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# CRI TECHNOLOGY DIGEST

## IMPROVED BURNERS FOR CEMENT ROTARY KILNS PART I

CEMENT RESEARCH INSTITUTE OF INDIA

# IMPROVED BURNERS FOR CEMENT ROTARY KILNS
# PART I

## INTRODUCTION

Fuelwise, Indian cement industry is not so comfortably placed as some other countries which happen to have easy access to oil, gas or good quality coals. Barring a few exceptions, Indian cement plants are generally getting high ash coals only, whose ash content ranges from 30 to 40%.

With high ash coals, the conventional burner pipe fitted to a cement rotary kiln does not adequately meet the requirements of efficient combustion. Consequently, it cannot give off a short, broad and intense flame desired for clinker making. Further, high ash coals present problems in coal mill and kiln operations. It has therefore become imperative to explore ways and means for tackling the problems of excessive ash content in coals.

This technology digest (Part I) deals with the operational and technological considerations of the problem; whereas Part II would cover the R&D work done by CRI in this regard in developing an indigenous improved burner suitable for high ash Indian coals.

## PROBLEMS ENCOUNTERED IN BURNING HIGH ASH COALS

The burner nozzles conventionally used for burning of pulverised coal in cement kilns, conform to a certain design evolved on the basis of coals having calorific values of about 6000 kcal/kg coal. On the other hand, coals presently available to Indian cement industry have calorific values ranging between 4000–4500 kcal/kg coal. Assuming that the heat consumption in a kiln system using pulverised coal is 1000 kcal/kg clinker, the requirements of different grades of coal would be as given in Table 1.

In addition to higher consumption of high ash coal, the excess mass of coal required to be fired per unit time, the aerodynamics of fluid (primary jet)and the thermodynamics of combustion are adversely affected.

TABLE 1

REQUIREMENT OF DIFFERENT GRADES OF COAL PER KG CLINKER

| Grade of Coal | Ash & Moisture Content (%) | Net Calorific Value kcal/kg Coal (1% MC) | Heat Required (kcal/kg Clinker) | Coal Required kg/kg Clinker |
|---|---|---|---|---|
| I | 19-24 | 6000 | 1000 | 0·166 |
| II | 24-28 | 4500 | 1000 | 0·222 |
| III | 28-35 | 4000 | 1000 | 0·250 |

## PROCESS OF COMBUSTION IN THE ROTARY KILN BURNER

The primary jet comprising the primary air and the pulverised coal particles issues through the burner nozzles at velocities varying from 40 to 100 m/s thereby giving rise to a turbulent divergent jet. The jet spreads in a conical form losing velocity and entraining gas, ie, secondary air from the surroundings which is drawn into the kiln through clinker cooler in which it receives heat from the cement clinker leaving the kiln. The typical percentages, temperatures and velocities of primary air and secondary air used in rotary cement kilns are shown in Table 2.

TABLE 2

TYPICAL PERCENTAGES, TEMPERATURES AND VELOCITIES OF PRIMARY AND SECONDARY AIR USED IN ROTARY CEMENT KILNS

| Parameter | Primary Air (Max) | | Secondary Air (Max) | |
|---|---|---|---|---|
| | Wet | Dry | Wet | Dry |
| Percentage | 25 | 15 | 75 | 85 |
| Temp (°C) | 80 | 80 | 600-650 | 800-900 |
| Velocity (m/s) | 40-100 | 40-100 | 4-5 | 4-5 |

Since the jet is confined by the refractory wall of the kiln, recirculation eddies are formed which provide a mechanism for the transfer of heat from the hotter regions of the combustor to the cold pre-ignition zone and also of combustion products from the tail of the flame to the inlet region. Under such conditions, the efficiency of combustion of the coal particles depends on the degree of entrainment and mixing of secondary air, the distance of the core of the recirculation eddies from the nozzle and the point where recirculation eddies start. Generally, the mass of the secondary air is expected to be wholly entrained by the primary jet before any recirculation gas is entrained. However, with high ash coals, it has been found on theoretical considerations that due to the shifting of the point of recirculation of eddies towards the burner nozzle, reduction in the mass of secondary air entrained occurs.

Reduction of the rate of secondary air entrainment means lowering of the rate of supply of oxygen for combustion of coal particles leading to a slowing down of the combustion reaction rate. Further, any increase in the mass of primary fluid necessitated by the increase in the mass of coal lowers the temperature of flame which again has an adverse effect on the kinetics of combustion. On the other hand, the rate of recirculation of combustion gases is increased in the case of high ash coal which causes fluctuations in the velocity, length and intensity of the flame depending on the recirculation rate. This creates a problem in controlling the flame stability. Moreover, high ash coal produces a comparatively longer flame which is also undesirable in the case of cement burning. In addition, due to shifting of the point of recirculation of eddies and the core of eddies towards the burner nozzle tip, relatively smaller eddies form which in turn, increase the chances of slip between the pulverised coal particles and the mixture of primary jet and secondary air on account of rapid fluctuations in eddy velocities. Slipping of particles damps the turbulence of the jet due to loss of energy. As a result, the combustion of coarse particles is either incomplete or delayed resulting in lowering of temperature, shifting of the zone of maximum flame intensity towards the kiln inlet, and shortening the effective length of reaction zones. The temperature gradient between the gases and the meal is reduced all along the kiln resulting in lower heat transfer rates and lower production from the kiln. The meal is not burnt with low ash and high calorific coal; and the chances of ash ring formation with its consequent effect on operation of kiln are increased.

## REMEDIES

The possible remedies for the utilization of high ash coals in cement industry are:

a) Beneficiation of coal,
b) Enrichment with oil,
c) Oxygen enrichment of air,
d) Development of improved burners.

The first alternative would be uneconomical due to the high capital and recurring expenditures involved, and the second one is precluded in view of the country's oil position. Oxygen enrichment of air is not only a costly process, but the availability of captive oxygen generating units of desired capacities also poses a problem at the moment. Under the circumstances, improved burners appear to offer a viable solution to the problem of high ash coals. Accordingly, CRI has undertaken the development of improved burner under its R&D programme.

## CONCEPT AND DESIGNS OF IMPROVED BURNER

Several types of burners have been tried abroad on high ash coals. The basic concept behind the design and development of all of them is;

i) to increase turbulence in the primary air jet so as to ensure thorough mixing of coal dust with air; and also.
ii) to increase the residence time of the coal particles in the flame zone through entrainment of secondary air.

All the designs that give off a satisfactory flame are also to be considered against such factors as wear and tear, pressure drops, simplicity and cost of fabrication, and the ease with which they can be installed in the existing kiln burner system.

The following burner designs have been suggested in the literature for im-proving the combustion of air-coal dust mixtures:

a) Tangential entry of fluid stream, or a part of it, into a cylindrical duct.
b) Rotation of mechanical devices which impart swirling motion to the fluid passing through them.
c) Use of guide vanes in axial tube flow.
d) Stepped burner nozzle.

Tangential fluid entry systems may lead to incorporation of considerable modifications of the existing burner system, while rotating mechanical devices, though excellent as far as efficiency is concerned, pose excessive wear and tear problems.

The guide vane swirlers, and to a lesser extent, stepped burners, owing to their simple and flexible design offer good scope for adoption. The stepped burners have the added advantage of being closer to the design of the existing conventional burners and hence amenable to ready acceptance by cement manufacturers. Swirl burners (guide vane swirlers), on the other hand, are considered definitely more effective.

The R&D work at CRI on the design and development of appropriate high-ash-coal burner has reached an advanced stage and it would be dealt in a later issue of the Digest (Part II).

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