Chapter 8

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ROUND BARS PRODUCTION PROCESS IMPROVEMENT INCLUDING THE TOYOTA MANAGEMENT PRINCIPLES

Abstract: This paper presents the results of the round bars rolling process under industrial conditions. Based on the study identified factors that may affect the degradation of manufactured products. Using the method 5 × why identified the main factor that is causing the greatest number of incompatibilities in the dimensional tolerance of round bars and the reasons for its occurrence. Based on the analysis of experimental results and theoretical proposes ways in improving the existing round bars production process to minimize the differences in tolerances.

Key words: method 5 x why, round bars rolling process improvement

8.1. Introduction

The accuracy of shape mills products is determined by the deviation of the actual size of the cross-section bandwidth compared to the nominal values. The main dimensions of products shape mills (round bars, square) is the height and width of the finished product and the weight of current one meter (ribbed bars). For round bars also determines the ovality, as the difference in the horizontal and vertical diameter, and for the square bars determines the difference in diagonals. Production of rolled products in the field below zero deviation tolerances is a growing interest of customers. Built new shape mills (GIACOMINI L. 2007) and modernized

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in recent years, existing shape mills (MUELLER H. 2007, DYJA H., MRÓZ S., SYGUT P., SYGUT M. 2012) manufactures finish products in dimensional accuracy of less than 1/4 of DIN. Upgrading an existing rolling process and rolling equipment and accessories and the production of rolled products within a narrow range of dimensional tolerance, which results in a considerable savings of metal, and reduced weight structure, equipment and machine parts (LESIK L., MRÓZ S., DYJA H. 2001, RUDSKOJ A. I., LUNIEV V. A. 2005).

One of the main factors that affect the dimensional accuracy of the finished product during the rolling process, is temperature distribution along the length of the charge. The nonuniform temperature distribution in the volume of the batch and then rolled band on changes in the plastic flow of metal into the roll gap, and the kinematics of the rolling process. Are changing then the conditions of friction and plastic properties of the rolled band along its length, resulting in changes in the delay and overtake, bandwidth expansion and forcefully change the parameters - power during the rolling process of shape mills products (COUCHAR G. 1963, GŁOWACKI M., MRÓZ S., LESIK L. 1999, KAWALLA R., DYJA H., CHEREDNIKOV V. A., BLOKHIN A. A. 2009, LESKIEWICZ W., JAGLARZ M., MORAWIECKI M. 1977, LUNDBERG S. E. 2004, ŁABUDA E., DYJA H., LESIK L. 1992, MORAWIECKI M., SADOK L., WOSIEK L. 1986, MRÓZ S., JAGIEŁA K., DYJA H. 2007, MRÓZ S., SYGUT P., DYJA H. 2009, MRÓZ S., LABER K., SYGUT P., DYJA H. 2013, MRÓZ S., LABER K., SYGUT P., DYJA H. 2012, SYGUT P., LABER K., BORKOWSKI S. 2012).

Predicting metal plastic flow during rolling rods and profiles in the grooves is one of the more complex issues, especially in the design of a new rolls calibration. Knowledge of changes in the shape of a rolled band and deformation indicators (widening, extension) is not sufficient for the proper rolls calibration development and rolling process in grooves technology. Theoretical determination of local velocity fields and peculiarities of plastic flow of rolled metal in the entire volume of the roll gap, taking into account the shape of the band, its temperature, rolling speed, changes in the metal yield stress and the friction of on metal contact surfaces with the rolls, can significantly speed up the design process and effectively rolling. It also reduces the cost and time-consuming empirical studies necessary for starting up production of new products in the shape mills or improvement of existing technologies. (BROVMAN M. 1991, DANCHENKO V., DYJA H., LESIK L., MASHKIN L., MILENIN A. 2002, MRÓZ S., SYGUT P., DYJA H. 2009, MRÓZ S. 2008, DYJA H., MRÓZ S., SYGUT P., SYGUT M. 2012).

8.2. Development trends of shape mills

Rolling mill Is called steelworks production department or an independent economic unit, equipped with complex machinery designed to carry its own rolling process and perform other technological operations (MRÓZ S., JAGIEŁA K., DYJA H. 2007). The main division of mill is dependent on the temperature at which the process is carried out, therefore, is distinguished by hot and cold rolling mills. In addition, mills divided by type of product produced and the arrangement of mills and their mutual cooperation (DYJA H., MRÓZ S., SYGUT P., SYGUT M. 2012, LESKIEWICZ W., JAGLARZ M., MORAWIECKI M. 1977).

Shape mills are independent production plants or departments steelworks, which produce the bars, profiles, wire rods and strip sizes. Linear shape rolling mills are with old structures, even though they are still used in the old metallurgical plants for the production of bars and profiles. To keep band between the stands cooling equipment is used or manual mode, which limits the speed and efficiency of the rolling mill. The development of rolling technology and rolling equipment caused the tandem rolling mills were built. Rolling mills are allowed to increase the rolling speed, yield and dimensional accuracy of the finished goods. When increasing the rolling speed and the placing on during rolling conveyor system band between individual stands, observed the benefits of reducing heat loss in roll band. This led to further development of the mill, the mill semi - continuous to continuous rolling mill. In addition to reducing heat loss from the rolled band of continuous rolling mills, also reduced the temperature difference rolled band end, compared with older rolling mills (linear) and increased the weight of the feedstock processed several times during the rolling process and the overall yield of the mill (NIESLER M. et all. 2007, DYJA H., MRÓZ S., SYGUT P., SYGUT M. 2012).

Currently being built shape continuous rolling mills are equipped with measuring equipment (temperature, geometric dimensions band, performance strength and energy, etc.) and individual control of individual working stands within rolling. This feedback loop measuring devices and equipment rolling mill enables the production of finished products about narrow tolerances (reaching the dimensional accuracy of less than 1/4 DIN). The introduction of fully automated continuous rolling mill equipment increased the speed of rolling mill (for round bars with a diameter of 10 to 25 mm speed increased to 16 m / s) and the weights of the feedstock, thereby increasing its efficiency. The total yield of the new mill is up to about 96%.

8.3. The round bars rolling process in technological terms

The round bars rolling process with a 70 mm in diameter in a analyzed continuous shape rolling mill D 370 (Fig. 8.1) is realized in the first eight rolling stands. Feedstock before the rolling process is controlled (dimensions, surface, number of melting) and then heated in a walking beam furnace according to the technology of heating of the steel grade. When heated to the appropriate temperature is subjected to descaling operations generated by the heating process. The next stages are technological operations of rolling in individual stands.

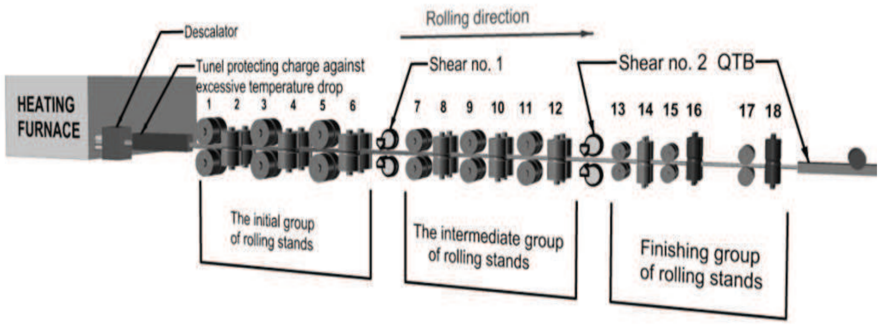

Fig. 8.1. Installation diagram of machines and equipment in continuous rolling mill D 370.

Source: DYJA H., MRÓZ S., SYGUT P., SYGUT M. 2012

After the hot rolling process band is stored in the cooling table, where it cools down to ambient temperature. The final stage of production is cut band on trade lengths, quality control, weighing and tagging (a type of bar, size, weight, grade of steel, etc.). A detailed diagram of the production of bars with 70 mm in diameter of is presented in fig 8.2.

Fig. 8.2. The round bars production process with 70 mm in diameter in technological terms

Source: Own elaboration

Where:

1 - charges storage,

2 - transport of charge for the position control,

3 - charge control before the heating process,
4 - charge transport to heating furnace,
5 - the charge heating process in a walking beam furnace,
6 - charge transport to descalator,
7 - the scale descaling process from the surface of the charge
8 - the charge transport to the mill stand No. 1,
9 - the charge rolling process in mill stand No. 1,
10 - the band rolling process in mill stand No. 2,
11 - the band rolling process in mill stand No. 3,
12 - the band rolling process in mill stand No. 4,
13 - the band rolling process in mill stand No. 5,
14 - the band rolling process in mill stand No. 6,
15 - cutting band beginning,
16 - the band rolling process in mill stand No. 7,
17 - the band rolling process in mill stand No. 8,
18 - band transport on the cooling table and its free cooling,
19 cooling, band storage and transport on the cooling table,
20 - band cut to the required trade length,
21 - control of the final product (weighing, tagging),
22 - transport the finished product on magazine of finished products,
23 - storage of the finished product.

8.4. Using method 5 x why in assessing the quality of the round bars production process

Method 5 x why, otherwise known as Root Cause Analysis, is an analysis of the causes of the phenomenon under consideration, consisting of five times the answer to the question "why?", is an integral part of kaizen. Kaizen is a business practice, which the basic principle is the continuing commitment and the desire to constantly improve the quality of the company and the product. Although kaizen is considered philosophy - because first of all change the way of thinking - in practice, implementation is a collection of "hard" and effective tools for introducing and maintaining changes in processes and organizational resources. Kaizen through the gradual improvement of all aspects of the company seeks to achieve the following objectives:

- reduce the time carrying out the work process and improve the quality,
- Technical adjustment of the system components,
- formation evaluation criteria and reward,
- cost reduction.

5 whys method is a simple and effective way to break through the layers causes the problem to get to the root causes and prevent recurrence. This method allows the detection of the root cause of the problem. The work begins with asking the question, why was the problem, then repeat the question why this problem existed until you find the last, the most important reason. How to use method 5 x whys? can be described in four steps (BORKOWSKI S. 2012, BORKOWSKI S. ULEWICZ R. 2008):

- selecting repeated problems
- to discover the first layer, It should be asked, why is this a problem or problems have occurred?
- taking into account the cause or causes of the problem in the first layer and the question why the problem or problems have occurred?
- repeat the question as to why there were previous reasons until you find the most important, the underlying cause.

Based on the presented method 5 x whys? which was carried out with the participation of the mill workers of different levels it was found that the main cause bars production about incompatible tolerances is to change the temperature of the rolled band. The main cause of non-uniform temperature along the length of the rolled band was non-uniform temperature distribution along the length of heated charge. This problem is formed during heating furnace exploitation. During the charge heating process on its surface creates a scale that peeling lying between fixed and moving elements of the furnace hearth. This causes wear on the furnace sealing and those locations into the furnace chamber gets into the cold air, which causes non-uniform temperature distribution along the length of heated charge.

8.5. Ways to improve existing round bars rolling processes in the analyzed mill

Therefore, in order to reduce the effect of non-uniform temperature distribution in the charge to homogenise the round bars dimensions along their length, should be carried out regeneration heating furnace or modify existing technology of rolling. Furnace repair, unfortunately, is a long term suspension of production and the high cost of repairs and the cost of stop the mill.

When modifying an existing line rolling and rolling technology can be much lower financial outlay minimize the existing problem. The existing mill line in this case should be equipped with temperature and rolled band speed sensors and measurement card - control, which would be connected on-line through the computer with the drive stand over the rolling. The proposed solution should be a rolling sequence equipped with sensors whose task is to measure the temperature and speed of the rolled band in real time. The signal from the sensor is transmitted by the measurement and control card to the computer with a program that, based on the data obtained will control the speed of rolls mill stands No. 7 and No. 8.

8.6. Conclusion

Round bar with a diameter of 70 mm were selected due to the fact of the greatest quantity of finished products in which there is a discrepancy between the dimensional tolerances during their production to the requirements of the standard.

Based on the results of Method 5 x whys? it was found that the change in temperature along the charge length is a major problem of the analyzed mill and causes dimensional incompatibilities in rolled bars. The non-unform temperature distribution in the rolled band is influenced by charge heating process. The differences between temperature along the charge length, resulting from the manner of heating prosess may be from 30°C to 110°C. While charge heating process, the areas of lower temperature, compared to the rest parts are formed usually in contact charge with seals of fixed and movable beam of walking beam furnace hearth. These are the places where to the chamber of heating furnace cold air leaks.

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