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Quality control in the process of rings of train wheels manufacturing

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ABSTRACT

Purpose: The paper presents an example of the application of the complex quality control process and shows the advantages of such approach. Moreover it presents the analysis of a specific manufacturing process of rings of train wheels.
Design/methodology/approach: In the presented works it has been presented a holistic approach to the process engineering. The investigations in the manufacturing plant and laboratory test allow showing the results of a complex quality control.
Findings: Results confirm the importance of the new process engineering which links the traditional approach with the modern quality control. Also it proves that the quality control system must cooperate with the training system.
Research limitations/implications: The investigation area has been limited to one industry plant. It was considered with the fact that the analyzed process is a much specified one. This situation doesn't make possible to compare results with the other data. The second limitation is considered with the commercial secret (some data is omitted).
Practical implications: First main practical results could be described as elaborating the methodology of quality assurance of the specific and rare manufacturing processes. Secondly the paper shows how to link the technical and human factors in one integrated process.
Originality/value: Firstly this paper presents the analysis of a very rare manufacturing process what is valuable of both scientific and educational points of view. Secondly it shows how to organize the rare production process with a complex quality control.
Keywords: Manufacturing and processing; Quality assessment

1. Introduction

The analysis of the manufacturing process of rings of train wheels is presented in this paper. It is a very specific manufacturing process [7, 16]. The manufacturer of these rings is one of Polish steel mills. This steel mill is of 160-years experience. The investigations have been made in the Rings Department.

The analyzed manufacturing process bases on the: circular conventional ingots, COS circular ingots, Mittal Steel ingots and rectangular bars. The charge materials are supplied by Polish or foreign ironworks. The ingots are rolled on the round bars with diameters: 190, 200, 225, 250 and 300 mm from rectangular bars. The rectangular bars are of next dimensions: 280x300. The bars are forging and skinning before utilizing in the process. The characteristic beginning parameters of ingots are: profile type and grade [8].

In the Fig.1 the scheme of a manufacturing process is presented. The first operation is considered with the quality control of a charge material. Then the charge material is cut and the next quality control operation is conducted. Then the charge material is heated to prepare it for plastic forming [3].

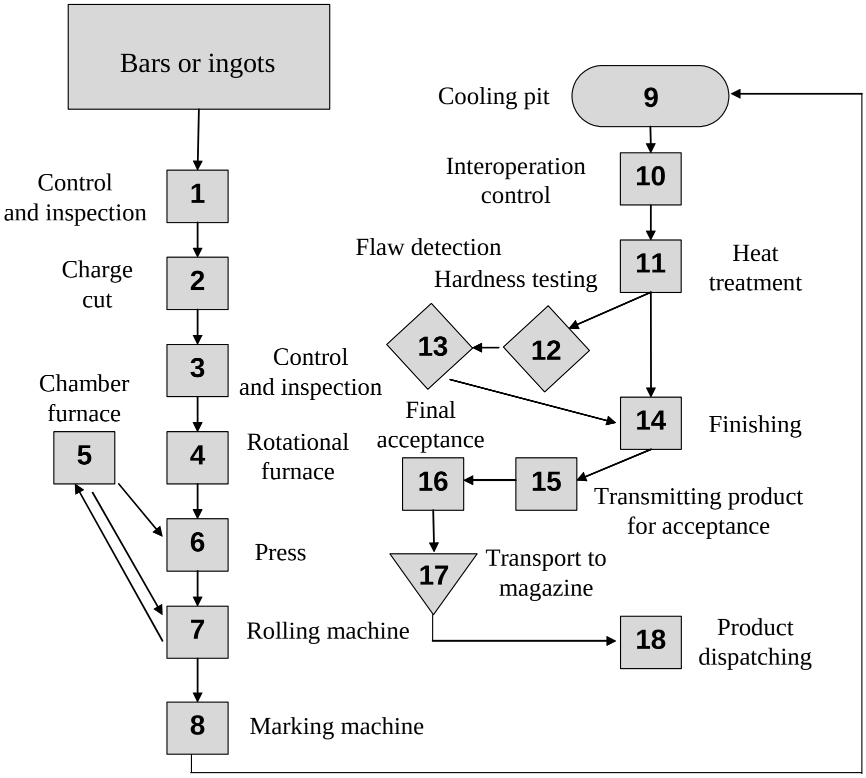

Fig. 1. The scheme of the manufacturing process of rings of train wheels

The prepared charge material is hot pressed or rolled. After this operation it is marked. Then it is cooled in a special bed. Cooling allows preserving the form of the rolled material. At the end of this level the charge material is formed in the shape of rings [1]. These rings are controlled to confirm their dimensional parameters. The control operation is very important at that process stage because it decreasing manufacturing costs [3,13].

Next the controlled rings are heat treated. This operation is very important because it strongly affects the final quality parameters of manufactured rings [4].

The last phase of the manufacturing process consists of finishing and final controlling. The manufacturer must control whether the requirements of the client are fulfilled [5, 11, 15]. Positively confirmed rings are stored.

Analyzing the schematic manufacturing process (Fig. 1.) one can find five quality control operations. Such number of operations allows the manufacturer to ensure the needed level of quality management. Also these quality control operations form a specific system of process monitoring. This is the key element for quality assurance in a low-serial manufacturing.

2. Introductory operations

During introductory operations the charge material must be tested to verify its parameters and compare them with the order parameters. Verified material is market according to next technological operations. The charge material is stored on a special buffer field. This field is the beginning of the production line (Fig. 2).

The next stage of the manufacturing process begins with the cutting operation (band-saw) to prepare the charged blocks. The charged blocks should be weighted because it is the best measure of their volume. This measure is very important for next plastic forming so the electronic balance is applied. Any larger fault of a weight measure results in defects of the manufactured rings or the utilized press.

3. Manufacturing process

In the main phase of the technological process the blocks are shifted to the store near the rotational furnace. The blocks are transporting using an overhead crane. At the storage place the blocks are controlled to check their: marks, dimensions and surface faults. This operation is important because the heat treatment operation is expensive and the charge material couldn’t be easily repaired after it. Next the charging car transports the blocks to the furnace chute.

In the rotational furnace the heating operation is conducted what is shown in the Fig.3. The rotational furnace has the hearth of diameter 13.3 and with of 2.8 m. It is computer controlled (a

CNC control system). The CNC control system allows monitoring all process parameters that are important for the heating operation. The furnace capacity is 9.5 t per hour.

To place the charge material in the furnace it is used a special hydraulic transport system controlled by an operator.

To generate the needed temperature it is used the combustion process of the natural gas. The flames from short torches, situated in the ceiling of a furnace chamber, heat the charged material. There are three heating zones in the chamber: preheating one, heating one and compensating one. Next blocks are soaking and scale hammering. Then they could be weighted.

Pressing is the main rings forming operation [10]. This operation is conducted on the HRP-4000 hydraulic press. It is a CNC controlled machine. The blocks are upset according to the process parameters. The pressing die could be flat or profiled.

The forming process is presented in Fig.4. It results in obtaining so called preformed rings.

Next is the rolling operation shown in the Fig.5. The radial-axis RAW 125/100 rolling mill rolls the preformed rigs to obtain the final form of rings. The rolling process is conducted synchronously in the radial and axial directions by the set of four rollers and special centering arms.

The centering arms control the position of the material along the axis. It results in avoiding the ovality of the manufactured ring. The diameter of rings increases during the rolling process. So the process must be computer supervised.

It is important to obtain the proper geometrical parameters because the properties of ring strongly depend on the obtained geometry factors. In this point ends the main machining process. In the next stage the other processes are conducted.

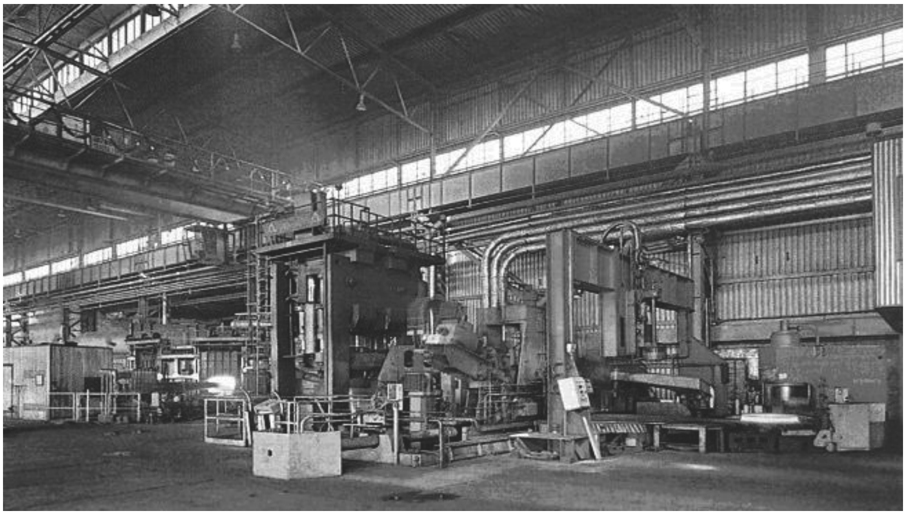

Fig. 2. The production line of rings of train wheels

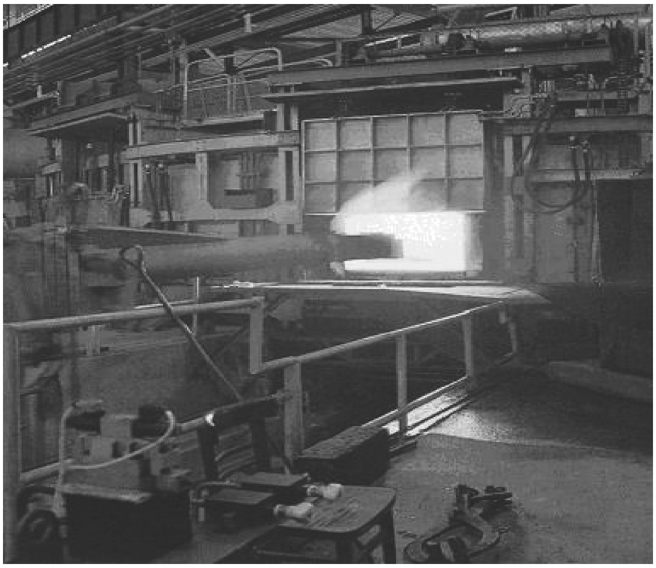

Fig. 3. The view of the rotational furnace

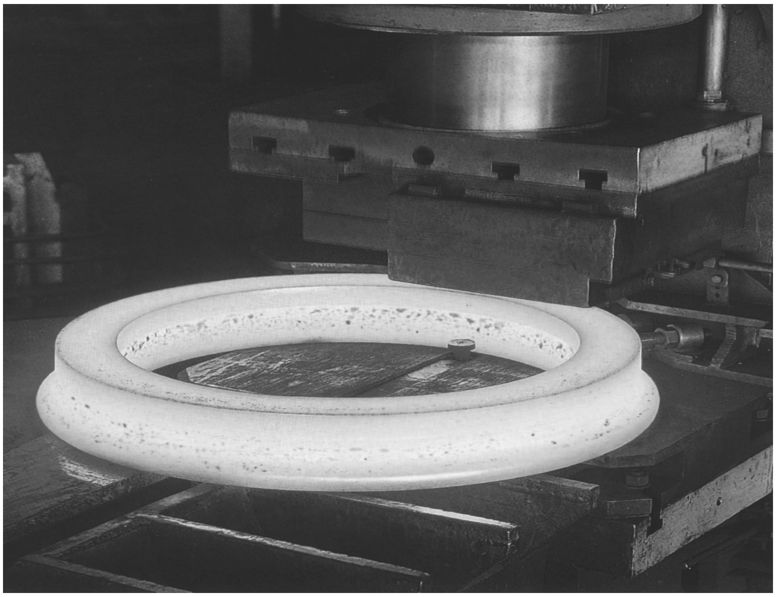

Fig. 4. Pressing of rings

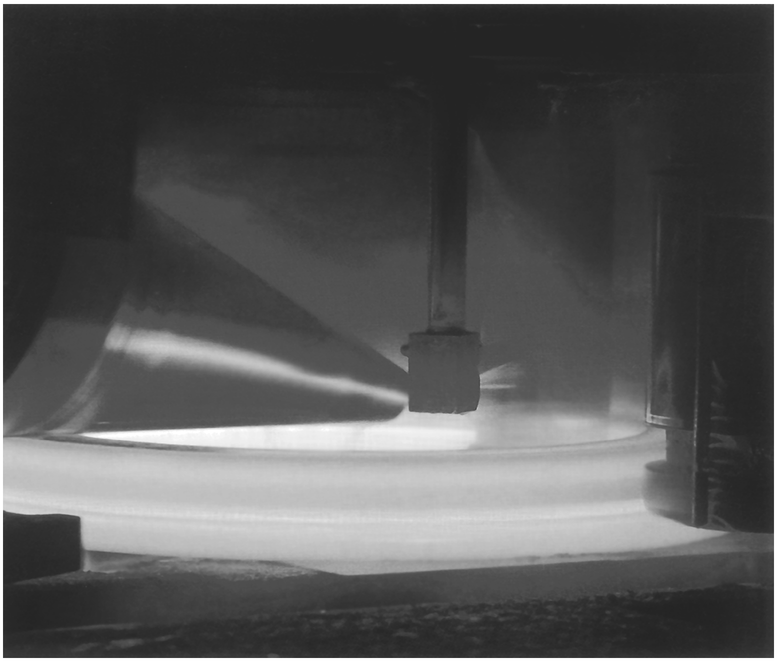

Fig. 5. The view the rolling process

4. Operation of heat treatment

The chamber furnace is complemented with shaft furnaces. In these furnaces the process of heat treatment is conducted. There are five such furnaces in the presented steel mill. The hardening bath is filled with water or special polymer.

Furnaces are equipped with modern torches as well as steering and recording apparatus. Rings designed to heat treatment according to technological plan are placed in stocks, and then loaded into furnaces. Furnaces are steered by a computer system, and whole process could be monitored and recorded in a memory of a computer. Moreover it is possible to identify the time and temperature parameters in a hardening bath. Rings after heat treating they are stored and transported to the next stage technological process.

5. Finishing

After heat treatment operation the ring is controlled on two stands: hardness testing machine and ultrasonic flaw detection machine. Next rings are measured to control their dimensions. During the finishing process they are also shot peening. The control process is automated. All data are stored in the computer.

The rings with large diameters are tested manually. Moreover are conducted the investigations using hand ultrasonic tester of type DI40 or DI60 from Inco firm. These investigations are conducted only when he client require them.

The positive checked rings are automatically transported to a rotational stand for hardness testing. In this test the BRE-AUT 100 hardness testing machine is used. Next the automated stamping machine marks the value of hardness.

The rings, which are of diameter larger then 1300 mm, are controlled manually.

After this operation it is possible to repair some rings that obtain the negative result of controlling. It is done by the machining operations.

6. Special quality tests

One of the most important groups of tests for the rings manufactured in the steel mill is the group of strength tests. These tests are conducted in the qualification laboratory in the mill. The tests include the determination of: a yield point, a strength resistance, an impact resistance, a fatigue resistance, a macrostructure, a grain size and the amount of non-metallic inclusions. The results of test are analyzed and compared with specifications [6].

The rings that obtain the positive confirmation are prepared for dispatching. They are packed an stored. Smaller rings are also palletized.

In this operation it is important to mark the packed rings properly. On the packages are placed proper labels according to clients' requirements. They show the main characteristics of the stored rings.

7. Analysis of faults

The manufacturing process could be affected by many faults. The most important of them are:

- the machine tools and its equipment condition,
- the process of measuring,
- the faults made by quality controllers.

Moreover it is crucial to conduct the technological operations in a proper way. Each wrong operation could result in a different type of a fault and only some of these faults could be reparable. So the proper process results in decreasing manufacturing costs.

Analyzing the whole production process it is possible to point some important operations and consider with them faults. Some of them will be analyzed below.

7.1. Charge investigations

In this stage one can distinguish two main faults. The first one could be called as bad surface state of blocks. All blocks are normalized according to their geometrical and material parameters. But sometimes suppliers prepare charge elements that are not according to the order. The faulty blocks are complained because this fault results in shape errors.

The second fault on this stage is considered with wrong chemical constitution. The results of this fault could be wrong using parameters of the ring. It is considered mainly with fatigue strength or corrosion resistance.

7.2. Cutting operation

The first fault considered with cutting operation is wrong measuring process. In the pressing and rolling operations it is important to prepare the charge material of precisely measured volume. When the pressing process is conducted for a too small block it results in a ring with lack o material. his fault is a nor repairable one.

The other fault is only related with the cutting operation. Namely, after the cutting operation the block is marked. Faulty marking results in bad machining process because the parameters are determined basing on the marks on blocks. So it is important to check the process parameters marked on blocks.

7.3. Plastic working

In this stage it is possible o find three main groups of faults consider with different elements of plastic working.

First group of faults is considered with heating process. This group could be called as wrong furnace parameters. This group includes:

- wrong heating temperature,
- wrong heating time,
- wrong temperature distribution.

The result of these faults is wrong plasticity of block. Particularly too cold block are dangerous because they could damage the rolling or pressing equipment. When the temperature is too high the block could be burned. Eventually it is possible that the structural constitution will changed and the rings will not have the required properties.

For the pressing operation the most important fault is considered with the determination the mass of a block. If it will not been determined correctly the obtained ring is of bad geometrical parameters.

The other problem f the pressing operation is the wrong shape of a slug. It causes that the slug could not been used in next operations.

The most frequent fault o rolling process could be determined as wrong geometrical parameters of a ring (a diameter or a height). The cause of this fault is considered with wrong parameters of a rolling machine.

Also in this process other faults could be detected. These faults include:

- shape faults (ovality, twist),
- surface faults (lapping, teeming).

The last fault detected in a plastic working process is faulty marking. It is consider with marking the parameters of heat treatment. Wrong parameters result in wrong technological process.

7.4. Heat treatment

The first, very important stage of the heat treatment is the control operation. It is important to check each ring to determine their state and verify heir process parameters. But sometimes, because of a hurry, this stage is skipped.

In the main process of heat treatment the group of detected faults includes:

- wrong heating time,
- wrong heating temperature,
- wrong temperature of cooling substance,
- wrong temperature of annealing,
- wrong time of annealing.

Results of the wrong heat treatment include: structural changes, surface changes, fractures and pits. Rigs with these faults are treated as scraps.

8. Analysis of losses

Researches allow pointing the causes of faults in the milling plant. Main researches have been conducted in the years 2004 and 2005. Basing on the main pointed faults t has been done researches considering their frequency. The Table 1 presents the comparison of frequency of main faults in particular years. It shows the absolute number and percentage ones.

Table 1.
Comparison of losses

Fault	2004		2005	
	Nr	[%]	Nr	[%]
Not filled profile	75	9.94	198	27.27
Wrong shape	50	6.62	17	2.34
Wrong dimensions	395	52.31	338	46.56
Wrong marking	85	11.26	78	10.74
Lapping	150	19.87	95	13.09
Total	755	100	726	100

The losses generate in the year 2004 are presented in the Fig. 6 and in the year 2005 in the Fig.7. They are presented in the form of a bar chart. Comparison of these charts lets to investigate trends in a losses distribution.

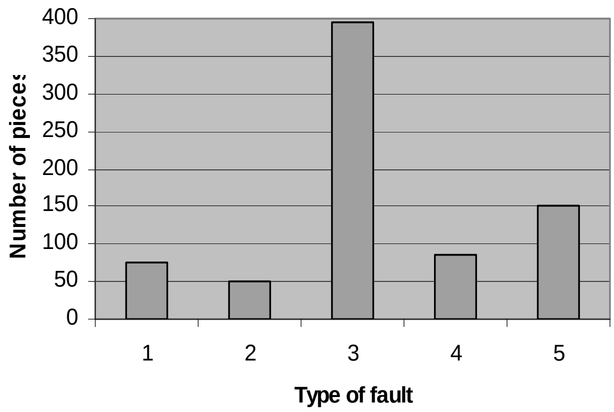

Fig. 6. The losses in 2004: 1 – not filled profiles, 2 – wrong shape, 3 – wrong dimensions, 4 – wrong marking, 5 – lapping

The comparison shows that first analyzed fault (not filled profile) increased from 9,94 % up to 27,27 %. It illustrates major alternation in the level of quality control. This fault is directly related with the process of cutting and marking charge blocks. So it should be changed the procedure of that operation to decrease this fault.

The second fault (wrong shape) decreased (from 6,62 % to 2.34 %) but in absolute numbers it is the less important fault. It is related with application of computer control of technological processes (pressing and rolling).

However the most important fault is the fault number three (wrong dimensions). In absolute value it is about 50 % of all faults. So it is important to control particularly this fault to improve the general level of product quality. It could be observed a small decreasing of number of faults (about 5.75 %) but it is still too slow. In other hand it could be treated as an occasional fluctuation.

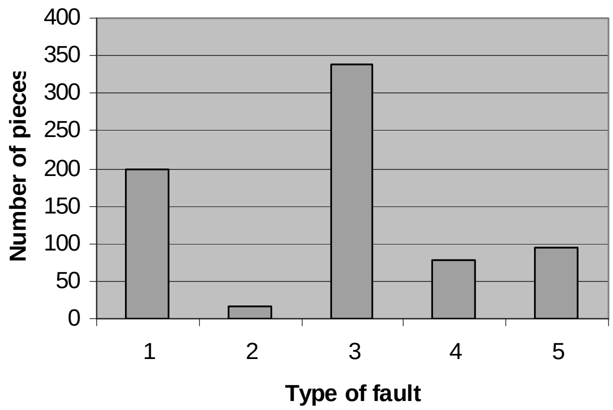

Fig. 7. The losses in 2005: 1 – not filled profiles, 2 – wrong shape, 3 – wrong dimensions, 4 – wrong marking, 5 – lapping

According to the Table 1 the fourth fault constitute about 10 % of total faults. It shows that it must be changed the procedure of marking and probably the training system of marking workers.

The last fault (lapping) also decreased (from 19.87 % to 13.09 %). It shows that the surface control operations and preparing operations are more efficient.

Generally it is possible to observe the decreasing of number of faults (from 755 pieces to 726) at the same production level. It allow to predict that changed quality control system improve the product quality level. But further improvements are needed.

9. Conclusions

The presented results prove that the process of continuous quality monitoring results in decreasing the number of faulty rings (about 30% in same cases). It also results in decreasing the manufacturing costs and in increasing the manufacturer profits. So the new production organization increased the quality level of that steel mill [14].

The conducted investigations show that next should be done the simulation researches [12]. They allow checking all important process elements in a virtual space. Such virtual model could help to transform the results to other specific manufacturing processes.

Taking into consideration the specific remarks for improvement the production quality one should point next propositions:

- apply the continuous process monitoring,
- introduce more precisely measurement techniques,
- change the training system,
- change chosen work procedures.

Utilization of these propositions allows improving not only the quality level but also the market identity of the mill plant. The last one is the necessary condition for survive the firm in the modern competitive and developed market.

References

[1] K. Abou El Hossein, Z. Yahya, High speed end milling of AISI 304 stainless steel using new geometrically developed carbide inserts, Proceedings of the 13th International Scientific Conference on Achievements in Mechanical and Materials Engineering, AMME'2005, Gliwice-Wisła, 2005, 1-6.

[2] J. Barzykowski, Modern Metrology, WNT, Warszawa (2004) (in Polish).

[3] M. Blicharski, Material Engineering. Steel, WNT, Warszawa (2004), (in Polish).

[4] L.A. Dobrzański, Metal Engineering Materials, WNT, Warszawa (2004) (in Polish).

[5] S. Fok, B. Mitchell, J. Smart, Testing to distinguish between failure laws for ceramics, Proceedings of the 9th International Scientific Conference on Achievements in Mechanical and Materials Engineering AMME'2000, Gliwice-Sopot-Gdańsk, 2000, 187-190.

[6] A. Gwiazda, The method of information ordering using the Pareto rule, Economics and Production Engineering, 11 (2002) 21-28 (in Polish).

[7] T. Karpiński, Production Engineering, WNT, Warszawa (2004) (in Polish).

[8] E. Kindlarski, Products Quality, Scientific Publisher PWN, Warszawa (1988) (in Polish).

[9] J. Oakland, Total Quality Management, Oxford Press, Oxford (1994).

[10] S. Rusz, The influence of technological parameters on the rotary pressing process, Proceedings of the 9th International Scientific Conference on Achievements in Mechanical and Materials Engineering, AMME'2000, Gliwice-Sopot-Gdańsk, 2000, 475-478.

[11] S. Tkaczyk, S. Topolska, 'Physico-Chemical Properties of TiN Films', Proceedings of Advanced Material and Technologies AMT 2001 (2001) 925-927.

[12] S. Topolska, Characteristic defects of metallic coatings obtained in the metallization process, Proceedings of the 13th International Scientific Conference on Achievements in Mechanical and Materials Engineering, AMME'2005, Gliwice-Wisła, 2005, 675-680.

[13] S. Topolska, Process of vacuum metallization - a simulation in the Taylor program, Proceedings of 11th International Scientific Conference on Contemporary Achievements in Mechanics, Manufacturing and Materials Science, CAM3S 2005, Gliwice-Zakopane, 2005, (CD-ROM).

[14] S. Topolska, Analysis of the Technological Process of Rings of Train Wheels, Journal of Achievements in Materials and Manufacturing Engineering 17 (2006) 405-408.

[15] J. Wyrzykowski, E. Pleszakow, J. Sieniawski, Strains and Fractures of Metals, WNT, Warszawa, (1999) (in Polish).

[16] Documentation of the Steel Mill (the enjoyment according to the reservation of the X Steel Mill).