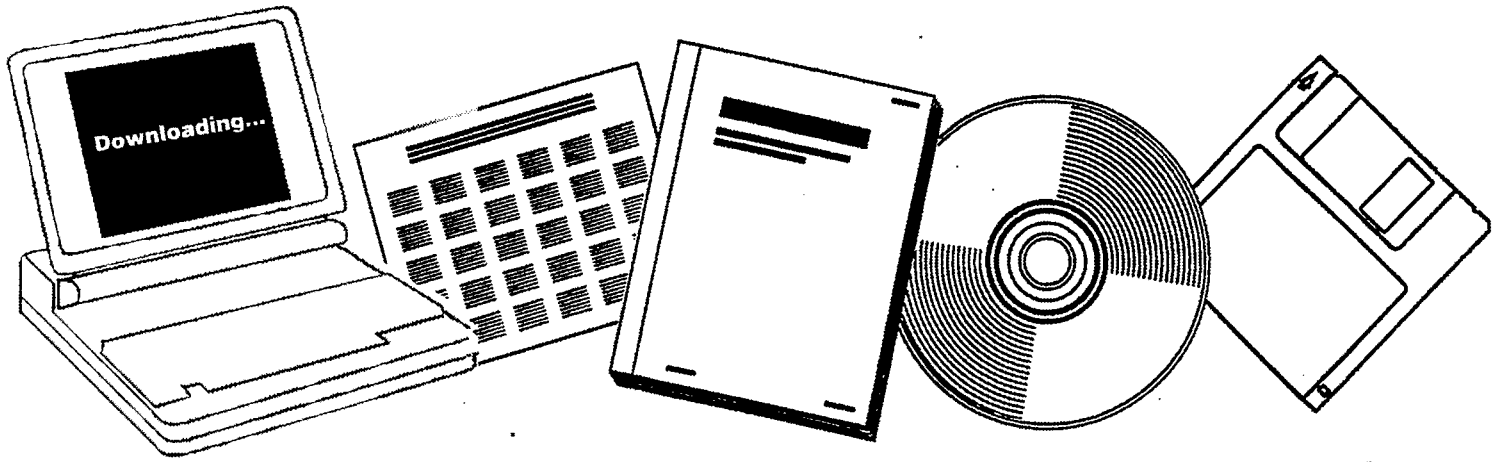
NOVEL EXPERIMENTAL STUDIES FOR COAL LIQUEFACTION. QUARTERLY PROGRESS REPORT, OCTOBER 1, 1984-DECEMBER 31, 1984

PITTSBURGH UNIV., PA

1984



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Quarterly Progress Report

Novel Experimental Studies for Coal Liquefaction

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October 1, 1984 to December 31, 1984

DISCLAIMER

Objective: Research is being carried out in two areas which are of interest to ongoing investigations at the Pittsburgh Energy Technology Center. They are:

a. Thermal behavior of slurry reactors used for indirect coal liquefaction.

b. Supercritical extraction and conversion of coal and oil shale using supercritical water.

The project was initiated October 1, 1984, and this report covers the period from October 1, 1984 to December 31, 1984. Progress in each of the two areas is summarized below:

Task 1: Thermal Behavior of Slurry Reactors Used for Indirect Coal Liquefaction

Removal of heat is often a primary limitation for the performance of reactors used for indirect coal liquefaction. The use of a slurry reactor with good mixing in the liquid phase is a promising alternative to the gas-solid reactors commonly used. In this work, the thermal behavior of a three phase slurry reactor is being investigated. A one-liter high pressure autoclave is being used in a semi-continuous mode--continuous feed of synthesis gas and continuous removal of gaseous products but without flow of catalyst or liquid. A major difficulty in using the reactor has been the measurement and control of the amount of liquid in the reactor. Extensive modifications to the reactor were made during the first quarter to remedy this and to improve the reactor performance. A high pressure sight glass was installed outside the reactor and used as an external liquid reservoir by providing a connection to the bottom of the reactor. This permitted determination of liquid level and addition of makeup liquid if needed. In

addition, the reactor container and mounting stand were modified so that the bottom port of the reactor are accessible. This opening is used for the external liquid supply and can also be used for discharging reactor contents and for removing or adding slurry when continuous circulation of slurry phase is studied. The electrical connections and instrumentation of the reactor were also simplified and improved. The computer being used to control the process was moved to an adjacent room for more convenient operation.

Work during the second quarter will consist of testing the reactor using a mixture of carbon monoxide and hydrogen and a copper oxide catalyst.

Task 2: Coal Liquefaction under Supercritical Conditions

Supercritical fluid extraction is an attractive process primarily because the density and solvent power of a fluid changes dramatically with pressure at near critical conditions and during the extraction of coal, the density of a supercritical fluid should also change the extractability of the coal. During the first quarter a non-reacting supercritical fluid, toluene, was studied to determine the effect of density on the coal extraction/reaction process. Extractions were carried out for 2 to 60 minutes at reduced densities between 0.5 and 2.0 and at temperatures between 647 and 698 K. The data obtained can be explained by the hypothesis that coal dissolution is required preceding liquefaction reactions and that the degree of dissolution depends upon solvent density and temperature. A kinetic model shows that higher solvent densities result in faster conversion rates and in higher total conversions. Figure 1 shows how the model fits the experimental data.

A second factor that makes supercritical extraction attractive is high mass transfer rates. At high pressures, mass transfer rates in a supercritical fluid are much higher than in a liquid, despite the fact that the supercritical fluid has liquid-like solvent powers. In the next quarter

we plan to measure mass transfer rates for naphthalene extraction by carbon dioxide. We are interested in determining how mass transfer coefficients vary with pressure since these parameters will influence the design of extraction or reaction processes which utilize supercritical fluids.

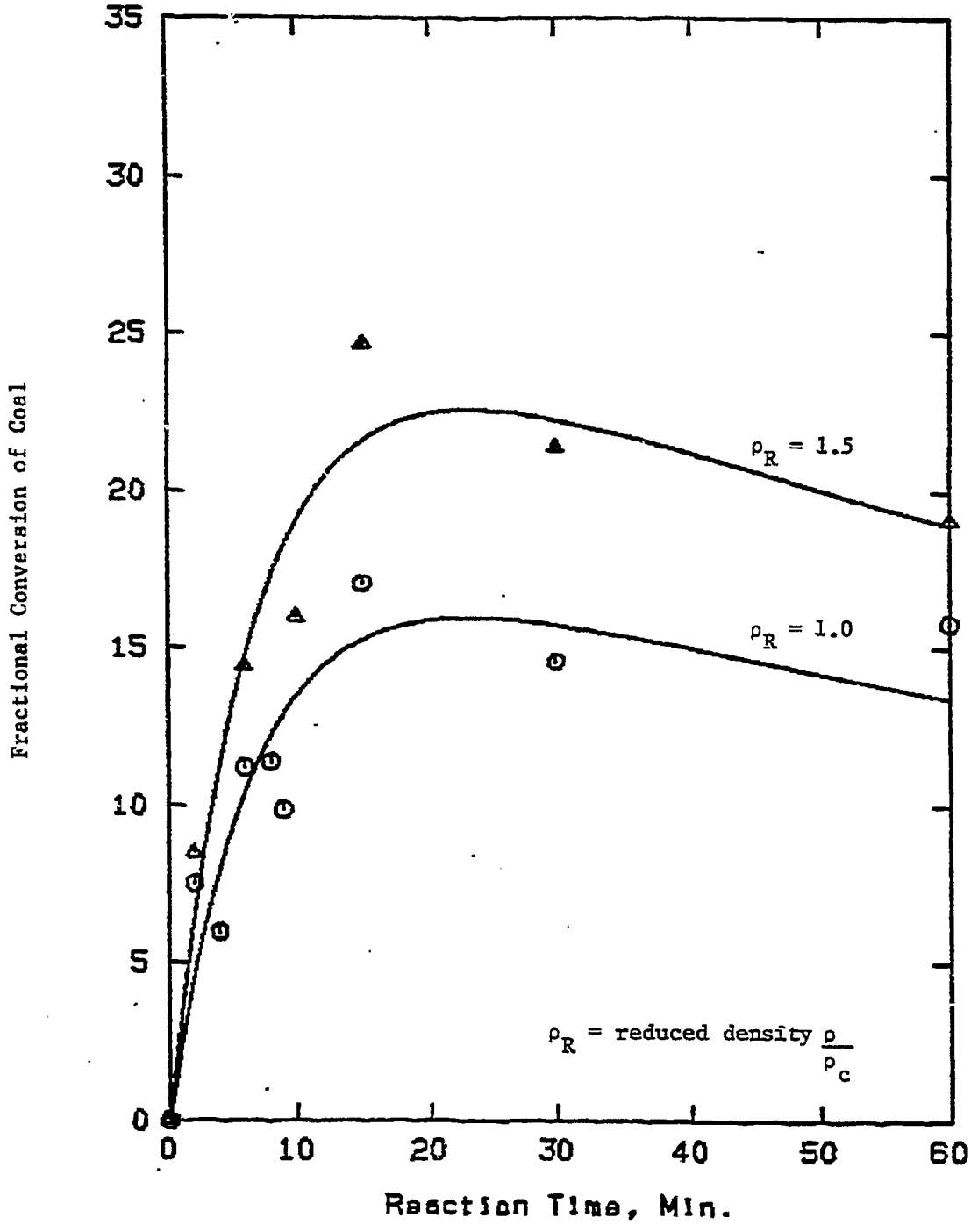

Figure 1: The Effect of Toluene Density on the Conversion of Coal to Liquids. Note that increasing density increases both the rate and the maximum conversion.

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