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ABSTRACT

Work continued on the basic mechanisms which underlie various processes for beneficiating aqueous suspensions of coal by selective agglomeration with oil. A new method was demonstrated for characterizing the agglomerability of coal suspensions. This method utilizes a photometric dispersion analyzer to monitor changes in the turbidity of a particle suspension as increasing amounts of oil are added to the suspension in a batch agglomeration test. Agglomeration of the particles leads to a marked decrease in the turbidity of the suspension. Application of the method to Upper Freeport coal, pyrite, and mixtures of this coal and pyrite showed that the method can distinguish between a suspension of homogeneous particles and a suspension which consists of two types of particles that differ in agglomerability. In addition, the method can indicate the relative agglomerability of different homogeneous materials. Therefore, the method can be used for comparing the relative agglomerability of different materials and for quickly and efficiently screening potential agglomeration promoters and depressants.

Another experimental technique was also demonstrated for characterizing oil agglomeration. This technique involves measuring the rate of growth of agglomerates in a continuous flow system operating under steady-state conditions. The data are analyzed by means of a population

balance. The results of a preliminary set of experiments in which Indiana V seam coal was agglomerated with tetralin seemed to fit a particular growth model very well. Equipment was also constructed for studying the kinetics of agglomeration in a batch process.

While earlier work showed that quebracho (a commercially available dispersant) is a strong agglomeration depressant for pyrite, recent experiments with mixtures of Upper Freeport coal and mineral pyrite showed that quebracho does not appear to be sufficiently selective. In somewhat acidic suspensions subjected to agglomeration with heptane, both coal and pyrite were depressed by quebracho. A pyrite depressant is not required to achieve a good separation of these materials in a basic suspension.

Further consideration was given to the separation of mixtures of coal and pyrite by agglomeration with heptane. In mixtures with No. 2 Gas Seam coal from West Virginia, the agglomerability of freshly ground mineral pyrite appeared very similar to that of previously oxidized pyrite which had been cleaned with hot hydrochloric acid. Consequently, both of these forms of pyrite proved more difficult to separate from coal by agglomeration than oxidized but untreated pyrite, particularly in neutral and basic suspensions.

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OBJECTIVE

The overall objective is to determine the basic mechanisms which underlie a number of selective oil agglomeration processes that have been proposed for beneficiating fine-size coal. An understanding of the basic mechanisms of selective agglomeration will greatly facilitate technical development and application of such processes to various types of coal.

INTRODUCTION

Although the oil agglomeration process has been studied for the most part by conducting small batch experiments to obtain coal recovery or yield data together with an indication of mineral matter rejection, the procedure has been laborious and time-consuming. Recently (1) a more efficient and less time-consuming approach has been demonstrated which makes use of a photometric dispersion analyzer to monitor the turbidity of a particle suspension as it is agglomerated. Results of applying the new approach to a study of the agglomeration characteristics of coal, pyrite, and various mixtures of these materials are presented below.

In a preliminary search for a suitable pyrite depressant to use in an oil agglomeration process to beneficiate coal, quebracho appeared to be a promising candidate. Quebracho is a natural tannin of vegetable origin which is available commercially for use as a dispersant. A more extensive evaluation of quebracho for use in oil agglomeration has been conducted and the results are also presented.

Previous work (2) showed that the separation of No. 2 Gas Seam coal and mineral pyrite by agglomeration with heptane was affected markedly by the state of oxidation of the pyrite. Experiments have been conducted to characterize the separation of this coal and freshly-ground mineral pyrite by oil agglomeration. The results are compared with those obtained previously which involved either oxidized pyrite or acid-cleaned pyrite.

Equipment has been designed and assembled for investigating the kinetics of the oil agglomeration process. The important features of this equipment are described and preliminary experimental results which have been obtained with this equipment are presented.

PROGRESS

Monitoring Turbidity Changes during Agglomeration

It has been found that much can be learned about the oil agglomeration process and the nature of particle surface properties by monitoring changes in the turbidity of a suspension undergoing agglomeration. As particles in a suspension become agglomerated, the turbidity of the suspension will decrease. Generally, the extent of agglomeration will increase and the turbidity will decrease as more and more oil is added to the system. However, there is a theoretical limit where agglomeration is complete and the turbidity approaches zero. The oil dosage required to achieve zero turbidity can be regarded as the critical oil dosage (C_t). This dosage seems to be a good measure of particle agglomerability and probably depends on both the oleophilicity and particle size of the material. It appears that the smaller the value of C_t , the more agglomerable is the material.

Previously it was shown that monitoring changes in the turbidity of a suspension subjected to oil agglomeration is a useful means for evaluating a potential pyrite depressant (1). To further demonstrate the usefulness of the method, several experiments were conducted in which the turbidity of various coal and pyrite suspensions was monitored during the agglomeration process. Handpicked Upper Freeport coal from Indiana County, Pennsylvania, and relatively pure mineral pyrite from Huanzala, Peru, were utilized as well as some material recovered from a coal refuse pile near Homer City, Pennsylvania. This material was received in the form of chunks which appeared to be largely pyrite intermingled with significant amounts of coal. The material had been discharged from a preparation plant which processes coal from the Upper and Lower Freeport seams. These materials were ground in the dry state with a high-speed impact mill and then screened to provide minus 200-mesh particles for agglomeration. Since the mineral pyrite had been prepared and stored for some time in an unsealed jar, its surface was well oxidized. However, the pyrite was washed thoroughly with water before using to remove soluble oxidation products.

Agglomeration experiments were conducted with the specially designed mixing unit which was described previously (1). This unit was connected to a PDA 2000 dispersion analyzer which provided a continuous readout of suspension turbidity.

For each experiment 6 to 10 g of particles and 480 ml of deionized water were placed in the mixing unit and stirred for 1-2 min. at 5500 rpm. The system was completely filled with the suspension to eliminate air. Measured increments of heptane from Eastman Kodak Company were introduced

and after each increment the system was allowed to stabilize as indicated by the dispersion analyzer before adding the next increment. For each increment of heptane the turbidity of the stabilized suspension was recorded.

The turbidity of Upper Freeport coal suspensions treated with increasing amounts of heptane is shown in Figure 1. For any given batch of coal most of the data fell on a straight line which was extrapolated to zero turbidity to determine the critical oil dosage of 25 v/w % (2.5 ml heptane/10 g coal). In actual practice zero turbidity was not achieved even with 30 v/w % heptane probably because the material was not homogeneous. More than likely the suspension contained some mineral particles and even some coal particles which were less oleophilic than the bulk of the material. These particles would have remained suspended even with the highest oil dosage.

Figure 2 shows that similar results were observed with mineral pyrite suspensions, which were treated with increasing amounts of heptane, except that the critical oil dosage was extremely large (20,000 v/w %) indicating that the material was much less oleophilic than Upper Freeport coal. Since the results had to be extrapolated a great distance to reach zero turbidity, the value of the critical oil dosage was probably subject to considerable error.

For mixtures of Upper Freeport coal and mineral pyrite, the turbidity data no longer fell on a straight line as the heptane dosage was increased (see Figure 3). The change in the slope of the turbidity curves with increasing heptane dosage suggests that at low heptane dosages the system tended to behave more like a suspension of coal particles whereas at high

Figure 1. Turbidity of coal suspensions resulting from the incremental addition of heptane.

Figure 2. Turbidity of pyrite suspensions resulting from the incremental addition of heptane.

Figure 3. Turbidity of suspensions containing coal and mineral pyrite after agglomeration with heptane.

Figure 4. Turbidity of coal-pyrite refuse after agglomeration with heptane.

heptane dosages it tended to behave more like a suspension of pyrite particles. In other words, agglomeration of the most oleophilic particles was favored by low oil dosages, and the process became less discriminating as the oil dosage was raised.

The effect on turbidity of two materials which differed in oleophilicity became even more apparent when the coal pile refuse was agglomerated with increasing amounts of heptane (see Figure 4). Apparently the coal fraction of this material was agglomerated with smaller doses of heptane at any given pH. With larger doses of heptane, some of the pyrite fraction was also agglomerated at low pH but not at high pH.

From the preceding results it is apparent that several important characteristics of a particle system can be determined by monitoring the turbidity of the system as it is agglomerated with increasing amounts of oil. By plotting the turbidity versus the logarithm of the oil dosage, it is possible to determine whether a particle system is homogeneous from the standpoint of agglomerability. If the system is homogeneous, the data will fall on a straight line and the relative agglomerability of the material will be indicated by the critical oil dosage required to achieve zero turbidity. If the system is not homogeneous, the data will fall on a curved line, and the degree of curvature and final turbidity at high oil dosage will be indicative of the relative amount and nature of the less agglomerable component.

Pyrite Depression

Previous results (1) indicated that quebracho is a good pyrite depressant in the sense that it suppresses the agglomeration of pyrite by

heptane. However, it was also established that quebracho tends to interfere with the agglomeration of Upper Freeport coal. Therefore, it remained to be seen whether quebracho can be used to advantage in separating coal and pyrite by oil agglomeration.

In order to further study the effect of quebracho on the separation of coal and pyrite, a series of agglomeration experiments was conducted with mixtures of Upper Freeport coal and mineral pyrite. The materials and mixing equipment were described in the preceding section. The particles were suspended in deionized water and the suspension was conditioned for 1-2 min. in the mixing unit operating at 5500 rpm. A single, measured dose of heptane was introduced and mixing was continued for 10 min. at the same speed. The agglomerates were recovered on a 100-mesh screen, dried, weighed and analyzed for sulfur.

The effect of pH on the separation of Upper Freeport coal and oxidized pyrite is shown in Figure 5 for the case where no quebracho was present. Below pH 5 both coal and pyrite were largely recovered by agglomeration with heptane, whereas above pH 7 only coal was recovered in large measure. For comparison the effect of pH on the separation of coal and pyrite in the presence of 15 mg/liter of quebracho is shown in Figure 6. It is apparent that quebracho strongly suppressed the agglomeration of pyrite in acidic suspensions. It is also apparent that quebracho depressed the agglomeration recovery of Upper Freeport coal to a lesser extent. However, the depression in coal recovery increased as the pH was lowered.

Since the recovery of Upper Freeport coal was depressed only slightly by quebracho at pH 4.5 while the recovery of pyrite was greatly depressed

Figure 5. Effect of pH on the recovery and separation of coal and mineral pyrite.

Figure 6. Effect of pH on the recovery and separation of coal and mineral pyrite in the presence of quebracho.

under these conditions, further agglomeration experiments were conducted at this pH to study the interacting effects of heptane dosage and quebracho concentration on the separation of coal and pyrite. For a quebracho concentration of zero, the results presented in Figure 7 were observed. These results indicate that with a moderate amount of heptane (i.e., 5.0 v/w %) coal recovery was 90% while pyrite recovery was limited to 30%. Larger amounts of heptane increased coal recovery only slightly while greatly increasing pyrite recovery. By increasing the quebracho concentration it was possible to depress the agglomeration recovery of pyrite even when large amounts of heptane were employed (see Figures 8 to 10). However, the larger concentrations of quebracho required to depress pyrite recovery to a low level also tended to depress the recovery of coal. No combination of heptane dosage and quebracho concentration seemed to provide an exceptionally good separation of coal and pyrite at pH 4.5.

The failure of quebracho to improve the separation of Upper Freeport coal and oxidized mineral pyrite is best illustrated by Figure 11 which shows coal recovery as a function of total agglomerate yield. Points representing results achieved with quebracho fall on the same curve as points representing results achieved without this material. Consequently quebracho was not effective in improving the separation efficiency at pH 4.5.

Separation of Coal and Mineral Pyrite

Results of agglomerating mixtures of No. 2 Gas Seam coal from Raleigh County, West Virginia, and acid-cleaned mineral pyrite from Peru with heptane were reported previously (2). Unfortunately, it was discovered

Figure 7. Effect of heptane dosage on the recovery and separation of coal and mineral pyrite.

Figure 8. Agglomeration recovery of coal and mineral pyrite with 2 ml heptane.

Figure 9. Agglomeration recovery of coal and mineral pyrite with 4 ml heptane.

Figure 10. Agglomeration recovery of coal and mineral pyrite with 6 ml heptane.

Figure 11. Coal recovery and total agglomerate yield resulting from various experimental conditions.

Figure 12. Effect of pH on the separation of No. 2 Gas Seam coal and acid-cleaned mineral pyrite.

later that an error had been made in analyzing the acid-cleaned pyrite. Therefore, the data reported for acid-cleaned pyrite in Figures 9-12 of our previous report were in error. However, the general trends exhibited by these figures were not greatly affected by the error. The data reported previously in Figure 9 were corrected and are presented here in Figure 12. The corrected data for pyrite recovery lie below those reported previously over the whole range of pH. Thus, at pH 2 the corrected pyrite recovery was 62% instead of 76% reported previously and at pH 11 the corrected recovery was 20% instead of 40%. The effect of this change was to increase the separation efficiency over the whole range of pH. Consequently, at low pH the corrected separation efficiency was 38% instead of 20% and at high pH it was 78% instead of 55%.

When the corrected recovery data for acid-cleaned pyrite are compared to the data for oxidized pyrite (see Figure 13), the differences between the acid-cleaned pyrite and the other forms of pyrite are not as great as before the data were corrected, but the general trends are similar. Thus, the recovery of the acid-cleaned pyrite was generally greater than that of the oxidized forms. The "oxidized" pyrite of Figure 13 represents material which had become oxidized by exposure to the laboratory atmosphere in an unsealed container for some time. In Figure 11 of our previous report (2) this material was labeled "normal" pyrite. The "oven-oxidized" pyrite of Figure 13 represents material which had been oxidized by air in an oven at 100°C for 1 h. Previously, this material was simply labeled "oxidized" pyrite.

Recently, further experiments were conducted to study the effect of pyrite surface properties on the separation of coal and pyrite by oil

Figure 13. Recovery of mineral pyrite from mixtures with No. 2 Gas Seam coal.

Figure 14. Effect of pH on the separation of No. 2 Gas Seam coal and freshly-ground mineral pyrite.

agglomeration. For these experiments No. 2 Gas Seam coal was mixed with freshly-ground mineral pyrite and agglomerated with 7 v/w% heptane. Interestingly, the pyrite recovery reported in Figure 14 for the freshly-ground material is very similar to that reported in Figure 12 for the acid-cleaned material which suggests that the surface properties of the two materials were similar. On the other hand, the coal recovery reported in Figure 14 is lower than that reported in Figure 12 which suggests that the surface of the coal may have become oxidized during the interval between the two sets of experiments. However, the pyrite recovery data are of greater interest because they show that clean pyrite particles are more difficult to separate from coal than pyrite particles which are heavily oxidized. Of course, the freshly ground pyrite particles may have been oxidized slightly since they were exposed to air for 1-2 h before being mixed with coal and subjected to oil agglomeration.

Kinetics of Agglomeration

Two methods are being used to investigate the kinetics of oil agglomeration. The first method utilizes a continuous flow system operating at steady-state while the second method utilizes a batch mixing system operating under transient conditions.

Continuous Flow System. In the continuous flow system, agglomeration takes place in the mixing vessel which is shown in Figure 15. The vessel is a 2-liter, stainless steel beaker which has been modified by inserting a draft tube, baffles, and an overflow tube. The contents of the vessel are mixed by an agitator consisting of a 4-blade impeller and drive system which delivers a constant speed that can be varied between 50 and 1850

Figure 15. Mixing vessel used in the continuous flow system.

Figure 16. Typical results obtained with the continuous flow system.

rpm. The pitch of the impeller blades is designed to produce an upward flow inside the draft tube and downward flow outside the tube. This circulation pattern tends to minimize particle segregation and to improve the likelihood that the material passing out the overflow tube is truly representative of the suspension in the vessel. The vessel holds 732 ml of liquid when filled to the overflow tube. The mixing vessel is supplied with a coal slurry which is prepared in a larger tank that is made of plastic and fitted with an agitator. The slurry is pumped at a controlled rate from the feed preparation tank to the mixing vessel by a peristaltic pump. Oil is also delivered to the mixing vessel at a controlled rate by a second peristaltic pump which draws oil from a storage tank. When the system is operating, the coal slurry and agglomerating oil are supplied at constant flow rates to the mixing vessel and a suspension of the agglomerated product passes out the overflow tube. The two streams entering the mixing vessel are introduced between the draft tube and outer wall of the vessel.

The materials selected for an extensive series of agglomeration runs include high volatile bituminous coal from the Indiana V seam. A sample of the coal was obtained from a preparation plant in Southwestern Indiana by the Illinois State Geological Survey. The sample was designated as sample No. 6 of the Illinois Basin Coal Sample Program. A proximate analysis of the sample indicated 39.6% volatile matter, 51.4% fixed carbon, and 9.0% ash. It was also reported to contain 3.8% total sulfur. A small portion of the sample was obtained for the present work, and it was ground with a high-speed impact mill and then screened in the dry

state. The material which passed a 200-mesh screen but not a 325-mesh screen was selected for agglomeration. Since the coal did not appear to agglomerate readily, tetralin was chosen as an agglomerant because of its superior binding characteristics.

The continuous runs are designed to measure the rate of growth of coal agglomerates under steady-state conditions. Before a run the feed slurry is prepared by mixing a weighed amount of coal with 10 liters of deionized water in the feed tank. The slurry feed pump is calibrated and set to deliver the required flow of material. The coal slurry and agglomerating oil are supplied to the mixing vessel at the required flow rates and the agitator speed is set. After the system has operated long enough for the contents of the mixing vessel to have been displaced 10 to 11 times, it is assumed that steady-state conditions have been achieved and a series of product samples are collected. Each sample is collected by holding a 50-ml beaker under the overflow tube and collecting 2-5 ml. of the final suspension. The sample is diluted carefully and poured onto filter paper which is placed in a petri dish. The dish is covered with plastic film to prevent evaporation. Later the agglomerates are sprinkled onto a larger sheet of paper which has been sprayed with an adhesive. The particle size distribution of the agglomerates is then determined by automatic image analysis.

The results of the steady-state runs are being analyzed by applying a population balance to determine the growth rate of the agglomerates. If it is assumed that growth is by layering and that breakage of agglomerates is negligible, the steady-state population balance for agglomerates of a given size can be represented by the following expression:

$$\frac{d(G_L n)}{d\chi} + \frac{n}{\tau} = 0 \quad (1)$$

where G_L is the linear growth rate, n is the number density of agglomerates of size χ , and τ is the mean residence time of particles in the mixing vessel. The number density is defined by the expression,

$$n = \lim_{\Delta\chi \rightarrow 0} \frac{N}{\Delta\chi} \quad (2)$$

where N is the number of particles within size range $\Delta\chi$ contained in 1.0 liter of the suspension. The growth rate of an agglomerate is generally assumed to be a function of its size as indicated below.

$$G_L = \frac{d\chi}{dt} = G_0 \chi^\alpha \quad (3)$$

G_0 and α are parameters which vary with operating conditions, and the present study is attempting to find the relationships between these parameters and particular conditions. By combining equations 1 and 3 and integrating between limits, the following relation is obtained:

$$\ln \frac{n}{n_0} = \alpha \ln \frac{\chi_0}{\chi} + \frac{1}{\tau G_0} \left[\frac{\chi_0^{1-\alpha} - \chi^{1-\alpha}}{1-\alpha} \right] \quad (4)$$

where n_0 is the number density corresponding to χ_0 which is the lower limit of agglomerate size. The value of χ_0 is taken to be equal to the upper limit of feed particle size. Equation 4 is fitted to the experimental data collected during any given run by applying a nonlinear regression

technique which determines the values of G_o and α that maximize the goodness of fit.

To study the effect of various operating conditions on G_o and α , a central composite statistical design is being employed. The conditions being varied include slurry concentration, oil dosage, agitator speed, and residence time in the mixing vessel. A list of the experiments is presented in Table 1. The first 11 experiments have been completed and the values of G_o and α which have been determined are indicated as well as the multiple correlation coefficient R . Since R was nearly 1.00 in every case, equation 4 fit the data very well. The fit is apparent from the results of a typical run which are plotted in Figure 16. The experimental data points represent an average of two determinations of the product size distribution. Further interpretation of the results must await completion of the series of experiments.

Batch Mixing System. The mixing system shown in Figure 17 has been constructed for conducting batch experiments that will be used to study the kinetics of agglomeration. Coal suspensions will be agglomerated in a closed vessel made of glass which is fitted with four vertical baffles, two sampling ports, and a turbine agitator. The vessel is circular in cross section and has a volume of approximately 500 ml. Material is introduced through an opening in the top of the vessel. Samples of the agglomerated suspension are removed through ports in the side of the vessel by employing a special sampling tube which is fitted with a plunger having a rubber tip for sealing. Agitation is provided by a flat-blade turbine impeller which is driven by a variable-speed motor having an operating range of 20 to 2500 rpm. The motor is operated by an electronic

Table 1. Agglomerate growth rate experiments conducted with the continuous flow system

Run No.	Slurry Conc., wt. %	Oil, v/w %	Agitator, rpm	τ , min.	G_o	α	R	R^2
T-1	10	40	1400	10	0.155	0.867	0.992	0.984
T-2	6	45	1200	8	1.548	0.364	0.991	0.983
T-3	10	40	1000	10	1.642	0.289	0.998	0.997
T-4	10	40	1000	14	0.843	0.367	0.996	0.993
T-5	6	45	800	12	3.400	0.148	0.994	0.988
T-6	10	40	1000	6	25.59	-0.139	0.992	0.985
T-7	6	35	800	8	0.221	0.744	0.992	0.984
T-8	10	40	1000	10	1.396	0.299	0.989	0.979
T-9	14	35	1200	8	0.015	1.464	0.969	0.939
T-10	18	40	1000	10	0.290	0.669	0.994	0.988
T-11	10	40	1000	10	0.002	1.688	0.977	0.954
T-12	14	35	800	12				
T-13	10	50	1000	10				
T-14	10	40	1000	10				
T-15	6	35	1200	12				
T-16	2	40	1000	10				
T-17	10	40	600	10				
T-18	10	40	1000	10				
T-19	10	30	1000	10				
T-20	14	45	800	8				
T-21	14	45	1200	12

Figure 17. Batch mixing apparatus for studying the kinetics of agglomeration.

control system which is designed to maintain a constant speed under varying load conditions. The control system provides an indication of both speed and torque which is monitored continuously by a strip chart recorder.

The mixing system geometry is similar to that used commonly in industrial practice. The six-blade impeller is based on a standard Rushton design and its location is such that the clearance between the bottom of the impeller blades and the bottom of the vessel is one-third of the overall liquid depth in order to maximize axial circulation and, hence, solids suspension. This geometry provides a high-shear region for dispersing the oil and fine coal particles surrounded by a turbulent low-shear region for agglomerate growth.

The mixing system will be used in the future to study various agglomerate growth regimes, to measure the so called inversion time, to measure agglomerate growth rate, and to measure the rate of separation of multi-component systems. The agglomerate growth kinetics will be evaluated in terms of the rate of change of the population density and the maximum and median agglomerate diameters. The separation kinetics will be evaluated in terms of the rate of combustible recovery and rate of mineral matter rejection.

SUMMARY

It was shown that much useful information about the agglomeration characteristics of a particle system can be obtained by monitoring changes in the turbidity of a suspension undergoing oil agglomeration in a batch process. When the oil is added in small increments and the system is

allowed to stabilize after each addition, a plot of the resulting turbidity versus the logarithm of the cumulative oil dosage is highly revealing. If the data fall on a straight line, the particle system is likely to be homogeneous from the standpoint of agglomerability, whereas if the data fall on a curved lined, the particle system is probably heterogeneous. For a nearly homogeneous system of agglomerable particles, the straight line can be extrapolated to zero turbidity to determine the corresponding critical oil dosage (C_t) which appears to be indicative of the characteristic agglomerability of the solids. Thus, a small value of C_t will be indicative of a highly agglomerable material whereas a large value of C_t will be indicative of a weakly agglomerable material.

Although quebracho was found to be a good depressant for pyrite, it did not prove effective when applied to mixtures of Upper Freeport coal and mineral pyrite which were subjected to agglomeration with heptane in a somewhat acidic suspension. Apparently the agglomeration of the coal was also suppressed by quebracho, so there was not a significant improvement in the separation of coal and pyrite. Quebracho was not applied to basic suspensions of Upper Freeport coal and pyrite because these were readily separated by selective agglomeration without additional reagents.

The separation of mixtures of freshly ground mineral pyrite and No. 2 Gas Seam coal from West Virginia by agglomeration with heptane proved more difficult than the separation of heavily oxidized pyrite and coal. The agglomerability of the freshly ground pyrite appeared similar to that of oxidized pyrite which had been cleaned by leaching with hot hydrochloric acid.

Two experimental systems have been developed for investigating the kinetics of oil agglomeration. One is a continuous flow system which is designed to operate at steady-state, while another one is a batch system. A number of experiments have been conducted with the first system to measure agglomerate growth rate under various conditions. The results seem to fit a particular growth model which has been proposed.

REFERENCES

1. T. D. Wheelock, J. Drzymala, R. W. Allen, Y.-C. Hu, D. Tyson, Qiu Xiaoping, and A. Lessa, "Mechanisms for Selective Agglomeration of Coals," Fossil Energy Quarterly Report for Jan. 1, 1989 - Mar. 31, 1989, IS-4997, Ames Laboratory, Iowa State University, Ames, Iowa.
2. T. D. Wheelock, J. Drzymala, R. W. Allen, Y.-C. Hu, D. Tyson, Qiu Xiaoping, and A. Lessa, "Mechanisms for Selective Coalescence of Coals," Fossil Energy Quarterly Report for Oct. 1, 1988 - Dec. 31, 1988, IS-4985, Ames Laboratory, Iowa State University, Ames, Iowa.

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