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Preliminary Study of Water-Oil Separation Process in Three-Phase Separators Using Factorial Experimental Designs and Simulation

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Abstract : Oil production is often followed by the joint production of water and gas. During the journey up to the surface, due to severe conditions of temperature and pressure, the mixing between these three components normally occurs. Thus, the three phases separation process must be one of the first steps to be performed after crude oil extraction, where the water-oil separation is the most complex and important step, since the presence of water into the process line can increase corrosion and hydrates formation. A wide range of methods can be applied in order to proceed with oil-water separation, being more commonly used: flotation, hydrocyclones, as well as the three phase separator vessels. Facing what has been presented so far, it is the aim of this paper to study a system consisting of a three-phase separator, evaluating the influence of three variables: temperature, working pressure and separator type, for two types of oil (light and heavy), by performing two factorial design plans 23, in order to find the best operating condition. In this case, the purpose is to obtain the greatest oil flow rate in the product stream (m3/h) as well as the lowest percentage of water in the oil stream. The simulation of the three-phase separator was performed using Aspen Hysys®2006 simulation software in stationary mode, and the evaluation of the factorial experimental designs was performed using the software Statistica®. From the general analysis of the four normal probability plots of effects obtained, it was observed that interaction effects of two and three factors did not show statistical significance at 95% confidence, since all the values were very close to zero. Similarly, the main effect "separator type" did not show significant statistical influence in any situation. As in this case, it has been assumed that the volumetric flow of water, oil and gas were equal in the inlet stream, the effect separator type, in fact, may not be significant for the proposed system. Nevertheless, the main effect “temperature” was significant for both responses (oil flow rate and mass fraction of water in the oil stream), considering both light and heavy oil, so that the best operation condition occurs with the temperature at its lowest level (30oC), since the higher the temperature, the liquid oil components pass into the vapor phase, going to the gas stream. Furthermore, the higher the temperature, the higher the formation water vapor, so that ends up going into the lighter stream (oil stream), making the separation process more difficult. Regarding the “working pressure”, this effect showed to be significant only for the oil flow rate, so that the best operation condition occurs with the pressure at its highest level (9bar), since a higher operating pressure, in this case, indicated a lower pressure drop inside the vessel, generating lower level of turbulence inside the separator. In conclusion, the best-operating condition obtained for the proposed system, at the studied range, occurs for temperature is at its lowest level and the working pressure is at its highest level.

Keywords : factorial experimental design, oil production, simulation, three-phase separator
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