TECHNOLOGICAL AND PRACTICAL ASPECTS OF ADOPTING AND IMPLEMENTING IN PRODUCTION OF SOME HIGH QUALITY CONSTRUCTION STEEL GRADES AT "STOMANA INDUSTRY" SA

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ABSTRACT

During the last 10 years "Stomana Industry" has developed the production of rounds for high-quality steel grades. For that period the produced amount of high quality rounds has been more than tripled.

Part of that result has been also achieved by adopting and implementing in the production route of new steel grades with respect to the up-to-that point traditional plant experience, like some low alloyed steels, medium and high carbon steels, boron steels and other customized grades.

The main reasons for the efficient adopting of the new steel grades into a successful process stem from: evaluation of the metallurgical behavior of these grades before entering them into our technological production line; definition of optimal process parameters for each grade starting from the scrap recipes and raw materials preselection till the final production step;

appraisal of all the important process parameters for melting and oxidation, secondary metallurgy, continuous casting, conditioning and rolling, getting any feedback coming from the final inspection lines and laboratory analyses, and examining potential rules for updating the process, finally, applying in practice the suggested improvements.

In this study, the main practical steps, taken by our company, are thoroughly marked. Furthermore, any development into the technical and technological capabilities of the plant that lead to an efficient production of an increased number of grades and high-quality final products will be discussed, as well.

Keywords: "Stomana industry" SA, hot-rolled long products, technological line, high-quality steel.

"Stomana Industry" SA has been producing for many years a big variety of final steel products, starting from plates, rounds, rebar, mining profiles, metal spheres, angles and UPNs, flats and other hot-rolled long products.

A program for increasing the production of rounds in high quality steels started about 10 years ago and from 40 to 50 thousand tons per year in 2006-2007, in 2015 we reached 156 thousand tons while expectation for 2016 is higher.

The development of that production passes through the implementation in production of new steel grades for our company. At the beginning of 2006 the main production was from medium carbon non-alloyed construction steels and low alloyed structural steels. In the last 4 years we faced an increase in the area of alloyed steels for quenching and tempering, alloyed structural steels, increased volume for the free cutting steels and case hardening steels.

The technological line of the melt shop of "Stomana industry" SA is presented in Fig. 1 and includes, scrap yard, AC EAF using 100 % scrap, LF, VD (used only for the high quality grades) and CCMs. A billet conditioning line is operating for the high quality surface requirements.

Adopting and production implementation of new for our company steel grades starts with evaluation of the metallurgical behavior before entering them into our technological production line. This process begins

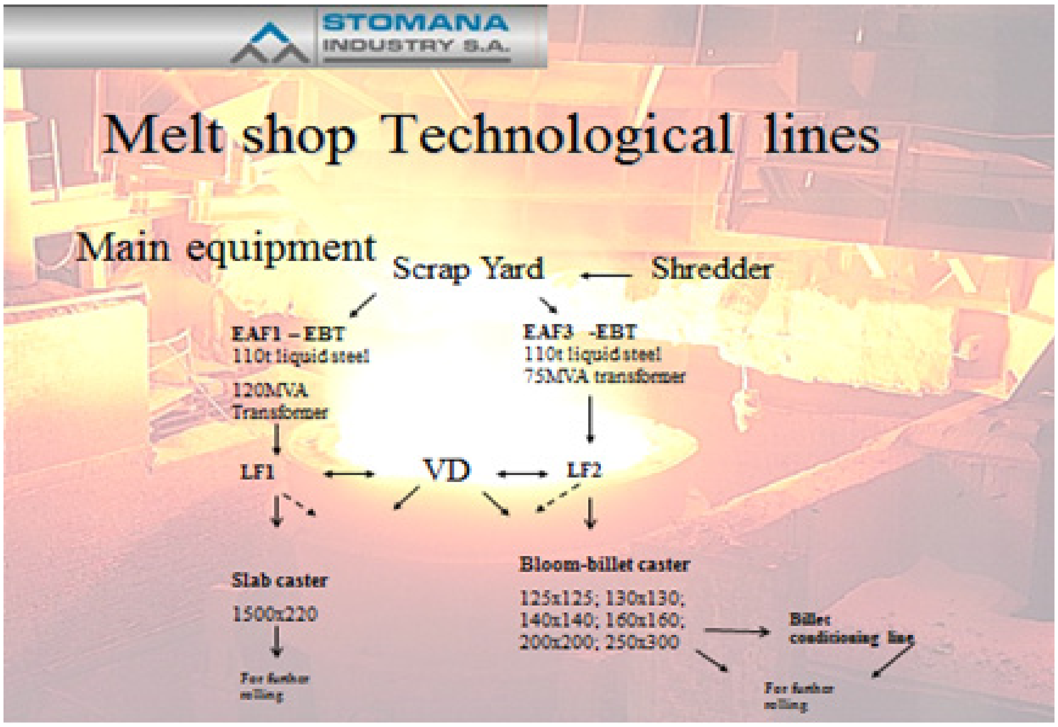

Fig. 1. Melt shop technological lines.

with optimization of the required chemical composition.

The initial variant starts with covering the specifications - composition and properties. One new standard or customized steel grade usually fix relatively wide limits for some elements and carbon equivalent. It requires achieving the limits of some mechanical properties after rolling. Some hardenability characteristics and guaranteed cleanliness rate from non-metallic inclusions are also requested.

Than additional elements for proper deoxidation and grain size control are added and calibrated by us. In many cases such elements like Al, Ti, Nb, V, become involved additionally in order to achieve the optimum of the quality and properties.

The first evaluation that we make having the initial variant, is whether a grade is crack sensitive (considering our production process) and in such case, we try to evaluate the extend. For example, if the grade is in the peritectic area, with high nitrogen content, aluminum killed and is alloyed with V, Nb or Cr, then the crack sensitivity is very high, so additional measures against appearance of defects have to be scheduled in order to start industrial trials. These measures have a target to avoid increasing further the crack sensitivity and if possible, even decrease it.

One of the approaches is avoiding chemical composition with very high percentage of elements that might increase the crack sensitivity. Another one is the use of alloying practice that will reduce the formation of some undesired nitrides, carbo-nitrides or compounds that might be involved in potential cracks formation. But sometimes the steel grade requires high percentage of elements that are increasing crack sensitivity, and it is unavoidable because of the demanded specification. An example could be the free cutting steels, having high P and S content by definition. In order to produce them successfully we target in our practice to remove from the peritectic area. In addition, we lower Cu content aiming at avoiding any further increase of the already given high risk of defects.

After finalizing the design of the complete composition, for steel grades which require certain hardenability, we apply a model for hardenability calculation. If the optimum composition for lowest possible defects, sensitivity, and sustainable mechanical properties is defined, and the model for hardenability is giving satisfactory results, we consider the case as successfully completed.

Then the process starts with the first practical step - choosing the scrap recipe. We consider the two main influencing parameters which have to be defined. First one, what should the Cu content be - very low, low or up to the allowed limits of the specification? And in case the crack sensitivity is high, the high Cu content might be an additional negative factor. Practically we consider Cu content as a "filter" for the scrap cleanliness. Our data prove statistically that low Cu scrap contains also lower amounts of P, S, As, Sn, etc. After answering the question how "clean" should the scrap be for a corresponding grade, we have to answer the next question related to the scrap recipe - what should be the carbon content of the used scrap? The evaluation is based on the target for the active oxygen during tapping from the furnace. One normal efficient value might be 550 ppm, but if the requirements for non-metallic inclusions are very strict then that target gets definitely lower. And if it is much lower it means practically that the carbon content in the scrap has to be increased (for example with the addition of pig iron), and additional technological measures have to be taken so that phosphorus content will not be high during tapping, considering that oxidation will not be strong enough to assure easy dephosphorization process.

The correct scrap pre-selection is extremely important due to the fact that it has not only to assure part of the targeted composition, but also has to be optimal from a cost point of view. This part of the evaluation does, to a certain extent, influence the production cost of the new product. After defining of the scrap recipe and limiting all the elements of the composition, we proceed with defining the parameters during production.

Normally, an EAF is following a standard profile for melting and oxidation. The parameters there are more oriented towards productivity and cost. The main technological parameters that have to be fixed per grade are: tapping temperature, final oxygen activity and tapping recipe. The tapping recipe has not only to do with the quantities of the relative materials, but with the sequence of their addition into the stream, as well. In many cases this sequence influences not only the type of the inclusions that are created but also the composition of the slag in the ladle.

The process of secondary metallurgy has a big influence on the final steel cleanliness from non-metallic inclusions. That is why we evaluate some of the parameters based on the requirements for the steel cleanliness. One of the most important target parameters, we aim to design, is the composition of the slag and practically the basicity, the amount of alumina and silica and the (FeO) and (MnO) content. Another very important factor is the stirring intensity for which we define an optimum profile. And last but not least, is adopting the technology for modification of non-metallic inclusions aiming at their removal from the steel, not only to make them liquid at a specific temperature.

The technological parameters of vacuum degassing are determined by the answers of two main questions:

- what is the flake sensitivity of the grade;
- what are the requirements for the internal quality of the solidified structure and what kind of thermal treatment might be applied from the end user.

Depending on the evaluation of how low the hydrogen content has to be, the parameters for treatment are defined.

In any case the high quality grades pass that production step by definition as far as it is not possible to achieve the same industrial result with and without vacuum for internal quality, especially for bigger sections.

The Continuous casting process needs some parameters that will be optimal for the corresponding grade. One critical parameter influencing the quality is the casting speed. Its optimum for every grade is an essential parameter as from practical point of view, higher than the optimal speed means more internal defects and lower speed apart from the negative impact on the productivity and cost might also create surface defects issues. Stomana's bloom caster is equipped with mold electromagnetic stirring and the intensity of the stirring (frequency and current) is one important parameter, influencing directly the success of the internal quality of the final product.

Important role during casting plays the path of the steel from ladle to the mold. But normally this is something that every plant applies either for all the cast products or per groups and is not something that needs to be specified per grade. Considering that a superheat of about 30°C is a standard practice, the parameters that must be customized for grade or group are:

- Casting speed (m/min);
- Grade of mold powder (means properties like basicity, viscosity, meting point, etc.);
- Stirring parameters (Hz, A);
- Specific secondary cooling in l/kg.

After casting of the blooms, there is another alternative. For an acceptable surface quality of the final product, many grades need surface grinding of the blooms before being charged in the reheating furnace. In order

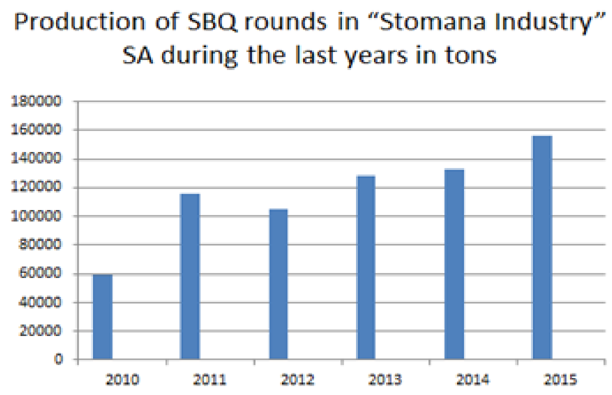

Fig. 2. Production of SBQ rounds in "Stomana Industry" SA during 2010 - 2015.

to determine the correct mode of grinding (depth, areas, etc.), a practical experience is required, which should be based on the feedback from the inspection lines. At this production step, each different grade may have different optimal mode. Up to that point there are more possibilities for the plant to make changes of the parameters per grade. In practice the reheating and rolling processes are much more standardized. It is not practical to have for example different pass design for rolling of one and the same product from different grades, and that is why the main option for optimizing the parameters per grade remains with the Melt shop.

The main source of feedback are the inspection lines which in Stomana plant include also surface quality evaluation using MLF and internal quality checks using automatic Ultrasonic testing devices. The cases of negative results from inspection lines are sent for laboratory investigation for finding out the respective root cause. These lines are the main source of feedback for optimizing the production parameters of the Melt shop also. Depending on this feedback, corrections in the process parameters are being scheduled. When the result from the inspection is close to 100 %, then the parameters are considered as optimized and the standard operational practice is established to all the control points of the technological route of the new product.

The systematic approach in implementing new steel grades in production helps us to be on the sustainable trend presented in Fig. 2.

CONCLUSIONS

As a conclusion could be summarized that the main steps for the efficient adopting of the new steel grades into a successful real production process are established on the base of:

• evaluation of the metallurgical behavior of these grades before entering them into our technological production line;

• definition of optimal process parameters for each grade starting from the scrap recipes and raw materials preselection till the final production step; appraisal of all the important process parameters for melting and oxidation, secondary metallurgy, continuous casting, conditioning and rolling, getting any feedback coming from the final inspection lines and laboratory analyses, and examining potential rules for updating the process.

These steps lead to the development into the technical and technological capabilities of the production with adoption of an increased number of steel grades in the high-quality final products.

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