Development of a High Pressure and High Shear Rate Capillary Rheometer for the Characterization of Extra-Heavy Oils

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At present oil still covers about 30 % of global energy needs. Extra heavy oils represent almost 7 % of this supply. Also in future, heavy crude oils will contribute as a relevant hydrocarbon source. Due to the declining oil reserves, an effective recovery of the available resources is becoming more important. Viscosity and flow behavior of heavy crude oils are key properties for the characterization, management and development of petroleum reservoirs. Under typical conditions, light petroleum fluids behave Newtonian while extra heavy oils tend to behave non-Newtonian. To measure the rheological properties of heavy crude oils with a high accuracy, a high pressure capillary rheometer has been designed and built. The experimental arrangement consists of two high-pressure vessels connected by a tube system and a calibrated capillary. Both vessels are equipped with a hydraulically operated metal bellow that can be varied in size by electrically driven spindle presses. By inflating one bellow and simultaneously shrinking the other one, the fluid is pressed through a capillary at a constant flow rate. The viscosity of the fluid is calculated from the volumetric rate of flow and the pressure drop with Hagen-Poiseuilles law solved for the viscosity. With the capillary rheometer, conditions up to 1000 bar and 200 °C can be generated. Viscosities between 0.5 and 80000 mPas can be measured under different shear rates. The capillary rheometer was calibrated with three Newtonian reference blends. For these standards the viscosity tables have been extended up to 1000 bar in the temperature range from 20 to 120 °C with a falling body viscometer. The capillary rheometer is then calibrated with the same reference fluids at the same conditions. Viscosity and flow behavior of different heavy crude oil samples are determined at reservoir conditions.