THE SCADA IN THE CLOUD CONCEPT FOR OPTIMIZING THE MANAGEMENT OF HEAT TREATMENT PROCESSES

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The article is based on two principles that are of increasing interest to the world economy not only reducing the pollution degree of the environment but also the efficient management of the consumption of raw materials that are part of the technological flow in the metallurgic field and the migration of the SCADA in the cloud concept. This new concept is part of the 4.0 industrial revolution and it helps with modernizing equipment within medium-sized enterprises such as SMEs. Considering these trends the article presents the optimization of the gas consumption the heat treatment installations using the SCADA in the cloud concept.

Keywords:management,optimization,mathematical modelling,SCADA,cloud

1.Introduction

The concept of SCADA (Supervisory Control and Data Acquisition) has been used for the last 30 years as a solution for modernizing and monitoring industrial installations because they provided alarms and real-time graphics with process data.

Industrialization 4.0 concept is an organizational concept that consists of four basic organizational principles. These principles support companies in identifying and implementing Industrialization 4.0 scenarios.

• Interconnection: machines, devices, sensors, and people can be networked and can communicate over the car internet or over the Internet between people.

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• Transparency of information: the data delivered by the sensors extend the digital information systems of manufacturing models to create a virtual image of the real world.
• Technical assistance: assistance systems support people with the help of collected, visualized and easy to understand information. Thus, clear decisions can be made quickly if problems arise. In addition, people who perform excessive or dangerous physical effort are being supported.
•Decentralized decisions: cyber systems are able to make decisions and solve problems autonomously. Only in exceptional cases, for example, in the event of interference or conflicts of interest, signals are transmitted at a higher level[1].

Taking into account Industry 4.0, we started to implement the scada concept with web packages and mobile interfaces using the Internet.

In order to optimize fuel consumption, it is necessary to create information systems that can manage the multitude of high quality indices, especially the precision through very small permissible deviations from the reference values.

The article presents a scada in the cloud solution in order to optimize the fuel consumption of a heat treatment furnace with a presentation of its implementation in the industrial environment.

The method used has an important economic impact, ensuring a possibility to move the activity and work remotely. At the same time, the advantage is also financial because the division of hard resources ensures a reduced cost.

2. Mathematical modeling of the thermal balance

The mathematical modeling of an energy balance consists in the description of a functional dependence between the input and output parameters on the established balance contour.

This dependence results either from a theoretical analysis based on the general principles of thermodynamics, or based on experimental results through statistical processing of data obtained on models of industrial installation.

Determining the need (consumption) of fuel for the development of a certain metallurgical process is an important step in the design of a metallurgical thermal installation (furnace), because according to it the heat production installation and the gas phase evacuation installation resulted from combustion (at fuel furnace) are dimensioned.

Taking into account these factors, a software application was developed in the Java language for a heat treatment installation.

The Java language used in the development of the application is a very secure programming language, providing strict security mechanisms for the programs materialized by: dynamic verification of the code for the detection of dangerous sequences[2].

Also, when choosing the application development platform, it was taken into account that it is a language independent of the work platform, without the need to recompile it on different operating systems such as Windows, Linux, Mac OS, Solaris, which brings substantial savings to application development companies as well as the possibility of running this software in the cloud.

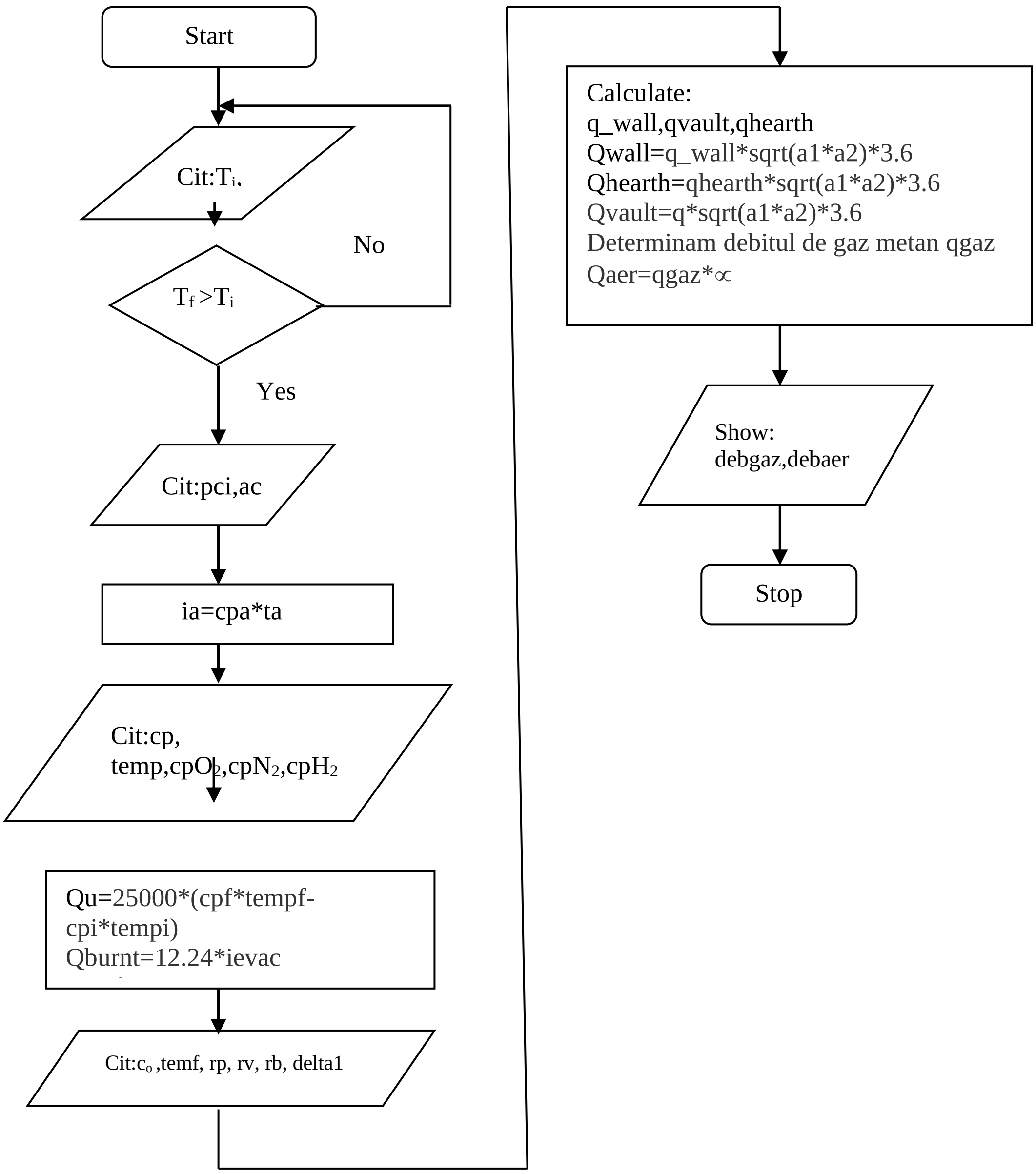

Fig.1 Logical scheme for determining the minimum fuel consumption

The general program called calculated_flow.java calculates based on the calculation algorithm presented and the database created in MySql Server the fuel flow required for the threshold values of temperatures ti and tf. The logic diagram of the program is presented in figure 1 [3].

The logical scheme of the program is shown in Figure 1 where pci is the calorific power of the fuel ,cp the specific heat of the fuel at a certain temperature, cpa the specific heat of the air at a certain temperature, cp temperatures at different temperatures of the material,Qu useful heat, Qburn heat of the burned gases,Qorif heat lost through the incisions, Qwall-heat lost through the walls, Qvault-heat lost through vault,Qhearth-heat lost through hearth.

The algorithm is based on the mathematical relationships (1-3), result in accordance with the first principle of thermodynamics energy conservation

The thermal balance, the particular form of the energy balance is expressed by the equation:

$$Q_i = Q_c \tag{1}$$

where:Qi is the total heat introduced in the furnace [kJ/h]

Qc total heat consumed in the furnace [kJ / h]

In the case of furnaces heated with fuels, the achievement of the thermal balance starting from relation (1) supposes the solution of the following equation [4].

$$Q_{cb} + Q_{fcb} + Q_{fa} + Q_{fm} + Q_{aux} + Q_{fz} = Q_u + Q_{aux} + Q_{pz} + Q_{acz} + Q_{pga} + Q_{pga(exf)} + Q_{pr} + Q_{ar} + Q_{nep} \tag{2}$$

The components used in relationship (2) for the incoming heat are: Q_{cb} represents the chemical heat of the fuel and those symbolized with Q_f represent the physical heat of the fuel, respectively of the combustion air, of the heated material, of the auxiliary materials, of the furnace's brickwork.

We have also symbolized with Q_u the useful consumed heat and with Q_p- the heat lost through the brickwork, the heat accumulated in the brickwork, the heat produced by the exhaust gases, the exfiltrated ones and the heat lost through radiations.

$$P_{ci} \cdot B_{cb} + B_{cb} \cdot c_{cb} \cdot t_{cb} + v_{a(r)} \cdot B_{cb} \cdot c_{pa} \cdot t_a + M_n \cdot c_n \cdot t_n + M_{aux} \cdot c_{aux} \cdot t_{aux} + \frac{\sum (M_{z(i)} \cdot c_z \cdot t_{z(i)})}{\tau_c} = M(i_f - i_i) + M_{aux} \cdot \Delta i_{aux} + q_p \cdot S_p + q_v \cdot S_v + q_b \cdot S_b +$$

$$\frac{\sum (M_{z(i)} \cdot \Delta i_{z(i)})}{\tau_{ac.z}} + \nu_{ga} \cdot B_{cb} - V_{ga(exf)} + C_o \cdot S_o \cdot \Phi[(\frac{T_c}{100})^4 - (\frac{T_a}{100})^4]\tau_{ro} +$$

$$(5 \div 10)\% \cdot \sum (Q_c - Q_{pga}) \tag{3}$$

where

Pci- calorific power of the fuel [kJ/kg] sau[kJ/m^{3}N]; Bcb- hourly fuel consumption resulting from the balance for a furnace in use [kg/h]; ccb-specific heat of the fuel [kJ/kg·grd]; tcb-fuel's temperature [^{o}C]; νa(r)- specific volume of real combustion air [m^{3}N]; cpa-air's specific heat at temperature ta [kJ/h]; ta-air's temperature in [^{o}C]; Mn-load mass in [kg/h]; cn-specific heat of the load [kJ/kg·grd]; tn-load's temperature [^{o}C]; Maux- mass of the auxiliary element [kg/h]; caux-specific heat of the auxiliary element [kJ/kg·grd]; Mz(i)-mass of the i layer from the brickwork [kg]; tz(i)-medium temperature of the layer i in [^{o}C]; cz-specific heat of the material from layer i [kJ/m^3·grd]; τt- the total duration of the technological cycle [h]; M-the mass of the load [kg]; if- enthalpy of load at the end of heating [kJ/kg]; ii- enthalpy of load at the begining of heating [kJ/kg]; Maux-auxiliar element mass [kg/h] ;Δiaux- the enthalpy difference of the auxiliary element between its final and initial temperature [kJ/kg]; qp,qv,qb- heat flux densities at wall, hearth, vault's level [kJ/m^2·h]; Sp,Sv,Sb- medium sided surfaces of the wall, hearth, vault [m^2]; Mz(i)-mass of the i layer from the brickwork [kg]; Δiz(i)- the enthalpy difference of the layer i in [^{o}C]; τacz-accumulation process duration up to steady state [h]; νga- specific volume of burnt gases [m^{3}N]; Vga(exf)- the volume of burnt gas exfiltrations [m^{3}N/h]; Co-StefanBoltzman constant(5.72[W/m^2·K$_4$]); So- open hole section [m^2]; Φ-diaphragm coefficient; Tc- absolute temperature in the furnace working space [K]; Ta- absolute ambient temperature [K]; τro- the fraction of time the hole radiates in an hour:τro=1/τd unde τd represents how long the hole is open for loading or unloading; Qc-consumed heat [kJ/h]; Qpga- heat entrained by the exhaust gases [kJ/h].

The program uses several functions created according to the presented model and which lead to obtaining the optimal methane gas fuel requirement because it calculates the required flow taking into account both the increase in heating rate and the cooling rate in the controlled cooling process.

The temperature thresholds are introduced at the beginning in the synopsis in figure 2, where a case study taken from the cloud is presented.

After entering the temperatures outside each stage as well as the time for the heating, maintenance and cooling level when the process button is pressed, the program for calculating the fuel flow necessary to reach the required heating speed is launched.

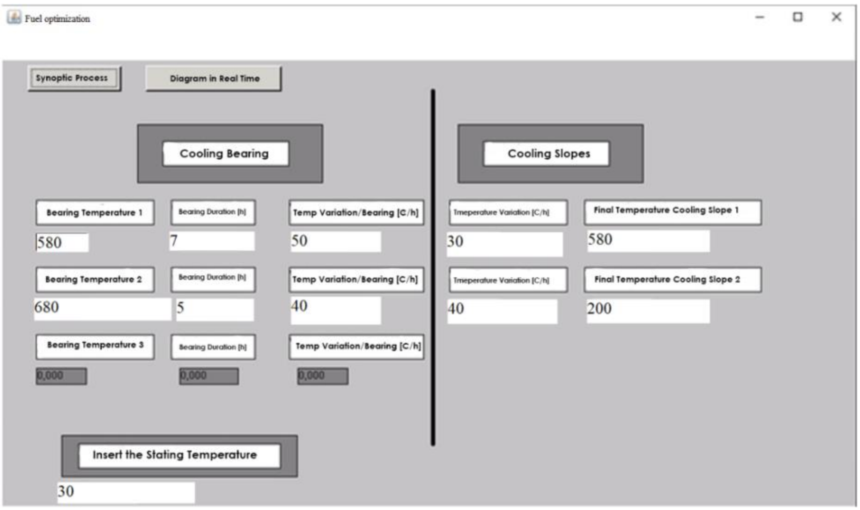

Fig.2. The synopsis for entering the temperature levels

Fig. 3 shows the process synopsis with the optimal gas and air flow required .

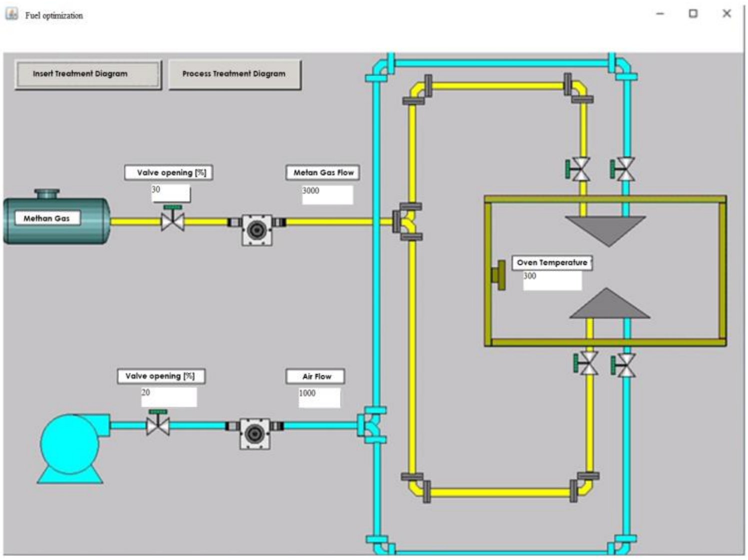

Fig.3. Process synopsis

Following the use of the mathematical model presented in figure 1. it was possible to obtain in real time the heat treatment cyclogram from figure 4.

This can be noticed from the evolution of the graph curves from the 4 zones for monitoring the temperature of the annealing furnace of the cold rolled parts noted in the legend with zone 1-4 during the heating and maintenance period where the influence of the realized algorithmhas effects.From figure 4 we can notice the evolution of temperatures inside the furnace using an optimized consumption which has led to the proper fulfillment of the heat treatment process.

Taking into account that in the classical automation of temperature control regulators whose parameterization is done during the design period based on the linearized mathematical model of the entire technological process are used, the presented version uses the concept of intelligent automation with online tuning of the controller parameters. This concept can compensate for accidental heat loss which in most cases are unavoidable and thus reduce the consumption of fuel used in the heat treatment process.

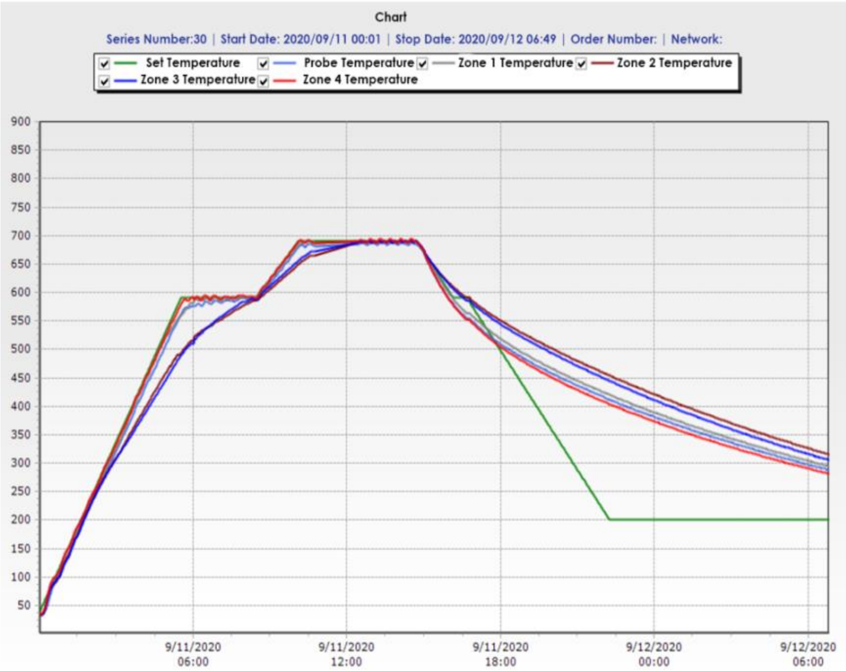

Fig.4. Real-time graph on the batch performed using the SCADA Cloud concept

Also, this solution for implementing the concept of scada in the cloud has the advantage that maintenance can be provided continuously 24 hours a day, allows reducing the costs of licensing the development programs used because the platform offers these facilities.

Using the solution presented in the article and analyzing the reduction of the cost elements generated by such a management system of the technological process, the average calculations hihglight a medium reduction of aproximately 15% of the production costs.

For example, we will consider a furnace for annealing the cold rolled parts with a capacity of 10 tons. Before the implementation of the solution, the fuel consumption per kg of the part subjected to the annealing heat treatment varies between 1.4 and 1.6 Kwh / kg. After the implementation of the SCADA system to optimize the management of heat treatment processes, for the 10t furnace was found a reduction in consumption to a maximum value of 1.2Kwh / Kg material.

Taking into account that the proposed and implemented solution limits a large part of the accidental losses that may occur in the operation of the equipment, was achieved a reduction depending on the operating regime of approximately 9% of them.

The cost of production included both the cost of fuel consumption and the cost of overhead generated by the need for a maintenance team whose wage costs amounted to an average of 3-5 percent of production costs.

To these costs is added the cost of licenses and any updates to those that are found in the direction in proportion of 2%. Under these conditions, a reduction of about 15 percent in production costs is possible and probable.

The fuel cost for a heat treatment for a 10 tons furnace before the automatization was about 1.5kwh/ton X 10 tons X 0.124 lei/kwh= 1860 lei hourly cost(fig.5).

As a result of the implementation of the SCADA system, the cost is reduced to 1.2kwh/ton X 10 tons X 0.124 lei/kwh= 1488 lei hourly cost

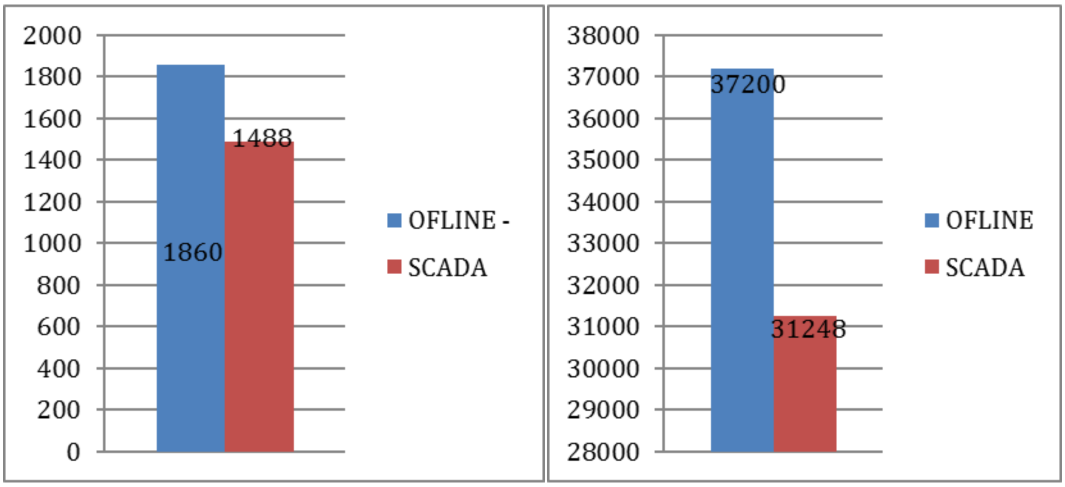

Fig. 5. Hourly cost and daily cost (for 20 hours of functioining) in RON

Through the case study presented in the article it can be seen that from an economic point of view the advantage of this solution is that it can be applied to any type of SME without requiring high costs with modernization and offers the advantage of receiving process information in real time on any mobile support.

3.Conclusions

The advantage of achieving this proposed solution is the management of fuel consumption whose price is rising and reducing the degree of pollution which after analyzing the cost elements implied in the technological process leads to a 15% reduction in specific costs.

The use of java language as a support in the implementation of this consumption reduction program offers the possibility to implement in a computer system for managing a technological flow without taking into account certain costs with the implementation platform which leads to reduced investment costs and its subsequently amortization in the shortest possible time.

Also taking into account that this program allows to reduce manufacturing costs makes the final product become competitive in the fight with other emerging markets where labor is cheap like Asian markets

The advantage of using the concept of scada in the cloud offers the facility to implement the new concepts of industrial revolution 4.0 and digitalization of the world economy, a process that is constantly growing taking into account the pandemic period we are currently in. This case study is received and implemented by more and more companies in the Romanian and European industrial field.

From a managerial point of view, such an approach allows the organization of the supervision of the remote activity, which ensures a positive impact on costs and efficiency. At the same time, the managerial control and evaluation function is improved especially by the possibility to ensure an almost instantaneous feedback to the production management decisions [5,6,7].

The use of IT cloud tools is undoubtedly an important advantage of the organization's management, through the possibility of following at any time the technological parameters of production, with a positive impact on the entire activity of the organization.

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