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FUEL RESEARCH INSTITUTE OF SOUTH AFRICA.

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A BRIEF DESCRIPTION OF THE CERCHAR COMBUSTOR AND THE SUBSEQUENT IMPROVEMENTS TO THE COMBUSTOR.

PROGRESS REPORT.

by:

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EXTRACT:

A study of the ignition aptitude of pulverized coal in a furnace was undertaken at the Fuel Research Institute of South Africa, along the lines set out by the French Fuel Research Centre. This report briefly describes the technique and the original apparatus. A few of the major difficulties experienced with the original apparatus are listed. These difficulties led to the redesign of the apparatus. The report is concluded with a description of the redesigned coal feed system as well as a technique for determining the final extinction of the coal.

INTRODUCTION:

The mechanism by which coal particles ignite in a pulvarized coal furnace determines the stability of the flame, the distance of ignition, and more generally, the characteristics of the flame in its initial phase. Knowledge of this mechanism constitutes a valuable guide, on the one hand, in the choice of construction features and design of pulverized coal furnaces, and on the other hand, in the choice of coals which can be used in a furnace of given characteristics.

The study carried out in the laboratory of Fuel Research Institute has thus far been conducted with the second aim in view, i.e. – to find a means of characterising the aptitude to ignition of coals in a pulverized coal furnace.

CHARACTERISING THE IGNITION APTITUDE OF COALS:

For characterising the ignition aptitude of coals, the method developed in France at the "Centre d'Etudes et Recherches des Charbonnages de France" was adopted. In this report frequent reference will be made to this method which, for convenience, will henceforth be termed the Cerchar method.

In the Cerchar method one effects in an experimental burner a flame of pulverized coal under strictly standardized conditions. One of the parameters is varied and one notes the limiting value of this parameter for which the flame ceases to be stable. The parameter chosen is the wall temperature of the furnace. The limiting value of the wall temperature is termed the "extinction temperature" of the coal and its magnitude serves as a relative measure of the inflammability of the coal.

This method does not demand any hypothesis on the ignition mechanism. However, the conditions under which ignition is effected must be comparable with those of pulverized fuel furnaces found in practice.

DESCRIPTION OF THE CERCHAR APPARATUS:

The brief description of the Cerchar apparatus given below can be amplified, if necessary by reference to the engineering drawings made available by Cerchar.

An axial jet of primary air and pulverized coal, surrounded by an annular jet of secondary air of low speed, flows into a vertical furnace which is electrically heated. The dimensions of the furnace are: Height 460 mm and inside diameter 175 mm. The furnace is extended by a

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cooled section where the flame is extinguished so as to facilitate the evacuation of the combustion products. Between the two sections of the furnace, a venturi of isolating material reduces the loss of heat by radiation between the hot and cold parts of the furnace. The wall temperature is measured by thermocouples distributed over different vertical levels and sunk into the fire-brick of the furnace, in the immediate vicinity of the inner surface.

The flame inside the furnace can be observed by means of three windows positioned along the length of the furnace.

The pulverized coal is extracted from an airtight conical hopper by an air-ejector at the bottom of the hopper, it then passes into a mixer where the necessary make-up air is introduced in order to obtain the desired proportion of primary air. The coal feed-rate is regulated by adjusting the position of the air-ejector in the hopper as well as the quantity of air supplied to the ejector, and is measured by means of a balance supporting the feed-hopper.

DIFFICULTIES EXPERIENCED WITH THE CERCHAR APPARATUS:

The Cerchar apparatus was duplicated at the Fuel Research Institute and subjected to a series of trial runs. During the trial runs the following major difficulties were experienced:

The rate of coal extraction from the hopper is to be controlled by two parameters viz., the position of the air-ejector and the quantity of air supplied to the ejector. It was found, however, that when the position of the ejector was varied the extraction abruptly changed from no-flow to near maximum extraction with little or no control thereafter. Increasing the quantity of air supplied to the ejector, thereby reducing the make-up air to the mixer, frequently caused blockage in the mixer.

In addition it was found that extraction could not be sustained over a prolonged period without interruption. Dismantling the extraction system after interruption indicated the interruption to be caused by bridging of the coal at the bottom of the hopper just above the air-ejector.

Furthermore, when extraction was successful the coal feed-rate was not constant and could not be duplicated.

ATTEMPTS TO IMPROVE THE ORIGINAL CERCHAR EXTRACTION SYSTEM:

Before attempting the achievement of a constant coal feed-rate it was

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first necessary to obtain uninterrupted extraction of coal from the feed hopper. With this objective in mind the following alterations were made to the Cerchar extraction system:

A pressure was applied to the feed hopper; the underlying idea was to force the coal to the bottom of the hopper. The taper of the hopper, however, compressed the coal on downward motion thereby increasing the tendency towards bridging. Extremely stable bridging results under the abovementioned conditions.

Both the feed hopper and the mixer were vibrated in order to eliminate the tendency towards bridging. The extraction properties of the system were improved, but flow interruptions could not be eliminated altogether.

Several modifications to the air-ejector were tried which included a pulsating air feed to the ejector as well as imparting a circular motion to the air leaving the ejector. Here again interruptions could not be eliminated.

Uninterrupted extraction from the feed hopper was obtained by the creation of a localized fluidized zone in the vicinity of the air-ejector. Extraction was, however, possible only within narrow limits of the quantity of fluidizing air; below the lower limit interruption occurred and above the upper limit extraction ceased. The control of the extraction rate was poor and the instantaneous feed-rate varied considerably. Reduction of the moisture content of the coal improved the extraction properties but this improvement did not warrant further exploitation of this system.

A REDESIGNED EXTRACTION SYSTEM:

It was decided to abandon the original Cerchar extraction system and design a new system to satisfy the following requirements:-

(i) The feed-rate must be variable within a wide range and,

(ii) Its instantaneous value must remain constant.

The first requirement can be satisfied by the adoption of positive displacement, such as afforded by a screw-feeder. A screw-feeder, displacing material volumetrically, imposes a further requirement in that the bulk density of the displaced material must be constant in order to obtain a constant mass feed-rate. In the new extraction system constant bulk density of the coal is ensured by vibrating the storage hopper.

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The second requirement viz., constancy of the instantaneous feed-rate, is achieved by causing the feed from the screw to pass through a vibrating screen, the apertures of the screen being such that build-up of the coal on the screen occurs and in so doing eliminates any pulses in the feed from the screw-feeder.

The new feed system thus consists of a vibrating storage hopper, ensuring a constant bulk density of the coal, from which the coal is extracted by means of a screw-feeder. The coal then passes through a vibrating screen and the resulting smooth coal stream then passes to the mixer where the coal is dispersed in the primary air stream. The coal is then pneumatically conveyed to the furnace. The mixer and piping to the furnace are also vibrated to prevent any coal adhering to the internal surfaces.

The coal extraction rate is readily varied by adjusting the revolutions of the screw-feeder and is determined by diverting the coal stream into a beaker and subsequently weighing the quantity collected in a known period of time.

With this feed-system it is possible to reproduce extraction rates within 1 per cent.

FLAME DETECTOR:

Upon cooling of the furnace the pulverized cool flame front gradually moves down the furnace and when the furnace temperature is close to the extinction temperature sporadic ignition occurs at the isolating venturi between the hot and cold sections of the furnace. Unfortunately the observation windows do not extend to the venturi which makes the determination of the extinction temperature difficult. To overcome this difficulty a flame detector was built and inserted in the throat of the venturi.

The detector consists of two neighbouring thermo-couples connected in opposition, one couple is bare and the other covered by a sheath. The output from the detector is zero when exposed to a constant temperature. When there is a sudden change in temperature, such as caused by sporadic ignition of the coal, the open couple will respond more rapidly than the sheathed couple and the output deviates from zero.

This detector records sporadic ignitions which normally go undetected by visual observation.

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PRETORIA.
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