Management Information System for Energy and Environmental Aspects of Small and Medium Scale Industries

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Abstract—**Traditionally Small and Medium Scale Industries (SMIs) have concentrated on physical resources but have often neglected the effective management information, though realisation of its importance is now growing. This requires fast and accurate computation and manipulation of huge amount of data. Information System can be used for energy and environmental planning and to reduce the energy wastage and environmental pollution.**

SMI's in India mostly cater the domestic market and use local sources. These industries are mostly labour intensive. Managerial and entrepreneurial skills are less, with limited access to information and financial sources. These limitations make it difficult for SMIs to upgrade their technologies and allocate their resources efficiently.

This paper examines possible implementation of Information System based Energy and Environmental Management System in selected SMIs. Some of the important factors identified to develop a model for this system are energy consumption, energy standards (benchmarks), emission generation, environmental standards and production details for various sections in a foundry. The application case study to highlight the benefits of energy and environment technology option for foundry is described in this paper

Keywords—**Data, Energy, Environment, Information**

I. INTRODUCTION

According to author [1] Energy and Environmental information system defined as a system for the collection, analysis and reporting data relating to Energy and Environmental performances that supports Energy and Environmental Management. The prime function of this system is the support of energy and environmental management as a part of the overall strategy of the organisation.

The International Energy Outlook 2000 [2] predicts that energy consumption will increase by 60% over period 1997 to 2020. Energy use worldwide will continue to grow at an average annual rate of 1.1% and by 2020 the world consumption will rise from 380 quadrillion British thermal units (Btu) in 1997 to 608 quadrillion Btu in 2020 It is the assumption of economic growth (especially in the developing world) that, more than any other factor, is the reason for the anticipated increase in energy demand.

The International Energy Outlook 2000 [2] also points out that world carbon emissions are projected to rise from 6.2 billion metric tons in 1997 to 8.1 billion metric tons in 2010 and 10.0 billion metric tons in 2020. In this forecast, world carbon emissions exceed their 1990 levels by 40% in 2010 and by 72% in 2020. Emissions in the industrialised world grow by 1.1 billion metric tons between 1990 and 2020, with nearly one-half of the increment attributed to an increase in natural gas use. Consideration of energy in relation to the built environment throughout the world's developed countries reveals that 20 – 55% of all delivered energy can be directly associated with buildings and industry [3]. Consequently, new technologies applied to the build environment and industry may be expected to make a significant contribution to a reduction in energy consumption. By raising the efficiency of energy utilisation, it is possible to reduce energy consumption by 10 – 30%, representing a saving of around 3Mtce per year [1]. According to [4] India shares about 2% of global emissions and accounts for 16.8% of world population. The rate of growth of GHG emissions is 4.6 % annually, which is more than double the world average (2%).

Some progress has been made in recent years as building energy management (sensors, HVAC control equipment) and information technology (IT) systems have evolved to a point where they can support and integrate the activities involved in energy management. With respect to environmental impact and economics, the ability to make well-founded decisions regarding energy consumption and supply is of the utmost importance. This requires some means to assess the current performance and agreed targets against which to judge performance [5].

As the energy management function grows in complexity, computer based "information systems" have been developed to support the process. These systems are able to record and monitor energy consumption, and to analyse data in such a way as to highlight any deviation from the normal based on historical trends and patterns. Realistic targets for reductions can then be set [6].

Eight per cent of an energy manager's day is dedicated to information receiving, communicating and use in support of a wide variety of tasks. Since information is the basis for virtually all activities performed in an organisation, systems are required to produce and manage it. The objective of such a system is to ensure that reliable and accurate information is available and presented in a useable and understandable form [7]. The term "Information System" is formally defined by [8] as: systems are required to produce and manage it. The objective of such a system is to ensure that reliable and accurate information is available and presented in a useable and understandable form [7].

The above literature survey and observation reveals that works have been carried out on the energy management studies on large-scale foundries. As far as the energy management system for small and medium scale industries are concerned, only specific research work has been carried out for selected industries and this leaves a lot to be researched in this domain. No detailed information System Tools for energy saving analysis and pollution reduction is available to handle huge industry data.

Further, literature survey substantiates the need for a suitable integrated energy management system for small and medium scale industries. Hence, it is thought that a comprehensive study of energy and Environmental management on the small and medium scale industries to understand and reduce the energy consumption, and also the system's ability to transform energy consumption data to equivalent pollution units thus allowing an assessment of environmental impact pollution reduction will be a useful work.

II. METHODOLOGY

The parameters collected from the industries were comparable on the basis of energy consumption related measurements and energy efficiency related measurements.

The energy management and performance evaluation of the industries involves finding out the relationship between the predominant variables like, current, voltage, power factor, charge composition, and coke consumption. To facilitate in energy saving analysis, in the present work, prototype software module has been developed. Visual basic 6.0 as the front end tool to display the calculation and MS Access as back end for storing databases were used. The proposed block diagram of industry energy management information system is illustrated in Fig.1.

The development of prototype software module involves the following activities

- Data collection
- Creation of database
- Creation of user interface
- Generating results in the form of charts/ graphs to study energy usage

Parameters Energy management system is illustrated in Fig.1

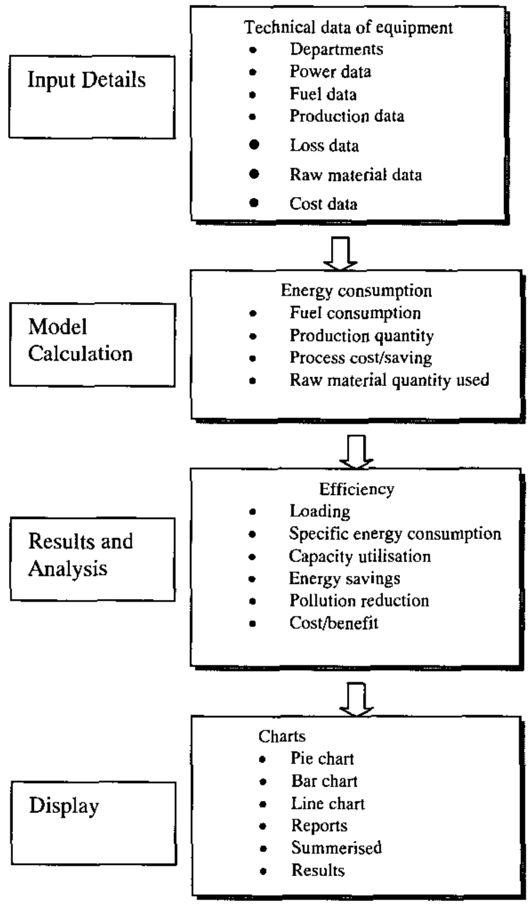

Fig.1Energy Management Information System

III. CASESTUDY

A. *Information Model Development for Foundry Industry*

The development of the system involves the activities such as data collection, creation of database, creation of user interface, generating results in the form of charts/ graphs to study energy usage

B. *Database Design*

Database design is an important aspect of system design. The Assessment and recommendation tables contain the information that has been gathered during the research study. Case study example of foundry is illustrated in this paper.

Input design consists of data recording, data validation and data correction. Input to the system can be static or dynamic. Static details are maintained in master tables. The user through the screen directly enters some input.

The user is interested in finding out the electrical energy/thermal energy use in all the states where an industrial assessment was conducted. For this query, the main criteria is the total electrical /thermal energy use and the states in which load, efficiency and energy consumption assessments were done. The various fields in the database that are of importance for these queries are voltage, current, power factor and fuel consumption.

C. *Preparation of Daily Schedule*

This operation consists of preparation of daily schedules for energy consumption, pollution details and production detail at individual department's entry in to the database for preparation of report. The logic flow chart for preparation of daily schedule in industry is shown in the Fig.2.

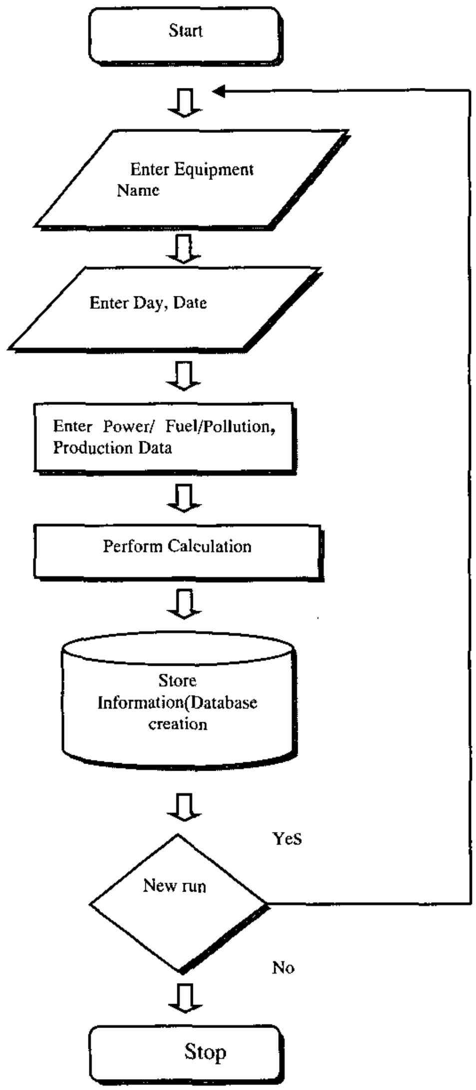

Fig.2 The Logical Flow Chart for Preparation of Daily Schedule

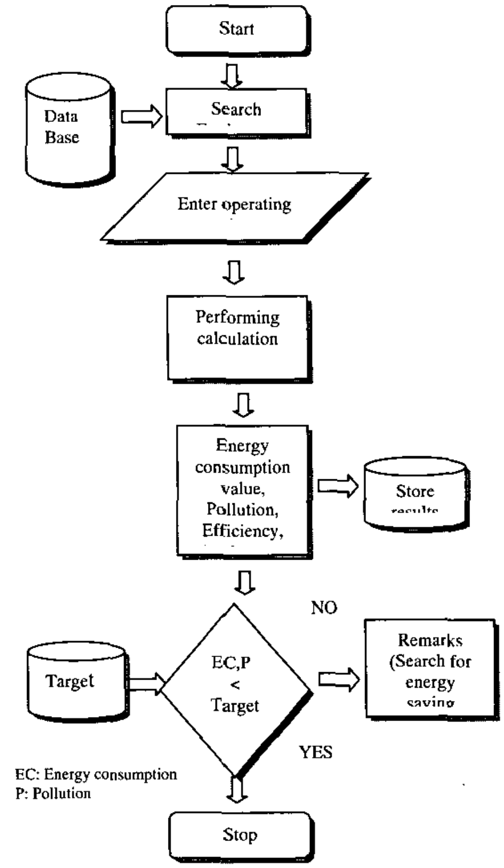

Fig.3 The Logical Flow Chart For Retrieving The Information

D. *Energy Consumption and Pollution Load Status*

The complete energy consumption and pollution load analysis can be got from the system in layered manner starting from the overall picture right down to the minute details. The logic flow chart for retrieving the information in foundry industry is shown in the Fig. 3

E. *Distributed Data Processing Network for Effective Implementation of Energy Consumption and Pollution Data Information at Various Departments in Industry*

The online system operates using common database controlled from single centre. Proper local area network is necessary to integrate all the systems for the online information and maintain the interaction between each department. These computer terminals can be located at relevant personnel at each department. From these terminals information relating to energy consumption and pollution load can be retrieved online. The schematic figure of network arrangement integrating all departments in typical foundry industry shown in Fig. 4

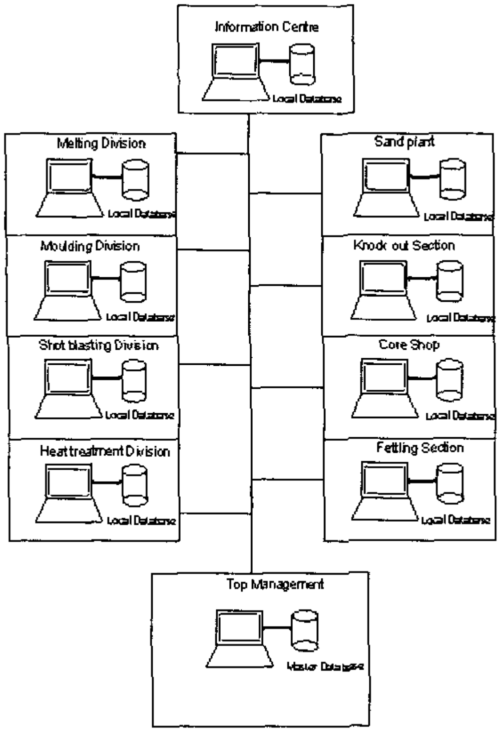

Fig.4 Integration of All Departments

F. *Performing Calculation*

The system's logic for performing calculation based on input data will be stored in the database. Information is available to show the different Electrical energy and fuel consumption over a period and amount of gaseous emissions based on the equation developed. This system logic code is coded in Visual Basic as front end and Microsoft Access as back end for data storage.

Specific energy calculation

$$SEC_{tm} = E_{tm} / P_{tm} \quad (1)$$

Where,

SEC_{tm} -- Specific energy consumption at given time

E_{tm} -- Energy consumption at given period of time in kWh(Electrical Utilities or KG/Ton (Coke consumption)

P_{tm} -- Production in tons at given period of time.

The cumulative Specific energy consumption is given by

$$CSEC_{tm} = \sum_{i=1}^{n} E_{tmi} / P_{tmi} \quad (2)$$

Where

n is amount of production.

Environmental calculation [4]

The equation defines the relationship between energy consumed and corresponding

CO_2 emissions[2] from the melting department given below

Energy source Electricity

Specific CO_2 Pollution = $0.28\ EL/ P_{tm}$ ton/ton(3)

Where, EL is electrical energy consumed.

Energy source Coke

Specific CO_2 Pollution = $2.4955\ CO / P_{tm}$ ton/ton(4)

Where, CO is Coke energy consumed.

Energy source Diesel

Specific CO_2 Pollution = $4.155\ DE / P_{tm}$ ton/ton (5)

Where, DE is Diesel consumed

Energy used related CO_2 Pollution of grey cast iron was determined from data energy consumption and fuel used.

Total Specific CO_2 Pollution=$0.28\ EL/ P_{tm}+2.4955\ CO / P_{tm}+ 4.155\ DE / P_{tm}$ (6)

IV. Discussion

The system basically makes a decision based on the parameters involved in the process. The system begins by identifying the input data shown in the Fig.2, which are required to develop the system. A competent operator should know these data, whose accuracy is vital to the quality of program output. The first input includes the date and time which initiates the starting of the production. The data in the system will be updated at any point of time. The software will display on time, the status of any department at a particular time. Information on moulding department is given in Fig 5. The logic built in to the system helps in making the selection of data required shown in the Fig.3. This analysis gives the specific energy consumption, production detail and related emission against benchmark norms [9] at each time logged in to the system, which is shown in Table 1.

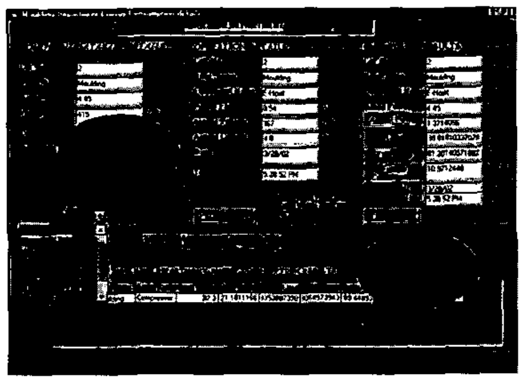

Fig.5 Information of Energy Details in Moulding Department

TABLE I
ENERGY AND ENVIRONMENTAL INFORMATION IN SELECTED FOUNDRY

Description	Bench Mark	Selected Foundry
Production (ton/annum)	500	2500
Labour productivity T/labour annually	3.8	7.8
Specific Energy Consumption	700-800 kWh/ton (Electrical) 135kg/ton of coke	1476 kWh/ton (Electrical) 170kg/ton of coke
Slag in kg	80	70
CO_2 Emissions kg/ton annually	333	650
Yield in %	68	60

The selection of energy efficient option is very important activity from the viewpoint of energy conservation and pollution reduction in Industrial plants. This information system model uses a data file, which contains proposed energy and environmental improvement option. This model then calculates energy savings, cost savings, payback period and pollution reduction (GHG emissions).

The industry selected for application is a medium scale producing grey cast iron castings. The unit is making about 10 - 15 ton of castings per day and uses cupola and induction furnaces for melting and holding purpose respectively. The foundry unit uses 3 different capacity of induction furnace and one rotary furnace in emergency situation. Operating days per year is 312 days. The benefits of two energy and environment options in foundry using this information system is illustrated in Table 2 and Table 3

TABLE II
BENEFITS OF ENERGY AND ENVIRONMENTALLY EFFICIENT TECHNOLOGY OPTION

S. No	Energy efficient Option	Description	Before Use	After Use
1	Installation of automatic star delta converters for the identified lightly loaded motors	Automatic star delta star is a energy saving device with built in load sensor. This sensor continuously senses the load and if the loading goes below 40%..	178464 (kWh)	69888 (kWh)
2	Duplexing of cupola and induction furnace	Cupola metal is poured into the induction furnace and the molten metal is held for clearance from lab. The induction furnace serves here as holding furnace rather than a melting furnace.	93600 (kWh) 1591200 (Coke kg/yr)	748800 (kWh) 1123200 (Coke kg/yr)

V. CONCLUSION

In this research an attempt has been made to develop information system for energy and environmental data analysis for a foundry industry. The IT based energy and environmental information system ensures departmental status of specific energy consumption and pollution load in real time. This system has been designed to know the departmental specific energy consumption and pollution load in against standard values. The software will display on time, the status of any department at a particular time. This information based system helps the management to take appropriate decisions and actions. Case study example of foundry Industry clearly shows the energy savings and reduction of pollution (GHG emissions) by using Energy and Environmentally Efficient Technology option.

TABLE III
ECONOMIC ANALYSIS

S. No	Energy savings	Expenditure Rs.
1	a) Total Electrical energy savings	108576
	Investment	167500
	Payback period	1.6 year
	Pollution(GHG Emissions) Reduction	7.60 tons of CO_2
2	a)Electrical energy (excess due to installation of induction furnace)	- 3276000
	b) fuel energy savings	+ 4680000
	Total savings	1400000
	Investment	50000,00
	Payback period	3.56 year
	Pollution(GHG Emissions) Reduction	980 tons of CO_2 / Year

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