Effective Solvent Extraction Incorporating Electromagnetic Heating is a relatively new concept that relies on Radio Frequency heating and solvents to replace steam in current thermal processes for the purpose of extracting bitumen from oil rich sands. The work presented here will further the understanding of the near wellbore flow of this two phase system in order to better predict solvent vaporization dynamics and heat rates delivered to the pay zone. This numerical study details the aspects of phase change of immiscible liquid/vapor systems confined in porous media heated by electromagnetic radiation, approximated by a spatially dependent volumetric heat source term in the energy equation.

The objective of this work is to utilize the numerical methodology presented herein to predict maximum solvent delivery rates to a heated isotropic porous matrix to avoid the over-saturation of the heated pay zone. For the mass content in the domain, a smooth decline, resulting from the increasing mean temperature, indicates solvent vaporization as the mass exiting the domain is entirely vapor. Abrupt change in the total liquid mass would indicate partial/incomplete vaporization. The distribution of the heat rate in the domain also decays away from the well bore where some of the heat is inefficiently used to superheat the already vaporized solvent away from the interface, requiring heat delivery rates that are many times greater than the energy required to turn the liquid solvent to vapor determined by an energy balance. Results of the parametric study from the pay zone simulations demonstrate the importance of the resistance forces added by the porous media to stabilize the flow being pulled away from the wellbore in the presence of gravity.

For all cases involving an increase in solvent delivery rate with a constant heat rate, the permeability range required for full vaporization must decrease in order to balance the gravitational forces pulling the solvent from the heated region. For all conditions of permeability and solvent delivery rates, sufficiently increasing the heat rate results in complete vaporization of the liquid solvent. For the case of decreasing solvent delivery rate, a wider range of higher permeabilities for a given heat rate can be utilized while achieving full vaporization. A three dimensional surface outlining the transition from partially vaporized to fully vaporized regimes is constructed relating the solvent delivery rate, the permeability of the porous near wellbore zone and the heat rate supplied to the domain. For the range of permeabilities (~3000mD) observed in these types of well bores, low solvent delivery rates and high heat rates must be utilized in order to achieve full vaporization.

Major: Mechanical Engineering

Educational Career:
Bachelor's of Mechanical Engineering, BS, 2013, University of Central Florida

Committee in Charge:
Ranganathan Kumar, Chair, MAE
Aravinda Kar, Professor of Optics & Photonics, MAE, MSE and ECE
Louis Chow, University Chair, Professor

Approved for distribution by Ranganathan Kumar, Committee Chair, on October 16, 2015.

The public is welcome to attend.