MODELING OF ASPHALTENES AND OIL SHALE PYROLYSIS

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Introduction

The world mainly focusses on the fossil fuels for energy and transportation needs with oil being the main source along with coal. With high demand and high prices of conventional oil the present research has been focused on energy generation from oil shale and asphaltenes.

Pyrolysis is the primary step in gasification process which involves formation of syngas that is valuable in energy production as well as synthesis of fuel and chemical.

Effect of parameters like size, organic content, porosity play an important role during pyrolysis condition.

Objective

- Integrate Grain model along with **COMSOL Multiphysics** to study the effect of processes occurring in pyrolysis.
- To study the effect of particle size and process temperature.
- To study the effect of organic matter content in oil shale.
- Explore limitations of diffusion and convection in pyrolysis process.

Modeling Framework

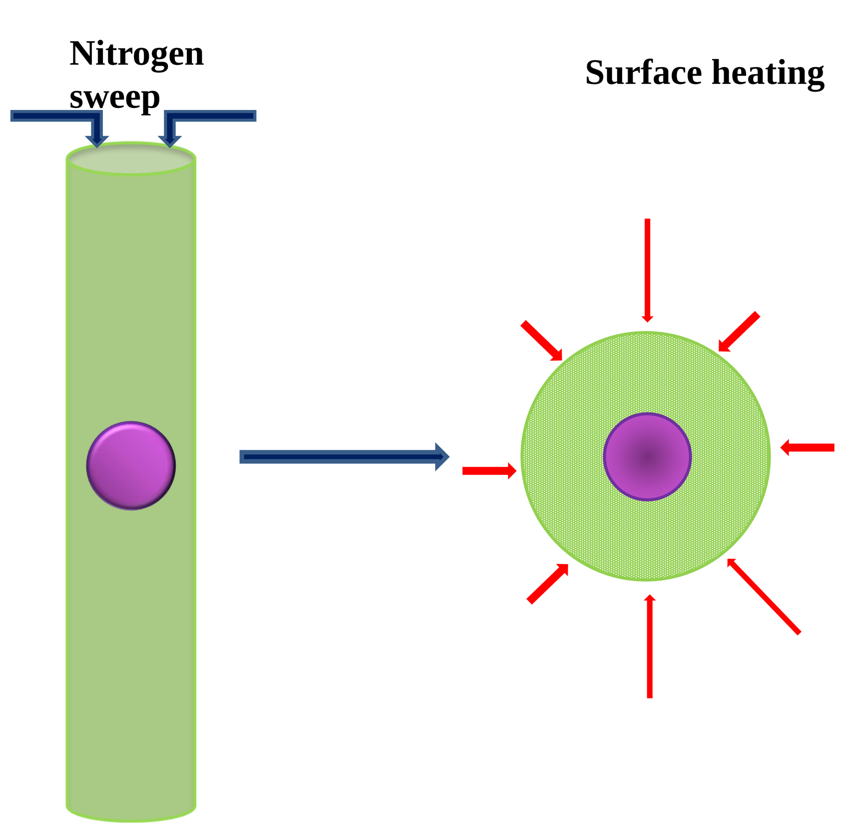

Fig 1: Simplified modeling approach

Assumptions:

- The heavy oil drop is considered static inside of the cylindrical furnace.
- The heavy oil drop is considered as a porous media with a constant size and porosity variation, following a grain model.
- An initial temperature of 300K is considered for heavy oil drop.
- The initial temperature inside the cylindrical drop tube furnace proposed will be same as that of the boundary condition (wall temperature).
- Nitrogen is used as a sweeping gas through the furnace.

Governing Equations

- Momentum transfer equation in gas

$$\rho\frac{\partial u}{\partial t} + \rho(u\cdot\nabla)u = \nabla\cdot\left[-pI + \mu\left(\nabla u + (\nabla u)^T\right) - \frac{2}{3}\mu(\nabla\cdot u)I\right] + F$$

- Equation of continuity

$$\frac{\partial\rho}{\partial t} + \nabla\cdot(\rho u) = 0$$

- Heat transfer in gas

$$\rho c_p\frac{\partial T}{\partial t} + \rho c_p u\cdot\nabla T = \nabla\cdot(k\nabla T) + Q + Q_{vh}$$

- Darcy's law

$$u = \frac{K_p}{\mu}\nabla P$$

- Permeability of asphaltenes

$$K_p = D_p^2 * \frac{\epsilon^3}{150 * (1-\epsilon)^2}$$

- Reaction

$$r_i = kc_i$$

Discussion

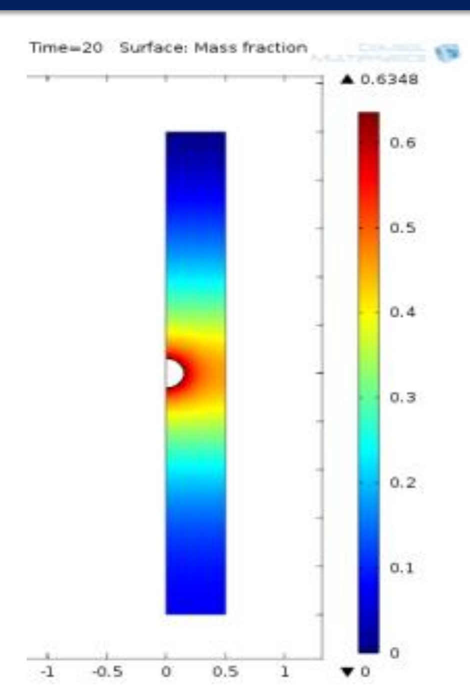

Fig 2: Mass fraction of volatile at 20 s

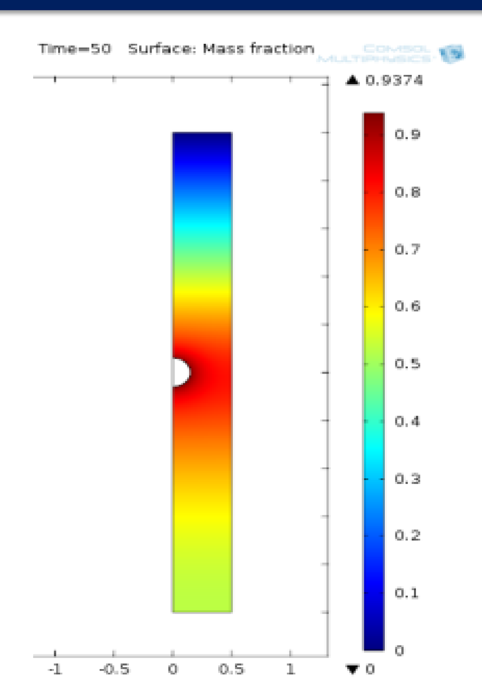

Fig 3: Mass fraction of volatile at 50 s

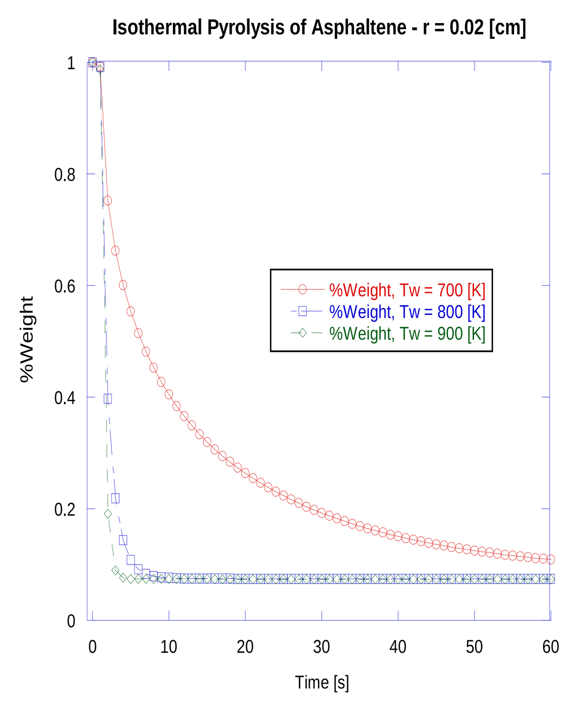

Fig 4: Decomposition of Asphaltenes at various wall temperatures

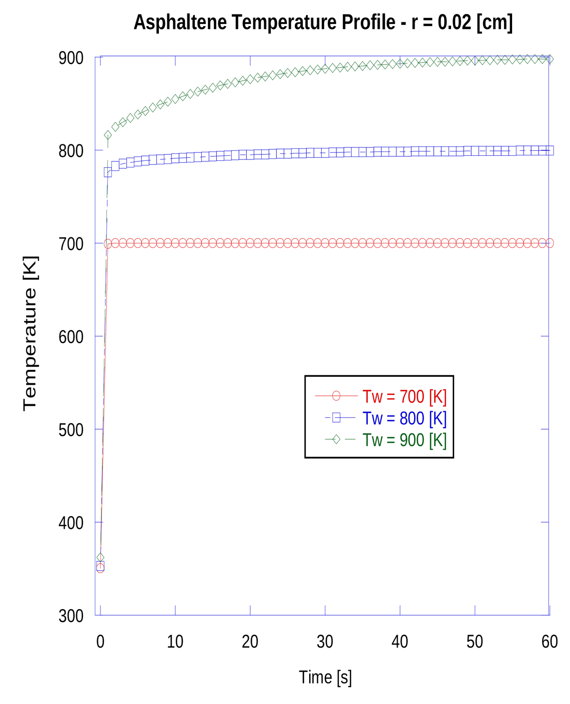

Fig 5: Asphaltenes temperature at various wall temperatures

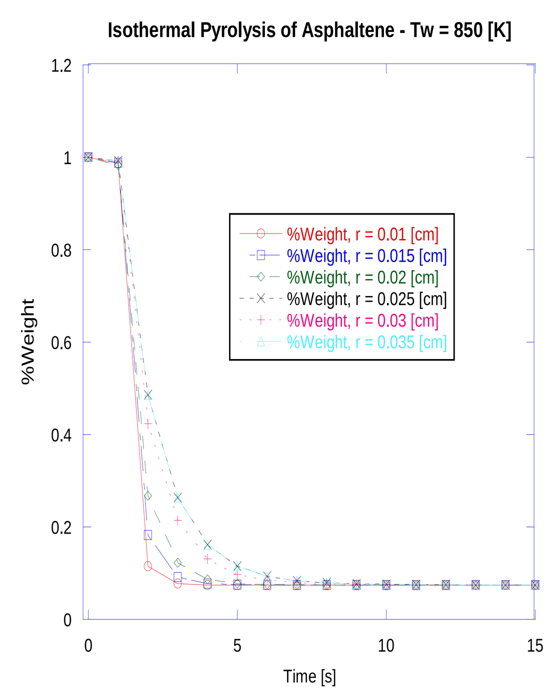

Fig 6: Decomposition of Asphaltenes at various sizes

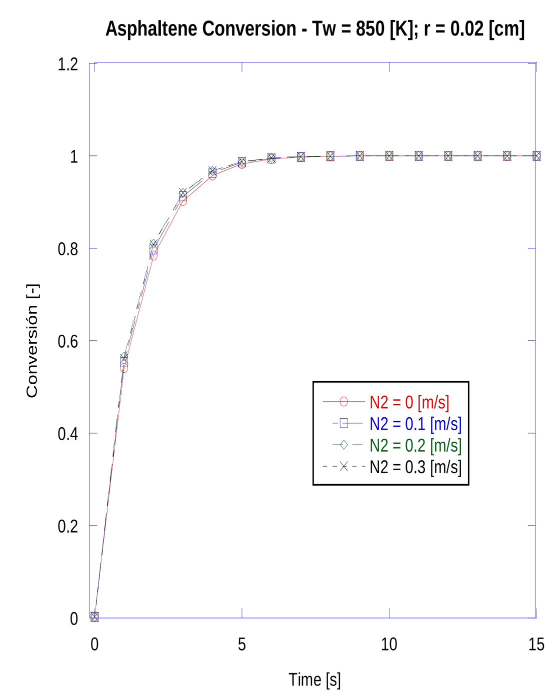

Fig 7: Asphaltenes conversion at various flow rate

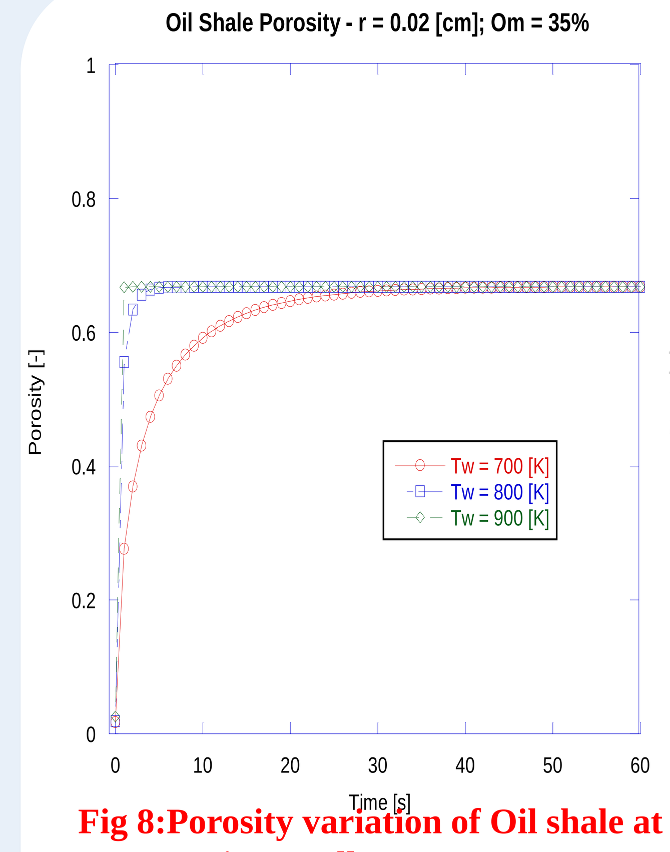

Fig 8: Porosity variation of Oil shale at various wall temperatures

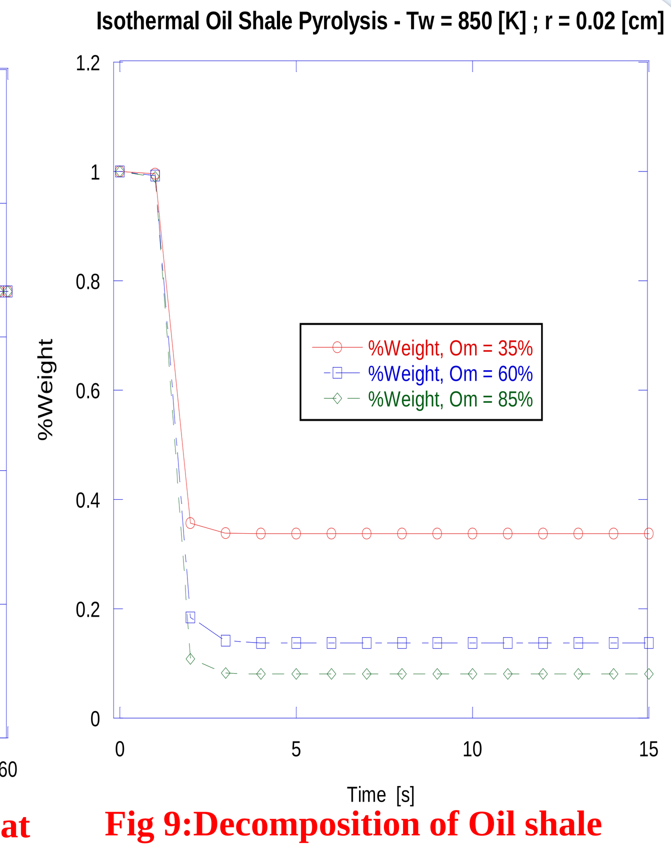

Fig 9: Decomposition of Oil shale

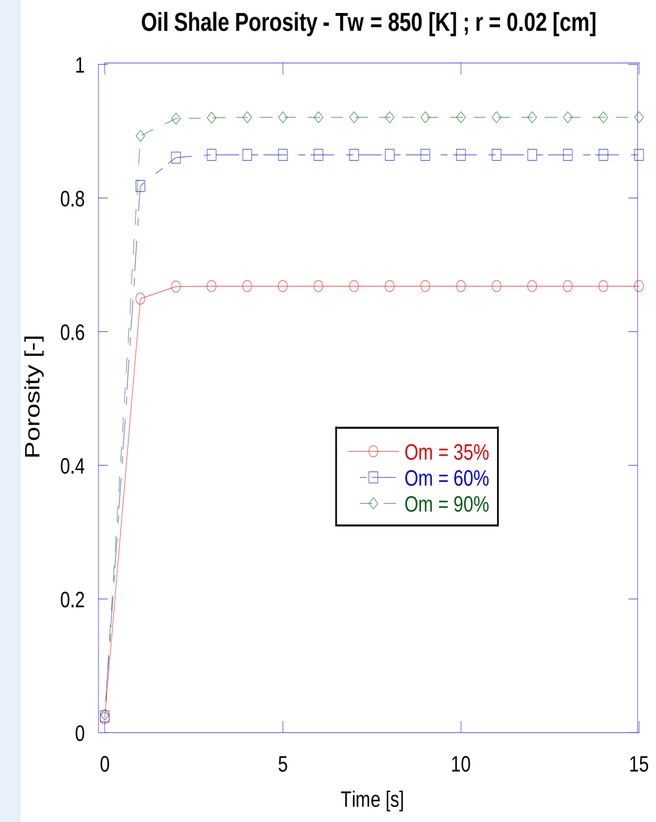

Fig 10: Porosity variation at various organic content

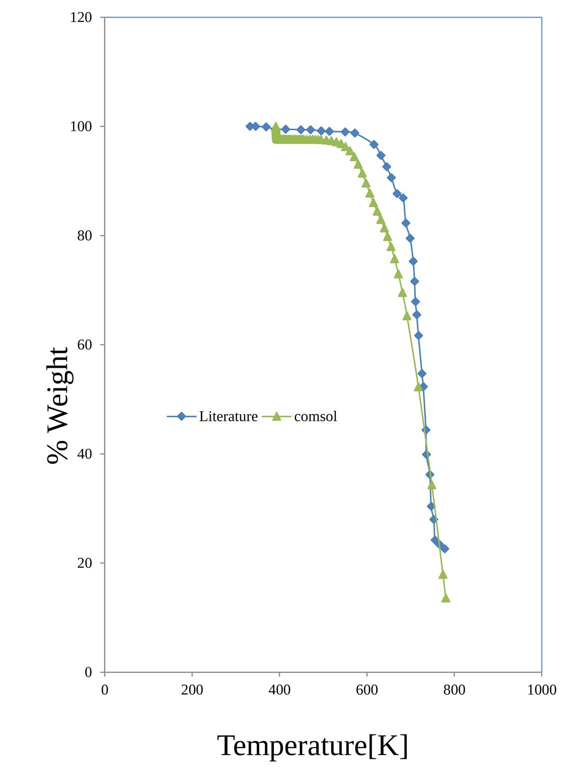

Fig 11: Validation of TGA profile

Conclusion

- For both asphaltenes and oil shale a higher conversion rate is achieved with increase in temperature and decrease in particle size.
- Asphaltenes decomposition is less compared to oil shale with temperature increase.
- With increase in organic content the decomposition time for oil shale increases.
- High porosity is achieved with increase in organic content thus getting less char at the end of pyrolysis.
- Different flow rates of nitrogen doesn't cause significant variation in conversion, it only affects the residence time.
- Weight percent profile for isothermal condition can be validated with the literature.

References

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