Bitumen Rheological Properties - Reconciliation with Viscosity Measurement

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Accurate thermochemical and transport property data for heavy oils and bitumen are in great demand in the oil industry. These materials are multi-component fluids and multiphase at operating temperatures [1], so their viscosities can be influenced by many internal and external factors. For example, the large deviation in reported viscosity values for Athabasca bitumen in the literature is well known. Location, depth of formation, extraction, and post-extraction processing can affect the measured "viscosity" of bitumen by three orders of magnitude even if the measurement method and temperature are fixed. The impact of measurement method and measurement method details, and thermal history on reported viscosity values has not been discussed. In order to recognize additional factors affecting reported viscosity values, we have studied the complex viscosity and phase angle for Athabasca bitumen and Maya crude oil in the (200 to 330) K temperature range applying different shear rates and shear stresses using a dynamic shear Bohlin Gemini 200 HR nano rheometer (oscillatory mode). Athabasca bitumen and Maya crude were both found to be solid-like materials up to (260 – 270) K and (220 – 230) K, respectively. Athabasca bitumen is a non-Newtonian shear-thinning fluid over the balance of the temperature interval studied, whereas Maya crude behaves as a shear-thinning fluid up to ambient temperature, and a Newtonian fluid at higher temperatures. The large range of shear rates and stresses applied led to three orders of magnitude variation in measured viscosity values for individual samples at fixed temperature. The thermal history of a sample was also found to influence viscosity values obtained. These behaviors are attributed to the phase behavior of the asphaltene and maltene fractions over the temperature range of interest.

[1] M. Fulem, M. Becerra, M.D.A. Hasan, B. Zhao, J.M. Shaw. Fluid Phase Equilibria, 2008, 272, 32-41.