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DEVELOPMENT OF A GAS-PROMOTED OIL AGGLOMERATION PROCESS

Quarterly Technical Progress Report

January 1, 1996 - March 31, 1996

T. D. Wheelock
Principal Investigator

M. Shen
Graduate Student

Chemical Engineering Department and
Center for Coal and the Environment
Iowa State University
Ames, Iowa 50011

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PURPOSE AND OBJECTIVES

The overall purpose of this research project is to carry out the preliminary laboratory-scale development of a gas-promoted, oil agglomeration process for cleaning coal using model mixing systems. Specific objectives include determining the nature of the gas promotion mechanism, the effects of hydrodynamic factors and key parameters on process performance, and a suitable basis for size scale-up of the mixing system.

INTRODUCTION

A preliminary analysis of a series of 35 agglomeration tests conducted to determine the effects of various parameters on the characteristics of a gas-promoted agglomeration process was reported previously (ref. 1). These tests were conducted with Pittsburgh No. 8 coal in 30 w/w% concentration using i-octane as an agglomerant. Tank size, impeller diameter and speed, oil dosage, and air concentration were varied among runs to study their effects. The progress of agglomeration in each batch test was monitored by observing changes in agitator torque and by frequent sampling and examination of the suspension with a microscope. It was found that the process of agglomeration involves several steps which can be identified and related to changes in agitator torque. An initial analysis of the data showed that the time required to produce spherical agglomerates appears to depend on the power input per unit

volume. The data were analyzed further during the past quarter and the results are presented below.

In addition, a smaller series of runs was carried out to study the effect of agitation time on coal recovery and grade. The runs in this series were all made using the same conditions except that the total agitation time was varied between 15 and 70 min.

WORK PERFORMED

Experimental Methods

Coal from the Pittsburgh No. 8 Seam in Belmont Country, Ohio, was used for the agglomeration tests described herein. The coal contained 5.0% sulfur and 28% ash on a dry basis. The preparation of this material and the equipment and procedure used for conducting agglomeration tests were described previously (ref. 1).

Previous Series of Tests

The conditions employed in a series of 35 agglomeration tests of Pittsburgh No. 8 coal were listed previously (ref. 1). These tests involved the use of three different sizes of mixing tanks and impellers and various agitator speeds ranging from 1100 to 2450 rpm. In addition, the tests were made with either 20 or 30 v/w% i-octane and different amounts of air ranging from 0 to 18 v/w% based on the weight of coal. Since the coal suspensions were degassed first, it was found that some air had to be added to the suspensions in order for agglomeration to take place.

Out of this series of tests, 24 runs produced results which could be analyzed and correlated. A statistical analysis of these results showed that the time required to produce

spherical agglomerations depended to a large extent on the power input per unit volume and to some extent on gas concentration. A linear regression of $\log t_e$ on $\log (P/V)$ produced the following correlation:

$$t_e = 506 (P/V)^{-1.05} \quad (1)$$

where t_e is the time in minutes between the introduction of air and the point where the formation of spherical agglomerates is complete and P/V is the power input per unit volume in watts per liter at that point. P/V was based on measured agitator torque and speed. Equation 1 accounted for much of the variation in the time required to produce spherical agglomerates as can be seen from a plot of the data (Figure 1) and from the value of the correlation coefficient R which for this case corresponded to $R^2 = 0.797$ and to an adjusted $R^2 = 0.788$.

Further regression analysis with consideration for the possible effect of air concentration C_a on t_e produced the following equation:

$$t_e = 1970 (P/V)^{-1.11} C_a^{-0.58} \quad (2)$$

In this equation C_a is the volume of air (cm^3) per unit mass of coal (g) expressed in percent. Equation 2 accounted for more of the variation in t_e than equation 1 since for this case $R^2 = 0.840$ and the adjusted $R^2 = 0.825$. While C_a made a significant contribution to t_e , its contribution was smaller than that of P/V .

For the experimental conditions employed, oil concentration did not make a significant contribution to t_e , and, therefore, it was not included in a correlation. But the lack of significance may have been due to the narrow range of oil concentration employed.

Figure 1. Effect of specific power input on spherical agglomeration time.

These rather preliminary results suggest that the size of the mixing system used for a gas-promoted oil agglomeration process can be scaled up on the basis of power input per unit volume since P/V seems to account for the effects of tank size as well as impeller size and speed on the time required to produce spherical agglomerates. However, this preliminary conclusion needs to be verified by additional experiments which will be undertaken in the future.

New Series of Tests

In a new series of tests Pittsburgh No. 8 coal was agglomerated to determine the effect of extended agitation time on coal recovery and grade. The coal was prepared and the tests were conducted as before. However, all of the tests were carried out with the 7.62 cm

(3.00 in.) diameter tank and the 3.65 cm (1.44 in.) diameter impeller operating at 2000 rpm. This speed was also used for conditioning the suspension before air was introduced. During an agglomeration test the mixing tank was cooled with an ice bath to maintain the temperature of the suspension close to room temperature. A sample of the suspension was collected at the end of the run, but no samples were withdrawn during the run. The following concentrations were employed in each test: 30 w/w% solids, 30 v/w% i-octane, and 9 v/w% air. Agitator torque was measured in each test and plotted against time. The results are indicated in Figures 2 to 5.

In every case it can be seen that following the introduction of air there was a sharp drop in agitator torque to point B followed by a rise to point C and another dip to point D. Then the torque rose to a peak at E which in the previous series of tests marked the completion of spherical agglomeration. However, a microscopic examination of the suspension following run MS 27, which is represented in Figure 2, showed the material to be incompletely agglomerated at E. In other runs, agitation was continued for various intervals beyond E, and spherical agglomerates were produced in each case. When agitation was continued for 18 min. beyond E in run MS 26 (Figure 3), spherical agglomerates having a diameter of 0.15-0.20 mm were produced. Increasing this interval to 36 min. in run MS25 (Figure 4) produced 0.2-0.3 mm diameter agglomerates, and increasing the interval to 58 min. in run MS 24 (Figure 5) produced 2.0 - 3.5 mm diameter agglomerates. The large agglomerates produced in run MS24 were clusters of smaller agglomerates. The formation and break up of clusters may have been responsible for the series of large swings in agitator torque observed near the end of run MS 24.

Figure 2. Changes in agitator torque during run MS 27.

Figure 3. Changes in agitator torque during run MS 26.

Figure 4. Changes in agitator torque during run MS 25.

Figure 5. Changes in agitator torque during run MS 24.

Figure 6. Effect of agitation time on coal recovery, ash rejection, and product ash content.

At the end of each run the suspension of agglomerates was diluted with more water and then poured onto a 60 mesh screen to recover the agglomerates. The agglomerates were dried, weighed, and analyzed to determine their ash content. The material which passed through the screen or tailings was also dried, weighed and analyzed. The coal recovery on a dry, ash-free basis and the ash content of the recovered product are shown in Figure 6. Also shown is the percentage of ash in the feed which was rejected in the tailings. It can be seen that as the agitation time was extended the coal recovery increased gradually and the product ash content decreased. In addition, a larger percentage of the ash in the feed was rejected in the tailings. Therefore, extending the agitation time improved the separation efficiency of the process. The improvement may have been a consequence of producing larger agglomerates

which were easier to separate. At the shortest agitation time agglomeration was incomplete which probably accounted for the corresponding poorer results.

CONCLUSIONS

Further analysis of the results of a series of oil agglomeration tests reported previously showed that the time required to produce spherical agglomerates depends on both the power input per unit volume and the concentration of air in the coal suspension. A subsequent series of tests has shown that extending the time of agitation beyond the point where spherical agglomeration seems to occur produces larger agglomerates which are recovered more easily and the separation efficiency of the process is improved.

FUTURE WORK

Additional agglomeration tests are planned to study the effects of various parameters on the separation efficiency of the gas-promoted oil agglomeration process.

REFERENCE

1. T. D. Wheelock, J. Drzymala, and M. Shen, "Development of a Gas-Promoted Oil Agglomeration Process," Quarterly Technical Progress Report, October 1, 1995, to December 31, 1995, Chemical Engineering Department and Center for Coal and the Environment, Iowa State University, Ames, Iowa.

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