

THE USE OF COAL AS FUEL FOR CEMENT MANUFACTURING AT PT. SEMEN GRESIK

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ABSTRACT

The conversion of fuel type, from oil to coal has considerable consequence as coal has very different combustion characteristics from oil. As the price of coal is much lower, the process is viable.

The use of coal as fuel in the cement industry requires more effort in technological treatment, such as: installation of the grinding plant, modification of the existing equipment, and the monitoring and continuous adjusting the blend. As the "ash" in the coal used for firing will combine with the raw mix during burning and thus causes a quite considerable change in the composition of the clinker.

The combination of different blends of coal with different ash contents has to be carefully monitored to ensure clinker quality.

I. INTRODUCTION

The rapid rise in oil prices after the 1970s induced a multitude of industries, especially the cement industry, to consider how to process fuel oil and use alternative fuels. As we know cement manufacture is one the energy-intensive industries.

After considering many aspects, PT. Semen Gresik has come to the conclusion that to convert from the usage of oil to coal at the present time has more advantages, especially from the economic and availability view points.

Since 1986 PT. Semen Gresik has been running with pulverized coal fuel. This decision, however, has had considerable consequences, as coal has very different combustion characteristics from oil. Due to these fundamental

differences very different preparative techniques are required. For instance, the coal needs to be pulverized, this requires the installation of a grinding plant and further modifications. The coal blend has to be continuously monitored and altered due to the variety of coal types supplied.

So it is necessary to take more care and enhance our knowledge to secure smooth and safe operation, as some pieces of equipment at P.T. Semen Gresik were originally designed for oil firing.

II. PULVERIZED COAL HANDLING AND PREPARATION

PT. Semen Gresik use: coal from three localities in Kalimantan: Loa Ulung, Embalut,

Kota Baru. The quality of the three coals varies from "best", "good" to "less good" respectively. The precise qualities of the three coals may be seen in Table 1 which contains the results from ultimate and proximate analyses. The various properties of the three coals will mean each coal has a different calounfic valve and different, refractory and clinker qualities. Consequently each coal type will require a slightly different handling procedure.

As pulverized coal is combustibles, it is also ignitable and therefore potentially explosive. Besides, coal has a certain tendency to self-ignition under the influence of the ambient temperature of storage. Therefore, handling of pulverized coal must be done carefully and the technical safety aspects of it must be understood (Table 2).

Table 1. Proximate analysis of some coals*

Analysis, mass percent	Loa Ulung	Embalut	Kota Baru
Fixed carbon	49	44	41
Volatile matter	42	40,5	40
Moisture	4	10	3.5
Ash	4	6	14
Sulphur	0.41	0.13	0.66
Gross heating value, Kcal/kg	7300	6375	6400
Ash composition			
SiO ₂	32.26	47.80	49.50
Al ₂ O ₃	24.50	29.21	45.20
Fe ₂ O ₃	14.00	7.29	3.26
CaO	15.28	3.04	0.48
MgO	2.60	0.41	0.43
SO ₃	9.19	4.80	0.46

* It refers to the test result of P.T. Semen Gresik laboratory.

The number of parameters in Table 2 depends on the physical properties, such as fineness and moisture content, and on the chemical composition, volatile matter and ash content: these properties will vary from coal to coal and from blend to blend.

Table 2

Safety criteria for pulverized coal		
Self-ignition	°C	140
Smouldering temperature	°C	290
Ignition temperature	°C	550
Max. explosion pressure	bar	8
Max. pressure rise in time	bar.s ⁻¹	120
Lower limit of flammability	g.m ⁻³	60
Upper limit of flammability	g.m ⁻³	6000

Self-ignition occurs as a result of heat evolution due to the reaction of finely divided coal (*dust or pulverized fuel*) with atmospheric oxygen without energy from an outside source. It is a process that can be accelerated by elevated initial temperature or by prevention of the escape of heat, and is promoted by large surface area of the pulverized material, i.e. by greater fineness of the particles. It can start even at moderate temperatures and be accelerated by raising the initial temperature or by obstruction of heat dissipation.

Smouldering is incipient open combustion, characterized by incandescence without flame. The smouldering temperature is defined as the temperature at which a 5 mm thick layer of dust or pulverized fuel on a heated plate is brought to the smouldering condition within two hours.

Ignition temperature is defined as the lowest temperature at which a mixture of dust or pulverized fuel and air burns in a sustained manner with a self-contained flame.

An explosion is defined as a rapidly occurring combustion process in which the thermal of the gases evolved brings about a measurable rise in pressure. With reference to the explosion behaviour of dust-air mixtures with varying concentrations, a distinction is drawn between the lower and upper limits of flammability. The range between the two limits is called the

explosive range or flammability range. Concentrations of coal suspended in air which are less than the lower limit and more than the upper limit are considered to constitute no threat of explosion.

However during start-up and shutdown of a coal-grinding plant the internal conditions always pass through the explosive range bounded by these two limits. So practically we cannot avoid this explosive range, but we should be aware of, and control, the other factors to avoid explosions.

After considering many aspects of the preparation of pulverized coal of the P.T. Semen Gresik comes to the conclusion that :

- a vertical mill/roller mill is selected for the grinding equipment.
- an indirect system is selected as a firing/feeding system of coal to the kiln.

The coal grinding plant is depicted in Fig. 1. There are two roller mills at P.T. Semen Gresik; the capacity of each is 15 tph to serve two cement rotary kilns. Hot gas operating these operating these coal mills is supplied by both : from the grate cooler when it is operating while the cement rotary kiln is running, and from the hot gas producer when the cement rotary kiln is shut down.

Before entering the coal mill, dust or clinker particles along with hot gas from the grate cooler are extracted by a dedusting cyclone.

Raw coal with moisture content between 10% and 15% is fed to the mill and introduced with hot gas of about 280°C. Pulverized coal from the roller mill is directly precipitated in the dust collector and then stored in the pulverized bin. This pulverized coal contains a residual moisture of 2-4% at a fineness of about 30% retained on a 0.09 mm mesh sieve (170 Mesh). Theoretically, higher fineness and lower moisture content would be better for completeness of combustion, but there are

difficulties in controlling feeding to the kiln due to the flushing of pulverized coal.

As pulverized coal is generally conveyed pneumatically over a substantial distance, the following statement must be kept in mind : the finer the material has been ground, the poorer is its flowability and the lower its bulk density, so that the conveying performance is correspondingly worse.

Based on this technical characteristic, P.T. Semen Gresik came to the conclusion to increase the particle size of the pulverized coal to achieve a better operation and reduce the danger of explosion and fire. Of course, a few problems are caused by increasing of the particles size. One of them is the increase of back end kiln temperature due to the incompleteness of combustion of coal particles at the burning zone. As a further effect, if using fuel oil it raises the degree of calcination up to 5% compared with the design condition.

The fineness of 15%-20% retained on 0.09 mm mesh sieve and moisture content of 1-2% are commonly used in many companies, but it is extremely difficult to control. It must be kept in mind, however, that the degree on pulverization depends likewise on the volatile content. For better combustibility, coal with a low volatile content has to be more finely pulverized than coal with a higher volatile content. Several companies have applied a rule of thumb which states that the percentage residue retained on the 4900 mesh per square cm sieve (corresponding to BS or ASTM 170) should be not more than half the content of volatile constituents.

As it is very dangerous, handling of pulverized coal has to be careful and much attention should be paid, especially from the safety engineering point of view. Safe operation of the coal grinding plant is ensured if the limit of values for the measured quantities, as indicated in Table 3, are not exceeded in any ope-

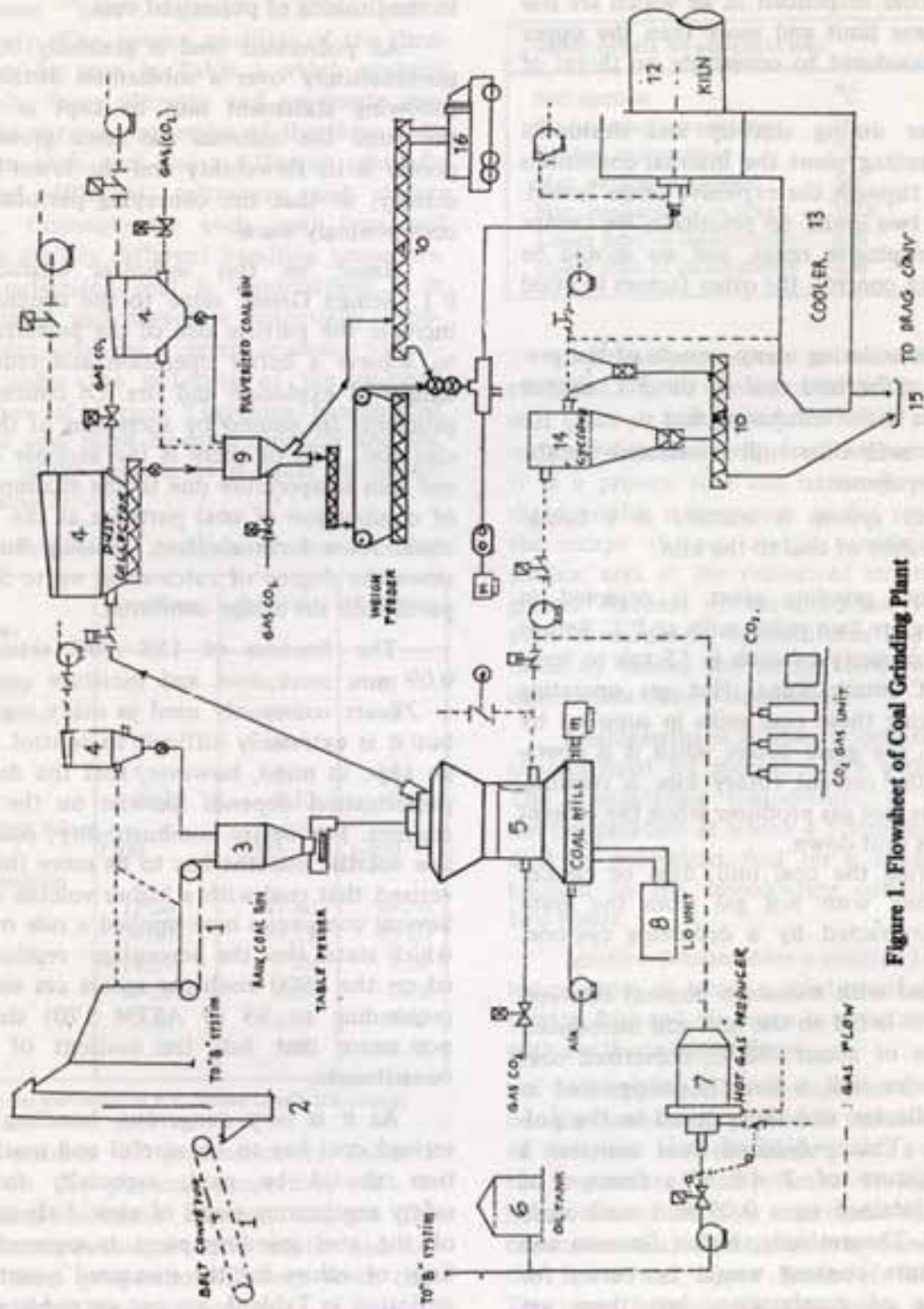


Figure 1. Flowsheet of Coal Grinding Plant

rating phase of the plant. If some of those values are exceeded, the plant must be shut down. Obviously, this is something to be avoided as possible. Therefore, shutdown response levels require two alarm levels, enabling the operator to intervene promptly and take action to prevent the limit values being exceeded.

Table 3. Limit values of measured quantities for coal mill operation at P.T. Semen Gresik.

Temperature at mill inlet	interlock	300°C
Gas temp. after mill, before filter	interlock	80°C
Gas temp. after filter	interlock	80°C
Gas temp. before mill, minimum	3°C above	dew point
Pulverized coal temperature	alarm	80°C
CO concentration: bag filter outlet	interlock	70°C
Coal mill: differential pressure	interlock	900 mm H ₂ O
Bag filter: differential pressure	interlock	250 mm H ₂ O

III. MODIFICATION OF THE EXISTING EQUIPMENT

As pulverized coal is substantially different from oil, especially in physical and chemical properties, it also needs a different treatment for achieving good operation.

One of the most important factors which affects the burning process is the burner nozzle design, because it determines the length and the shape of the flame, the size of the burning zone and the thermal rating.

The length and the shape of the flame themselves depend on the following factors:

- good mixing of the fuel and oxygen, which depends mainly on the burner nozzle design and primary air velocity
- intensity of heating
- reactivity of the fuel.

By paying attention to all these factors we should make alterations and/or modifications - from an old burner nozzle design is

suitable for burning oil to a new one which conforms to the use of coal fuel - to achieve a perfect burning system. Fig. 2 shows the modification from an oil burner nozzle to a coal nozzle.

We can see the relationships between all the factors which influence the combustion of pulverized coal in the formula derived by Gumz:

$$Z = 4.784 \cdot 10^6 \frac{\kappa \cdot v^{0.15} \cdot d^{1.85}}{T(W_s^{0.15})} f(n) \left(1 - \frac{V}{100}\right)$$

$$\frac{1}{1 - \frac{x}{n}} \xi^{-0.383} \cdot f(w, \xi)$$

- Where:
- z = burning time (s)
 - κ_0 = gross density of the initial fuel (kg/m³)
 - v = kinematic viscosity of the carrier gas in the combustion chamber (m²/s)
 - T = mean absolute temperature of the carrier gas in the combustion chamber (oK)
 - d = grain diameter
 - W_s = sinking speed of grain (m/s)
 - $f(n)$ = corrective factor for the influence of excess air
 - n = excess air ratio
 - V = volatile content
 - x = portion of oxygen requirement for combustion of the volatile content relative to the total oxygen requirement (%)
 - ξ = degree of swelling, i.e. the volume of the inflated grain in proportion to the initial volume of grain
 - $f(w, \xi)$ = correction factor for the influence of the rate of swelling and the volatile content on the sinking speed.

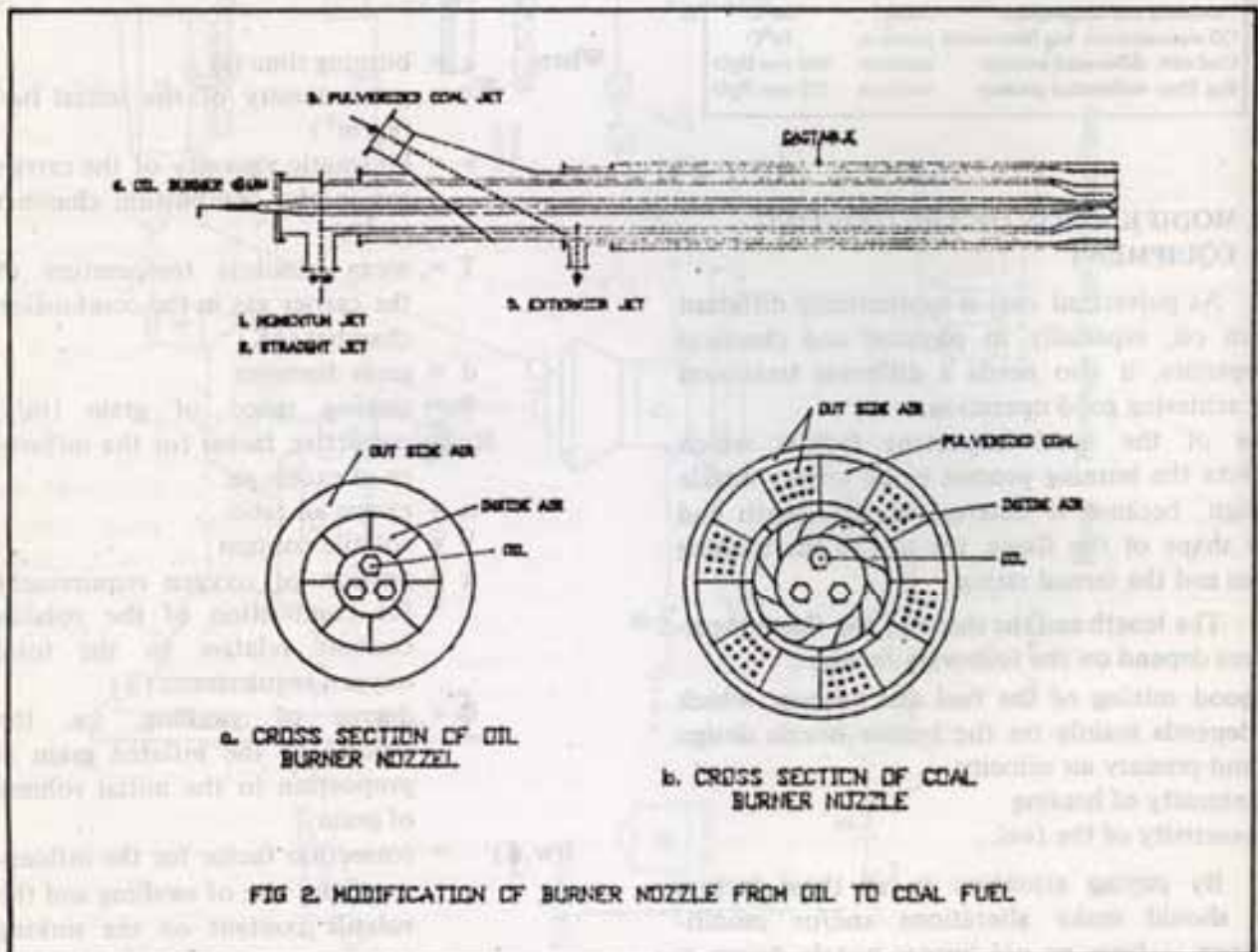
In the Gumz formula the following factors are the most influential :

- grinding fineness; the burning time of a coal dust grain increases approximately with the square of its diameter
- volatile content, the higher the volatile content, the shorter the burning time
- temperature in the combustion chamber, the higher the temperature the faster the burning process
- rate of swelling the higher the expansion of the grain during heating, the lower its density, the shorter the burning time.

IV. INFLUENCE TO THE CLINKER QUALITY AND RAW MIX DESIGN

Combustion of coal results in ash. The amount depends on the coal quality. The ash will combine with the other oxidized material in combustion process to form clinker the ash oxide composition victually the same as that of the clinker oxides. The quantity of each oxide in the clinker may impair the clinker quality.

In order to maintain the clinker quality, we have to take into account the addition of ash absorbed doing the process of combustion. In other words, when we are carrying out the calculation of the raw mix design, we have to



predict how much ash will be absorbed in the clinker. By knowing which oxides are present in the ash we can decide whether we have to increase or decrease a certain oxide in the raw mix to provide the correct clinker oxide balance.

As a rule, the calcium oxide must be increased, in raw mix, to compensate for the larger addition of silica from coal ash, so that we will have an appropriate clinker composition. The amount of increase in calcium oxide, in raw mix, depends on the silica ash content.

When the coal type used is changed, either a proper raw mix design must be used for insuring kiln stabilization, or a good quality coal.

V. CONCLUSION

Experience hitherto gained in practice shows that pulverized coal fuel handling can be carried out safely provided we master all the relevant working conditions and parameters.

It is really important to use sensitive measuring instruments to detect early indications of dangerous circumstances.

REFERENCES

1. Dupa W.H., "Cement data book".
2. El-Wakil M.M., "Powerplant technology".
3. Engel O.A., "Seminar on coal and cement".
4. Feige F., Rossner, P. Schutze K., 1914, "Technological possibilities for the production on pulverized lignite fuels". *Translation ZKG* No. 4/84 (pp.181-184).
5. Forrest M.J. "Rotary kiln technology"

A Word Cement Publication.

6. Kunnecke M., Heilmann H., 1981, "Refractory lining of the burning zone in coal-fired rotary cement kilns". *Translation ZKG* No. 8/81 (pp. 407-411).
7. Labahn O., "Cement engineers handbook"
8. Ludera L.M., 1986; "Burning zone lengths and burner nozzle diameters in rotary kilns". *Translation ZKG* No. 11/80 (pp. 558-568)
9. Moye R.S., "Development in the conversion of cement kilns to coal firing".
10. Rouze W., Beckum, 1980, "Requirements to the electrical equipment of cement works using as fuel". *Translation ZKG* No. 11/80.
11. Scherrer, 1984, "Present-day concepts of safety engineering in the handling of pulverized lignite". *Translation ZKG* No. 4/84 (pp. 175-180).
12. Schmidt R.J., 1980, "Controls for coal pulverizing systems". *Translation ZKG* No. 11/80.
13. Schneider, 1984, "Operating experience in coal-grinding plants from the safety engineering viewpoint, and the conclusion be drawn therefrom". *Translation ZKG* No. 4/84 (pp. 167-174)
14. Schneider L.T., Becker O., "Mechanical and process aspects coal grinding plants". *Coal Technology and The Cement Industry*.
15. Their B., 1984, "Safe operation of coal grinding plant" - Results of the working group "solid fuels" of the VDZ. *Translation ZKG* No. 4/84 (pp. 163-166);
16. Wolfrum E., Scherrer E., "Pulverized lignite - Properties and safety engineering aspects of its use". *Translation ZKG* No. 8/81 (pp. 417-423).
17. ———, "Flame technology" *Cement Seminar Process Technology* - Holderbank.