# SEVERCORR, A NEW STEEL COMPLEX IN THE USA. PLANT TECHNOLOGY, COMMISSIONING AND FIRST OPERATIONAL RESULTS[1]

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**Abstract**

SeverCorr is the most modern facility for the production of high-quality flat rolled products in the USA and the first minimill to produce sheets for exposed automotive applications. The greenfield plant supplied by SMS Demag went on stream in 2006/2007 and includes electrical steelworks, CSP® plant, combined pickling line/tandem cold mill and hot-dip galvanizing line. The processes and all production facilities have been optimized to achieve the targeted steel quality and surface finishes, starting with the selection of charge materials and the secondary metallurgical treatment, then with the avoidance of inclusions and scale in the CSP® plant, the turbulence pickling technology and the in-line strip inspection after cold rolling and ending with the galvanizing line. In addition, the IPQS® is a powerful tool for the development of quality-oriented production strategies. The ramp-up of SeverCorr's CSP® plant was the fastest in the history of CSP®. Very good quality results during commissioning were achieved.

**Key words**: SMS Demag AG; SeverCorr; CSP®; Exposed automotive applications

## SEVERCORR, UM NOVO COMPLEXO DE PRODUÇÃO DE AÇO NOS EUA. TECNOLOGIA DA PLANTA, COMISSIONAMENTO E PRIMEIROS RESULTADOS OPERACIONAIS

**Resumo**

SeverCorr é atualmente o mais moderno complexo de produção de aço plano laminado de alta qualidade nos Estados Unidos, e também a primeira miniusina de laminação para a produção de chapas automotivas. A nova planta, construída a partir do zero, foi fornecida pela SMS Demag e entrou em operação em 2006/2007. Ela engloba uma aciaria de forno elétrico, uma linha CSP®, um trem laminador combinado de decapagem / tandem e uma linha de galvanização a quente. O processo global e as unidades de produção foram otimizadas para as qualidades de aço e de superfície requeridas, desde a seleção dos insumos e da metalurgia secundária, passando pela prevenção de formação de inclusões e carepa na linha de CSP®, pela tecnologia de decapagem com turbulência e a inspeção inline das tiras após a laminação a frio, até a galvanização a quente. Além disso, o IPQS® comprovou ser uma potente ferramenta para o desenvolvimento de estratégias de produção orientadas para a qualidade. A curva de início de operação até atingir plena produção da linha CSP® na SeverCorr foi a mais rápida em toda a história da tecnologia CSP®. Durante o comissionamento já foram obtidos excelentes resultados de qualidade.

**Palavras-chave:** SMS Demag; SeverCorr; CSP®; Chapas automotivas.

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## INTRODUCTION

The South of the United States has in recent years become a new centre for the US industry. Mainly the automobile industry and its suppliers have set up a number of new production facilities there. Since the steel industry is still concentrated mainly in the north of the country, SeverCorr decided in 2005 to set up a new facility for the production of high-quality hot and cold rolled steel strip on a "greenfield" site in the US state of Mississippi.
SeverCorr's works complex includes all stages of production from steelmaking to hot dip galvanizing. All key equipment, which consists of the electrical steelmaking plant, CSP® plant, combined pickling/tandem cold mill, continuous hot-dip galvanizing line with inline skin pass mill plus offline skin pass mill was supplied by SMS Demag including the electrical equipment and automation system for the steelmaking plant and CSP® plant plus the Level 3 production planning system. The facilities were started up between December 2006 and November 2007.
SeverCorr's plant technology was tailored completely to the requirements of the automobile industry as main customer. In this sector it is mainly sheets for exposed applications that are a special challenge to plant engineering, as they require a top-quality surface finish. SeverCorr is the first company to produce these materials in a mini-mill. These steel grades were until now a domain of integrated steelmakers.
Even with its maximum strip width of 1,880mm, the largest produced so far in the CSP® sector, the mill is rated for the requirements of the automobile industry.
The following pages present the project and its progress and describe the technology involved. At the focus here are the measures designed to produce top-quality surface finishes along the process route of electric steelmaking and CSP® technology. Further, the most important results of the commissioning phase of the CSP® plant are summarized and the initial operating experience is presented.

## GENERAL OVERVIEW

### Location and plant layout

As location for its new facility SeverCorr chose the small town of Columbus in the north east of the state of Mississippi. The site was chosen due to its central location with no less than 14 automobile factories situated within a radius of 300 miles, its excellent traffic connections inside the US and to Mexico and the availability of low-cost electrical power.[1]
As the facility was built on a "greenfield" site, an optimal layout of the production plant could be chosen. It is based on a "U" shape in which the steelmaking plant, CSP® plant and cold-rolling complex are arranged at an angle of 90 degrees relative to each other. This basic layout allows short distances between the facilities as well as simple coil handling. SeverCorr can withdraw after the various stages each of the overall process intermediate products for sale, in order to flexibly meet market demands. The product line thus comprises all products form black hot strip to hot-dip galvanized steel strip and annealed tin plate (Figure 1).

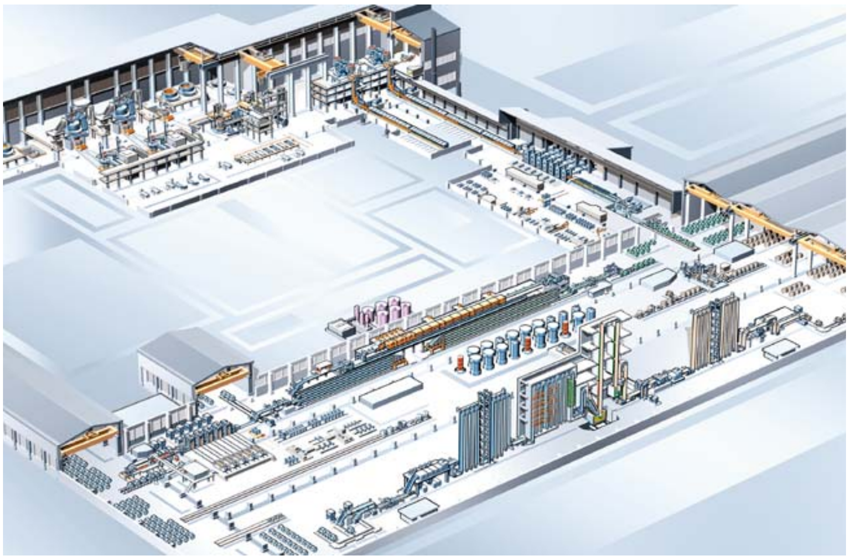


**Figure 1**: Overall layout of the works complex (final stage of construction).

The plant concept envisages the extension of production in several steps. In 2006/2007, SeverCorr started the first phase of production with a total capacity of around 1.35 million tons per year. With the extension of the steelmaking plant and CSP® plant and the installation of additional pickling and annealing facilities, annual production can be raised to up to 3 million tpy.

## Product mix

Table 1 shows the dimensions for the main steps of processing from hot strip to galvanized plate.

**Table 1**: Product mix and strip sizes.

| Product | Thickness | Width |
|---|---|---|
| Hot rolled strip | 1.4 – 12.7mm | 914 – 1,880mm |
| Hot rolled pickled (& oiled) | 1.4 – 5.0mm | 914 – 1,880mm |
| Cold rolled | 0.28 – 1.4mm | 914 – 1,829mm |
| Hot dip galvanized/galvannealed | 0.28 – 1.4mm | 914 – 1,829mm |

In terms of steel grades, SeverCorr's product mix includes soft, unalloyed steels for cold forming, IF steels for extreme deep-drawing grades, structural steels, HSLA steels and a wide range of carbon steels. In addition to automobile manufacturers and their suppliers, the company also sells its products to the construction and home appliances industries. In the future SeverCorr also intends to produce non-grain oriented electric steel strip and feedstock for pipe and tube-making.

## Production overview

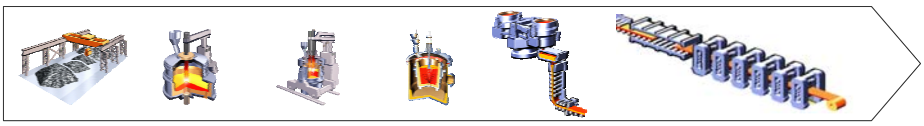
In its first stage of construction the steelmaking plant consists of a direct-current electric arc furnace with a tapping weight of 150 tons, a twin-type ladle furnace and a twin-type vacuum degasser. It has an annual capacity of 1.35 million tons, which will be doubled in the second stage of construction.
The CSP® plant is the heart of the SeverCorr works complex. The CSP® caster produces thin slabs that are 1,880mm wide and rolled to finish gauges between 1.4

and 12.7mm in the six-stand CSP® rolling mill. The annual capacity of 1.35 million tons can be doubled by the installation of a second casting strand.
Downstream, the strip is pickled and then cold rolled in a combined pickling line/tandem cold mill (PL-TCM) to final gauges between 0.28 and 1.4mm. The PL-TCM mill is rated for a total capacity of 1.8 million tpy.
The cold-rolled strip is then either annealed in a batch annealing furnace and skin-passed or galvanized. For this purpose a continuous hot-dip galvanizing line with inline skin pass mill and a current capacity of 360,000 tpy is available to SeverCorr.

**Figure 2**: SeverCorr plant with cold mill complex, CSP® plant and steelmaking plant (from left to right).

## PRODUCTION FACILITIES

The production facilities have been optimized to achieve the targeted steel quality and surface finishes. The quality of charge materials, the cleanliness of steel, the internal quality of the thin slabs and the avoidance of scale are of utmost importance (Figure 3).



| Steel Analysis | Slab Surface | Strip Surface | Strip Geometry | Mechanical Properties |
|---|---|---|---|---|
| **Close tolerances**<br>• low tramp elements<br>• low residuals<br>• high internal cleanliness | **Zero defects**<br>• inclusions<br>• mould powder<br>• oscillation marks<br>• all damages<br>**Uniform scale** | **Zero defects**<br>• shells<br>• damages<br>• scale<br>**Uniform look**<br>• shadows streaks | **Tight tolerances**<br>• thickness<br>• profile<br>• flatness | **High demands**<br>• formability for deep drawing<br>• strength<br>• ductility<br>• isotropy |

**Figure 3**: Process challenges for advanced automotive applications.

### Steelmaking plant

Scrap and scrap substitutes are melted down in a 150-ton electric arc furnace that operates on the SMS Demag-developed and patented direct-current technology. To achieve the aimed-at high production capacity of 220 t/h (which corresponds to a tap-

to-tap time of around 40 minutes), a maximum transformer output of 160 MW is available.
The metallic charge materials of the electric arc furnace are selected by SeverCorr according to the steel grade to be produced. The objective here is to set the proportion of undesired tramp elements such as Cu, Sn, Cr, Ni, Mo, etc. to the low level aimed at for the respective steel grade. Available here are low tramp-element scrap substitutes such as sponge iron (DRI/HBI) and pig iron, but also specially selected scrap grades with a very high degree of cleanliness. To meet the extremely stringent surface-finish requirements of automobile sheets used for exposed applications, the share of charge materials with a high degree of cleanliness such as sponge iron and pig iron rises to around 80% for these grades. The remaining 20% of the charge material consist of specially selected scrap grades such as return scrap from the press works of the automobile industry.
The actual quality of the steel is achieved through the secondary metallurgical treatment of the crude steel by means of a twin-station ladle furnace and a twin-tank vacuum degasser.

## CSP® plant

SeverCorr's CSP® caster produces thin slabs that are 912 to 1,880mm wide and 65mm thick. The vertical solid bending machine consists of four segments and has a metallurgical length of 8,065mm.

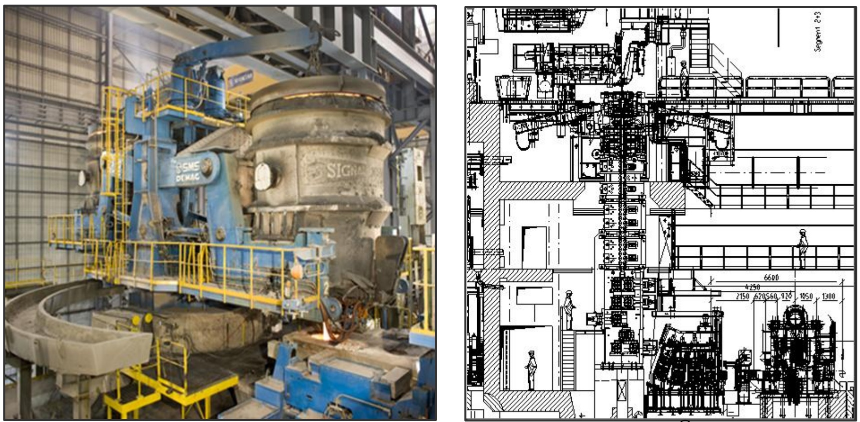


**Figure 4**: View on casting deck and cross section of CSP® thin slab caster.

The main technical data of the thin slab caster are listed in Table 2.

**Table 2**: Main technical data of CSP® caster.

| | |
|---|---|
| Ladle capacity | 150 t |
| Tundish capacity | 36 t |
| Caster type | Vertical solid bending caster |
| Metallurgical length | 8,065 mm – 4 segements |
| Bending radius | 3,250 mm |
| Casting speed | max. 6.0 m/min |

The CSP® caster incorporates all technologies and components for casting of high quality thin slabs and thus ranks among the most modern units of its kind.

The system of CSP® funnel-shaped mould and submerged entry nozzle is the process core in terms of productivity and product quality. It has been the subject of

continuous development. An electro-mechanical stopper rod mechanism which is actuated via a servo drive with linear ball guidance results in a system without clearance/backlash. The system ensures a very accurate mould level control.
For a high-quality surface finish the formation of inclusions must be avoided in the caster. In addition to the selection of the right casting powder, the use mainly of the hydraulic mould oscillator and electromagnetic brake are important factors here. The hydraulic oscillator features variable oscillation strokes and frequencies by means of which the oscillation marks can be clearly influenced to produce a flat and open shape. This makes it possible in the following process to ease the removal of scale and casting powder residues from the oscillation mark and to avoid so-called ghost lines caused on the hot strip by the oscillation mark. The electromagnetic brake (EMBR) is an effective tool which aids in the prevention of surface flaws in the form of non-metallic inclusions.
On the exit side of the continuous caster, a special slab cleaning facility is arranged between the withdrawal and straightening units and the pendulum shear to remove primary scale from the top and bottom of the slab by low-pressure water.
The 269-meter long tunnel furnace connects the caster and rolling mill and ensures uniform heating of the thin slab. In the furnace, too, the formation of scale must be controlled to ensure that it can be easily removed again later on and to avoid the build-up of scale on the rollers. This is done mainly by the proper control of oxygen and temperatures.
In the 6-stand CSP® mill the thin slabs are rolled down to strips with final thicknesses form 1.4 to 12.7 mm. The main technical data of the CSP® mill are listed in Table 3.

**Table 3**: Main technical data of CSP® mill.

| | |
|---|---|
| Roll separating force | 46 MN (F1-F4), 32 MN (F5-F6) |
| Main drives | 8,700 kW (F1-F2, F6), 10,000 kW (F3-F5) |
| Work roll size | 2,300 x 950/820 mm (F1-F2)<br>2,300 x 750/660 mm (F3-F4)<br>2,300 x 620/540 mm (F5-F6) |
| Backup roll size | 2,100 x 1,500/1,370 mm (F1-F2)<br>2,100 x 1,500/1,350 mm (F3-F6) |

The 6-stand CSP® rolling mill is fitted with all technologies and components for the cost-effective production of high-quality hot strip with excellent product tolerances. These include hydraulic adjustment systems and CVC plus® technology in all millstands, as well as hydraulic loopers from F1 to F4 and differential tension loopers between the last two millstands. In the first stage of construction one downcoiler winds the strip into coils.
At the entry of the CSP® mill a high-pressure descaler is arranged. At the top and bottom of the descaler, two vertically adjustable rows of spraying headers are arranged which supply a maximum water pressure of 380 bar. This reliably removes all scale before the deformation.
In the CSP® mill a number of actions was taken to suppress the renewed formation of scale. Especially the formation of the particularly hard hematitic tertiary scale needs to be minimized, as this will cause surface defects if rolled in.

To influence the strip surface temperatures in the finishing mill, adequate strip cooling units were arranged in front of F1 and between F1, F2 and F3 which are rated specifically for the requirements of surface-critical materials.

In addition, roll-gap lubrication (F2-F4) and anti-peeling devices (F1-F4) were installed. Roll-gap lubrication reduces the level of roll forces and in case of high thickness reduction suppresses the tendency for vibrations to occur. Targeted cooling of the strip in front of the roll rap minimizes peeling of the rolls, which contributes like the roll-gap lubrication to achieving the long service life of the work rolls and hence to the avoidance of surface defects. Further potential for a longer service life will in the future exist in the use of work rolls made from HSS steels in the first stands and more wear-resistant work rolls in the rear stands.

**Figure 5**: CSP® mill.

### Combined pickling line/tandem cold mill

The combined pickling line and tandem cold mill (PL-TCM) is capable of processing steel strip with an entry-side thickness of 1.4 to 5.0mm. For main technical data see Table 4.

**Table 4:** Main technical data of PL-TCM.

| | |
|---|---|
| Pickling line, entry speed | 450 m/min |
| Pickling line, process | 150 m/min |
| Cold mill, exit speed | 1,250 m/min |
| Roll separating force | max. 30 MN |
| Coil weight | max. 40 t |

In the entry section a welding machine joins the material to form an endless strip, thus allowing continuous operation. The strip is then descaled in the turbulence pickling line. In the SMS Demag-developed turbulence pickling process, the strip passes through several acid-filled pickling tanks. By injecting acid into the shallow pickling duct from the entry and exit side, turbulences are formed which additionally reinforce the pickling process. Via the acid temperature and strip speed, but also via the volumetric flowrate and the injection pressure the pickling process may be controlled with such accuracy that an ideal pickling result is achieved for all materials. In the five-stand tandem cold mill, the steel strip is reduced to final gauges of 1.4 to 0.28mm (Fig.6). The four-high millstands are equipped with numerous state-of-the-art sensors, actuators and control systems. All millstands are fitted with CVC plus® technology featuring positive and negative work-roll bending. Together with the multi-zone cooling system and actuators, the flatness measuring roll installed on the exit side ensures optimal flatness. Downstream of the last millstand the DS- (dry strip) system is installed to yield an excellent, dry strip surface without residues of rolling emulsion. By supplying a controlled air flow (for blow-off and suction) it seals off the strip without any mechanical contact to protect it against the emulsion.


**Figure 6**: Tandem cold mill.

The "Rotary Inspect" in-line inspection line allows the surface finish to be inspected right at the line, thereby allowing suitable corrective actions to be taken at an early stage, i.e., just one coil away. The in-line inspection facility is arranged downstream of the coilers in the exit of the tandem cold mill. The dividing shear of the reels cuts off samples; these are delivered to the inspection facility via a magnetic belt conveyor. The samples are then clamped into the sample table. The table can be rotated around its longitudinal axis, thus allowing the top and underside of the strip to be inspected without the need for re-clamping the sample. This avoids scratches and improves the accuracy of the inspection result (Figure 7).

**Figure 7**: In-line inspection “Rotary Inspect”.

## Continuous hot dip galvanizing

Continuous hot dip galvanizing also meets the exacting surface-finish requirements of the automobile industry. Prior to galvanizing, the material is welded to form an endless strip, degreased, cleaned and recrystallization annealed in the annealing furnace. The material then passes through the zinc pot. The thickness of the zinc coat may be precisely set by the air knife. For GA grades the zinc pot is followed by a galvannealing furnace.

After cooling, the galvanized strip may be skin-pass rolled in an inline four-high skinpass mill. This is followed by a tension leveller and processing lines for chromate-free products and products containing phosphorous.

# AUTOMATION

## IPQS®

Apart from the numerous individual measures and technologies that serve to ensure a high product quality, SeverCorr use IPQS® (Integrated Product Quality System) developped by SMS Demag. The focus of this powerful quality control tool is on the integrated observation and processing over all process stages of the plant and process data and their correlation with the product qualities. The system allows SeverCorr to correlate quality results with the parameters of the overall process. It forms the basis for the development of quality-oriented product strategies.
IPQS® is based on the quality database that contains all quality-relevant process and inspection data as well as the data generated in the quality models. The data are available in a comprehensive and product-oriented format for a long period of time. The work platform allows the compilation of all kinds of evaluations from this database (Figure 8).

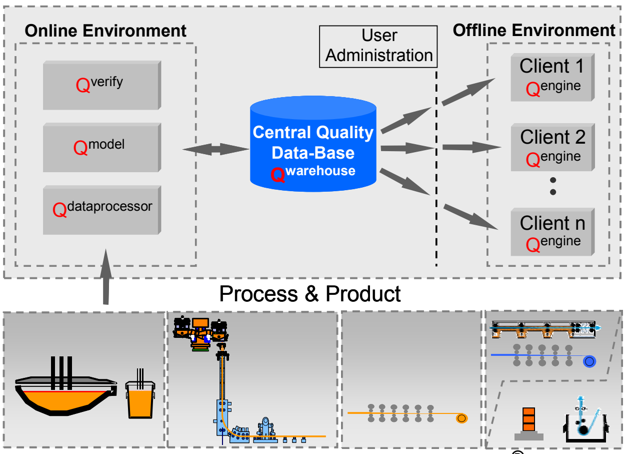



**Figure 8**: Schematic view of IPQS®.

Acting as a monitor and control medium, IPQS® signals already during production whether a product varies from the required quality. The variation detected may then be used for short-term re-scheduling to avoid scrapping. IPQS® can be integrated as a module in any customer computer environment.

## Plug & Work

The SMS Demag scope of supply included the electrical equipment and automation system for the steelmaking and the CSP® plant. The automation system was tested before delivery using SMS Demag's Plug & Work concept. Plug & Work tests use the software and hardware of the original supply scope and perform a real-time simulation of the complete production process. For this purpose the customer-specific designs are used and the relevant geometrical data, the kinematic and dynamic behaviour of the corresponding plant unit as well as the function of the field instruments arranged on the unit are translated in automated draft process and simulated against the automation system. Reality can thus be imaged as precisely as possible and the automation system can be optimised already before its commissioning.

## COMMISSIONING AND OPERATIONAL RESULTS OF CSP® PLANT

The first unit that went in operation on 21 December 2006 was the pickling line. The tandem cold mill and offline temper mill followed in May 2007. The heart of the new works complex, the steelmaking plant and CSP® plant, started operation in August. This was followed in November 2007 by the continuous hot dip galvanizing line.
The ramp-up of SeverCorr's CSP® mill was the fastest in the history of CSP®, with exceeding the nominal production capacity as early as April 2008. This clearly proves the benefits of having the mechanical and electrical equipment plus automation system supplied from a single source as well as of advanced commissioning by means of the Plug & Work concept. After the facility at Jiuquan Iron & Steel (Jisco), China, SeverCorr's CSP® mill was the second one for which SMS Demag supplied the complete electrical equipment and automation system. Following the already very fast commissioning at Jisco, the period of time needed could be reduced again at SeverCorr (Figures 9 and 10).

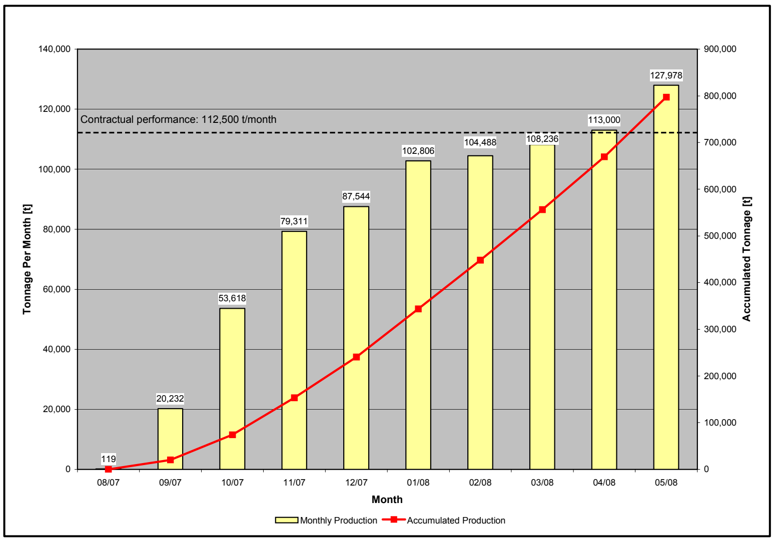



**Figure 9**: Development of production in SeverCorr's CSP® plant.

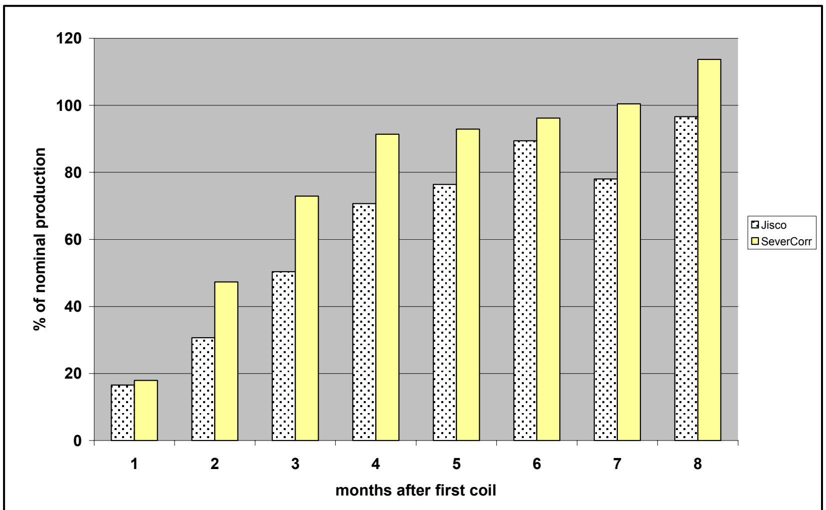
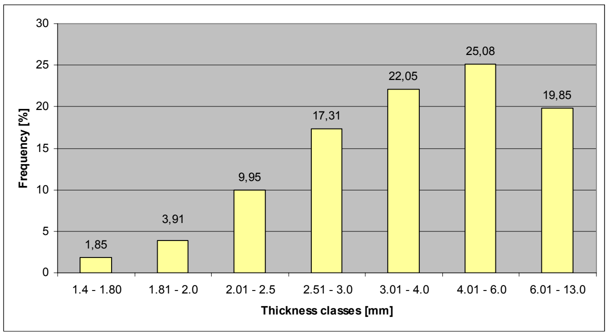
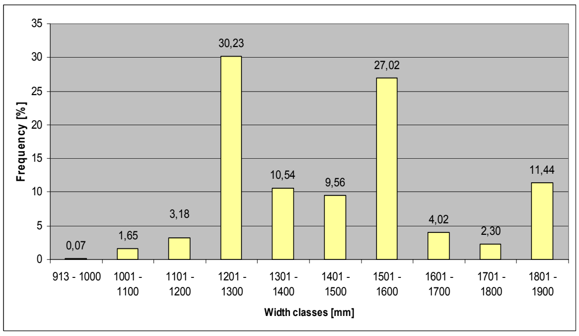



**Figure 10:** Comparison of ramp-up curves of SeverCorr and Jisco CSP® plant.

Figures 11 and 12 show the thickness and width distribution during the first seven months after commissioning of the CSP® mill.

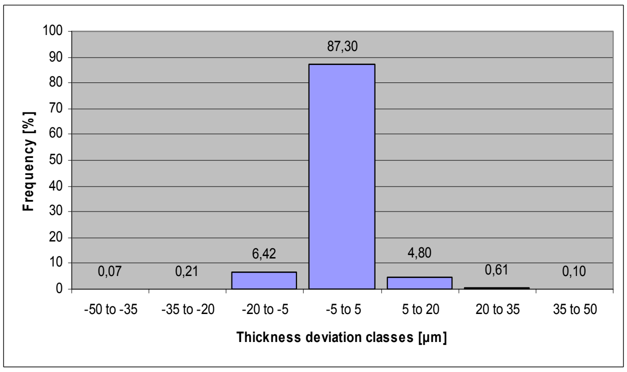


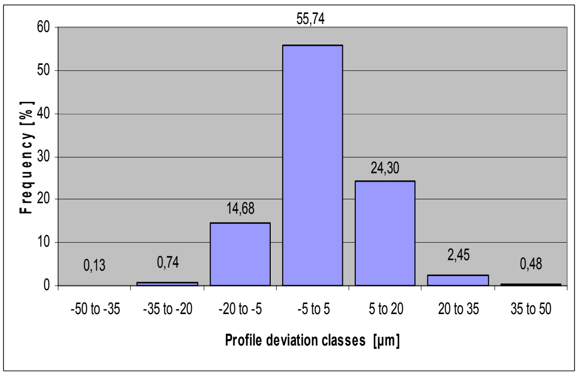




**a)** **b)**

**Figure 11**: a) Distribution of production by thickness classes (Aug 2007-Feb 2008); b) Distribution of production by width classes (Aug 2007-Feb 2008).

In terms of the hot-strip geometry, very good values were achieved during the commissioning phase, as evidenced by the evaluation of all 4,052 strips rolled in January 2008 (Figures 12 and 13).




**a)** **b)**

**Figure 12**: a) Thickness deviation throughout complete production in January 2008; b) Profile deviation throughout complete production in January 2008

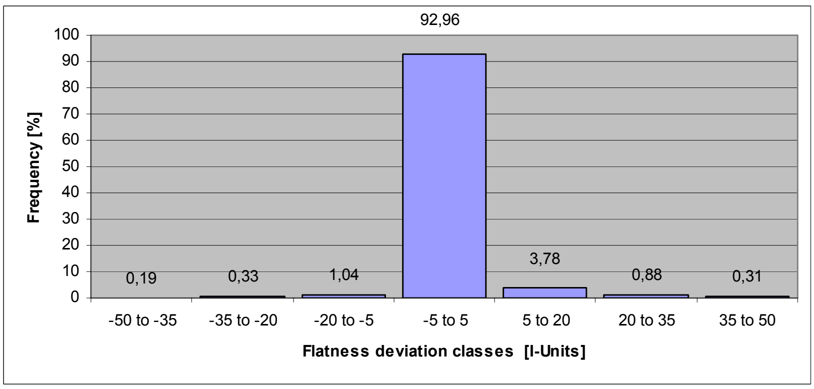



**Figure 13**: Flatness deviations throughout complete production in January 2008.

## OUTLOOK

Following the successful commissioning, the fast ramp-up of production and the excellent sale of products in the US market, SeverCorr are already preparing the next steps to further boost their production. For example, planning is under way to double the steelmaking capacity by adding another electric arc furnace, an additional ladle furnace plus a second twin-tank vacuum degasser. Accordingly, the capacity for rolling hot strip is to be doubled by installing the second casting strand and the second coiler. The pickling capacity is to be raised to around 2.3 million tpy by the installation of a fourth pickling tank and by setting up a push-pull pickling line. The galvanizing capacity will be doubled by installation of a second continuous galvanizing line.(2)

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