Self-lubricated flow of heavy oils

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The oil industry is currently phasing increasing challenges derived from the need of transporting heavier oils. In particular, the reserves of oil producing countries, such as Mexico, are increasingly composed of heavier oils that need to be efficiently transported. Heavy oils have high viscosities and are definitely non-Newtonian fluids. In the Mexican case, these fluids (with API as low as 13 or even lower) will have to be transported at starting temperatures of around 330 K but which can drop as low as 310 K or lower.

In this work, Mexican heavy oils ranging from 13 to 21 °API have been modelled with the non-Newtonian version of the Friction Theory [1]. Figure 1 show the rheological behaviour of a 13 °API Mexican oil.

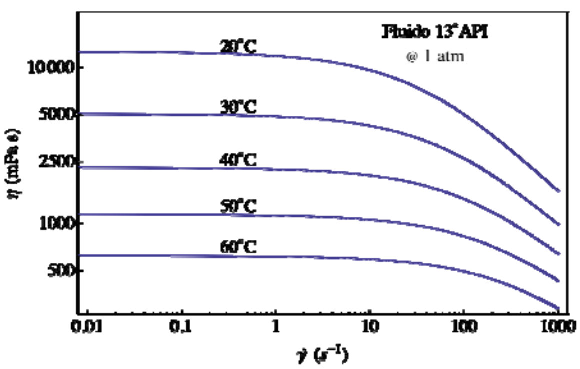

Fig. 1. Rheological behaviour of an extra-heavy oil.

In order to facilitate the transport of heavy oils the viscosity can be efficiently reduced by two procedures 1) dilution with lighter fluids, such as light gases, and 2) mechanically – naturally, the combination of both would be optimal. There are, of course, other procedures but we believe are not as efficient and sound as those discussed in this work.

In order to demonstrate the efficiency of the technological alternative presented in this work, we have simulated the flow conditions necessary for the transport of such heavy fluids using the Ansys Computational Fluid Dynamics (CFD) package. As theoretical expected, the shear rate is highest at the pipe´s wall. If the fluid is transported at high shear conditions, the non-Newtonian viscosity behaviour will effectively develop self-lubricated annular flow. Figures 2 and 3 show, respectively, shear rate and dynamic viscosity contours showing the development of self-lubricated annular flow.

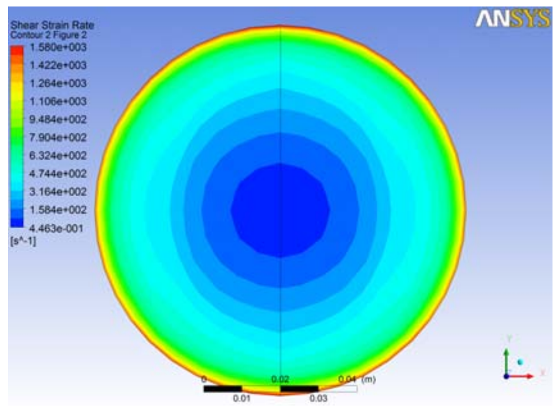

Fig. 2. Shear rate contour of a self-lubricated heavy oil.

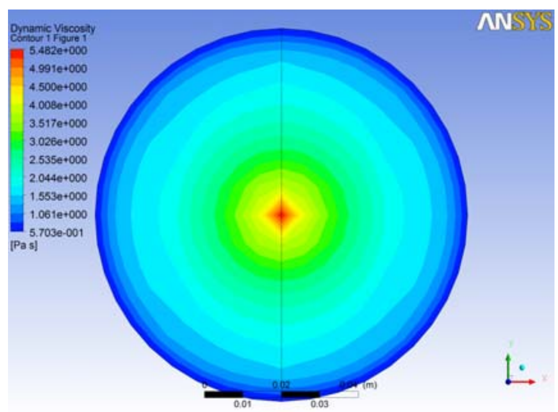

Fig. 2. Dynamic viscosity contour of a self-lubricated heavy oil.

In summary, this work explores the combination of dilution and mechanical as viscosity thinning techniques in order to determine the operational conditions for the flow assurance of heavy oils. The study will be presented for one as well as two-phase (oil and water) conditions.

References

[1] Ramírez-González, P. V.; Aguayo, J. P.; Quiñones-Cisneros, S. E.; Deiters, U. K. International Journal of Thermophysics 2009, 30, 1089.