Thesis Title:

REMOVAL OF COLLOIDAL ASPHALTENE FROM SURFACES AND EFFECT OF AEROSOLS ON SOLAR POWER

Student Name:

SYED HAIDER ABBAS RIZVI

ENTRY NUMBER:

2015CHZ8431

Abstract

The study deals with problems in the energy sector resulting from sub-micron-sized particles suspended in fluid and their deposition on surfaces. In its first part, the study investigates the deposition and removal of colloidal asphaltene particles on contact surfaces in the crude oil industry. The second part of the study targets the solar energy sector, where aerosols in the atmosphere and particulate matter deposition on solar panels cause a reduction in light intensity.

With an increased demand for oil on a global scale, heavy oil (low API) that contains a considerable amount of asphaltene has captured the interest of oil producers. Asphaltene deposition on the surfaces in contact is a severe problem for the crude oil industry. The prospect of the first half of the study is to remove asphaltene by shear forces with pH-controlled conditions and ionic surfactants in aqueous media. The deposition occurs on glass surfaces from an asphaltene dispersion in heptane, mimicking the possible reservoir conditions. The removal is carried out in a parallel plate channel where controlling the shear rates tune the hydrodynamic forces on the surface. The flow inside the apparatus is of the order of Reynolds number from 10^3 to 10^4. The study hypothesizes that detachment will occur when the hydrodynamic forces overcome the adhesion forces binding the asphaltene with asphaltene or asphaltene with the glass surface. The electrostatic double-layer charges in the medium affect the removal efficiency. The study correlates the zeta potentials for asphaltene under pH-conditioned aqueous media with the removal efficiency. Atomic force microscopy characterizes the extent of deposition and asphaltene removal in terms of surface roughness and fractional volume on the surface.

The results show that the aqueous media pH significantly affects asphaltene's roughness and fractional volume. At extreme pH values (2-3 or 8-10), the hydrophilicity of asphaltene increases due to the ionization of functional groups, causing more significant swelling of the asphaltene aggregates. The removal efficiency increases proportionally with the hydrodynamic forces and the pH. The anionic surfactants adsorb on asphaltene surfaces with hydrophobic interactions that stabilize surface asphaltene, resulting in inefficient removal. The cationic surfactants adsorb on negatively charged asphaltene surfaces through acid-base or electrostatic

interactions, significantly increasing removal efficiency. The study provides strategies to remove surface deposited asphaltene based on their effective zeta potential with asphaltenes in crude oil.

The work's second part studied the solar beam's attenuation due to particulate matter suspended in the atmosphere and deposited on the PV modules. The radiative transfer model, *Py6S* approximates the total irradiance reaching the earth's surface, assuming absorption by gases and extinction due to aerosols. The model's accuracy is compared with ground measurements by pyranometers considering no or partial cloud cover. The deviations are more prominent during the monsoon and post-monsoon periods than pre-monsoon. The study also compares the losses due to soiling between two pyranometers, of which one is regularly cleaned. The study constitutes eight cycles of 21 days each, constituting months from March to November, and estimates soiling losses as a function of particulate matter deposition per unit area. The findings report that soiling losses vary across months, where meteorological parameters such as rainfall and relative humidity play a key role.

Moreover, soiling loss strongly correlates to the regional ambient particulate matter concentrations, size distribution, and chemical composition. Estimating irradiance as a function of air quality is required to estimate power production by a solar plant. Soiling loss estimations are necessary to plan for the cleaning cycles of a plant and accurate predictions of solar power generation.