Thermal Energy Management of Cement Rotary Kiln – A tool for self appraisal of pyro section of a Cement Plant

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Abstract

In the energy intensive cement manufacturing process, the expenditure on Thermal energy is almost equal or some times higher than that on electrical energy. Cement plants have a practice of closely monitoring and analyzing electrical energy consumption. But thermal energy consumption is not as closely monitored and analysed, as it should be. This could be due to tedious time consuming process measurements and calculations involved in arriving at the accurate accounting of thermal energy usage in the plant.

This paper describes the salient features of the versatile software developed by ERCOM Consulting Engineers Pvt. Ltd, Chennai, (ERCOM) which helps to monitor, analyze and store thermal energy data and reports, with ease and accuracy.

This software not only gives a detailed heat balance of pyro system but also evaluates the performance indices of the equipment in the pyro section. The reports generated are appropriately designed to help the engineers and management to quickly analyze the performance. Graphical trends of total thermal energy consumption and break up of thermal energy consumption are available to make a comparative analysis over a period of time.

By use of this software, thermal energy management in a cement plant becomes persons independent, allowing the management to analyze the performance frequently and take necessary action immediately resulting in cost reduction.

1.0 Introduction

Cement manufacturing process is a highly energy intensive process using Thermal energy and electrical energy. The component of cost of energy in the production cost of cement is prominently high. With depleting energy sources and rising energy costs, it is essential for every cement manufacturer to continuously put in efforts to reduce the energy consumption in the manufacturing of cement.

Energy reduction not only helps to improve the bottom line but also helps to reduce the contribution of green house gases to the atmosphere.

Close monitoring of electrical energy and analyzing the section wise consumption has been practiced in many cement plants. But thermal energy consumption is not as closely monitored and analyzed, as it should be. This could be due to tedious time consuming process measurements and calculations involved in arriving at the accurate accounting of thermal energy usage in the plant.

ERCOM Consulting Engineers Pvt. Ltd., Chennai (ERCOM), have developed versatile software, which helps the plant personnel to monitor and analyze the thermal energy data, more frequently facilitating to take remedial action resulting in cost reduction.

This paper describes the salient features of the software.

2.0 Why develop new software when many worksheet programs are available?

Most of the heat balance softwares available in plants are,

- Generally developed as EXCEL work sheets
- Not flexible to the extent necessary
- Data entry generally is a big job and needs a person conversant with the program and calculations
- No Check on wrong data entry. If the data are entered by mistake at a wrong place, the program ends up with wrong results as there is no fool proof data entry system.
- Calculations may not be very detailed and may not give all the performance indicators of the pyro system
- Generally such programs are not user friendly

- Report generation may not be so elaborate
- Saving reports and retrieving old reports is not possible
- Such programs might not be developed taking Thermal energy management as a total activity in the plant

To overcome the above shortcomings of many programs available in cement plants for thermal energy calculations, ERCOM has developed a software that is handy for process/energy engineers and management in cement plants to quickly analyse the thermal performance of pyro-processing system and get insight into the areas requiring attention for improvement.

3.0 Objectives of the software

The objectives of the software are

1. To enable process Engineers calculate Heat Balance Instantaneously.
2. To present thermal performance of pyro-processing section of cement plant.
3. To help management in focusing on areas requiring improvements for better performance.
4. To make the cumbersome and complicated heat balance of a rotary cement kiln accessible to non- process personnel also, enabling them to carry out heat balance of a kiln in a matter of 5-10 minutes.

4.0 Some salient features of the software

- The software is easy to install and does not need external support.
- No special training is required for using the software as meaningful help menus are provided wherever necessary.
- Application instructions are built in each format and the user has to simply follow the instructions.
- The software is user friendly and does not require special computer skills.
- Critical design parameters are password protected to deny access to un-authorised persons.
- Critical parameters that are entered are checked for validity and if abnormal values are entered, the same are rejected with a warming.
- Almost all practical conditions are taken into account and made highly flexible.
- Provision is given to add a number of alternate fuel in calciner.
- In the complete calculations, no assumptions are made and entire calculation is based on user's input. Thus the result of the calculations is realistic.
- Program can be used when a very detailed process measurements are carried out or even when limited process measurements are made.
- When measurements like shell temperatures are not taken, provision to run with old data is given.
- Design parameters also can be varied e.g. number of cooler fans and compartment sizes etc.
- Thermal performance data related to pyro system like cooler efficiency, degree of calcination etc., are also calculated.
- Data on false air entry into preheaters is indicated to focus the attention on the loss due to false air infiltration.
- The program arrives at the fuel consumption from the calculation using various field measurements entered by the user. A comparison of fuel consumption calculated and fuel consumption recorded helps to locate if any error in fuel metering exists.
- If the fuel measurement is correct and still the difference between measured and calculated fuel values exists indicating a possible error in process measurements, then related field measurements need to be repeated.
- The software can also work on-line wit the data acquisition system of the plant. In the option parameters to be read on-line can be selected by the user depending on the facilities available in the plant.

- **Reports**
  - → The software generates very detailed reports.
  - → Reports can be either viewed on the monitor or can be printed.

→ These reports generated can be saved separately for future reference.
→ There is no need to maintain any paper file as far as thermal energy management is concerned in the plant, if this software is used.
→ Graphical trends of total heat consumption and break up of heat consumption under various heads facilitate the plant personnel to quickly analyse the areas contributing to abnormal energy loss.

5.0 Reports generated by the software

The reports generated by the software are so designed that all the important data are recorded and are placed in appropriate report for effective analysis. Various reports generated by the software are

1. **Process parameters** showing various gas/air flows measured
2. **Heat Balance on kiln** giving a detailed account of various heat inputs and heat output /loss.
3. **Performance Indicators** giving the parameters indicating the performance of the equipment viz., preheater, kiln and cooler and the amount of false air ingress.
4. **Data on feed, clinker and fuel** recording the analysis of kiln feed, clinker and fuel at the time of measurements
5. **Combustion data** of fuel giving details of air requirement, combustion products formed etc.
6. **Design parameters** showing the dimensions of equipment and diameters of ducts wherever flow measurements were carried out.
7. **Miscellaneous data** which includes all other important parameters used in the calculations.
8. **Summary Report** detailing the nature of measurements carried out for arriving at the result. This report lists how some important parameters are measured and the basis of estimation of fuel consumption.

Apart from the above reports in Table form, for easy analysis of heat balance, the heat loss and material/gas flow are shown in the form of a process flow diagram.

When the software is used on-line, separate set of reports pertaining to the period of on-line operation are generated.

6.0 Graphical reports

Two graphical reports are generated by the software.

1. Trend of heat consumption.
2. Analysis of heat consumption.

With the help of this graph, it is possible to analyse what component of heat loss Contributed how much in the total loss over a period of time.

7.0 Typical reports generated by the software are shown below.

ERCOM, Chennai

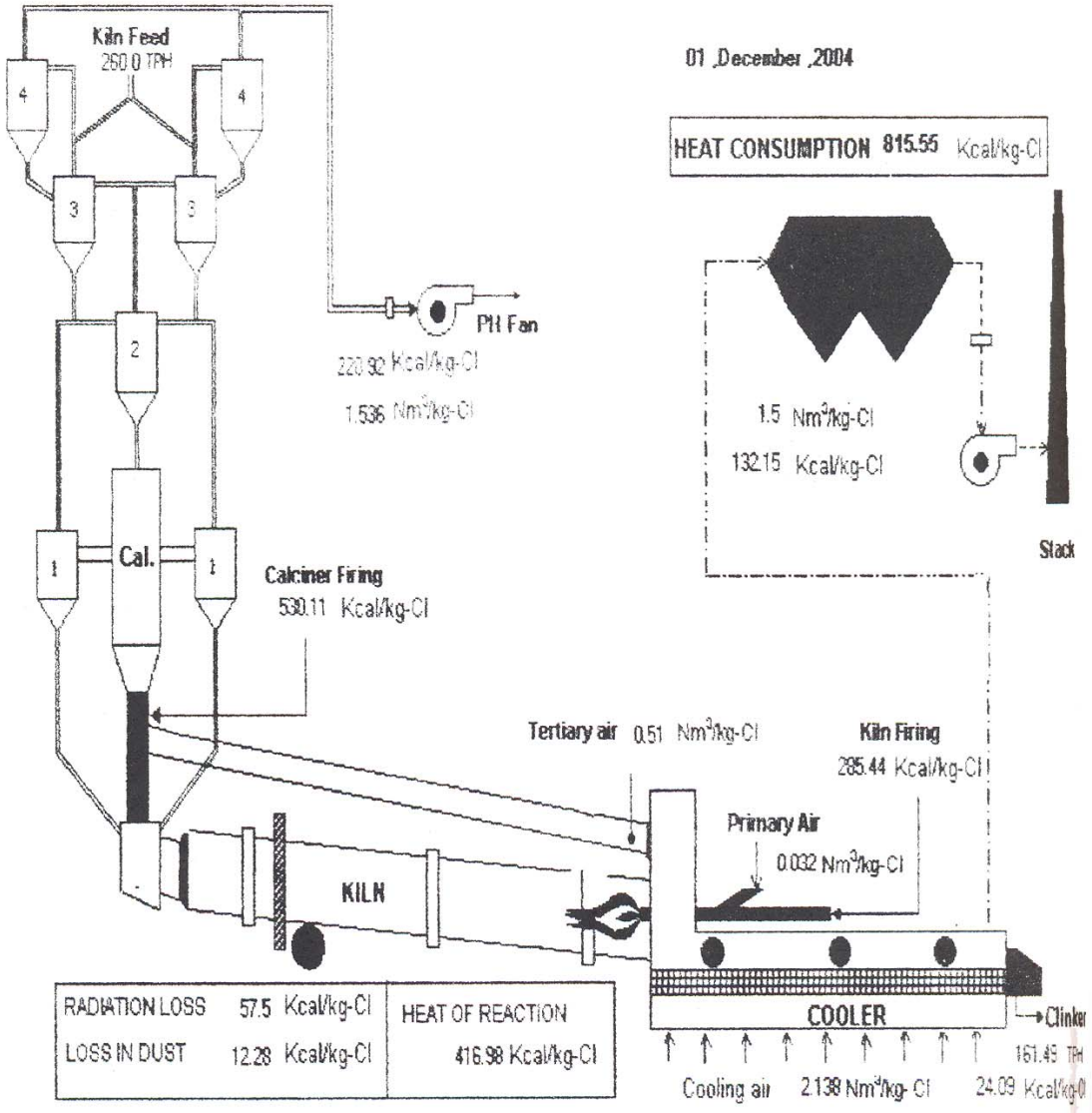
01, December, 2004

Clinker Production 161.49 tph

HEAT INPUT	868.19 Kcal/kg.cl	HEAT OUTPUT	868.2 Kcal/kg.cl
Sensible Heat in		Heat of Reaction	416.98
AIR	27.37	Preheater Exit gasses	220.92
FUEL	1.76	Dust in Preheater Exit gasses	12.28
FEED	23.52	Evaporation of Moisture	2.11

TOTAL	**52.64**	**Clinker Leaving Cooler**	**24.09**
Combustion heat	**815.55**	**Radiation loss**	**57.5**
		Kiln	**21.64**
Fuel consumption	**15.05 %**	**Preheater+Ph exh. duct.**	**28.65**
Avg.NCv of fuel	**5419.63 Kcal/kg.fuel**	**Cooler + Tert air duct**	**7.2**
Heat input to kiln	**285.44 Kcal/kg.cl**	**Incomplete Combustion**	**2.16**
Heat input to PC	**530.11 Kcal/kg.cl**		

Heat Balance Summary



HEAT BALANCE – PROCESS FLOW SHEET

ERCOM, Chennai

01, December, 2004

Clinker Production	**161.49 Tph (3876 tpd)**
Degree of Calcination	**88.4 %**
Thermal loading of kiln	**3.74 million Kcal/m2.hr**
Specific output from kiln	**4.84 Tpd/m3**
Heat consumption (Fuel)	**815.55 Kcal/kg clinker**
Fuel consumption	**15.05 %**
Percent fuel fired in kiln	**35 %**
Cooler loading	**42.36 Tpd/m2**
Cooler efficiency	**58.57 %**
Heat input to Kiln	**285.44 Kcal/kg clinker**
Heat input to Calciner	**530.11 Kcal.kg clinker**

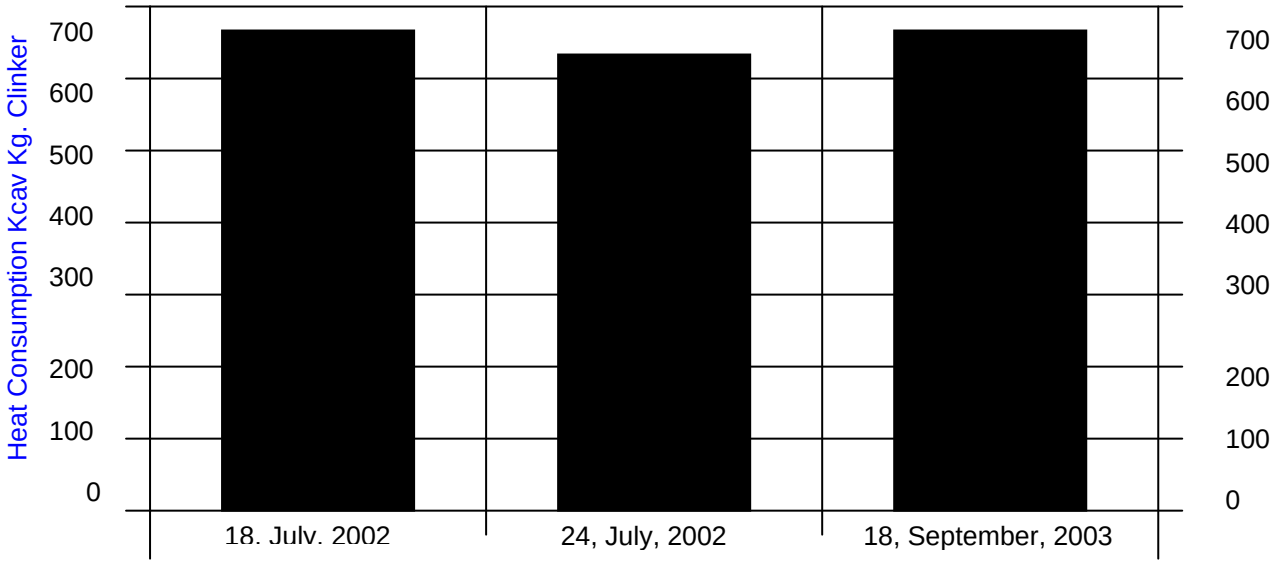
Specific air flow in cooler fan areas m3/m2/sec.			
Comp 1	**1.95**	**Comp 6**	**1.16**
Comp 2	**2.3**	**Comp 7**	**0.64**
Comp 3	**1.89**	**Comp 8**	**0.79**
Comp 4	**1.94**	**Comp 9**	**0.27**
Comp 5	**1.36**		

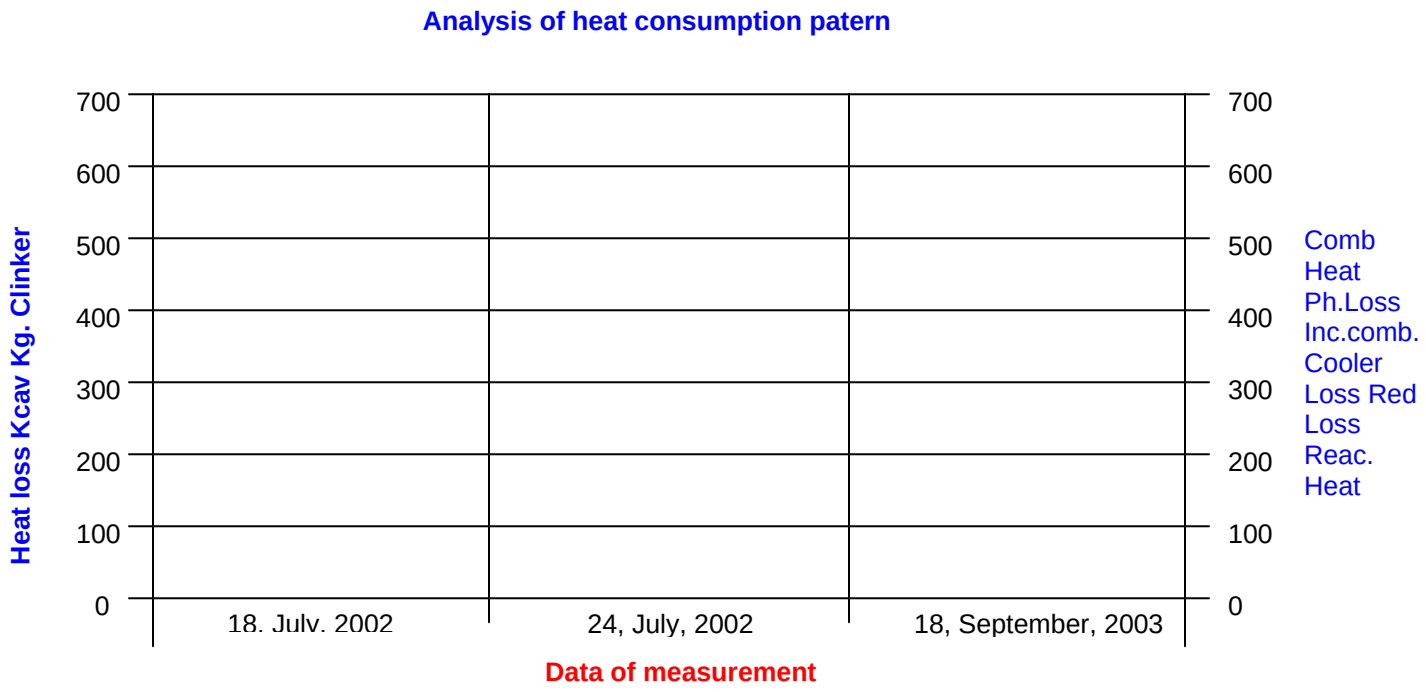
Calculated False air entry into preheater	**0.19 Nm3/kg clinker or 7.63 %**

Kiln performance indicators

Graphical reports

Heat consumption trend





8.0 Benefits of the software

- The software gives a quick insight into the performance of the process and allows for a focused attention on the areas requiring improvement.
- Reports generation are handy and complete to enable easy analysis of the process
- Top management also can obtain the performance details with a very little time and effort.
- As takes only 5 – 10 minutes for calculating heat balance, the management can monitor with the concerned department on a weekly basis and losses can be arrested allowing to reap benefits instantaneously.
- With the use of this software, any individual even without much knowledge of process or calculations can carry out heat balance and performance calculations very easily within a few minutes.
- As there is a provision to store reports, any report can be retrieved at any time. Hence, thermal energy management can become paperless when this software is used.
- Generally payback of installing the software is less than a year.

9.0 Conclusion

Cement manufacturing process being highly energy intensive, monitoring of thermal and electrical energy on a regular basis is necessary to control the cost of energy in the production cost. It is also necessary to monitor the thermal performance of equipment to improve the productivity and availability. This software helps cement plant management and process engineers to monitor and record the performance of equipment and heat balance of kiln within a few minutes enabling then to take corrective action for improvement immediately.

Reference Book:

National Council for Cement and Building Materials
8 – 11 November 2005
Volume: 4