ANALYSIS OF FACTORS LOWERING THE LEVEL OF QUALITY DURING WELDING PIPE WITH SEAM

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Abstract

The paper presents the results of research carried out in one of the domestic enterprises of the metallurgical industry. It is an enterprise mainly engaged in the production of steel pipes with seams welded induction. The production of welded pipes generates lower costs compared to the production of seamless pipes, therefore, the world's thinner welded pipe mill with thinner walls is still being developed, which can not be produced using the methods used to manufacture seamless pipes. Production is also less material consuming for seamless pipes (saving steel). In most of the major manufacturers of pipes is observed systematic seek to increase the production of welded pipes and reduce the production of seamless pipes for such assortments as drill pipe, boiler pipes and pipes thick-walled construction. The aim of the research is to detect incompatibilities in the production of welded pipes, which significantly affect the quality of the final product and finding sources of these incompatibilities. In the course of these studies, quality management tools as the Pareto-Lorenz and Ishikawa diagrams and the FMEA method are used. These tools make it possible to detect significant incompatibilities and errors arising from the planning stage and during the manufacturing process of welded pipes in the analyzed company. While using the Ishikawa diagram and FMEA method sought to eliminate the possibility of any faults and incompatibilities. The results obtained will allow to improve and streamline the production process of welded pipes.

Keywords: Production of welded pipes, Pareto-Lorenz diagram, Ishikawa diagram, FMEA method

1. INTRODUCTION

Product quality is a random variable in a system of probability. Ability to properly estimate of this distribution ensures the reliability of the results. The adoption of an appropriate distribution of the quality is related to the used definition of quality measures. The concept of quality measures is not clear, which means that you can specify several alternative measures of quality [1]. In each cycle of the production process there are various types of incompatibility or quality deficiencies. In the case of metallurgical processes rather an important element that you have to consider the conditions of the technological process implemented. Their change can result in a number of incompatibilities [2-5].

Nowadays, customers are becoming more demanding and are more confident in what they expect from a potential producer. The progressive development of technology, the production of ever more surprising things lead to increased product quality. In order to increase its quality, there should be created measurable methods and tools for the detection of deficiencies and incompatibilities. The application of these methods will allow for the incompatibilities detection, and later allow to analyze and make adjustments to the production process which is carried out. These tools and methods may include MEA method and Pareto-Lorenz and Ishikawa diagrams. FMEA method is a method of analysis of the effects and types of possible errors. The premise of this method is to detect weak points and determine the risk degree for them. This method aims to identify and evaluate the kind of potential damage and its causes related to the design and manufacture of the product. This method is also designed to the process document, and to determine the procedure, which would help to eliminate the occurrence of damage. Using this method allows to identify the factors that influence the damage of the product and the consequent elimination of defects. Analysis of Pareto-Lorenz used to prioritize corrective action and preventive, it is a technique that allows carrying out activities aimed at improving the level of quality.

On the other hand the key to success in solving quality problems is proper diagnosis. Helpful here is Ishikawa diagram. It allows you to graphically see the interconnectedness causing problems with a specific concept to solve this problem. This is an effective way of writing out factors affecting the quality, for example and it is used to study the complex organizational problems [1, 6, 7].

Production of steel pipes with seam welded induction generates lower costs compared to seamless tubes. Thus, significant saving in steel compared with seamless pipes. In most of the major manufacturers of pipes is observed systematic seek to increase the production of welded pipes and reduce the production of seamless tubes for such assortments as drill pipe, boiler and thick-walled construction [8-10].

2. RESULTS AND ANALYSIS

The paper presents the results of research carried out in one of the domestic enterprises of the metallurgical industry. It is an enterprise mainly engaged in the production of steel pipes with seams welded induction. The aim of the research was carried out to detect incompatibilities in the production of welded pipes, which significantly affect the quality of the final product and to identify the reasons for these incompatibilities. During the implementation of these studies used quality management tool as: Pareto-Lorenz and Ishikawa diagrams and the FMEA method. **Table 1** shows the numerical list of incompatibilities in the production process of the steel pipe with a seam welded induction observed in the period considered.

Table 1 List of incompatibilities

Incompatibilities	The number of defects per 1000 tested profiles	The percentage of qualities [%]	Cumulative percent of the qualities [%]
N6	21	20.8	20.8
N2	20	19.8	40.6
N7	17	16.8	57.4
N3	15	14.9	72.3
N1	13	12.9	85.2
N5	9	8.9	94.1
N4	6	5.9	100

The names of incompatibilities presented in **Table 1**:

- N1 - crack sealing (13 defects per 1000 tested profiles),
- N2 - a rant on the profile (20 defects per 1000 tested profiles),
- N3 - incorrect radii (15 defects per 1000 tested profiles),
- N4 - incorrect diameter (6 failures in 1000 examined the profiles),
- N5 - incorrect length (9 defects per 1000 tested profiles),
- N6 - a rant has not removed (21 defects per 1000 tested profiles)
- N7 - incorrect cutting of weld (17 faults per 1000 tested profiles).

Figure 1 shows the diagram Pareto - Lorenz for incompatibilities presented in **Table 1**.

By analyzing the data obtained from the graph (**Figure 1**) and **Table 1**, it can be stated that there is no single dominant incompatibility. These values are close to each other, because 1000 examined objects can contain incompatibilities in the range of 0.6 to 2.1%. However, the elimination of the three most frequent incompatibilities (flash has not removed, a rant on the profile and abnormal shear of weld) will eliminate the production of approx. 60% incompatibilities and these are the incompatibilities directly related to emerging weld. Therefore, another tool in the work was Ishikawa diagram, which was prepared for the problem of defective weld (**Figure 2**). This graph allows see graphically the interconnectedness of causes and effects.

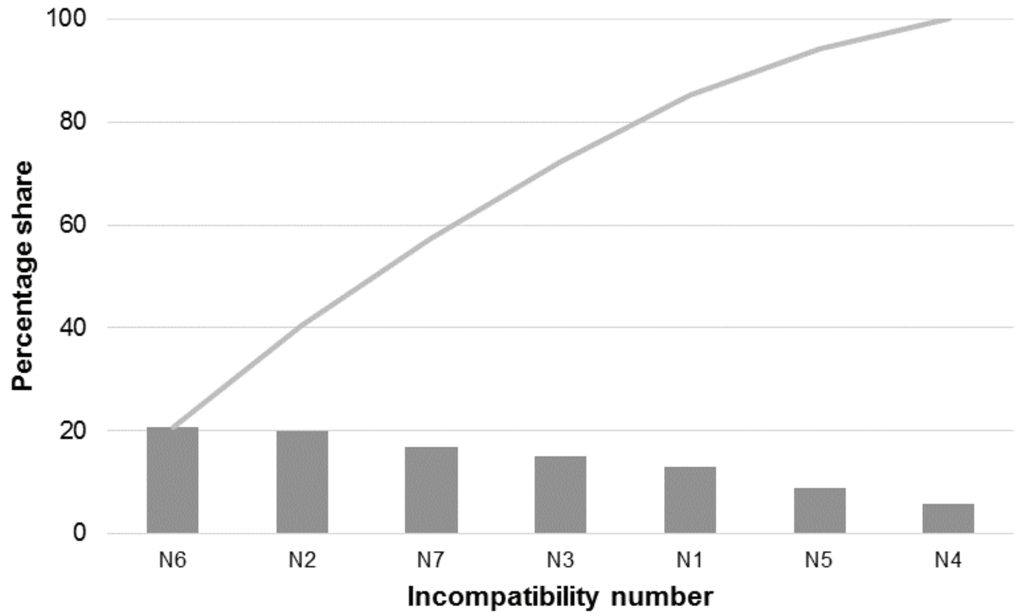

Figure 1 Diagram Pareto - Lorenz for incompatibilities occurring during the production of welded pipes

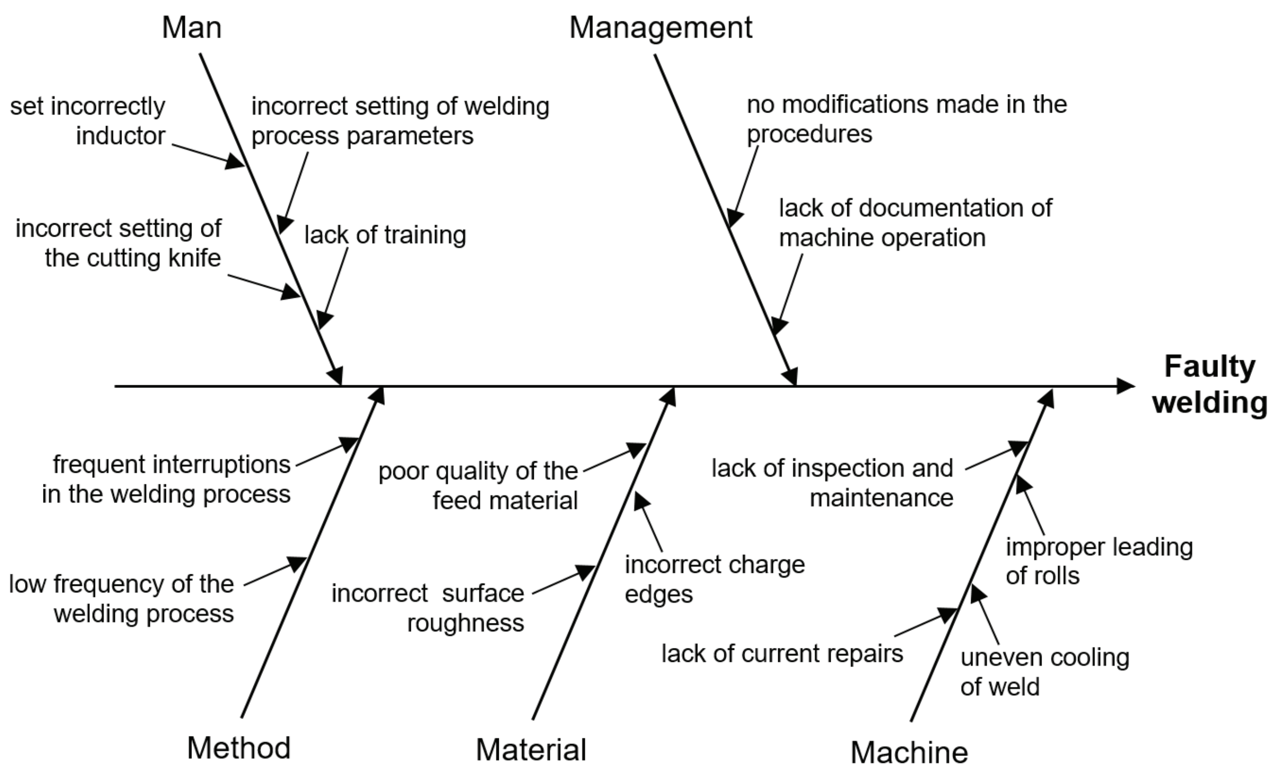

Figure 2 Ishikawa diagram for the problem of defective weld

On the basis of Ishikawa diagram and the research can be divided into three basic groups of elements that have the greatest impact on the poor weld quality in the production of pipes. These elements are: production method (approx. 30%), the machine (approx. 30%), man - human factor (approx. 20%).The above-mentioned groups play a key role in the manufacturing process. They need the most attention, frequent checks interoperable and training for employees, because the lack of these activities is the source of most of the resulting errors. Especially incorrect operation of the machine by employees also contributes to faster wear of the machine and a greater frequency of its failure. The group of elements which have the least impact on the formation of a weld defective are material (approx. 10%) and management (approx. 10%), because in these areas should be carried out a detailed inspection and complement to keep the deficiencies in the documentation. With this tool, quality management revealed the source of the causes of a weld faulty. Thus formed then collection of information on potential causes of incompatibilities has been used in further analysis using the FMEA method. **Table 2** presents the level of risk of incompatibilities for a weld faulty. It was located as many as 16 errors that can occur in the analyzed manufacturing process. Mistakes in the FMEA method cause a number of incompatibilities in the products. Removing the cause of some incompatibilities sometimes requires stopping the machine park. In most cases the cause of the errors responsible man. Both employees and managers make mistakes, which most often result from a lack of knowledge (lack or insufficient number of training), neglect and self-control. Another important reason there are problems with the technical equipment (no input: working time machine, maintenance and repair). For individual errors were calculated risk priority number according to the formula (1).

$$RPN=O\cdot S\cdot D \quad (1)$$

Where: *RPN* is risks priority number, *O* is occurrence, *S* is severity and *D* is detection.

On the basis of the figures in **Table 2** and graphically shown in **Figure 3** it can be concluded that the four problems exceeded the value of 100 for the *RPN*. These are the wrong set exciter (RPN = 252), a rant on strip (RPN = 135), misconduct rollers (RPN = 216) and non-uniform cooling of weld (RPN = 216).The results should be interpreted in such a way that these types of errors play a key role in the production process and they should be carried out as soon as possible remove them or minimize their occurrence and importance to a minimum.

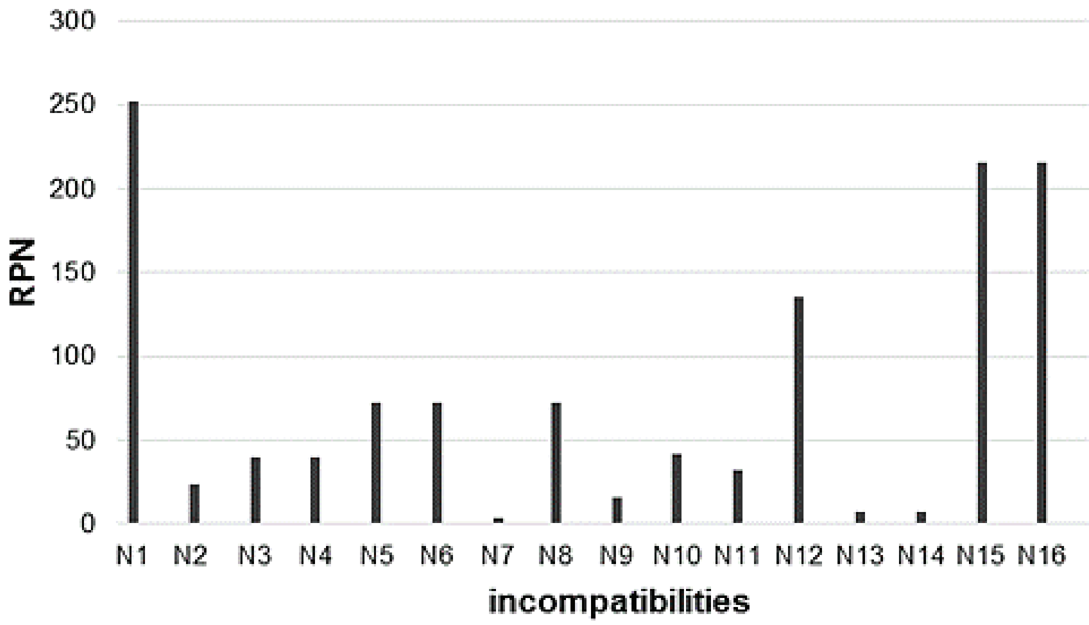

Figure 3 Graphical presentation of results based on the FMEA method

Table 2 FMEA method

Symbol	Type of incompatibilities	Effects of error	Causes of error	Evaluation				Corrective action
				O	S	D	RPN	
N1	Wrong set exciter	- heated material - the formation of cracks	- error of employee - lack of training	7	9	4	252	- more frequent inspections - conducting training
N2	Incorrect setting of the cutting knife	- too strong or too weak of weld beheading - the formation of uneven surfaces	- error of employee - lack of training	2	6	2	24	- more frequent inspections - conducting training
N3	Wrong choice of frequency	- low temperature of weld resulting in low power of weld	- lack of documentation - error of employee	4	5	2	40	- record keeping on the frequency of weld
N4	lack of training	- incompetent setting machines	- lack of financial resources - negligent management	4	5	2	40	- raising funds for staff training
N5	Incorrect selection of the charge to the diameter of the pipe	- the formation of cracks	- lack of documentation - error of employee	3	8	3	72	- keeping records - more frequent inspections
N6	Lack corrections up procedures	- lack dimensional tolerances	- lack of financial resources - negligent management	3	8	3	72	- care management - information about the need for change
N7	Lack of documentation concerning the operation of the machine	- machine failure	- neglect of management and employees	2	1	2	4	- care workers - inspections duties - checks on the appliances
N8	Low frequency welding	- weak weld - cracks	- lack of documentation - problem of maintaining parameters	3	8	3	72	- keeping records on the frequency of weld - control device
N9	Frequent interruptions in the welding process	- lack of continuity of weld	- negligence of employees	2	8	1	16	- control management - break adjustment for employees
N10	Bad quality material	- corrosion - frequent overheating	- negligent management	7	3	2	42	- charge control - corrosion protection
N11	Improper roughness of steel	- bad weld quality	- negligence of employees - lack inter-operational control	2	8	2	32	- control of surface roughness - employee awareness about the problem
N12	Rant on strip	- of weld cracks - incompatible dimension	- defective equipment - lack repairs	5	9	3	135	- control machinery and equipment
N13	Lack inspections and maintenance	- frequent stasis - interrupt the process	- neglect conservator - negligent management	2	2	2	8	- control machinery and equipment - inspections duties
N14	Lack of current repairs	- frequent stasis - interrupt the process	- neglect conservator	2	2	2	8	- control machinery and equipment - inspections duties
N15	Misconduct rolls	- rise a rant on the tube - incompatible dimension	- lack of documentation - error of employee	6	9	4	216	- keeping records - more frequent inspections
N16	Uneven cooling of weld	- overheating of the of weld - uneven surface	- machine failure - incorrect setting of the mechanical	8	9	3	216	- control cooling - control equipment and machinery

3. CONCLUSION

Based on extensive investigations, it was found that using tools such as Pareto-Lorenz and Ishikawa diagrams and FMEA method can be found incompatibilities that arise in the process of production of welded pipes and their causes. Using the Pareto - Lorenza diagram identifies the main incompatibilities in the stage of welding the pipes, which were transferred to the final product. Diagnosed seven incompatibilities surveyed 1,000 objects. The most common scrap which has occurred is not removed, a rant on the profile and abnormal shear seal are directly related to incompatibilities with the emerging weld. The elimination of the causes of the production process will be approx. 60% reduction of non-compliance. Using Ishikawa diagram searched for reasons that may affect the phenomenon of defective weld. Used with the principle of 5M. For individual groups determined how they can contribute to the resulting phenomenon. Based on this study, it was found that a key role for the resulting errors corresponds to a method for producing (approx. 30%), the machine (approx. 30%) and man (approx. 20%).The above-mentioned groups play a key role in the manufacturing process. They need the most attention, frequent inspections interoperational and training for employees, because the lack of these activities is the source of the most resulting errors. In contrast, using the FMEA method sought opportunities to eliminate any faults and incompatibilities realized the production process. It was located as many as 16 errors that can occur in the analyzed manufacturing process. Mistakes in the FMEA method cause a number of incompatibilities in the products. Removing the cause of some incompatibilities sometimes requires stopping the machine park (generating additional costs for stopping the production line). In most instances the cause of these errors corresponds to man and machine. The results of completed studies will help to improve and streamline the production process of welded pipes production.

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