)+\nabla\cdot\left(r_\alpha\left(\rho_\alpha U_\alpha \otimes U_\alpha\right)\right) = -r_\alpha \nabla p_\alpha + \nabla\cdot\left(r_\alpha\mu_\alpha\left(\nabla U_\alpha + \left(\nabla U_\alpha\right)^T\right)\right) + \sum_{\beta=1}^{N_p}\left(\Gamma^+_{\alpha\beta}U_\beta - \Gamma^+_{\beta\alpha}U_\alpha\right) + S_{M\alpha} + M_\alpha \qquad (2)$$

Figure 1b shows streamline curvature of the continuous phase (glycerine/streamline red) provides an environment for inertial separation of a dispersed phase (water/streamline blue). The centrifugal forces exerted by vortex carry glycerine to the cyclone wall and water moved to the central axis of the cyclone and carried out by the overflow stream. Fig. 1c gives a velocity vector map of the axial and tangential water velocity field in the yz-plane near the vortex finder (top). The results clearly indicate that the reversal axial flow occurs near the vortex finder and it is characteristic of the operating conditions imposed. The water volume fraction indicates that the water in the glycerine concentration was reduced in the underflow (Fig. 1d in the yz-plane). This indicates that the hydrocyclone operated slightly is efficient to separate the glycerine/water to small flow rates. Similar results were obtained in [2].

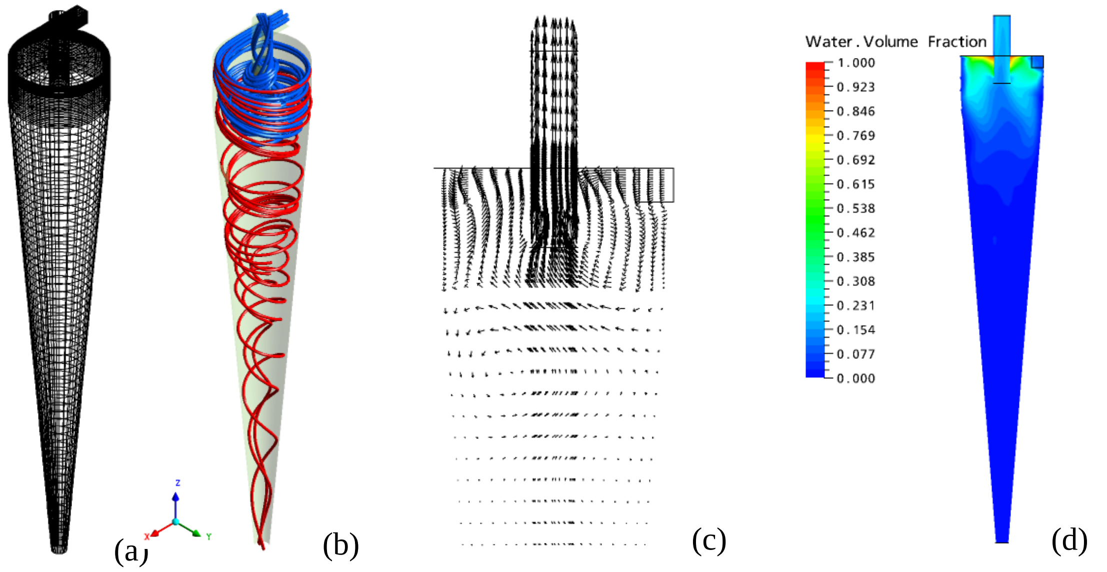

Figure 1 – (a) Computational grid; (b) Streamline of the water (blue) and glycerine (red); (c) Water velocity vector map; (d) Water volume fraction.

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