OIL-TO-COAL CONVERSION IN CEMENT KILNS *

By

ROGELIO Z. ALDOVER

INTRODUCTION

The country's long-term fuel diversification strategy aims to displace a large portion of oil, especially imported oil, as a major energy source. Our heavy dependence on oil at about 91 percent of the country's total commercial energy requirements has tied us to the grip of countries endowed with this highly political commodity. The strategy therefore is to develop indigenous and low cost energy resources such as coal geothermal, hydroelectric, and non-conventional energy forms. For coal, the targetted markets are largely NPC's planned coal-fired power plants and the conversion of existing oil-fired cement kilns to coal-fired.

We will focus our discussions on cement kiln conversion. The cement industry is the most immediate large consumer of coal and its fuel conversion to coal firing may enable the reduction of fuel oil consumption by 4 million barrels a year. Studies show that conversion of existing oil-fired thermal power plant is not yet economic due to major alterations that need to be done and a considerable operational down time during the actual change of equipments.

Of the country's eighteen (18) cement plants distributed across the archipelago, four are now coal users. The rest are in various stages of planning and implementation of individual coal conversion programs. The first conversion is expected before the end of next year.

ECONOMIC CONSIDERATIONS

The biggest incentive for conversion from oil-to-coal burning is the profit margin in fuel cost brought about by rapidly escalating oil cost compared to coal cost. On a Btu-per-Btu count and on a delivered-to-plant basis, this incentive is highlighted by the following Luzon-based cement plant case:

---

* For discussion purposes only. Presented by Mr. Rogelio Z. Aldover, MSC, at the National Engineering Center Workshop for Mechanical Engineering Teachers.

COST COMPARISON
(₱/million Btu)

	Oil	COAL Local	COAL Imported
Cost Delivered	20.98	12.27	12.43
In-plant handling and Processing Cost	0.18	0.52	0.45
TOTAL COST	21.16	12.79	12.88
SAVINGS OVER OIL			
Per MMBtu (₱)		8.37	8.28
Annually (thousand ₱)		13,854	13,667
BREAK-EVEN DELIVERED PRICE			
Per MMBtu (₱)		20.64	20.71
Per ton of 10,000 Btu Coal (₱)		454	456

The above estimates are based on the following assumptions:

1. Coal delivered to plant includes such items as FOB cost, insurance freight, duties, specific tax, brokerage fees, wharfage fees, stevedoring, checking charges, trucking costs and other pier costs.
2. In-plant handling and processing refer to items like, cost of pumping and heating in case of oil, power cost, maintenance, maintenance, fuel for heavy equipment and driers, and labor costs.
3. Coal is delivered at the following prices per metric ton early 1978 estimate):

   Local — ₱270/MT (10,000 Btu per pound)
   Imported — ₱320/MT (11,700 Btu per pound)

   Fuel oil is delivered at ₱0.35/liter (18,000 Btu per pound) Recent price increases have further widened the gap between oil and coal cost.
4. Total conversion cost of equipment is assumed at ₱25 million including coal dryer cost for a 1500 MTD cement plant.
5. Actual fuel oil consumption is 4.4 per bag of production or 100 metric tons per day for 1500 MTD cement production. Equivalently, coal consumption is 218 MTD.

TECHNICAL CONSIDERATIONS

COAL FUEL PROCESSING

A coal pulverizer reduces run-of-mine (ROM) lump coal into dust coal for eventual firing in cement kilns. In its powdered form, pulverized coal has better combustion characteristics than lump coal.

The extent of fineness has been specified to be 85 per cent passing through 200 mesh. Under conditions providing for enough oxygen supply and minimum amount of heat, any amount of processed coal is greatly liable to spontaneous combustion. This critical stage of fuel handling should be sufficiently equipped against untoward ignition.

Process Flow Diagram

From the stockpile, ROM coal is pushed by a bulldozer into a pick-up pit of the bucket elevator which discharges direct into the crusher. Coal is crushed into 1" x 0 sizes and then fed by granty into the dryer.

Drying is done by a separate coal-fired furnace with outlet temperature maintained at 80° to 90°C at the maximum, making the moisture content at 1 percent to 8 percent.

A second bucket elevator picks dried crushed coal and discharges into a daybin which can hold 4 to 8 hours supply. From the bin, coal is fed into the pulverizer by a variable feeder.

The pulverized coal (at least 85% passing through 200 Mesh) is air-swept into a classifier. Find coal is sucked by an exhauster fan and conveyed directly into the burner, in case of direct firing system; or into a day bin, in case of an indirect fiiring system. Coarse coal particles are returned by gravity back into the pulverizer.

The pulverizer is operated at a negative pressure which is regulated by butterfly valves for both atmospheric and hot air intakes. Atmospheric air prevents the temperature of dust coal from exceeding 200°F (93°C) to avoid spontaneous combustion.

Feeding pulverized coal into the cement kiln may be done directly or indirectly.

Comparison of Coal Pulverizer Types

1. Ball or Tube Mill
2. Roll and Race Mill
3. Bowl Mill
4. Attrition Mill

Factors in Section

1. Feed Range Capability
2. Reliability of Performance
3. Simplicity of Design
4. Product Quality
5. Power Consumption
6. Maintenance

COMPARISON OF COAL PULVERIZER TYPES

Ball or Tube Mill	Horizontal rotating cylinders or balls grind coal by impact, attrition and crushing	1. Lower maintenance cost 2. Good consistency of product fineness 3. Higher availability factor	1. Because of massive structures, consumes about a third more of power 2. Excessive noise
Roll and Race Mill	Three equally spaced hollow toroidalrolls which travel in a concave grinding ring controlled by a uniformly loaded thrust ring.	1. 25% force power consumption compared to ball mill 2. Silent operation 3. More compact	1. High maintenance cost (about 5 times that of ball mills) 2. Lower availability factor compared to ball mill 3. Requires more attention
Bowl Mill	Similar to the roll and race type except for tapered rollers and a rotating bowl.	Same with Roll and Race Mill	Same with Roll and Race Mill
Attrition Mill	High speed pulverizer that imparts high velocities to coal particles through a rotating impeller that provides a searing effect.	Same with Roll and Race Mill	Same with Roll and Race Mill

Studies show that advantages of the ball mill outweigh its disadvantages and more so with other mill types. Cement companies express their preference in using ball mills as applied to coal conversion.

KILN OPERATION

The kiln operational characteristics may be affected by factors that could be directly attributed to considerable variability of coal quality.

Firebrick Life — Temperature fluctuations as a result of variable heating value cause thermally-induced cracking of the firebrick lining.

— Ash ring formations inside the firing zone constrict the opening of the combustion chamber that result to greater wear and tear of the lining.

Stability of Kiln Operation — Combustion and material flow characteristics need to be closely monitored to compensate for lower heating value of coal.

— Ash rings may form and impede normal flow materials.

— In case of dual firing, the proper combustion of coal and oil burning need to be assured for better combustion efficiency and stability.

Clinkering — Low quality coal results to lower flame temperature and shorter flame length thus limiting the extent of cooking of feed materials.

Against these setbacks which are attributable to the relative difficulty of solid fuel burning, coal fuel supply, distribution and processing must therefore assure fairly consistent quality of coal within acceptable bands.

To put quality aspects into a common reference point, coal quality is normally guaranteed by suppliers meeting the minimum requirement of the industry as follows:

Heating Value	9,500 Btu/1b minimum (as received)
Total Moisture	10% maximum
Sulfur	3% maximum
Ash Content	10% average
	8% maximum
Volatile Matter	20% minimum

Largescale mining, in lieu of quality-inconsistent "camote" mining operations, is expected to put these externalities under manageable proportions. This will make both the mining and utilization aspects of coal more viable operations.

Likewise coal logistics, distribution, processing systems, whether centralized or individualized, are programmed to support the coal conversion program requirements attuned to the aforementioned considerations.

CONVERSION LEADTIME

The total time alloted for a conversion project from initial proposal and feasibility studies to actual commissioning is about two (2) years. Presently, individual cement plants have undertaken their own feasibility studies. In this connection, actual leadtime, under favorable conditions would take only eighteen (18) months. Kiln operation downtime would take at the most two (2) months to "hook up" the coal-firing devices to the original oil-firing system.

FINANCIAL CONSIDERATIONS & INCENTIVES

Under Presidential Decree No. 972, otherwise known as the "Coal Development Act of 1976", the Development Bank of the Philippines is committing itself to totally finance conversion projects. The direct and indirect foreign currency costs will be funded through a DBP-IBRD tie-up.

Financial projections at costings quoted in 1977 already showed that a coal conversion project for oil-fired cement kilns are self-paying ventures on at least 30 percent rate of return on investment, on a worst case. As coal-against-oil price margin widens the financial incentives go further.

Under the same P.D., coal conversion projects can also avail of fiscal incentives enhancing the financial position, namely:

1. Accelerated depreciation
2. Tax exemption on imported equipment
3. Tax credit on capital equipment
4. Net operating less carry-out

ENVIRONMENTAL IMPACT ASSESSMENT

Coal burning is frequently associated with environmental pollution to a very harmful level imagined by most people. Three type of potential pollutants, viz, coal dust, coal ash, and combustion gaseous products.

1. Coal dust

   Coal dust generated during handling is minimal compared to the dust produced in the cement manufacture itself. Sprinkling water over the pile surface prevents the spread of dust from this source. When coal is pulverized, the process is done in a closed system under negative pressure. In addition, cyclone dust collectors are aptly installed within the system.

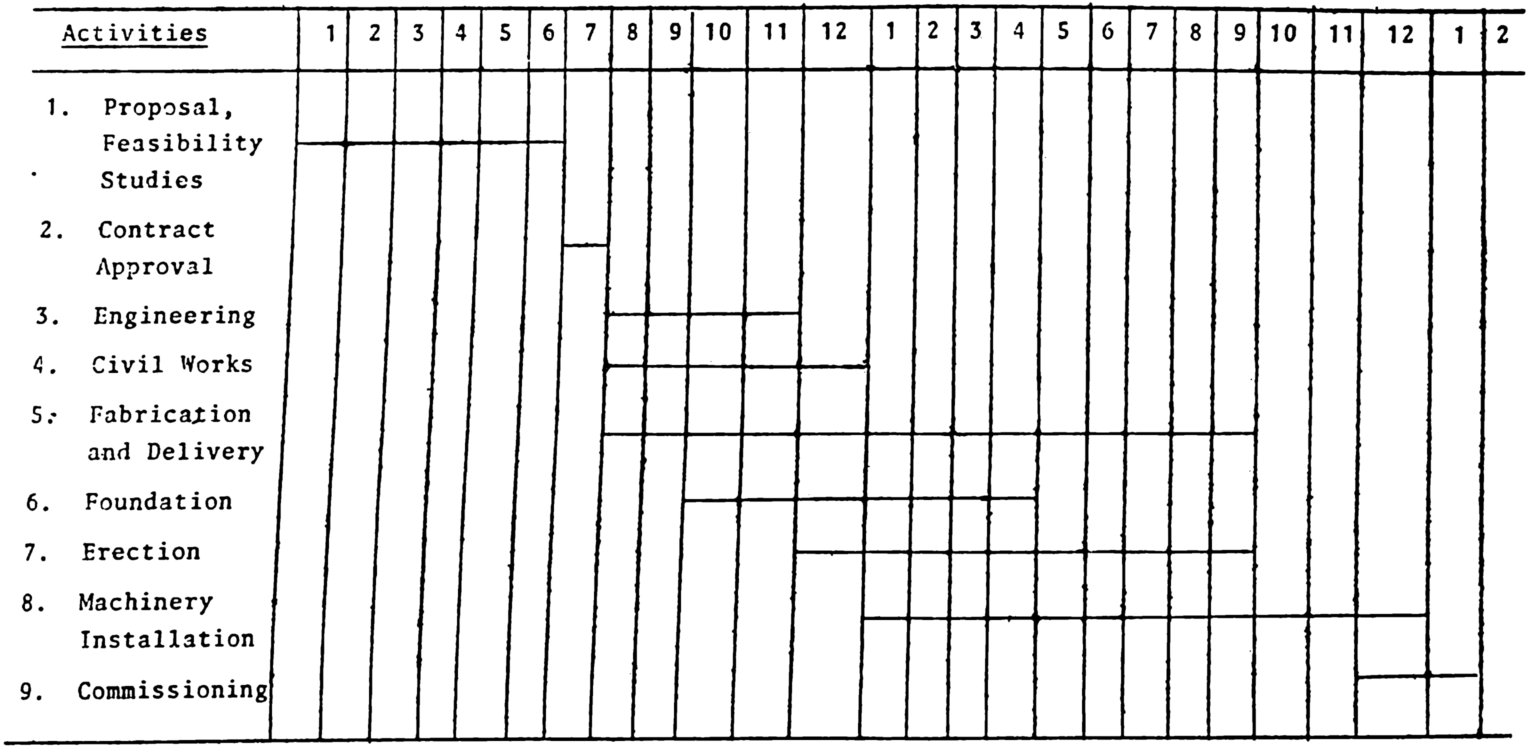
2. Coal ash

   Solid combustion products, or ashes, are predominantly silica, alumnina and iron oxides which are major raw materials in cement manufacture. Larger ash particles combine with feed materials and become part of the clinker. Lighter particles with sizes less than 40 microns or fly ash, constitute only a negligible portion of the ask products and are handled by cyclone collectors, dust collecting bags or precipitators.

3. Gaseous products

   During burning, carbon in coal is transformed to carbon dioxide (CO_2), or incompletely to carbon monoxide (C)) and sulfur to sulfur dioxide (SO_2). CO and SO_2 are potential pollutants. Efficient combustion lessens the formation of CO. On the other hand, sulfure presence below 3 percent is actually beneficial to cement manufacture because the enough SO_2 formed combines with lime to form gypsum, which is another cement ingredient. Excessive sulfur should therefore be avoided and this is the responsibility of coal supply arrangements.

CONVERSION LEADTIME



FLOWSHEET OF CEMENT MANUFACTURE