1. Introduction

This is a report on a work in progress in which our research group is currently involved, in the framework of a contract awarded by Snamprogetti to the University of Florence (Department of Chemistry and Mathematical Institute) and Eniricerche. The members of the group are: E. Comparini, A. Fasano, P. Paoli, A. Papini, S. Paveri-Vontana, G. Pettini, M. Primicerio, R. Ricci and M. Ughi. The aim of our study is to develop a mathematical model for the rheological behaviour of coal slurries, i.e. of stable concentrated coal-water suspensions (C.W.S.). The oil crisis of the Seventies made it economically interesting to explore the possibilities offered by coal as energy source, trying to reduce its cost and in particular transportation costs which influence the final price up to 60% (of course this is a rough average estimate). Using pipelines to transport suspensions of solid particles in a carrier fluid is a rather old technique. In case of coal, the production of highly concentrated slurries could result in cutting transportation costs, especially because the CWS can be fired directly in burners, without a preliminary dewatering process, if the concentration of coal is large enough.

The growing interest of industries and of scientists in these fields is testified by the annual international meetings in which a very large number of papers have been presented in different areas such as preparations of CWS, characterization and rheology, hydraulics and pipelining, atomization, combustion, environmental effects, economic analysis and so on. The proceedings of these meetings and in particular [1], [2], [3], [4] are very good sources of information.

"This paper is in final form and no version of it will be submitted for publication elsewhere."
High concentrations (up to about 70% in weight) have been obtained by means of an optimized grain size distribution: approximately bi-modal distributions have proved to give the best results (typical values of the peaks of the distribution function are 10 and 100 microns).

Moreover, suitable fluidizing additives are studied to form a sort of protective film around coal particles so that most of the water is prevented to enter the coal grains and is available as a lubricant to reduce friction forces between adjacent particles. At these concentrations slurry can be burned without drying, although several technical problems have still to be solved for the construction of engines using CWS as fuel.

Concerning stability, static and dynamic stability have to be considered separately. Static stability, against sedimentation, is typically measured as follows: slurry is left for 5 days in a cylindrical container (radius 10 cm, height 50 cm). Then the sample is frozen and two slices of it are taken at the top and at the bottom of the cylinder and the ratio \( r = \frac{\text{concentration at the top}}{\text{concentration at the bottom}} \) is taken as the measure of the static stability. The usual requirement for stability is \( r_5 > 0.95 \). A stability ratio after 20 days can also be defined. Typical requirement is \( r_{20} > 0.90 \).

The most delicate point is dynamical stability: experiments show that the rheological properties of CWS may exhibit dramatic changes after the slurry has been kept in motion for several hours in test circuits. Indeed, the pressure gradient needed to maintain a given flow rate in the pipe loop increases during the motion and there maybe a progressive thickening of the slurry up to a level in correspondence of which it is no longer pumpable.

The mechanism of this degradation phenomenon is the main object of our research. The goal is to identify the relevant factors affecting it, to give a possible mathematical description of the process in order to suggest, accordingly, laboratory tests to predict the "degradation time" of the slurry.