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Title:

A NOVEL COAL FEEDER FOR PRODUCTION OF LOW SULFUR FUEL

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SUMMARY

The project started after the initial paper work between the University of Cincinnati and the Department of Energy. A graduate assistant, Mr. Linong Lin, was recruited and assigned to this project during the month of October, 1989. About a half of the first quarter was used for the administrative side work of the project.

The first task of the project is to evaluate and model the pyrolysis section of the proposed coal feeder. Literature reviews on coal pyrolysis have been conducted and a mathematical/computer modeling of this work has begun. Both isothermal and non-isothermal conditions are considered for this model. A pseudo-component approach was adopted for coal pyrolysis kinetics. Initially, the literature values of pyrolysis kinetics are planned to be utilized. Later, actual kinetics will be measured from a feeder-pyrolyzer. A separate feeder-pyrolyzer is under construction for this purpose.

TECHNICAL DESCRIPTION

The key element of pyrolysis studies is the decomposition kinetics which provide a vital information for equipment design. The difficulty in obtaining the details of the reaction is due partly to the complex organic structures in coal and partly to the physical diffusional process through the solid matrix. The difficulty of maintaining an isothermal condition during heat up period inherently prevents an isothermal experimental condition. In order to avoid this difficulty, a series of first-order, independent decomposition kinetics of coal have been postulated and successfully adapted for the decomposition reaction. [Anthony and Howard, 1976; Suuberg et al., 1978; Vargas and Perlmutter, 1986]

Let us consider the coal of interest to consist of i pseudocomponent fractions, each with different activation energy E_i . Each pseudocomponent is decomposing according to a first-order kinetics:

$$dW'_i/dt = k_i(W_{\infty,i} - W'_i) \quad (1)$$

where W'_i is the weight loss from an initial amount $W_{\infty,i}$ and k_i is the first-order rate constant following the Arrhenius law,

$$k_i = k_{i0} \exp(-E_i / RT). \quad (2)$$

E_i is an activation energy associated with the i th component decomposition.

Equation (1) can be further simplified by replacing the term $(W_{\infty,i} - W'_i)$ with the present weight of component i , W_i in each coal particle, thus Equation 1 becomes

$$-dW_i/dt = k_i W_i. \quad (3)$$

Let us consider the following schematics of the feeder-pyrolyzer.

Figure 1. Pyrolysis section simulation

Let us take a steady-state material balance in the control volume with respect to component i in coal:

$$\text{Rate of input: } \dot{n} W_i \Big|_x$$

$$\text{Rate of output: } \dot{n} W_i \Big|_{x+\Delta x}$$

$$\text{Rate of disappearance: } k_i W_i \alpha \pi D^2 / 4 \Delta x$$

where $\dot{n}$ and α are the number of coal particles being transported per second by screw feeder (coal flow rate in the units of particle numbers per second), and the number of coal particles per volume (particle density in the feeder). The feeder internal diameter is denoted by D , and the length of feeder by x . The above material balance produces the following differential equation:

$$dW_i/dx = -(\alpha/\dot{n})(\pi D^2/4) k_i W_i \quad (4)$$

By adding all components, the total material balance becomes

$$dW/dx = -(\alpha/\dot{n})(\pi D^2/4) \sum k_i W_i \quad (5)$$

The total volumetric gas flow rate from the pyrolysis section can be shown as follows:

$$v = RT(\alpha/\dot{n})(\pi D^2/4) \int \sum (k_i W_i / M_{wi}) dx \quad (6)$$

where M_{wi} is the average molecular weight of pseudo-component i . Equation (6) can be used to predict the amount of gas production by pyrolysis.

FUTURE PLAN

During the second quarter of the project, an energy balance equation will be derived and the desulfurizer modeling will begin. Actual coal pyrolysis work will be performed using an existing coal screw feeder. More realistic kinetic data will be measured and compared with the literature values.

References

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- Vargas, J. M.; Perlmutter, D. D. "Interpretation of Coal Pyrolysis Kinetics", *Ind. Eng. Chem. Process Des. Dev.* 25, 1986, 49-54

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