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ЕКОЛОГИЧНО ИНЖЕНЕРСТВО

Topic:
ECOLOGICAL ENGENERING

DESIGNING THE TQM SYSTEM FUNCTIONS TOWARDS THE PROTECTION OF ENVIRONMENT

Elizabeta Mitreva, Violeta Chepujnoska

Abstract The implementation of the TQM (Total Quality Management) strategy as well as the correlation analysis as a mathematic method of quality projection of the manufacturing processes regarding the environment, the technological process of steel hardening becomes optimised by the use of the MATLAB program, simultaneously having in mind the costs of the working.

The steel hardening is executed within a temperature interval ranging from (820 – 860) °C in a (5 – 7) % solution of NaOH, and the normalization of the steel is accomplished on a (600 – 610) °C temperature.

By the help of these methods, the optimal values of the parameters concerning the steel hardening process are determined, i.e. a temperature of 820 °C as well as a concentration of sodium hydroxide of 2.38 %, upon which the defined quality of steel solidity of 195 by Brinel is achieved. Thus, both the losses in electricity and the consumption of NaOH are calculated on a yearly level, according to the hardening conditions that have been practiced until now with a help of the projected standard operative procedures in the factory.

According to this basis the total saving amount per year for steel hardening of 100 000 pieces is 18 033 euros. By the application of this methodology the defined quality can be achieved by the lowest possible costs during the process of work.

Key words: Mathematic methods, costs, optimisation, hardening, steel S1530, environment, TQM, MATLAB.

INTRODUCTION

Every company, regardless of the size and function, presents a part of the environment – it both influences and changes the environment. The environment can differ in various aspects: chemical-technological, technical, economic, judicial, sociological-psychological, etc. The concern about the environment is becoming more and more actual due to the apparent endangerment of the people, animals and plants.

Therefore, the companies must not limit themselves only upon the most critical aspects of environmental degradation, but also, they have to master completely the environmental management and to practice the eco-protection systems as well.

The environmental management should solve the contradictory gap which appears between the economic and the ecological requirements of the organisation.

The ISO 14 000 standards allow the companies to manage the influences over the environment, but how successful the implementation would be dependant of the understanding and support of the managing team, as well as of the behalf of all of the employees in the companies.

The ISO 9000 standards which refer to a system for quality provision of the companies have been designed for a customer's protection from a low-class product/service. The ISO 14 000 standards are complementary to them and their common goal is creation of quality processes and products for protection of the environment.

The environmental concern must be present from the very beginning of the quality decision of the manufacturing processes stadium. At the same time, we should bare in mind not only the danger of pollution, but conservation of resources also. All available resources should be evident while making the decision: the employees, raw materials, machines, energy, etc. This is important so that a good quality at optimal conditions could be provided.

With this type of approach we can get a good quality, more efficient work, eco-protection, and all that with lowest possible costs.

The provision of designed quality should go according to Deming's circle of quality (Plan – Do – Check – Act), which puts the act of planning on the first place, then provision of all conditions for realization of the planned, followed by a control of whether it has been realized. If not, corrective measures should be put into action in order to stop reoccurrence of the same mistake.

In other terms, the provision of quality requires proper, correct, expeditious realization of all activities of the projected quality of the manufacturing processes, as well as provision of suitable ecoconditions. Also, the tasks of all of the employees should be clearly defined in a form of a matrix of obligations and responsibilities.

MATERIAL AND METHODS

Optimization of the technological process of steel hardening S1530

While practicing the system of quality provision according to ISO 9001 from year 2000, the need of designing and application of the standard operative procedures for all working processes became stressed in order to achieve the defined quality and to protect customers from faulty products.
The factory's management gave themselves a brand new task – to improve the system of managing the environment, which includes reducing the amount of waste, reducing the pollution of the air, water and soil, conservation of resources by following the energy and material consumption, as well as adapting to all national and local regulations and normative which refer to the environment.
According to the ISO 9001 standards, the standard operative processes have been projected by QC-CE (Quality Circle-Cause and Effect) model, (Fig. 1) and the standard operative procedure for steel hardening within (Fig. 2).

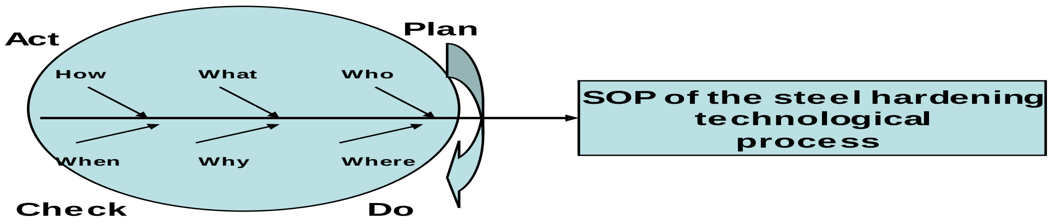
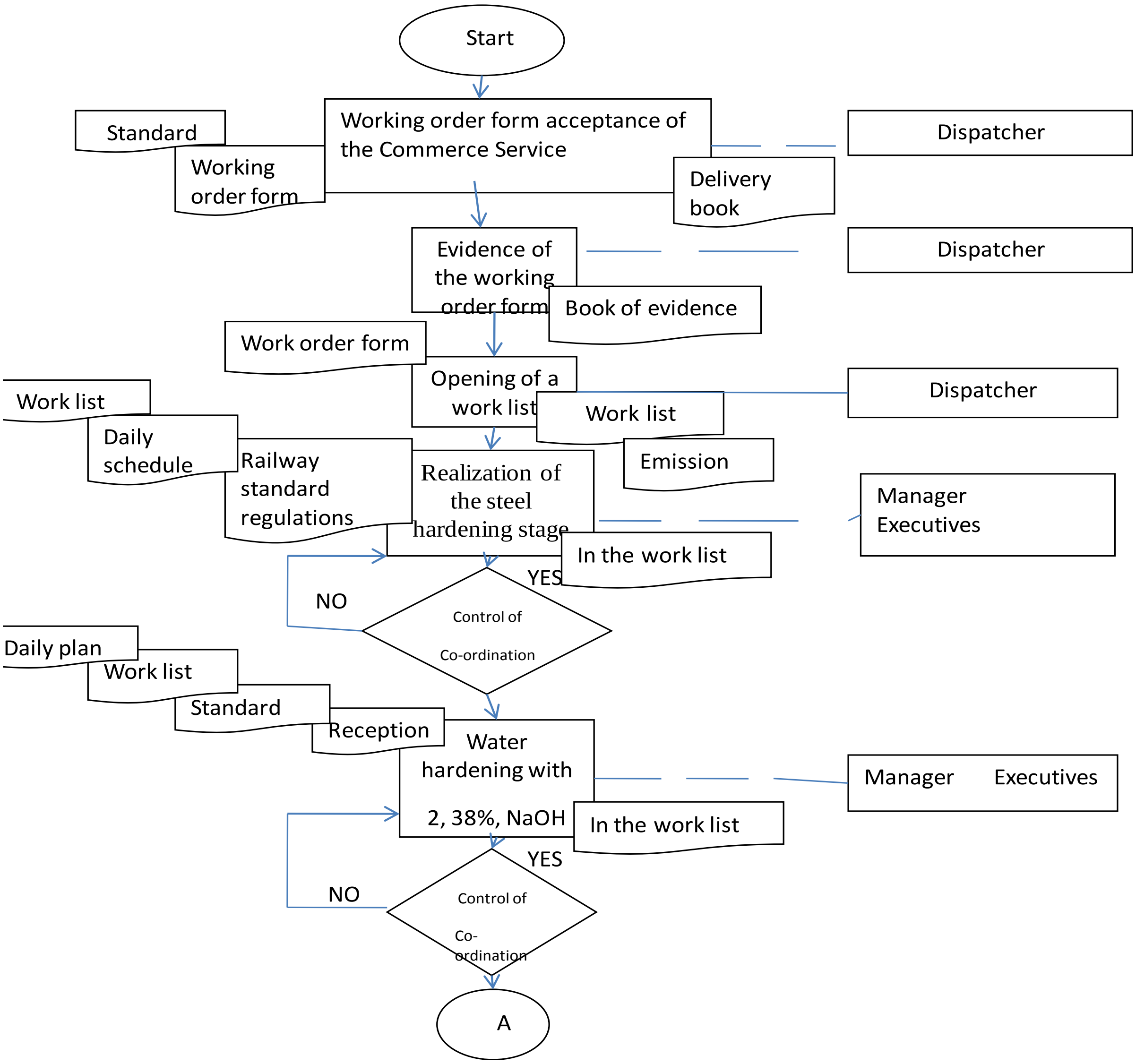


Figure 1 Application of QC-CE model at the designation of quality of the steel hardening S1530 technological process

In accordance with the process of steel hardening, we have set a task for us to follow the energy and material consumption in order to determine the optimal parameters.
We conducted an optimization of the technological process of steel hardening S1530 in the mint department. There is a process of steel hardening in the mint department by which certain properties are acquired and which need to correspond to both the assigned standards and the rail regulations.

As a subject of this research shafts with f 35 x 180 made of steel S1530 were taken. Explanation of the symbols: S – steel (as a material), 1 – guaranteed composition, 5 – up to 0.5 % carbon (C), 30 – steel for improvement marked as: from (30 – 39).


Start
Working order form acceptance of the Commerce Service
Standard
Working order form
Delivery book
Dispatcher
Evidence of the working order form
Book of evidence
Dispatcher
Work order form
Opening of a work list
Work list
Dispatcher
Work list
Daily schedule
Railway standard regulations
Realization of the steel hardening stage
Emission
Manager Executives
In the work list
YES
NO
Control of Co-ordination
Daily plan
Work list
Standard
Reception
Water hardening with 2, 38%, NaOH
Manager Executives
In the work list
YES
NO
Control of Co-ordination
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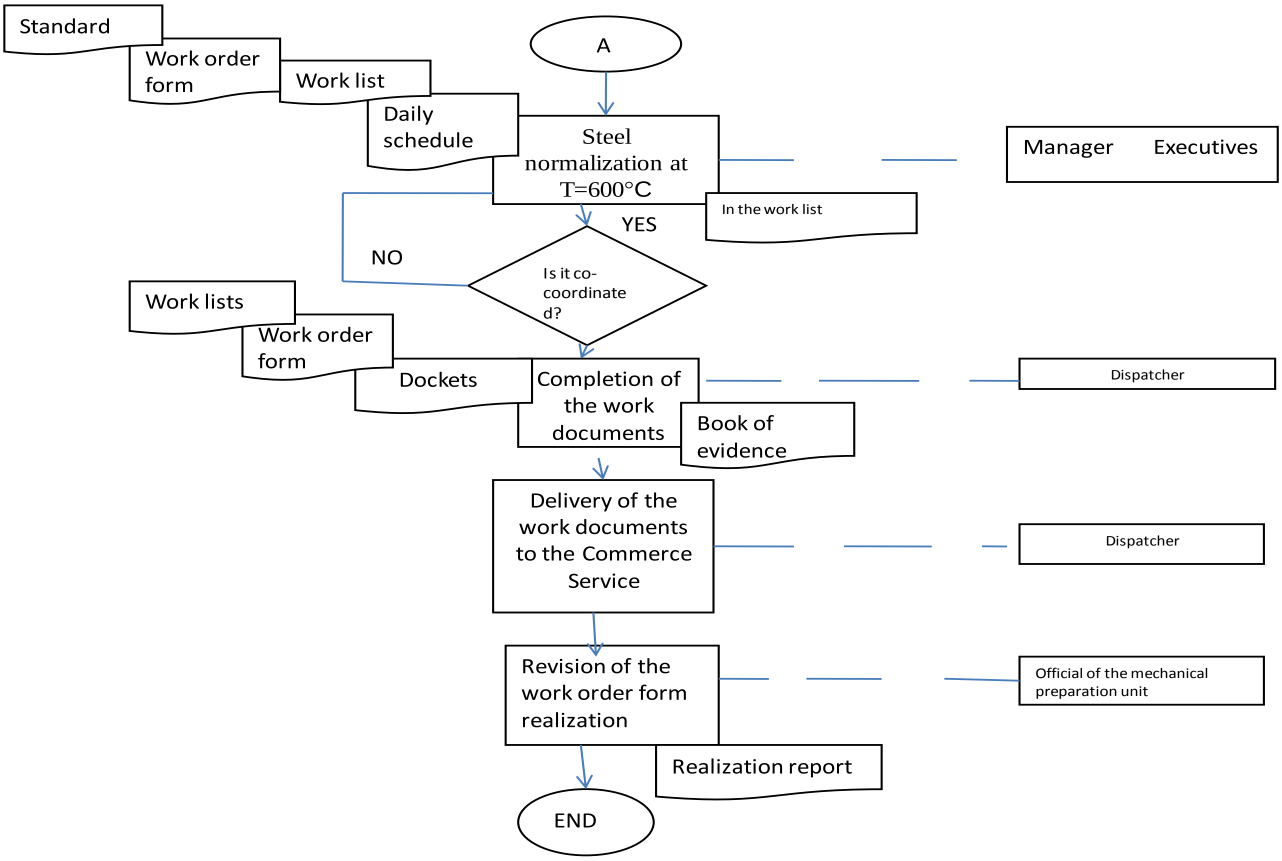

Figure 2 Standard operative procedure of steel hardening

The chemical composition of steel S1530 is presented in the following table 1:

chemical composition	***C***	***Si***	***Mn***	**P**	**S**
%	*0.42-0.50*	*0.15-0.35*	*0.50-0.80*	0.045%max	0.045%max

The following are theoretical parameters of quality hardening developed during three phases table 2:

Heating temperature of the furnace °C	**Hardening in water on a temperature of (18 – 19) °C and concentration of NaOH %**	**Normalisation of the material on a temperature °C**
820-860	(2 - 7)	(550 - 660)

According to the theoretical acknowledgements on achieving quality in steel hardening S1530, the mechanical properties of the shafts after the process of hardening are supposed to be, table 3:

Solidity	**Plastic deformation**	**Extrication**

(HB brinel)	(N/mm²)	(N/mm²)
195-207	380-420	600-670

According to the measurements of the properties in the real process of steel hardening in the factory, the mechanical properties of steel S1530 after the hardening are as presented in the table 4:

Solidity (HB brinel)	**Plastic deformation (N/mm²)**	**Extrication (N/mm²)**
195-210	380-420	600-610

This quality of steel hardening in the real system is acquired due to the following parameters, table 5:

Heating temperature of the furnace °C	**Hardening in water on a temperature of (18 – 19) ° C and concentration of NaOH %**	**Normalisation of the material on a temperature °C**
860	(5 - 7)	(600 - 610)

Designing of the mathematical form:

The first step in the designing of the mathematical form [7, 18, and 22] is to acknowledge the subordinations among the factors that describe the process. In our case, it is the solidity of the steel, the temperature of the hardening process, as well as the sodium hydroxide concentration.

1. The influence of the temperature from the NaOH concentration has been investigated.
2. The subordination of the solidity of the steel, HB, of the NaOH concentration when exposed to temperature of T = 820 °C.
3. An analysis of the solidity of the steel HB as a function of the NaOH concentration when exposed to temperature of T = 860 °C.

We have applied the correlation and regression analysis as mathematical methods in the MATLAB program [19, 20, and 24].
As of this, we are able to derive more equations, but we selected the exponential equation, because this equation provides physical acknowledgement of the process. In order to continue with, this model was tested due to the fact that it is a presentation of the real process by its nature. However, it cannot enclose all of the variables within the surrounding. Therefore, it is of high importance to compare the results of the model to the ones we find in the reality.
But, once a model that provides good solutions is set, it does not mean that the model will function properly in the future. This is due to the expectable changes in the surrounding or within the relationships among the some of the factors. An eventual change could cause a change in the exit of the system, so we must provide a controlling system to work on the model. This control is mainly organized by setting a return connection [6, 7, and 8].
In addition to this, we make a change of the standard operating procedure.

RESULTS AND DISCUSSION

a) Subordination of the temperature from the NaOH concentration

By entering the experimental data on the temperature (in dependable variable) and % of NaOH (dependable variable) in the MATLAB software [19, 20, 24], we can get the numerical values of the parameters derived with the exponential, gradable equation, fraction-rational equation, as well as the value of the coefficient in correlation to those functions. Table 6.

Table 6: Numerical values of the parameters derived with the exponential, gradable equation, fraction-rational equation, as well as the value of the coefficient in correlation to those functions

Type of equation	Exponental	Gradeable	Rational
Appearance	$\%NaOH = a \cdot e^{-b/T}$	$\%NaOH = a \cdot \left(\frac{1}{T}\right)^b$	$\%NaOH = \frac{a}{\left(\frac{1}{T}\right) + b}$

Parameters	$a = 1.94 \cdot 10^{13}$	$a = 4.376 \cdot 10^{-87}$	$a = 0.00025$
	$b = 2.434 \cdot 10^{4}$	$b = -29.77$	$b = -0.00114$
Correlation coefficient	0.99735	0.99716	0.97567

According to correlation coefficient, the best fitting is achieved for the exponential equation, r = 0.9735; for the gradable equation r x,y = 0.99716, and for the fraction-rational equation r = 0.97567. Therefore, the form of % of NaOH = f (T) = f (1 / T) will be as presented**:**

$$\%NaOH = 1.94 \cdot 10^{13} \cdot e^{-2.434 10^{4}/T}$$

T – Temperature in °C

b) Subordination of the solidity of the steel, HB, of the NaOH concentration when exposed to temperature of T = 820 °C.
By entering the experimental data for the % of NaOH (in dependable variable) and the solidity HB (dependable variable) in the MATLAB software [19, 20, 24], according to correlation coefficient, the best fitting is achieved with the Langmuir – equation with a correlation coefficient of 0.99991 (Table 7). Next, with the custom equation we get a correlation coefficient of 0.897.

Table 7 Langmuir – equation with a correlation coefficient of 0.99991

Type of equation	Langmuir
Appearance	$HB = \dfrac{a \cdot (\%NaOH)}{1 + b \cdot (\%NaOH)}$
Parameters	$a = 1763$
	$b = 8{,}55$
Correlation coefficient	0,99991

Fig. 3 displays an optimal concentration of NaOH under constant solidity. In this way we can determine the optimal concentration of NaOH of 3.85 % under constant solidity minding the losses that are expected to appear as well as the additional costs for a NaOH solution.

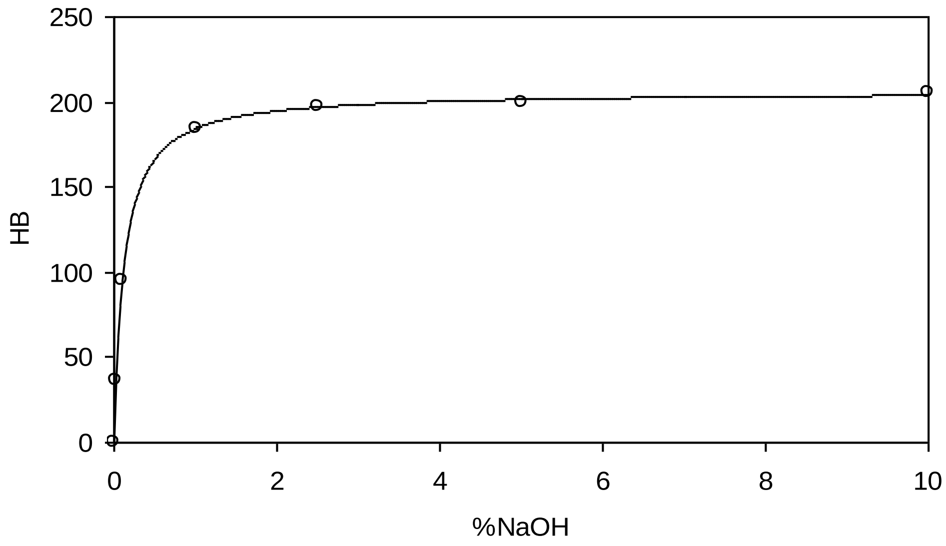

Figure 3: An analysis of the solidity of the steel HB as a function of the NaOH concentration

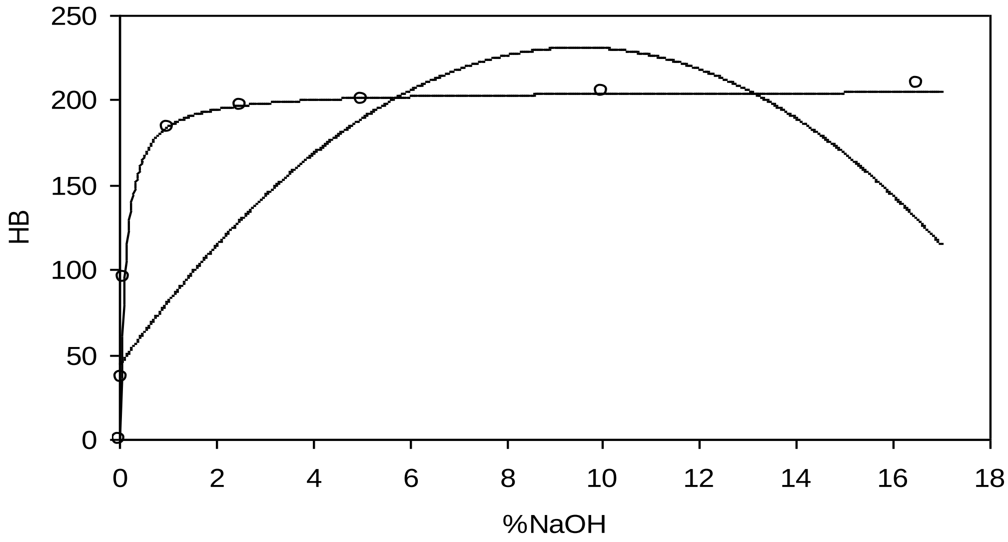

Figure 4: Subordination of the solidity of the steel, HB, of the NaOH concentration when exposed to temperature of T = 820 °C.

From the results displayed on the Fig. 4 it is obvious that the determined solidity of the steel of 195 HB is achieved with 2.38 % solution of NaOH.

In order to observe the reaction of the system under increased temperature, we increase the heat to 860 °C so we can evaluate whether there is an improvement or not.

c) An analysis of the solidity of the steel HB as a function of the NaOH concentration when exposed to temperature of T = 860 °C

By entering the experimental data [9, 10 and 11], on both the solidity of the steel and the percentage of NaOH, we can base a conclusion that the best fitting is achieved with the custom equation, with a correlation coefficient of 0.99936, even though we get 0.75031 correlation coefficient for the square equation.

Thus, we determine an optimal concentration of NaOH of 3.85 % under constant solidity minding the losses that are expected to appear as well as the additional costs for a NaOH solution.

From the results displayed on the Fig. 5 it is obvious that the determined solidity of the steel of 195 HB is achieved with 3.06 % solution of NaOH.

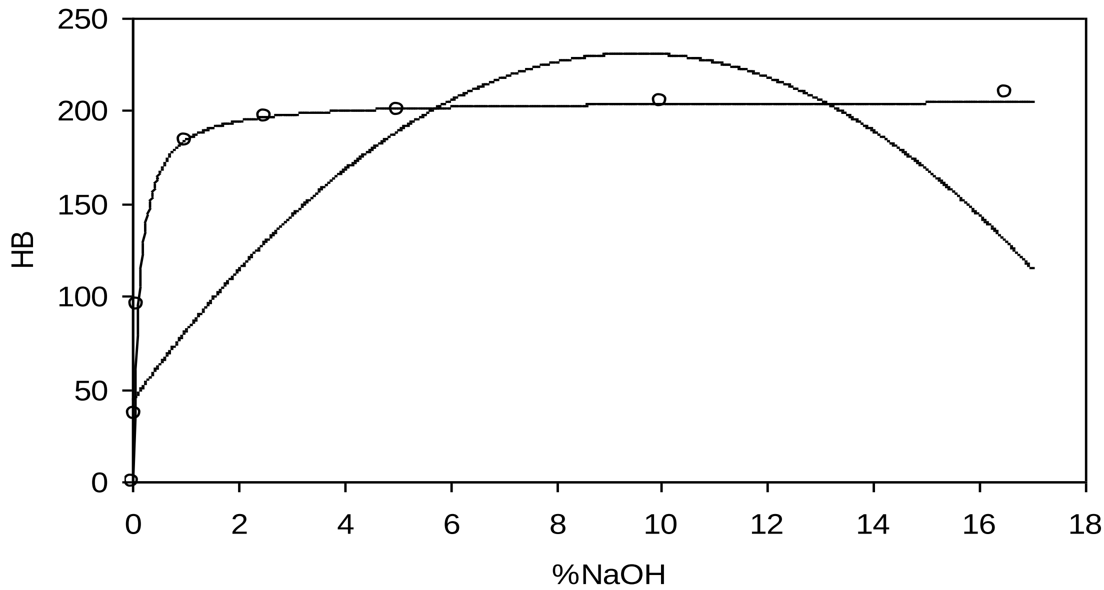

Figure 5: An analysis of the solidity of the steel HB as a function of the NaOH concentration when exposed to temperature of T = 860 °C

To conclude with, we can say that optimal parameters for achieving solidity of steel of 195 HB are: NaOH concentration of 2.38 % and a temperature of 820 °C.

For a realization of the following activity according to Deming's circle, it is of great importance for us to provide all of the required conditions. This means that the model has to be tested, because, by its nature it is a presentation of the natural process, but it cannot enclose all of the variables from the surrounding. Thus, it is necessary to compare the model results with the real condition.

However, ones established model which provides good solutions does not mean that it will function well in the future due to the expected changes within the surrounding or among some of the factors. Eventual changes could lead to changes in the system's exit, so a controlling system for a proper functioning of the model must be provided. In most of the cases, the control is organized by establishing a returning connection.

Due to this, the standard operative procedure is changed.

CONCLUSION

The politics of maintaining a healthy environment of the factory for reconstruction and maintenance of rail vehicles anticipates provision of quality in all of its processes and objects at any time and any place. This can be achieved if the factory submits to the laws and regulative, programs and procedures which refer to safe environment, because this presents an important component of the training, the construction of the activity, as well as of the stimulation of the employees.

Based on these researches, we formed a conclusion according which the application of the MATLAB program, i.e. the mathematical modelling of the steel hardening process (S1530) can aid the determination of the most favourable parameters for steel hardening, which present temperature of 820 °C as well as concentration of NaOH of 2.38 %. All this is due to the provision of the defined quality of the steel shafts when the solidity of steel is 195 HB with the lowest possible costs of energy and materials. At the same time, we are preserving the environment.

These researches led us to the acknowledgement according which we make savings in amount of 0.13 euros per piece based upon the electricity costs, while the savings from the consumption of NaOH

amount 0.05 euros per piece. This makes total of 0.18 euros per piece. In other words, for steel hardening of 100 000 shafts per year, the yearly savings would amount 18.033 euros.
The application of the system for eco-management allows lowering of the dangerous influences over the environment, but also lowering of the expenses required for maintenance of the environment, which creates a good image of the company.

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