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Final Report on the Joint Development of Emulsions for the GranuFlow Process, CRADA 98-F017

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BACKGROUND

NETL entered into a Cooperative Research and Development Agreement with Russell Standard Corporation in 1998 for the joint development of emulsions to be used in GranuFlow research being conducted by NETL. The specific objective was to determine the modified water-based emulsions that would be most effective in dewatering fine coal and improving product handling. The first phase of this CRADA involved the lab testing of three custom emulsions. These emulsions were tested in November 1998 and a Phase I report delivered in December 1998.

In this Phase II effort, Russell Standard emulsions were tested in NETL's Bird screen-bowl centrifuge circuit in an attempt to compare them to Orimulsion, which has been extensively tested in the centrifuge.

The GranuFlow Process was developed by NETL as a novel fine coal dewatering and reconstitution process. A bitumen emulsion is added to a fine coal slurry, which is then mechanically dewatered to form a cake or granules. The emulsion used most in initial testing was Orimulsion, which was imported from Venezuela and is not a reliable source for continued GranuFlow research and commercialization. Transportation costs are also a factor. It was determined that the development of a domestic, inexpensive, and effective emulsion was needed. Newly available emulsions could benefit the energy industry that is continually looking for cost-effective and successful ways to reduce waste and lower costs.

This cooperative effort involved the production of modified emulsions by Russell Standard with technical support and expertise available from NETL scientists. The emulsions were tested at NETL according to accepted procedures so that comparisons were made under similar conditions.

EXPERIMENTS

Test materials

The coal used in these experiments was the flotation concentrate (-100 mesh) from the Ginger Hill pond recovery plant in Pennsylvania operated by CQ Inc. This coal has been used extensively in past experiments and was utilized due to proximity to NETL. It contained approximately 16% solids.

The emulsions used in this series of experiments were a commercial emulsion called Orimulsion from Venezuela, and two custom emulsions developed by Russell Standard. They were developed in accordance with other emulsions that had produced favorable fine coal dewatering results in past GranuFlow tests. A third custom emulsion that was prepared was unable to be utilized. The emulsions were produced at Russell Standard's Mercer, PA plant in small quantities and in batches. The emulsions are denoted A and B1. Both of the emulsions consisted of 70% bitumen in water.

Emulsion A used a local bitumen, and was formulated to 169.02 Cst @ 275 degrees F using a kinematic viscosity machine with a #9 Visc tube. Emulsion B1 used a local bitumen and a 9% cut from a phase II 1st run formulated to 1992 cp @ 275 degrees F using a Brookfield viscosity machine with a #21 spindle.

Proprietary surfactants and other additives may have been used in their production. Other properties are not known.

Centrifuge and feed system configurations

The screen bowl centrifuge used was a 6” x 12” Bird centrifuge with a 5” x 3.75” screen section, 2” long beach zone, 0.5” pool depth, 2500 rpm bowl rotation, 100:1 conveyor differential, feed ports 2.75” from beach zone, and 35 mesh screen. A 50-gallon feed tank was used with a Turbon mixer and centrifugal recirculation pump. The coal slurry samples were fed to the centrifuge using a 6 gpm Moyno pump and Micromotion mass flow meter. The pump used to inject the emulsions was a 0.1 gpm pump, which fed into a 0.5” X 20’ feed line.

Test series

Two tests were run using the flotation concentrate coal slurry in the screen bowl centrifuge to remove water. Each test series included an untreated coal run, a 6% Orimulsion addition, and a 6% Russell Standard emulsion addition. The tests were run at 20 C to 25C, the temperature of the room.

Table 1. Test series conditions for Russell Standard tests

Test series	1	2
Feed rate (gpm)	3.2	3.1
solids/min (grams)	1907	2036
Feed solids, %	16.7	16.7

Moisture content

The moisture contents of the product coal samples from each test were determined by placing the coal in a pan that was placed in a drying oven at 105-degree C. The pans were removed and weighed several times until no change in the weight was noted.

Dust index

The dust index is defined as the percent mass of a coal sample that passes through a 100-mesh screen. The coal sample is placed in a series of mesh screens, which is placed on a RoTap for 5 minutes. The fractions in each screen are removed and weighed.

RESULTS AND DISCUSSION

The moisture content results for the two emulsions tested are shown in Figures 1 and 2 below. Emulsion A at a 6% addition reduced the coal moisture from 27% to 19.1% while the 6% Orimulsion addition reduced moisture to 18.5%. Compared to the 26.7% moisture content of the untreated coal, both emulsions achieved about the same level of moisture reduction. In the second test series, the 6% Orimulsion addition reduced moisture to 17.7% while Emulsion B1 reduced moisture to 20.2%. Compared to the untreated coal, the Orimulsion lowered moisture about 2.5 percentage points lower than Emulsion B1.

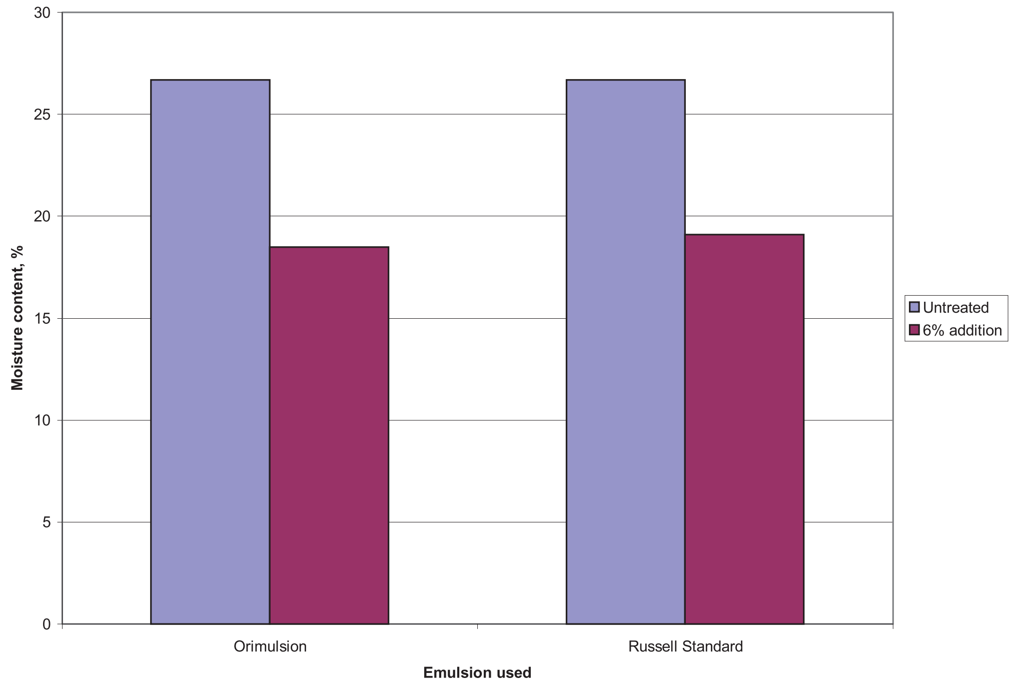

Figure 1. Moisture Content Results for Russell Standard Emulsion A Screen Bowl Centrifuge Tests

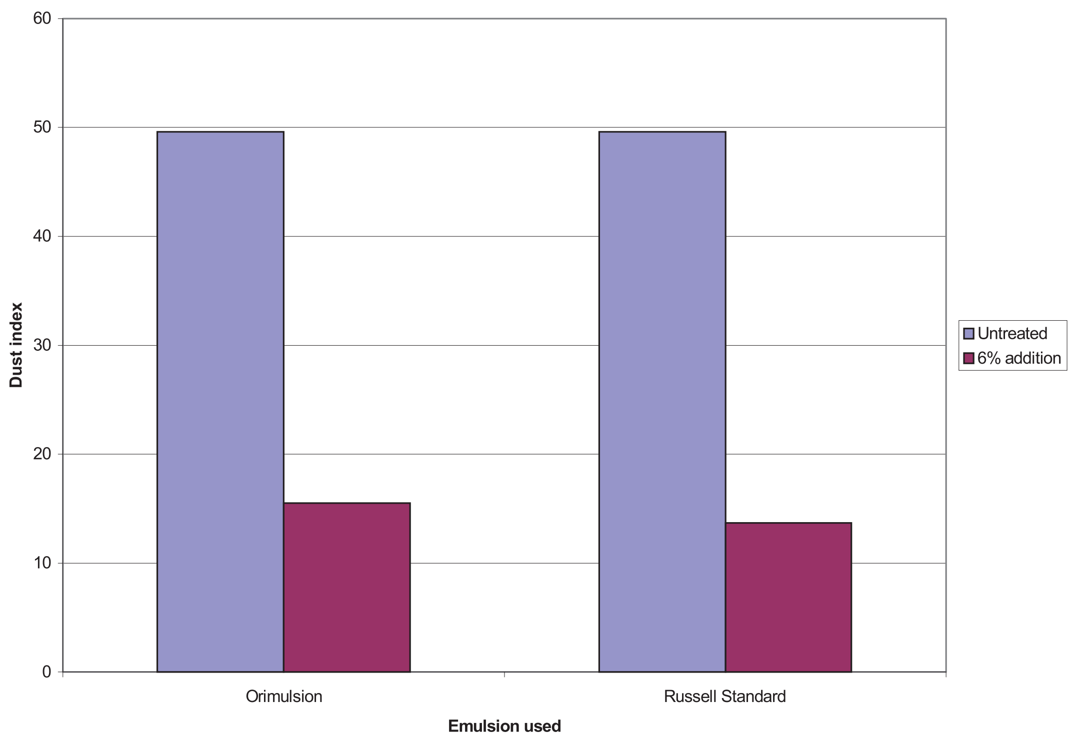

Figure 2. Moisture Content Results for Russell Standard Emulsion B1 Screen Bowl Centrifuge Tests

The dust index results for the testing of emulsions A and B1 are shown in Figures 3 and 4 below. The 6% addition of all of the emulsions was quite effective in reducing the dustiness of the coal. The untreated coal in test series 1 had a dust index of 50.3 while the Orimulsion reduced the dust index to 10.7 and Emulsion A to 15.1. This represents 79% and 70% dust reductions, respectively. In the second test series untreated coal had a dust index of 49.6. The 6% Orimulsion addition had a dust index of 15.5 while the 6% Emulsion B1 had a dust index of 13.7. This represents reductions of 68% and 72% respectively.

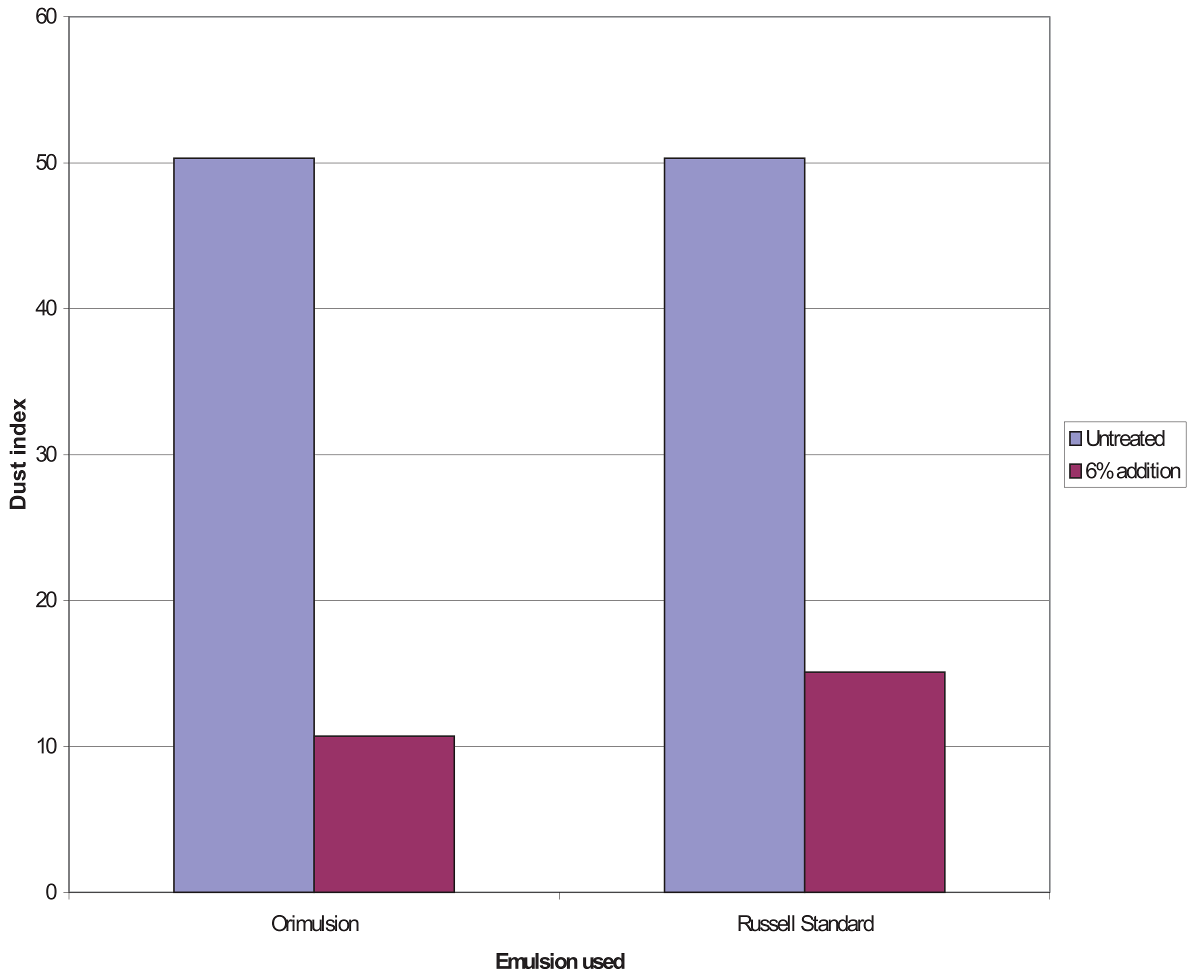

Figure 3. Dust index results for Russell Standard Emulsion A Screen Bowl Centrifuge Tests

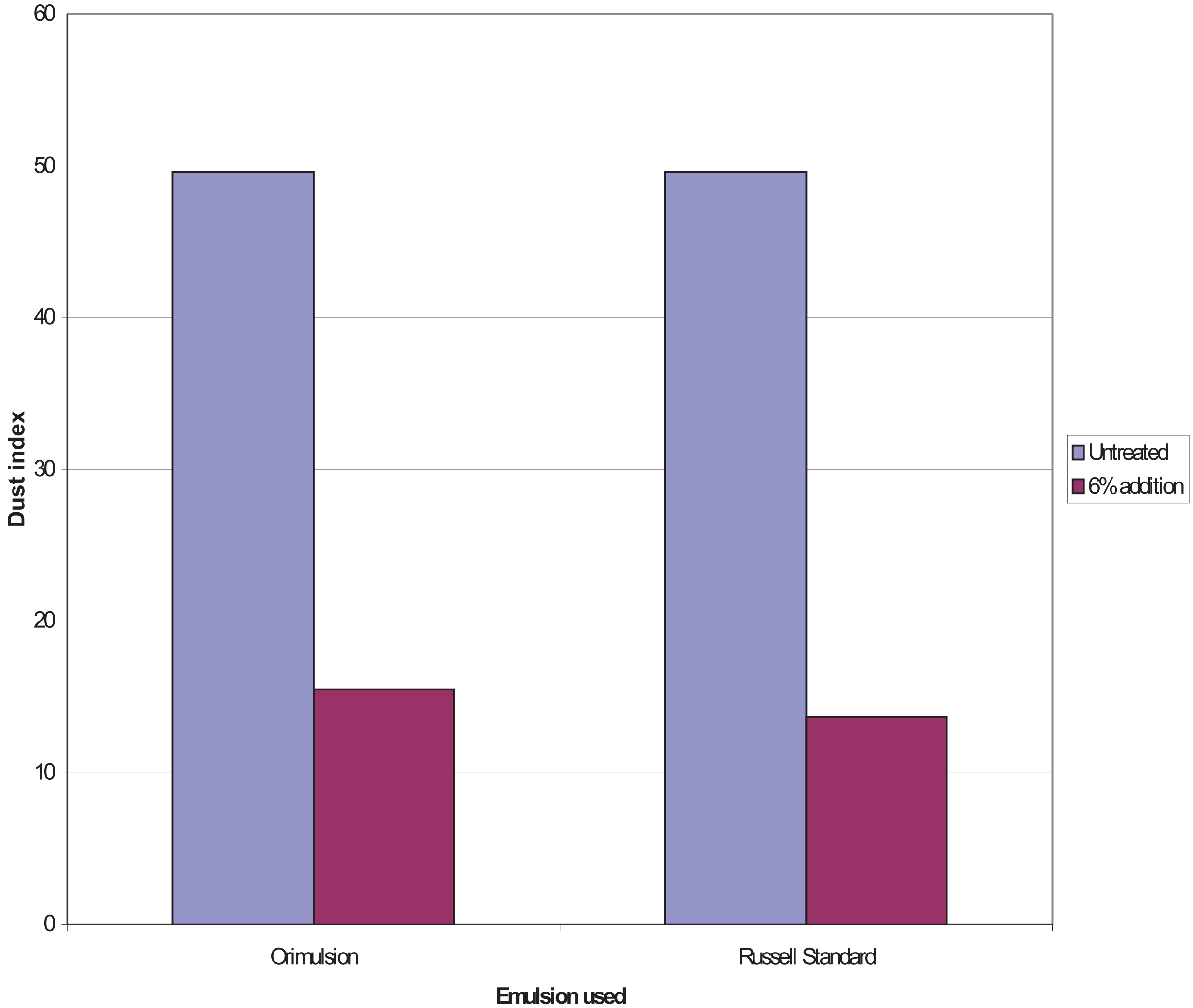

Figure 4. Dust index results for Russell Standard Emulsion B1 Screen Bowl Centrifuge Tests

The effect of the emulsion additions on the distribution of solids in the untreated and treated coals is shown in Figures 5-6.

The addition of an emulsion did increase the percentage of solids in the product fraction. The coal treated with 6% of emulsion A had increased solids in the product while the solids in the screen effluent decreased. Solids in the main effluent stayed fairly constant.
Coal treated with 6% of emulsion B also showed an increase in the percent of solids in the product with a removal of solids from the screen effluent.

The coal treated with 6% Orimulsion had slightly larger increases in the percent of solids in the product than the Russell Standard emulsions. The screen effluent solids were reduced in addition to a reduction in the main effluent solids as well.

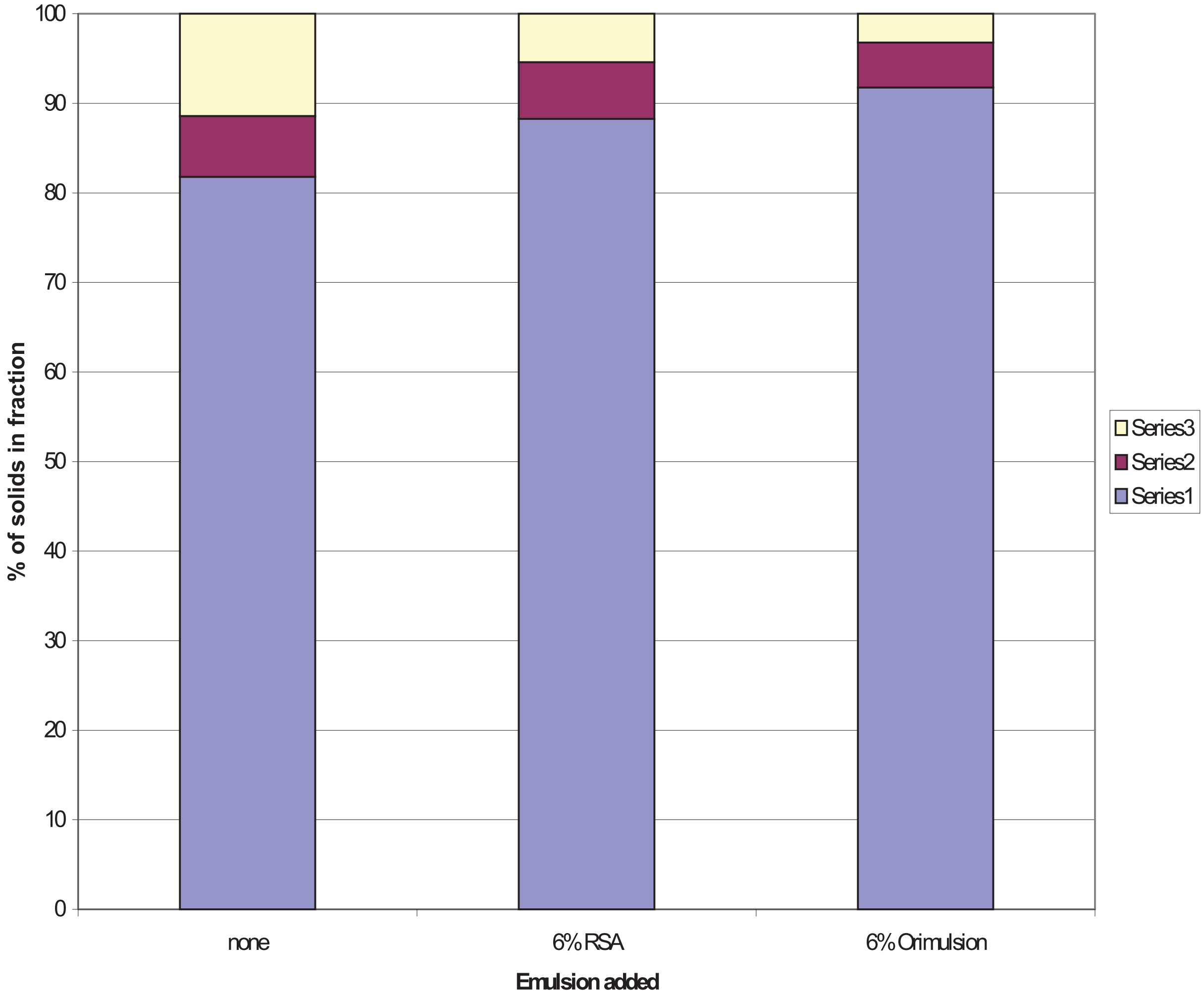

Figure 5. Solids distribution for flotation product treated with RSA emulsion and Orimulsion and dewatered with the screen-bowl centrifuge

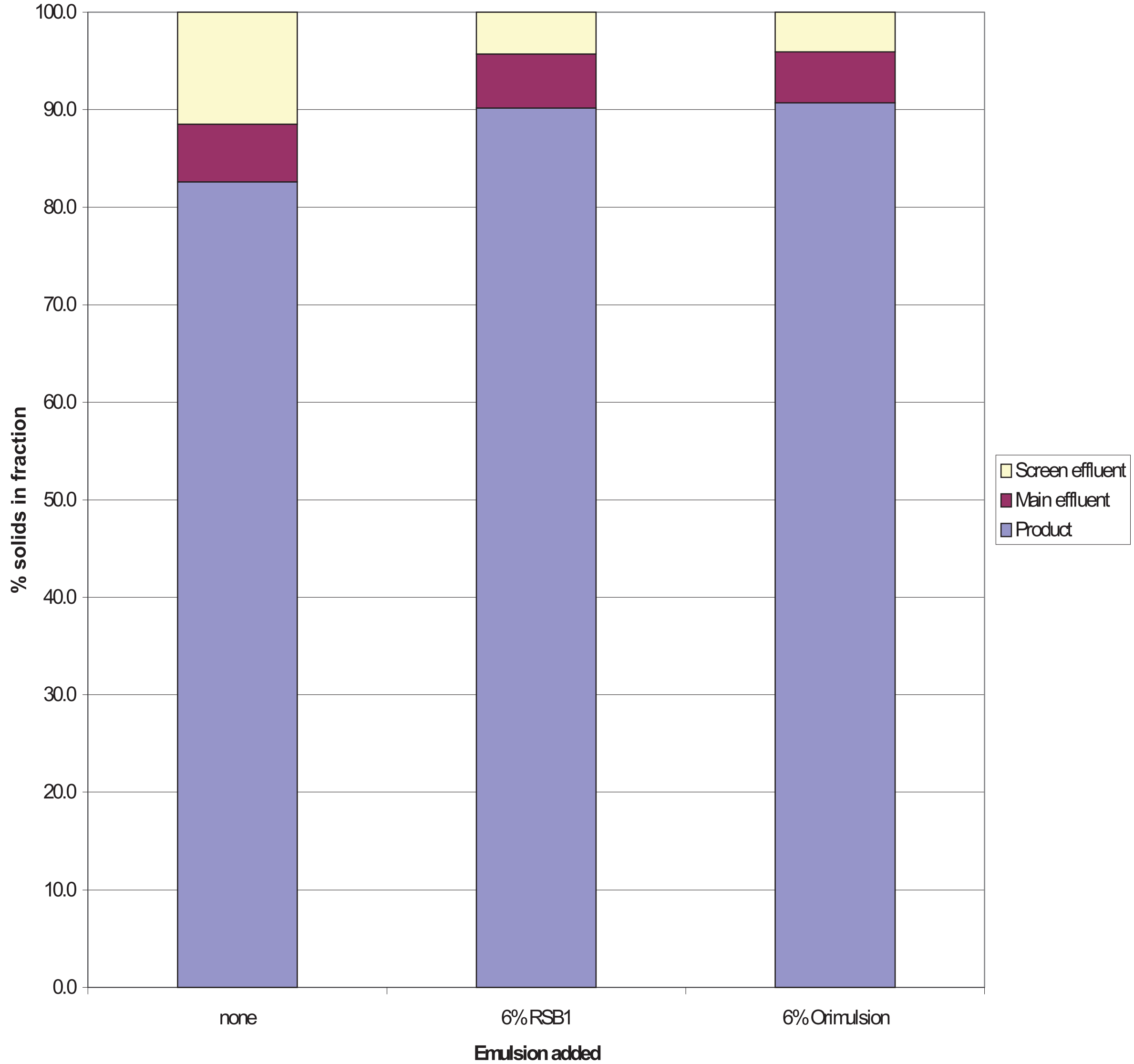

Figure 6. Solids distribution for flotation product treated with RS B1 emulsion and dewatered with the screen-bowl centrifuge

CONCLUSIONS

The Russell Standard custom emulsions A and B1 performed comparably to the Orimulsion that has been used in past GranuFlow tests. Overall, Orimulsion was the slightly better performer at reducing moisture content and dustiness of the product coal. Both custom emulsions reduced moisture and dustiness as well, but to a slightly lesser degree than the Orimulsion. The experimental emulsions also increased the amount of solids recovered in the product coal as compared to the untreated coal. As Emulsions A and B1 were custom emulsions developed just for the GranuFlow application, it appears that more reformulating might need to be performed, but a good basic formula has been developed. The choice of what emulsion to use in a commercial application of the GranuFlow Process largely depends on the technical performance of the emulsion, its impact on the equipment, and its cost.

Appendix
Raw Data

Emulsion A test

CENTRIFUGE TYPE	screen	screen	screen
BITUMEN EMULSION			
type	none	6% RSA	6% Orimulsion
dosage, %	0.0	6.0	6.0
FEED SLURRY			
concentrate type	flotation	flotation	flotation
flow rate, gpm	3.2	3.2	3.2
% solids	16.7	16.7	16.7
dry % ash	5.0	5.0	5.0
PRODUCT			
% water	26.7	19.1	18.5
dry % ash	3.9	3.8	4.0
MAIN EFFLUENT			
% solids	1.6	1.5	1.4
dry % ash	18.3	18.1	21.8
SCREEN EFFLUENT			
% solids	38.2	17.2	15.5
dry % ash	4.9	5.2	5.0
SOLIDS DISTRIBUTION			
product %	81.8	88.3	91.8
main effluent %	6.8	6.3	5.0
screen effluent %	11.4	5.4	3.2
PRODUCT DUSTINESS			
dust index, %	50.3	15.1	10.7

Emulsion B1 test

CENTRIFUGE TYPE	screen	screen	screen
BITUMEN EMULSION			
type	none	6% RSB1	6% Orimulsion
dosage, %	0.0	6.0	6.0
FEED SLURRY			
concentrate type	flotation	flotation	flotation
flow rate, gpm	3.1	3.1	3.1
% solids	16.7	16.7	16.7
dry % ash	5.0	5.0	5.0
PRODUCT			
% water	27.5	13.7	15.5
dry % ash	4.0	3.9	3.9
MAIN EFFLUENT			
% solids	1.5	1.4	1.2
dry % ash	17.6	19.1	18.6
SCREEN EFFLUENT			
% solids	35.7	13.4	13.2
dry % ash	4.5	4.8	5.0
SOLIDS DISTRIBUTION			
product %	82.6	90.2	90.7
main effluent %	5.9	5.5	5.2
screen effluent %	11.5	4.3	4.1
PRODUCT DUSTINESS			
dust index, %	49.6	13.7	15.5