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20 March / 22 April 1986
English

15604

IMPROVEMENT IN THE USAGE OF LOW GRADE FUEL IN THE CEMENT INDUSTRY

DP/IND/84/020/11-23/31.4.B

Technical report: Approaches to mitigating the effects of the high ash content of coal, and to increasing the efficiency of energy use

Prepared for the Government of India
by the United Nations Industrial Development Organization
acting as executing agency for
the United Nations Development Programme

Based on the work of Brian Locke,
expert in combustion, gasification,
the use of low grade fuels and efficiency improvement

United Nations Industrial Development Organization
Vienna

This report has not been cleared with the United Nations Industrial Development Organization which does not, therefore necessarily share the views presented.

EXPLANATORY NOTES

<u>Currency</u>

Rupees 17.82 = £1.00 Sterling
Rupees 11.97 = $1.00 US
(mid values for £ and $ cash and travellers' cheques)

<u>Unusual technical abbreviations</u>

VM	=	Volatile matter in coal (%)
FC	=	Fixed carbon in coal (%)
DAF	=	Dry ash free
DMMF	=	Dry mineral matter free
tpa	=	tons or tonnes per annum
cv	=	calorific value kCal/kg

<u>Unfamiliar acronyms etc</u>

NCB	-	National Council for Cement and Building Materials, Delhi (also, apparently, NCBM or NCCB
CRI	-	Cement Research Institute, Ballabhgarh
ACC	-	Associated Cement Companies, India
JK	-	Jammu and Kashmir Cement, India
CFRI	-	Central Fuel Research Institute, India
RRL-H	-	Regional Research Laboratory, Hyderabad, India
BHEL	-	Bharat Heavy Electricals Ltd, India
APCM	-	Associated Portland Cement Manufacturers,
Blue Circle	-	Synonym for APCM
ESP	-	Electrostatic precipator

(Note: in the United Kingdom, NCB stands for National Coal Board, CRE - Coal Research Establishment of the National Coal Board)

II ABSTRACT

Title - Improvement in the usage of low-grade fuel in the cement industry.

Number - DP/IND/84/020/11-23/31.4.B.

Objective - To improve the total productivity factor in the industry and the technological levels of the various units of the cement industry in India through strengthening of the national centre - the National Council for Cement and Building Materials.

Duration - One month overall.

Main Conclusions and Recommendations

1. The programme is worthwhile and its results should be of value to India's cement industry, especially as it not only modernizes itself but also expands to meet government targets for over double the output by AD 2000.

2. The particular purpose - to develop technology to accommodate coals whose ash content is already too high for the plant and processes concerned, and that is rising - is essential for the continuing capability of the industry to meet demands upon it.

3. The general purpose - to strengthen the National Council for Cement and Building Materials to assist the development of the industry - is equally important.

4. A programme has been recommended covering the subjects of improvement of coal supplies; improvement of availability of data essential to the National Council in its task of assisting the industry and encouraging its development; working with outside expert organizations in India and elsewhere to investigate and develop suitable processes from those described for beneficiation, combustion and gasification of coals and for other energy-related aspects of cement making; working closely with, and using the resources of, the industry; and encouraging campaigns for improved energy usage and management in both existing and new plants.

5. The National Council should arrange for staff from itself and from the industry to visit recommended bodies abroad to extend horizons and provide bases for transfer of technological philosophy.

6. If a further visit is made in six months' time then progress can be reviewed and the programme further developed. If sufficient progress is made earlier, then the author can recommend details of training for National Council staff.

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INTRODUCTION

Over a third of the Indian cement industry's capacity (42.4 million tpa, 94 works) is out of date plant. Government plans aim at raising the total capacity by 50% in three years, and at doubling it before the end of the century. Coal supply represents some 30% of the cost of making cement; and its ash content, at 30-50%, is already too high for the plant and processes involved, and is rising. Much of the ash is finely-divided and widely disseminated throughout the coal substance (the inherent ash) and both it and the extraneous ash are difficult to separate from the coal. Some of the coal travels 2000 km to the cement works, and transporting the useless ash represents considerable waste of railway and road truck resource as well as of cement works handling capacity.

The National Council for Cement and Building Materials (NCB) is tackling these energy issues as part of a comprehensive UNDP-funded programme to aid modernisation of the cement industry for development into the future. The programme, costing some $3 million, is to involve more than 30 UN consultants over some three years. This assignment is the fourth in the sequence and took place while the NCB energy team was being put together.

In the past the cement industry has managed to use the coals supplied because cement chemistry could accommodate the constituents of the coal ash, while maintaining quality and keeping to cement specifications for the grades concerned. Already, however, the ash contents of the coals have risen to levels that are unsatisfactory for cement making. Further increases in ash content will jeopardize output and quality, so a dual approach is needed - to reduce ash contents of coals if possible, and to mitigate their effects if not. The programme set out in this report is the result of discussions with the Cement Research Institute (CRI) staff, and has these purposes, along with general improvement of energy usage and production efficiency. Optimal use should be made of the resources of expert external organizations in India and abroad, and also of facilities within the cement industry. Detail technological matters are discussed in this report. The recommendations and programme are based on morphological analysis of the CRI priorities in the light of discussions with the staff and of questions and points made at the lecture and seminars given by the author. Much literature has been given to CRI illustrating points made.

NCB wishes to strengthen its resources to assist development of the industry. Accordingly, as well as increasing technological strengths in its staff, there is also need to develop and systematize the collection and use of data from cement plants and from coal suppliers. Staff say that, while NCB does not regularly collect industry statistics, the government does to some extent in the form of cement production and despatches, under the aegis of the Cement Comptroller's Office of the Ministry of Industry. Such statistics should be made available to NCB along with disciplined related coal data as indicated in the report. Such data would improve the NCB perspective on essential details of operations in the industry, and provide proper technological bases for technological work for the future.

The energy issues of the cement industry in India are not the same as those in other countries, and generally new processes cannot be simply imported and used directly to overcome present coal problems. If suitable processes existed they would already either be being used or be components of existing programmes. Processes available elsewhere will require to be adapted, and new processes will need to be developed, for use with the coals that will be available in the future.

Provision should be made in budgets for laboratory and statistical work, for pilot plants, and for plant trials, preferably using underloaded plant or dormant works. It is not possible at this early stage to produce cost estimates, but they should be derived as and when essential data becomes available during the programme of work.

There will be much work to do, and the recommendations and programme herein should form a basis for progress to worthwhile objectives. When sufficient information has been obtained by NCB on the coals used in their industry, then a selection can be made from the wide range of potentially useful processes, so as to concentrate on those most applicable to the coal characteristics concerned. Then, in conjunction with data on the experience of the staff, it should be possible to recommend the areas for study by suitable staff, on visits abroad.

SHORT SUMMARY OF RECOMMENDATIONS

(These are derived and more fully delineated in the main body of the report. There is also an NCB format for recommendations, that follows on p 49)

The ash in coal fired into cement kiln becomes part of the cement. Five years ago, the ash content of coal supplied to cement plants did not cause concern. However, the ash content is rising year by year and there is difficulty now in maintaining cement quality with the increasing component of ash in the product. Already the clinker is having to be ground more finely to maintain quality and this adds to the cost of cement manufacture. As the ash content of the coal rises further, cement output, far from increasing in accordance with government and industry plans, will fall owing to inability to maintain output to specification.

Something must be done. and there are four successive approaches :

a) reduce the ash content of coal delivered to cement plants;

b) reduce the ash content of the fuel fed to the cement kiln;

c) reduce the energy consumption of the kiln;

d) consider new energy-reducing types of cement-making process.

Accordingly, the following recommendations are based first on change or adaptation of the system for supplying coal to the cement industry, then on the use of expert external agencies. In parallel, there is also work for the industry itself with suitable balance between NCB, plants and research resources.

In discussion with NCB and after considering issues involved and technological possibilities, the following recommended approach has been agreed :

1. Set going specific negotiations to improve the system of allocating coals to cement plants

   a) to include coals of less-high ash contents

   b) to label coal waggons with the source as well as the grade of coal

   c) to increase the allocations to plants to allow suitable stocks to be maintained for blending coals to optimize their characteristics.

2. Continue, and encourage, arrangements with other bodies in India to develop improved processing methods for use before supplying coals to cement plants

a) with CFRI, to extend to present and possible future cement grade coals the work already done for coking coals for the steel industry. This could include investigation of ash and coal characteristics with regard to the potential for, eg., hand picking, jigging, froth flotation - to establish the extent of technical feasibility

b) with Coal India, as regards the economic feasibility and practicability of establishing beneficiation plants at points central to cement plant groupings, or at collieries, with extra saving in transport costs.

3. Continue arrangements with other bodies in India to develop processing methods for use at cement works

a) with RRL Hyderabad, as regards gasification for part of the coal fed to kilns, so as to fire gas ash free, instead - for possible adaptation of their techniques

b) with BHEL Tiruchirapalli, as regards their work on fluidized bed combustion and on gasification, for possible adaptation of their techniques.

4. Use low ash lignites where conveniently located for cement plant use to the extent allowed by cement chemistry.

5. Continue arrangements with other bodies in India to investigate specific areas of coal science for cement grade coals; eg. CFRI or the Dhanbad School of Mines to ascertain the relationship between inherent and extraneous ash, and the particle size ranges, proportions and d ities, with a view to treating different screen or p verized fractions differently.

6. Investigate new approaches as regards the possibility of using or adapting technologies available elsewhere

a) Conveyor & Ropeway Services, Calcutta, have connections with hydroclone suppliers in the United Kingdom for treatment of high ash coals

b) Warren Spring Laboratory (government) and Paladon, in the United Kingdom, have much experience of new approaches to classification and separation of particles considered difficult to separate

c) The Coal Research Establishment of the National Coal Board in the United Kingdom have developed a fluidized gasification process that offers potential for adaptation to handle part of the coal fed to a cement kiln. The same organization has valuable fluidized combustion technology that could be of use, as do other organizations in the United Kingdom. Previous experience with cyclone combustion can also be made available.

The same organization is developing a process for solvent refining of coal that may be worth considering in the future although it seems unlikely to be economically feasible in the short term. There has also been useful American work aimed at liquid boiler fuels, a simplified version of which may be adaptable for cement kiln use

d) Pelletising raw meal to contain part of the coal supply suitably within the pellets (as in the Gottlieb process) could lead to combustion part way along a rotary kiln, and better incorporation of ash within clinker

e) Processes such as those of Scientific Design, and pretreatments of the Rohrbach/Dottenhausen type, that are useful for high mineral content shales, may have value for use with Indian coals

f) The use of oxygen-enriched combustion air to increase flame temperature and reduce gas volume could be considered when all other energy efficiency measures had been adopted.

7. Tackle the opportunities for general energy savings that are common to all industry - audit, survey, improve, report, target and monitor. Reduction of kiln losses and use of waste heat are most important, as reducing the coal input to the kiln reduces the ash input too.

8. Systematize within NCB or CRI the seeking and receiving of information from cement plants so as to enable a quantitative view to be maintained of the pattern of events and of change. This will be particularly important as regards changes made, and their effects, and to enable improvements to be monitored.

9. Strengthen the techno-economics side of NCB or CRI so as to provide hard-fact back-up for discussions and negotiations on subjects such as coal quality, the adverse effects of ash content, cement price and the advantages of cleaner coal. The disposal of rejects or their sale for use, is also a component of such thinking, as also is the disposal of ash from combustion or gasification external to the kiln.

10. Arrange for NCB or CRI people to take part in work done elsewhere, both in India and abroad, and for them personally to acquire experience of the research and development of the operations concerned. Appropriate visits and tours can be arranged, when NCB needs are defined.

11. Set going the programme outlined so that work can be not only begun, but progress can be monitored and kept in line with the timescale and the objectives. The programme includes provision of data essential for selecting coal-using processes of use to NCB, and for which NCBstaff could be trained abroad.

IV ACTIVITIES AND OUTPUT

A Objectives, Job Description, and Priority Areas to be Discussed

The Project Brief that was received after the period of work in India had ended includes, amongst the first of the "Immediate Objectives","strengthening the existing capabilities of the National Council for Cement and Building Materials (NCBM) in diagnosing problems, formulating programmes and implementing solutions in order, inter alia, to enable it, in cooperation with the industry, to (Project Brief numbering):

1.3 introduce energy conservation schemes in 10 to 15 cement plants in India so that

1.3.1 power consumption figures are decreased by at least 5 percent

1.3.2 heat consumption figures are reduced by at least 5 percent"

The second "Immediate Objective" was

> "To establish a central data base at NCBM for monitoring various productivity indicators at cement plants".

In the energy field, activities were to include the subjects of energy conservation and coal combustion technology; and training fellowships were also envisaged in these areas. The present mission was apparently the fourth of some thirty or more covering different aspects of cement industry operations over some three years.

The job description follows; then the list, proposed by CRI, of priority areas to be discussed. Pages 16 - 30 summarize these subjects.

Annex 5 describes the cement industry in India.

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

UNIDO

PROJECT IN THE REPUBLIC OF INDIA

JOB DESCRIPTION

DP/IND/84/020/11-23

Post title	Expert in Productivity Improvement through Coal Combustion Technol
Duration	Two months in the first mission with the possibilities of furthe: four months in subsequent missions. (Initially one month, as from October 1985)
Date required	1 December 1985 (February 1986, as from October 1985)
Duty station	New Delhi, with extensive visits to cement plants and with the possibility of travel to other NCBM-Units within the country, as may be required.
Purpose of project	To improve the total productivity factor in the industry and the technological levels of the various units of the cement industry in India through strengthening of the national centre - the Natio Council for Cement and Building Materials (NCBM)
Duties	The expert will be attached to NCBM as a part of the internationa team lead by the Project Director, and will work under the superv of the Council's Chairman & Director General.

Whilst the field of work of the expert will cover the entire spect of activities relating to coal combustion technology.

The special thrust will be in the following area :

First Mission : Identification of various characteristics of low grade fuel with a view to improving fuel efficien development of appropriate techniques for utilisa of lowgrade fuel.

Subsequent Missions : Evaluations of the techno-economics & design of c gasifications system; evaluation of models for improved heat transfer and reaction rate and its application for improving burning characteristics low grade fuels.

In the above areas the expert will specifically be expected to as NCBM in strengthening the existing capabilities of NCBM in :

a) Effectively diagnosing technological problems and productivit constraints;
b) Formulating programmes and methodologies for solving technolo problems and improving productivity and
c) Implementing solutions as arrived at in (b) above.

..../..

Applications and communications regarding this Job Description should be sent to:

Project Personnel Recruitment Section, Industrial Operations Division
UNIDO, VIENNA INTERNATIONAL CENTRE, P.O. Box 300, Vienna, Austria

Duties (continued) to enable it, in cooperation with the industry, to achieve increase in capacity utilisation reduction in heat consumption, reduction in kiln down time and establish a central data base at NCBM for monitoring the various productivity indicators.

The expert will also be expected to prepare a technical report, setting out the findings of the mission and recommendations to Government on further action which might be taken.

Qualifications : Engineer/Fuel Technologist with at least 20 years of extensive experience including adequate experience at responsible and senior levels in the area of coal combustion technology in cement industry. The expert should have an intimate background of productivity management in relation to the above and be familiar with methodologies of studies for Productivity Enhancement.

Language : English.

Background Information : Today the cement industry in India comprises 94 cement plant - having a total annual installed capacity of 36.5 million tonn Poor and varying quality of coal with as high as 40% ash and as low as 3000 Kcal/kg calorific value as received by the Indian Cement Plant has become one of the major bottlenecks in achievir higher capacity utilisation. This required the designs of new and improved burners and development of better burning technique

The National Council for Cement and Building Materials (attache to the Ministry of Industry, Government of India) is the nation centre devoted to Research Technology Development and Transfer, Education and Industrial Services; it provides the necessary technological services to the Cement Industry at the national level. The Institute has an on-going programme on productivity enhancement and modernization, and a number of cement plants hav already derived benefits from this programme.

PRIORITY AREAS TO BE DISCUSSED

- Gasification
- Beneficiation : Dry
  Wet
  Oil Agglomeration
  Chemical Dimineralization
- Oxygen Enrichment
- Coal Combustion Technology : Improved Burners
  Flame Characteristics
- Use of Lignite
- Fluidised Bed Combustion
- Coal Preblending, Crushing, Drying, Grinding, Mechanical & Pneumatic Transport.
- Coal Slurry Process
- Cyclonic Combustion
- Energy Audit & Monitoring Technology.

B The Work

People met, and at work in the fuels area, are listed in Annexes 1 and 2.

The CRI chronology of the mission is Annex 3. Arrival in and departure from India were on 23 February and 12 March respectively. The duration of 18 days in India is two days short of a working lunar month.

Discussions were held with CRI people, individually, and as groups, and illustrated with slides as appropriate. Such data on coals etc as were received, were reviewed, and observations were made. These follow. The following documents were included in discussions:

"Other UN reports of relevance to the project" (provided by the author) (Annex 7) CRI were shown the reports, and had opportunity to photocopy.

"Other Indian literature of relevance to the project" (provided by CRI) (Annex 8)

"Techno-economic evaluation of establishing coal washeries for the beneficiation of coal" (provided by CRI) (Annex 9)

Also, the following sets of documents were all provided by the author, and left with CRI:

Papers describing examples of British work on energy usage reduction in the cement industry (Annex 10)

Papers on gasification (Annex 11)

Papers on fluidized bed combustion (Annex 13)

General papers as background (Annex 15)

Papers on recent specific relevant equipment (Annex 16)

British government papers on energy saving and efficiency improvement generally (Annex 17)

General building materials - some summaries of United Kingdom government Energy Conservation Demonstration Projects - in related areas (Annex 18)

Slides used in discussions are listed as follows:

Fluidized bed gasification slides (Annex 12)

Fluidized combustion slides (Annex 14)

A lecture on "Dealing with problems of high-ash coals in the cement industry", illustrated by slides of gasifiers and fluidized combustors, was given to some fifty people on 7 March. The lecture notes follow.

The Gagal Cement plant, near Bilaspur, Himachal Pradesh, was visited on 8 and 9 March. The visit report follows.

1 Gasification

Gasification is one of several approaches to "removing" coal from ash by making outside the kiln a combustible gas that can be burnt in the kiln. Gasification processes can be categorized variously

a) high pressure or ambient pressure

b) oxygen-blown or air-blown

c) with separation of by products, or incorporation of by products into the gas

d) large-scale (eg 10 lakhs tpa) or small-scale (eg 3000 tpa)

e) slagging or non-slagging

f) up draught, cross draught, down draught or devolatilization

g) descending bed, suspension or fluidized bed.

The processes were outlined in a seminar, and slides were shown of a fluidized bed process that might be adapted especially for use with cement kilns.

RRL-Hyderabad is understood to be at work on high pressure oxygen- and also air-blown gasification on a large scale potentially, with separation of by products, and under both slagging and non-slagging conditions. (Note the only ash analyses seen suggest that the two coals concerned would not be suitable for slagging processes.) Also BHEL, Tiruchirapalli, is understood to be at work on gasification.

Papers on gasification were given to CRI and are listed in Annex 11. Slides used in the seminar on gasification are listed in Annex 12.

The fluidized bed gasification process described was developed by the UK National Coal Board, and is licensed to Otto Simon Carves Ltd. The India office is

Otto-India Private Ltd
9 Camac Road
Calcutta 700 017.

2 Beneficiation

The conventional view seems to be that it is not feasible (either technically or economically, or both) to beneficiate Indian non-coking coals for the cement industry. Yet to transport coal at, say 40% ash, over perhaps 2000 km is to waste much of the cost of transport (costs of rail trucks, demurrage, locomotive fuel, track and rolling stock maintenance, etc) and much of the investment and operating cost of coal-handling and using equipment at cement plants. Also, there are suggestions of the possibility of providing some reduction in ash content - such as the CRI study (Annex 9), and the claims of Conveyor and Ropeway Services of Calcutta apparently made to CRI in May 1985.

There seem to be two problems caused by the wide dissemination of small-sized inherent ash particles throughout the coal substance (up to some 25-28% ash),

a) coal substance specific gravity will be higher when it contains inherent ash, thereby decreasing the difference in density between coal substance and extraneous ash upon which much coal washing depends

b) the inherent ash particle sizes are small, so requiring very fine grinding to achieve a mix of particles for possible separation.

In both types of separation density difference is important, and generally, the smaller the density difference the higher must be the "efficiency" of the separating equipment to achieve worthwhile separation.

Wet Separation

As regards problem a) the Conveyor and Ropeway Services claim to have access to UK technology that should wash coals in question, should be investigated. The author has agreed to follow this up with his connexions with that firm in India; and also any relevant developments by the UK National Coal Board, and the (government) Warren Spring Laboratory experts, inter alia, in mineral separation.

Dry Separation

As regards problem b), CRI provided the following undated unreferenced Tables 1, 3 and III concerning ash distribution and size consist of some ground and pulverized coals.

It seems possible that there can be a substantial proportion of material under 45 microns in size (Table 1), of higher ash content than the rest (Table 1, also Table 3). Table III suggests that ash materials may range from perhaps 4 to 30 microns in size.

As the coal for cement kilns is pulverized anyway, it would be worth investigating new improved methods of separation and classification. The Warren Spring Laboratory has developed improved dry separation techniques that would be worth investigating.

The author has agreed to follow up these lines of investigation.

TABLE - 1

ASH DISTRIBUTION ON PULVERIZED COAL OBTAINED FROM CCI MANDHAR

Screen Size	% age fraction	% ash in the fraction
+ 90	6.83	32.47
- 90 + 63	14.74	29.94
- 63 + 45	15.21	28.81
- 45	63.21	35.75

Proximate Analysis of Coal

FC	=	29.23 %
VM	=	31.66 %
MC	=	4.83 %
Ash	=	34.28 %

Ultimate Analysis of Coal

C	=	43.86
H	=	3.66
S	=	0.68
N	=	0.69
O	=	12.0

Calorific value (Net) Kcal/Kg coal = 3745

TABLE - 3

ASH DISTRIBUTION IN VARIOUS SIZE FRACTIONS OF DALLA COALS :(Source - Bihar Coal Fields, Giddi, Pataratu, Sayal)

Sieve size	Average Size mm	% Amount	% Ash content
- 3mm + 1 mm	2.175	72.95	37.53
- 1mm + 850	-	-	-
- 850 + 600	0.725	9.14	34.77
- 600 + 425	0.5125	6.61	35.86
- 425 + 212	0.3185	4.85	35.95
- 212 + 90	0.151	2.65	35.38
- 90 + 63	0.0765	0.88	37.69
- 63 + 45	0.054	0.60	38.96
- 45	0.225	2.32	44.06

TABLE - III

GRANULOMETRIC STUDY OF COAL SAMPLES PROCURED FROM THREE CEMENT PLANTS

PLANT	SAMPLE NO	Quarts (grain size in microns)			Other Mineral Matters (grain size in microns)		
		Minimum size	Maximum size	Average size	Minimum size	Maximum size	Average size
	1	6.5	24	12.0	4.0	10.0	5.0
I	2	7.0	20	13.5	5.0	11.0	5.0
	3	6.5	22	13.5	4.0	12.0	6.0
	1	10.0	30	18.0	4.0	8.0	5.0
II	2	7.0	28	17.5	6.5	13.5	10.0
	3	10.0	30	16.5	5.0	13.5	7.0
	1	10.5	18	13.0	6.0	13.0	5.0
III	2	10.0	29	14.0	5.0	10.0	6.5
	3	11.0	28	13.0	6.0	12.0	8.0

- quarts and other mineral matter are sporadically distributed with the coal substance.

Also, the new Paladon multicyclone has been tested recently by the Warren Spring Laboratory, and the report is awaited. Previous independent tests show that separation efficiencies with this equipment are higher, for lower particle sizes, than previous separators. The Paladon device "design" might, therefore, provide the basis for an improved "classifier-separator" to go into the coal grinding circuit of the pulverized fuel firing system for a cement kiln.

The document containing the earlier test reports was given to CRI (Annex 16).

Oil Agglomeration

In the absence of suggestions from washery specialists, such as at CFRI, then oil agglomeration would be expected to apply more to the inherent ash in micron-sized material, than to the extraneous ash in mm-sized material.

This is a technique that would be more likely to be applicable in a washery than at a cement plant. If air-separation was at least partly effective it would be likely to be cheaper and easier than wet methods.

Chemical Demineralization

Some ash constituents may be dissolved by alkalis, some by acids. If both were considered, then complete washing would be needed between low and high pH treatments - so making at least three stages to avoid interreaction of the two separate reactants. One stage would be much simpler.

This technique could be costly in terms of reactant and equipment. Other methods should be investigated first.

3 Oxygen Enrichment

Exit gas analysis ranges were given by CRI as

CO_2	22-24%
O_2	2 - 4%
CO	0-0.5%
N_2	72-75%

Kiln exit gas temperatures are some:

350-320°C dry process

180-200°C wet process

This illustrates the problem over using enriched air for cement-making. Enrichment of air from 21% O_2 to say 25% O_2 would effect only a small reduction on the N_2 content. The reduction would be unlikely to bring cost benefits or increased combustion efficiency to compensate for the enrichment cost - even with new techniques, such as pressure swing absorption.

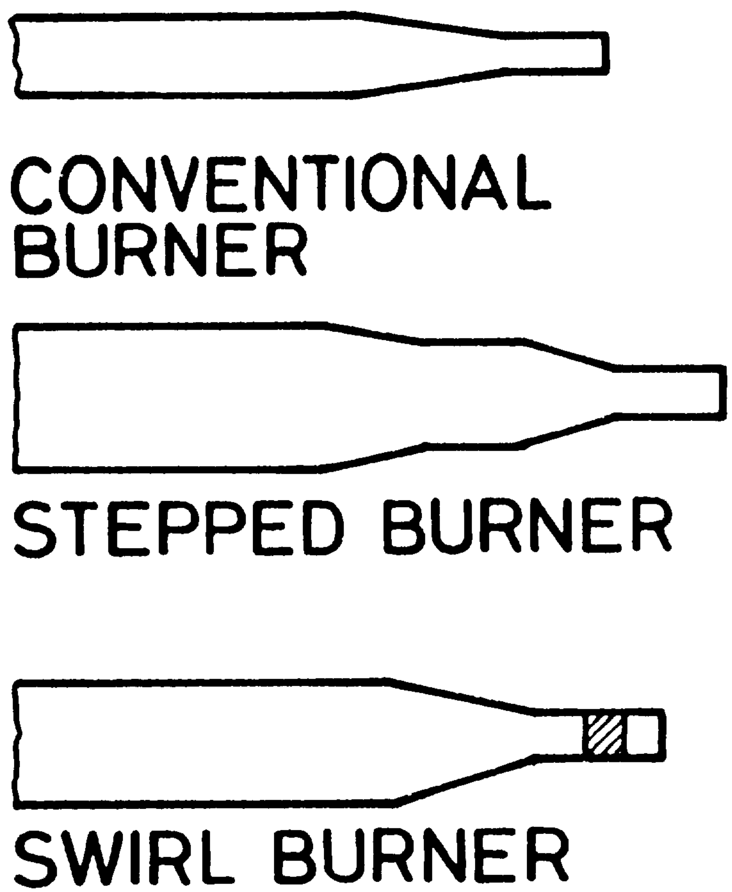
ACC have experimented with enrichment, and they should be asked if their experience confirmed the views above.

4 Coal Combustion Technology

CRI had apparently developed and patented improved burners as shown as photocopy overleaf, but no details nor patent claims were divulged. Accordingly no opinion could be given.

The general characteristics of flames were briefly reviewed in discussions including coal characteristics such as volatile matter, and reactivity. Flame length also tended to increase with furnace temperature and with the ratio of mass flow to velocity (usually to a fractional power, often ½); and decrease with excess air. With high ash coals actual experiment was essential, and experience with one cement kiln could be applied to others.

The presence of up to 0.5% CO in kiln exhaust gas suggested that improvements should be possible, probably in mixing and in proportioning at the burner. It was recognised, however, that high ash content and varying coal characteristics make combustion control difficult.



BURNERS FOR ROTARY KILN

5 Use of Lignite

CRI provided data on lignites, as on the following page.

Advantages of using lignite include low ash content and high reactivity. Disadvantages include the alkali metal salt content of the ash (that could impose a limit to the extent of its use), and the need to dry the lignite (by fluidized bed dryer using waste heat). Comminution and burning tests would need to be done in order to ensure that a flame would suit a kiln.

First of all, of course, it would be necessary to investigate the likely timetables and cost structures for lignites that could be supplied to cement plants. Tonnages and analytical data are needed.

There is much experience of use of lignites in a number of countries in Europe, including the British Isles.

Lignites

(data from CRI)

Deposits	Millions of tonnes
Tamil Nadu (Neyveli)	2,000
Gujarat	100
Kashmir	130
Kerala	270
Rajasthan	20
Total	2,520

Typical characteristics include

Moisture content as named	-	40-50%
Calorific value (dry basis	-	5000-5500 kCals/kg
Ash content (dry basis)	-	8-10%

The industry would like to substitute dried lignite for some 30% of the present coal usage.

Since the lignite deposits are all within reasonable distance of cement plants, transport costs would be small.

The most important deposits - in Tamil Nadu - could supply the following cement plants :

Tamil Nadu Cements	Aryalur
Dalmia Cement (B)	Dalmiapuram
Chettinad Cements	Karur
India Cements	Sankaridrug
ACC	Madukkari
Tamil Nadu Cements	Alangulam
Madras Cements	Tallukapati
India Cements	Sankarnagar

6 Fluidized Bed Combustion

A seminar was held in which an outline was given of the origins and present status of the different forms and applications worldwide. Slides were used to illustrate some British work, and they and literature left with CRI are listed as Annexes Much use was made of the blackboard.

Deep and shallow beds, high and low fluidizing velocities, in-bed and other means of bed temperature control, ambient and elevated pressure operation, and boiler, furnace, gas generator, dryer, gas turbine, mixed cycle and energy storage systems were outlined.

Also means of handling high ash coals and unreactive coals, including circulating beds, and multiple beds, were described. Incidentally countries such as Brazil, China, North Korea and South Korea have to use coals with higher ash contents than those supplied to the Indian cement industry.

Fluidized bed combustion required bed temperatures to be well below ash fusion temperature. So the technique was valuable for dryers and calciners, but not for supplying combustion gas to a cement kiln for clinkering purposes. Fluidized gasification, however, being sub-stoichiometric, would be worth considering: the ash would be left outside a kiln and the gas would be burnt inside it with combustion air.

Arrangements could be made for visits to British fluidized combustion installations including plaster calcining and clay drying for cement works. There are some 900 MW of capacity in some 100 installations in the UK, with more, and larger, plants being built, and planned.

7 Coal Preblending, Crushing, Drying, Grinding, Mechanical and Pneumatic Transport

These matters figured in discussions generally, but being more general and components of other considerations, did not warrant a separate session.

8 Coal Slurry Process

This technology, useful for firing boilers, hitherto oil- or gas-fired, depended much on the ash content of the coal and on the absence of pockets in the boiler where ash accumulations would be deleterious. High ash coals posed a special set of problems - most work so far having used low-ash coals.

There was little point in firing coal slurry into cement kilns, where the aim was to reduce, not increase, the drying part of their duty.

Coal slurry technology could be made available if required.

9 Cyclonic Combustion

The two broad approaches - one firing crushed coal, the other pulverized - were outlined; also the layout differences - vertical, and inclined or horizontal, according to the function. Ash is caught in slag lining the combustor, which runs out to discharge.

It should be possible to fire a cement kiln with suitable coal via a cyclone combustor, tapping the slag (fused ash) out of the combustor while the high temperature combustion gases passed to the kiln. There would, of course, be some volatilization, and possibly subliming, of ash constituents that would need to be considered in the light of the cement chemistry. But the overall quantity of ash incorporated into the cement would be reduced almost in proportion to the amount of coal fired in the cyclone combustor.

CRI provided two unidentified unreferenced coal analyses, Tables 6 and 7 that follow. The sets of figures do not seem to add up to 100% as they would be expected to do. Ash analysis can suggest the likely ash fusion temperature by using the criterion of silica ratio - that of silica to the sum of the contents in ash of (silica plus oxides of iron, calcium and magnesium). The ash in Table 6 would be expected to flow at about 1550°C, and that of Table 7 at over 1700°C. Also, see the paper on slagging, Annex 15.

Much more data on ash analyses would be needed before further considering the feasibility of using cyclone combustion in the form in which the work has been done for boiler and furnace use.

Cyclone combustion technology can be made available if and when required. For considering properly any process likely to be useful, proper coal and ash analyses are required, related to the tonnages of the coals as supplied to cement plants.

10 Energy Audit and Monitoring Technology

The whole basis of not wasting money by not wasting energy was described. The general approaches are summarized on the subsequent page.

Specific equipment for metering and controlling (Gervase) and for reduction of power consumption for lighting, motors, etc (Energy Management UK) is described in documents left with CRI (forming Annex 16). These are merely two examples of the vast range of new equipment that is available.

Literature on

Fuel efficiency improvement in most aspects of industrial works

Energy use in four groups of industries related to building materials (pottery, bricks, refractories, etc)

was outlined briefly and given to CRI, and is listed in Annex 17.

Literature on relevant energy-saving demonstration projects in the cement industry and industries related to building materials in UK was also given to CRI. These are listed in Annexes 10 and 18.

TABLE - 6

CHEMICAL ANALYSIS OF COAL OBTAINED FROM UP STATE CEMENT CORP DALLA

Proximate Analysis

VM	=	23.17
FC	=	36.37
Moisture	=	4.20
ASH	=	36.26
		100.00

Ultimate Analysis

% C	=	44.93
% H	=	3.02
% N	=	0.62
% S	=	0.44
% M.C	=	2.02 / 51.03
Calorific value	=	4566 Kcals/Kg

Ash Analysis

SiO_2	=	54.38
Fe_2O_3	=	9.07
Al_2O_3	=	27.67
CaO	=	3.26
MgO	=	0.88
Alkali	=	1.49
		96.75

TABLE - 7

CHEMICAL ANALYSIS OF COAL OBTAINED FROM CEMENT CORPORATION OF INDIA, NEEMUCH

Proximate Analysis

VM	=	29.72
FC	=	41.42
Moisture	=	1.69
Ash	=	29.72

Ultimate Analysis

% C	=	46.63
% H	=	3.12
% N	=	0.96
% S	=	0.65
% MC	=	1.09
Calorific value	=	4963 Kcal/Kg

Ash Analysis

SiO_2	=	64.39
Fe_2O_3	=	4.31
Al_2O_3	=	24.48
CaO	=	3.09
MgO	=	0.26
SO_3	=	1.45
Alkalies	=	1.46

General Energy Saving - approaches include

1. Reduction of heat losses from plant,eg kilns - insulating refractories - an example of UK work was outlined with reference.

2. Control of motor loads, scheduling, power factor, efficiency.

3. Maintenance of all plant, and keeping-up of mechanical efficiency of drives.

4. Modernization of large-load equipment,eg crushers and pulverizers to models that use less energy.

5. Utilization of waste heat and exhausts at minimal volumes and temperatures.

6. Rescheduling operations on the flowsheet so as to reduce maximum heat loads (eg wet-to-drier process, thickening slurries while maintaining pumpability, pelletizing feed).

7. Monitoring performance, setting targets, reporting results and improvements - probably in relation to the tonnage of cement produced.

8. Transport, offices, laboratories, godowns, housing which are all sources of waste of energy/money - eliminating waste by turning off lights, taps, engines etc, scheduling work (eg transport journeys), maintenance (bulk cooking equipment, vehicles etc) - and, again, monitoring, targeting and reporting results and improvements.

The author's 200+ pp course book for "Energy Management in Industry" seminars, was lent to CRI, who had the opportunity to read and to photocopy. The first 25 pp, of introduction, and about energy audits, was commended to CRI. There is much use (by arrangement) of the UK Department of Energy fuel efficiency material, some of which is listed in Annex 17.

9. Installing computerized process controls and energy usage optimization equipment when the processes and plants have been brought up to cost-effective efficiency.

10. When other aspects are satisfactory, then consider the use of "wastes" in substitution for part of the coal, as Blue Circle do - paper, Annex 10; list, Annex 19.

11 Coal Supplies

On 28 February, the three following documents about coal were provided, plus two maps, one showing coal mines, and the other, cement works. The documents, photocopied here, are "Table 3" showing reserves in 29 coalfields, in six qualitative categories: "Annexure A" containing ash and moisture contents of coals from some collieries to some cement plants; and "Quality of coal supplied to Indian cement industry", containing figures for moisture, ash, volatile matter (VM%), fixed carbon (FC%), C%, H%, N%, S% and calorific value (cv) kgCal/kg for 18 unidentified samples. "Annexure A" forms Annex 6.

The impression was received that coal analyses were considered mainly from the points of view of their ash and moisture contents, and that a cement plant would neither know what a particular waggonful of coal consisted of as regards likely burning characteristics, nor even where it came from. The analyses provided were described as "typical", though it did not seem to be known what orders of tonnage the individual analyses might represent.

Accordingly the analyses were examined.

Coal Type

The figures in this last document were analysed, and where possible certain of the missing figures were "created" by inference and calculation. The original table is followed by sortings on the Dry Ash Free basis (DAF) according to VM%, calorific value and the sum of the elements (C%, H%, N%, S%) in rising order in each case.

The DAF basis had to be used instead of the more rigorous Dry Mineral Matter Free basis (DMMF) owing to lack of related ash analyses : any errors will be small and less than the likely errors in the figures used.

It did not seem to be known precisely how analyses and cv determinations were performed and calculated, nor whether the cv figures were net or gross. Methods should, of course, be standardized.

Grades

It is understood that batches of coal are separated into grades, as they are loaded into waggons, as follows

under	19%	moisture + ash	Grade	A
"	24%	" "	"	B
"	28%	" "	"	C
"	35%	" "	"	D
over	35%	" "	"	E

Apparently coals in Grades D and E are allocated to power stations and cement works. Judging by the amounts of visible dust, and of black smoke, coming from power stations in the Delhi area, power stations have problems with dust separation plant and with combustion control. Apparently modern coals are worse than those of 'Annexure A', Grade E being the norm.

TABLE 3— COAL RESOURCES OF INDIA

In situ RESERVES (MILLION METRIC TONNES, TOTALS OF PROVED, INDICATED AND INFERRED RESERVES IN SEAMS ABOVE 1·2 M THICK AND UP TO 610 M DEPTH UNLESS OTHERWISE STATED

COALFIELDS	Bituminous				Anthracitic	Lignite
	Prime coking	Medium coking to semi-coking	Weakly caking	Non-caking		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Assam	—	500?	—	3300	—	—
2. Darjeeling	—	—	—	—	100	—
3. Rajmahal	—	—	—	215	—	—
4. Deoghar	—	—	—	55	—	—
5. Barjora	—	—	—	25	—	—
6. Raniganj						
(a) Raniganj Measures	—	492*	—	12589*	—	—
(b) Barakar Measures	—	6238*	—	—	—	—
7. Jharia						
(a) Raniganj Measures	—	322*	—	—	—	—
(b) Barakar Measures	5158*	7201*	—	—	—	—
8. Giridih	8	30	—	—	—	—
9. East Bokaro	—	4407*		—		—
10. West Bokaro	—	1000?	100?	—	—	
11. Ramgarh	—	1335	—	—		—
12. North Karanpura	—	300?	—	4280	—	—
13. South Karanpura	—	—	600?	1825	—	—
14. Chope-Itkhori	—	—	—	2	—	
15. Palamau (Auranga, Hutar, Daltonganj)	—	—	—	170	—	—
16. Sone Valley						
(a) Sohagpur	—	—	300?	3765	—	—
(b) Singrauli	—	—	—	29100	—	—
(c) Others (Bisrampur, Jhilimili, etc.)		—	290	735		
17. Mahanadi Valley						
(a) Talcher	—	—	—	30000	—	—
(b) Others (Ib River, Korba, Chirimiri, etc.)	—	—	—	2685	—	—
18. Pench-Kanhan Valley	—	100	—	1570	—	—
19. Pathakhera	—	—	175	—	—	—
20. Satpura Basin	—	—	—	9	—	—
21. Nagpur Group (Kamptee & Umrer)	—	—	—	515	—	—
22. Wardha Valley (Ghugus, Chanda, Ballarpur, etc.)	—	—	—	3610	—	—
23. Godavari Valley (Lingala, Wamanpalli, Kothagudium, Singareni, etc.)	—	—	—	8015	—	—
24. Jammu	—	—	—	—	105	—
25. Nichahom (Kashmir)	—	—	—	—	—	100
26. Palana	—	—	—	—	—	20
27. Umarsar	—	—	—	—	—	10
28. Sothu Arcot (Neyveli)	—	—	—	—	—	2030
29. Kerala		—	—	—	—	100
Totals	5166	21925	1465	102465	205	2260
Grand Total	5166 +	21925 +	1465 +	102465 = 131021		

*Reserves in seams above 0·5 m. thick and above as published in *Report of the Committee on Assessment of Resources*, Vols. I, II and III, Coal Council of India, Ministry of Mines & Fuel, 1963.

QUALITY OF COAL SUPPLIED TO INDIAN CEMENT INDUSTRY

	Mois %.	Ash %.	VM %.	FC %.	C %.	H %.	N %.	S %.	C.V Kcal/kg	
	2.11	46.37	27.10	26.53	33.07	3.06	1.05	0.62	3145	
	2.28	29.47	29.49	41.04	NA	NA	NA	NA	4958	
	4.69	33.75	NA	NA	46.79	3.05	0.47	0.69	4502	
	2.79	34.57	27.67 ~~26.67~~	34.97	46.85	3.28	0.88	0.76	NA	
	2.39	33.16	27.90	36.55	43.53	3.91	0.02	0.72	4739	
	1.47	36.89	23.37	38.27	46.37	3.11	NA	0.36	4746	
	1.74	36.77	24.97	36.92	44.27	3.86	0.019	0.45	4467	
	2.74	26.99	27.52	NA	53.18	3.21	NA	NA	5637	Assam
	3.83	39.47	25.06	31.64	NA	NA	NA	NA	4020	
0.	0.99	31.69	25.24	42.08	48.14	2.92	NA	0.96	5097	
	2.41	35.26	24.38	37.95	44.82	3.01	—	—	4582	
	6.59	24.49	24.98	—	51.27	3.24	0.9	0.57	5323	
3.	1.14	37.61	27.12	34.10	42.22	2.54	0.68	0.61	4419	
4.	4.37	37.75	27.61	30.27	40.29	2.26	0.92	0.66	4188	
5.	2.67	27.42	28.43	—	54.67	4.06	0.87	0.68	5218	Assam
6.	1.12	17.99	28.70	—	66.48	4.24	0.62	0.59	6561	
7.	4.20	36.26	23.17	36.37	44.93	3.02	0.62	0.44	3736	
8.	4.37	37.75	27.61	30.27	40.29	2.26	0.92	0.66	4188	

The 18 coal analyses sorted by Volatile Matter

	Sample	VM% DAF	CV kgCal/kgDAF	
Over 36% VM	16	35.5	8111	A
	12	36.2	7723	
	10	37.5	7571	
	6	37.9	7700	
	17	38.7	6275	
	11	39.1	7351	
	8	39.2	8022	A
Over 40% VM	7	40.3	7218	
	15	40.7	7464	A
	2	41.8	7030	
	5	43.3	7352	
Over 44% VM	4	44.2	-	
	9	44.2	7090	
	13	44.3	7218	
	14	47.7	7236	
	18	47.7	7236	
Over 48% VM	1	50.5	5864	

A means reputed to have come from Assam.

The 18 coal analyses sorted by calorific value

Sample	VM%DAF	CV kgCal/kgDAF	
1	50.5	5864	
17	38.7	6275	
2	41.8	7030	
9	44.2	7090	
7	40.3	7218	
13	44.3	7218	
12	36.2	7223	
14	47.7	7236	
18	47.7	7236	
11	39.1	7351	
5	43.3	7352	
15	40.7	7464	A
10	37.5	7571	
6	37.9	7700	
12	36.2	7723	
8	39.2	8022	A
16	35.5	8111	A

A means reputed to have come from Assam.
There was no cv figure for sample 4.

The 18 coal analyses sorted by sum of elements C% H% N% S%

Sample	Sum of elements DAF	CV DAF	
1	37.80	5864	
14	44.13	7236	
18	44.13	7236	
13	46.05	7218	
5	48.18	7352	
7	48.59	7218	
17	49.01	6275	
3	51.00	7313	
4	51.77	-	
12	55.98	7723	
15	60.28	7464	A
16	71.93	8111	A

A means reputed to have come from Assam.
Missing samples have insufficient reported data.

The 18 Coal Analyses - proximate and chemical

Proximate Analyses

Of 18 analyses; 5 are incomplete; 4 do not add to 100%.
Since successive percentages are obtained by weighing and subtraction during the analysis, then any deviation of the total from 100% shows inaccuracy either of determination or of reporting, and unreliability of the figures for the drawing of conclusions.

Two of the samples, nos. 14 and 18, were identical in all four of the proximate analysis figures, and also in C%,H%,N% and S%, which makes the figures suspect.

The lowest ash content samples, nos. 8, 15, 16, were ascribed to Assam - all being below 30%, and one under 20% - among the highest cv figures reported, but not exclusively so on the dry ash free basis.

All the analyses showed low moisture contents, only one (6.59%) being over 5% - though on coal substance the figures would vary from +1.18% to +9.56%. However, only second-order deductions can be drawn from moisture contents of such low rank coals, so any further implications of moisture figures can be considered later if there are sufficient data.

Chemical Analyses

The sums of the figures for C%,H%,N% and S% range from 37.80% to 71.93%. It is possible that oxygen may be much of the balance to 100%. For six of the samples there are figures for fewer than the four elements reported for the remaining 12 samples.

General Conclusions derived from the Analyses

1. The sulphur content figures are all low - though the figures do not constitute complete analyses.

2. The moisture content figures are all low.

3. The majority of the samples lie with the limits of 36 to 48% VM, and 7000 to 7750 kCal/kg cv including one reputedly from Assam.

4. One sample (1) was of higher VM% (50.5%) and lower cv (5864 kgCal/kg) than the majority.

5. One sample (17) had a significantly lower cv (6275 kgCal/kg) despite its VM% in the main range (38.7%).

6. The two remaining samples reputedly from Assam (15, 16) had higher cv's (8022 and 8111 kgCal/kg) and VM% broadly in the main range (39.2% and 35.5%).

General Conclusions concerning the Coals

If the samples were, as reported,representative of the coals received and used at the cement works, then the following conclusions may be relevant.

1. On the basis of the figures, most of the samples represent the lowest end of the bituminous range - on the Coal Rank Code basis, 902 and onward. This could be confirmed if Gray-King Coke Assay or B S Swelling Number results were provided for the samples. On the Seyler basis, they would be considered Ortho Lignitous. They would be expected to contain some 20% oxygen.

2. Two samples reported as from Assam (15, 16) would on the Seyler basis be considered as Meta Lignitous, and would be expected to contain some 10% oxygen.

3. Samples 1 and 17 seem to be of entirely different types, both from each other and from all the other samples.

A further document "Quality of Coal" (photocopied here) listed forty plants, with ash analyses "as received" and "as fed to the kiln". The spread of positive and negative differences suggested that for each plant the ash %'s were not necessarily for the same coals.

Observations based on the figures

1. Since the calorific value can vary widely - from 5864 to 8111 kgCal/kg of coal substance, it is desirable for analyses to be complete, and to have been accurately determined and reported. Ash and moisture content determinations are not sufficient for process control, thermal input calculations, or air supply adjustment. Only proper analyses and calorific value figures can serve these purposes properly.

2. Data on Indian coals exist, as such publications as "Indian Coals, quality evaluation data" (CFRI, 1978) and "The mineral and nuclear fuels of the Indian subcontinent and Burma" (Goggin Brown and Dey, OUP, 1975) outline. A preliminary to more detailed consideration of "various characteristics of low grade fuel ...." (vide Job Description) is proper data on the coals involved. It is recommended that referenced and dated data collection for coals (and for the cement production related to the coals) be systematized, so that patterns of supply and usage, and of change with time, can be derived. In parallel, the identification of coals supplied to plants would allow their burning characteristics to be taken into account in the control of combustion. Also, it would be possible to select combustion, gasification and other processes to suit the coals used in the cement industry.

QUALITY OF COAL

S No	Name of the Plant	Percent ash content in coal (Average)	
		As received	As fed to the Kiln
1.	ACC - Bhupendra	29.8	30.5
2.	ACC - Chaibasa	28.7	30.8
3.	ACC - Jamul	37.5	38
4.	ACC - Khalari	28.3	28.9
5.	ACC - Kistna	32.5	34
6.	ACC - Kymore	32.5	35
7.8	ACC - Lakheri	29.7	31
8.	ACC - Madukkarai	33.7	32.7
9.	ACC - Mancherial	25.5	27.5
10.	ACC - Porbandar	27.7	30.1
11.	ACC - Sevalia	28.2	-
12.	ACC - Shahabad	35.0	-
13.	ACC - Wadi	33.7	36.1
14.	Andhra Cement	35.9	35.2
15.	Birla Cements	32.64	30.7
16.	Century Cement	40	40
17.	Chettinad Cements	33.77	27.42 (with 30% lignite)
18.	Hira Cements	28.2	28.5
19.	India Cements, Sankarnagar	31	31
20.	J & K Cements	31	30.5
21.	J K Cement	30	29
22.	Kaktiya Cements	32.5	30.0

S No	Name of the Plant		Percent ash content in coal (Average) As ereceived	As fed to the Kiln
23.	K C P, Macherla		32.00	32.8
24.	Kesoram Cement		32	28
25.	Lakshmi Cements		30	29
26.	Lokapur Cements (coke breeze)		32	-
27.	Madras Cement		37.3	29.8
28.	Maihar Cement		37	37
29.	Malabar Cements		33	35
30.	Mawmluh Cherra		18.1	17.3
31.	Mysore Cements		38.3	-
32.	Narmada Cements	i/	26	29.3
		ii/	40	
33.	Orissa Cement		24.2	28.4
34.	Panyam Cements		34.5	33.1
35.	Ramkrishna Cements		32	31.8
36.	Raymond Cements		32.4	31.22
37.	Satna Cements		31	30
38.	Saurashtra Cement		28	26.3
39.	Udaipur Cements		30.63	31.54
40.	VISL, Bhadravati		35	35

12 Lecture, 7 March 1986, on "Dealing with Problems of High-Ash Coals in the Cement Industry"

Other UN specialists are dealing with the cement processing issues - here the concern is with high-ash coal. However, the coal aspects are of necessity related to other aspects of processing that have effects on the energy input required.

There are four approaches in logical order

1. Reduce the ash in the coal received by the cement plants

   a) arrange for allocation of lower-ash coals, and the concomitant

      (i) disclosure of the sources of coals delivered whatever the ash content. The different types of coal work best with appropriately adjusted combustion conditions, that can be based upon knowledge of what the coal is, that is being fired.

      (ii) opportunity to build up stocks, so as to blend coals according to experience gained of their quality and behaviour.

   b) beneficiate the coals (i) at the coal mine(s)
      (ii) centrally to cement plants

   - relevant work at CFRI and in the United Kingdom may be useful. Negotiation is required as well as some technological work.

2. Reduce ash in the coal fed to kilns

   a) gasify part of the kiln feed, ie substitute ash-free gas, - relevant work at RRL-H, BHEL, and in the United Kingdom - particularly fluidized gasification which is most likely to fit well into the cement industry.

   b) burn some of the coal outside the kiln by fluidized combustion, by one or two stages - relevant work at BHEL and in the United Kingdom as well as elsewhere. The cyclone combustor is also a possibility.

   c) use lignite which is available in five major cement-making areas, and has a low ash content - according to the constraints of its alkali content as regards cement chemistry. It needs to be dried, preferably in a fluidized bed, using heat otherwise inevitably wasted. Lignite is used in many countries, including the United Kingdom.

   d) develop (if possible) processes for separating some of the extraneous ash from coal substance containing the inherent ash -

      (i) at the crushed, mm, stage, by new fluidized separation and washing techniques

      (ii) at the pulverized, 90 micron stage, by a new centrifugal separation technique.

   Equipment that should be useful for these techniques are being developed in the United Kingdom and may be useful, especially in cascades.

e) much further ahead, solvent extraction of coal may one day hold out possibilities, as also chemical dissolution of ash - but both avenues hold out problems of cost, rate of reaction, and only partial yield. There was relevant work in USA and in the United Kingdom, the former aimed at producing a boiler fuel.

All these approaches need process development to apply to the cement industry.

3. Reduce the amount of coal fed to kilns

This means improving the thermal efficiency of the whole process operation by the use of specialist equipment for each purpose, ie by

a) reducing the moisture content of the raw material. A kiln is an inefficient and expensive dryer - there are better ways of removing water,

(i) by filter pressing, externally

(ii) by drying externally with waste heat

(iii) by using the dry process without water

b) reducing the low temperature reactions carried out by precalcining, using waste heat or fluidized bed combustion

c) incorporating into the kiln (whose real speciality is clinker production at high temperature) lower thermal transmittance refractories to reduce external heat losses

d) maximum use of waste heat

then comes:

e) control of combustion to reduce excess air to the optimum, and so to reduce the volume (and mass) of combustion gases, raising flame temperature and reducing exhaust gas heat loss.

These methods not only reduce the amount of coal required, and its cost, but will simplify operational control and maintenance. As a consequence of the coal saving, the amount of ash fed per ton of clinker will be reduced pro rata to the reduction in coal requirement.

These approaches can be applied directly already, and e) requires no capital outlay, being a matter for good day-to-day operational practice.

4. Investigate new energy-reducing cement process developments

Possibly-useful approaches include

a) the use of Gottlieb-type pellets of meal containing coal particles, as part of the kiln feed. Then the coal would react during its passage along the kiln and the ash would be within the pellet, not outside it - thus avoiding one of the problems of high ash content coal, where ash coats the outside of a piece of clinker, and so may require the clinker to be more finely ground. It would be possible with two-stage pelleting to coat pellets with raw meal, and so delay the decomposition and combustion of the coal until the pellet had gone an appropriate distance along the kiln.

b) the Rohrbach/Dottenhausen type of process that is in use in Malaysia for processing oil-shale for cement-making. Oil-shale is also a high-ash material.

c) the Scientific Design process that has also been considered for making cement from oil-shale.

d) the use of oxygen-enriched air to reduce the mass of combustion gas, and to reduce the unavoidable exhaust gas heat losses accordingly. Such a development would best be considered when all the other energy-reducing improvements had been made; and after working out the effects on heat transfer from the flame whose characteristics will be changed according to the extent of enrichment. Economics are problematical.

General

Examples of all the different relevant gasification and combustion techniques were described, drawn on the blackboard and for the more important examples, illustrated with slides. There was discussion.

13 Visit to Associated Cement Companies Ltd, Gagal Cement Works

P.O. Barmana
District of Bilaspur
H.P. 174013
Telephone Dehar 36

on 8 and 9 March 1986

Persons met - Mr M.L. Narula, General Manager, plus some of the senior staff listed in Annex 4.

Purpose of the visit - Back up to consultancy on low grade fuels for NCB.

General outline - The works output, by the dry process is, based on kiln throughput, 1700 tonnes per day. The limestone is local; coal comes some 2000 km by rail to Chandigarh, thence by road, mostly from Bihar. Pozzolanic materials, fly ash, clay and other materials come by road. The power supply is local, primarily hydroelectric, and distribution failures can disrupt operations: a 500kW diesel generator is to be installed for emergencies. Despatch is mainly by bag with provision for bulk handling as required.

Main data - Primary hammer crusher, 600hp, 400tph - truck fed.
Regenerating belt conveyors, &c, to works.
Stacker reclaimer, 17 bays, 50,000 tonnes limestone, clay 600 tons. 42 metre span, being extended.
Coal and other materials, ground stocked.
Raw mill, 2500hp, 85tph - 2 units.
Blending silos 1500 tonnes - 2 units: storage silo 3100 tonnes.
Mitsubishi fluidized calciners and 4 stage preheater - 2 units.
Rotary kiln 4.11m dia, 64m long, 1700 tph.
Drag chain conveyor from clinker cooler.
Clinker silos 10,000 tons - 2 units.
Cement mills 1650hp twin drive, 50tph - 2 units.
Cement silos, 4000 tonnes.
Rotary packers, 12 spout, 60tph - 2 units.
Coal mill - E type - 20tph.
Senior staff - 8
Total personnel - 780
Age of plant - approximately two years, teething troubles, largely overcome, some remaining and being dealt with.
Also, laboratories, offices, workshops, fire station, first aid.

Observations

The condition of the plant was generally good, and the cement has a secure market well into the future, on account of its quality and nearness to points of use. Extension, and also replication in the area, are possible in future. There are large local reserves of good quality limestone.

Failure of power supplies has been a problem but the new diesel generator should keep things going, operating from storage and into silos. Local power developments should improve matters in future.

As regards energy the main potential savings had been taken care of in designing the plant, pre-heating, fluidized calcining, reuse of waste heat from the clinker cooler &c. However an Energy Manager should be appointed, the duties preferably to be given to one of the existing senior staff. It should be his task to audit and survey the works for identifying and quantifying the energy flows (heat, also power) and usages. Each item and flow would then be considered and any excessive usages, and wastages, would be dealt with. Power saving is worthwhile directly; heat saving also reduces ash fed into cement.

One particular point was the gaseous discharge from the coal plant electrostatic precipitator. The layout of the coal plant could not been seen and does not appear on the diagrammatic plant layout, so no detailed observations can be made. However fine coal should preferably be fed to the kiln, or otherwise used profitably. Coal/air explosion limits (to be avoided) should be obtainable from the mining research organization.

As other energy developments are worked out by NCB some may be applicable here.

Conclusion

This well-run works contributes well both to the industry and to the district. It will be interesting to see how its performance compares with other works in India and with practice elsewhere in the world, when its teething troubles are entirely cured, and power supplies become reliable - so that the plant can settle down to regular running.

Note

There are different approaches to explosion prevention, and to venting in the early stages of explosions before undue rise in pressure. A recent design of simple relief panel is made by BS&B Safety Systems Ltd of Gable House, Turnham Green Terrace, London W4 1QP, UK. Tel 01-994 1083. The Indian company is

BS&B Safety Systems (India) Ltd
147 Karapakkam Village
Madras 600 096
Tel 413 202, 413 881
Telex 041-7776

The Sales Director is Mr Ramachandra.

C OBSERVATIONS AND RECOMMENDED PROGRAMME

The Aim

To reduce the amount of coal used in the cement industry.

The Problems

A The coal supply costs more than it need.

B There is too much ash in the coal (eg 30+% ash) to incorporate satisfactorily into the cement made with it.

C The source of the coal is not known or controllable, and its characteristics vary widely (eg ash from 17% up to 57%. CV from 3145 to 6561 kCal/kg).

Note - burning characteristics and ash behaviour depend on coal source and analysis as well as on ash content and cv.

NCB desires its existing capabilities to be strengthened as regards

a) diagnosis of technological problems and productivity constraints. For this much more information is needed than is available according to CRI staff. Data need to be comprehensive, specific, attributable and up-to-date. The energy team was being put together during this assignment. Learning to work together is important, and can be helped by setting going the programme outlined below.

b) formulating relevant programmes and methodologies. For this the programme outlined below can be a beginning. It should also become the basis for working ever more closely with the individual plants and companies to the overall good of the industry and themselves. The energy team can develop itself as they develop interest in energy efficiency improvement throughout the industry.

c) implementing solutions. Some solutions will be short term, some longer term. The general part of the programme below may lead to shorter term solutions. The process development part of the programme will take longer because processes will need to be adapted from elsewhere, or developed for the needs of the Indian cement industry.

The Programme should include:

General

(1) Arrange for the supplier, after determining the grade of coal and its destination, and labelling the waggon, to add the source of the coal to the label. Then the cement plant can build up a picture of the coal supplies, and come to know what to expect.

(2) Collect data for relevant collieries on coal analyses (at least proximate analyses, preferably also ultimate and ash analyses).

(3) Draw up criteria based on ash content and analyses for allocation of grades D and E coals (over 28% ash and over 35% ash respectively) between the cement industry where ash quantity and analysis are more important, and the electricity industry where they are less important. Negotiate improved allocations.

(4) Negotiate for lignite supplies, arranging to dry it with waste heat: fire it to the extent allowed by ash analysis when it becomes available.

(5) Arrange where possible for cement works always to have some coal stock for blending.

(6) Arrange with cement plants for regular (perhaps monthly) information to be supplied to NCB on coal supply sources, analyses and tonnages, and the cement production involved. Then NCB can build up a quantitative picture of its industry instead of a qualitative one, and select useful processes.

(7) Arrange for each plant to have an Energy Manager to tackle his own responsibilities, and confer with others at regular meetings NCB could well organize.

These initiatives should all begin straight away. Significant progress should have been made within six months. Certain items (such as data collection and marshalling) should be in action within this period.

Specific

a) Investigate, with CFRI, Coal India, and other bodies in India, and abroad (eg National Coal Board, Warren Spring Laboratory, Paladon, and the UK connexion of Conveyor and Ropeway Services) the possibilities of new technologies for coal beneficiation.

b) Investigate with RRL-H, BHEL, Otto-India and other bodies in India, and abroad (eg National Coal Board, Lurgi, Scientific Design, Gottlieb) the possibilities of new technologies for usage of high ash coals for coal usage directly, and indirectly, for kiln firing.

c) Work out the silica ratios of all relevant coals so as to determine whether or not it is worth considering slagging processes further.

d) Investigate with CFRI and other bodies in India and abroad (eg National Coal Board) the minutiae of lignite firing.

e) Draw upon the resources of the cement industry in India (eg ACC) and abroad (eg Blue Circle) as regards technologies they can contribute.

f) Draw up lists of foreign visits and fellowships that would be useful to supplement the knowledge already within NCB.

These initiatives should be begun within six months, to a time-table depending on the availability of staff. Details of the processes involved, and their implications, are all in the body of this report. The author can make connexions as required if they are not already known to NCB.

The Future

It has been proposed that the author should make another visit, and discussion in Delhi suggests that November 1986 would be appropriate timing. At that time he could review progress with the above programme.

In particular he could, in the light of the progress made,

(i) suggest further action as regards coal supplies

(ii) help coordinate the use and application of the data being collected

(iii) help draw up in more detail the work and training of plant Energy Managers and the coordination and development of their activities

(iv) suggest detail components of the programme for developments of processes for the use of high-ash coals, according to the initial responses from the relevant organizations inside India and abroad.

(v) suggest timescales for the work envisaged, and resources required.

(vi) help with arrangements for foreign visits.to study coal-using processes when they have been selected (when the necessary coal data have been obtained by NCB). Annex 20 lists possibilities.

(vii) help in any collateral matters, should there be a need, as regards UK connexions and relationships.

D EXPERT APPRAISAL (NCB FORMAT, REVISED LAYOUT OF 11 FEBRUARY 1986)

UNDP PROJECT IND/84/020 ON "STRENGTHENING NCB CAPABILITY IN PRODUCTIVITY ENHANCEMENT OF CEMENT INDUSTRY (PEP)"

EXPERT : Mr H B Locke (11.23)

JD : Annexure 1
Work Plan : Annexure 11

NCB Counter parts :

i) Sh V K Arora
ii) Dr S N Yadav
iii)

Location : Delhi

Productivity Enhancement Aspect

Sl No	Aspect covered / Subject covered in the First Mission		Diagnosis	Methodology	Implementation	Outcome in terms of project objectives: Achieved	Outcome in terms of project objectives: Expected
i/	Identification of the various characteristics of low grade fuel for the purpose of improving fuel efficiency		Note 1 The ash contents of the coals received are reported to be too high for cement making for the ash analyses involved. The systems were not designed for such coals. Note 2 All these measures should be considered in the light of other changes made, especially those deriving from the PEP. These measures will relate to, and intermingle with, those for task (ii)				
		a)	the burning characteristics of the coals received are reported to be not known at the plants.	Make the sources of the coals, and their analyses, known to the plants.	1. Have waggons labelled with coal source as well as grade. 2. Ascertain proximate analyses for the coals from collieries supplying the plants.	Recommendations made, discussed, and implementation described.	Better bases for control of combustion, and some reduction in coal use.

Sl No	Subject covered in the First Mission / Aspect covered	Diagnosis	Methodology	Implementation	Outcome in terms of project objectives: Achieved	Outcome in terms of project objectives: Expected
				3. Take coal and combustion gas analyses into account when controlling combustion.		Possible to select processesfor coals when coalproperties are known (and see Aspect (ii))
		b) It is uneconomic to transport, handle and use coals of such high ash content, and that are reported to be supplied "on a hand to mouth basis" precluding the building up of stocks for blending.	Improve the quality and quantity of coal supplies.	1. Negotiate for less-wasteful coal supplies. 2. Arrange for sufficient stock(s) of coal(s) to allow blending when necessary.	Recommendations made and discussed.	More satisfactory coal supplies; improved economics nationally and for cement plants; ability to blend when advantageous.

Sl No	Aspect covered: Subject covered in the First Mission	Diagnosis	Methodology	Implementation	Outcome in terms of project objectives: Achieved	Outcome in terms of project objectives: Expected
ii/	Development of appropriate techniques for the utilization of low-grade fuel.	Note Improved combustion systems for firing low-grade fuels into cement kilns will not by themselves suit the need - the ash contents of the coals are too high for cement making, however advanced the combustion, for the quantities of coals used now. Combustion control and supply/blending improvements are covered in task (i) for the reduction of coal consumption.				
		a) More coal is being fired than is good for cement making or cement economics.	Appoint an Energy Manager at each plant with support from top-level - to reduce coal usage per unit of cement output. Set up targets, monitor progress, and have reporting done regularly to top-level in each firm and to NCB.	Improve energy usage efficiency throughout the plant - including waste heat utilization, process energy optimization, firing at minimum temperatures for good clinker production, use of insulating refractories and reduction of kiln heat loss; return ESP coal dust to the firing supply.	Recommendations made and discussed and the approach to co-ordinated energy efficiency improvement and energy management described.	Reduced coal usage and cost.

Sl No	Aspect covered / Subject covered in the First mission	Diagnosis	Methodology	Implementation	Outcome in terms of project objectives	
					Achieved	Expected
		b) Control of combustion air with high ash content coal is more difficult as the ratio of conveying air requirement to combustion air requirement increases with ash content.	Improve the facilities for combustion control.	Apply computer controlled process/ combustion systems when the operating input/output variables are sufficiently well known; and plants and flowsheets have been optimized.	Recommendations made and discussed, and some technologies and sources indicated.	Improved kiln temperature control, and energy usage efficiency : reduced coal use and cost.
		c) The ash content of coal received, or used, needs to be reduced.	i) Investigate means whereby it may be possible to separate lower-ash-content fractions of coal from what is currently available.	i) Investigate (with external expert bodies) new techniques (wet, also dry) with promise for better separations of coal substance from ash than have hitherto been possible. This includes attention to separation of coal from extraneous ash by beneficiation	Recommendations made and discussed, and relevant technologies and sources described.	Lower-ash-content coal supply to cement plants.

Sl No	Subject covered in the First Mission / Aspect covered	Diagnosis	Methodology	Implementation	Outcome in terms of project objectives: Achieved	Outcome in terms of project objectives: Expected
				i) cont'd.... techniques suitable for treatment at a coal mine or a plant central to several cement plants - such as the technique offered by Conveyor and Ropeway Services.		
			ii)Investigate new means whereby it may be possible to separate ash from coal during the processing it receives anyway at a cement plant.	ii)Investigate (with external expert bodies) the application both of newer fluidized separation techniques and of a new artificial gravity (centrifugal) technique capable of achieving a better size separation cut than possible hitherto (the Paladon multicyclone). These may be able to be incorporated into	Recommendations made and discussed,and the relevant technologies and sources described.	Lower-ash-content coal fed to cement kilns.

Sl No	Subject covered in the First Mission	Aspect covered	Diagnosis	Methodology	Implementation	Outcome in terms of project objective: Achieved	Outcome in terms of project objective: Expected
					ii) cont'd...... improved classifiers for pulverized coal to separate some of the micron-sized inherent ash disseminated throughout the coal substance.		
			d) Since there is too much ash in coal at present fired, for cement making, there will be need to reduce the low-grade coal component of energy input to the kiln.	i) Replace some of the high-ash coal energy input to the kiln with combustible ash-free gas made from that part of the coal.	i) Investigate (with external expert bodies) gasification techniques including those of CFRI, BHEL and the UK National Coal Board, that may be able to be adapted for use with Indian Coals for cement kiln use.	Recommendations made and discussed, and relevant technologies and sources described.	Reduction in ash fed to kiln: improved control of combustion.

Sl No	Aspect covered / Subject covered in the First Mission	Diagnosis	Methodology	Implementation	Outcome in terms of project objectives: Achieved	Expected
			ii)Replace some of the high-ash coal energy input to the kiln with hot combustion gas derived from that part of the coal.	ii)Investigate (with external expert bodies) cyclone combustion techniques including those of the (then) British Coal Utilisation Research Association.	Recommendations made and discussed, and the relevant technologies and sources described.	Reduction in ash fed to kiln; improved control of combustion.
			iii)Lignite should be used whenever feasible, drying it with waste heat.	iii)Examine the economics and technological feasibility for cement making : and negotiate on appropriate bases, according to the extent possible.	Recommendations made and discussed.	Lower ash quantities fed to the kiln : shorter transport distances.
			iv)Remove non-clinkering functions from the kiln.	iv)Install external drying and calcining equipment to reduce the kiln duty to clinker production (shortening kilns as appropriate), making optimum use of waste heat.	Recommendations made and discussed.	More efficient use of components of plant : overall reduction in coal usage.

Sl No	Aspect covered / Subject covered in the First Mission	Diagnosis	Methodology	Implementation	Outcome in terms of project objectives: Achieved	Outcome in terms of project objectives: Expected
			v)Consider new processes of potentially higher energy efficiency.	v)Investigate new cement process approaches for partial incorp-oration into works-particularly the family of fluid-ized approaches to cement making such as Rohrbach/Dottenhau-sen : also investigate the possibility of incorporating part of the coal into a Gottlieb-type pellet as kiln feed.	Recommendations made and dis-cussed, and sources of technology given.	More efficient use of energy in cement making, with lower costs.
			vi)Train staff	vi)Decide needs, arrange in India and abroad.	Recommendations made and means described.	Technological progress.

General

NCB should :

1. Institute energy audits and surveys at all plants, and both encourage measures for improvement, and inaugurate operator training.

2. For new plants make energy usage (and high ash contents in coal, if this is still necessary) an important factor in process and plant selection. It may (perhaps) be necessary to plan to use higher ash contents still.

General (cont'd ......)

3. Arrange for NCB and company staff to visit research bodies and plants abroad. Annex 20 lists possibilities.

4. Publicize these efforts and try to inspire a spirit of competition to improve throughout the industry.

Officials Contacted on 25/2/86 at CRI

1.	Sh D B Irani	Director 557
2.	Sh S J Raina	Sr Scientist (Refractory) 609
3.	Dr Mrs S Laxmi	Sr Scientist (Cements)
4.	Dr A K Mallick	Joint Director (Civil Engg)
5.	Dr S K Handoo	Sr Scientist (DTA)
6.	Dr S N Yadar	Sr Scientist (Process Engg & Fuels) 654
7.	Sh V K Arora	Sr Scientist (Process Engg & Fuels) 658
8.	Sh Naresh Kumar	Scientist (Energy Conservation)

at The Cement Research Institute, Ballabhgarh

Officials Contacted on 26/2/86 evening at NCB

Dr H C Visvesvaraya, Chairman and Director General, NCB, and colleagues

at M-10, Southern Extension - 11, New Delhi 110049

DIVISION : CPE

A	Stationed at NCB-B	Discipline	Expertise Group
1.	Sh Kamal Kumar - Programme Leader	Chemical Engg	FUE
2.	Sh V K Arora	Chemical Engg	FUE
3.	Dr S N Yadav	Chemical Engg	PRE
4.	Sh H C Hans	Electrical Engg	ELE
5.	Sh N V R Mohan	Mechanical Engg	PMA
6.	Sh T N Verma	Chemical Engg	SMT
7.	Sh A Pahuja	Chemical Engg	PRE
8.	Sh P Otto	Mechanical Engg	PMA
9.	Sh K I Romi	Mining Engg	KIR
10.	Sh A K Dembla	Chemical Engg	PRE
11.	Sh Rajinder Singh	Electrical Engg	AUT
12.	Sh Rabinder Singh	Chemical Engg	PRE
13.	Sh A S Hatti	Chemical Engg	FUE
14.	Sh Y P Sethi	Chemical Engg	FUE
15.	Sh K Prakash	Chemical Engg	PRE
B.	STATIONED AT NCB-H		
16.	Sh M Vasudeva	Chemical Engg	ENE
17.	Sh P S Sasturkar	Mechanical Engg	PMA
18.	Sh C D Elkunchwar	Chemical Engg	PRE
19.	Sh D Bhaskar Rao	Chemical Engg	SZR

UNDP / UNIDO PROJECT IND/84/020 - STRENGTHENING NCB CAPABILITIES IN PRODUCTIVITY ENHANCEMENT OF CEMENT INDUSTRY (PEP)

WORK PLAN FOR UNIDO EXPERT MR HARRY BRIAN LOCKE FOR POST 11.23 - EXPERT IN PRODUCTIVITY IMPROVEMENT THROUGH COAL COMBUSTION TECHNOLOGY AS PART OF NCB TEAM ON PRODUCTIVITY ENHANCEMENT AND MODERNISATION PROGRAMME

Commence of first Mission : February, 1986

Duration : 18 days

ACTIVITY	DATE
UNDP formalities	24 February 1986
Briefing by the UNDP Project Director & Chairman and Director General - NCB	26 February 1986
Briefing by the Director - NCB and visit to NCB-B Unit.	25 February 1986
Discussion with experts in NCB on Coal Technology Areas (Annexure I) with reference to Indian Cement Industry.	25 Feb - 7 March 1986
Discussion with NCB Programme Leader	28 February 1986
Visit to a Cement Plant ACC- Gagal	8 - 9 March 1986
Finalisation of UNIDO Expert's Mission Report.	10 March 1986
Finalisation of the Mission	11 March 1986
Briefing by UNDP	11 March 1986

The Associated Cement Companies Limited
Gagal Cement Works
near Bilaspur, H.P.

List of Managerial Staff

Messrs

1.	M L Narula	General Manager
2.	M D Joshi	Deputy General Manager (presently out of station)
3.	M S Gilotra	Manager Engg
4.	G Mishra	Manager Mining
5.	G K Nangia	Manager Quality & Process Control (presently out of station)
6.	P Pabby	Manager Personnel
7.	R K Garg	Ag Manager Quality & Process Control
8.	M N Bhagwat	Senior Accounts Officer

Also ACC Research and Development Division
L.B. Shastri Marg
Thane 400,604

Dipak M Sheth	Research Coordinator Fuels & pyroprocessing

CEMENT INDUSTRY IN INDIA

The cement industry in India which is about 70 years old presently comprises of 80 cement plants (excluding small plants) spread all over the country with an annual installed capacity of about 42.4 million tonnes. Processwise there are 33 wet plants accounting for about 35% of the total capacity, 41 dry process plants accounting for 62% of the capacity and 6 semi-dry plants accounting for about 3% of the total capacity. Of the dry process units, 15 plants are equipped with precalcinators, covering a capacity of about 12 million tonnes. The Indian Cement industry has been fairly quick to adopt the latest generation technology, and the units installed during the last 5 years or so have been of this type.

The industry has undertaken comprehensive modernization/ expansion programme at a capital cost of about Rs. 25000 million based on the condition of the individual plant, and continuous efforts are being made towards technology upgradation.

The total demand of cement in the country by the end of the decade is estimated to be around 49 million tonnes. To meet this level of demand, an installed capacity of 62 million tonnes of cement is envisaged by the year 1989-90. The capacity is further planned to be raised to about 91 million tonnes by 1994-95 and about 100 million tonnes by the year 2000.

(CRI information, 28 February 1984)

ANNEXURE 'A'

WESTERN COALFIELDS LTD (A/C A.C.C.)

	Total No. of samples sourcewise Name of the Colliery	Name of the Cement Plants	Average Analysis Result Mois%	Ash%	Ash Percentage Max%	Min.%	Moisture Percentage Max.%	Min.%	As per Grade	Below Grade
From 17.5.82 to 26.11.83	WARDHA AREA									
	Nakoda (298)	Chanda Cement Plant	9.51	22.77	30.4	13.35	10.75	5.8	85	213
From 11.4.82 to 18.11.83	SOHAGPUR AREA									
	1. Burhar (I, II, III) (222)	1. Lakheri Cement Plant 2. Kymore Cement Plant	5.74	28.93	41.0	15.9	8.4	4.0	135	87
	2. Govinda (105)	1. Lakheri Cement Plant 2. Kymore Cement Plant 3. Porbandar Cement Plant	5.81	18.53	26.5	17.4	7.9	4.0	77	28
	3. Kotma (78)	1. Lakheri Cement Plant 2. Kymore Cement Plant	6.05	26.74	27.2	17.8	7.9	4.0	52	26
	4. Jamura (15)	1. Kymore Cement Plant	5.81	26.9	27.5	26.3	6.05	5.5	10	5
From 15.4.82 to [illegible]	Jhagrakhand Area									
	1. Bijuri (91)	1. Lakheri Cement Plant 2. [illegible] Cement Plant	5.09	26.4	34.15	10.6	5.5	3.85	54	37
	2. [illegible] ([illegible])	1. [illegible] Cement Plant 2. [illegible] Cement Plant	[illegible].94	27.83	33.8	[illegible]	6.[illegible]	[illegible]	[illegible]	34

Other UN reports of relevance to the project

1. "Feasibility report for reconstruction of alumina calciner for energy conservation at Korba alumina plant." Project number SI/IND/82/802. Leningrad 1983.

   Concerned changes to plant, and its modernisation, including installation of fluidized coolers to replace planetary coolers of rotating kilns, and replacement of rotary kilns by a fluidized bed calciner.

2. "Coal gasification - Terminal tripartite review report meeting (summary) 28 January 1986, also "Coal gasification - Terminal Report", Regional Research Laboratory, Hyderabad 500 007; Council of Scoemtofoc and Industrial Research. October 1985. Project number IND/80/004.

   Concerned with the inauguration and the programme of gasification work for non-coking coals.

These were shown to CRI, who had opportunity to photocopy before the originals were returned to UNDP.

Other Indian literature of relevance to the project

The 9th International Coal Preparation Congress

New Delhi November 29-December 4, 1982. India

Paper E1 "Beneficiation of non-coking coals for power generation in India"

R N Ghosh, National Thermal Power Corporation;
S Ghose, CFRI; S P Mathur, Coal India

As well as mentioning obvious points - saving in freight costs, waggon capital &c - boiler plant advantages include a 1% increase in thermal efficiency for every 10% reduction in ash content, plus 0.5% increase in total output owing to reduced energy usage in auxiliaries. This example was for a reduction from 45% to 35% ash.

The estimate of costs of deshaling is R_s10.50 per tonne included a capital cost and profit element of 15%. The capital cost of a plant of 13.10^6tpa capacity for a 3 x 200 MW power station would be $R_s.10.10^6$, or 4-5% of the cost of the station. Washing would add some R_s48.77 per tonne to washed coal, equivalent to R_s35-45 per tonne of raw coal.

"Coal preparation and use - a world review"

Ed. S Ranga Raja Rao - for the 9th International Coal Preparation Congress, New Delhi, India, 1982, Oxford and IBH Publishing Co.

Contributions of particular relevance were numbers 2, 11, 12, 18, 26, 27. 28. None actually contained data immediately of use for reducing the ash content of coals currently received by cement plants; but there was the implication that extraneous ash could be separated from coal substance containing inherent ash, in non-coking coals.

Brief summary of the CRI document

"Techno-economic evaluation of establishing washeries for the beneficiation of coal" NCCBM.. no reference, no date
47pp or so + 27 tables

1. Washeries at pit head should be able to separate shale + 75mm by hand picking, and +10mm by two-product jig, to reduce coal ash content from 35-38% to 27-28%. Rejects would be some 25%-30% (presumably by weight) of over 60% ash. Figures are taken from CFRI coking-coal experience.

   Taking (coal) recovery at 75%, return on equity at 20%, selling price of rejects at Rs40 per tonne, "sales realization" at Rs292.35 per tonne for a 500 tph washery - then the payback period is 2 years 11 months. For a 350 tph washery, with "sales realization" at Rs297.94 per tonne - then the payback period is 3 years 3 months.

   Note - cost of rom coal - Rs195 per tonne; capital at Rs1118.46 lakhs and Rs955.48 Rs lakhs for 500 & 350 tph respectively. Debt:equity ratio 2:1:break-even on installed capacity 54% and 55% respectively.

2. Modular 100 tph washery equipment at a site chosen to supply nearby cement works would use technology basically that for 1.above, though differing in details of arrangement.

   The payback perios is 3 years 4 months for a throughput of 1300 tpd (100 tph). The cost of production is Rs269.89 per tonne, and sales realization Rs297.82 based on 20% post-tax return on equity.

   Note - capital Rs324.31 lakhs; debt:equity ration 2:1.

   The delivered prices for prepared coal for the case considered in South India, 420 km from the mines, were Rs674.00 per tonne for road trasnport or Rs482.69 for rail transport, both with 53.85% capacity utilization.

Papers describing examples of British work in energy usage reduction in the cement industry

(a) "Low cost wet to semi-wet conversion in cement manufacture"

Government-supported scheme involving Rugby Portland Cement Ltd, F L Smidth Ltd, and Manor Engineering Ltd. Lower cost than Lepol grate pelletising and preheating: a kiln feeding system of filter cake with no major kiln alterations.

(b) "New insulating refractory bricks in the burning zone of a cement kiln".

Government-supported scheme involving Tunnel Cement Ltd and GR-Stein Ltd.
Laminated brick of hard-faced refractory backed by insulation.

(c) "An improved process for domestic refuse burning in cement kilns".

Government-backed scheme further to develop the Blue Circle Ltd scheme.

(d) "The use of solid wastes as fuel in the cement industry."

M.Coomoraswanny, C.A.C. Haley, E. Giles, I.C.E. Conference on The practical implications of the re-use of solid waste, London, England, 1981.

(e) "The Westbury Process" - Blue Circle Ltd brochure about the preparation and use of urban garbage to save up to 20% of fuel usage.

(f) "Project Planning" - Blue Circle Ltd brochure about consultancy services in planning new works and in planning of works improvements.

(g) "Recovering energy from wastes".

C.A.C. Haley, D. Watson, Blue Circle Consultancy Services, updated from paper for China Energy Conservation Conference, Shanghai, June 1985, China.

Papers on gasification

A. "Economic aspects of gasification of different solid fuels"

H.D. Greenwood. Joint conference on gasification processes, Institution of Gas Engineers and Institute of Fuel", Hastings, England, 10-14 September 1962.

Reviews, and costs, ambient and elevated pressure processes in relation to the range of industrial needs for fuel gases.

B. "Feedstocks and fuels from coal: the need for process changes"

Brian Locke. Energy World, February 1982.

Outline of large-scale processes, applications, and developments needed.

C. "Demonstration of fluidized bed gasification for industrial applications".

R.C. Green, N.P. Paterson, I.R. Summerfield. Energy World, July 1984.

Outline of National Coal Board (NCB) work, producing ambient pressure producer gas for small industrial works use.

D. "The development of small coal gasification plant for process purposes in the U.K."

C.G. Thurlow, J. Whitehead, N.C.B. England, 1985.

Review of the N.C.B. work, aimed at cheap, simple coal gasification for industry.

E. "Industrial fuel by coal gasification".

Otto-Simon Carves Ltd brochure, England, 1985.

Industrial packaged gasifiers to 4 tonnes coal per hour, gas cv 4-5 MJ/Nm^3, pressure 100m bar, flame temperature up to 1500^{o}C, under N.C.B. licence.

The papers, lettered this way, were left with N.C.B.

Fluidised bed gasification slides - National Coal Board - Coal Research Establishment

CRE Spouted bed gasifier	86/82
Fluidised bed gasifier	86/67
0.15m diameter atmospheric pressure gasifier	86/59
0.3m gasifier	86/60
Thomas Ness plant modified	86/85
Partial gasification experiments	86/87
Range of experimental operating conditions	86/86
Fluid bed gasification plant	86/66
Flow diagram of 12tpd pilot plant CRE	86/83
0.5 ton/hour pilot plant	86/73
Merits of the NCB spouted fluidized bed gasifier	86/8
Present development programme	86/100
Cost of coal-derived low calorific value gas	86/96
Relative cost of making sng, medium and low btu gas from coal	86/84

Papers on fluidized bed combustion

Selected so as to concentrate more on high ash coals, and including dryers and furnaces, than on the more numerous boiler applications)

I "Fluidized combustion for advanced power generation with minimal atmospheric pollution."

Brian Locke, Sonderdruck aus Dechema - Monographien, Band 73, Germany 1973.
Outline of the purposes and beginnings of British work on fluidized combustion.

II "Fluidized combustion of fossil fuels"

A.G. Roberts, H.R.Hoy, H.G. Lunn, H.B. Locke, Coal Processing Technology 1975.
History, applications, developments and plans of the British programme.

III "Fluidized combustion power generation applied to Santa Catarine coal"

H.B. Locke, H.G. Lunn, The Florianopolis Coal Seminar, Florianopolis, Brazil, 21 October 1975.
Status report and consideration for use with a coal of 40% ash.

IV "Advances in pollution-free heat and power generation made possible by developments in fluidized combustion technology"

Brian Locke, Howard Lunn, Dechema-Monographien, Volume 80 Part I/1976.
Status report of work worldwide, and list of UK fuels burnt including 75% ash coal.

V "Operating experience with industrial fire-tube fbc boilers"

Michael J.Virr, Fluidized Combustion: is it achieving its promise? Institute of Energy Conference, London, 1983.
Operating data from 27 boilers including use of high ash coals in Brazil (55%) and Yugoslavia (30%).

VI "A summary of bubbling fluidised bed combustion in the UK"

P. Mills, Combustion Systems Ltd., England, March 1985.
Review of types of plant including dryers, air heaters, recycling ash, and distributor plate systems for high ash coals.

VII "Technical expertise available from CSL"

Combustion systems Ltd., England 16 December 1986.
Outline of design know-how, training, operational experience, information, back-up, test facilities and design manual contents list.

/ 2 ....

VIII "Plant reference lists"

Combustion Systems Ltd., England, January 1986.
Selection of CSL licensed plants in 12 countries, also UK, including gas generators, dryers, calciners and incinerators, as well as boilers.

IX "Fluidised combustion of coal"

National Coal Board Report, England, 1985.
Description of the whole subject, with examples, including use of high ash coals.

X "Combustion Systems Ltd"

Combustion Systems Ltd. Brochure, England 1985.
Summary of licensing, test facilities and geographical coverage.

The papers, numbered this way,were left with NCB.

Fluidized combustion slides - from various sources

The principles	-	58/74
Vosper horizontal boiler	-	58/35
Gibson Wells boiler	-	60/47
Fluid fire boiler	-	58/31
ME Boilers boiler	-	58/76
Hybrid boiler	-	59/51
Babcock & Wilcox boiler	-	15
Babcock & Wilcox boiler	-	13
Combined cycle power system	-	A
Air cycle system	-	B
Tailings combustor	-	40/58
Encomech air heater	-	58/8
Hot gas generator	-	58/47
Ketton cement works dryer	-	57/59

General papers - as background

1. "Resources, innovation and investment in the construction industry"

   Brian Locke, Dinner discourse at the Royal Society, Faculty of Building, London, England, 9 February 1973.
   Background, also some examples including fibre reinforcement of cement products, prestressed concrete pipes.

2. "Energy policy, technology, and the diffusion of innovation"

   Brian Locke, First International Conference on Energy and Community Development, Athens, Greece, 10-15 July 978.
   Covering balance of energy resources, some advances, implications, technology transfer.

3. "Throwing money away?"

   Brian Locke, British Business, Energy conservation special report, 3 October 1980.
   Reasons for industry to improve profits by improving energy usage efficiency.

4. "Process rearrangement - designing from new"

   & C Brian Locke. Energy World, July 1984.
   Considerations for designing energy usage efficiency into new plants.

5. "Where are science and technology going?"

   Brian Locke, Chemistry in Britain, Vol.21 No.6. June 1985.
   Some considerations of development and application including some energy issues.

The papers, numbered this way, were left with NCB.

Also, sent to Dr Visvesvaraya (14 April 1986)

"Slagging in boiler furnaces ...."

D. P. Kalmanovitch, A. Sanyal, J. Williamson. J. Inst.E. March 1986.

Papers on recent specific relevant equipment

I Paladon - an improved particle separator.

II Gervase - an improved flow metering system - essentially an automatically varying orifice, with a linear flow characteristic. Also associated control equipment.

III Energy Management (UK) - power reduction systems for lighting and for motor starters and controls.

The papers, numbered this way, were left with CRI.

These organizations, also the UK government Warren Spring Laboratory, do not have offices in India. The author will be happy to make connexions.

British Government Papers on energy saving and efficiency improvement generally - cement manufacture itself is covered in other lists

(i) Fuel Efficiency booklets

covering all of industry generally including cement.

Energy audits	1
Utilisation of steam for process and heating	2
Compressedair and energy use	4
Steam costs and fuel savings	5
Recovery of heat from condensate flash steam and vapour	6
The economic thickness of insulation for hot pipes	8
Controls and energy savings	10
Energy management and good lighting practices	12
The recovery of heat from industrial processes	14
Economic use of gas-fired boiler plant	16
Economic use of coal-fired boiler plant	17
Boiler blowdown	18

These apply for offices, housing, laboratories, and all the other components of industry, other than kilns and dryers.

(ii) Industrial energy thrift scheme

Energy use in the pottery industry	2
Energy use in the bricks, fireclay and refractory goods industry	3
Energy use in the abrasives and miscellaneous building materials industry	5
Energy use in the glass industry	23

These apply for factories and processes with some similarity to, or peripheral relevance to, the cement industry.

These papers were all left with CRI.

General building materials - some summaries of United Kingdom government Energy Conservation Demonstration Projects - in related areas

Number of leaflet	Condensed description
9	Refractory fibre insulation - pottery kilns.
19	Ceramic recuperator for muffle kiln - sanitary ware.
21	Carbon additions to brick clays.
56	Drying with exhaust heat via a heat exchanger.
83	Direct firing a muffle kiln - sanitary ware.
97	Heat exchanger for intermittent kiln heat recovery - pottery.
98	Heat exchanger for kiln heat recovery - bricks
99	Tunnel kiln temperature control - refractories
129	Dewatering press - magnesium hydroxide.
133	Pulverized coal firing of rotary dryer - coke.
135	Monitoring energy saving - stone dryer.
139	Reducing tunnel kiln firing cycle time - earthenware.
150	Lightweight aggretate from coal waste - tailings.
153	Landfill gas as fuel for firing.
166	Air solar drying/curing - concrete building blocks.
169	Once-firing, fast firing - glazed ceramics.
177	Microprocessor control of 80 suspension storage tanks - ceramics.
180	Fast once-firing - ceramic tiles.
181	Tunnel kiln automatic control - bricks.

These papers were all left with CRI.

Annex 19

Some non-conventional fuels used in Blue Circle plants in different countries

Material	Cement Works	Country
Urban garbage	Westbury	UK
Landfill gas	Cambridge	UK
Scrap tyres	Hope Cauldron Weardale	UK UK UK
Charcoal fines	Pedra do Sino	Brazil
Rice husks	Kanthan	Malaysia
Wood waste	Sagunto	Spain
Oil shale	Rawang	Malaysia

Annex 20

Some sources of relevant technology, possible as sources of training for NCB staff

Coal beneficiation - wet and dry

National Coal Board Establishments
Warren Spring Laboratory
Paladon
UK connexion of Conveyor and Ropeway Services

Use of high-ash coals in processing - fluidized, cyclone, and other types of combustion; all types of gasification; newer cement processes

Combustion Systems
National Coal Board
Blue Circle
Cadogan Consultants connexions
Gottlieb
and, abroad,
Lurgi, Frankfurt a M.
Scientific Design, New York

General - coal analysis; new technologies; energy management &c

Universities - Imperial College, Sheffield, and others
Fuel analysts
Cadogan Consultants connexions
- all according to need.