INVESTIGATING THE WAYS TO REDUCE ENERGETIC CONSUMPTIONS AND ENVIRONMENT POLLUTION IN BUILDING MATERIALS INDUSTRY WITH A SIMULATION PROGRAM

Adriana PRIBEANU[1], Roxana PĂTRAŞCU[2]

Obiectivul acestei lucrări este prezentarea unui program pentru simularea analizei reducerii consumurilor energetice şi a poluării mediului ambiant. Aplicaţia este o analiză energetica şi de mediu pe bază de audit într-un contur industrial. Modul de abordare al aplicaţiei prezintă un grad mare de generalitate şi o flexibilitate ridicată, putându-se extinde în viitoare utilizări şi la alte conturuti industriale.

The objective of this work is to present a simulation program for the investigation of the ways to reduce energetic consumptions and environment pollution. The application is intended to assist the energetic and environment audit at industrial contour level. The approach has a high degree of generality and flexibility in that it enables the auditor to describe an industrial contour in terms of energetic consumers and to store the description for future use.

Keywords: simulation, industrial contour, energetic audit, balance sheet, impact on the environment, energetic efficiency

1. Introduction

Energetic and environment audits require a lot of data entry and data processing. The measurement data are processed together with the technical data describing the technical characteristics of an energetic consumer. In order to investigate various ways to reduce the energetic consumption and environment pollution a model simulation is needed.

This work presents an approach to reduce the energetic consumptions and environment pollution in an industrial contour. In order to assist energetic and environment auditors in their work, the simulation program has been integrated with a data base application that enables the description and preserving of the simulation model.

The benefits of this approach are twofold.

[1] Eng., CEPROCIM – Reasearch and Engineering Institute for Cement
[2] Associated Prof., Dept. Of Power Plant, University “Politehnica” of Bucharest, Romania

First, it provides for a computer-aided tool to investigate the ways to reduce energetic consumption and pollution. The simulation program enables the calculation of the energetic balances and environment indicators. Based on these results, the quantification of energetic efficiency is performed and the impact on the environment is estimated.

Second, it provides the auditors with a computer-aided tool for data entry. The data base design separates two kinds of data: description of the industrial contour and audit measurements. The contour is described in terms of energetic consumers, which confers a high degree a generality in that it can be used for any particular industrial contour for the building materials industry. The data in entered only once and is preserved for future use. Then measurement data could be added in a structured way each time an audit is performed.

The rest of this paper is organized as follows. In the next section, the application functions are presented. Then, the software solution and data base design are described, with a focus on the typical entities in the application domain. Then the model validation and calculation of energetic indicators are briefly outlined. The paper ends with conclusion and future work.

2. Functions of the application

From an energetic perspective, the application implements the following functions:

- Organization, description and storing of the data at industrial contour level;
- Description and storing of data energetic consumer level;
- Elaboration of the energetic audits on the basis of the balance-sheets at consuming centers and contour level;
- Elaboration of the environment audit;
- Elaboration of the technical – economical analysis.

From an information technology perspective, the application integrates a data base, several data processing modules for the computing of energetic and environment indicators needed in a balance-sheet and a user interface [1].

3. The hardware – software solution

The technical complexity of the application is associated with the complexity of the mathematical modeling of the industrial processes and materialization through calculation relations of the balance-sheet elements and indicators.

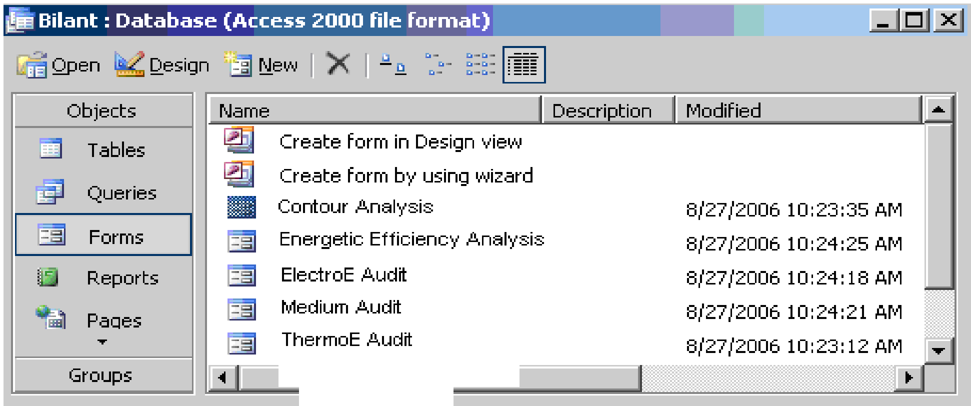

Fig. 1 The development environment

On another hand, the data input takes a considerable time so separating the measurement and technical description data is needed to properly assist auditors in their work and enable iterative simulations on the energetic model.

A suitable solution for these requirements is to develop an application using a data base management system. The application presented in this paper is a Microsoft Access (a trademark of Microsoft Corporation) application running on personal computers. Microsoft Access is a relational data base.

The generality of the approach is sustained at two levels:

- The structuration of the data , through the definition, at a general level, of the consumption centers and installations;
- The functional structure of application, which follows the general model of analysis;

4. Data base of the industrial contour

A data base is an ensemble of interrelated data collections, through which it is possible to accomplish:

- The modeling (representation) of a real world entity (in our case energetic consumption centers) ;
- The data integration and reduction of the unprofitable redundancies;
- The centralized control and data security, the data partition between many users;
- The data independence.

From a technical point of view, installations are grouped together in consumption centers.

In a relational data base, each entity is represented by a table where records are represented as rows and attributes as columns. The key entity in this application is an installation referred in this paper as an energetic consumer or consumer. Each entity of this type is defined by identifier and a set of general attributes, which are common for all installations.

The relationships between entities are based on common attributes (like identifiers) and ensure the referentially integrity of the data base. This means to automatically perform cascade deleting and updating of the data base when one entity is deleted and or modified.

In Fig. 2 the relationship between centers and installations is illustrated. The relation between centers and consumer is one-to-many (1:N) since each center has one or several installation.

In order to take a general approach, a separation between general and specific consumer data is needed. All technical and constructive characteristics of a consumer are defined in a separate table through a set of attributes. The detailed consumer table has a one-to-one (1:1) relation with the general consumer data. The associated key is the installation identifier, which is unique for a particular consumer.

In a similar way is defined the energetic consumption center which has the same attribute structure for all types of centers and the categories of industry.

For each consumer several measurement data could be recorded. In a similar way, for each consumption center several energetic balances could be computed.

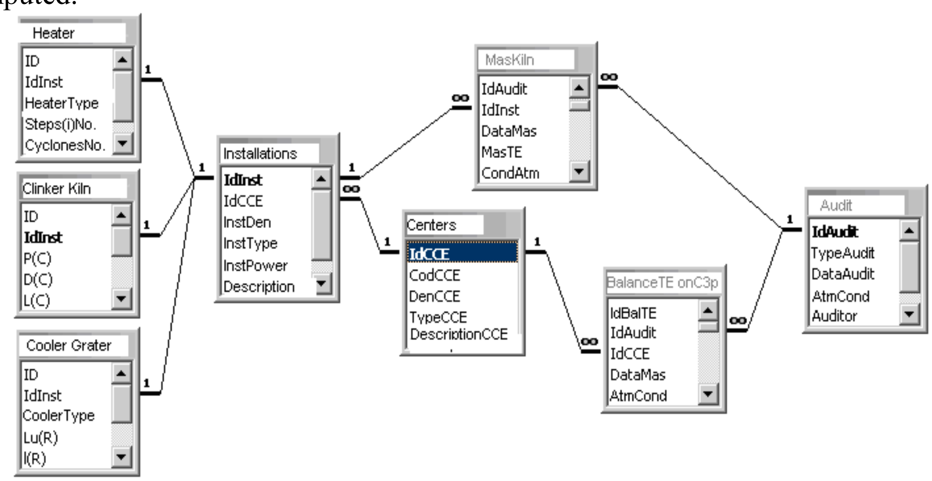

Fig. 2 Relationship between entities

In Fig. 2 it is illustrated for the purpose of exemplification, the energetic consumption center "C3p – Center" of the clincker fabrication and the particularly installations: preheater, clinker kiln and cooler grater in cement industry.

As following, the relationship 1: N (one-to-many) between centers and installations is made through the key "IdCCE", the unique identifier of the energetic consumption center. These tables and the relationship between them enable the general abordation, independent of a particular industry or industrial contour.

The relationship between the entity “Installations” and the entity “Cooler Grater” is of type 1:1 and it is made through the unique identifier of the installation “IdInst”. In a similar are associated all energetic consumption centers.. For each particularly installation will be available a recording in the entity “installations” which will store the general data and the associated specific data for an installation in a target industrial contour.

5. The data entry and the validation model

In this program we distinguish between two categories of inputs:

- Data regarding the industrial contour and the technical – energetic characteristics of the installation of the energetic consumption centers;
- Data regarding the measurements and the context in which these measurements have been done.

The data for the first category are introduced only once, at the description (or modification) of the industrial contour. The operation is independent of the calculus of the balance and the technical – economical analysis [2].

The input data for the second category are introduced at each audit accomplished, being identified through the balance/audit identificator and the date when this is accomplished. Once introduced, the data are retained, so it is possible to perform comparative analysis and simulations at different moments in time. This means to repeat the energetic measurements and evaluation after the implementation of different recommendations to increase the energetic efficiency or just to simulate the evaluation with different energetic parameters [3].

The validation model is implemented with the facilities provided by the development environment. This way it is possible to validate the data input for admissible values which are required by the technical characteristics of each installation.

6. The model validation - case study for the calculation of energetic eficiency indicators

In Table 1 the energetic model validation for the proposed case study is presented [4].

Table 1 – The energetic model validation – study

The calculation of the energetical efficiency indicators				
Signification	**Symbole**	**U.M.**	**Relationship by calculation**	**Value**
C_{3p} – Fabrication of clincker				
1. Specific consumption by the fuel :	C_c/z	**[tep/year]**	$C_C/z=(\Sigma B_i)/V_z$ 1 tep = 10.000.000 kcal	**0,0821 tep/t cl**
- The amount of quantities by fuel and the hot gases admittances in the contour :	ΣB_i	[tonne equivalent oil]		31123
Methane gas consumption				27883
Tyres used consumption				2826
Fuel consumption				374
Oil used consumption				40
- The volume of the production by the Z product (the clinker production)	V_z	[t cl/year]		379130
2. Specific consumption of thermal energy	C_t/z	**[MJ/t cl]**	$C_t/z=(\Sigma Q_i)/V_z$	**3437**
-The thermal energy admitted in the contour by the exterior of its:	ΣQ_i	[MJ/year]		1.303.116.969
The thermal energy admitted in the contour with the methane gas				1.167.456.924
The thermal energy admitted in the contour with the tyres used				118.319.964,3
The thermal energy admitted in the contour with the fuel				15.675.463
The thermal energy admitted in the contour with the oil used				1.664.617
3. Specific consumption by electrical energy	C_e/z	**[KWh/t cl]**	$C_e/z=(\Sigma W_i)/V_z$	**31,97**
– The electrical energy admitted in the contour by the exterior of its:	ΣW_i	[kwh]		12.120.786
4. Complex specific consumption of energy	$C_{complex}/z$	**[tep/t cl]**	$C_{complex}/z=(\Sigma E_i)/V_z$	**0,0848**
– The sum of the electrical , thermal, fuel and hot gases energies admitted in the contour by the exterior of its	ΣE_i	[tep]		32.165
The thermal energy admitted in the contour	ΣB_i	[tep/year]		31.123
The electrical energy admitted in the contour	ΣW_i	[tep/year]		1.042
5. Degree of recuperation by the reusable energetic resources	i_{RER}	**[%]**	$i_{RER}=(\Sigma E_{rec})/(\Sigma E_{RER}) \times 100$	**42,6**
- the sum of the thermal energies recovered;	ΣE_{rec}	[kJ/h]		60.585.129
Thermal energy recovered to the raw mill (raw mill – combustion gas by the rotary kiln for the		[kJ/h]		40.699.599

drying of the raw materials)				
Thermal energy recovered to the slag drying (slag drying – hot air from the cooler for the slag drying)		[kJ/h]		19.885.530
– the sum of the thermal energetic resources available	ΣE_{RER}	[KJ/h]		142.337.395
Available energetically resources, output preheater – combustion gas from the fabrication of clincker		[kJ/h]		101.748.997
Available energetically resources, output cooler – air in excess from the cooler		[kJ/h]		40.588.398
6. Weight of the consumption by electrical energy in the total consumption of energy	p_e/z	**[%]**	$p_e/z=(\Sigma W_i)/(\Sigma E_i) \times 100$	**3,2%**
– The electrical energy admitted in the contour	ΣW_i	[kwh]		12.120.786 kwh = 1042 tep/year
– The total energy admitted in the contour	ΣE_i	[kwh]		32.165 tep/year
7. Value of the energetic costs for the realization of one product unit	V_{en}/z	**[lei/u.p.]**	$V_{en}/z=(\Sigma C_{en})/V_z$	**411.845 lei/t cl.**
– Total expenses with the energy for the fabrication of a total volume V_z by production of the product considered	ΣC_{en}	[lei]		

7. Conclusions

The importance of the approach presented in this paper lies in the increase of energetic efficiency simultaneously with the reducing of the impact on the environment in the building materials industry. The approach is indicated in this case because the building materials industry is an energetic intensive industrial branch where the energy cost represents an important share in the total production cost. These industries must have in mind a continuous procedure for the application of the suitable measurements needed to increase the energetic efficiency.

The module proposed has a general degree of applicability and could be particularly adjusted to fit the various needs of the technologies in this industrial branch.

The general logical diagram which is at the basis of the program is structured in four main modules: The A Module – General Analysis, The B Module – Energetic Audit, The C Module – Environment Audit, The D Module – Economical evaluation. This structure allows a sequential approach to the problems, with a high degree of flexibility, following the user demands: only the energetic analysis or only ecological analysis (on the base of the audits).

R E F E R E N C E S

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