ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

Imre KISS

THE IRON CAST ROLLING MILLS ROLLS MANUFACTURING: METHODS, APPROACHES AND TENDENCIES FOR THE QUALITY ASSURANCE

University Politehnica of Timişoara, Faculty of Engineering Hunedoara, ROMANIA

Abstract: *Our approaches the issue of quality assurance of the rolling mills rolls, from the viewpoint of the quality of materials, which feature can cause duration and safety in exploitation. The experimented durability research, as well as the optimization of the manufacturing technology, allows the conclusion of direct results for the rolls. The beneficiaries of these results are the unit in which the rolls are manufactured, as well as the unit that exploits them. The technological manufacturing process of the rolling mills rolls, as well as the quality of material used in manufacturing them, can have a different influence upon the quality and the safety in the exploitation.*

Keywords: *rolling rolls, quality assurance, manufacturing, safety in exploitation, materials, MATLAB*

INTRODUCTORY NOTES

Rolls are the most important means of hot– and cold–forming bulk products in the ferrous industries. The concept and introduction of rolling mills made the forming of large quantities of metal economically feasible. Rolling mill construction and the art of rolling experienced a sharp growth when production of steel in molten form began and, along with improvements in roll materials, have remained closely connected with the development of the steel industry.

From the standpoint of materials, the above line–up of rolls for hot–rolling remained unchanged although advancing metallurgical and material developments improved the quality significantly. Roll producers learned how to improve the cast–steel rolls by suitable heat treatment and to adapt cast–iron rolls to specific applications by properly balanced charges and further advances in modeling techniques.

Alloying additions for cast–iron rolls probably first came into consideration for rolling sheet, where improvements in the surface of the hot–rolled product were especially necessary. Subsequently it was found possible to increase the performance of shape rolls also by alloying. The innovations in rolling mills placed unprecedented requirements on rolls and users demanded better surface quality on the rolled products, which were often high–strength and therefore difficultly workable steels. Thus, the rollers insisted on longer roll life. Further improvements in the existing types of rolls were made and new roll materials were developed. Today, the roller has available a number of roll types but it is not always simple to select the best one.

The rolls must present high exploitation qualities, which are determined from the hardness, resistance and high temperature stability. These qualities guarantee the high resistances at wear in the dried friction conditions and the unexpected temperature variation stability in the rolling operation. In addition, they assure the resistance at the thermal fatigue, (because the rolls are heated at the contact with the laminate), high resistance at the thermal shock stress, and the bending strain resistance. Also, the rolls must assure the clamping of materials, as well as the high quality of the laminate surface.

Quality of rolls is determined through hardness and through wear resistance, last index having a special importance for all modern rolling mills with a growth production. Of major importance for the rolls exploitation is not merely growth resistance, but also the ability to oppose to different types of wear. Thus, rolling mill rolls considerable influence the specific production and the qualitative level of laminates, reason for which they are given a special attention, in manufacturing, as well as in usage. These requirements cannot be completely fulfilled, compelling to the granting of priorities depending on the type of laminates, therefore to compromises. At large, the problem is reduced to the correct material choice, eased by the rich available experience in the current conditions of manufactured and burdened, in the same time, by the large diversity of material used.

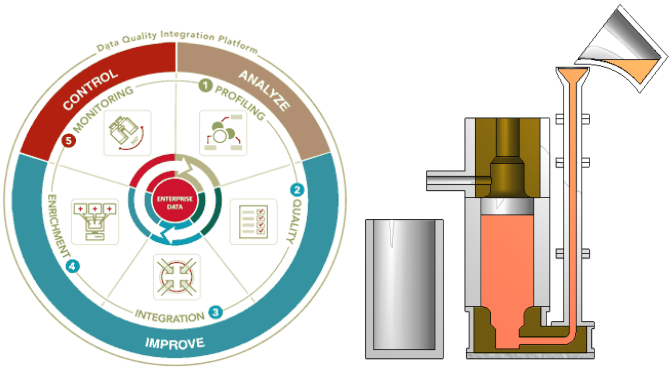

Figure 1*. The Quality control phases*

Although the manufacture of rolls is in continuously perfecting, the requirements for superior quality rolls are not yet completely satisfied, in many cases, the absence of quality rolls preventing the realization of quality laminates or the realization of productivities of which rolling mills are capable.

To the selection of materials is considered the type of rolling mill, the sizes of rolls (in specially this diameter), the speeds of lamination, the stands from the train of lamination for which is achieved rolls, the working temperature in the lamination process, the module of cooling during work, the size caliber, the pressure on rolls, the rolled material hardness, etc.

The choice of material for rolls is the operation which takes into consideration the own solicitations of the lamination process afferent to the type of rolled products, and the features of different materials considerate optimum in the fabrication of different typo–dimensions of rolls.

METHODS, APPROACHES AND TENDENCIES

The technological manufacturing process of the rolling mills rolls, as well as the quality of material used in manufacturing them, can have a different influence upon the quality and the safety in the exploitation. Our proposal approaches the issue of quality assurance of the rolling mills rolls, from the viewpoint of the quality of materials, which feature can cause duration and safety in exploitation.

In these sense, our researches propose, on aside, to analyze the durability in industrial exploitation of the iron cast rolling mills rolls (Figure 2) – analysis materialized from prism of the laboratory experiment (Figure 3), and on another side, the optimization of manufacturing technology of the cast rolls, especially those from cast–iron – using electronic calculus technique as the modeling phenomenon (Figure 4) and mathematical interpretation of the technological processes.

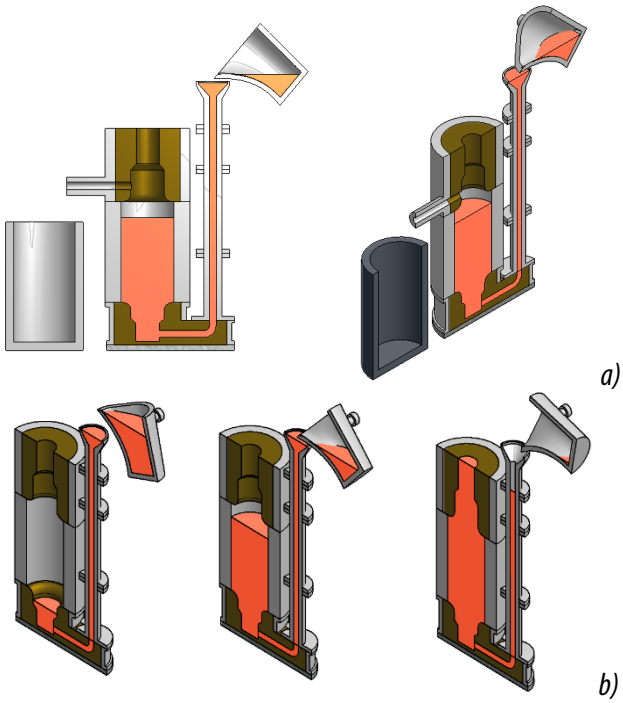

Figure 2. *The of the rolling mills rolls casting technology: a) the casting equipment; b) the casting phases*

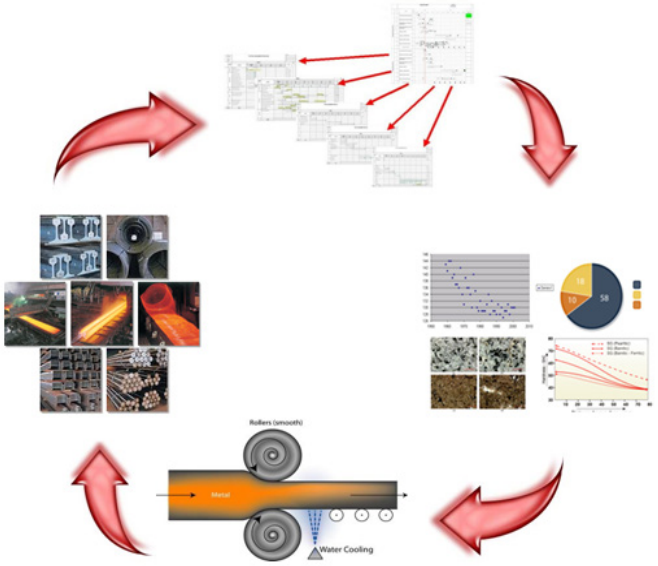

Figure 3*. Quality assurance of the rolling mills rolls through the laboratory experiment*

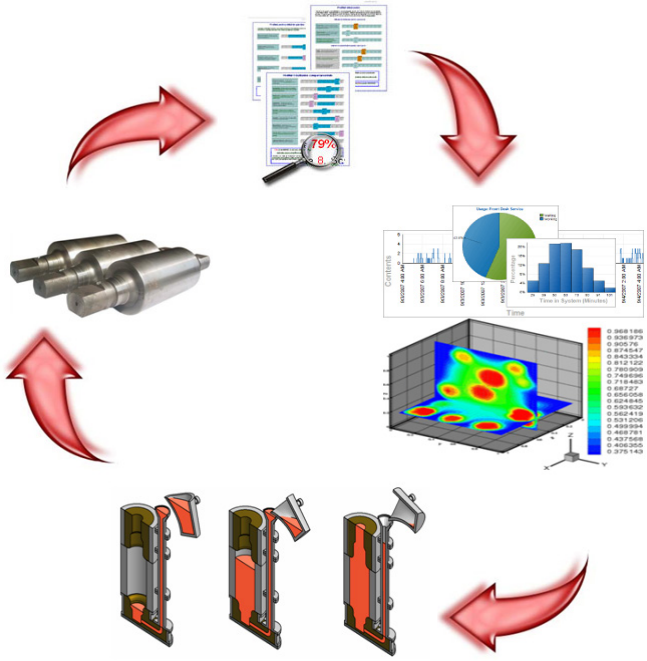

Figure 4*. Quality assurance of the rolling mills rolls through the modeling phenomenon*

The quality assurance research fields can be defined through the general research area, through the different experiments effectuated in the laboratories, and, also, through the modern calculation programs, optimization technologies and the better capitalization of the manufacturing data.

QUALITY OF ROLLS ASSURED BY THE LABORATORY EXPERIMENTS

The researches of durability in the exploitation of cast from cast–iron rolls, constitute a scientifically novelty, and experimentally define an important chapter from the thermal fatigue of the organs of machines in the movement of rotation, in variable temperature mediums. Hot rolling mills rolls work the in the variable compound solicitations, due to lamination process and which repeated to regular intervals of time.

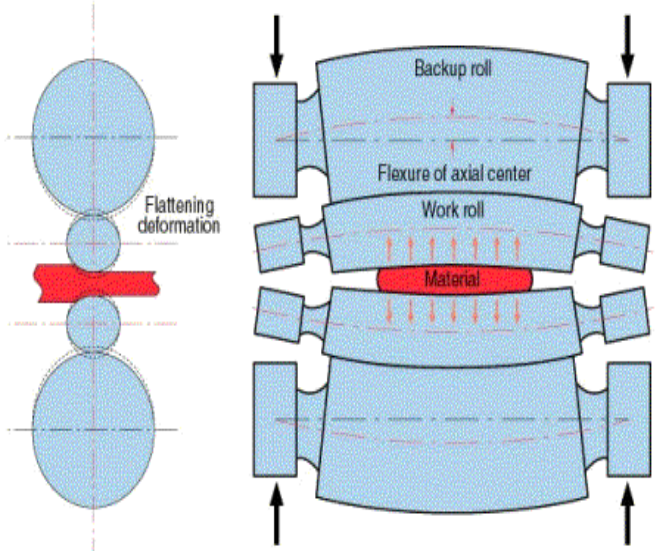

Figure 5. *Hot rolling mills rolls work the in the variable compound solicitations*

All these phenomena, which are more or less emphases depending on the type and typical of rolling mills, are not taking into consideration in the classic calculus of rolls. If the study of the rolls resistance is extended upon their durability, we must consider the whole complex of tensions with mechano–thermal influences. The research on durability in exploitation of hot rolling mills rolls assures relevant conditions for the appropriation of the research methods of the thermal regimes that are submitted the rolls or other organs of machines, that works in constant (symmetrical) or variables (asymmetrical) thermal solicitation conditions.

The recommendations for the increase of the duration of exploitation and remove of the damages through the accidental rupture of rolls from the stands of lamination, the attenuation of rolls thermal fatigue, the avoiding of thermal shock and their rational exploitation are actuality issues that must be continuously researched. In this trend is situated the research of the thermal fatigue phenomena, materialized in technical reports, whose beneficiary is the unit in which the rolls are exploited, as well as through scientific papers, that can develop the framework of scientific research. These researches results lead to direct conclusions about the cast–iron rolls, and permit their comparison with date about steel rolls, area studied thoroughly researched of specialists.

The work is of practical immediate utility, inscribing itself in the context of technical capitalization of the manufacturing technologies and of exploitation of cast–iron rolling mill rolls, for which exists an attentive preoccupation both from foundry sectors, as well as from lamination sectors, having as determinate aim the quality assurance and increase the durability in exploitation.

QUALITY OF ROLLS ASSURED BY THE MODELLING OF MANUFACTURING DATA

Starting from the principle of modeling process, used as necessary basic instrument, both in phase of conception, as well as in the industrial technologies analysis, is determined the optimum regimes of the cast rolls, from the view from chemical composition, as one as the most important parameters of disturbance of the manufacturing process.

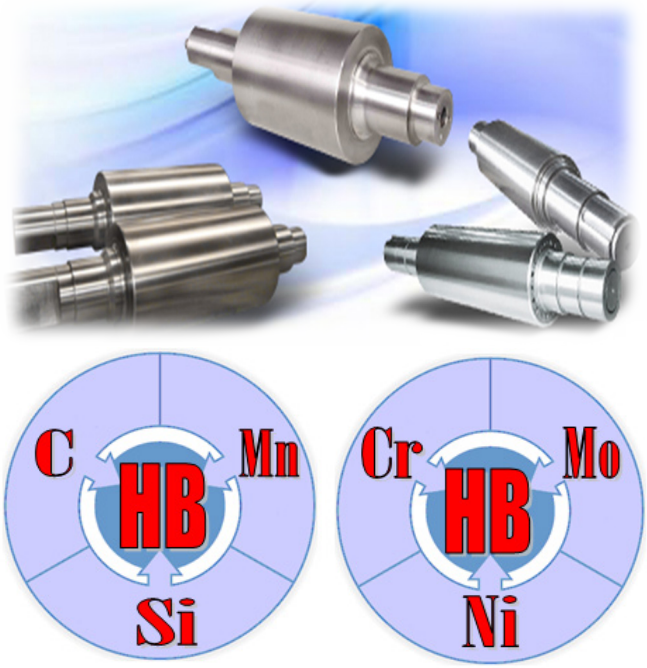

Figure 6. *The influence of the basic and the alloyed elements upon the Brinell hardness, in mathematical perspective*

The enunciation of some mathematically modeling results, described through a number of multi–component equations determined for the spaces with 3 and 4 dimensions, as well as the generation of some regression surfaces, of some curves of levels, of the volumes of variation, of the lines of outlines of the volumes of variation of surfaces and the areas of variation of these, can be represented and interpreted by technologists and can be considerate diagrams of correlation between the analyzed variables. From this point of view the research is inscribes in context of scientific capitalization of the process and the industrial technologies optimizations, on the way of the analysis and the mathematical experiment.

The MATLAB functions permit the graphical representations drawing in both planes, in 2D, which allows the display the reflector right and regression), as well as in 3D plane (which enable the plan of regression). The regression hyperplanes and the representations variation areas of the cast–irons chemical composition in the Figures 7-14 are presented.

In this way, using the regression analysis analytic by the calculation of statistical parameters could determine the regression equations. Areas of variation described by the regression equations, which can be realized that projections of the regression surfaces in the plan are used as the basis of a valuable called technologists who work in the manufacturing sectors.

The statistical calculations by MATLAB functions for the processing of data start with identification and determination of the highest and the lowest values, the calculation of the average, sorting items in ascending or descending order, the calculation of the regression equations, the calculation standard deviation, as well as the coefficient of correlation.

On the basis of the values determined in the statistical parameters, the MATLAB program allows the generation of the technological agreed areas, determined by the regression equations (degree 1.2 ... n), and,

also, the numerical equations that determine and describe the mathematical interpreted regression surfaces.

The regression equation surface described by an equation of degree 1 are described in Figures 7-8. Similarily, the regression equation surfaces described by an equation of degree 2, 3 and 4, are described in Figures 9-14, in some examples.

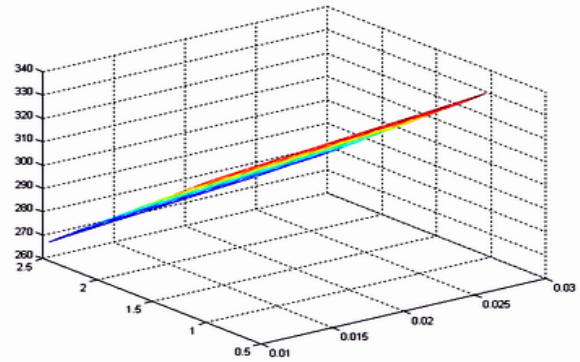

***Figure 7**. The regression surface, described by an equation of degree 1*

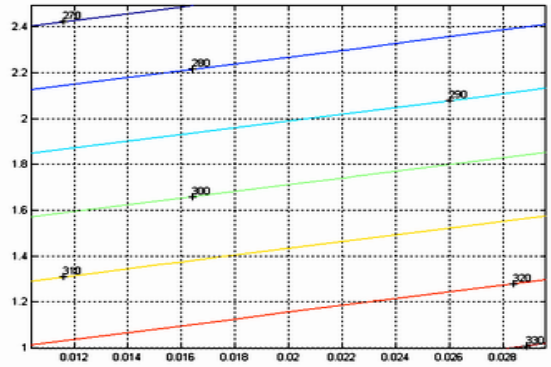

***Figure 8**. Areas of variation described by the equations of degree 1*

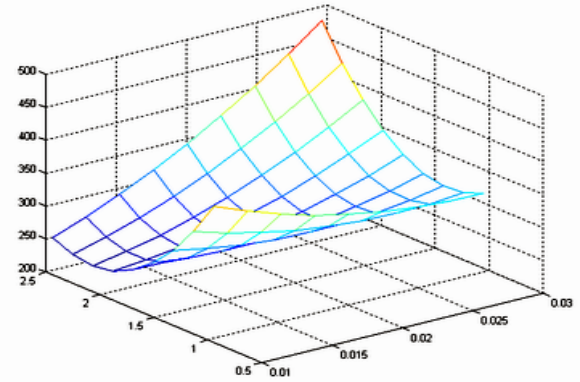

***Figure 9**. The regression surface, described by an equation of degree 2*

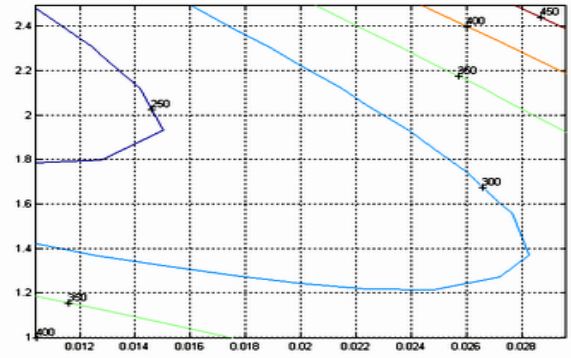

***Figure 10**. Areas of variation described by the equations of degree 2*

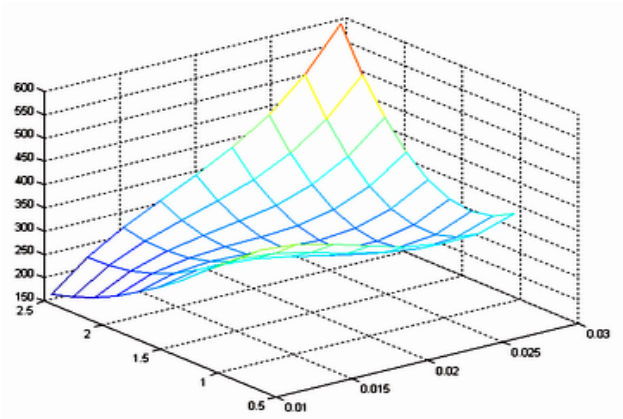

***Figure 11**. The regression surface, described by an equation of degree 3*

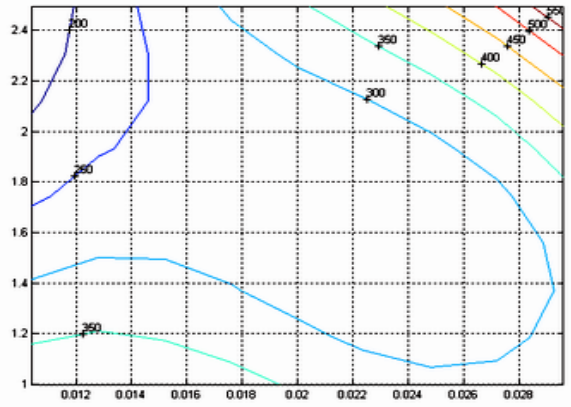

***Figure 12**. Areas of variation described by the equations of degree 3*

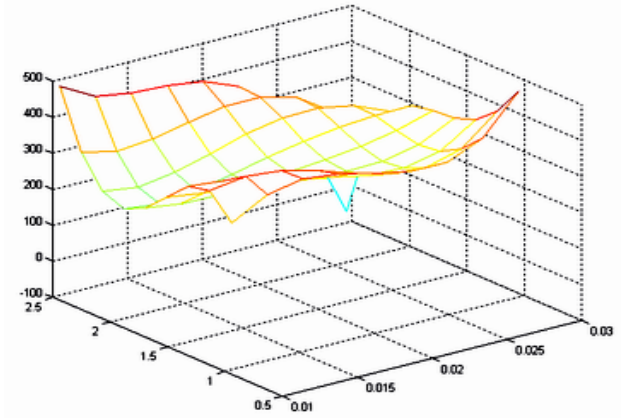

***Figure 13**. The regression surface, described by an equation of degree 4*

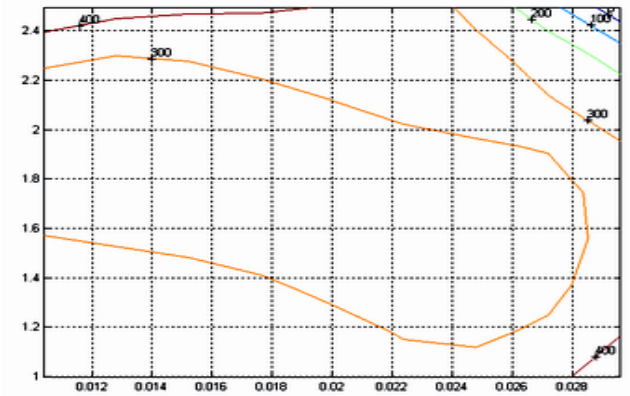

***Figure 14**. Areas of variation described by the equations of degree 4*

On the basis of the number variables (independent technology parameters) that are taken into consideration, regression analysis is a

simple regression analysis, when analysing influence a single independent variables "X" variable dependent on "Y": Y = f(X), or multiple regression analysis, when we analysing the cumulative influence of the several independent variables X1, X2, ... on the dependent variable "Y".

The character of the metallurgical processes optimization is influenced by the complex peculiarities of these, which take place into a great number of variables (parameters) that operates independently or cumulate.

For this reason, to analyze the metallurgical processes is used, mainly, the statistical fundamental methods that permit to draw conclusions, from the observed values, about the repartition of the frequencies of various parameters, about their interaction, about verification validity of certain premises, and about the research of the dependencies among different parameters. However, the statistical methods of the metallurgical process analyses do not solve a series of aspects regarding the mode of establish the decisions for the management of the process. Thereof, parallel with the statistical methods it was developed optimization methods.

The optimization of any technological process has, as a base, a mathematical model. The search for the best solution, for the truth, requests either to find, on the way of a study, definitive truths, or of relative valid truths, valid only in certain conditions, and which, in relation with the definitive truths, include implications and errors.

Areas of the technological variations, described by the regression equations, which can be realized that the plan projections of the regression surfaces (figure 8, 10, 12 and 14) are used as correlation diagrams by technologists who work in the sectors of production of the cast iron rolling rolls . These graphical representations as diagrams serve to determine the exact areas of variation of the variables the manufacturing processes of the cast irin rolling rolls.

CONCLUSIONS

The aim of these kind of research is to answer to as many questions possible regarding the general and peculiar quality of the rolling rolls. In this sense, durability in exploitation is extremely current, both for immediate practice, and for the scientific research attributed to the cast–iron. Also, the realization of optimum chemical compositions of the cast–iron can constitute a technical efficient way to assure the exploitation properties, the material from which the rolling mills rolls are manufactured having an important role in this sense.

The research on durability in exploitation of hot rolling mills rolls assures relevant conditions for the appropriation of the research methods of the thermal regimes that are submitted the rolls or other organs of machines, that works in constant (symmetrical) or variables (asymmetrical) thermal solicitation conditions. Also, it can be emphasized the thermal shock, phenomenon that constitutes a permanent danger, which leads to rupture, specific to rolling mills rolls.

On another hand, the realization of an optimal chemical composition can constitute a technical efficient mode to assure the exploitation properties, the material from which the rolling mills rolls are manufactured having an important role in this sense. From this point of view is applied the mathematical modeling, which is achieved starting from the differentiation on rolls component parts, taking into consideration the industrial data, as well as the national standards regulations, which recommends the hardness, for different chemical compositions.

Statistical calculations by MATLAB functions for the processing of data start with identification and determination of the highest values of the lowest values, the calculation of the average value, the calculation of the terms product regression, sorting items in ascending or descending order, the calculation standard deviation, as well as the coefficient of correlation.

The optimum solution is determined through some mathematical restrictions to the input values that the mathematical modeling is started. The realization of a mathematical model starting from industrial data, gathered at the rolls hardness measurement, and at the national standards regulations, which recommends the hardness, for different chemical compositions, also determines the degree of originality of the suggested project. The determination of the equations of regression hyperplanes, which describe the mathematical dependency between the chemical composition and the hardness, the determination of the multi–component relations and the realization of the graphic interfaces for the representations variation areas of the cast–irons chemical composition, completes this area of preoccupations within a processing mathematical of modeling and optimization. Through the original aimed elements mentioned above, the suggested research allows the enunciation of new approaches in the area afferent to the theme.

REFERENCES

[1.] Kiss, I. 2005, The quality of rolling mills cylinders cast by iron with nodular graphite, Mirton, Timisoara

[2.] Kiss, I., 2008, Rolling Rolls – Approaches of quality in the multidisciplinary research, Mirton Publishing House, Timisoara

[3.] Schroder, K. H.1988. Rolling conditions in hot strip mills and their influence on the performance of work rolls, Metallurgical Plant and Technology, no.4/88, 44–56, Dusseldorf

[4.] Schroder, K. H. 2000, Questions, answers, more questions – Twenty–five years of experience in discussing rolls and rolling technology, 42nd Mechanical Working and Steel Processing Conference Proceedings, Toronto

[5.] Pellizzari M., Molinari A., Straffelini G., 2005, Tribological behaviour of hot rolling rolls, Wear, Volume 259, Issues 7–12, 1281–1289

[6.] Kiss, I., 2012, Investigations upon the indefinite rolls quality assurance in multiple regression analysis, Revista De Metalurgia, CENIM, 85–96

[7.] Kiss, I., 2008, Research upon the quality assurance of the rolling–mill rolls and the variation boundaries of the chemical composition, Revista De Metalurgia, CENIM, 335–342

[8.] Kiss I., 2010, About the durability in exploitation of the cast iron hot rolling mill rolls in few experimental results, Acta Metallurgica Slovaca, 16 (1), Kosice, Slovakia, 35–41

[9.] Kiss, I., Heput, T., Cioata, V. G., 2010, Some interpretative research in the area of cast iron rolls quality assurance, Acta Metalurgica Slovaca, 16 (1), Kosice, Slovakia, 26-33

[10.] Kiss, I., Cioata, V.G., Alexa, V., 2010, Increasing the rolling–mill rolls quality – In some multidisciplinary research, Acta Technica Corviniensis – Bull. of Eng., Fascicule 2, 31–36
[11.] Kiss, Imre, Rațiu, S., Maksay, St., 2003, Triple correlation between the rolls hardness and the cast irons main alloyed elements. Annals of the Faculty of Engineering–Hunedoara – Int. J. of Engineering, 3
[12.] Kiss I., Alexa V., Cioata V.G., Ratiu S.A., 2011, Industrial and laboratory approaches for quality assurance in the rolling–mill rolls manufacturing, 1st Regional Conference – Mechatronics in Practice and Education MECH – CONF 2011, Subotica, Serbia
[13.] Kiss I., 2014, Laboratory researches upon the thermal fatigue of the organs of machines in movement of rotation, in variable temperature mediums, International Conference on Science and Technique based on Applied and Fundamental Research – ICoSTAF 2014, Szeged, Hungary
[14.] Nakamura, Shiro, Masahiro Fukuda, Akitoshi Okabayashi, 1983, Ductile cast iron roll and a manufacturing method thereof., U.S. Patent No. 4, 396-442
[15.] Goto, K., Matsuda, Y., Sakamoto, K., & Sugimoto, Y., 1992, Basic characteristics and microstructure of high-carbon high speed steel rolls for hot rolling mill, ISIJ international, 32(11), 1184-1189
[16.] Hashimoto, Mitsuo, Osamu Kubo, Yasuhiro Matsubara, 2004, Analysis of carbides in multi-component white cast iron for hot rolling mill rolls, ISIJ international, 44/2,372-380
[17.] Colás, R., Ramírez, J., Sandoval, I., Morales, J.C., Leduc, L.A., 1999, Damage in hot rolling work rolls, Wear, Volume 230, Issue 1, 56–60
[18.] Guerrero, M.P., Flores C. R., Pérez, A. , Colás, R., 1999, Modelling heat transfer in hot rolling work rolls, Journal of Materials Processing Technology, Volume 94, Issue 1, 52–59
[19.] Kudo, T., Kawashima, S., Kurahashi, R., 1992, Development of Monobloc Type High-carbon High-alloyed Rolls for Hot Rolling Mills. ISIJ International, 32(11), 1190-1193
[20.] Breyer, J. P., Walmag, G., 2002, Metallurgy of High Chromium-Molybdenum White Iron and Steel Rolls. Rolls for the Metalworking Industries, Warendale, Pittsburgh, 29-40
[21.] Kiss, I., Maksay, St., 2010, Bimetallic cast iron rolls–some approaches to assure the exploitation properties, Tehnički vjesnik, 17(2), 173-178
[22.] Kiss, I., Maksay, St., 2008, Technological correlations between the hardness and main alloyed elements in the area of cast iron half-hard rolls, Tehnički vjesnik, 15(1), 33-37
[23.] Belzunce, F. J., Ziadi, A., Rodriguez, C., 2004, Structural integrity of hot strip mill rolling rolls. Engineering Failure Analysis, 11(5), 789-797
[24.] Krawczyk, J., Pacyna, J., 2009, The influence of microstructure of mottled cast iron for mill rolls on its properties, 18th International Conference on Metallurgy and Materials Metal, 100-106

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809