ERT-EBROS BILLET WELDING TECHNOLOGY FOR LONG PRODUCTS *

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Abstract

The ERT-EBROS system welds consecutive billets together so that they can be rolled in an endless rolling process. This increases output, enhances the utilization of cooling bed and makes the production of customized coil weights possible, even when only small-weight billets are available. ERT-EBROS employs a dynamic flash welding process, in that all the process parameters are dynamically controlled in real time, ensuring a high quality of the joint as well as a reduction of consumed energy and material loss. The quality and reliability of the installed components limit the maintenance requirements, so that a high availability of the system is granted. Among the advantages offered by ERT-EBROS there are: metallic yield improvement, increased mill utilization, coil weight flexibility. The main technical concepts of the system and the latest installation of ERT-EBROS in the PROC are presented.

Keywords: Billet welding, Yield improvement, Flexibility, Utilization

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1. Introduction

Endless rolling processes have the goal of increasing the plant productivity, improving the yield, favor the consistency of product quality, allow a smooth rolling mill operation, favor the flexibility, lower the production costs.

Billet welding is one of the available endless processes for long products rolling. Originally conceived around mid-20th century, the first industrial installation was realized in 1990 at an Austrian mill where 62 mm round billets were welded with a productivity of some 20 t/h. Trials were then done in Asian countries and showed how the billet welding could be profitable for long products production. Several mills later installed a billet welding system. Early installations were affected by problems with equipment malfunctions, maintenance and product quality, which would lead to frequent stoppages and discontinuous operation. These issues were addressed and solved by the technology providers during the 2000s.

The ERT-EBROS system by Primetals Technology is based on an innovative design and process, and it enables the uninterrupted production for more than one shift. Its anti-spatter protection and dynamic flash control feature allow a clean and smooth opera-tion.

Installed for the first time in Europe in 2006 (Figure 01), ERT-EBROS was further improved and innovated in the subsequent realizations. It consists of a complete technological package and operational know-how.

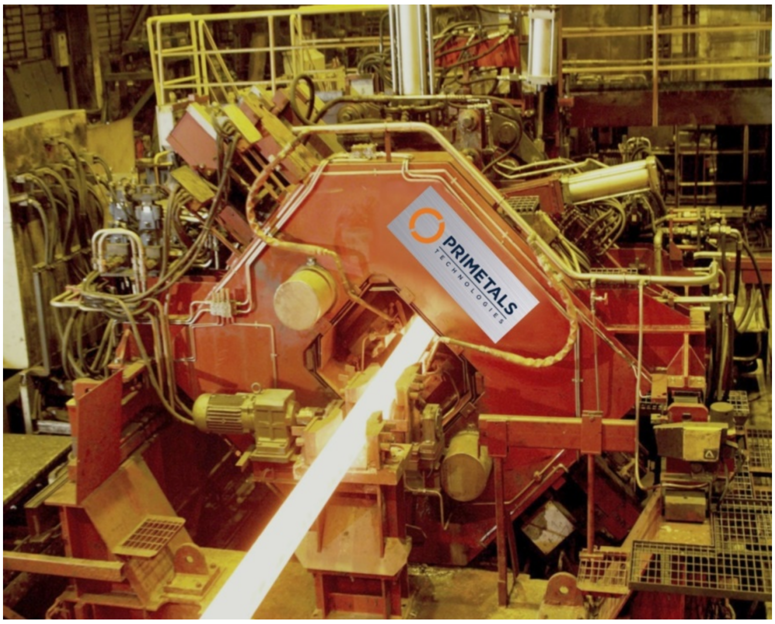

Figure 01 ERT-EBROS installed in 2006

2. Description of ERT-EBROS

2.1. Welding process

After being heated to the scheduled temperature, the billets are discharged from the re-heating furnace, descaled with high-pressure water and transferred by a variable-speed roller table to a sturdy welding unit mounted on a car which travels in synchronization with the rolling speed at the first stand (Figure 02).

The walking-beam type furnace (figure 02) has a rated production capacity of 90 tph

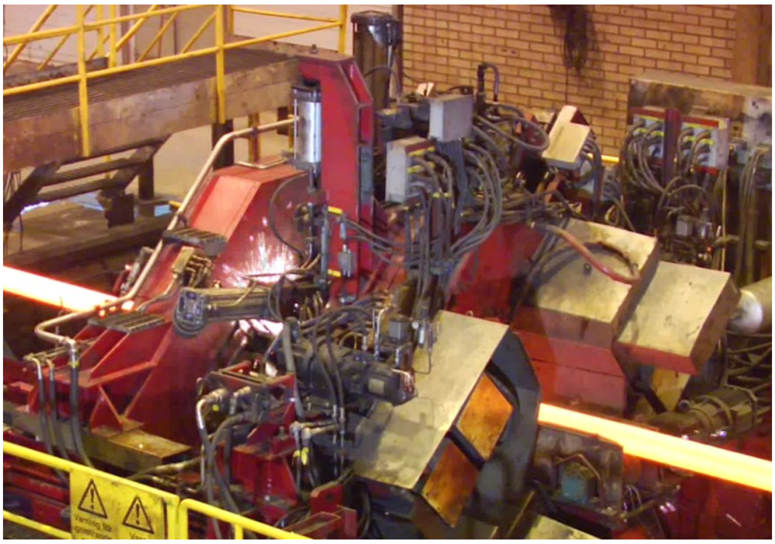
Figure 02 Welding unit of ERT-EBROS

The tail and the head of two adjacent billets are securely clamped at the correct relative position, and a very intense current flow in the joining area is established. The melting speed of the material is controlled by dynamically adjusting the gap between the billets which is generated as consequence of the melting.

A few instants later, when the quantity of melted portion of the billets has reached the desired value, an hydraulic upsetting mechanism presses the two billets one to another so that a joint is established (Figure 03).

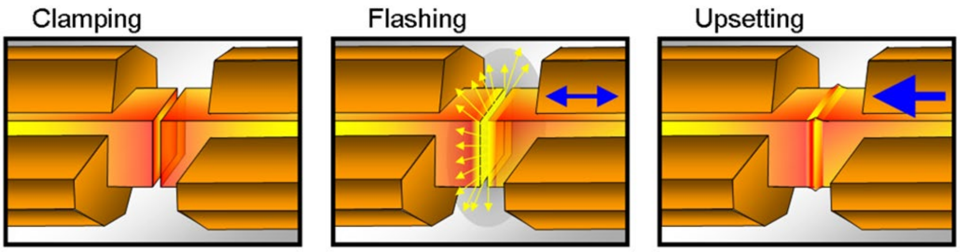

Figure 03 Phases of ERT-EBROS

As the joint area swells under the upsetting action, the melted metal is squeezed out into burs which quickly solidify (Figure 04).

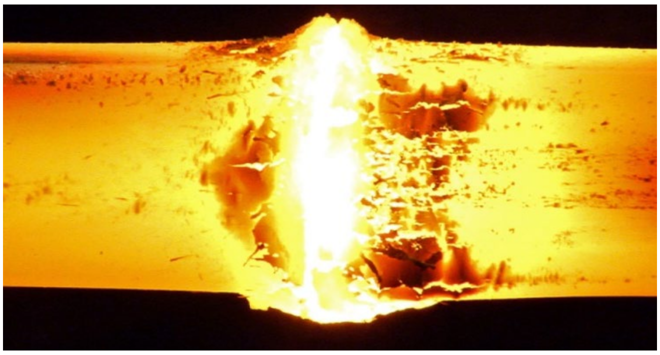
Figure 04 Welded joint before cleaning

When welding is completed, the joined billets are released, the car quickly returns to its home position and a new cycle starts.

During the return travel of the welding car, an automatic cycle cleans the welder and removes the spatter. The frequent cleaning operation allows to keep the operation efficient, and reduces the need for maintenance.

When the welding unit is not in use, it is conveniently removed offline by a transverse car operated by a hydraulic cylinder. On the same car, a roller table is mounted to guarantee the continuity of the rolling operation (Figure 05).

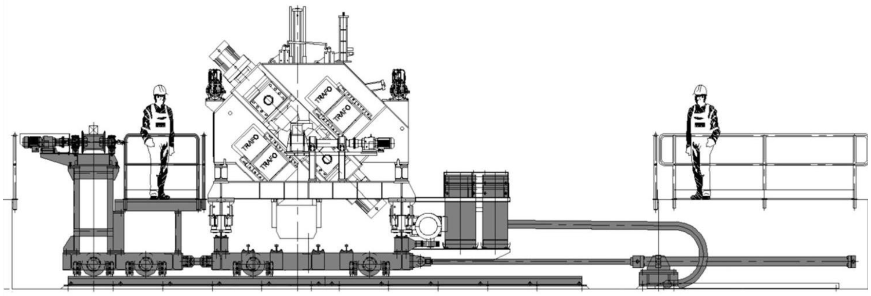

Figure 05 Welding unit with transverse car

2.2. Welding control

A Dynamic Flash Control fed with DC power is used by ERT-EBROS (Figure 06).

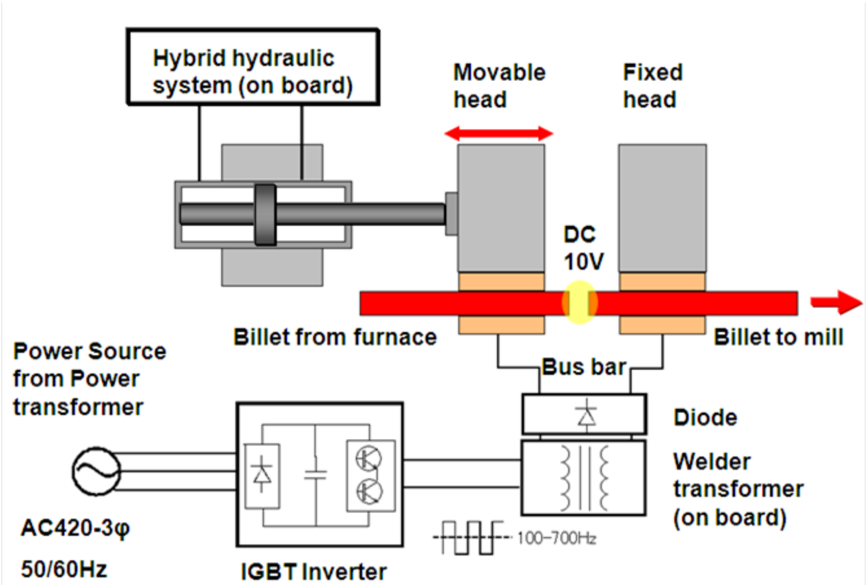

Figure 06 Dynamic Flash Control with inverter

During the initial flashing phase an electric arc forms between the billets whose surface temperature is quickly increased, so that opposite faces start to melt. During the continuous flashing phase, the distance between the two billet faces is continuously adjusted by the Dynamic Flash Control, according to the welding parameters monitored in real time, in particular the melting rate of the material and the currents (Figure 07).

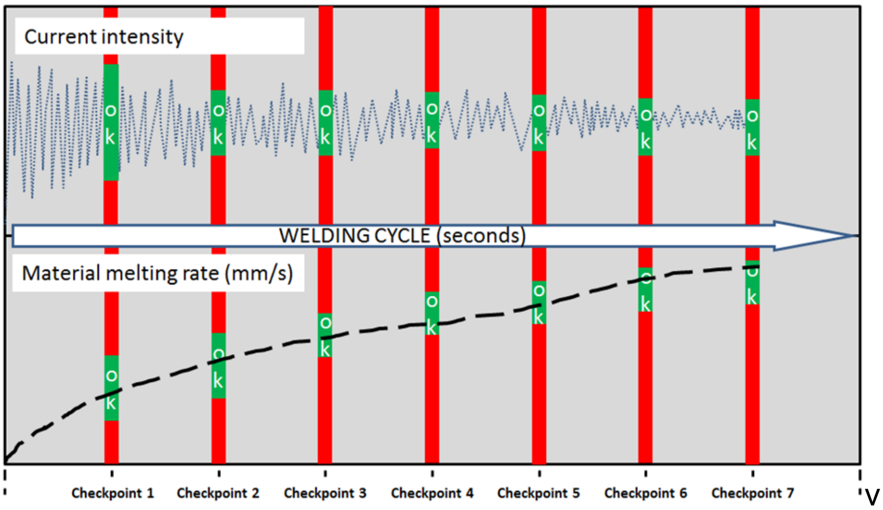

Figure 07 Welding current and melting rate

Among the advantages of the Dynamic Flash Control there are:

- High efficiency with limited consumption of energy
- Minimum loss of metal
- High joint quality
- Flexibility to accommodate also billets with uneven or rough faces
- Homogeneous joint microstructure without formation of martensite

The core of the electrical system are the integrated, high-frequency transformers. These compact components are extremely reliable and can perform an indefinite number of welding operations without maintenance. Each transformer is equipped with diodes that convert the high-frequency square-wave voltage into a stable, extremely flat DC voltage. The square-wave voltage is generated by converters with which the current can be controlled ten times faster than with thyristor circuits. A stable voltage and short control times are essential for a stable and repeatable process flow.

2.3. Bur removal and edge trimming

The welded joint is very irregular, with melted metal squeezed out by the upsetting action and solidified into burs and irregular edges, which need to be cleaned in order for an acceptable billet geometry to be restored before rolling can start.

Bur removal and edge trimming are performed in separate stations, these operations occurring in shadow time and without adding to the total welding cycle (Figure 08).

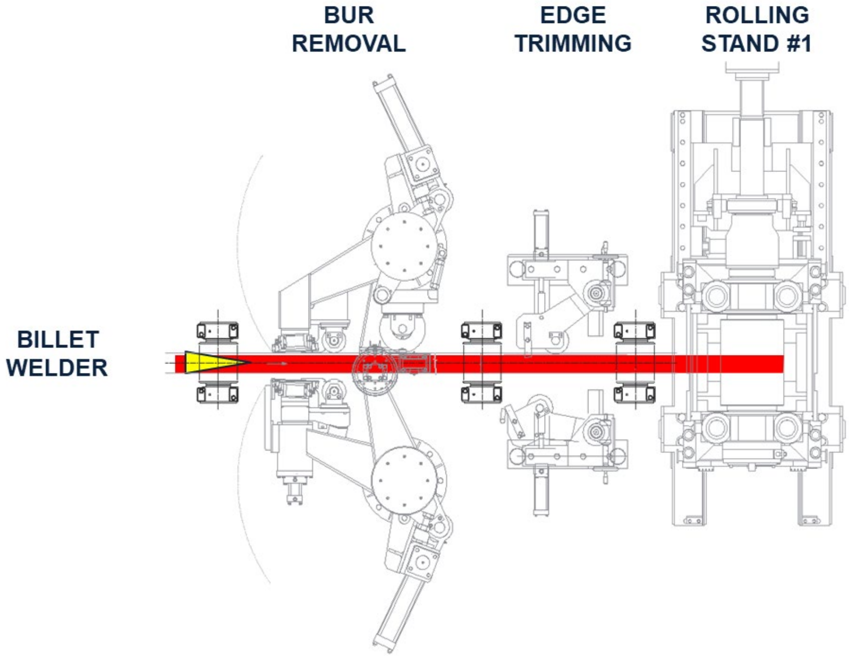

Figure 08 Top view of bur removal and edge trimming stations

Solidified metal burs need to be removed from the four billet surfaces around the joint area. For the deburring, the billet transits between two towers, each equipped with a pair of pivoting arms.

Two idle cutting disks are accommodated on each arm, off-set relatively to the billet center axis, so that the billet movement makes the disk rotate and remove the burs from all the four surfaces of the welded joint (Figure 09).

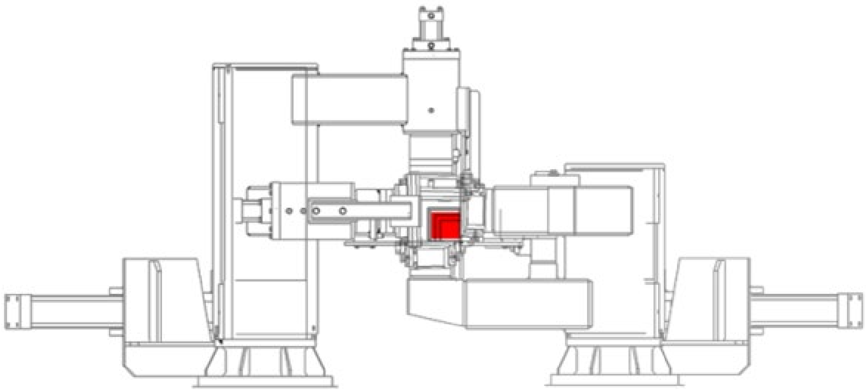

Figure 09 Cross view of bur removal

The pivoting arms are hydraulically operated, while the position of the disks can be adjusted to accommodate different billet sizes.

Immediately after deburring, edging knives trim the remaining solidified metal off the billet edges, so that the correct geometry of billet edges is restored fit for rolling. Edging knives are mounted on adjustable levers moved by hydraulic cylinders (Figure 10).

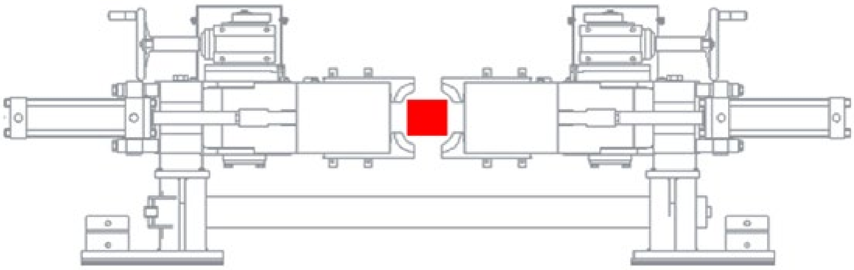

Figure 10 Cross view of edge trimming

The cut burs and trims are collected in a bin for separate recycling/disposal.
Both the deburring disks and the edging knives are brought close to the billet only during the cleaning operation, so that disk and knife life is improved and the amount of required cooling water reduced.

The deburring and edge trimming equipment are self-cleaning, and the pivoting and lever arrangement allow quick and easy maintenance operations.

It is worth noticing that both the deburring and edge trimming operations take place in shadow time and independently from the welding operation. No time is added to the overall cycle, which allows to achieve high productivity in a clean operation, without risking poor quality joints or equipment troubles.

A possible add-on to the system is an artificial vision system, which with the use of high-precision equipment (e.g. laser beams) can continuously monitor the welded billet shape and provide real-time information to the operator.

After deburring and edge trimming, the correct geometry of the billet faces and edges is restored so that rolling can start (Figure 11).

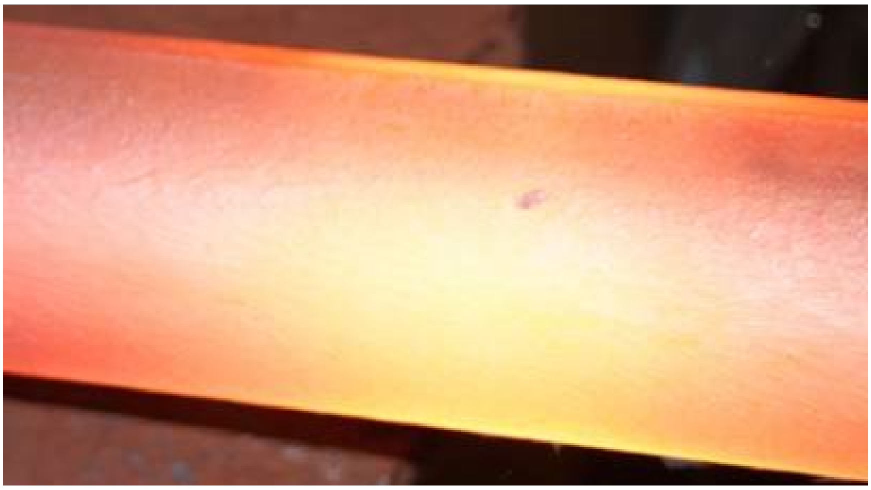

Figure 11 Welded joint after cleaning

2.4. Active Spatter Protection

During the flash welding operation, the melted metal is expelled at high speed and spattered around the joint area. Without adequate protection the spatters would quickly accumulate and reduce the efficiency of the operation, which would in turn increase the frequency of stoppages required to clean the equipment, ultimately reducing the benefits of endless rolling. As a matter of facts, accumulated spatters used to be among the major issues affecting the early applications of billet welding technologies.

ERT-EBROS is equipped with the Active Spatter Protection design, specifically developed to minimize the impact from spatters. The design directs the spatters towards a catching area which can be easily accessed for cleaning. At the same time, the Active Spatter Protection protects the core mechanisms and the electrical power circuits.

The system is also equipped with a self-cleaning scraping mechanism which operates in shadow time after each welding phase, and significantly reduces the maintenance requirements. The welding efficiency can so be maintained for longer intervals between maintenance operations.

The power unit and circuits are also well protected from the heat radiation. Welder transformers are installed inside protection boxes and cooled by a dedicated water system.

2.5. ERT-EBROS Mechatronic Package

The mechanical and electrical equipment of ERT-EBROS are complemented by a proprietary mechatronic package, which provide the operator with a quick startup, a short learning curve, a consistent and repeatable operation, effective maintenance protocols.

It also provides easy and quick integration with upstream / downstream processes.

The operator is assisted by a user–friendly HMI where all the process parameters and measures are shown, and where the status of the individual components is represented. The HMI also includes information and warnings to help with preventive and predictive maintenance protocols. Depending on the installation, a remote connection may be added, for software upgrades and remote troubleshooting assistance.

2.6. Metallurgy of the joint

Caused by the high temperature during flash welding, a slight decarburization takes place at the joint area, as indicated by the whitish trace line which can be detected in the cross section around the joint. Yet, during rolling, the joint area will spread out. After a sufficient total applied reduction, the decarburization effects will become irrelevant in the final product metallurgy. In fact, a cross section of intermediate-rolled samples show the spread effect and indicate that the whitish trace line moves counterflow to the rolling direction, forming a C-shape (Figure 12).

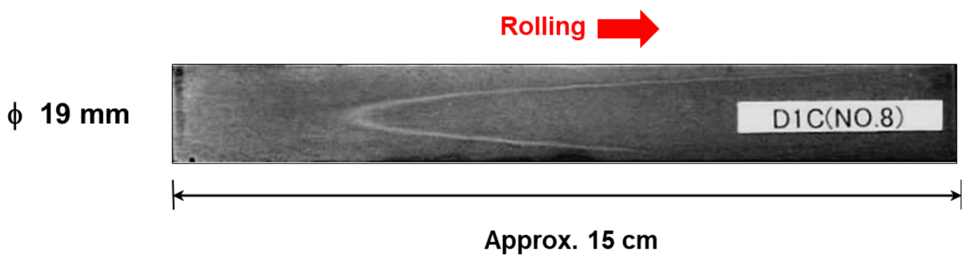

Figure 12 Spread of decarburized during intermediate-rolling

The final product shows negligible microstructure differences between the base material and the welded joint material, with respect to grain size, phase structure and mechanical properties such as yield and ultimate strength, elongation, reduction of area (Figure 13).

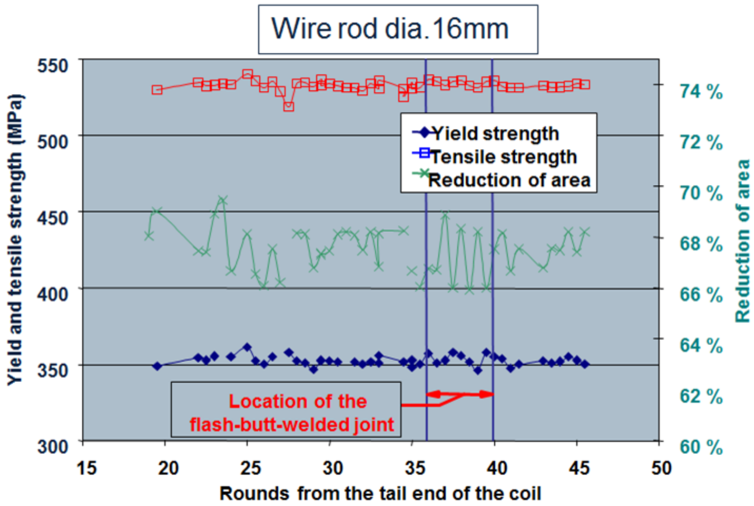

Figure 13 Mechanical features of dia. 16 mm wire rod from welded billets

The ERT-EBROS process produces saleable materials, and the correctly applied welding process does not pose problems to the as-rolled products, nor to the subsequent post-rolling operations.

3. Benefits of ERT-EBROS technology

Several benefits are offered by the ERT-EBROS Endless Rolling Technology, from the increase of production due to the elimination of billet gap time, to the improvement of stability of operation, the increase of metallic yield due to savings of material losses, the improvement of product quality and the savings of energy.

Production increase and cost reduction

When rolling individual billets, there is a inter-billet gap time of several seconds. By eliminating this time, the hourly production is increased, which leads to a significant boost of plant output, according to billet size and original rolling rate (Figure 14).

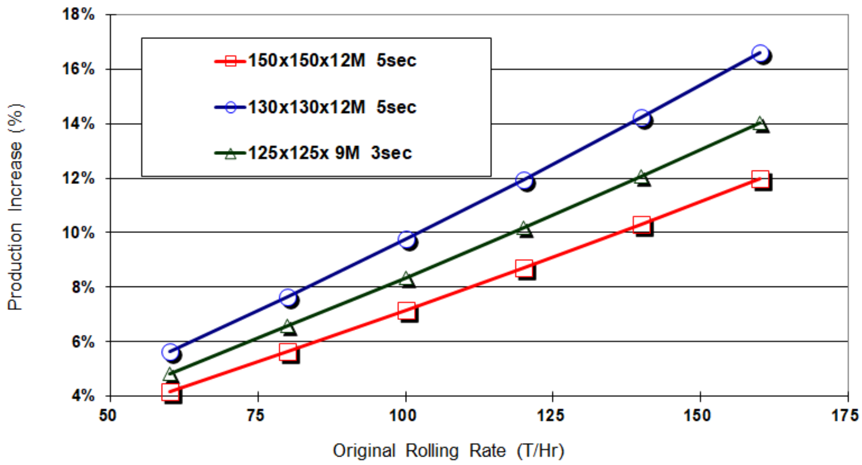

Figure 14 Increase of production due to gap elimination

Utilization level of the plant is also increased, and overall specific transformation costs reduced.

3.1. Stability of operation

The continuous rolling operation dramatically reduces the number of billet biting occurrences at the rolling stands. Therefore overloads of stand motors happen less frequently. Chances of misroll events, such as billet slippage and cobbles are less likely to occur. Roll and guide wear generated by mechanical and heat shocks is reduced.

The under-rolling tension and inline cooling conditions are more uniform and stable. All in all, a more stable operation is established with consistence and repeatability, which this means lower operating cost and higher production time.

3.2. Metallic yield

Endless rolling promotes an overall increase of metallic yield. The loss of melted material generated during welding is more than made up for by the metal savings obtained with the elimination of crops, and by those associated to the lower incidence of cobbles and to the lesser risk of quality nonconformities (Figure 15).

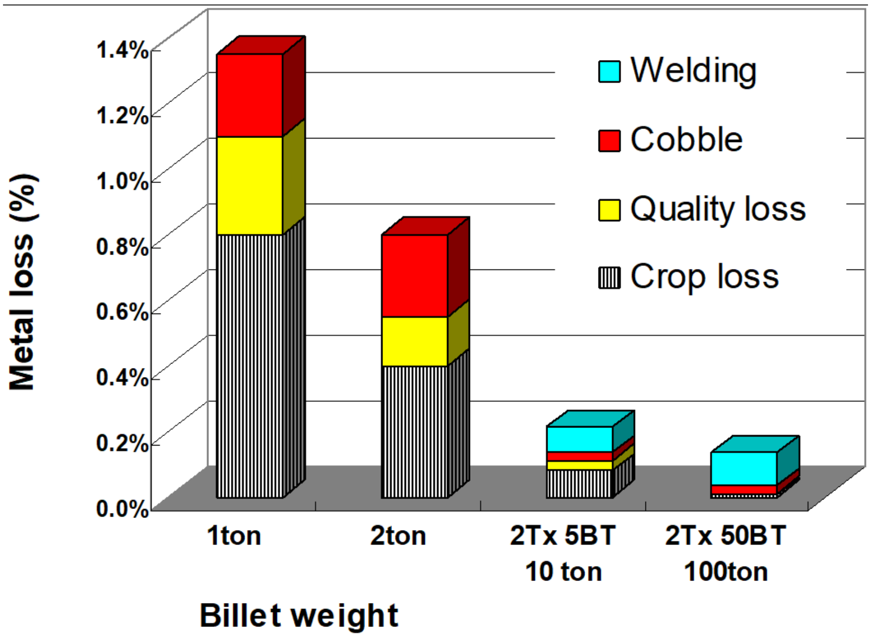

Figure 15 Comparison of metallic losses

When rolling straight bars, the hot shear croppings are eliminated and no short bars are delivered to the cooling bed which can be used at its full capacity. When rolling rod coils or bars-in-coil the hot shear croppingsare eliminated, and the need for coil trimming is reduced during the handling operations.

3.3. Product quality

Endless rolling significantly lessens the product quality issues, such as out-of-tolerance and uneven mechanical properties, which originate mostly at the product extremities. Material quality is homogeneous and consistent among bar lots and among coils. Also the production of free-weight coils becomes possible, even when only small-weight billets are available. This possibility of customization may improve the attendance to the market, by offering more product flexibility and shorter delivery times.

3.4. Energy savings

With conventional rolling, the motors of the rolling stands and other equipment run also during the inter-billet gap times, in a no-load or idle condition. The corresponding consumption of energy may be a significant fraction of the nominal value. With endless rolling instead, there are no inter-billet gap times and therefore the no-load electrical consumption is eliminated. Another saving of electricity with endless rolling is brought by the reduction of motor overloads.

Although minimized by the Dynamic Flash Control system which governs the electrical operation of ERT-EBROS, there is an amount of consumed energy due to the flash welding. However, this is more than compensated by the energy savings earlier described.

4. The ERT-EBROS installation at YongFeng (PRC)

Shandong LaigangYongFeng Steel Corp. (YongFeng Steel) is a subsidiary of Yongfeng Group Co., Ltd. and is one of the most important steel producers in Shandong province, People Republic of China.

Its principal products are ribbed steel and wire rod. In 2015, the company produced around four million metric tons of crude iron and steel products. YongFeng Steel's bar rolling mill has an annual production capacity of 1.2 million metric tons of steel rods.

In 2016, YongFeng Steel placed an order with Primetals Technologies for the supply of the ERT-EBROS endless rolling technology and process at the existing bar rolling mill in Qihe, Shandong province. The new system aims to boost plant output and utilization levels by three to six percent.

The first ERT-EBROS system in China, it is designed to process billets of low-carbon and low-alloy grades, with a square cross-section of 150x150 millimeters and a length of 12 meters, which are rolled into reinforcement steel bars with diameters between 12 and 50 millimeters (Figure 16, Figure 17).

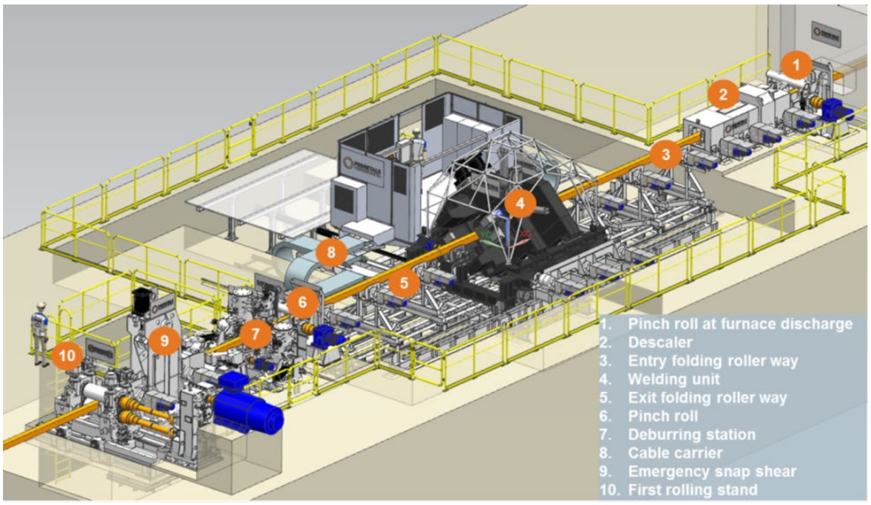

Figure 16 Layout of ERT-EBROS area at YongFeng


Figure 17 ERT-EBROS welding unit for YongFeng during manufacturing

The ERT-EBROS went into hot commissioning in early 2018.
At 2016 market prices, it is expected to pay for itself within 18 months from the beginning of its industrial operation.

5. Conclusion

Billet welding is one of the available endless processes for long products rolling. The problems occurring in the early billet welding installations were solved during the 2000s. The ERT-EBROS system by Primetals Technology enables the uninterrupted production during several hours. The process, based on the proprietary Dynamic Flash Control, provides a maintenance-friendly operation.

The ERT-EBROS technology is advantageous in several aspects, from productivity, to operation, yield and energy saving.

One of the most recent ERT-EBROS installations, and the first in PRC, is at YongFeng Steel, where the hot commissioning phase started in early 2018. The investment payback is expected to occur within 18 months of industrial operation.

6. Trademarks

EBROS is a registered trademark of Steel Plantech Co.
ERT-EBROS is a registered trademark of Primetals Technologies in some countries