NIFES CONSULTING GROUP

COMMERCIAL IN CONFIDENCE

FINAL REPORT

ON THE

PROVISION OF EQUIPMENT AND TRAINING

for a

MOBILE DIAGNOSTIC UNIT

to the

National Council for Cement and Building Materials
INDIA

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CONTENTS

PAGE NO.

EXECUTIVE SUMMARY i and ii

1.0 INTRODUCTION 1

2.0 INSTRUMENTATION, HARDWARE AND SOFTWARE

2.1 Instrumentation and Hardware 2
2.2 Software 6
2.3 Documentation 6

3.0 VEHICLE

3.1 Mobile Diagnostic Unit 7

4.0 TRAINING : UK

4.1 UK Training Phase 8

5.0 TRAINING INDIA

5.1 On-Site Training India 11

6.0 ENERGY AUDITS

6.1 Demonstration Energy Audits 14

7.0 DISCUSSION AND CONCLUSIONS

7.1 Instrumentation, Hardware and Software 17
7.2 Vehicle 17
7.3 Training 17
7.4 Demonstration Energy Audits 18
7.5 Future Programme 19

APPENDICES

1. Terms of Reference
2. Instrument List
3. List of Energy Auditing Manuals
4. Energy Bus - Snag List
 - Standing Instructions
 - Photographs
5. Preliminary Energy Audit Report - Vasavadatta
6. Preliminary Energy Audit Report - Priyadarshini

EXECUTIVE SUMMARY

UNIDO instituted a project to provide a Mobile Diagnostic Unit (MDU) to the National Council for Cement and Building Materials (NCB) in India, equipped to carry out energy audits and other investigations in the Cement Industry.

In December 1988, NIFES Consulting Group were awarded a contract to provide equipment and software for the MDU and training in the UK and India.

The MDU comprises a vehicle designed and built in India to a NIFES specification. It was ordered by the NCB in January 1989 and delivered to their Hyderabad offices in September. A set of instruments, a micro-computer and software were procured by NIFES in the UK and freighted to India.

A training course on energy auditing and conservation was given in the UK by NIFES, in conjunction with Blue Circle Industries. Then, following delivery of the MDU in September, two NIFES' engineers spent one month in India commissioning the MDU, training NCB engineers and directing demonstration energy audits on three cement plants.

The instruments functioned well on site without any significant problems. The computer and software proved invaluable in carrying out analyses and producing reports.

The MDU vehicle proved capable of fulfilling its primary function to transport the instruments safely to site. Some teething problems were experienced but these are being rectified by the NCB

The MDU is also equipped with recorders and analysers to enable more extensive investigations into energy efficiency improvement options, productivity enhancements and trouble-shooting. The NCB's ability to carry out investigations and to present reports quickly has been greatly strengthened by the acquisition of the MDU.

The MDU programme proposed by the NCB for use of the MDU should enable identification of significant savings in energy throughout the cement industry, particularly in South India. The scope for identification of energy savings is considerable; a typical cement plant in India would use 30-40% more energy than the UK equivalent and many are performing badly in comparison to the best Indian plants.

To ensure success however, the MDU must be well organised and promoted and, to this end, it is recommended that an MDU promotional manager be appointed. This or another person should be given the clear overall responsibility for the care and maintenance of all instruments and equipment in the MDU.

1.0 INTRODUCTION

This report describes the work carried out by NIFES Consulting Group as part of the UNIDO project to provide the National Council for Cement and Building Materials in India with a Mobile Diagnostic Unit (MDU) equipped to carry out energy surveys in the Cement Industry. The MDU comprises a customised vehicle equipped with measuring and recording instruments and with a micro-computer and associated software.

NIFES' involvement was to specify and supply the instruments, the computer and the software, to provide a specification for the MDU vehicle and to provide training, both in the U.K. and in India, for the operating staff of the MDU.

The aims of the project were :

> To increase the expertise of the staff of the National Council for Cement and Building Materials (NCB) in energy conservation practice in the cement industry through development and introduction of an energy audit system capable of providing on-site diagnostic analysis of the efficiency of energy use at various cement plants and of providing recommended energy conservation recommendations. The system should also contribute towards improvement of :
>
> (a) technological processes,
>
> (b) intensification of production,
>
> (c) trouble-shooting

The project was divided into the following stages :

1. System procurement comprising specification, purchase and testing of instruments in the U.K.
2. Fellowship training in the U.K. in the use and care of instruments and in energy conservation techniques, both general and specific to the Cement Industry.
3. Delivery of instruments and other equipment.
4. On-site training in the NCB office at Hyderbad, India in the techniques of energy auditing on cement plants.
5. Demonstration energy audits on three cement plants in South India.
6. Preparation of a final report.

1.0 INTRODUCTION Continued

The contract was signed in December 1988. The vehicle was ordered by the NCB in January 1989 and finally delivered to their Hyderbad office in September 1989. The U.K. training took place in May and June prior to which all the instruments and computers had been purchased. The training phase in India took place between the end of September and middle of October.

The report here describes the equipment, training undertaken and the demonstration audits and discusses the effectiveness of the approach and arrives at appropriate conclusions.

2.0 INSTRUMENTATION, HARDWARE AND SOFTWARE

2.1 Instrumentation and Hardware

The instrumentation supplied by NIFES for the Mobile Diagnostic Unit is detailed in Appendix 2. It can be summarised as follows:

Temperature Measuring Instrumentation

- Type K Thermocouples
- Digital temperature meters
- Mercury in glass thermometers
- Digital RH meters

Gas Flow/Pressure Instrumentation

- Vane anemometer
- Pitot tubes
- Electronic flow meters (for pitot tubes)
- Manometer

Gas Analysis Instrumentation

- CO_2 continuous analysis
- O_2 continuous analysis
- CO_2/CO sampling tubes
- O_2 meters
- Gas conditioning system

Continuous Recorders

- 3 channel chart recorder for electrical measurement
- 18 channel chart recorder for temperature (analogue recordings)
- Maximum demand recorder

Miscellaneous

- Ultrasonic gas leak detector
- Current ammeters
- Electrical multimeters
- Photometers
- Bomb Calorimeter
- Calibration gases
- Safety Equipment
- Tools

2.0 INSTRUMENTATION, HARDWARE AND SOFTWARE

2.1 Instrumentation and Hardware Continued

Computer System

- IBM PS2 Model 30 computer
- Epson dot matrix printer
- Microlink data collection system
- Signal input box

A list of operating limits of each instrument was prepared for display in the MDU and is also included in Appendix 2.

All of the equipment was tested and then demonstrated at the offices. It was subsequently demonstrated on site with the exception of the Microlink system. This could not be used on site due to some teething problems with the vehicle.

No problems were experienced with the equipment in use or in transit.

The maintenance requirements of the instrumentation and their limitations of use were demonstrated to the NCB staff.

It can be seen from the detailed list of instruments that most of the smaller items were duplicated or triplicated. Care was also taken to ensure that adequate spares were provided for at least one years' running for the single items items such as the bomb calorimeter and chart recorders.

Some of the instruments are commented on below :

Gas Analysis

It is possible to carry out gas analysis either intermittently or continuously. Whilst continuous sampling is not essential for an energy balance around the kiln, it can be useful when longer tests are being carried out. To enable continuous analysis using the O_2 and CO_2 analysers, an electric sampling pump and gas conditioning equipment were provided. Considerable difficulty was experienced, however, due to dust clogging the inlet of the sampling tube. This problem may be improved by restricting the gas sampling rate to the minimum necessary and by using a larger diameter sampling tube with a dust filter as near as possible to the sampling point. Another suggestion would be to use air blow-back but this would have to be carefully designed to avoid damage to the instruments.

2.0 INSTRUMENTATION, HARDWARE AND SOFTWARE

2.1 Instrumentation and Hardware Continued

Continuous Recorders

The continuous recording facilities provided comprised a 3-pen chart recorder, a combined power analyser/meter reader, an 18 channel programmable chart recorder and the on-line computer micro-link facility with 30 channels.

The first two items are quick and easy to use and most useful in carrying out rapid energy audits. The second two items would not normally be supplied within a standard energy auditing equipment package. However, given that this MDU is for a single industry, and is to be operated by process experts in that industry, this higher level of instrumentation is justified in that it will enable them to carry more sophisticated investigations and analyses, not just in energy efficiency but also in quality enhancement and in trouble-shooting.

During the demonstration audits it was apparent that there would be scope for carrying out longer term targeted investigations on certain high energy using items of plant. In particular, there seems to be considerable scope for energy savings in and around milling and grinding equipment and we could foresee that the on-line data collection equipment could usefully be used in carrying out plant trials and tests to assess the best conservation measures.

Automatic Bomb Calorimeter

The automatic bomb calorimeter for measuring the calorific value of fuels was provided with its own water cooler and water heater and bucket filling system. These facilities could enable it to be operated in the bus. This, however, is not considered practical because firstly the system would take 4-5 hours to assemble and to stabilise, secondly, it would take up about half the working area of the bus, thirdly it requires laboratory facilities such as accurate weighing and chemical titration.

The calorimeter was used in the NCB Hyderabad offices to determine the calorific value of coals collected on site during the demonstration audit.

2.0 INSTRUMENTATION, HARDWARE AND SOFTWARE

2.2 Software

Software facilities were provided as follows :

- o Spreadsheet package
- o Word Processing package
- o Database package
- o Statistical Analysis package
- o Monitoring and Target Setting package
- o Kiln Heat Balance Programme
- o On-line Data Collection Programme
- o Calculation of Heat Loss
- o Calculation of Gas Flow Based on Pitot Tube
- o Calculation of Combustion Efficiency
- o Calculation of Moisture Content

A standard spreadsheet was developed for analysis of data and production of charts and graphs. This is capable of further enhancement as the MDU audit teams gain experience. In the same way, a standard report format was provided using the word processing package which was adapted to NCB requirements and which can be altered as required.

Apart from the spreadsheet and word processing facilities, the most important computer facility was the Kiln Heat Balance programme.

The other software facilities including the statistical analysis, database and monitoring and target setting packages will find valid application in longer term and more detailed studies.

2.3 Documentation

The NCB were supplied with full operation and maintenance manuals on all the instruments, hardware and software. They were also supplied with a set of energy auditing manuals as detailed in Appendix 3.

3.0 VEHICLE

3.1 Mobile Diagnostic Unit

The Mobile Diagnostic Unit or Energy Bus was designed and built in India to a specification provided by NIFES. NCB ordered the vehicle and supervised the design and construction.

The vehicle is fitted with air conditioning to enable the computer to be operated on site in the elevated temperatures experienced in India.

A petrol driven generator is also fitted for use in remote sites where power cannot be provided from the plant's supply. It also provides a standby facility to maintain the electrical supply during the power interruptions often experienced in Indian industry. A well designed uninterrupted power supply system utilising a 12 voltage regulator protects the computer during data processing.

Other facilities include :-

- o Refrigerator for storing temperature sensitive materials
- o Storage for instruments and paper work
- o A signal input box for connecting cables into the vehicle without passing them through open doors or windows.

During the demonstration audits, the vehicle transported the instrumentation safely over very poor roads. The driver was instructed and supervised in the initial journeys by NCB and NIFES. It was found that speeds up to 70 km/h could be safely maintained on good roads but only 5 km/h on particularly bad roads with large potholes.

Some electrical problems were experienced during the course of the pilot study which restricted the full use of the vehicle. On rectification of these problems it is considered that the vehicle should perform well in its function as a mobile diagnostic unit.

A list of snags to be cleared up on the bus is given in Appendix 4.

The importance of cleanliness in the vehicle was stressed in order that problems would not be experienced with the computer. A set of standing instructions were agreed for operators of the vehicle. A copy of these instructions is to be found in Appendix 4.

4.0 TRAINING UK

4.1 UK Training Phase

Two engineers, A.Pahuja and S.Ramarao, attended a four week study and training course in the UK. Pahuja had 13 years experience in cement technology, 3 in energy auditing; Ramarao had 4 years experience, 2 in energy auditing.

The programme for the four weeks is given in Table 4.1. It was devised to give them a wide overview to energy auditing and energy conservations techniques in the UK relevant to cement technology. A series of visits were arranged with instrument and equipment suppliers. They also visited the Energy '89 exhibition where most of the UK energy systems suppliers were represented. NIFES staff participated in giving lectures, training sessions and individual tuition on various aspects of energy auditing.

The instruments had been delivered before the training course commenced so the trainees were able to obtain direct instruction in their use. In the case of the more sophisticated items, they were given demonstrations by the suppliers.

They also attended a one week intensive training course with Blue Circle Cement Limited on practical energy auditing techniques for the cement industry. This course comprised discussions and lectures on energy consuming plant in the cement industry and the measurement and data reduction techniques for efficient auditing on cement plant.

The programme was as follows:-

On the first day Blue Circle gave demonstrations of computer techniques used in energy auditing including the use of the 'KILN' heat balance programme. The Blue Circle's Energy Manager presented the company's energy management policy and its implementation in practice. This was followed by a day on practical energy audit measurements and computer calculations at Westbury Cement Works, a wet process plant.

One day was dedicated to seminars on :-

- Control and Instrumentation
- Energy efficiency in materials handling
- Energy efficiency in coal, cement and raw meal grinding.

4.0 TRAINING UK

4.1 UK Training Phase Continued

The last two days with Blue Circle were spent on practical energy audit measurements and computer calculations at Cauldon Cement Works, which is a modern, computer controlled, dry process plant.

All during the week, the NCB trainees were able to hold useful discussions with Blue Circle managers, engineers and operating staff on a number of practical problems and techniques concerned with efficient operation of plant.

Following the one month training course in the U.K, the two trainees were awarded NIFES´ training certificates.

4.0 TRAINING UK

4.1 UK Training Phase Continued

Table 4.1 : PROGRAMME

Week 1	M	15/5	Introductions/Computer Practice/Review of Vehicle and Equipment.
	T		Attendance at Energy '89 Exhibition.
	W		Demonstration Chessel Recorder/Instrument Training.
	T		Bomb Calorimeter Training and Demonstration.
	F		Demonstration Crest Recorder/Audit Training with P Horan head of Auditing, NIFES Manchester.
Week 2	M	22/5	Auditing on Cement Plants, Energy Conservation principles, Blue Circle Training Centre.
	T		On site Training, Westbury Cement Works.
	W		Controls and instrumentation, Conservation in Crushing and Grinding, Materials Handling, Blue Circle Training Centre.
	T		On-Site Training, Cauldon Cement Plant.
	F		On-Site Training, Cauldon Cement Plant.
Week 3	M	29/5	
	T		Instrumentation Training/Draeger Gas Analysis.
	W		Visit Rugby Cement Group.
	T		Auditing Large Compressed Air Plant, Broadstone Sewage Treatment.
	F		Visit Department of Energy, London, and supplier of Expert Systems for Cement Plant.
Week 4	M	5/6	Electricity Research Council visit.
	T		On-site training NIFES, Glasgow - Dr J Barr, NIFES.
	W		On-site training Energy Management - ICI Glasgow, with G Bilkhu, Principal Engineer, NIFES.
	T		Software Training - M J Soars, NIFES.
	F		On-line data gathering - M J Soars, NIFES.

5.0 TRAINING INDIA

5.1 On-Site Training India

Training in India took place over the four week period from the 25th September to 20th October. The first and last weeks were spent at the NCB Office in Hyderabad. The middle two weeks were spent carrying out energy audits on three cement plants.

The four week schedule is detailed in Table 5.1.

A total of 8 NCB engineers took part in the course all from the energy branch of the Cement Productivity Enhancement division of NCB.

The engineers trained had between 3 and 18 years experience and all had had experience in carrying out energy audits on cement plants. One of the engineers had attended the UK training course in June.

The training consisted of :

- Practical Use of the Instruments
- Use of Computers and Software
- Care and Maintenance of Instruments
- Fundamentals of Auditing, as appropriate.

Due to the level and experience of the engineers, training was of an interactive and informal nature. Some were given individual tuition in areas where they were weak. As far as possible the engineers were trained in all the disciplines irrespective of their professional specialisation.

Particular emphasis was placed on the importance of a pragmatic approach to carrying out audits, taking measurements and interpreting results. Training was also given in certain practical skills necessary for instrument installation and maintenance such as use of tools, wiring practice, fault tracing, soldering, measuring, safety procedures, instrument piping, calibration and testing.

At the cement plants, the work was organised to give everybody a chance to use each of the instruments as far as possible. The use of each new instrument on-site was supervised until the trainers were satisfied that the engineer was using it properly.

The demonstration audits enabled the engineers to gain practical experience in carrying out analyses on-site using the computer programmes and they were encouraged to propose energy saving measures before leaving the site. These were then presented and discussed with the management at the end of the visit.

5.0 TRAINING INDIA

5.1 On-Site Training India Continued

This approach, which is essential to the success of the MDU concept, was very successful particularly at the third plant where we had got to the stage of being able to present a typed report prepared on the word processor. Prior to the MDU the NCB methodology had been to carry out analysis after leaving the site and present a report at a later date. At the end of the training, NCB engineers appreciated the advantages of advancing the work as far as possible on-site.

Originally, for the last week, the NCB had planned a training course in energy auditing and energy conservation to be attended by their own engineers and engineers and managers from cement plants. NIFES would have participated as lecturers and trainers on this course. Unfortunately it was cancelled at the last moment.

Instead the week was usefully spent in further training on instruments and computer techniques. The audit reports were advanced. The calorimeter was fully tested and demonstrated to work well.

The final day and a half were spent in a review meeting with the NCB Director in charge of the project.

5.0 TRAINING INDIA

5.1 On-Site Training India Continued

Table 5.1 : PROGRAMME

Sun.25/9	Arrive Hyderabad
Mon.26/9 – Fri.29/9	Unpack and check equipment. Training and demonstration - Use of Instruments - Care of Instruments - Use of Computers : LOTUS Spreadsheet Heat Balance Programme - Set up and trial runs with recorders and on-line data collection - Assemble automatic bomb calorimeter
Mon.2/10	Travel to Cement Plants.
Tue.3/10 - Thu.5/10	Demonstration Audit - Priya Cement
Fri.6/10 - Sat.7/10	Demonstration Audit Sagar Cement Travel back from Cement Plants
Mon.9/10 - Tue.10/10	National Holiday
Wed.12/10 - Sat.14/10	Demonstration Audit Vasavadatta Cement
Mon.16/10 - Thu.19/10	Further Training NCB Hyderabad Initial Tests Bomb Calorimeter Further works on demonstration Audit reports. Lecture on Energy Auditing practice in UK
Thu.19/10 - Fri.20/20	Final Review of project with NCB Director. Presentation of Audit Results. Demonstration of Statistics and Database packages.

6.0 ENERGY AUDITS

6.1 Demonstration Energy Audits

The MDU was used to carry out demonstration energy audits at three cement plants. These followed the broad methodology outlined in the flow chart shown in Figure 6.1.

Prior to the audits the NCB had sent out a questionnaire to the plants. Not enough time was allowed for these to be returned by the plant prior to the MDU visits. Instead they were completed while we were on-site. Also, a preliminary visit was not undertaken prior to the MDU visit.

The demonstrations audit visits lasted 2-3 days although it was agreed that to do a thorough job would require about 5 days for a single kiln plant.

During the first two audits at Priya and Sagar Cement Plants, the audit teams were not that familiar with the equipment and a lot of time had to be spent in demonstrating it. Also the time for these two audits were effectively only two days each. As mentioned in chapter 3, certain difficulties were experienced with the electrical circuits on the MDU which meant that we had to arrange to run the MDU computer in the plant's own air-conditioned rooms.

Despite these delays, teams were able to complete all necessary measurements for the audits and to arrive at preliminary conclusions. These were discussed with plant management in a meeting prior to leaving the site. The preliminary reports for these two plants were prepared back at the Hyderbad office.

At the third site, Vasavadatta Cement, we had more time, nearly three days, and the teams were more familiar with the use of the instruments and methodologies to be followed. As a consequence, we were able to present the preliminary report to the plant management in written form prior to leaving the site.

Copies of the preliminary reports for the Vasavadatta and Priyadarshiri plants are included in Appendices 5 and 6.

It would normally be expected that a written report containing preliminary results and conclusions would always be presented to plant management before leaving site. However, many conclusions regarding energy saving potential on cement plants can only be arrived at after detailed analysis. This is because of the high degree of inter-dependence which means that simple proposals can have effects on the overall performance, both upstream and downstream of the point of interest.

6.0 ENERGY AUDITS

6.1 Demonstration Energy Audits Continued

Prior to leaving the site the NCB engineer in charge gave the plant management a target date for production of the final report.

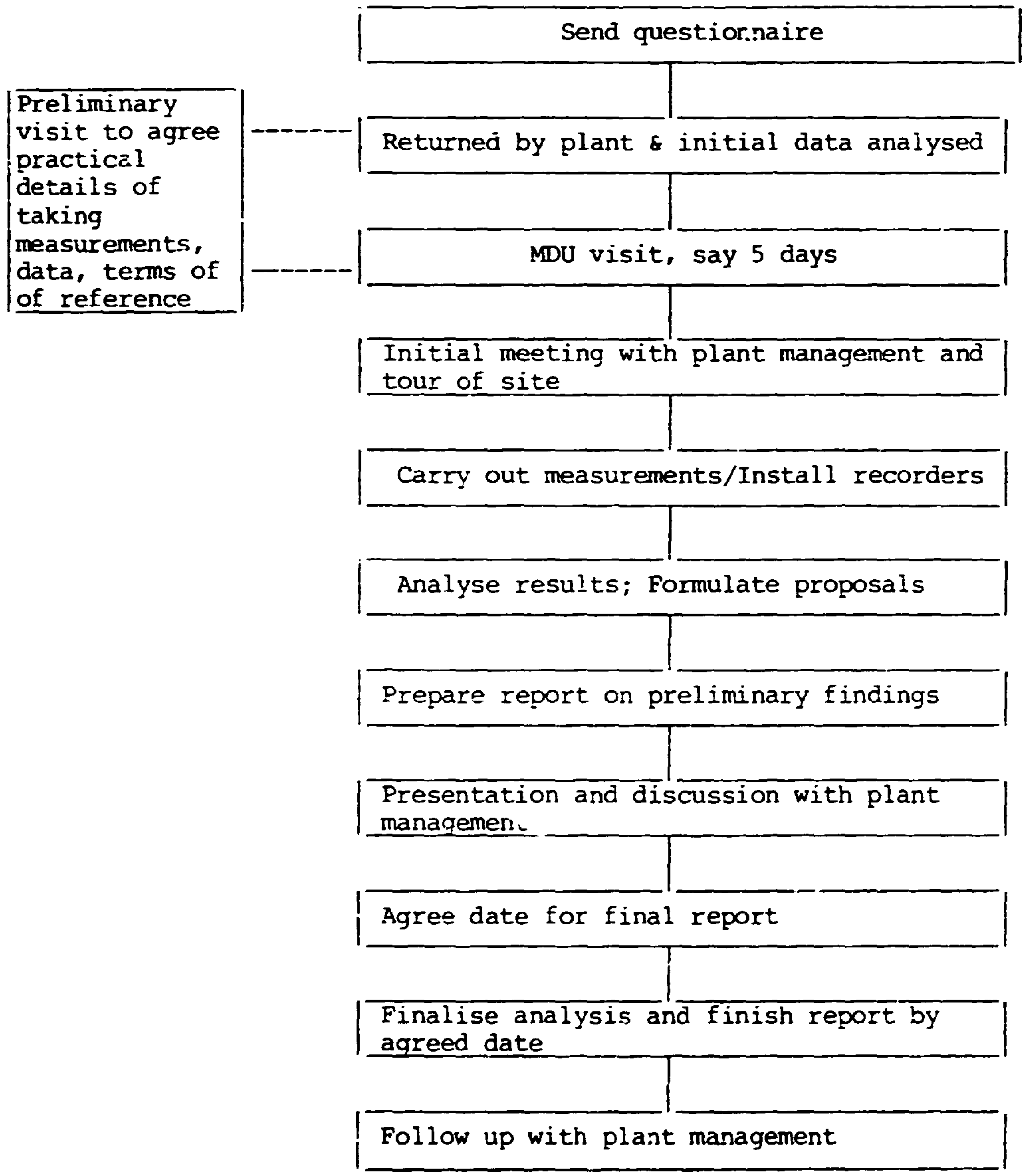
It was found that the MDU approach, which allowed a complete survey to be carried out in a short time and which allowed for a high degree of involvement of the plant's own management and which enabled preliminary results and conclusions to be developed prior to leaving the site, resulted in a strong and positive management response. In two meetings with plant management, subsequent to the MDU audits, they reported very favourable reactions to the approach and in one instance had actually implemented some of the recommendations within three days of the MDU team leaving the site.

At the concluding review meetings at the Hyderbad offices during the fourth week, a number of points were raised regarding the preparation and execution of energy audits using the MDU facilities. One was that the pre-audit questionnaire should be shortened and some other alterations to it made which would make it more acceptable to the plant and require less time to fill in. Secondly, that a preliminary visit prior to the visit of the MDU team would be very useful in ensuring that practical details such as provision of measuring points, repair of meters and availability of data are completed in time for the start of the audit. This preliminary visit would also allow for an early clarification of the objectives of the MDU audit.

At the final review meeting the NCB expressed the view that the MDU may be able to complete between 15 and 20 audits in its first year of operation rising to 30 audits in subsequent years.

6.0 ENERGY AUDITS

Figure 6.1 : ENERGY AUDITS USING THE NCB/UNIDO MDU



7.0 DISCUSSION AND CONCLUSIONS

7.1 Instrumentation, Hardware and Software

The instrumentation proved to be more than adequate to carry out the measurements necessary for a thorough energy audit. The software enabled the energy audit team to carry out data reduction and analysis on site and to produce a preliminary written report for the plant management before leaving site.

The instrumentation, hardware and software package is also comprehensive enough to allow extended testing and analysis for more detailed studies. Hence its use is not just restricted to energy auditing but can easily be extended to process investigations and trouble-shooting.

In addition to the mobile equipment, the NCB was also supplied with an automatic bomb calorimeter for measuring the calorific value of fuels, in particular coal. This instrument is very useful given the poor availability and methodologies for estimating calorific value of coals and given the rather uncertain and variable qualities of the coal supplied to cement plants. The calorimeter will not only allow them to support their energy auditing activities, but could also form the basis of a very useful service to the Indian Cement Industry.

7.2 Vehicle

The MDU had a number of problems revealed during the demonstration audit. However, it was felt that the vehicle was rugged enough for the job and demonstrated that it was more than capable of transporting the instruments safely.

We would not see any significant alterations in the design for a similar vehicle. There may be, however, some minor alterations in detail.

7.3 Training

The training was in two sections. The first section was in the U.K. which was attended by two NCB engineers for 1 month. This provided them with a very broad view of energy conservation practice in the U.K. and also with specific energy conservation practice in the Cement Industry. The second training phase was in India and was attended by eight NCB engineers in total.

7.0 DISCUSSION AND CONCLUSIONS

7.3 Training Continued

An important part of this training in India was the three demonstration audits carried out on cement plants. The time allowed for these was shorter than normal, and whilst they were very useful, and most of the objectives were met, we felt it would be more beneficial in future to ensure that at least one of the demonstration audits carried out would be long enough to allow all aspects of the audit to be completed thoroughly.

In general the trainees on the course were relatively young engineers. We found them to be of a good academic standard with a good grasp of engineering fundamentals and cement technology. At the end of the course we did feel that they had a much better appreciation of the practical limitations of instrumentation, the necessity for an efficient approach to measurement-taking, a suitably sceptical awareness of the possibility for errors in measurements and an appreciation of the necessity to check conclusions for internal and external consistency. Their practical skills in handling and using instruments were greatly improved.

7.4 Demonstration Energy Audits

The results of the three demonstration audits indicated the relatively poor level of efficiency of the Indian Cement Industry compared to typical cement plants in Europe or even compared to the most efficient cement plants in India.

We did find however, that nearly everybody we met on the plants was well aware of the need for energy conservation efforts, and on the face of it, there is certainly enthusiasm for undertaking measures where they can be shown to be beneficial and economic. Many of the problems of low energy efficiency are due to the poor supply of equipment replacements and the high level of power cuts in India. However, even allowing for this, the three demonstration audits highlighted simple measures that can easily bee undertaken and that can make significant energy savings.

It was apparent from our discussions with plant management that they had a high degree of acceptance of the MDU concept and we formed the impression that the presence of the MDU vehicle and energy auditing team provided a significant boost to the energy conservation efforts of the plant management.

7.0 DISCUSSION AND CONCLUSIONS

7.5 Future Programme

It is to be hoped therefore that the NCB can organise to undertake an extensive programme of audits throughout the Cement Industry, particularly in South India. It was suggested by the Director at the final review meeting that a target would be 15-20 in the first year of operation, rising to 30 for subsequent years.

We understand that the NCB intend to charge for energy audits carried out using the MDU once the concept and its advantages has been demonstrated. We have found that charging is important as the plants concerned are more likely to take the investigations and results seriously and are more likely to ensure full co-operation with the audit team.

The NCB are a very technically competent body and possess engineers with the ability and enthusiasm to make a success of the MDU We have found however, in similar projects which NIFES have undertaken, that to have good equipment and good engineers is not on its own enough to ensure success. We would recommend that the NCB appoint somebody with the appropriate abilities as Promotional Manager for the MDU. This person should not only have a good understanding of the technology but should also possess a high level of communication skills and a certain flair for persuasion. We would envisage that this person would visit companies and sites to sell the service and to make brief reports and possibly to agree practical details of carrying out surveys. This person would also be heavily involved in promotion of the MDU concept and energy conservation in general through seminars, publications, workshops and plant visits.

APPENDIX 1

TERMS OF REFERENCE

TERMS OF REFERENCE

for Consultancy Services to be Subcontracted through UNIDO for Project DP/IND/84/020 "Strengthening of NCB Capabilities in Productivity Enhancement of Cement Industry"

Subcontract III - "ENERGY AUDITING SYSTEM"

I. General Background Information

The project DP/IND/84/020 is aimed at improving the total productivity factor as well as technological levels of the cement industry in India through strengthening capabilities of the National Council for Cement and Building Materials (NCB).

The cement industry in India comprises 52 companies owning 72 cement plants - including mini cement plants - spread all over India with an annual installed capacity of about 36.5 million tonnes. The capacity is planned to be raised to about 81 million tonnes by 1994-95; by the year 2000 the capacity is expected to reach about 100 million tonnes. The tempo of growth of the cement industry has been witnessing an accelerative trend during the past few years. With a view to maintaining this tempo, a two-pronged attack for development of the industry will be necessary: on the one hand new capacity needs to be installed and commissioned; and, on the other, the existing capacity will have to be fully exploited. For the industry to achieve the targets set, it will need increasingly better and stronger technological support in its endeavours.

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

The activities under this programme involve identification - jointly by NCB and cement plant - of the areas to be investigated which require technological services support, visits by teams of NCB experts to such plants, data collection on the actual operations and working performance of the plant and of the individual units of machinery as considered necessary, collection of samples of materials - raw, intermediate and finished - wherever necessary, analysis of materials and data, formulation of suitable recommendations for remedial measures or modernization, communication of the recommendations to the plant and subsequent monitoring of implementation work and its feed-back all with a view to improving the productivity of the plant.

Although the pursuit and implementation of the above referred programme at various cement plants, have rapidly reinforced and strengthened the links between NCB and the industry, it has been experienced in the perspective of world-wide technological developments in cement industry that in India the levels at which the technological problems of the plants are being diagnosed, the levels at which remedial as well as suggested measures are being recommend and - most importantly - the methodologies being adopted for implementation of recommendations need to be raised. There are certain gaps, essentially in the availability of expertise.

Among the areas where the expertise needs to be strengthened is energy conservation in the cement industry since the energy consumed forms a substantial proportion of the total energy available in the country.

The projected rapid rate of growth of the cement industry would further accelerate the demand on energy. The escalation of energy prices in recent years has increased the production cost of cement significantly, forcing the industry to take a serious look at the energy situation and evolve ways and means of cutting down on the energy cost. The fuel energy cost in the cost of production of cement is of the order of 25 per cent to 40 per cent depending on the process while the power cost is of the order of 10 to 15 per cent. Poor quality of coal and a deteriorating power situation have also added their bit to the situation. In this context, energy audit becomes an important tool to tackle the present energy crisis. With the emergence of large sized plants and massive expansion under way, energy audit acquires an increasingly important role in the Indian cement industry.

II. Objectives of Subcontracting

To increase expertise of NCB staff in energy conservation practices in the cement industry through development and introduction of an energy auditing system capable to provide on-site diagnostic analysis of the efficiency of energy use at various cement plants and recommended energy conservation measures. Alternatively the system should also contribute towards:

- improvement of technological processes
- intensification of production
- trouble-shooting

as far as energy aspects of the above subjects are concerned.

III. Main Characteristics of the System

1. Mobility

The System should be based on a concept of a Mobile Diagnostic Unit (MDU) which is capable to provide qualified expertise and service to a large number of cement plants on a periodic basis.

2. Areas of Application

The System should be applicable to the main stages of cement manufactures as well as to the various types of cement clinker making processes and equipment.

3. Composition of the System

a) Basic vehicle

A van with sufficient space to house the instruments and the crew of at least three persons and with separate space for auxiliary equipment. The van should be equipped with suspension means in order to protect the instruments from damage and losing the accuracy.

b) **Equipment**

All equipment should be portable and heavy-duty-type suitable for tropic conditions. The measuring equipment should have sufficient accuracy and reliability to identify operation of cement and energetic installations. Preference should be given to instruments with locally available service.

1. Measuring instruments

The following parameters should be basically measured:

- temperature
- pressure
- heat flow
- gas composition
- flow velocity of different media
- electrical values
- humidity
- steam parameters
- other (time, revolution, mass, etc.)
- auxiliary materials (tools, cable, compensating cables, etc.)

The equipment should cover the ranges to suit various types of cement-producing equipment and energetic installations.

2. Recording and evaluating equipment

- data logger
- on-board computer. (IBM compatibility is recommended)
- associated software
- peripheries

c) Personnel (MDU Crew)

The recommended staff:

- Energy Management Expert
- Expert on Measurement and Evaluation
- Technologist (when necessary)
- Technician (driver)

d) Manual

The manual should contain the information on:

- Methodology of Energy Auditing
- Equipment Manuals
- Supporting Technical Data
- Basic Information of Energetic Installations

e) Energy Data Base

Methodologies and procedures for analysis of energy audit results, maintaining the reports and collecting relevant statistics.

IV. Scope of Subcontracting Services

The subcontracting should include:

1. Equipping and delivering of MDU with corresponding software of energy auditing and for Energy Data Base.
2. Fellowship training of two NCB specialists in energy auditing (one month each).
3. On-site training of NCB staff in using MDU (two weeks at NCB pilot cement plant).
4. Conducting three to four energy audits of cement plants jointly with NCB counterparts (two weeks).

V. General Time Schedule

Proposals on the composition of MDU including list of instruments and their technical data should be presented in the bid of subcontracting.

Two alternatives are recommended:

a) Basic vehicle will be provided by the subcontractor within the total hard and software package.

b) The subcontractor will provide only instruments and corresponding software while the basic vehicle will be locally available and its equipping will be done on-the-spot.

Prior to signing the contract the selected alternative may be further specified in the light of evaluation to be done by UNIDO and project staff.

Training of two NCB specialists should take place before MDU is delivered.

After MDU is equipped and delivered to the field the Subcontractor's team will arrive in India for one month to train NCB staff on-the-spot and conduct the pilot energy audits. After commencement of this work the Subcontractor's Team Leader will arrive in Vienna for debriefing (for two days) on his way from India to his home country. The Draft Final Report should be prepared within one month after debriefing takes place and will be evaluated by UNIDO within three weeks. The Final Report should be submitted to UNIDO within three weeks after receiving UNIDO's comments.

VI. Personnel in the Field

The Subcontractor's team should consist of two persons.

1) Team Leader - specialist in energy management and auditing

2) Specialist in measurement and evaluation.

Both specialists should have a good command in English. Their CVs should be presented along with the proposals.

VII. Reports

1. Proposals on the composition of MDU to be included into the bid (5 copies)
2. Draft Final Report (five copies)
3. Final Report (ten copies)

Language: English

APPENDIX 2

INSTRUMENT LIST

and

OPERATING LIMITS

Resident Representative,
UNDP,
P.O.Box 3059,
New Delhi 110 003,
INDIA

Ref : NAT 040/JM/MB
Date: 28th July,1989

PRO-FORMA INVOICE

	Not licensable for export	Quantity
1	KM 3000 Digital Electronic Thermometer	2
2	KM 3013 Digital Electronic Thermometer	2
3	Infratrace 1000 Non-contact Thermometer	1
4	Infratrace 2000 " "	1
5	KS1 Surface Probe	6
6	KS3 " "	6
7	KC1 Chisel Probe	1
8	KC5 HD Insertion Probe	2
9	KA1 300 Air/Liquid Probe	2
10	KA1/45 Air Liquid Probe	1
11	KSM Sub-miniature Connectors Male	3 packs
12	KSM " " " Female	3 packs
13	305 mm Lab Thermometers	6
14	Mineral Insulated T/C Assemblies	6
15	" " " "	6
16	200 m Compensating Cable	1
17	Vaisala Humidity and Temperature Probe	2
18	Draeger Oxywarn 1000 I	2
19	Draeger Multi Gas Detector Kit Model 21/31	3
20a	Draeger Gas Detection Tubes	
20b	Draeger Gas Conditioning Unit MSI 2000p	1
21	Servomex Paramagnetic O_2 Analyser	1
22	Air Neotronics MP6 KAV	2
23	" " MP3 KDS	2
24	British Rototherm Manoflex 36"	1
25	Airflow Developments KCA 6000 Anemometer	2
26	" " Pitot Static Tube	2
27	" " PVC Tubing	
28	Airflox Developments Manometer Valve	2
29	John Firth Instr.Fluke 77	2
30	" " " Heme 1000p	3
31	" " " Robin Lux meter	2
32	Crest Energy PCT 30c Energy Monitor	1
33a	Chessell Ltd. Recorder 301	1
33b	" " Multirange clip-on Ammeters	3
34	" " Model 4001 Logger	1
35	Safeman Safety Helmets Ref HC41	4
	Poly cotton Boiler suits Ref HC41	4
	Poly cotton Coats Ref HC41	4
	Respirators Ref RR1000	4
	Filter Ref RC54	4
	Safety spectacles S29CNC	4
	Asbestos Gloves ASI/10	4
	Ear Defenders EM85	2
	Rigger Gloves L69R	4

38	Maester Ultrasonic Gas Detector	1
39	Scientific and Medical Automatic Bomb Calorimeter with water system, cooler, heater, spares kit and pellet press	1
40	Charles Clush Pumps assembly	1
44	Microlink Computer Interface Systems	1
50	Gas Test Cylinders	
51	Miscellaneous items: Instrument Manuals, Pens, Charts, Batteries, Torch, Servomex Aspirator, Draeger Pump Spares, Cable Coils, Solder, Plug Tops, Heat Sink, Screwdrivers, Pliers,Sidecutters, 2 Extension Cables, T/C Cable, Tubing, Plugs	1
52	ADC Carbon Dioxide Analyser	
53	Cable Entry Box	

Licensable for export

41 IBM PS/2 M30-286 H21 Microprocessor
IBM RAM enhanced keyboard, etc.

42 Epsom LX-800 80 col printer with cable

45 Software:

Wordstar Professional
Lotus 123 Spreadsheet
Paradox II Database
Stats plus statistical package
Application Programs
Kiln heat balance plus others

TOTAL VALUE INCLUDING SUPPLY AND DELIVERY : £ 45,000

K. Valentem
29/9/89

EQUIPMENT LIST WITH OPERATING LIMITS

1/ **MEME -1000 P - CLIP ON POWER METER** - 3 Nos

DC and AC current upto 1000 Amps (AC-RMS)
DC and AC voltage upto 750 volts (AC-RMS)
True power AC-DC upto 199.9 KW (AC-RMS)
Apparent power AC upto 199.9 KVA (True RMS)
Power factor - 0.3 cap .... to 1 .... 0.3 ind
Frequency - 0-1000 Hzs

2/ **DIGITAL LIGHT METER - CM-200** - 2 Nos

Operating temperature - 10°-50° C
Operating humidity - less than 80% RH
Range - 0-50,000 LUX

3/ **FLUKE - 77 - MULTIMETER** - 2 Nos

Temperature range - 0-50°C
Voltage - 0-1000 volts DC
- 0-750 volts AC (RMS)
Current - 0-10 Amps (RMS)
Resistance- 0-30 M

4/ **INFRATRACE - 1000** - NON CONTACT INFRARED DIGITAL THERMOMETER - 1 No
INFRATRACE - 2000 - 1 No
Full scale range = 0-1000°C - INFRATRACE-1000
-do- = 600-2000°C - " -2000
Minimum target size=20mm dia at 1 mt
Operating temperature = 0-45°C
Distance/Target dia = 40:1

..2/-

5/ VAISALA- HUMIDITY AND TEMPERATURE INDICATOR - 2 Nos

Type - HMI-31

Humidity = 0-100% RH

Temperature= -40 to +115°C (Range)

Operating temperature = +5 to+55° C

Measuring range = -40 to+80°C Max

+115°C for sensors only

6/ CARBON DI OXIDE ANALYSER - SB -100 - 1 No

Range = 0-50%

Recommended standardising mixture = 40% CO_2 in Air or Nitrogen

Gas flow rate = 0.5 lt/min

7/ OXYGEN ANALYSER - SERVOMEX 570A - 1 No

Range = 0-100% O_2

Operating temperature = 0-50°C

Initial pressure = Min 2.3 Kpa (1/3 psig)
Max -70 kpa (10 psig)

Flow control = An automatic flow control device control the cell flow to between 80 and 150 cc/min.

Calibration cases = oxygen free nitrogen
minimum purity of this nitrogen must be 99.9%.

8/ OXYWARN - 100 I - 2 Nos

Range = 0-100% O_2

Operating temperature = 0 - + 45°C

9/ GAS CONDITIONING UNIT - MSI 500 - 1 No

Gas flow rate = Min - 0.8 lts/min
Max - 3 lts/min

10/ DRAEGER MULTIGAS DETECTOR KIT - 3 Nos - Model-31

Sucking capacity of bellows pump = 100 Cm^3 per stroke

11/ VANE ANEMOMETER - LCA-6000 - 2 Nos

Normally = 0-30 mt/sec

Operating environment = Barometric pr -500 m bar to 2 bar

Temperature = -10°C to +50°C

12/ MICRO MANOMETER

TYPE : MP 3 KDS - 2 Nos

TYPE : MP 6 KAV - 2 Nos

	MP 3 KDS (Digital)	MP 6 KAV (Analogue)
Velocity ranges	1.5 - 70 Mt/Sec	0-10 Mt/sec 0-32 " 0-100 "
Pressure ranges	0 - ± 3 kpa	0- ± 60 pascals 0- ± 600 " 0- ± 6000 "

Recommended operational limits = 0 - 50°C

storage limit = -5 to + 55° C

13/ ULTRASONIC LEAK DETECTOR - 1 No

It gives audible and visual signal of leaks

14/ TEMPERATURE MEASURING INSTRUMENTS - 4 Nos

KM = 3000 - 2 Nos
KM = 3013 - 2 Nos

15/ ENERGY MONITOR - 1 No

CREST- PCT -31

Line current = 5-1000 Amps

Maximum range for 3 phase 415/440 V = 750 KVA

Insulating voltage range = 750 volts

Frequency = 40 - 500 HZ

..4/-

16) RECORDER (Logger)

Chessel-4001 - 1 No

No of recording channels - Maximum of 30

Type of input/output modules- Analogue (Volts DC, ma DC, T/c)RTD, RELAY OUT PUT

Scanning speed - 1 second for all active channels

Environment

Temperature limit - operation - 0-50 ^{o}C

Humidity limit - operation - 10-80% RH(non condensing

Analogue input module

No of inputs - 6

Type of inputs - DC volts-0.62 mv to 10.24 volts
(DC volts > 10.25 volts requires fitting of 100:1 ratio alternator)

- DC mA- Maximum current
50 mA (Requires fitting of 100ohms current shunt in signal interface module)

Mix of inputs - Thermocouples

Limits of opertion - Max input to alternator= 250 VDC
- Max input to module = 100 VDC

Resistance thermometer input module . (using 100ohms source with zero lead resistance)

No of inputs - 6

Type of input - 2,3 or 4 wire resistance temperature detectors

Limits of operation = -7 to + 14 volts

17) RECORDER

Chessel= 301 - 1 No

Ambient temp range = 0-50^{0}C

Humidity (Non condensing) = 0-90% RH

Power requirement = 115, 220 or 240 V AC

18) MULTI RANGE CLIP ON TRANSFORMER - 3 Nos

Current range = 0-500 Amps (RMS)

Line voltage = upto 600 volts

output = 5 volts rms full scale

19) CHARLES PUMP ASSEMBLY = 1 No

Operating temp = -5^{0} to + 30^{0}C

20) ADAIBATIC BOMB CALORIMETER - 1 No

21) MANOMETER = 36" - 1 No

22) MICROLINK COMPUTER INTERFACE - 1 No

23) IBM COMPUTER - 1 No

APPENDIX 3

LIST OF ENERGY AUDITING MANUALS

LIST OF ENERGY AUDITING MANUALS

1. Instruments for Energy Audits.
2. Heat Transfer
3. Industrial Energy Management
4. Economic Aspects of Energy Conservation
5. Compression
6. Basic Information
7. Co-generation
8. Industrial Heat Generation and Distribution
9. Auditing Principles
10. Electricity Utilisation
11. Heat Balances in Cement Industry

APPENDIX 4

ENERGY BUS

- Snag List
- Standing Instructions
- Photographs

MDU SNAG LIST
as of
20th October, 1989

1. Check all wiring particularly earthing and fuse protection.
2. A/C cutting out at times.
3. Voltage stabiliser - check operation.
4. Spare wheel bracket broken.
5. Seal secondary glazing.
6. Provide cable entry for mains power cable.
7. Exhaust pipe for generator to be fixed.
8. Extra insulation on A/C cold pipes.
9. Regulator for refrigerator power supply failed.
10. MDU wiring diagram required.
11. Locks on front cupboard and one drawer not opening.
12. UPS battery leaking.

STANDING ORDERS FOR MOBILE DIAGNOSTIC UNIT (MDU)

1. All instruments to be packed in assigned location.

2. All instruments to be cleaned before replacement in bus.

3. All faults to be reported to offices in charge of bus.

4. All instruments to be accounted at the end of each day.

5. All portable instruments and equipment to be returned to the bus at the end of each day

6. Keep the bus tidy.

7. No shoes to be worn in the bus.

8. No smoking in bus or near computer.

9. Dirty overalls etc. to be removed before entering the bus.

10. No instrument to be used by any engineer unless he is fully conversant with its correct operations in accordance with the manuals and within its specified limitations.

11. The computer requires AC to be operated and shall not be operated in conditions of condensation.

12. Alterations to computer operating systems and DOS shall not be carried on in the field.

13. Prior to moving bus ensure all instruments are properly stored and doors are locked.

14. Instruments and cables must be used with proper plug and socket. No bare cables should be used.

15. Ensure good and adequate earthing of powered instruments.

16. When bus connected to external mains earth continuity must be ensured.

17. Draeger tubes, spare batteries to be stored in fridge.

18. Switch off lights/fans when not required to reduce additional heat load in bus.

19. A/C to be set at 20^{o}C, not lower.

20. Fridge to be started only on mains or generator supply, not on inverter.

21. A/C can only be run on mains or generator.

23. THINK BEFORE YOU ACT.

24. Officer in charge of bus - responsible for all instruments and equipments.

25. Computer files for each plant to be stored as its own separate sub directory in the data mini disc.

26. Plant details must be stored only on mini disc, not on hard disc.

27. <u>CHESSEL 4001</u>

Can only be used in clean environments.

28. <u>CHESSEL 4001 & 301</u>

Ensure transit screens in place before transit, and removed before use.

29. Follow computer parking procedure before and after transit.

MDU ON-SITE

MDU ON THE ROAD

AUTOMATIC ADIABATIC BOMB CALORIMETER

COMPUTER TRAINING, NCB HYDERABAD

LIST OF ENERGY AUDITING MANUALS

1. Instruments for Energy Audits.
2. Heat Transfer
3. Industrial Energy Management
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5. Compression
6. Basic Information
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8. Industrial Heat Generation and Distribution
9. Auditing Principles
10. Electricity Utilisation
11. Heat Balances in Cement Industry

APPENDIX 5

PRELIMINARY ENERGY AUDIT REPORT : VASAVADATTA

OBSERVATIONS AND PRELIMINARY FINDINGS

ENERGY AUDIT STUDY

AT

VASAVADATTA CEMENT PLANT

14th OCTOBER 1989

NATIONAL COUNCIL FOR CEMENT AND BUILDING MATERIALS

NIFES CONSULTING GROUP, UK

INTRODUCTION

This document represents a review of the work carried out at the plant and gives an initial impression of the results and indicates the formative conclusions at this stage. A full report will be produced at the end of the study which will expand on the analyses and develop the conclusions.

The work was carried out using the NCB Mobile Diagnostic Unit or Energy Bus. This unit was provided under UNIDO/UNDP funding. The study was part of the training and initial demonstration period supervised by NIFES Consulting Group from the UK.

ENERGY AUDIT

Tables and graphs are presented for the year August 1988 to July 1989. The Specific Energy Ratios for that period are:

Overall Specific Power Ratio	145.92 kWh/tonne cement
Kiln Specific Thermal Ratio	829.77 kCal/kg clinker
Kiln Specific Power Ratio	50.84 kWh/tonne clinker
Raw Mill " " "	19.54 kWh/tonne l/stone
Cement Mill " " "	46.30 kWh/tonne cement
Coal Mill " " "	45.09 kWh/tonne coal
Crusher " " "	2.30 kWh/tonne l/stone
Despatch " " "	1.57 kWh/tonne cement
Misc. " " "	3.64 kWh/tonne cement
Generation Spec. Thermal Ratio	3.94 kWh/litre oil

The following comments are made with respect to these Specific Energy Ratios:

The overall specific power ratio is high mainly due to the high consumption in the kiln and cement mill. The specific thermal ratio as indicated is also high but this figure is not representative asit is based on the "useful heat value" instead of the "net calorific value" of the coal.

KILN SECTION

A kiln heat balance was developed based on measurements taken using portable instrumentation on the 12th October 1989. The results of the heat balance indicate a coal utilisation rate of 868.23 kCal/kg of clinker. This can be compared with the figure derived from the weighfeeder readings when the coal NCV for the day has been determined.

A printout of the heat balance is given in the Appendix.

Other points to note were:

The secondary and tertiary air temperatures were low.

The heat loss in the cooler exhaust gases is quite high due to higher volumes of gases.

The temperature of the clinker leaving the cooler is too high (180-220 deg C).

The entry arrangement at the cooler fans leads to very high velocities in excess of 70m/s in one case and consequently high pressure drops before the fan. An improved design of the inlet duct should be examined and there could be useful energy savings.

High CO content and low O2 content in the gases at the kiln inlet indicates low excess air and poor combustion efficiency.

The oxygen at the preheater outlet varied between 5.5-6 % indicating false air leakage in the preheater system.

The temperature of the tertiary air at the cooler is 700 deg C whilst at the precalcinator it is 300 deg C indicating a considerable drop in the temperature due to false air leakage in the damaged tertiary air pipe.

Leakage in the conditioning tower is about 20% leading to a higher load on the preheater fan.

The temperature of the preheater exit gas varied between 350-360 deg C. This is higher than the expected 330 deg C for a five stage preheater and hence amounts to a greater heat loss.

COMPRESSED AIR

A leakage survey was carried out of the compressed air lines using an ultrasonic leak detector. The following air leaks were identified:

SERVICE	LOCATION
Kiln aeropol blower	Receiver safety valve.
RM silo aeropol blower	Outlet pipe valve *
Weigh bin, silo, central chamber aeration blower	Valve *
Central chamber aeration blower	Valve
Coal purging compressor	Valve
PH purging compressor	Receiver valve *
Coal dust collector comp.	Valve *

NOTE * - Significant leaks.

It was noted that some air inlet filters were fouled with dust. This leads to increased power consumptions.

The air intakes to the compressors are all located in places with temperatures up to 5 deg C above ambient temperature. This can increase the power consumed to compress the air by upto 1%. A fan system is installed to supply air to the compressor house but due to poor air distribution it is ineffectual.

RAW MILL

The plant Management have reported problems of air ingress into the raw mill and have indicated difficulties of achieving its full rated capacity of 140 tph. However measurements taken indicate that there is only a relatively small inleakage of air across the raw mill circuit. Most of the inleakage appears to be occuring at the conditioning tower.

Although the raw mill has a slip ring power recovery system, this is of little benefit as the fan is normally operating at full speed. Should the inleakage be reduced then the fan speed may also be reduced and power saving achieved.

ELECTRICITY

The power factor at the plant is very low at 0.85 . This is due to the failure of some capacitors. The replacement of the capacitors to achieve a power factor of 0.95 will lead to a reduction of kVA maximum demand and thereby achieve financial savings. The lower power factor also causes higher electrical currents leading to higher copper losses in the transformers, cables and motors.

The electrical load factor varied between 41.43% and 83.43% during the year analysed. Various plant interruptions during this period contributed to the varying load factor.

The average current loading in the LT induction motors of 30 kW and above rating was observed to be only 55%. This corresponds to about a 40% power loading of the motors. This underloading causes a fall in the efficiency and power factor of the motors and leads to the inefficient operation of the motors.

DIESEL GENERATION

The Diesel generation station contains 3x 4MW Diesel sets running on high speed Diesel (HSD).

Due to supply interruption problems one unit is kept running continuously to meet the kiln electrical demand. This results in a high cost of power to the plant.

The generators are producing 3.98 kWh/litre of fuel.

Consideration is being given in the study to the possibility of the recovery of waste heat from the exhaust.

APPENDIX

KILN HEAT BALANCE (TENTATIVE)

F

HEAT INPUT	kCal/kg	HEAT OUTPUT	Kcal/kg
Combustion	868.23	Waste gases	239.83
Kiln feed	9.38	Dust	12.26
Feed con. air	1.05	Heat reaction	412.27
Kiln fuel	0.58	Cooler exhaust	120.34
Kiln prim air	0.57	Clinker	35.38
Calciner fuel	0.00	Raw meal H2O	0.94
Calciner p air	0.00	Fuel H2O	1.77
Inleaking air	1.03	Shell losses	70.07
Cooler air	12.33	Incoplete comb	0.30
Organic carbon	0.00		
TOTAL	893.15	TOTAL	893.15

KILN HEAT BALANCE - VASAVADATTA CEMENT 10-14-1989

DATA INPUT

WASTE GAS EXIT TEMP.	(Deg C)	351.0	: WASTE GAS EXIT O2	(%)	6.00
WASTE GAS EXIT CO	(%)	0.005	: GROSS DUST LOSS	(Tph)	8.5
NET DUST LOSS	(Tph)	8.25	: DUST LOI	(%)	35.00
KILN FEED LOI	(%)	36.68	: RAW MEAL LOI	(%)	36.68
KILN FEED MOISTURE	(%)	0.10	: ORGANIC CARBON	(%)	0.00
KILN FEED RATE	(Tph)	110.0			

COAL ANALYSIS (%) :

ASH 32.40 VOLATILES 28.00 SULPHUR 0.00

N[illegible] CALORIFIC VALUE	(Kcal/Kg)	4300	: COAL MOISTURE as fired	(%)	1.5
COOLING AIR FLOW	(Nm3/hr)	226875	: COOLER EXHAUST TEMP.	(Deg C)	200.0
CLINKER TEMPERATURE	(Deg C)	200.0			

SHELL LOSSES (Kcal/Hr) :

[illegible]HEATER 1242000 KILN 3147000 COOLER 414000

KILN PRIMARY AIR TEMP.	(Deg C)	32.0	: CALC. PRIMARY AIR TEMP.	(Deg C)	0.0
PRIMARY AIR to KILN	(Nm3/Hr)	10417	: PRIMARY AIR to CALCINER	(Nm3/Hr)	0
FEED CONVEYING AIR	(Nm3/Hr)	7725	: FEED CONVEYING AIR TEMP.	(Deg C)	50.0
INLEAKING AIR	(%)	24.0	: AMBIENT AIR TEMPERATURE	(Deg C)	32.0

CLINKER ANALYSIS (%) :

SiO2 22.00 Al2O3 6.20 Fe2O3 3.40 CaO 66.00 MgO 1.30

DATA OUTPUT

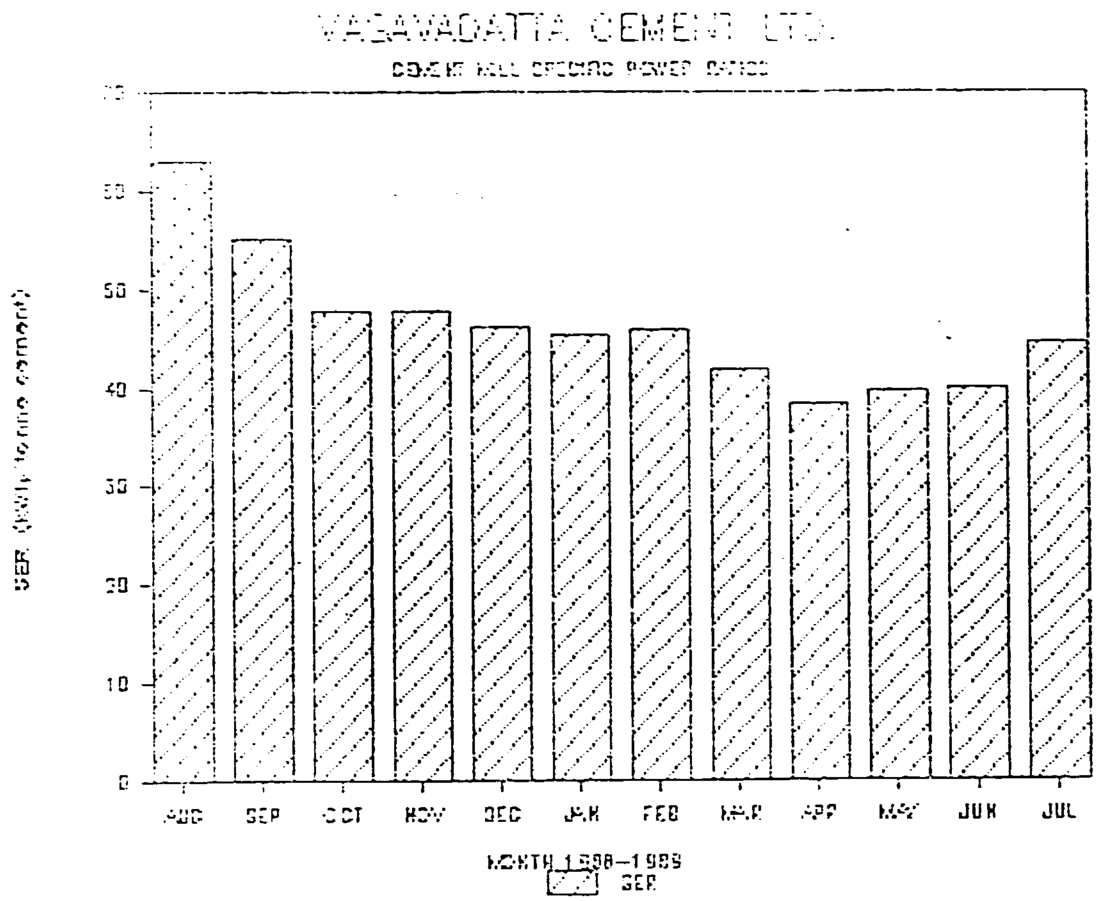
NET DUST LOSS	(%)	12.0	: OVERALL RAW MEAL FACTOR		1.600
GROSS DUST LOSS	(%)	12.4	: KILN FEED RAW MEAL FACTOR		1.603
CLINKER OUTPUT	(Tph)	68.5	: FUEL CONSUMPTION	(Kcal/Kg)	868
PRIMARY AIR to KILN	(Kg/Kg)	0.196	: PRIMARY AIR to CALCINER	(Kg/Kg)	0.000
INLEAKING AIR	(Kg/Kg)	0.359	: RAW MEAL CONVEYING AIR	(Kg/Kg)	0.146
			: SECONDARY AIR to KILN	(Kg/Kg)	1.519
COOLING AIR	(Kg/Kg)	4.278	: COOLER EXHAUST AIR	(Kg/Kg)	2.759

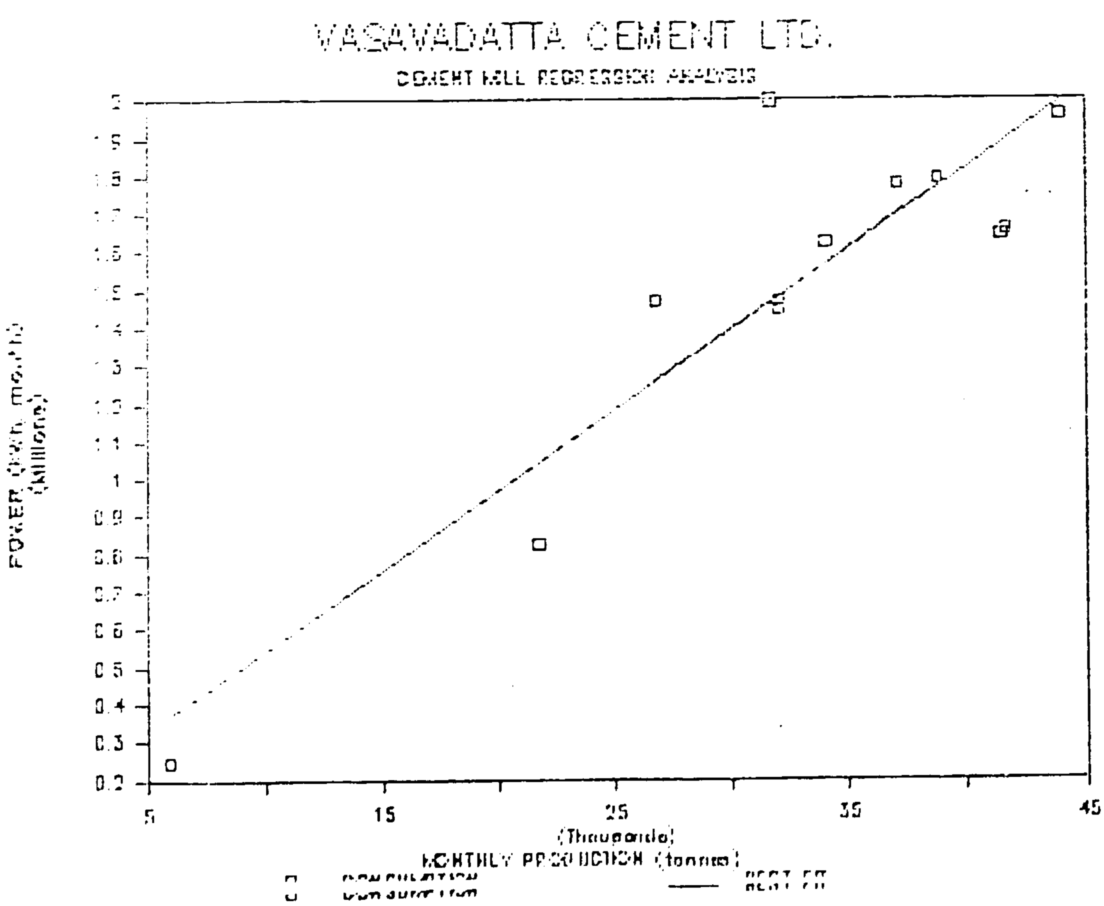
WASTE GAS FLOWS (Kg/Kg Cl) :

O2 0.169 N2 1.704 CO2 0.96 H2O 0.071 SO2 0.000 CO 0.000 TOTAL 2.905

HEAT INPUT :	Kcal/Kg	: HEAT OUTPUT :	Kcal/Kg
COMBUSTION	868.23	: WASTE GASES	239.83
KILN FEED	9.38	: DUST	12.26
FEED CONVEYING AIR	1.05	: HEAT of REACTION	412.27
KILN FUEL	0.58	: COOLER EXHAUST	120.34
KILN PRIMARY AIR	0.57	: CLINKER	35.33
CALCINER FUEL	0.00	: EVAP. of RAW MEAL MOISTURE	0.94
CALCINER PRIMARY AIR	0.00	: EVAP. of FUEL MOISTURE	1.77
INLEAKING AIR	1.03	: SHELL LOSSES	70.07
COOLER AIR	12.33	: INCOMPLETE COMBUSTION	0.30
ORGANIC CARBON	0.00		
TOTAL	893.15	: TOTAL	893.15

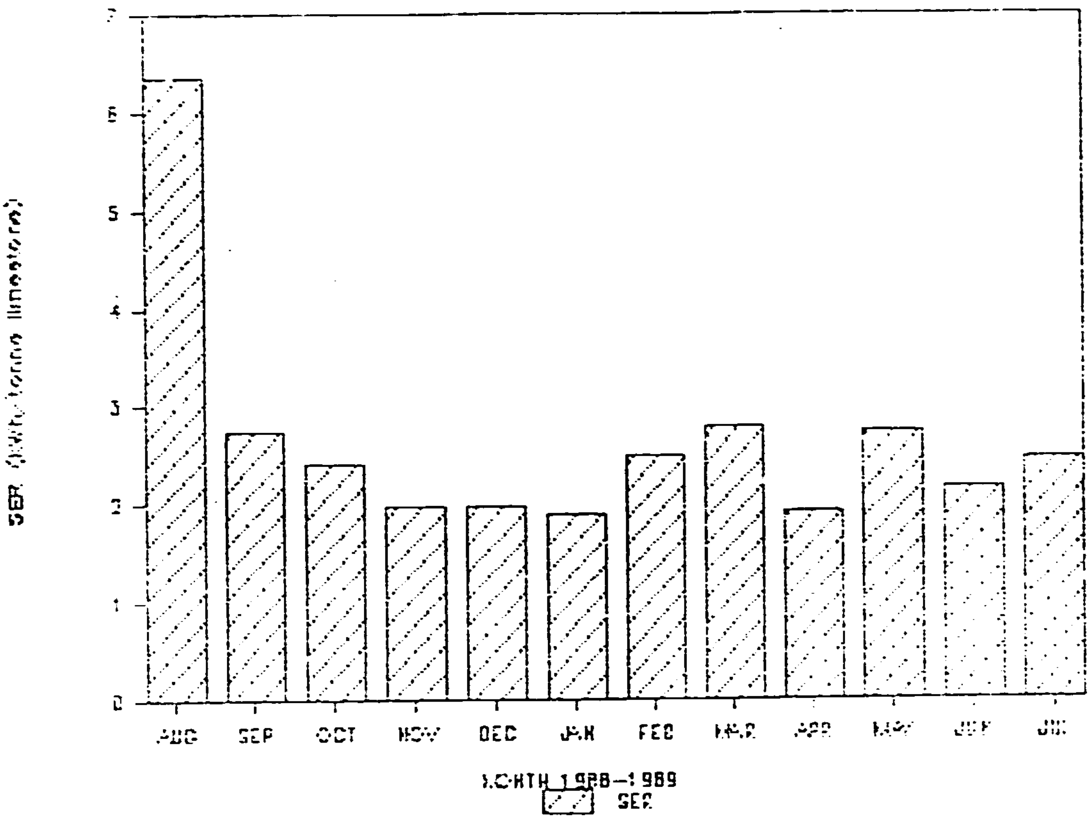
NIFES Consulting Group, UK
11:00


VASAVADATTA CEMENT LTD.
CEMENT MILL SPECIFIC POWER RATIOS
SER (kWh/tonne cement)
0
10
20
30
40
50
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
MONTH 1988–1989
SER


VASAVADATTA CEMENT LTD.
CEMENT MILL REGRESSION ANALYSIS
POWER (kWh/month)
(Millions)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
5
15
25
35
45
(Thousands)
MONTHLY PRODUCTION (tonnes)
BEST FIT

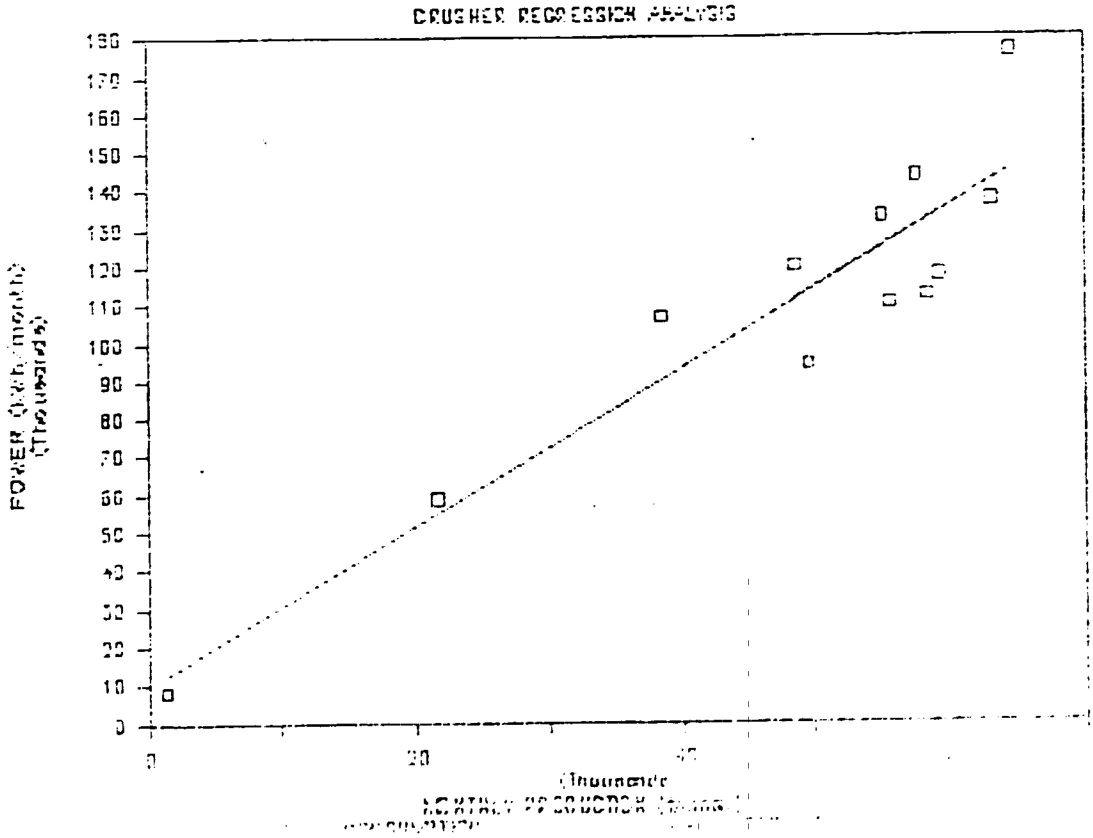
VASAVADATTA CEMENT LTD.

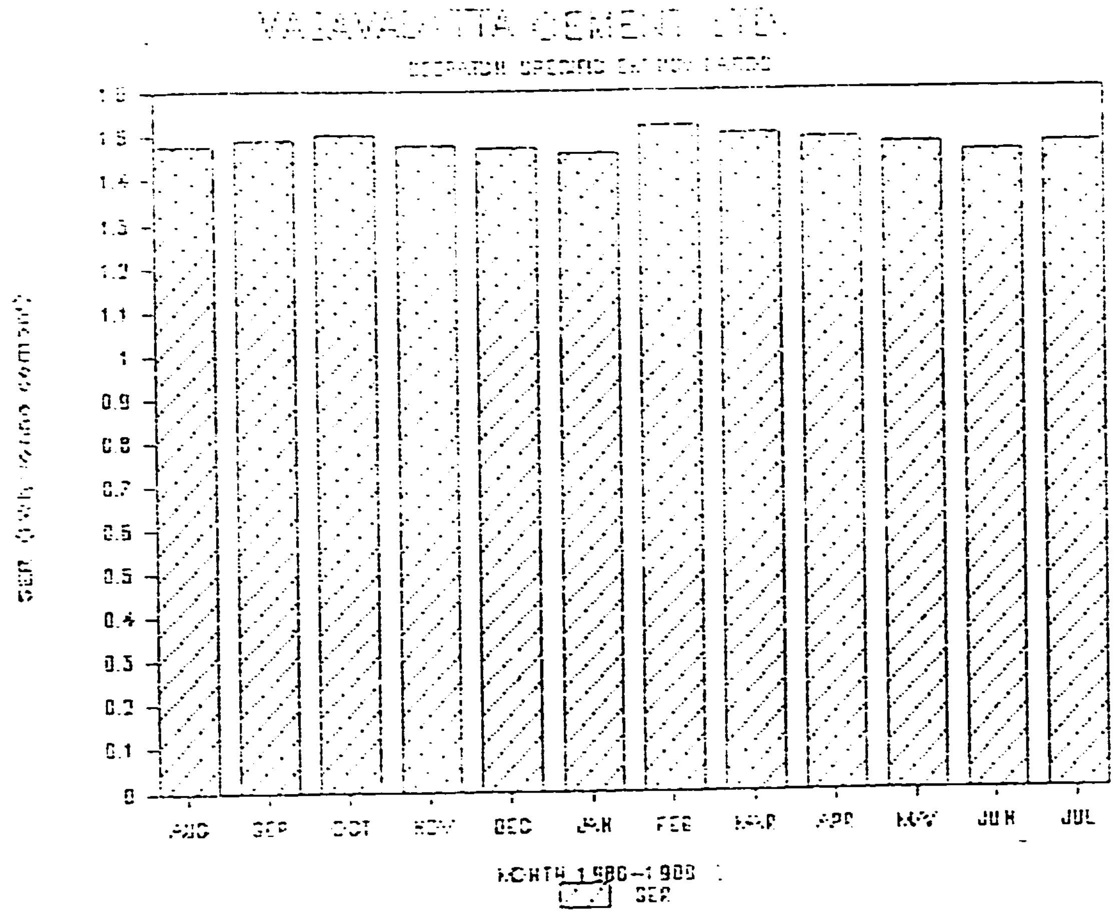
CRUSHER SPECIFIC POWER RATIOS

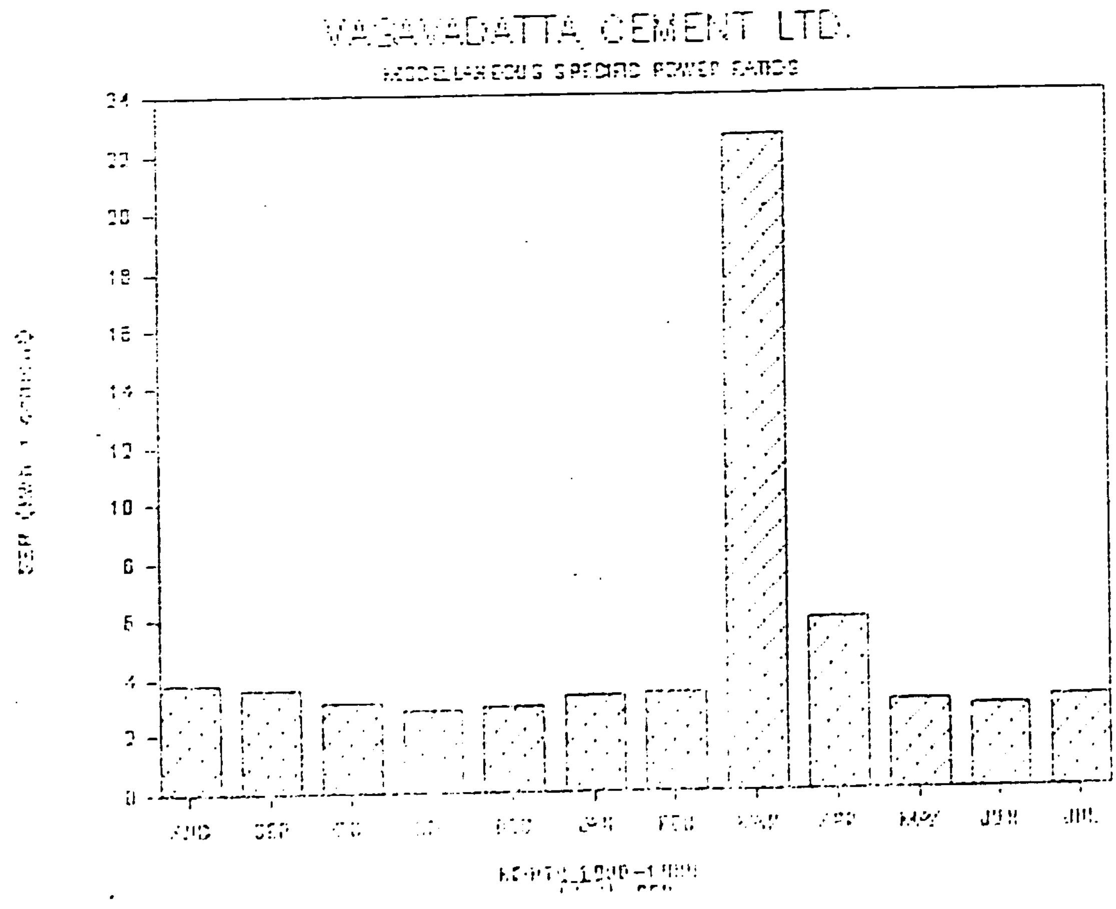


VASAVADATTA CEMENT LTD.

CRUSHER REGRESSION ANALYSIS




VASAVADATTA CEMENT LTD.
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
SEP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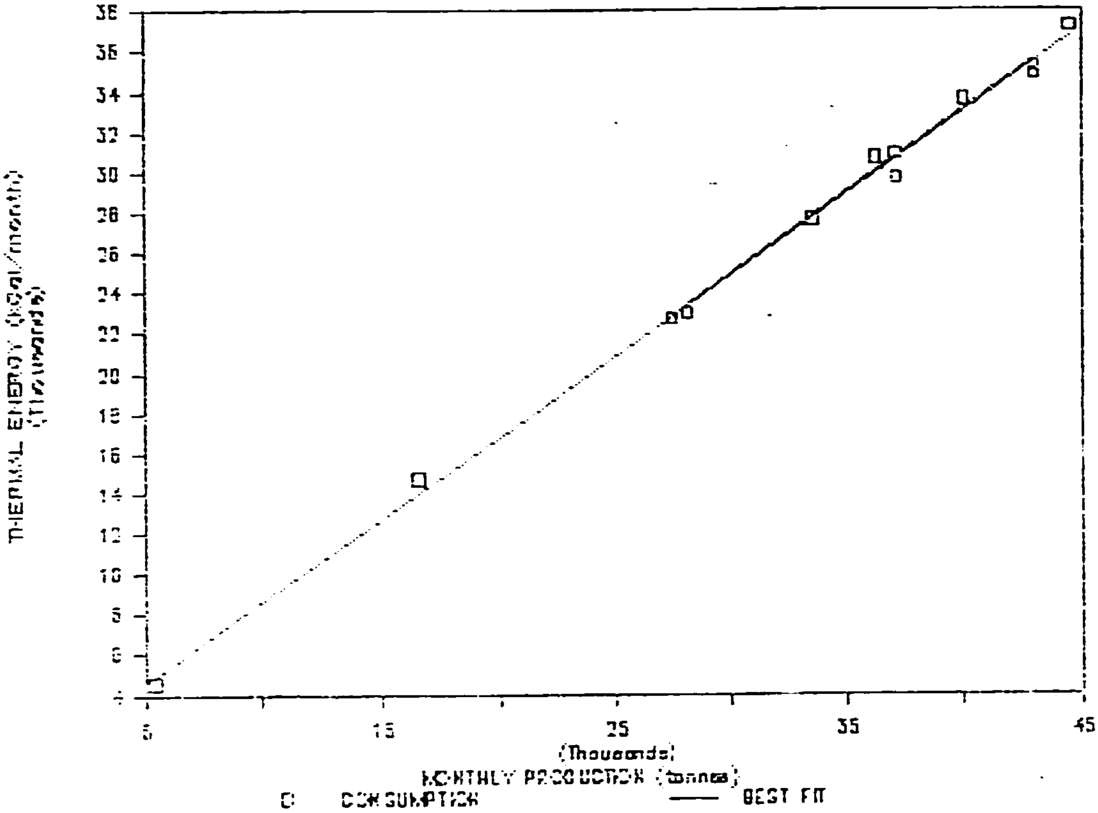
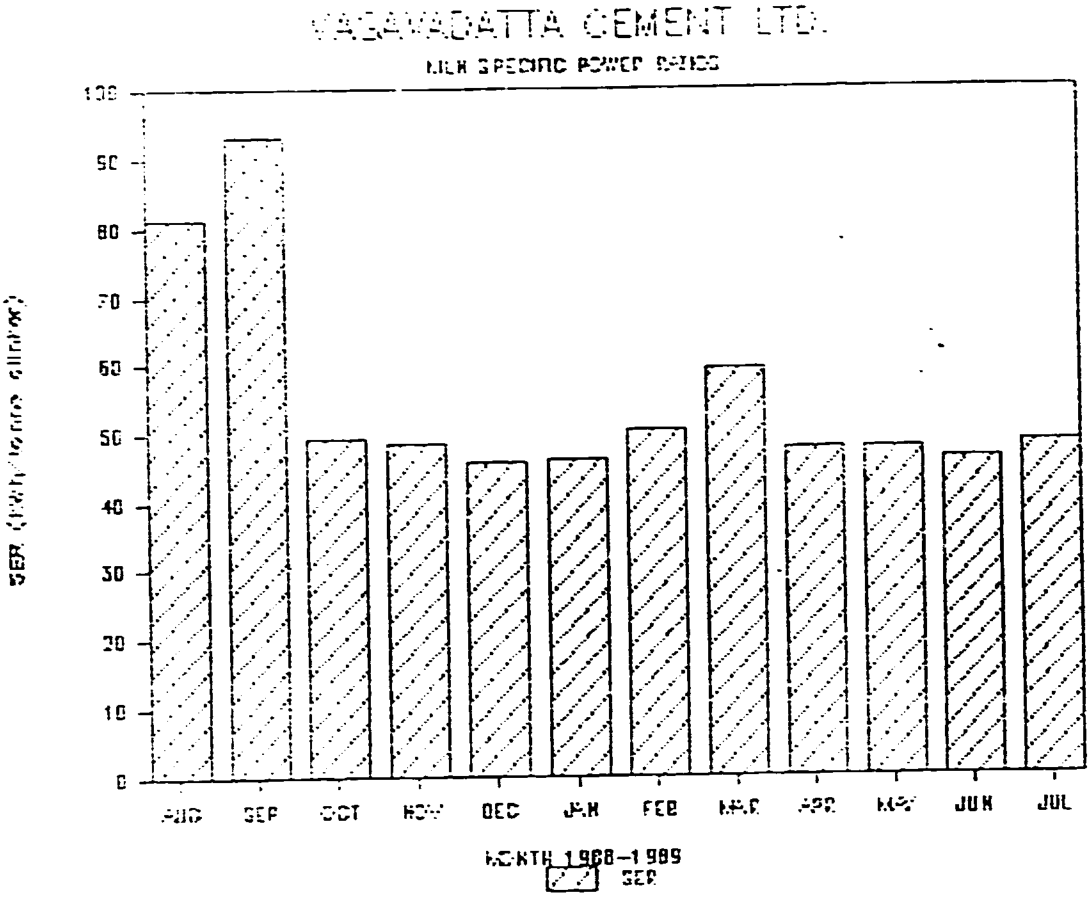
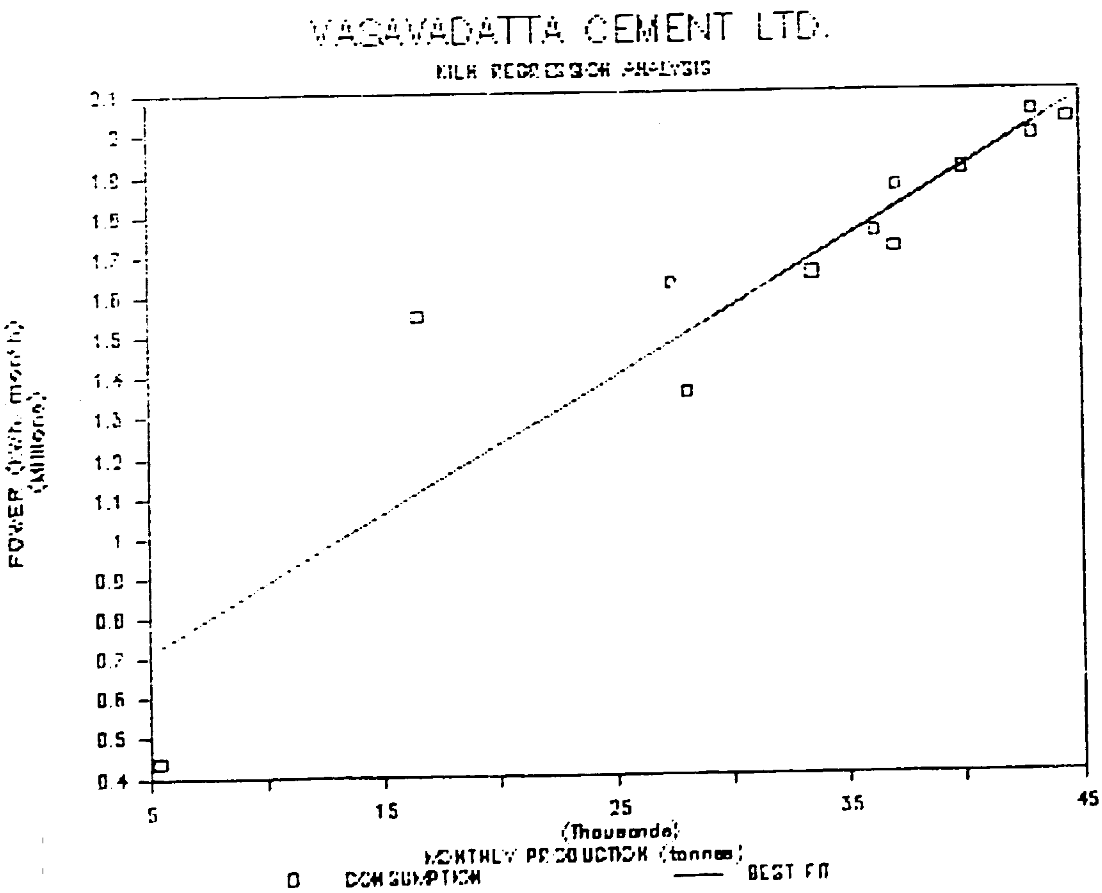
24
22
20
18
16
14
12
10
8
6
4
2
0
AUG
SEP
JAN
FEB
MAY
JUN
JUL

VASAVADATTA CEMENT LTD.

THERMAL REGRESSION ANALYSIS




VASAVADATTA CEMENT LTD.
KILN SPECIFIC POWER RATIOS
0
10
20
30
40
50
60
70
80
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
MONTH 1988-1989
SER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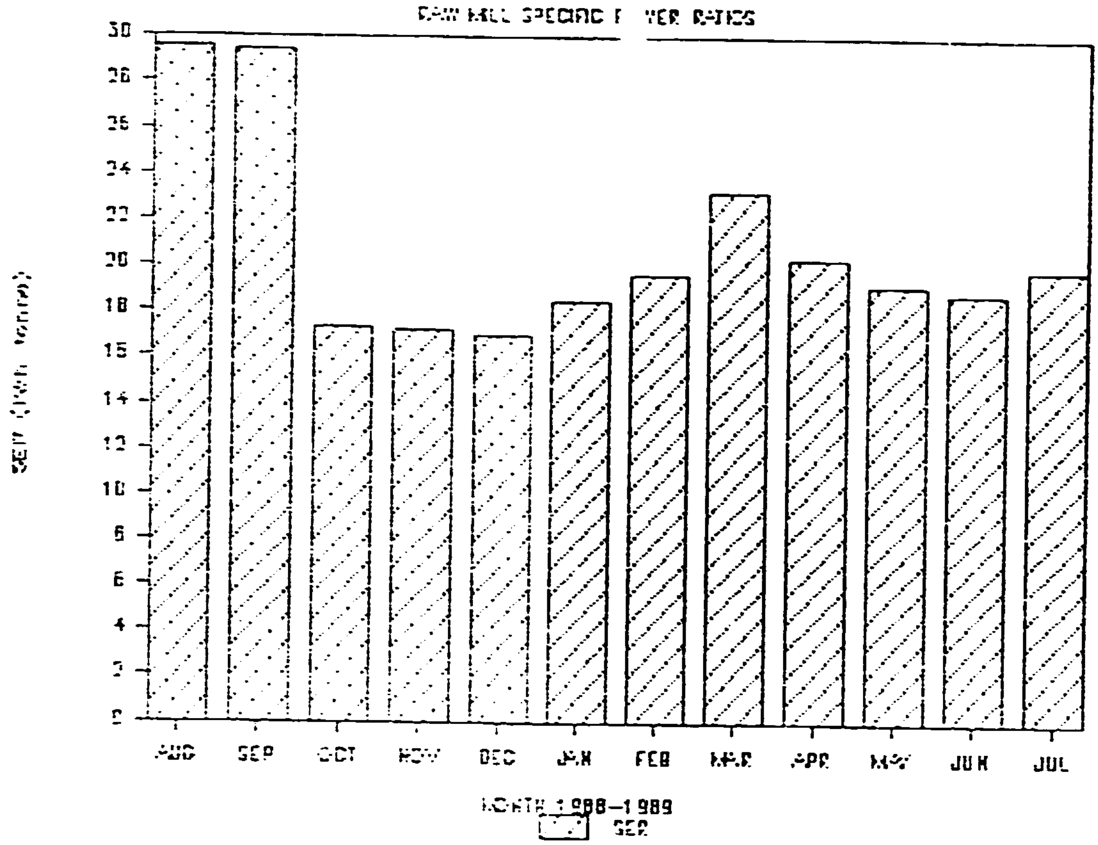
KILN REGRESSION ANALYSIS
POWER (kWh/month) (Millions)
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.5
1.7
2
5
15
25
35
45
(Thousands)
MONTHLY PRODUCTION (tonnes)
CONSUMPTION
BEST FIT

VASAVADATTA CEMENT LTD.



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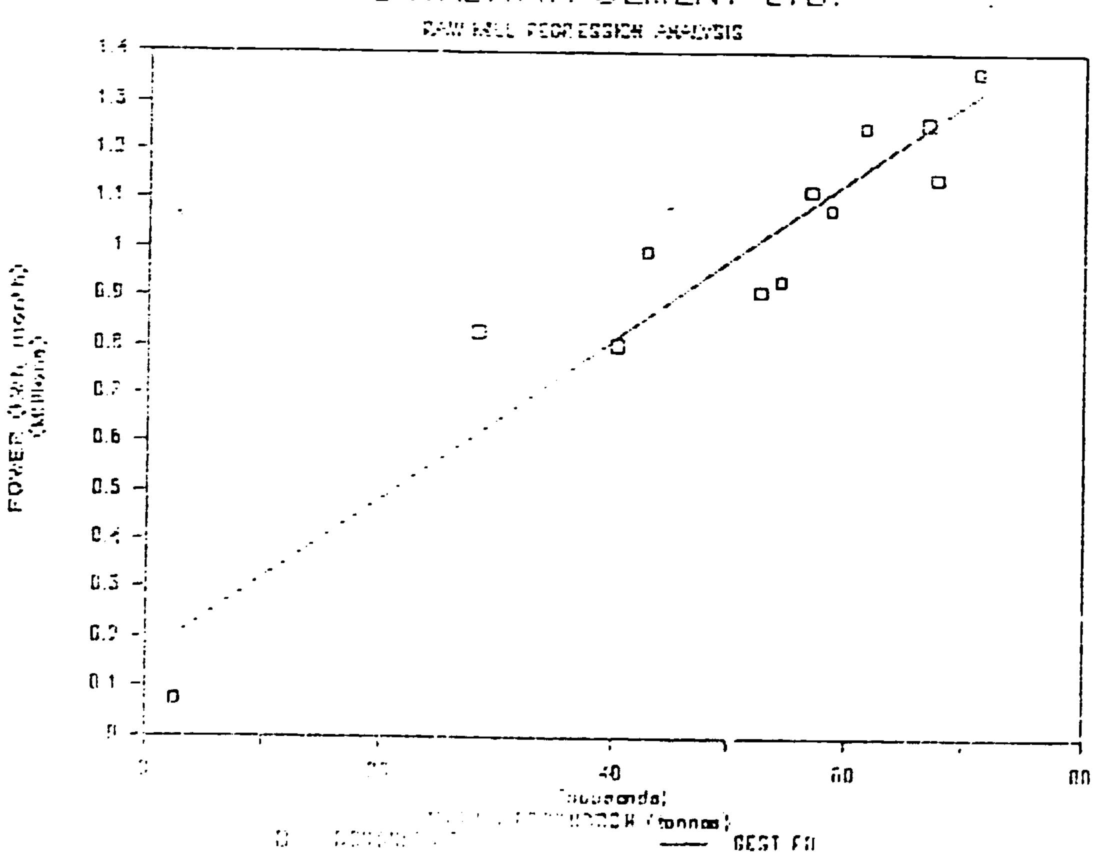
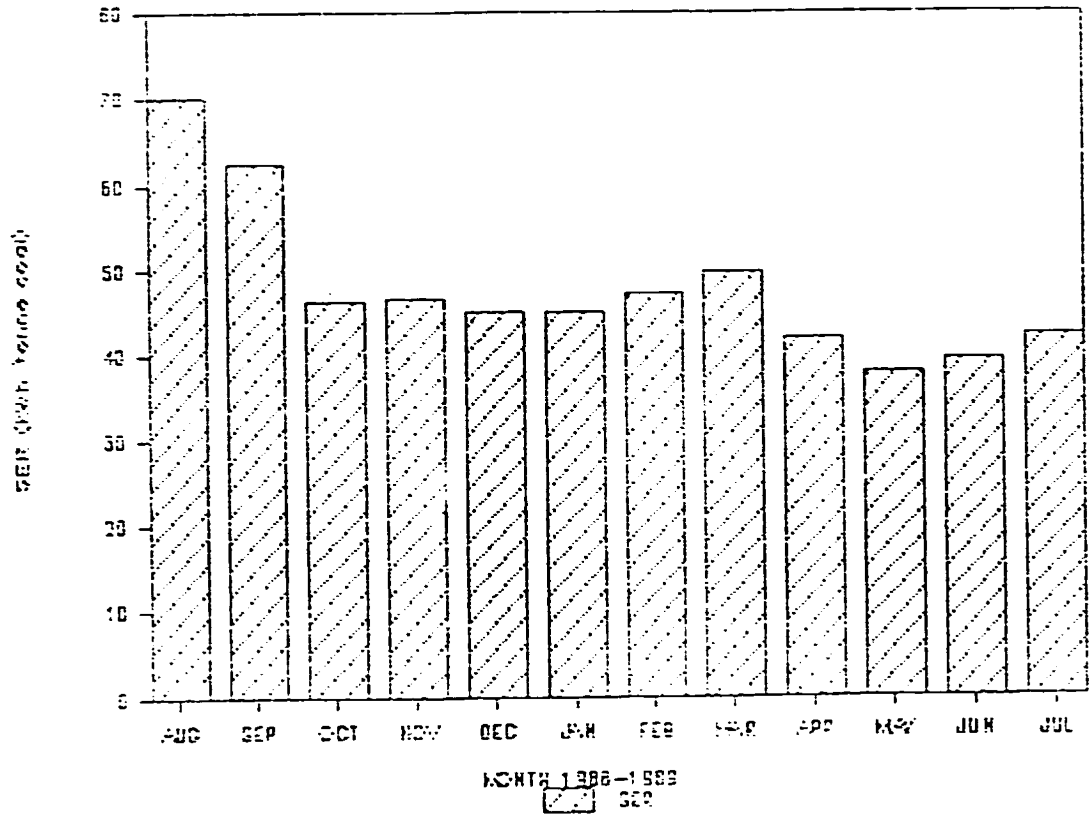


VASAVADATTA CEMENT LTD.

COAL MILL SPECIFIC POWER RATIOS



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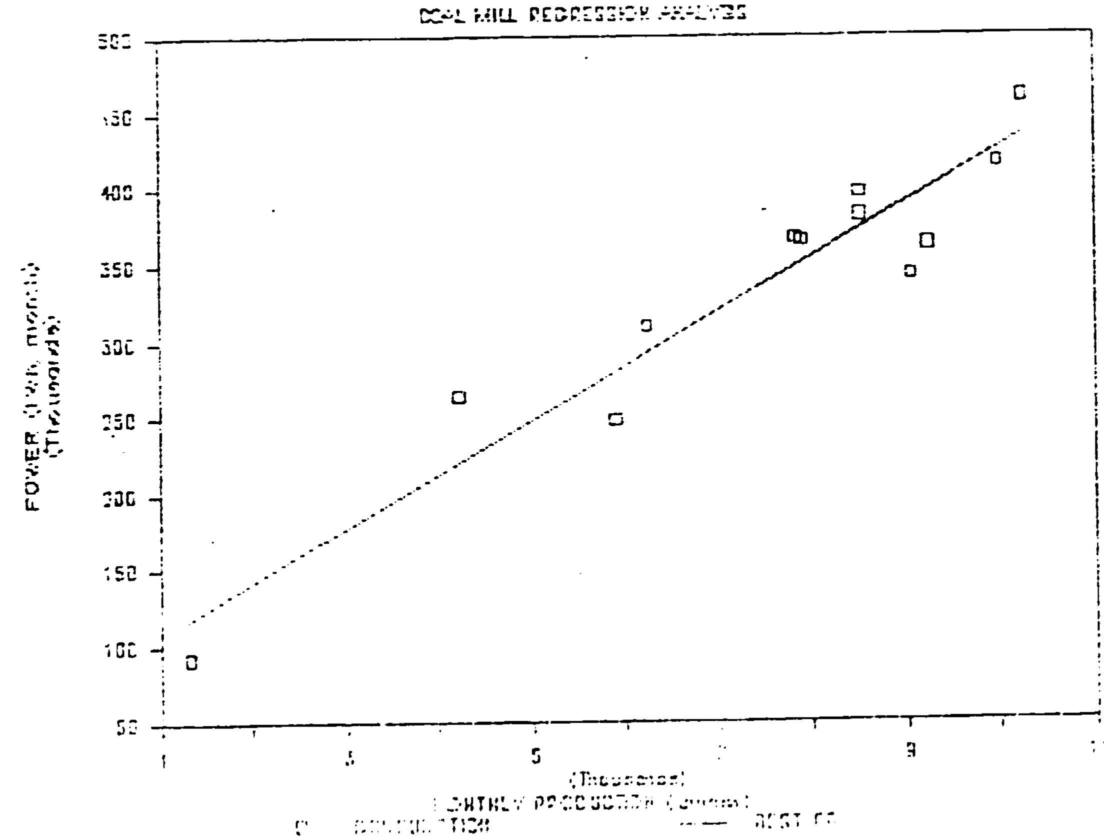
COAL MILL REGRESSION ANALYSIS



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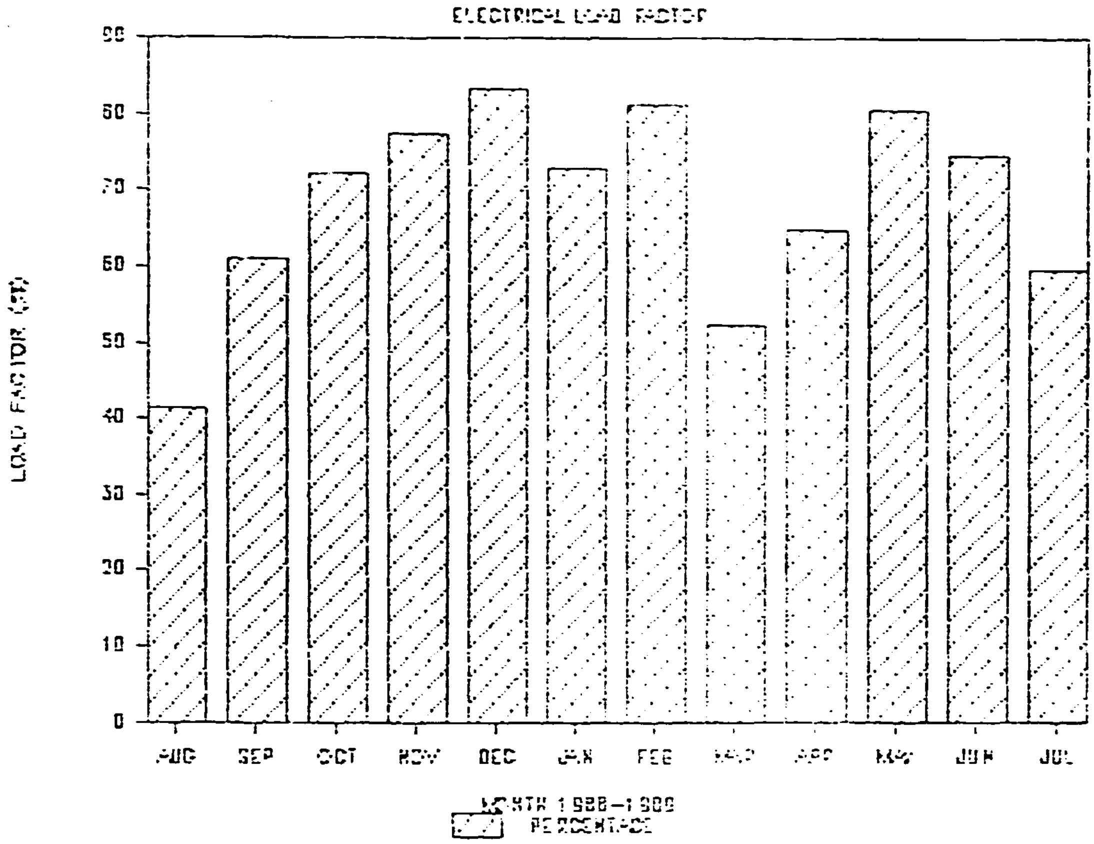

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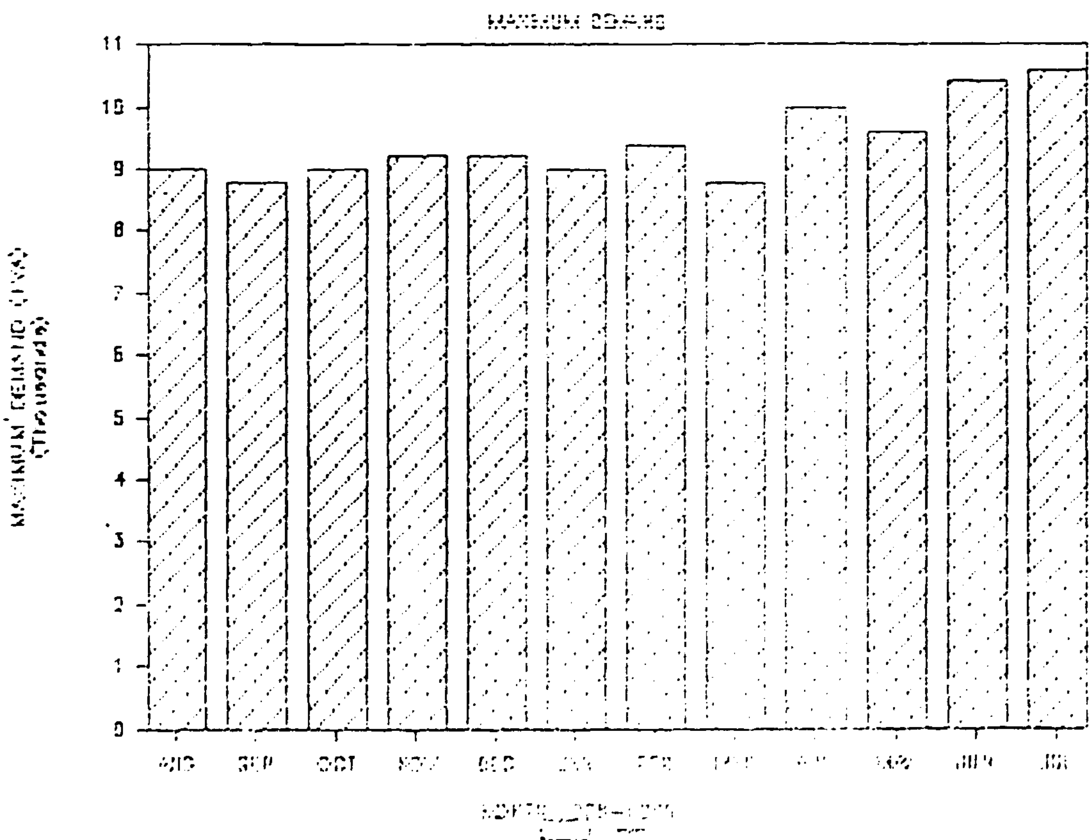
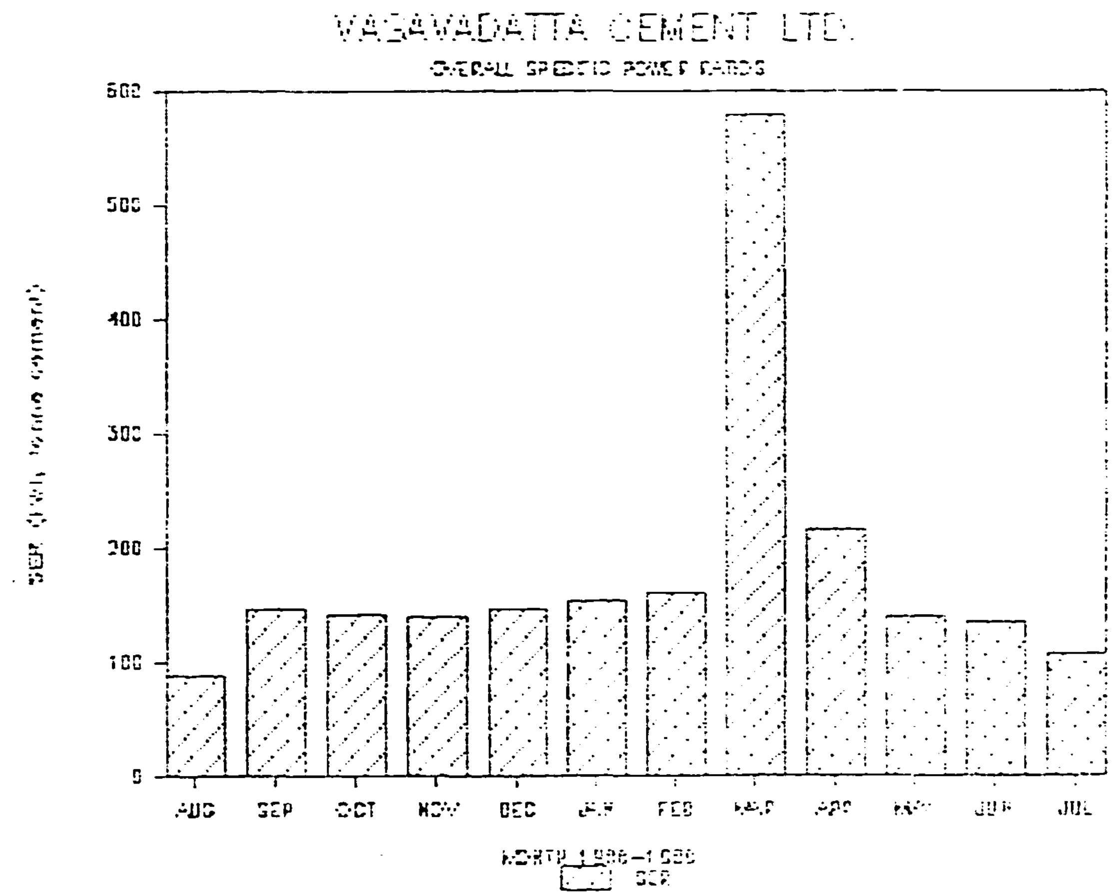
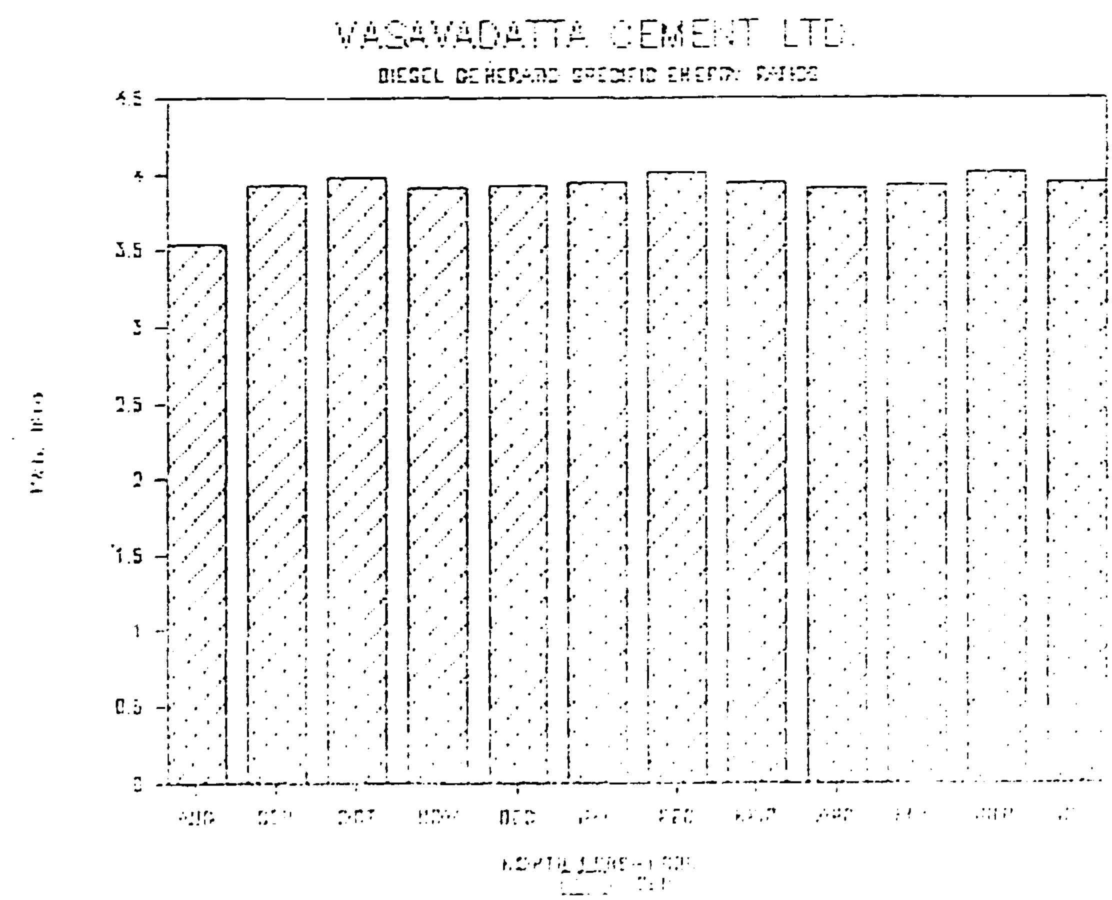
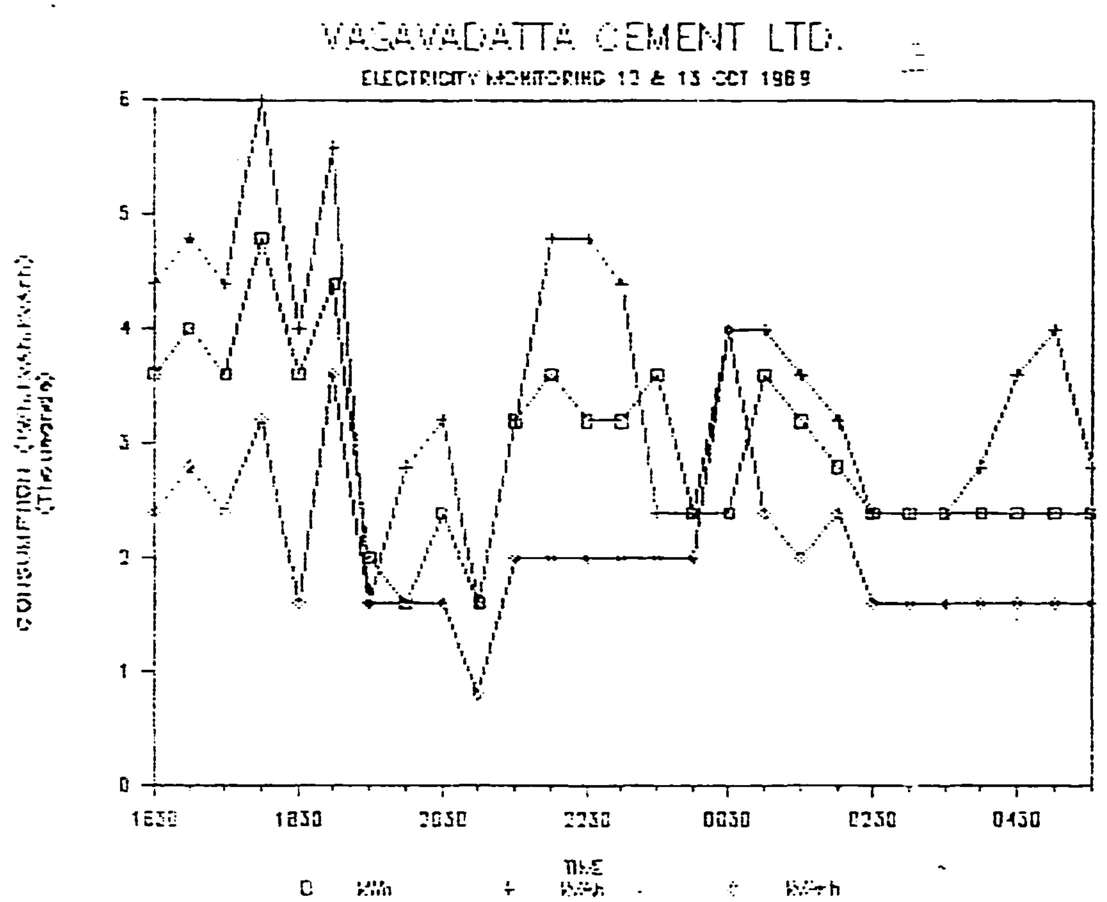
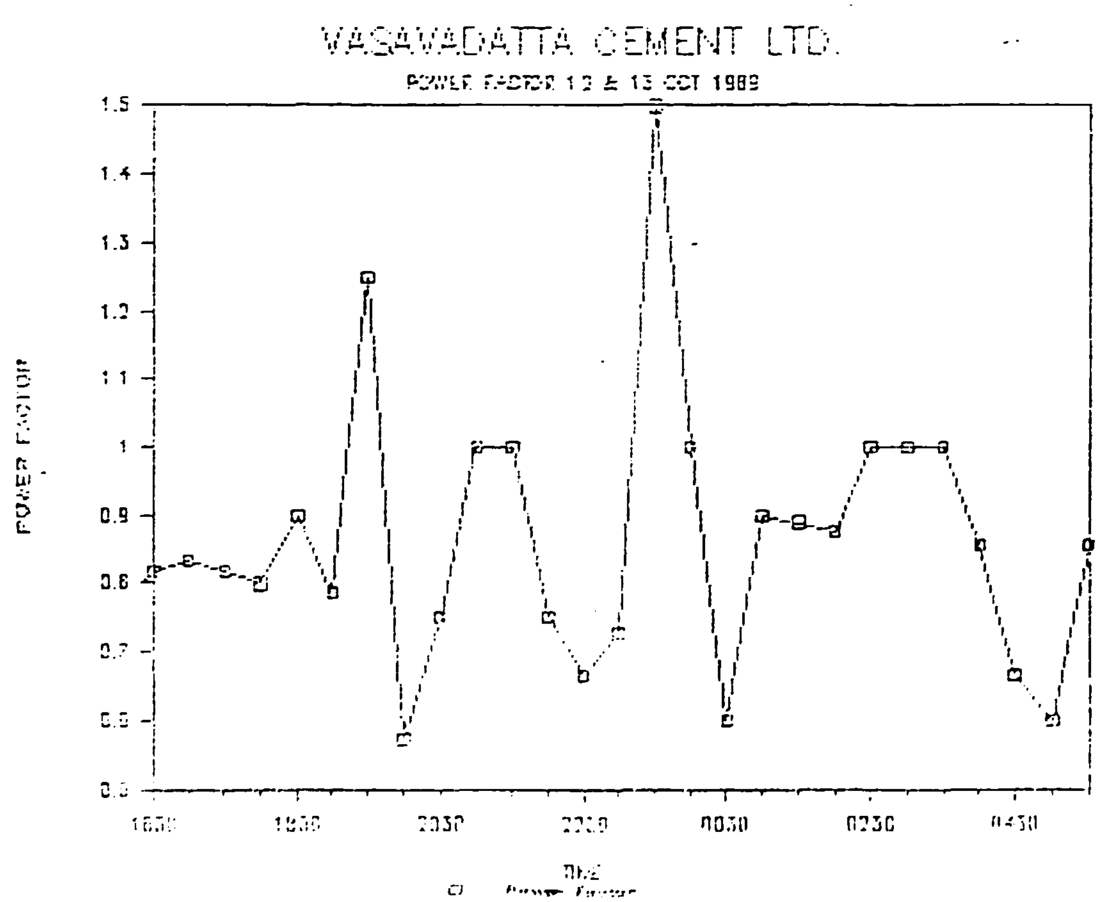



VASAVADATTA CEMENT LTD.
OVERALL SPECIFIC POWER RATIOS
600
500
400
300
200
100
0
AUG
SEP
OCT
NOV
DEC
FEB
JUL

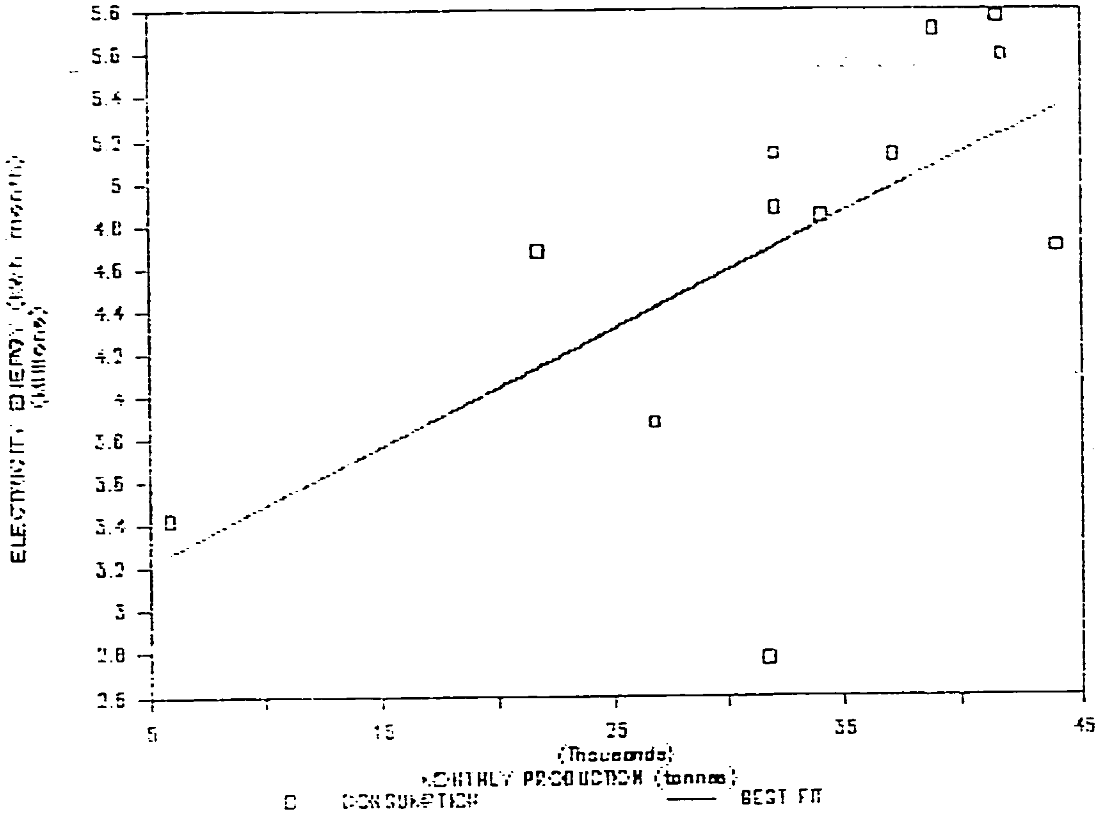

VASAVADATTA CEMENT LTD.
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
AUG
OCT
DEC


VASAVADATTA CEMENT LTD.
ELECTRICITY MONITORING 12 & 13 OCT 1989
CONSUMPTION (KWh/KVAh/KVArh) (Thousands)
TIME
KWh
KVAh
KVArh


VASAVADATTA CEMENT LTD.
POWER FACTOR 12 & 13 OCT 1989
POWER FACTOR
TIME
Power Factor

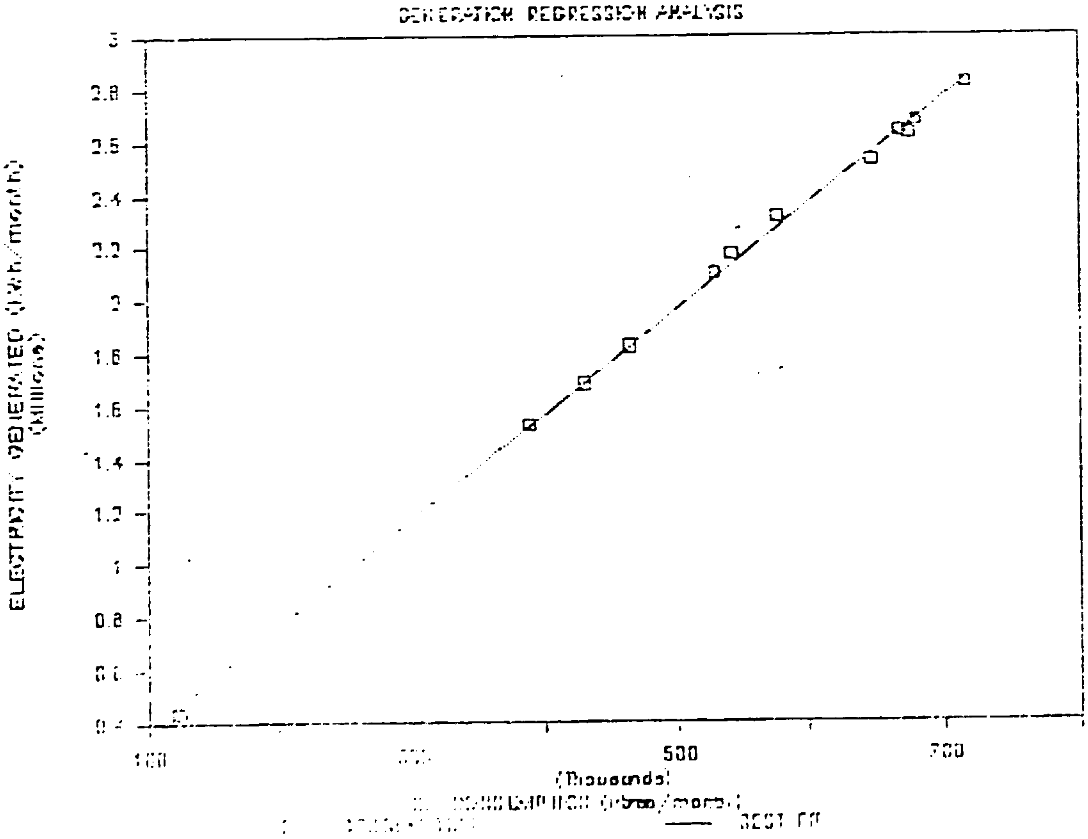
VASAVADATTA CEMENT LTD.

ELECTRICITY REGRESSION ANALYSIS



VASAVADATTA CEMENT LTD.

GENERATION REGRESSION ANALYSIS



ANNEX

VASAVADATTA CEMENT, SEDAM WORKS

PLANT DESCRIPTION

This plant is located at Sedam in Gulbarga District of Karnataka and has an installed capacity of 5 LTPA of cement. It was commissioned in May 1986. This plant is based on the modern pre-calcinator technology and vertical roller mills for raw grinding as well as coal grinding and has a 1500 tpd pre-calcinator kiln. The important specifications of the major equipment are given in Annexure 1.

The plant receives its coal supplies from Western coal fields and Singereni Collieries. As power supplied by the Karnastaka State Electricity Board is found to be generally short of the plants´ requirements, diesel generator sets of 12 MVA capacity have been installed to avoid loss of production.

SPECIFICATIONS OF THE MAJOR EQUIPMENT

Equipment	Type & Make	Size	Capacity	Motor rating
Crusher	Impact-Hazemey APPM-1822	1800 mm x 2250 mm	800 TPH	1000 KW
Raw mill	Roller Mill Polysius	Table dia 4.4 m Ø Roller dia 2.15 m Ø	140 "	2000 "
Kiln	Dry process precalcinator (prepol AS) Polysius	3.8 m Ø x 56m	1500 TPD	260 "
Coal mill	Roller mill Polysius	Table dia 2.1m Roller dia 1.05m	19 TPH	315 "
Cement mill	Open cirucuit ball mill Buckan Wolf India Ltd	4.4 m Ø x 16 m	115 "	2x2475 KW

APPENDIX 6

PRELIMINARY ENERGY AUDIT REPORT : PRIYADARSHINI

OBSERVATIONS AND PRELIMINARY FINDINGS

ENERGY AUDIT STUDY

AT

PRIYADARSHINI CEMENT PLANT

5th OCTOBER 1989

NATIONAL COUNCIL FOR CEMENT AND BUILDING MATERIALS

NIFES CONSULTING GROUP, UK

INTRODUCTION

This document represents a review of the work carried out at the plant and gives an initial impression of the results and indicates the formative conclusions at this stage. A full report will be produced at the end of the study which will expand on the analyses and develop the conclusions.

PLANT DETAILS

M/S Priyadarshini cements is located at Ramapuram in Nalgonda district of Andhra Pradesh. It is a 6.0 LTPA capacity plant based on Dry process technology having a 5 stage preheater with RSP precalcinator supplied by ONODA.Specification of major equipment is given at annexure I.

ENERGY AUDIT

The work was carried out using the NCB Mobile Diagnostic Unit or Energy Bus. This unit was provided under UNIDO/UNDP funding. The study was part of the training and initial demonstration period supervised by NIFES Consulting Group from the UK.

Tables and graphs are presented for the year August 1988 to July 1989. The Specific Energy Ratios for that period are:

Overall Specific Power Ratio	119.71 kWh/tonne cement
Kiln Specific Thermal Ratio	928.63 kCal/kg clinker
Kiln Specific Power Ratio	47.20 kWh/tonne clinker
Raw Mill " " "	20.57 kWh/tonne l/stone
Cement Mill " " "	34.01 kWh/tonne cement
Coal Mill " " "	41.69 kWh/tonne coal
Crusher " " "	2.04 kWh/tonne l/stone

KILN SECTION

A kiln heat balance was developed based on measurements taken using portable instrumentation on the 4th-5th October 1989. The results of the heat balance indicate a coal utilisation rate of 898.00 kCal/kg of clinker. This can be compared with the figure derived from the weighfeeder readings when the coal NCV for the day has been determined.

A printout of the heat balance is given in the ANNEXURE 11

Other points to note were:

The heat loss in the cooler exhaust gases is quite high due to higher volumes of gases(4.329 kg/kg clinker).

The oxygen content at preheater exit was 6.9% indicating false air leakage in preheater system.

The radiation loss in the preheater tower is on higher side since there is no linining provided in the 5th stage cyclones.

The temperature at the preheater exit was about 329 deg C which is normal in case of 5 stage preheater system.

Preheater fan is eqipped with slip power recovery system. Since the requirement is to always have full flow from the fan .fan is always operating at full speed with full damper opening.

COMPRESSED AIR

A leakage survey was carried out of the compressed air lines using an ultrasonic leak detector. The following observations were made:

Raw Mill compressed air system :

It was not possible to examine the raw mill system as the rawmill was not operating at the time of visit .

Kiln compressed air system :

. No leakages were found.

. Kiln main root blowers operating efficintly.

. three machines were operating at 74%,74% and 57% full load current equivalent to 65%,65% and 50% full power .further study can be made to determine the possibility of operating two machines instead of three.

ELECTRICITY

The average power factor at the plant is 0.92 during the year 1988/89 . Replacement of the capacitors to achieve a power factor of 0.95 will lead to a reduction of kVA maximum demand and thereby achieve financial savings. The lower power factor also causes higher electrical currents leading to higher copper losses in the transformers, cables and motors.

The electrical load factor varied between 43.00% and 29.00% during the year analysed. Various plant interruptions during this period contributed to the varying load factor.

A motor rating analysis has been carried out for motors of 30 kW and the results were given at annexure 111.

ANNEXURE 11

KILN HEAT BALANCE (TENTATIVE)

HEAT INPUT	kCal/kg	HEAT OUTPUT	Kcal/kg
Combustion	897.83	Waste gases	240.89
Kiln feed	9.46	Dust	11.49
Feed con. air	1.09	Heat reaction	401.32
Kiln fuel	0.59	Cooler exhaust	197.33
Kiln prim air	3.06	Clinker	12.86
Calciner fuel	0.00	Raw meal H2O	0.17
Calciner p air	0.00	Fuel H2O	3.76
Inleaking air	1.34	Shell losses	59.99
Cooler air	14.45	Incoplete comb	0.00
Organic carbon	0.00		
TOTAL	927.81	TOTAL	927.81

ANNEXURE 1

SPECIFICATION OF MAJOR EQUIPMENT

SECTION	TYPE	MAKE	CAPACITY
CRUSHER	IMPACT	L&T	500 TPH
RAWMILL	C CKT BALL MILL	WIL	135 TPH
KILN	5 STAGE RSP PC	ONODA	1800 TPD
COALMILL	AIR SWEPT BALLMILL	WIL	23 TPH
CEMENT MILL	O CKT BALL MILL	WIL	120 TPH

KILN HEAT BALANCE - PRIYADARSHINI CEMENTS 10-05-1989

DATA INPUT

WASTE GAS EXIT TEMP.	(Deg C)	329.0	: WASTE GAS EXIT O2	(%)	6.90
WASTE GAS EXIT CO	(%)	0.000	: GROSS DUST LOSS	(Tph)	14.5
NET DUST LOSS	(Tph)	0.14	: DUST LOI	(%)	35.60
KILN FEED LOI	(%)	36.20	: RAW MEAL LOI	(%)	36.20
KILN FEED MOISTURE	(%)	0.02	: ORGANIC CARBON	(%)	0.00
KILN FEED RATE	(Tph)	141.0			

COAL ANALYSIS (%) :

ASH 33.50 VOLATILES 30.00 SULPHUR 0.00

NET CALORIFIC VALUE	(Kcal/Kg)	4200	: COAL MOISTURE as fired	(%)	3.0
COOLING AIR FLOW	(Nm3/hr)	336840	: COOLER EXHAUST TEMP.	(Deg C)	208.0
CLINKER TEMPERATURE	(Deg C)	90.0			

SHELL LOSSES (Kcal/Hr) :

PREHEATER 1868400 KILN 3320561 COOLER 19030

KILN PRIMARY AIR TEMP.	(Deg C)	31.0	: CALC. PRIMARY AIR TEMP.	(Deg C)	687.0
PRIMARY AIR to KILN	(Nm3/Hr)	77205	: PRIMARY AIR to CALCINER	(Nm3/Hr)	0
FEED CONVEYING AIR	(Nm3/Hr)	10143	: FEED CONVEYING AIR TEMP.	(Deg C)	50.0
INLEAKING AIR	(%)	30.0	: AMBIENT AIR TEMPERATURE	(Deg C)	32.0

CLINKER ANALYSIS (%) :

SiO2 21.80 Al2O3 6.38 Fe2O3 4.12 CaO 65.54 MgO 0.00

DATA OUTPUT

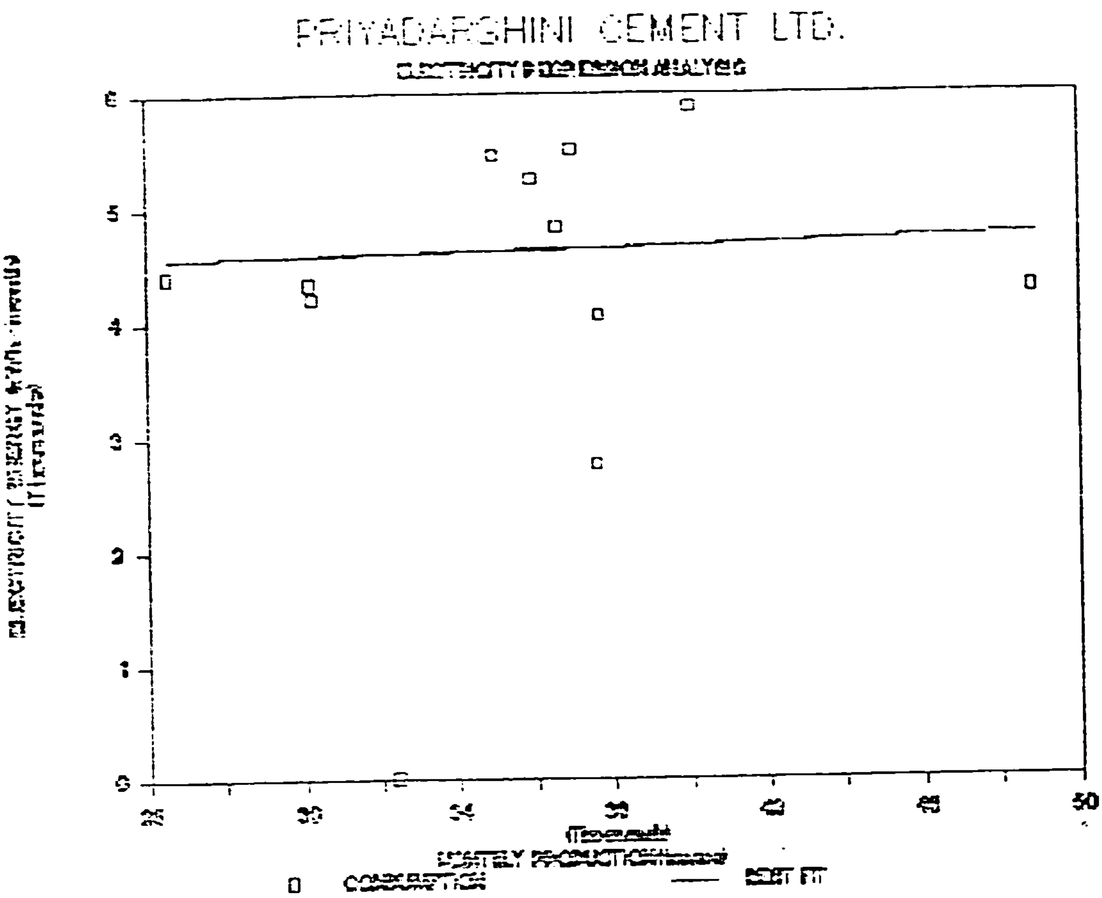
NET DUST LOSS	(%)	0.2	: OVERALL RAW MEAL FACTOR		1.457
GROSS DUST LOSS	(%)	16.7	: KILN FEED RAW MEAL FACTOR		1.624
CLINKER OUTPUT	(Tph)	86.8	: FUEL CONSUMPTION	(Kcal/Kg)	898
PRIMARY AIR to KILN	(Kg/Kg)	1.158	: PRIMARY AIR to CALCINER	(Kg/Kg)	0.000
INLEAKING AIR	(Kg/Kg)	0.465	: RAW MEAL CONVEYING AIR	(Kg/Kg)	0.151
			: SECONDARY AIR to KILN	(Kg/Kg)	0.684
COOLING AIR	(Kg/Kg)	5.014	: COOLER EXHAUST AIR	(Kg/Kg)	4.329

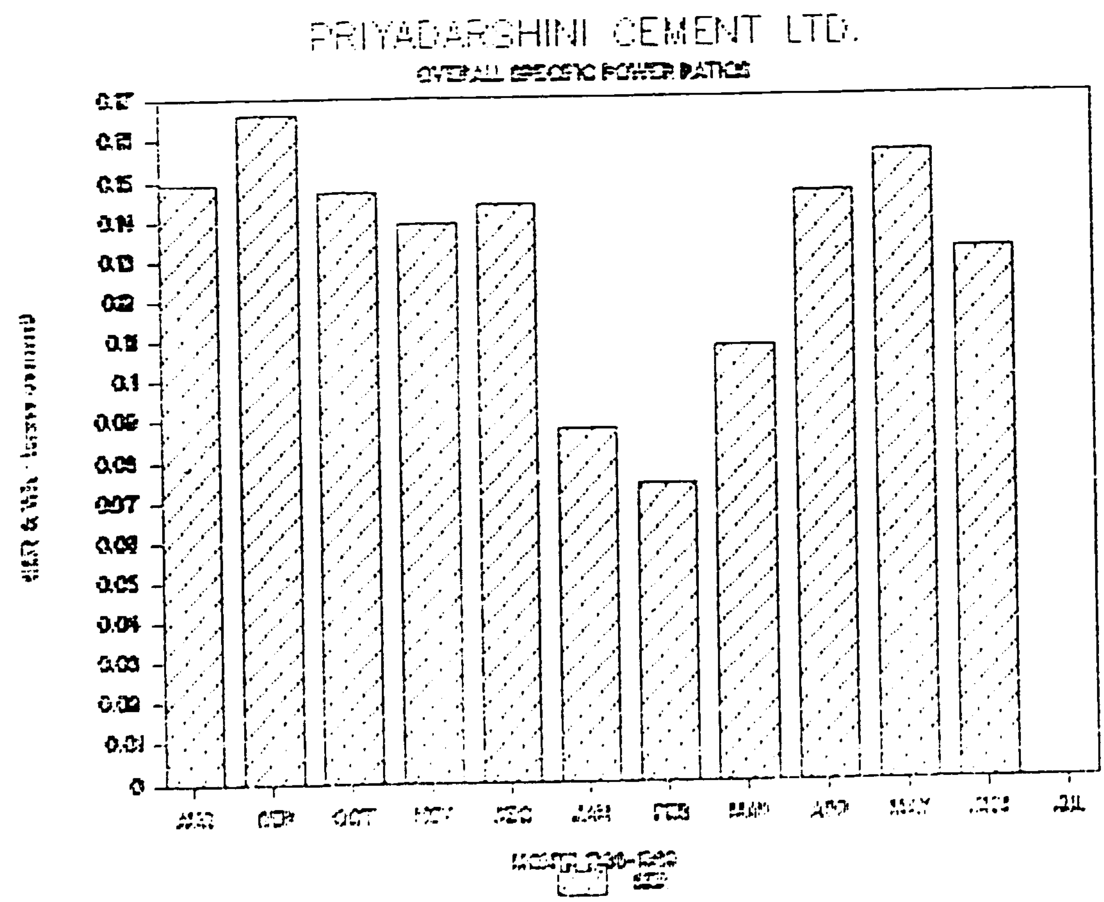
WASTE GAS FLOWS (kg/Kg Cl) :

O2 0.212 N2 1.888 CO2 0.96 H2O 0.076 SO2 0.000 CO 0.000 TOTAL 3.135

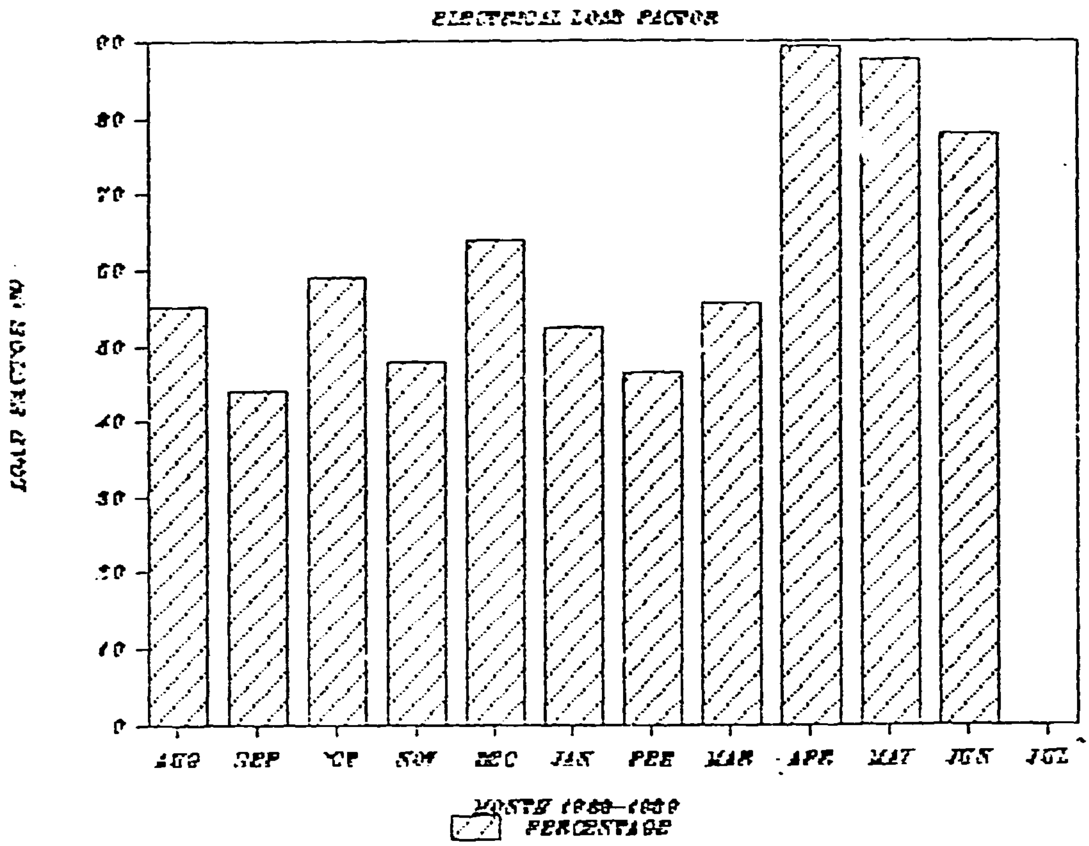
HEAT INPUT :	Kcal/Kg	: HEAT OUTPUT :	Kcal/Kg
COMBUSTION	897.83	: WASTE GASES	240.89
KILN FEED	9.46	: DUST	11.49
FEED CONVEYING AIR	1.09	: HEAT of REACTION	401.32
KILN FUEL	0.59	: COOLER EXHAUST	197.33
KILN PRIMARY AIR	3.06	: CLINKER	12.86
CALCINER FUEL	0.00	: EVAP. of RAW MEAL MOISTURE	0.17
CALCINER PRIMARY AIR	0.00	: EVAP. of FUEL MOISTURE	3.76
INLEAKING AIR	1.34	: SHELL LOSSES	59.99
COOLER AIR	14.45	: INCOMPLETE COMBUSTION	0.00
ORGANIC CARBON	0.00		
TOTAL	927.81	: TOTAL	927.81

NIFES Consulting Group, UK


PRIYADARSHINI CEMENT LTD.
0
1
2
3
4
5
6
30
50
CONSUMPTION
BEST FIT


PRIYADARSHINI CEMENT LTD.
OVERALL SPECIFIC POWER RATIOS
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL

PRIYADARSHINI CEMENT LTD.



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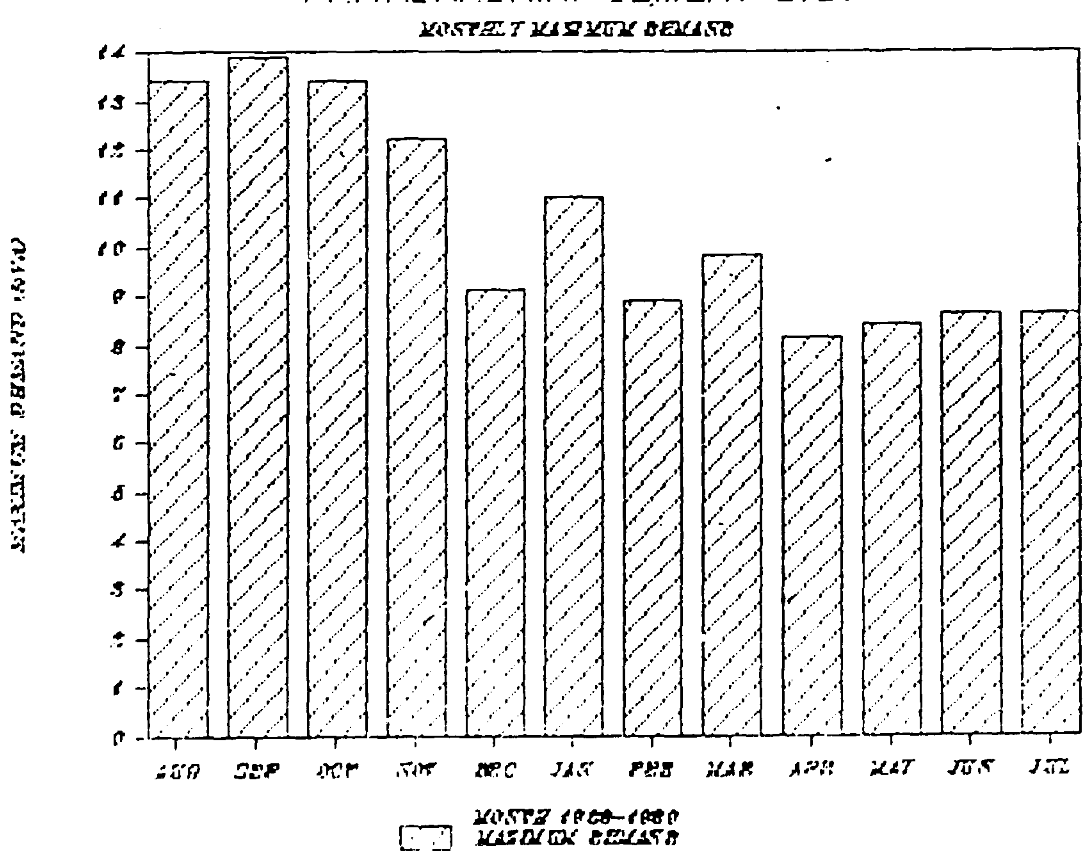

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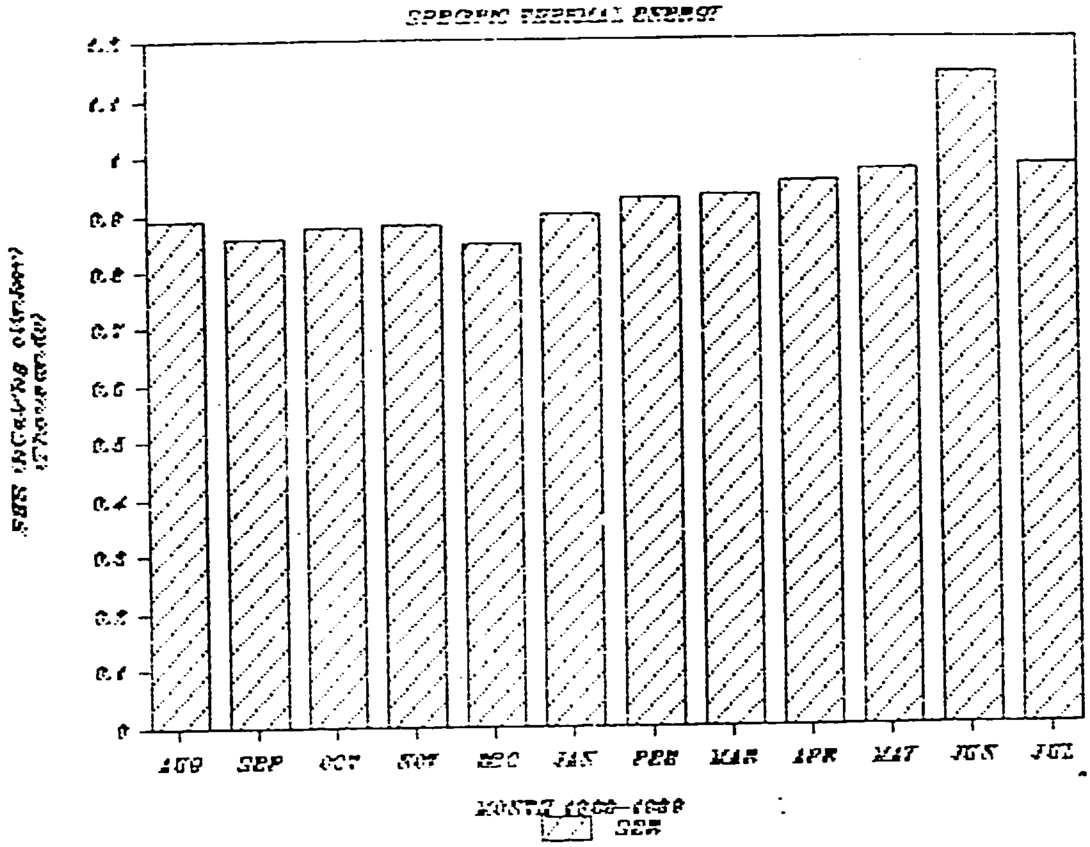

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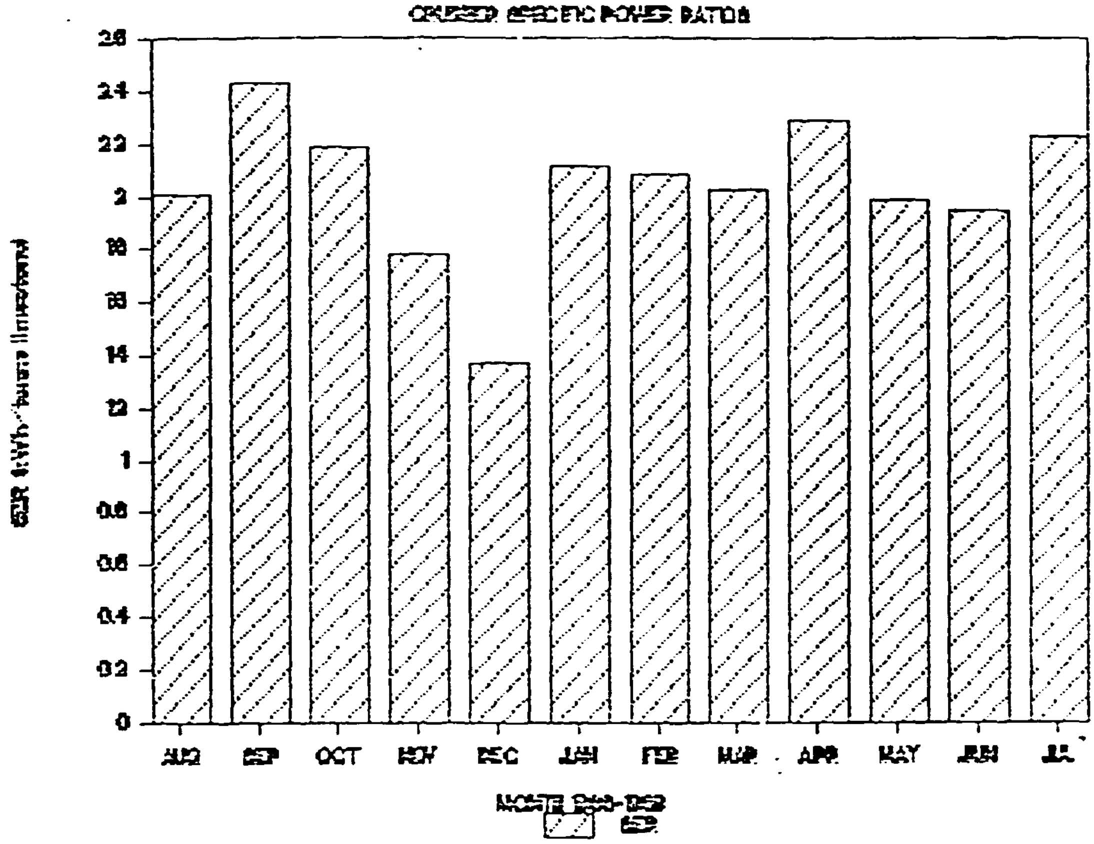

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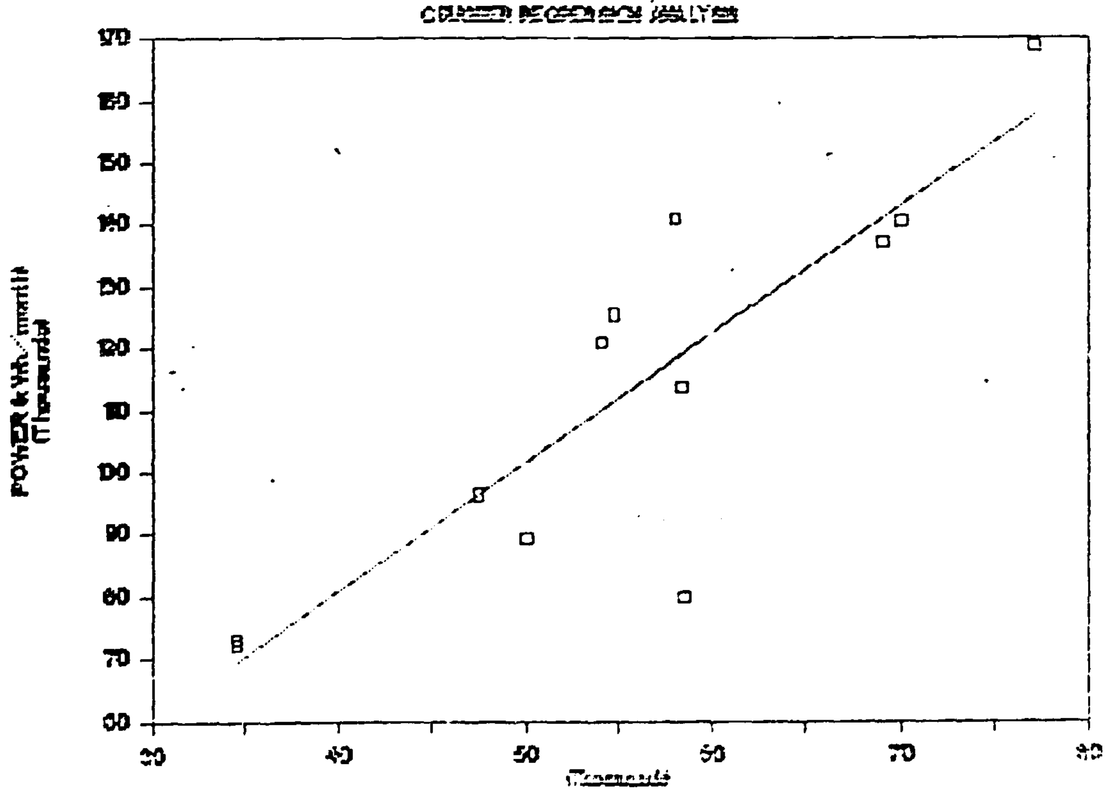

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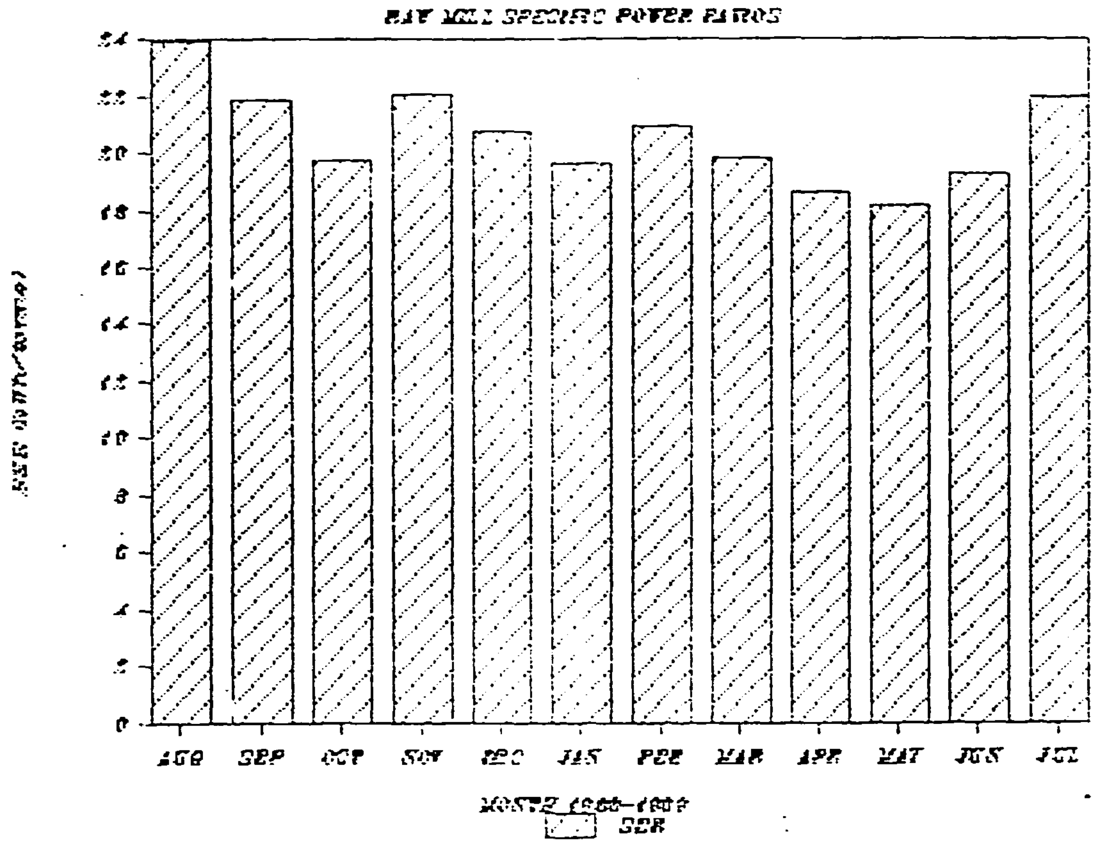

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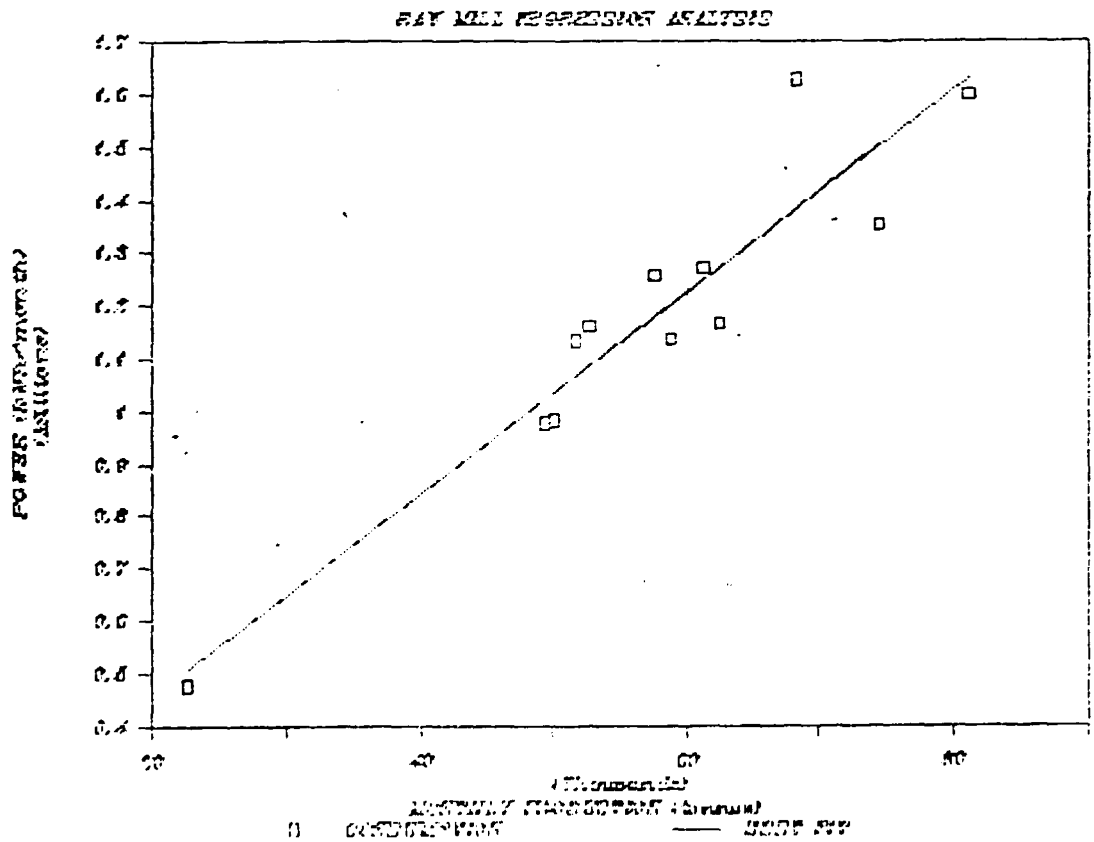
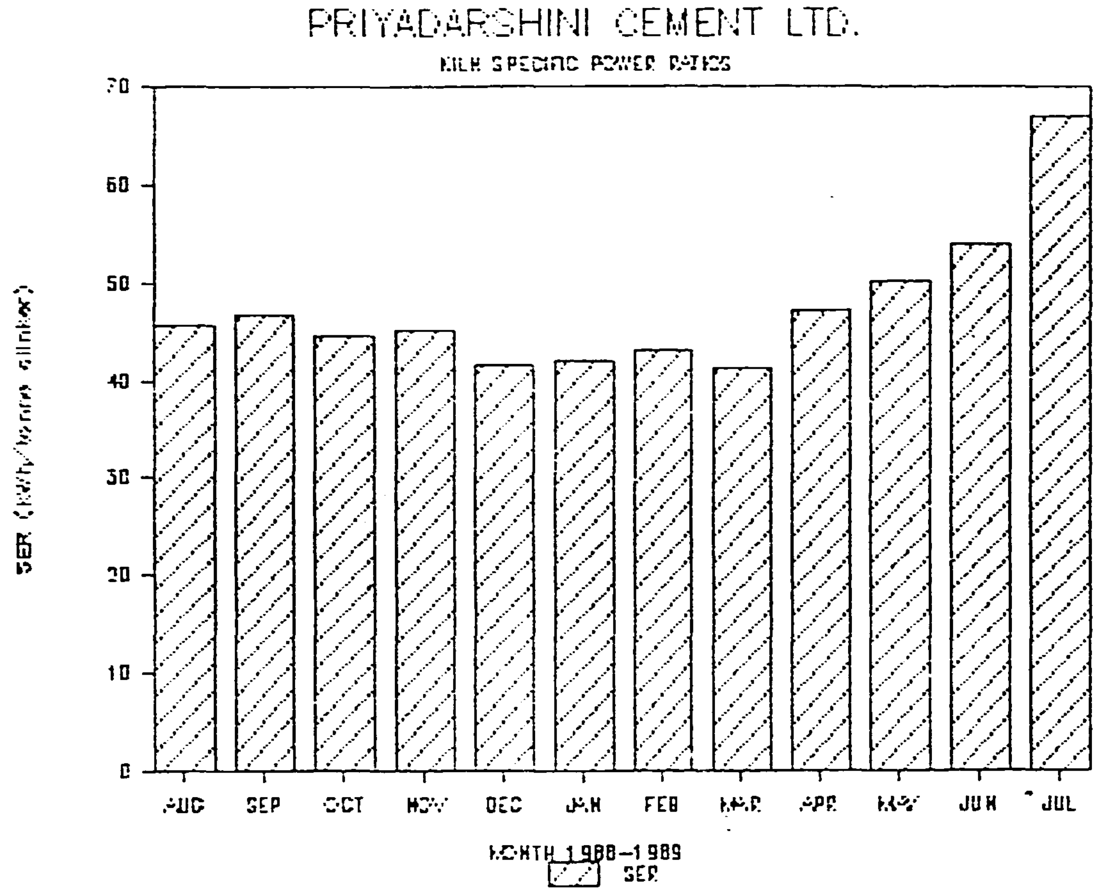
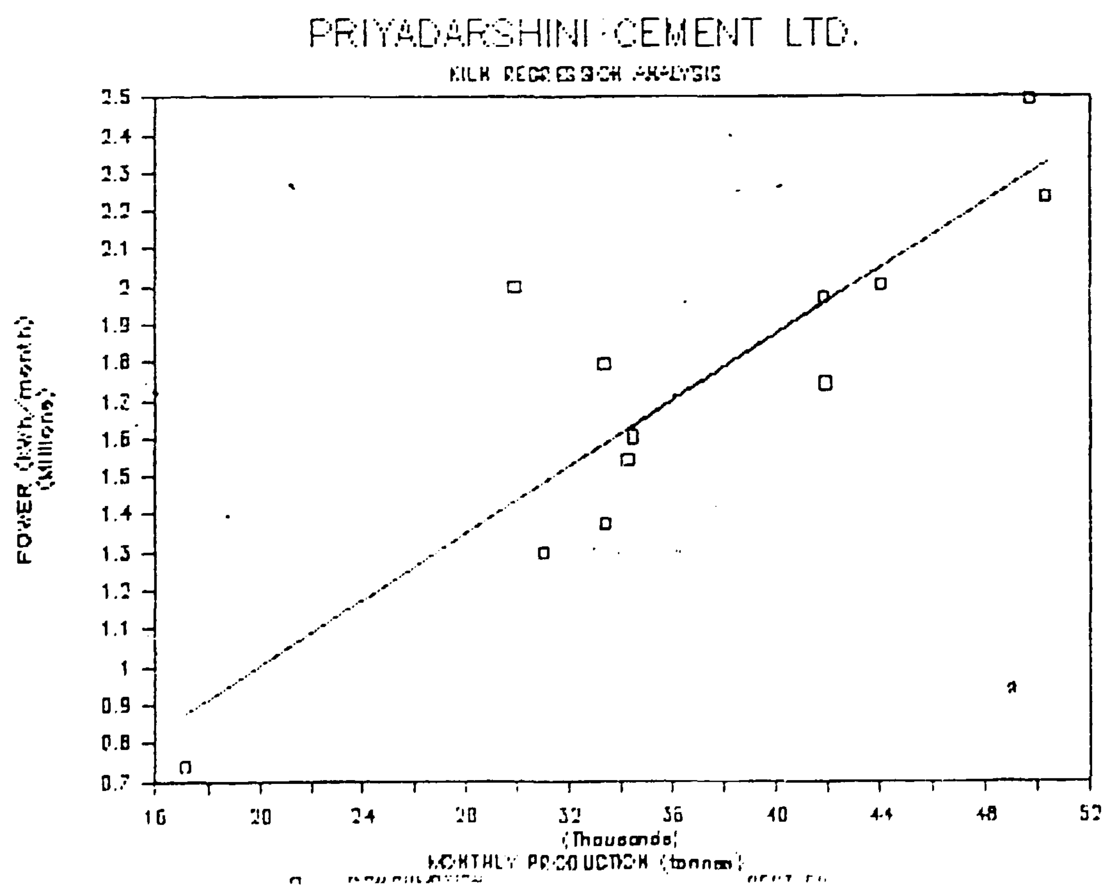
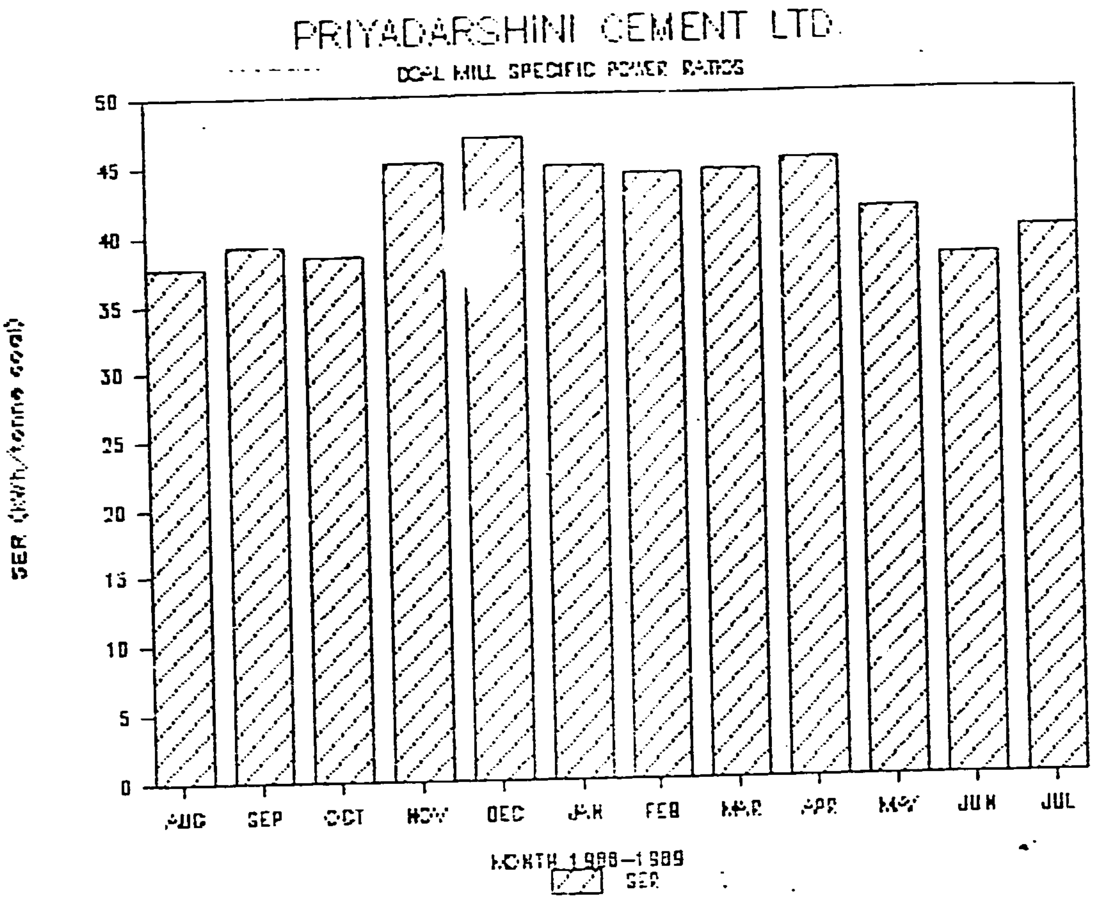
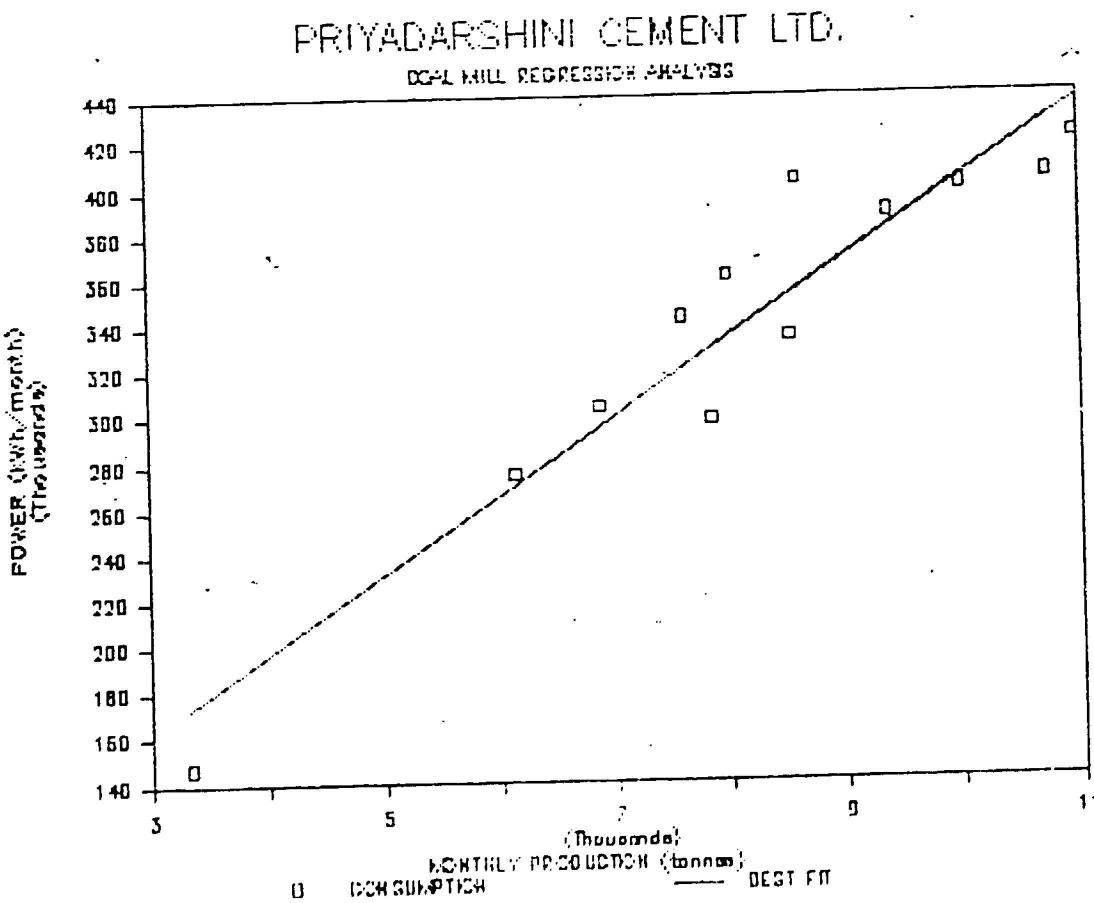



PRIYADARSHINI CEMENT LTD.
KILN SPECIFIC POWER RATIOS
SER (kWh/tonne clinker)
70
60
50
40
30
20
10
0
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
MONTH 1988–1989
SER


PRIYADARSHINI CEMENT LTD.
KILN REGRESSION ANALYSIS
POWER (kWh/month)
(Millions)
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
16
20
24
28
32
36
40
44
48
52
(Thousands)
MONTHLY PRODUCTION (tonnes)

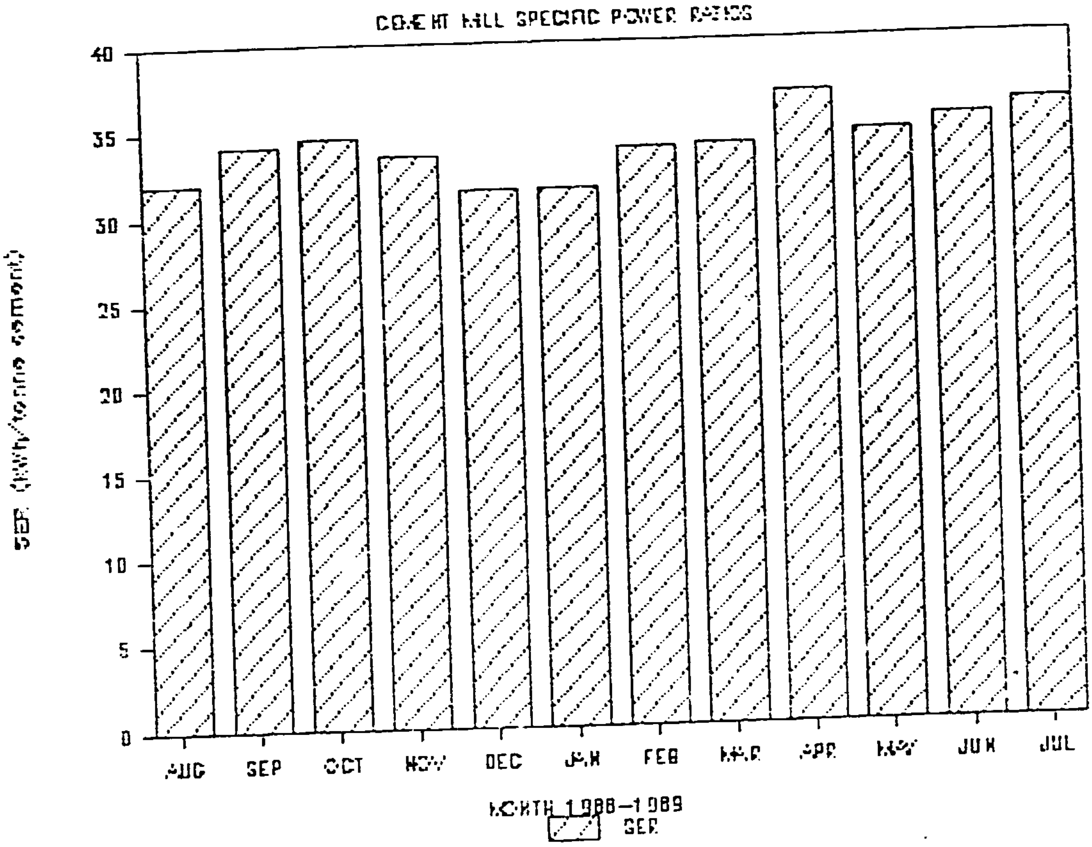

PRIYADARSHINI CEMENT LTD.
COAL MILL SPECIFIC POWER RATIOS
SER (kWh/tonne coal)
50
45
40
35
30
25
20
15
10
5
0
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
MONTH 1988–1989
SER


PRIYADARSHINI CEMENT LTD.
COAL MILL REGRESSION ANALYSIS
POWER (kWh/month)
(Thousands)
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
3
5
7
9
11
(Thousands)
MONTHLY PRODUCTION (tonnes)
CONSUMPTION
BEST FIT

CB

PRIYADARSHINI CEMENT LTD.

CEMENT MILL SPECIFIC POWER RATIOS



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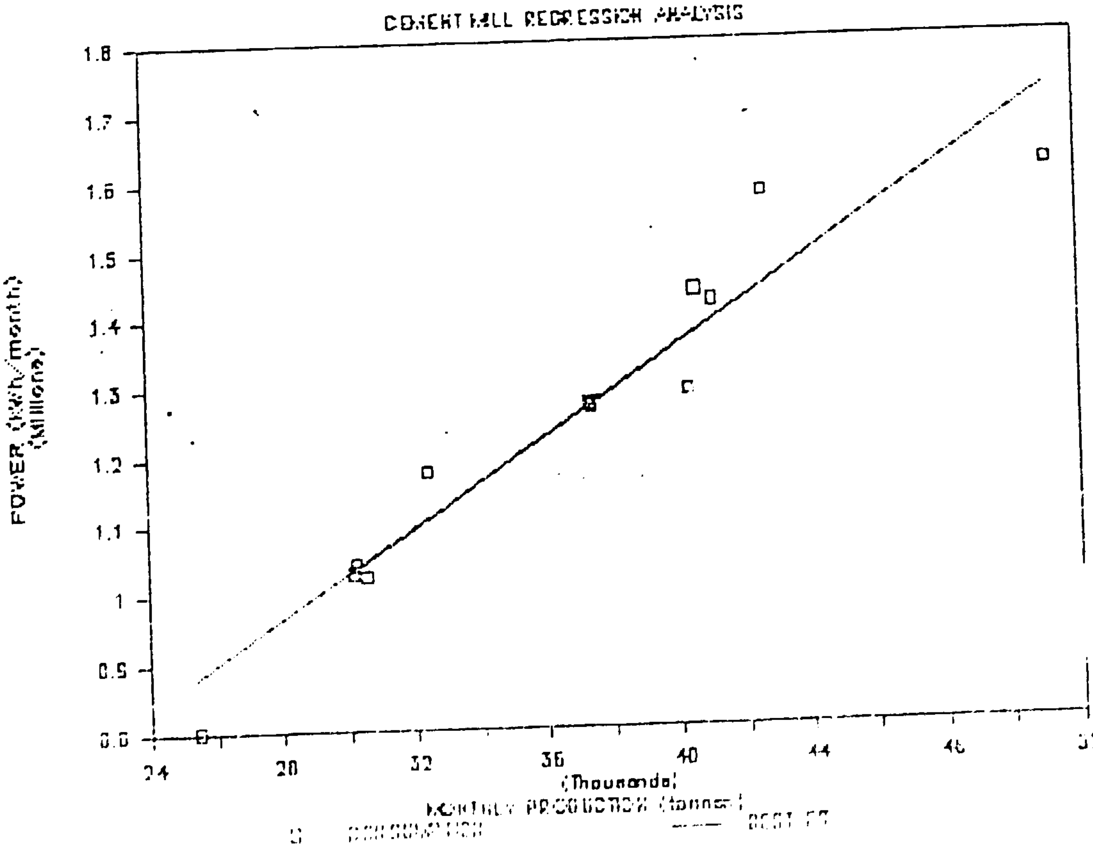
CEMENT MILL REGRESSION ANALYSIS



PRIYADARSHINI CEMENTS LTD.
PRODUCTION ENERGY DATA AUG 1988 - JULY 1989

DATE		PRODUCTION CEMENT tonnes	CLINKER tonnes	OVERALL ENERGY ELECTRICITY PURCHASE MWh	GENERATE MWh	CONSUMP MWh	MAX DEM MVA	COAL CONSUMP tonnes	Average CV kCal/kg	kCal*10**6
1988	AUG	36965	44096	5512.9	0	5512.9	13.44	9773	4008	39170.18
	SEP	26533	34400	4409.3	0	4409.3	13.92	7968	3704	29513.47
	OCT	40037	50362	5898.2	0	5898.2	13.44	11836	3725	44089.10
	NOV	30257	34177	4208.1	0	4208.1	12.24	7833	3845	30117.89
	DEC	30174	41891	4342.7	0	4342.7	9.12	9042	3920	35444.64
1989	JAN	48824	30935	4292.4	0	4292.4	11.04	6972	3985	27783.42
	FEB	37545	17147	2760.5	0	2760.5	8.88	3731	4255	15875.41
	MAR	37644	33311	4075.4	0	4075.4	9.84	7343	4233	31082.92
	APR	35921	41830	5253.8	0	5253.8	8.16	9220	4335	39968.70
	MAY	34939	49760	5471.9	0	5471.9	8.4	11488	4225	48536.80
	JUN	36575	33282	4835.5	0	4835.5	8.64	8745	4350	38040.75
	JUL	32402	39825	0	0	0	8.64	9920	3952	39203.84
	TOTAL	427616	451016	51060.7	0	51060.7		103871		418827.12

PRIYADARS
PRODUCTIO

DATE	OVERALL SER ELEC/CEM kWh/t	COAL/CLIN kCal/kg	GENERATOR kWh/l	kWh/kWh oil	LOAD FACTOR %
1988	0.15	888.29			55.13
	0.17	857.95			43.99
	0.15	875.44			58.99
	0.14	881.23			47.75
	0.14	846.12			64.00
1989	0.09	898.12			52.26
	0.07	925.84			46.26
	0.11	933.11			55.67
	0.15	955.50			89.42
	0.16	975.42			87.56
	0.13	1142.98			77.73
	0.00	984.40			0.00
	0.12	928.63	ERR	ERR	

CLINKERISATION

DATE		PRODUCTION tonnes	kWh	Hours	PROD RATE tph	SER ELECTRIC kWh/t
1988	AUG	44096	2005600	564	78.18	45.48
	SEP	34400	1603700	438	78.54	46.62
	OCT	50362	2236200	651	77.36	44.40
	NOV	34177	1544600	440	77.68	45.19
	DEC	41891	1743000	510	82.14	41.61
1989	JAN	30935	1299600	388	79.73	42.01
	FEB	17147	741500	216	79.38	43.24
	MAR	33311	1374100	425	78.38	41.25
	APR	41830	1971930	509	82.18	47.14
	MAY	49760	2496048	638	77.99	50.16
	JUN	33282	1798246	441	75.47	54.03
	JUL	29825	2000702	484	61.62	67.08
	TOTAL	441016	20815226	5704	77.32	47.20

CEMENT GRINDING

DATE		PRODUCTION tonnes	kWh	Hours	PROD RATE tph	SER ELECTRIC kWh/t
1988	AUG	40328	1287700	351	114.89	31.93
	SEP	30126	1030300	278	108.37	34.20
	OCT	41051	1418150	385	106.63	34.55
	NOV	30556	1023000	295	103.58	33.48
	DEC	25418	800680	254	100.07	31.50
1989	JAN	51150	1610437	518	98.75	31.48
	FEB	37386	1267500	383	97.61	33.90
	MAR	37327	1270900	414	90.16	34.05
	APR	42601	1575489	428	99.54	36.98
	MAY	30227	1044520	286	105.69	34.56
	JUN	40570	1433618	503	80.66	35.34
	JUL	32429	1175621	375	86.48	36.25
	TOTAL	439169	14937915	4470	98.25	34.01

COAL MILL

DATE		PRODUCTION tonnes	kWh	Hours	PROD RATE tph	SER ELECTRIC kWh/t
1988	AUG	10743	404940	455	23.61	37.69
	SEP	8510	334220	366	23.25	39.27
	OCT	10973	421430	480	22.86	38.41
	NOV	7584	343200	406	18.68	45.25
	DEC	8586	403100	461	18.62	46.95
1989	JAN	6123	275100	330	18.55	44.93
	FEB	3325	147200	186	17.88	44.27
	MAR	6857	304100	356	19.26	44.35
	APR	7979	360951	401	19.90	45.24
	MAY	9367	388580	468	20.01	41.48
	JUN	7834	298091	362	21.64	38.05
	JUL	10000	400106	474	21.10	40.01
	TOTAL	97881	4081018	4745	20.63	41.69

CRUSHER

DATE	PRODUCTION tonnes	kWh	Hours	PROD RATE tph	SER ELECTRIC kWh/t
1988 AUG	70020	140720	284	246.55	2.01
SEP	57960	140980	284	204.08	2.43
OCT	77160	168820	323	238.89	2.19
NOV	50040	89500	224	223.39	1.79
DEC	58530	80000	248	236.01	1.37
1989 JAN	34530	73150	144	239.79	2.12
FEB	34530	72170	146	236.51	2.09
MAR	47493	96400	197	241.08	2.03
APR	54750	125518	158	346.52	2.29
MAY	69070	137400	208	332.07	1.99
JUN	58426	113809	219	266.79	1.95
JUL	54103	120864	178	303.95	2.23
TOTAL	666612	1359331	2613	255.11	2.04

RAW GRINDING

DATE	PRODUCTION tonnes	kWh	Hours	PROD RATE tph	SER ELECTRIC kWh/t
1988 AUG	68114	1629300	527	129.25	23.92
SEP	57442	1257540	417	137.75	21.89
OCT	81083	1600500	529	153.28	19.74
NOV	52628	1161500	353	149.09	22.07
DEC	61198	1273300	355	172.39	20.81
1989 JAN	49972	981600	295	169.40	19.64
FEB	22689	475700	133	170.59	20.97
MAR	49292	976600	283	174.18	19.81
APR	62418	1164501	345	180.92	18.66
MAY	74342	1353200	401	185.39	18.20
JUN	58762	1135225	333	176.46	19.32
JUL	51589	1133727	345	149.53	21.98
TOTAL	689529	14142693	4316	159.76	20.51

SAGAR CEMSAGAR CEMENT LTD.
PRODUCTIOPRODUCTION ENERGY DATA AUG 1988 - JULY 1989

DATE	DATE		PRODUCTION CEMENT tonnes	CLINKER tonnes	OVERALL ENERGY ELECTRICITY PURCHASE KWh	GENERATE KWh	CONSUMP KWh	MAX DEM kVA	COAL CONSUMP tonnes	Average CV kCal/kg	kCal*10**6
1988	1988	AUG	6594	8382	0	0	1184477	2520	2180	4001	8722.18
		SEP	11063	8440	0	0	1238369	2760	2199	3960	8708.04
		OCT	10889	10761	0	0	1456832	3240	2754	3988	10982.95
		NOV	11706	10230	0	0	1443202	3240	2660	4000	10640.00
		DEC	9788	9631	0	0	1308925	2520	2505	4017	10062.59
1989	1989	JAN	10458	9395	0	0	1311896	2460	2490	4017	10002.33
		FEB	10255	9230	0	0	1285901	2520	2400	3932	9436.80
		MAR	10645	10566	0	0	1423585	2550	2690	4040	10867.60
		APR	9035	10032	0	0	1286619	2550	2510	4015	10077.65
		MAY	11310	11020	0	0	1493618	2070	2760	4070	11233.20
		JUN	10916	9580	0	0	1348153	2370	2490	4029	10032.21
		JUL	9773	9202	0	0	1271045	2250	2390	4070	9727.30
		TOTAL	122432	116469	0	0	0		30028		120492.85

SAGAR CEM
PRODUCTIO

DATE	OVERALL SER ELEC/CEM kWh/t	COAL/CLIN kCal/kg	GENERATOR kWh/l	kWh/kWh oil	LOAD FACT %
1988	179.63	1040.58			63.18
	111.94	1031.76			62.32
	133.79	1020.63			60.44
	123.29	1040.08			61.87
	133.73	1044.81			69.81
1989	125.44	1064.64			71.68
	125.39	1022.41			75.93
	133.73	1028.54			75.04
	142.40	1004.55			70.08
	132.06	1019.35			96.98
	123.50	1047.20			79.01
	130.06	1057.09			75.93
	0.00	1034.55	ERR	ERR	

CRUSHER

DATE	DATE		PRODUCTION tonnes	kWh	Hours	PROD RATE tph	SER ELECTRIC kWh/t
1988	1988	AUG	12610	30134	180	70.06	2.39
		SEP	5890	14157	86	68.49	2.40
		OCT	16150	38150	224	72.10	2.36
		NOV	15300	36981	220	69.55	2.42
		DEC	14215	33774	203	70.02	2.38
1989	1989	JAN	14550	33770	199	73.12	2.32
		FEB	13765	32138	198	69.52	2.33
		MAR	15926	37180	227	70.16	2.33
		APR	15010	34838	211	71.14	2.32
		MAY	16234	38125	225	72.15	2.35
		JUN	14812	34989	203	72.97	2.36
		JUL	14768	34680	205	72.04	2.35
		TOTAL	169230	398916	2381	71.08	2.36

RAW GRINDING

DATE	DATE		PRODUCTION tonnes	kWh	Hours	PROD RATE tph	SER ELECTRIC kWh/t
1988	1988	AUG	12484	252723	367	34.02	20.24
		SEP	12715	257312	379	33.55	20.24
		OCT	16000	323567	470	34.04	20.22
		NOV	15255	309015	446	34.20	20.26
		DEC	14308	290628	423	33.83	20.31
1989	1989	JAN	14002	282451	412	33.99	20.17
		FEB	13655	275675	396	34.48	20.19
		MAR	15686	316444	448	35.01	20.17
		APR	14878	277035	435	34.20	18.62
		MAY	16414	331826	471	34.85	20.22
		JUN	14316	289012	420	34.09	20.19
		JUL	13816	279117	406	34.03	20.20
		TOTAL	173529	3484805	5073	34.21	20.08

CLINKERISATION

DATE	DATE		PRODUCTION tonnes	kWh	Hours	PROD RATE tph	SER ELECTRIC kWh/t *
1988	1988	AUG	8382	358116	537	15.61	42.72
		SEP	8440	359898	527	16.02	42.64
		OCT	10761	458649	681	15.80	42.62
		NOV	10230	436017	647	15.81	42.62
		DEC	9631	411280	602	16.00	42.70
1989	1989	JAN	9395	401008	598	15.71	42.68
		FEB	9230	393776	595	15.51	42.66
		MAR	10566	450120	686	15.40	42.60
		APR	10032	427371	647	15.51	42.60
		MAY	11020	469574	689	15.99	42.61
		JUN	9580	408806	598	16.02	42.67
		JUL	9202	392866	590	15.60	42.69
		TOTAL	116469	4967481	7397	15.75	42.65

CEMENT GRINDING

DATE	DATE		PRODUCTION tonnes	kWh	Hours	PROD RATE tph	SER ELECTRIC kWh/t
1988	1988	AUG	6594	397143	432	15.26	60.23
		SEP	11063	457995	602	18.38	41.40
		OCT	10889	450596	616	17.68	41.38
		NOV	11706	482986	630	18.58	41.26
		DEC	9788	405039	524	18.68	41.38
1989	1989	JAN	10458	431064	588	17.79	41.22
		FEB	10255	423332	531	19.31	41.28
		MAR	10645	438555	553	19.25	41.20
		APR	9035	373698	494	18.29	41.36
		MAY	11310	465248	599	18.88	41.14
		JUN	10916	449972	533	20.48	41.22
		JUL	9773	403630	495	19.74	41.30
		TOTAL	122432	5179258	6597	18.56	42.30

COAL MILL

DATE	DATE		PRODUCTION tonnes	kWh	Hours	PROD RATE tph	SER ELECTRIC kWh/t
1988	1988	AUG	2180	82363	363	6.01	37.78
		SEP	2199	82759	366	6.01	37.63
		OCT	2754	103966	444	6.20	37.75
		NOV	2660	99047	422	6.30	37.24
		DEC	2505	93743	417	6.01	37.42
1989	1989	JAN	2490	91350	415	6.00	36.69
		FEB	2400	89840	369	6.50	37.43
		MAR	2690	101973	413	6.51	37.91
		APR	2510	97026	386	6.50	38.66
		MAY	2760	105333	418	6.60	38.16
		JUN	2490	93346	385	6.47	37.49
		JUL	2390	89094	367	6.51	37.28
		TOTAL	30028	1129840	4765	6.30	37.63

DESPATCH

DATE	DATE		PRODUCTION tonnes	kWh	SER ELECTRIC kWh/t	MISCELLANEOUS kWh	kWh/t
1988	1988	AUG	8475	12543	1.48	51455	7.80
		SEP	10039	14958	1.49	51290	4.64
		OCT	11006	16509	1.50	65395	6.01
		NOV	11051	16356	1.48	62800	5.36
		DEC	10164	14941	1.47	59520	6.08
1989	1989	JAN	10383	15160	1.46	57093	5.46
		FEB	10026	15240	1.52	55900	5.45
		MAR	10504	15756	1.50	63557	5.97
		APR	10389	15480	1.49	61171	6.77
		MAY	10871	16090	1.48	67422	5.96
		JUN	9459	13810	1.46	58218	5.33
		JUL	10441	15453	1.48	56205	5.75
		TOTAL	122808	182296	1.48	710026	5.80