USE OF A DEFECTOSCOPE AS A TOOL FOR ELIMINATING THE HUNDRED-PERCENT QUALITY CONTROL IN A STEELWORKS

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Abstract: Technological progress in the vast majority of cases allows for eliminating destructive methods in the quality control of products in the metallurgical industry. At present we can use devices using e.g. ultrasounds or Eddy currents to test the quality of the produced product without destroying the sample. Properly calibrated control devices can check in real time whether a particular item complies with applicable standards and customer requirements, significantly improving the company's image and decreasing the costs associated with product returns. The article presents a solution aimed at improving the efficiency of quality control of the sealing of a product manufactured in a metallurgical production facility. The facility in question is located in Silesia, Poland.

Keywords: defectoscope, quality control, quality management methods

1 Introduction

The technological progress that we have observed over the last dozen or so years has had an impact on everything that surrounds us. New inventions can be found in many areas of everyday life. We try to use them as much as possible for the purpose of improving our quality of life, daily functioning and most importantly, to aid us at work. In the past, testing of products and manufactured goods was conducted using destructive methods. If it was not possible to check something using visual methods, destruction of the part, material or product was the only other choice.

Nowadays, when time plays an increasingly important role, we can use devices which utilise ultrasounds or Eddy currents to test the quality of a product without the need to destroy the sample [4,2]. Properly configured, they can check in real time whether a particular item meets the applicable standards or fails to do so and should be discarded or repaired. The article presents the results of the implementation of a defectoscope (automatic weld defect testing device) into the production cycle at the cambering line at the metallurgical plant's production site, to improve the quality control of the weld.

2 Cold-bent section line

Launched at the end of 2009, the FCF (Flexible Cold Forming) production line for the production of closed sections with a square or rectangular cross-section was the most modern in Poland and the third in Europe at that time. The advantage of these lines is their saving of the input material (5-20%) in the form of black or aluminum sheet. In lines of this type sections are produced directly from square and rectangular sheet in the ranges of 70x70 - 140x140 and 80x50 - 160x120 with wall thickness from 3.0 mm to 6.0 mm, made of S235, S275 and S355 grade steels from the JR, JO and J2 quality group according to PN-EN 10219-1, -2: 2007 ("Cold formed welded structural hollow sections of non-alloy and fine grain steels") for steel constructions. Shapes are produced in the roll forming process, and welded longitudinally using the inductive method.

The section production line consists of several main sections, such as:

1. Spreader - band preparation section. Includes a sheet metal swivel, spreader, straightener, guillotine to cut the beginning of the sheet and a welder. The output of this section is a single long sheet of metal, which is then rolled onto the battery.
2. Horizontal spiral battery - allows for storing more rolls of tape. It eliminates the need to stop at every consecutive joining of sheet metal in the previous section.
3. Forming section - These are three FCF blocks which, by alternatingly forming the sheet, give it the intended shape. The position of the plates is changed automatically, controlled from the desk at the welding section.
4. Welding section - In this section, a high frequency generator is used to heat the edge of the sheet and then, after plasticizing it by pressing it with the upper and lateral rollers and removing the flash, the most uniform surface possible is formed.
5. Calibration section - This section gives the final shape to the profile - its height and width. An important rule is that each of the four rolls is spinning.
6. Saw blade section - here the section is cut to the desired dimensions. Controlled by a CNC machine.
7. Packing machine - creates a package of sections, the number of pieces in each package depends on the quantity ordered by customers or the weight of the package. At the end of the process, each pack is weighed and a label with the necessary data is printed. Upon completion of the production and validation of the performance and non-destructive testing results, the label of each batch is attached by the quality assurance officer.

2.1 Product quality control

Sections intended for the construction market must meet the dimensional, material and delivery requirements specified in the standards set out in Table 1.

Table 1. Quality requirements for cold-bent sections

Cross-section of the section	Dimensional standard	Material standard	Delivery conditions
Square and rectangular	BN-79/0656-01	PN-88/H-84020	PN-EN 10219-1,-2:2007

In addition, the manufacturer confirms that the delivered products comply with the requirements stated in the order in the Factory Production Control document bearing a CE certificate number. The facility described from the beginning of the FCF line has been constantly monitoring the quality of its closed sections since the launch of the FCF line, which include:

- dimensional control,

- surface control,
- welding quality control.

The method of quality control testing in the initial period of operation of the Section Department was visual inspection carried out by employees of the production line. The effectiveness of this method depends on the level of training, knowledge, skills and experience of the staff. In the initial period, with a low number of orders, this method proved to be successful, but increasing production volumes and seeking maximum production capacity utilization, the company began to notice more and more problems with the quality of the sections and in particular with the quality of the weld consisting in weld discontinuity, as shown in Figure 1. Table 2 lists complaints due to defects in welds in the years 2011-2014.

Table 2. complaints pertaining to weld defects in the years 2011-2014

No.	Year of complaint	No. of complaints [pcs]	Returned amount [kg]	Production volume [Mg]	Ratio of defective products to production volume	Price discount given [%]	Cost* [PLN]
1	2011	3	10 400	600	1.73	3%	7 250
2	2012	4	9 540	6000	0.16	4%	5 400
3	2013	2	8 280	12 300	0.07	5%	40 000
4	2014	3	8 400	19 000	0.04	5%	30 100
						Total cost	**82 750**

**this position takes into account the approximate cost of the discount granted to the customer and provision of a defect-free product.*

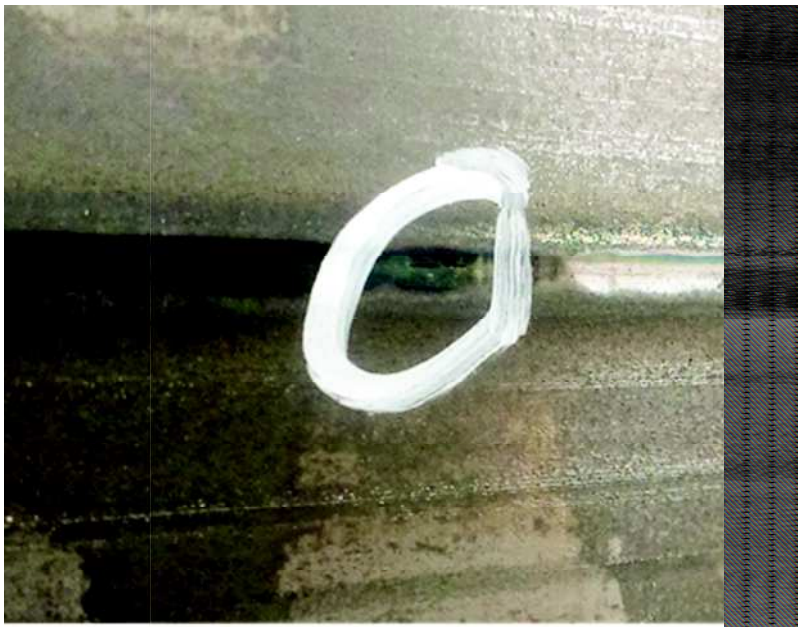

Fig. 1. Weld defects in form of holes in the flash

When analysing Table 2, it can be seen that the percentage of sections defective due to weld defects decreases year by year. However, with continuous increase in production volumes and increasing competition in the market, the occurrence of defects, even to a small extent, is undesirable and needs to be eliminated. Also presented in Table 2, the costs associated with complaints that the steelworks had to pay (over PLN 80,000) were too high for the problem of the

defective to be ignored. In addition, the so-called hidden costs of credibility in the market should also be added to the identified costs. With this in mind, at the beginning of 2015, it was decided that a method for quality control of the seam should be developed, which, in addition to the visual inspection of the worker, would significantly increase the effectiveness of weld defect detection. Customer requirements, as well as the provisions in the standard for delivery conditions, indicate that it is best to use a device capable of measuring the quality of the weld during the operation of the line, which will allow for 100% control. There are two technologies available for conducting such testing in the market. These are devices that can perform ultrasonic or Eddy current testing [13]. The method of ultrasonic testing is applicable in cases where thick plates, i.e. ones over 8 mm, are used in the production This is a volume method. Eddy current testing using a coil is a surface-based method, which in this case is the best solution, therefore it was recommended to purchase, install and commission a device for measuring the weld quality using the eddy current method, and mount it in the production line. The cost of purchasing and installing such a solution is approx. 50 thousand PLN , which gives av return on the investment within two years of the department's work.

2.2 Closed section Eddy current testing device

After analyses, the EddyCheck 5 defectoscope with X-Y and Y-t imaging and LAB 3961R UN-type coil with 2-1000 kHz frequency and a differential and absolute circuit was purchased. Aspects such as price, implementation time, difficulty iof use, availability of technical support and possibility of mounting in the already existing technological line were taken into account when choosing the solution. EddyCheck 5 is a device used to measure weld quality obtained by applying a high frequency generator and pressing the edges of a section together. The resulting surface is smoothed using a lathe tool to remove the flash. The prepared surface is checked by the segment coil, part of the defectoscope. As a result of the measurements, the device receives the information from the coil, processes it and interprets whether weld discontinuity has occurred. In this method not only holes and bad welds, but also weld fractures on the inside of the test wall can be detected, which is an additional advantage of this solution [3,1,5].

Figure 2 shows the eddy current testing device's screen. On the left is a screen with the current information. At the top of the screen you can see the current speed of the line, the set length of the section, the number of good and bad pieces, and the total number of sections produced. Below, on the time chart we can see when a defect has occurred in the past. The moment of occurrence of defects in the weld is marked in red. Detecting a defect in the tested weld by the head caused rejection and preventing the given section from moving further in the production cycle.

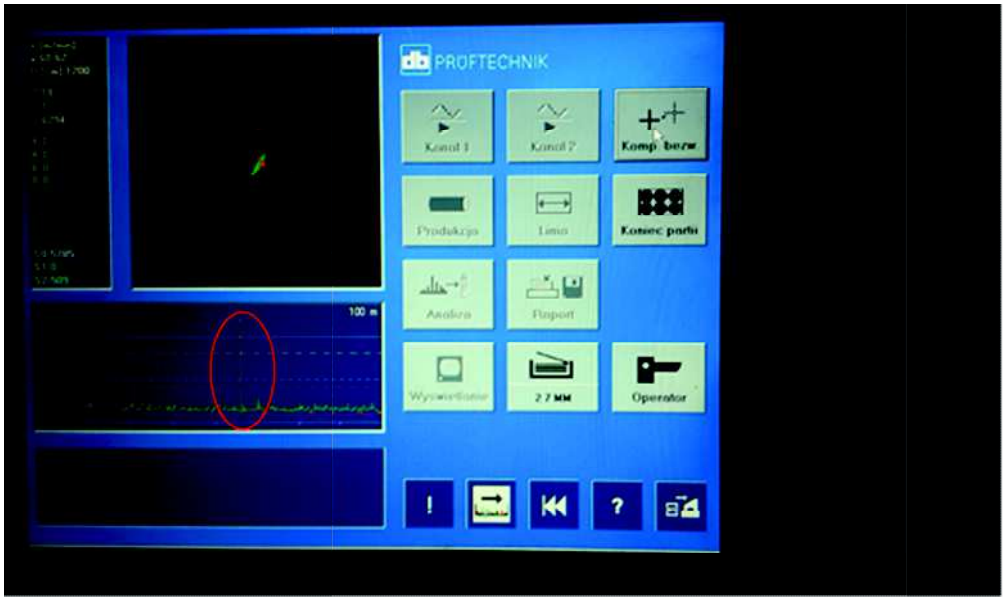

Fig. 2. Eddy current testing device screen showing the detected defect

3 The benefits of using the Pruftechnik EddyCheck 5 defectoscope

When launching a completely new production in the steel industry, where the plant had no experience in such production, it was assumed that in the initial period there might be some problems in terms of productivity, efficiency and quality of the manufactured products. The moment of the launch came at a time when the situation on the steel market was difficult. Each mistake brought costs and problems with establishing a presence in the market. In the fight for customers not only the price is a determinant but also the quality. The use of the defectoscope made it possible to completely eliminate the welds defects in the finished products, which, with successive increase of production volumes from year to year (Table 3) puts the steelworks in a good market position.

Table 3. Production volume of finished products in the period analysed

Year	2011	2012	2013	2014	2015
Production volume [Mg]	600	6000	12 300	19 000	22 300

Continuous improvement of the production process and application of solutions which help to achieve high quality of manufactured products allows the company to obtain positive opinions in the steel market. Today the steelworks enjoys a good brand in the market.

Conclusion

1. After the application of an automatic weld quality control device, the problem of complaints concerning bad welds or holes stopped. Employees responsible for proper production focus on the production process and do not need to personally check the quality of the weld

2. As a company entering the domestic market of cold-bend sections, the steelworks has shown that it cares about the quality of its products and is able to incur additional financial expenses to improve the testing process of the sections.
3. After several months since the launch of the eddy current testing device, there are no weld defects in the final product, which meets the applicable standards for sections.

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ZASTOSOWANIE DEFEKTOSKOPU JAKO NARZĘDZIA ELIMINUJĄCEGO STUPROCENTOWĄ KONTROLE JAKOŚCI W ZAKŁADZIE HUTNICZYM

Streszczenie: Postęp technologiczny pozwala w zdecydowanej ilości przypadków na wyeliminowanie metod niszczących w kontroli jakości produktów w branży hutniczej. Obecnie możemy za pomocą urządzeń wykorzystujących np. ultradźwięki bądź prądy wirowe dokonywać badań jakości wytwarzanego produktu bez potrzeby niszczenia próbki. Odpowiednio skalibrowane urządzenia kontrolne mogą sprawdzać w czasie rzeczywistym, czy dany detal jest zgodny z obowiązującymi normami i wymaganiami klienta, co w znaczny sposób poprawia wizerunek firmy i niweluje koszty związane z reklamacjami produktu.
W artykule zostanie zaprezentowane rozwiązanie mające na celu poprawienie efektywności kontroli jakości zgrzewu produkowanego wyrobu w zakładzie produkcyjnym branży hutniczej. Omawiana huta znajduje się w Polsce na terenie Śląska.

Słowa kluczowe: defektoskop, kontrola jakości, metody zarządzania jakością