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The wire rod superficial processing and the quality and environmental criterion

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ABSTRACT

Purpose: Purpose of the presented paper is meant to enlight the common points between the application of practically well-matched methods of investigation and opinion of quality and usage of the modern technical, technological or organizational solutions, in this issue in the technological processes of preparation the wire rod surface to the plastic processing.
Design/methodology/approach: Applied for the survey has comprised the adequate integrated expert methods of technological processes' analysis and opinion, as well as the integrated opinion of technological processes using the Integrated Risk Ratio.
Findings: of the led survey are as follows: the realization of quality and environmental policy in accordance with the proposed model results in the improvement of analyzed productive processes of steel wire rod, and in consequence - to their optimization both in the range of view of products' quality and in the aspect of quality of environmental influence.
Practical implications: Can refer to the substituting the chemical etching of wire rod by taking advantage of the technology, taking into account the method of mechanical removing of cinder.
Originality/value: of the presented paper has been achieved by application of the new methodology covering the usage of integrated opinion of technological processes, including the Integrated Risk Ratio.
Keywords: Quality management; Environmental management; Technological process analysis; Integrated risk ratio

1. Introduction

The constantly rising needs of the clients lead to up-grades in both the quality management and the minimization of enterprise's influence on environment.

According to the above mentioned, in the technological processes management, aiming to achieve the high effectiveness of the set aims realization, one should pay close attention not only to the aspect of articles quality, but also to the environmental problems.

Therefore, appeasing of the conflicting enterprise's businesses and the environmental demands, in the context of Integrated Quality and Environmental Management System in the strength of the standards ISO of series 9000 coherent with the standards ISO of series 14000, is perceived as the adequate resolution.

ISO 9001:2000 standard is in this case especially recommended because of the "system approach" and "process approach" permitting on identification of the interrelated and interacting processes and their improvement, according to the model of "continuous improvement", described by Edward Deming as the abbreviation: PDCA (Plan - Do - Check - Act).

The process of improvement of the customers' requirements in accordance with the quality criterion by the creation of the profile of product or service in such a way, that the imposed customers' requirements could be fulfilled in the highest degree thanks to accessible technical resources and technological processes causes the necessity of using in the frames of Integrated Quality and Environmental Management System the proper tools and methods of quality.

The application of practically appropriate methods of investigation and opinion of quality, based on "the model of perfection" comprising the identification and analysis of processes as together with the creating the goals and undertaking the optimizing workings, makes the starting point to use the modern technical, technological or organizational solutions, also in the technological processes of preparation the wire rod surface to plastic processing.

2. Integrated Environmental and Quality Management System

Due to the fact, that „the total quality" is the profit of the final product or service, and at the same time creates no danger for the environment, in fact requires looking for the resolutions allowing join the interests of the conflicting organization's businesses with legal regulations as well as internal requirements of environmental protection.

This kind of resolution joins the integration of Quality Management System with Environmental Management System (Fig. 1) [5-8, 15, 16].

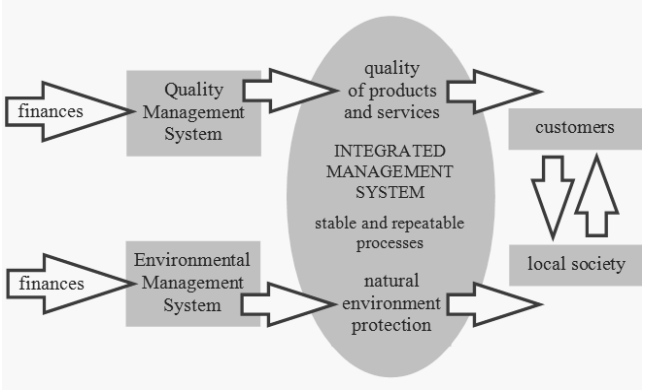

Fig. 1. Pattern of influences of Integrated Quality and Environmental Management System [7, 16]

The idea of the quality and environmental management, based on the Edward W. Deming's quality philosophy, is the same in both presented systems, and the basic target to be gain is to protect the formation the defects and threats, together with the appropriate economical and ecological strategies [6,-8, 15, 16].

That is why, the analyzed management system is taken as regular one; in connection with the resources, processes, aims and procedures, as well as with the documentation based on the norms connected with individual subsystems [6,-8, 15, 16].

The realization of the integration by seizing and listing the common and specific points in organizational and operating structure the Quality Management System, Environmental Management System as well as Technology Management System brings the unquestionable advantages, both for consumers and the manufacturers, resulting from [6-8, 10, 15, 16]:

- improvement of the transparency as a result of introduction into the enterprise the internal structural system defining the aim of the enterprise, ranges of responsibility and authorizations and describing the procedures,
- lowering of the costs of lacks being the result of liquidation of costs of repairs, lowering of costs of lacks, guarantee, the and customers' service and punishments money,
  - improvement of efficiency of realized processes as a result of the economic businesses of natural environment protection connection,
  - growth of turns and parts on market by the enlargement of the customer's satisfaction,
  - better position in the competitive fight by the improvement of organizational and productive possibilities, and at the same time - widely understood image of the company.

As the most efficient way of Quality Management System and Environmental Management System integration the simultaneous implementation of the both above-mentioned systems supported by the PN ISO 9001:2000 stsndard, with regard to Technology Management, currently has been pointed out [9, 11, 12].

The foundation of ISO 9001:2000 standard states the straight and comprehensible assumption - the quality of any article depends directly on the process quality, during which this article came into being [2].

In connection with the PN-EN ISO 9000 standard "for organizations to function efficiently, they must identify and manage various interrelated and interacting processes" [19].

This kind of „process approach" by [1, 20]:

- defining and analysis of processes indispensable to achieving the quality aims,
- choice of proper methods of measurement processes effectiveness and efficiency,
- estimation of the effectiveness and efficiency processes' degree, seems to be crucial for individual processes and system of processes, in the context of technology (Fig. 2).

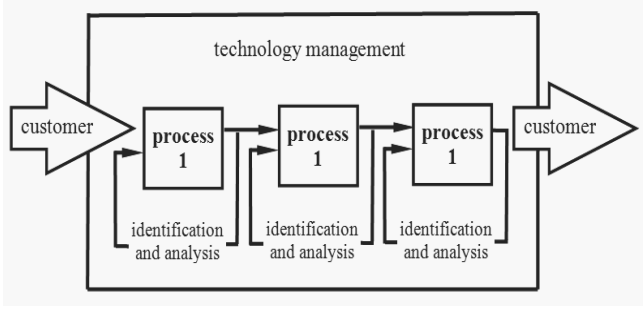

Fig. 2. Pattern of identification and analysis of processes based on the "process approach" in the technology management

The basic tool required by PN-EN ISO 9001 standard and always used in opinion of identified processes is the process audit[19].

This kind of audit should give the answer on the following questions:

- is the applied procedure proper to the achievement of the set aim?
- is the given procedure being obeyed?

First of all the process audit makes possible the opinion of qualitative ability, opinion of the settled working mode, as well as settlement of preventive and corrective actions.

Accepting such a point of view one can notice that the process audit should show the potential places of improvement of the process as well as identify the direct causes of nonconformities formation.

Audits, versed on process, being the instruments of optimization of management, lead to:

- disclosing real problems appearing in practice,
- effective solving of the problems by maximum simplifying the processes,
- understanding by the participants of processes, what happens with the results of their work in the next processes as well as what kind of influence it has on final quality of articles.

The meaning of the audit results from the fact that it is the starting point to undertake in its consequence corrective and preventive actions, which imply the improvement of functioning Integrated Quality and Environmental Management System, that is why they are the repeated elements of typical Edward W. Deming's cycle (Fig. 3).

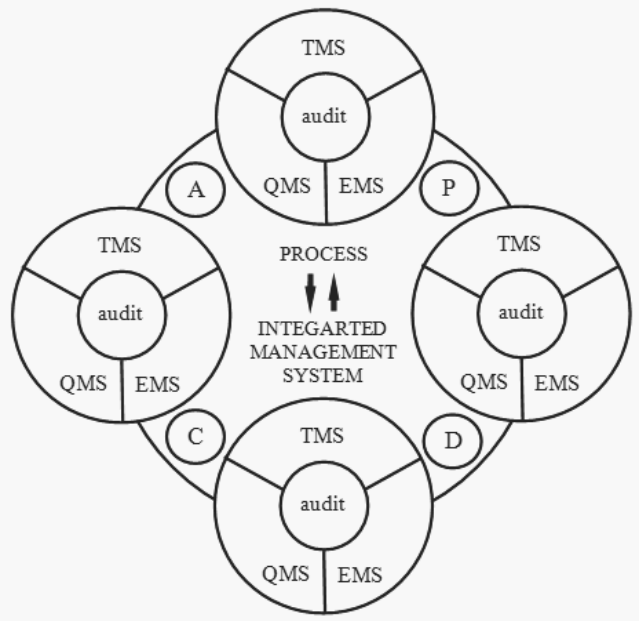

Fig. 3. Pattern of process audit in the Integrated Management System and Deming's cycle; QMS-Quality Management System, EMS-Environmental Management System, TMS-Technology Management System, P-plan, D-do, C-check, A-act

The presented issues are connected with the question of technology and technological processes management, and at the same time to the analyzed processes of etching the steel wire rod [5, 15, 17]. The appropriate way of plastic processing of wire rod, mainly requires its good blank state, which means the high quality of surface of cinder devoid. Very often happens that the wire rod delivered from foundries to wire institutions is covered with the layer of cinder with different thickness and composition. Therefore, before accession to the plastic processing, the circles of wire rod are exposed to surface processing; mainly by way of treating with acids solutions [5, 13, 14, 15].

Therefore, the introduction to the managements process of technology of wire additional interventions is crucial, firstly the management of the quality of etched wire rod and quality of etching processes, which leads to obtain the best technological and economic parameters of the process and, as the result, semi-manufactured products to plastic processing [5, 10, 15].

However the formation of large quantities of used acid accompanies the process, and the work in such harmful conditions creates direct threat of the workers' life.

The Quality Management System comprises the qualitative acting only. It doesn't take into account the environmental aspects as well as the aspects relating to the safety and the work's hygiene, and at the same time - it doesn't reflect the realized processes in full [4, 5, 15].

Therefore, the simultaneous existence of the Quality Management System together with Environmental Management System seems to be indispensable [5-8, 15-17].

3. Own research

The carried out survey comprised technological process of superficial processing of wire rod species C66D, which has taken place on the spot of the national producer of wires and steel ropes [5].

The application of treating the wire rod with solution of sulphuric acid is based on the chemical reaction of iron oxides making up the cinder with acid.

The mentioned above treatment is quickened by giving off hydrogen, which influences on tearing cinder off the mould, therefore as a result the acid is in easy access to the cinder layers being in its vicinity.

This applied due to:

- low price,
- possibility of the acid usage in the wide ranges of concentration (3 - 25%),
- possibility of usage in the wide scopes of temperature (70 - 80^{o}C).

Nevertheless, to prepare the surface of etched wire rod properly to the plastic processing, and to protect the structure of mould against the acid influence, its parameters are exposed to constant control defined in the instructions adequate for etching process.

Constantly the documentation is being prepared in order to confirm or not keeping the set conditions. The specific features and conditioning of process as well as incomplete possibility of interfering and making the corrections during the etching not always give the possibility of fulfilling the qualitative foundations. However the range of executed inspections connected with the semi-manufactured article, which is etched wire rod, permits on detecting these parties of material which shouldn't be passed to the further processing.

At the same time the constant problem present at the etching process is the formation of large quantities of used sulphuric acid, being the great danger for natural environment.

Etching of the wire rod runs till the moment the etching bath is used up. Then the used acid is removed from the etching bath container and steered to the neutralization point. The

concentration of the acid in bath is marked by the solution density, which depends on the content of the acid in the solution. According to the mentioned above, the measurement of H_2SO_4 concentration executed strictly to the proper instructions aiming at the maintenance of suitable parameters of technological process, and the same time - the fulfillment of qualitative foundations connected with etched wire rod, is used in the neutralization point to qualify the quantity and parameters of neutralizing solution.

The etching operation is burdensome for service not only because of the danger of direct contact with sulphuric acid, but also because of the strong evaporation of this acid, including the arsenic admixtures, in the temperatures in which process is led.

Work in such conditions requires strict obedience of the rules as well as conducting according to the worked out instructions. Unfortunately the etching bath containers directly connected with winding ventilators and absorptive devices are rarely used. After all with very high isolated evaporation of the sulphuric acid and large total surface of etching bath containers the acid emission to the atmosphere is so large that usage of the hermetic sealing of the etching line worth revising.

The closed etching bath containers not only protect the workers against the harmful effect of the acid, but also have a direct influence on etching quality (considerable decrease of the acid usage in the production unit, the obtainment of the approximate effects of etching with considerably lower liminal concentration of sulphuric acid in solution) and the decrease of negative environmental influence (lowering of the acid emission to the atmosphere).

That is the reason for the requirements related to the etching process of wire rod to different greatly from requirements, which individual organization has to fulfill in connection with environmental protection.

However, the fact which focuses the attention is the existence of many coherent points in organizational and operating structure of the well functioning Quality Management System and Environmental Management System.

In all the above-mentioned management systems the basic aim is to prevent defects and threats formation as well as suitable economic and ecological strategies.

The organization is obliged to the constant presentation of the product's conformity, conformity of the management system as well as continuous improvement of the effectiveness of the processes management system in the way of proper qualitative and environmental policy.

Due to the above mentioned, the processes management, aiming at their continuous improvement, should contain:

- monitoring of their courses as well as monitoring of products on the proper stages of realization processes, in order to confirm the conformity with the requirements, relatively the undertaking of the proper actions for the nonconformities,
- correcting and eliminating of the possible affirmed nonconformities as well as
- prevention of the formation of the potential causes of nonconformities.

The quality control of technological process, due to the above mentioned, states the serious question not only from the point of view of the prevention of passing to the external and internal recipients products with a quality unfulfilling requirements, but first of all in the reference to the applied methods of investigations, opinion and optimization of technological process. These methods, applied on different stages of production, permit on quality formation, and the same - the realization of the set up qualitative aims.

To the most popular methods of quality investigations and opinion, beside the widely used statistical methods, belong the expert methods, containing: Quality Function Deployment as well as Failure Mode and Effect Analysis, permitting on elimination of the possible problems appearing in the process by eliminating the sources of their formation.

The basis of execution of system Failure Mode and Effect Analysis was, similarly as in the case of the Quality Function Deployment analysis, division of the system on the possibly smallest elements as well as qualification of the cause-effect relationships among them. Basing on such a division it was possible to consider the defects existing in the system as a result of the nonrealizing function by the individual elements of arrangement as draughts of defects, their causes and results; the defects were looked for in the incorrect working of the arrangement of lower line, not in arrangement itself, and the results of defects were looked for in defective working of the arrangements of higher line, as well as in this whole system.

Each level of the analysis comprised planning and preparation, analysis of probable defects together with the causes and results of these defects, and qualification of risk present at the defect presence. The carried out analysis was accompanied with creating Failure Mode and Effect Analysis form.

Failure Mode and Effect Analysis of the process involved:

- the qualification of system structure and individual functions; for common identification of neuralgic points in product formation in the case of defects analysis, and in the case of opinion of environmental influence - environmental aspects, the algorithm of opinion of defects and environmental aspects compatible with Failure Mode and Effect Analysis as well as "Environmental Aspects and Impacts Analysis", can be accepted,
- the analysis of nonconformities and environmental aspects; according to the standards ISO of series 9000 nonconformity is "the non-fulfillment of a requirement", defect however means "non-fulfillment of a requirement related to an intended or specified use" [19]. According to the standards ISO of series 14000 environmental aspect is "element of an organization's activities or products or services that can interact with the environment", and environmental impact is "any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's environmental aspects" [22],
- the opinion of importance of nonconformities and environmental aspects; the opinion of importance of nonconformity was based on three elementary questions: what is the probability of appearance of nonconformity/ environmental aspect, what is the probability of detection of nonconformity/environmental aspect, how painful the after-effect of nonconformity/environmental aspect can be as well as the qualification of preference number of appearance of cause of nonconformity/environmental aspect. The answer to the above mentioned is the estimation of the preference number of appearance of nonconformity cause (LPW), the preference number of detection of the nonconformity cause (LPO) as well

as the preference number of nonconformity importance (LPZ), and as a last calculation - the qualification of coefficient of the risk level (WPR) expressed in scale 1 ÷ 1000,

- the choice of significant nonconformity and environmental aspect; the coefficient of risk level, expressed as product WPR = LPO · LPW · LPZ, illustrates the level of the risk probability connected with the nonconformity or environmental aspect appearance, however the product LPO LPW defines the probability in which the existing nonconformities or environmental aspects will stay undetected,
- the choice of the proper corrective and preventive workings; the high coefficient of risk level shows the necessity of undertaking the optimizing corrective and preventive action.

The high coefficient of risk level (WPR), showing the treat connected with occurrence of the given nonconformity or environmental aspect in process, means the necessity of the corrective and preventive optimizing workings. These workings can include:

- growth of the reliability of conception aiming at lowering of the frequency of occurrence of nonconformity or environmental aspect cause,
- growth of the effectiveness of detectability of nonconformity or environmental effect cause.

The optimizing workings based on the change of process conception require renewed Failure Mode and Effects Analysis including all its stages. The optimization connected with growth of the conception reliability or with growth of the delectability effectiveness requires only the risk opinion.

The need of integrated opinion of the studied models of technological processes created the necessity of Integrated Risk Ratio of processes focusing on, besides the importance and problem with realization of set technological parameters, also the risk coefficient due to the appearance in the process probable nonconformities and influential environmental aspects.

Taking advantage of created coefficient allowed to chose processes creating the particular danger for environment and suggest the elimination or lowering of the negative influence of analyzed processes on environment, however, together with maintenance of the set product parameters, at the same time.

The options of optimizing solutions suggested in the frames of realized technology of the steel wires productions were opinioned with the obtained methodology, and that fact made it possible to specify the model solutions lowering the Integrated Risk Ratio in reference to all actions aiming to the obtainment the agreement of product with specified requirements compatible with the set quality and environmental criterions.

The carried out analysis has proved, that the processes of preparation the surface of wire rod to the plastic processing characterize with moderately troublesome realization the set technological parameters and moderated possibility of the potential nonconformities in the process, with the greatest importance of occurrence of the after etching fragility, after etching pittings simultaneously with the presence of unetched places. The company of significant coefficient of risk level results with great probability and potential results of their appearances present as a lack of possibility of usage in farther processing and also damaging the machine park.

Taking into consideration aspect of the environmental influence the realized technological process is connected with almost one hundred-percent probability of appearing the highly crucial environmental aspects, which are accompanied by the high risk coefficients. It is due to inscripted in the process presence of after etching sewages, after rinsing sewages, after neutralization sediment coexisting with the risk of appearance of breakdown.

The process of chemical preparation of wire rod surface to the plastic processing was classified as highly difficult and troublesome procedure to realize on the basis of investigations in support of criterion of possibility of article formation with desirable stamina, plastic and technological properties together with the gravity of environmental aspects involved in the process.

Considering present from few years in Poland growth of waste of water for industrial aims (67% of the total usage), the increasing process of pollution of overground and underground waters together with rising quantity of stored wastes, the solutions called “the end of pipe solutions”, based on installation in process the additional module permitting only on lowering the load of pollution passed to environment, is the barrier in initiation, and what is more - in certification of Integrated Quality and Environmental Management System.

Taking it into account the functioning of neutralization station of sewages coming into being as the result of preparation of surface of wire rod with method of chemical etching in sulphuric acid to plastic processing as a solution restrictiving the emissions doesn’t seem to be the best one from possible. By anthropogenic substances in the character of pollution included in sewages coming into being in the etching processes as well as after neutralization sediment the process is accompanied by the risk of industrial breakdown occurrence.

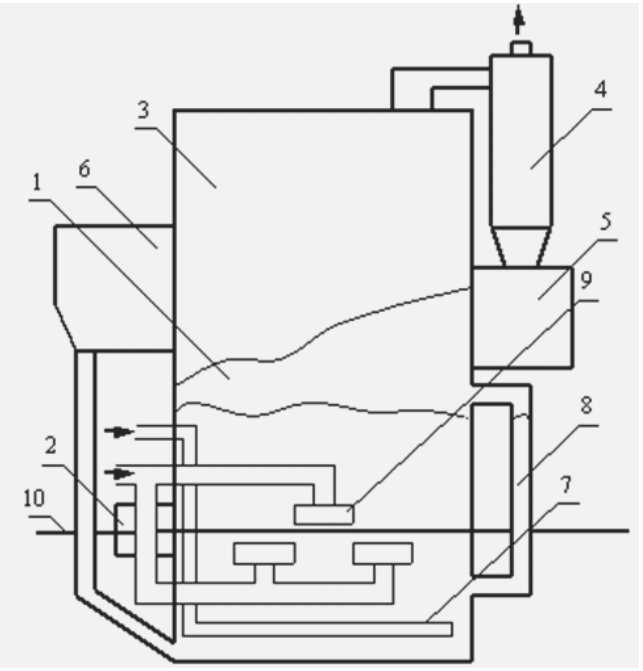

Fig. 4. Scheme of the prototypical fluid - stream cleaner; 1- working chamber, 2 - blower, 3 - separation column, 4 - cyclone, 5 - dust container, 6 - loading tray, 7 - grate, 8 - chamber filling level indicator, 9 - stream inducing tool, 10 - wire rod [18]

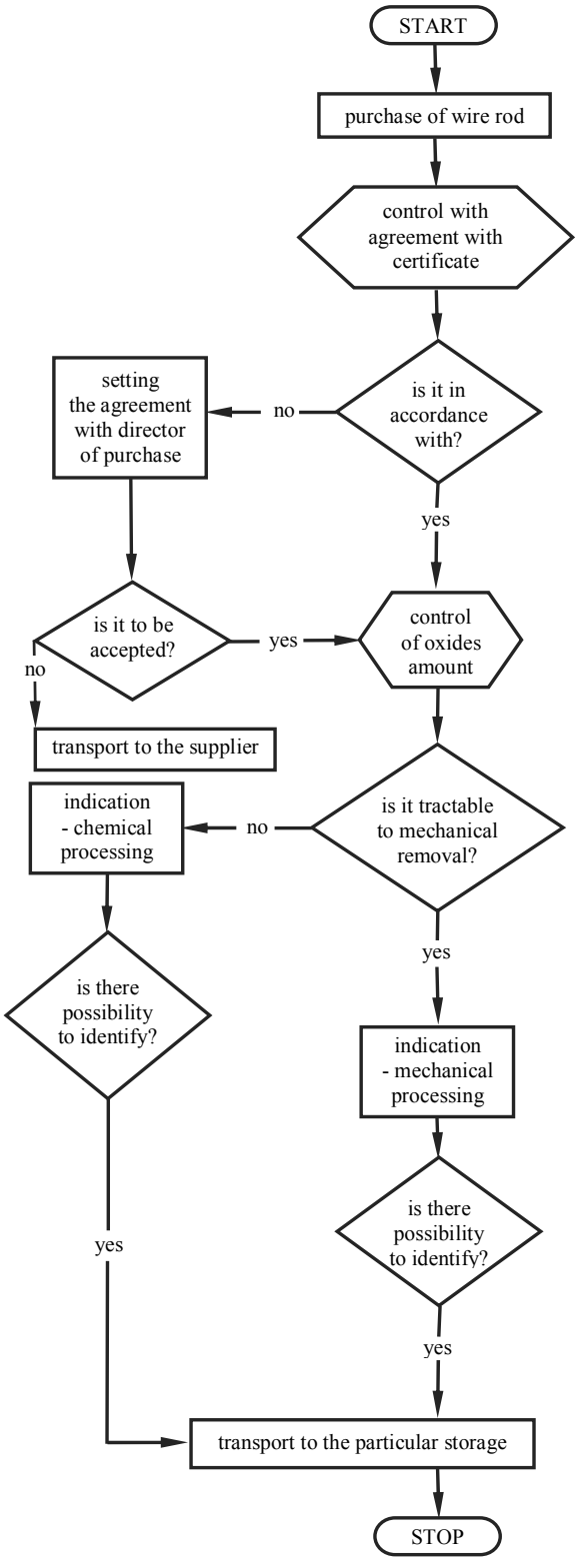

Fig. 5. Algorithm of selection of chemical or mechanical method of wire rod surface processing

That is why, the idea of using the technology of mechanical removing of cinder permits on the decrease of:

- waste of water for the industrial aims,
- waste and emission of sulphuric acid,
- load of pollution in sewage accompanied to municipal sewages system,
- quantity of after production wastes by the partial or total elimination of after neutralization sediment,
- possible risk of appearance of industrial breakdown connected with the processes, in which the sulphuric acid is present.

In order to solve the existing problem one can propose mechanical cleaning of the wire rod surface using, for instance, the fluid - stream method, which working mechanism bases on bombarding with the abrasive grains the surface, which is being cleaned (Fig. 4) [18].

While selecting the method of removing the cinder from the wire rod surface one should take into account the possibility of its usage depending on the quantity of oxides, which cover the wire rod before plastic processing.

In practice, the standards ruthlessly define the requirements, that should be fulfilled by materials added to wire-drawing, it means the mechanical and technological properties as well as specification of the defects disqualifying basic material in plastic processing of wires with destination for tenches; similarly the certificate, making up the confirmation of the agreement of wire rod property with the standard.

However the PN - EN 10016:1999 standard doesn't define the admissible quantity of oxides on the wire rod prepared to plastic processing. Meanwhile the thickness of cinder and rust layer is the basic factor directly deciding about the selection of method of the cinder removing [21].

While selecting the proper method one should consider the time and the place of the wire rod storing before accession to its removing and resulting the loss of mass of wire rod as a result of increase of rust quantity (Table 1).

The priority should be, besides the confirmation of the conformity with certificate, the qualification of quantity of oxides on surface of the wire rod, and at the same time - its susceptibility to the chemical and mechanical removing.

It will permit for the proper selection, which means - chemical or mechanical method of preparation of wire rod surface to the plastic processing (Fig. 5).

Table 1.
The composition of the average increase of rust on the wire rod in time of its warehousing on closed storage yard [3]

wire rod specie	average increase of rust in time of warehousing [kg/Mg]	
	after 6 months	after 12 months
D 35	2.7	18.3
D 55	**2.7**	**23.1**
D 85	12.7	27.5

The usage of mechanical removing of the cinder from the surface of the wire rod prepared to the plastic processing practically eliminates the problem of:

- occurrence in process the nonconformities resulting from the chemical working of sulphuric acid,

- occurrences of significant environmental aspects in the form of after etching and after rinsing sewages, after neutralization settlings, as well as the risk of industrial breakdowns connected with presence of the environmental aspects mentioned, which is confirmed by the restated analysis (Table 2).

Table 2.
The comparison of the Integrated Risk Ratio studied processes of chemical and mechanical superficial processing [5]

kind of process	Σ TPI	ΣTPD	ΣQRL	ΣERL	IRR
chemical superficial processing	1902	24	839	368	**326**
mechanical superficial processing	306	7	212	70	**24**

where the symbols mean:
IRR - Integrated Risk Ratio taking into account products' quality and environmental aspects,
TPI - index of the importance of individual technological parameters in the realization of quality and environmental aims,
TPD - index of difficulty of realization of individual technological parameters,
QRL - index of the risk level of analyzed incompatibility,
ERL - index of the risk level of analyzed environmental aspect.

4. Conclusions

While facing the fierce competition on the market there can be stated that exclusively the continuous up-grading of all processes in the organization can guarantee the winner's position on market. The improvement should be applied to all technical, technological and organizational aspects both in connection with quality of the manufactured products and the impact on the natural environment.

Being aware, that the realization of well ordered and simultaneously innovative workings in the range of realization of manager function in the organization, based on data collecting and their analysis, the advantage of process improvement in support about quality criterion will be increasing, should be pivotal stimulus to take up the activity, fulfilling the recipients' expectations.

The selection of technological processes methods of investigation and opinion, permitting not only for realization of as well the quality policy as the environmental protection, is starting point of every analysis and optimization.

In the survey the test of analysis of wire rod surface preparation processes to the plastic processing has been applied, and due to that fact, both Failure Mode and Effect Analysis and "Environmental Aspects and Impacts Analysis", were used. Integrated Risk Ratio, worked out on their basis, was applied in opinion of realized technological processes.

Due to that fact, the superficial processing preparing the wire rod surface to plastic processing was estimated as connected with considerable number of potential environmental aspects and nonconformities with high probability of appearance and low possibility of detection, therefore - with high level of Integrated Risk Ratio.

Taking into consideration particular difficulty of auxiliary operations of preparation material to plastic processing for realization of qualitative and environmental aims, the possibility of applying various ways of preventing the vital nonconformities in the form of after etching fragility, after etching pittings as well as unetched places and minimizing at the same time the waste of water on industrial aims, the waste and emission of sulphuric acid, load of pollution in sewages accompanied to municipal sewage system, the amount of stored after neutralization sediment as well as reducing the risk of appearance of industrial breakdown was considered.

The suggested model of process has been exposed to the extended analysis. The final results of research have proved the thesis, that the realization of quality and environmental policy being in accordance with the suggested model leads to the improvement of analyzed productive processes of steel wire rod, and as the result - to their optimization from the point of view of products' quality and also in range of quality of environmental influence.

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