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LOW GRADE COAL UTILIZATION AND PROPERTY ANALYSIS

DP/ROK/82/029

Technical report: Coal Water Mixture Technology*

Prepared for the Government of the Republic of Korea
by the United Nations Industrial Development Organization
acting as executing agency for the United Nations Development Programme

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Appendix III

New Findings and Suggested Research Problems

New Findings

1. Measurement of Rheological Properties

   From cone and plate rheometer, one can measure storage modulus (G') and loss modulus (G") for coal slurry. These measurements could contain more rich information than the conventional measurements of viscosity. Measurement of G' and G" for concentrated slurry with (or without) surfactant will give a guideline towards the characterization of dispersion qualities for coal slurry.

2. Rotating Disc Devices

   The rotating disc devices used mainly by naval research laboratories in the United States to study turbulent drag reduction can be adapted to study the dispersion qualities of coal slurry under high shear. Measurement of torque versus rotation speed will give a criteria of dispersion quality. A theoretical model should be developed to obtain such a criteria. The testing sample will be chosen from the suspension of magnetic particles: α-iron oxide and γ-iron oxide particles or CrO_2 particles (below and above Curie temperature during experiments).

Suggested Research Topics

1. The viscometer in KIER cannot cover the viscosity measurements for wide ranges of shear rate. To obtain the complementary measurements I suggest using a cone and plate rheometer for the low shear rate and a capillary rheometer for the high shear rate. Once reliable data is obtained one can develop a theoretical model by correlating the shear viscosity and various physical parameters. The high shear rate data can be further used to obtain design criteria for slurry transport.

2. I would suggest using viscometric measurement for the dilute suspension to understand interparticle force. Light scattering measurement is also suggested.

3. Rotating disc apparatus can be purchased to measure drag. Studies on turbulent drag reduction and characterization of particle dispersion from this equipment is possible.

4. From the measurement of G' and G" for slurry, one should correlate particle dispersion and G'-G" plots. Various blending ratios (different particle sizes or different coal particles) could be chosen in this experiment.

5. Graphite slurry and heat and mass transfer enhancement due to drag reducer may lead to important industrial applications. The slurry technology we learned can be used to study these projects.

Final Report for UNIDO Mission

The research developed by the Korean Institute of Energy and Resources (KIER) on coal water mixture (CWM) technology appears to be extremely useful in industrial applications for the existing industrial furnaces and oil-fired boilers in South Korea.

Yu Kong (formerly Korean Oil Corporation), for instance, is building large scale manufacturing facilities to produce CWM, and more extensive research and development effort by KIER is encouraged. This type of R&D may be beneficial to Korean heavy industries in finding an alternative, economical source of energy in the future.

However, as a rheology expert, I found that the fundamental understanding of characterization and dispersion to develop CWM preparation technology is still in the primitive stage at present. As a consequence, most of my consulting activities at KIER were focused on these problems.

I gave seven informal seminars (I called them "group meetings": see Appendix I) instead of formal seminars. Each meeting typically lasted two to three hours. The meetings were well received by the scientists and technicians in the coal slurry technology group in KIER. The topics discussed are given in Appendix II. The group meetings consisted of answering their trouble-shooting problems, teaching the fundamentals of coal slurry rheology and slurry transport processes, developing new techniques on characterization and stabilization of CWM, and discussing the direction of future research on CWM technology at KIER. Three additional research topics which are not directly related with CWM technology were also discussed. They are: graphite slurry, magnetic particle slurry, and turbulent drag reductions. The new findings and suggested future research projects we discussed will be given in Appendix III.

The UNIDO expert program was beneficial both for me and for the researchers in the coal slurry group in KIER. We developed mutual research interests in the area of slurry technology during my stay. In the near future, we intend to publish a few papers (on the basis of our discussions during my visit to KIER) and to train some researchers in KIER by inviting them to Carnegie Mellon University.

Appendix I

Agenda for UNIDO Mission

Date	Activities
Dec. 8 (Mon.)	Leave Pittsburgh, PA; Arrive Los Angeles, CA
Dec. 9 (Tues.)	Leave Los Angeles, CA
Dec. 10 (Wed.)	Arrive Seoul, Korea
Dec. 11 (Thurs.)	Report to UNIDO Seoul. Leave Seoul, arrive DaeJeon. Visit KIER Test Facilities.
Dec. 12 (Fri.)	Preliminary discussion with section head in coal slurry; finalize detailed schedule.
Dec. 13 (Sat.)	Group Meeting I
Dec. 15 (Mon.)	Preparation for meeting and consulting
Dec. 16 (Tues.)	Group Meeting II
Dec. 17 (Wed.)	Group Meeting III
Dec. 18 (Thurs.)	Preparation for meeting and consulting
Dec. 19 (Fri.)	Preparation for meeting and consulting
Dec. 20 (Sat.)	Group Meeting IV
Dec. 22 (Mon.)	Group Meeting V
Dec. 23 (Tues.)	Preparation for meeting and consulting
Dec. 24 (Wed.)	Group Meeting VI
Dec. 26 (Fri.)	Final Summary Meeting
Dec. 27 (Sat.)	Discussion of future research
Dec. 29 (Mon.)	Telephone report to UNIDO at Seoul. Leave Seoul, Korea; arrive Pittsburgh, PA
Dec. 30 - Jan. 2	Illness due to travel
Jan. 3 - Jan. 6	Preparation of final report and selection of relevant research documents for KIER.
Jan. 7 (Wed.)	Typing final reports and sending them to UNIDO Vienna, UNIDO Seoul, and KIER.

Appendix II

Group Meeting Topics

1. Introduction to fluid mechanics - lectures based on my notes.

2. Rheological properties for coal slurry

   i. characterization; measurement of viscosity

   ii. modelling - relate viscosity data with various parameters (size, size distribution, surfactant, slurry concentration, and time)

   iii. future experiments

3. Particle dispersion

   i. characterizations

   ii. new instrument design

   iii. related subject - graphite slurry, magnetic particle suspension

4. Turbulent drag reduction

   i. with polymers - possible applications toward energy saving

   ii. with coal particles - may be useful in characterizing suspension exposed in high shear

5. Slurry flow - application for the pipe line transportation of CWM