DEVELOPMENT DIRECTIONS OF THE INTEGRATED PRODUCTION PROCESSES OF FLAT PRODUCTS

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Abstract

Aspiration to reduce production costs of rolled products extorts a need to minimize energy consumption as well as the quantity of rolling stock. Direct rolling implementation without heating thin steel ingots is one of ways to achieve this objective. The work presents assumptions of integrated process called AST – Arvedi Steel Technology, in which rolling strips proceeds directly after ingot output from the casting machine. A main aim of this concept is to eliminate the reheating process by a maximum use of heat contained in the liquid steel. The most important advantages of this process compared with the conventional are: a huge energy consumption, pollutants reduction as well as the entire technological process and production line reduction. Moreover, a needed time to produce flat products of liquid steel is only 15 minutes. AST integrated process is supposed to appoint new directions in the production processes of steel strips.

Keywords: hot - rolling mill, steel, strip, steel industry, integrated processes

1. INTRODUCTION

Hot-rolled metal sheets and strips are very important amongst produced products. They constitute a necessary material for operation and development of many industries, such as motorization, aviation, household, energetics, architecture and many others. Production of steel strips in the world still increases over the last decades. In highly industrialized countries, more than 50% of total rolled products production constitutes hot-rolled sheets and strips. An increase in the steel strip production was achieved both by construction of new rolling mills, as well as by improvement of the rolling process.

In initial development stage of a sheet mill and strips the main purpose was to increase productivity. It was held by applying a greater number of mills, larger engine power and higher rolling speeds [1]. At a certain stage of rolling mill development the final objective was changed to produces product about the best quality. Greater automation of rolling process and next the computer technology implementation contributed to achieve this objective.

In today's changing and competitive market the key principles in production technology of rolled products are: high performance, low operating costs, high quality and high flexibility. These objectives force steel manufacturers for continuous improvement and development of production technologies, seeking intelligent and innovative solutions, as well as to apply modern equipment of rolling mill.

2. TECHNOLOGICAL PROGRESS AS A FACTOR INTEGRATING PROCESSES IN THE METALLURGY

A development process of production flat products is conditioned by obtaining a product, which would meet in the widest degree of increasing user’s requirements. Only products corresponding to the highest quality standards, produced in the competitive costs and on time delivered, can find recipients in an increasingly global and strongly focused on the buyer’s market. At present the quality became a basic parameter, which determines products competitiveness.
Development activities in the production field of flat products are adequate to eliminate preliminary stages of plastic forming, at simultaneous maximum casting and rolling process integration. Main factors which enforce or support production integration process of metallurgical products are as follows [2]:

- aspiration to reduce capital costs - reduce devices number,
- aspiration to reduce production costs - reduce number of technological operations, individual energy consumption and auxiliary materials, labor intensity as well as reduction or liquidation of semi-finished products storage cost,
- aspiration to increase the output,
- take into account requirements associated with the environmental protection,
- need to increase quality and properties of products as well as aspiration to produce products about new features, by increasing a degree of controllability.

Technological integration processes is one of main progress directions in the production field of metallurgical products. Currently, progress in the integration processes consists on partial integration, involving a few production stages functioning individually so far, or on a new technologies introduction with the highest integration degree. In integrated rolling mills the following developmental trends are noticeable, both in terms of devices and applied hot rolling mill technology of steel strips [3]:

- casting ingots out about shape more similar to the finished product and direct rolling without reheating,
- further technological processes integration of already existing integrated rolling mills with other metallurgical processes,
- casting technology improvement of thin flat ingots - increase in the casting speed, purity improvement of steel and ingots quality, greater use of heat in a liquid steel.

The idea of integrated casting and rolling was presented schematically in Figure 1.

![Fig. 1. Outline of basic operations in the integrated process of casting and rolling strips [1]](image)

In the integrated production process of hot strips in a constant way the following operations were connected:

- ore reduction as well as carrying out the concentrate of iron, provided as a stock to the steel furnace at a temperature over 600°C,
- melting of steel and secondary metallurgy,
- constant casting of thin or indirect ingot,
- cutting the strip into sections,
- reheating the strip in order to level a temperature on its section,
- rolling on the thickness of final product,
- cooling and coiling finished strip.

A next step in the production development processes of steel strips is implementation technology, based on direct casting of very thin ingots about thickness below 5 mm as well as integration with the rolling process, which will eliminate or significantly reduce the initial rolling phase, obtaining the following benefits [4]:

- eliminate many devices applied in the traditional production strips lines,
- reduce halls area by shortening the production strips line,
- uses for rolling a part of heat contained in the liquid steel,
- reduce production time of strips from the delivering liquid steel, with over 5 h for the conventional process, to 15 minutes in case of an integrated process.

A maximum heat use, which is contained in the liquid steel, reduce energy consumption, reduce environmental pollutions, reduce investments and operating cost of the rolling mill are a main aims of the integration technological processes.

**Computer Control System:** The concept of an integrated casting and rolling process assumes applying a wide automation range. In order to obtain the highest product quality, at possible the lowest production costs, it is necessary to apply constant operating procedures as well as control the entire process in a real time. Such requirements meet only a first-class computer system.

Automation system includes various hierarchical levels. Central System of the Production Management CEDA is on the highest level, which performs following functions for the entire unit:

- management and programming of the production,
- central management with the production cycles,
- process supervision,
- manage storage zones of rolled products.

Individual areas are controlled by autonomous computers: CBCC (Ceda Billet Caster Control) and CRMC (Ceda Rolling Mill Control). The following functions meet these local systems:

- monitoring process with the help of user interface,
- technological databases management,
- sequences control of logical devices (data exchange with PCL drivers).

Program periodically checks the value of certain significant variables, which have an impact on the metallurgical quality. In case when e.g. in ingot crystallization an acceptable deviations will be crossed, this irregularity is valid to the report quality and may be indicated by operator. In such a way the ingot can be removed from the roll line for later more accurate inspection.

Control system applied in the process among others presents the following advantages:

- allows for a significant employment reduction. Service staff is limited to a minimum and may work in one branch, without a need to divide it into COS and rolling mill,
- increases safety and improves working conditions. Both the COS machine and mills of roll line are fully automated. They are controlled from central desktops, which impacts on safety and comfort of the work service,
- excludes possibility to make mistake by the service. Operating errors may impact on the quality deterioration, and what's more may be a cause of production stops or accidents. Therefore, automation provides better production continuity as well as the highest products quality.

### 3. ECONOMIC AND QUALITY ASPECTS OF ROLLING STRIPS FROM THIN INGOTS

Economic positive effects of applying integrated technologies results from a direct casting process connection of thin ingots and finishing rolling in the roll line. Industrial implementation of this technology enables for a maximum reduction in the production line, in terms of its length as well as time passing from the release of liquid steel into the tank, all the way to receipt of finished product.

Casting process of thin flat ingots effectively opened the rolled flat products market for so-called minihot, which since then were more associated with the production of long products. Integrated strip mills can be built for the annual production on a level of 1.5-2.0 mln Mg using one-strand machine COS. Both investments and subsequent operating costs are competitive in relation to level of a conventional strip mills.
Implementation of modern integrated rolling strips technologies, among others: ISP type (Inline Strip Production), CSP (Compact Strip Production), resulted in a drastic reduction of plastic processing degree from about 125-150 to 7 and even below 3 during strips casting (Direct Strip Casting – DSC) [5]. Processing degree has impact on the final structure as well as mechanical properties of finished products. Generally it is assumed that as a processing degree is higher, the properties of obtained products in the plastic forming processes are better. In order to limit the reduction effects of processing degree it is aspire to obtain the best properties of thin ingots, applied as a stock for hot rolling mill. Steel strips received in integrated processes of CSP or ISP type are applied in the most demanding automotive industry to the internal car body elements. However, best received strips are suitable for the most responsible outside parts of sewing car body in conventional rolling mills, mainly due to very large degree of plastic processing and obtained properties, including surface quality. Currently integrated mills CSP or ISP rolls a wide range of steel kinds. However, the largest group of 50-80% constitutes non-alloy steels, from very low to the high content of coal 0.04-1% C. Remaining part constitutes steels of HASLA, silicon (electro-technical) as well as DP and TRIP types [6].

Both investments and subsequent operating costs for the integrated process are on a competitive level in relation to the conventional mill. For example, investments were of row:
- about 200 USD/Mg for CSP rolling mill with productivities of 2.5 Mg/r,
- about 900 USD/Mg for conventional rolling mill with productivities of 4 Mg/r.

In CSP rolling mills an average productivity increased fourfold compared with the conventional rolling mills:
- 0.3-0.6 rb. h/Mg (average 0.5 rb. h/Mg) for CSP rolling mill,
- 1.5-3.0 rb. h/Mg (average 2 rb. h/Mg) for conventional rolling mills.

4. NEW DIRECTIONS IN THE PRODUCTION PROCESSES OF STEEL STRIPS

As a result of research over drawing up new technology of casting flat ingots about thickness the most similar to finished product appeared assumptions [7], which are a basis for the integration technological processes of casting and rolling strips:
- large differences in a speed of casting and rolling force the need to cut flat ingots into appropriate lengths directly after casting,
- ingot length after cutting results directly from the standard individual mass range of ready strip, which cannot be smaller than 18 kg/mm,
- minimal individual mass range of 18 kg/mm gives as a result the length of ingot equal to 47.4 m at thickness of 50 mm as well as 59.2 m at thickness of 40 mm,
- ingots use with a thickness in the range of 40-50 mm allows for a total elimination of the initial mills group, cluster, and thus initial rolling to obtain wire rod,
- length limitation of heat furnace and the entire technological line causes that the ingot thickness equal to 40 mm is a minimum stock thickness.

Direct rolling implementation of thin steel ingots, i.e. without reheating, is a research aim from many years in the metallurgical industry. Elimination of the reheating process carries many benefits, ranging from a reduction in energy intensity, pollutants emission, all the way to technological process as well as the entire production line reduction. A response to those requests is an innovative integrated process called Arvedi Steel Technology - AST drawn up based on ISP line experiences [8], in which rolling strips proceeds directly after ingot output from the casting machine. This process is supposed to start appoint new directions in the production processes of steel strips. Layout of the basic devices in this rolling mill type was described in Figure 2.
This process idea is to reduce energy consumption through better use of heat contained in the liquid steel, what leads to an elimination of reheating ingots process. Roll line AST consists of seven mills, from which three are four-high rolling mills of HRM type, and four mills have a typical structure for the finishing group. Planned production capacity is supposed to amount up to 2.2 m Mg/year, and minimal thickness must amount in a range of 1-0.8 mm. Length of the entire technological line, from COS machine pivot to coiler pivot, will take about 70 m. In this process there is no need of discharge, storage and repeat material loading between individual operations, therefore a total material number, space used in the process as well as number of employees are reduced significantly, thereby investments and operating costs also are reduced, among others: energy consumption necessary to drive the devices, employees remuneration, depreciation, etc. Compared with the integrated ISP process, energy conservation are considerable, since AST process requires it less of about 81.5%. Investments as well as operating costs to build such an integrated installation in Europe are estimated at about 115 million euros. These costs are much smaller than building costs and operation of a conventional installation; moreover the energy consumption in integrated installations is lower of about 80%, what makes this installation a developmental and future trend in the metallurgical industry.

5. CONCLUSIONS

An integrated production processes are the future technology in metallurgy, which are characterize by a very high degree of technological development, low production costs and the best products quality. These processes will have an increasing share on the marketplace of rolled products as well as will include wider dimensional and types range of strips and sheets. Currently, there are carried out advanced AST technology research, which are supposed to appoint a new directions in the production processes of steel strip. The main aim of this idea is to eliminate reheating process for further pollutants emission reduction, the entire technological process and production line reduction as well as production costs by increasing material’s output. In addition, energy consumption in the integrated installations is lower compared with the conventional production of flat products about 80%, whereas total production costs of rolled products are smaller about 20%. Integration processes has not only an impact on increasing metallurgical units productivity, but above all improves their economic balance.

LITERATURE


