Viscous Pumping in Focus

The performance of a pump is influenced when it handles viscous fluids such as crude oil. For the configuration and design of pumps, this is key.

In the industry, pump performance curves are developed by testing with water at temperatures around 25 °C and corrected to a specific gravity of one. Engineers use this standard so that they have comparable measurement values around the world. The performance of a pump is impacted, when it handles viscous liquids, such as oil. This starts to be significant when industrial installations are pumping liquids with viscosities above 40 centistokes (cSt). It can be substantial when the viscosity reaches 300 cSt or above. For a midsize pump transporting 1000 m³/h of oil with a viscosity of 200 cSt, the efficiency will drop to three-quarters of the efficiency achieved when pumping water. At the same time, the dynamic head will decrease by a little more than 6% at its best efficiency flow rate in water (Fig. 1, H_w and H_v). Consequently, its corresponding flow at the best efficiency with viscous fluid is also reduced by an equivalent amount. This drop in performance is caused mainly by the higher friction of the viscous fluid within the hydraulic waterways of the pump. If the flow rate and viscosity increase, the performance impairment of the pump performance rises as well.

Test bed in Winterthur, Switzerland

Antonio Morisco, Head of the development test bed team in Winterthur speaks about the many different testing loops available in the 1500-square-meter facility located in Switzerland. “Our impressive test bed inspires the dreams of many of our visitors. However, you can be sure that we are not giving our test team or equipment any time to sleep.” He points to the five-meter-high installation full of pipes, cables, and various measuring instruments. “We perform tests under different conditions to gather technical values related to viscous flow behavior in the pumps. With our viscous test loops, we evaluate pump efficiency in relation to the viscosity of the pumped fluid. First, the values of our test bed are used to realistically confirm pump capacity for our customer projects. Second, our R&D department uses the test bed to evaluate and improve the pump performance and energy efficiency. This test bed has already seen pumps with different coatings, bearings, and hydraulic shapes in all sizes. Our tests also show whether our development leads to the expected energy savings.”

Antonio Morisco in front of the test bed installation for viscous pumping.
Having an accurate prediction of the pump efficiency curve is essential if one wants to make the best selection of the pumps and their drives for viscous pumping applications. Several years ago, the Hydraulic Institute (HI) developed correction factors for viscous liquids. These correction factors enable engineers to predict the performance impairment with viscous applications relative to the water performance curves that are usually published by the pump manufacturers. The current HI standard is ANSI/HI 9.6.7-2010 “Effects of Liquid Viscosity on Rotodynamic Pump Performance” and is widely accepted. Lately, however, an increasing number of publications have been reporting discrepancies between the performance rates predicted according to the ANSI/HI 9.6.7 standard and those that are measured with viscous fluids.

The correction factors developed by the Hydraulic Institute are based on tests with pumps of small power levels. Furthermore, they are generated with pumps mainly of the single-stage overhung type rather than with the pumps of the large power double-suction single-stage or multistage between bearing type usually used in viscous applications. These differences are likely responsible for the discrepancies.

Deepened know-how in viscous pumping
Sulzer has upgraded two loops of its development test bed in Winterthur so that it can examine pumps with single or multiphase viscous fluids up to 2000 cSt. Sulzer runs intensive test campaigns with single-stage, double-flow pumps, typically used in pipelines, or multiphase helico-axial pumps, typically used to boost oil production. Sulzer R&D department collects essential know-how with these tests regarding the causes of performance impairment with medium- and high-viscosity fluids as well as the impact of specific pump design features. The results of these in-house tests highlight the need to refine Hydraulic Institute’s viscous correction factors in the future. They must better account for the pump types used in the petroleum industry today.

Identifying the influencing factors of the future
The pump performance rates measured for a single-stage, double-flow pump with a fluid viscosity of 330 cSt (Fig. 2) indicate the following: the measured performance impairment due to the viscosity of the fluid is higher than the one calculated using the HI correction method. Sulzer tests different design parameters for pumps that transport viscous materials. Thereby, Sulzer always keeps the pump efficiency and, thus, the energy consumption of the pumps in mind. Sulzer’s systematic trials at the test bed, combined with field tests at customers’ sites, will pave the way to innovative solutions for pumping viscous fluids.

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