10.1 Mathematical Model For Pyrolysis and Combustion Reactions in an Oil Shale Particle

Karim Ghesmat[1], Sanjiv Save[1], Wei Sun[1], Lowy Gunnewiek[2]

[1]Hatch Associates Ltd., Calgary, Alberta, Canada, [2]Hatch Associates Ltd., Mississauga, Ontario, Canada

Oil shale extraction refers to the process in which kerogen, a mixture of organic chemical compounds found in oil shale, is converted into synthetic crude oil through the chemical process of pyrolysis. In this process, oil shale is heated in the absence of oxygen to a temperature at which oil shale is decomposed and kerogen is pyrolysed into shale oil. Combustion also occurs in the retort reactor to provide the heat for the pyrolysis reaction. This work aims at developing a fundamental mathematical model of oil shale pyrolysis and understanding effects of various operating parameters.

In order to investigate a reactive oil shale particle, a mathematical model was developed and mass conservation equations for each component analytically solved. A rectangular geometry was assumed for the oil shale particle. The pyrolysis reaction was considered to be a chain reaction in which the kerogen was converted to bitumen and bitumen in turn produced light hydrocarbons, fuel gas and water. In order to estimate the amount of carbon dioxide generation during pyrolysis process, calcium carbonate decomposition was also considered as a part of reactions.

A set of partial differential equations was obtained for each component in the particle. The equations were solved analytically using different techniques like separating variables and integral method. The results indicated the variation of each component concentration such as bitumen, kerogen, and carbon dioxide during time and inside the particle.

In this work, the development of the reaction inside an oil shale particle, concentration profile, carbon dioxide generation and calcium carbonate decomposition during pyrolysis and combustion reactions will be presented. The effects of the particle size, diffusion coefficient inside the particle, and reaction constants are also explained and the results will be discussed.