



ARVEDI ESP
REAL ENDLESS STRIP PRODUCTION

QUICK AND FLEXIBLE RESPONSE TO MARKET REQUIREMENTS

INCREASING MARKET DEMANDS

Compact plants with a high degree of availability that produce products with a high standard of quality and at high yield levels offer decisive competitive advantages for steel manufacturers. Short throughput times and high flexibility in combination with solutions that meet the highest environmental and safety standards require fully optimized plant equipment and automation from an experienced supplier.

HOW WELL ARE YOU PREPARED?

Does your current plant meet the market requirements for quality, flexibility and reliability? Are you confronted with significant yield losses on your hot-strip mill from strip threading and tail-out operations, high operational and maintenance costs or limited flexibility to respond to changing market demands? If yes, a new solution is available to meet these challenges.

DESIGN YOUR FUTURE!

Technological know-how acquired over decades of plantbuilding experience is the decisive factor for optimizing the strip-production process. Solutions from Primetals Technologies focus on the crucial points that determine quality, economy and environmental compatibility. The more flexible and productive your strip production line, the more you can boost your competitiveness and success in the market.

We invite you to design your future with Primetals Technologies, the company with combined continuous casting, rolling and automation expertise. Work with us to meet the market demands of tomorrow..

The steel market is rapidly changing and becoming increasingly difficult to anticipate. Optimized and flexible solutions from a reliable plant supplier is vital for succeeding in today's difficult market

YOU EXPECT ...

- Higher productivity and improved flexibility from your steel mill
 - Single-source expertise from a world-leading supplier of continuous casting and rolling plants,- including the related metallurgical, mechatronic and automation know-how
 - Modular and highly efficient technological packages that meet individual requirements
 - Lifecycle services that include professional training, in-house spare-part production up to continuous technology updates
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HIGH-QUALITY HOT-ROLLED COILS FOR CONVENTIONAL AND PREMIUM THIN-GAUGE MARKETS

A NEW ERA IN STEEL PRODUCTION

Based on the proven ISP (In-line Strip Production) technology, Acciaieria Arvedi S.p.A. (Arvedi) has developed a new thin-slab casting/continuous rolling process for the production of hot-rolled coils under the known name Arvedi ESP. With this pioneering development, 0.8 mm thick strip is produced without the disadvantages of strip threading. Depending on the produced steel grades and the average strip width, the production capacity of a single-strand line exceeds two million tons per year. Arvedi has already installed the new ESP line at its Cremona works, Italy, incorporating additional plant and process improvements supplied by Primetals Technologies.

OPTIMIZED PRODUCTION WITH ESP

The new generation of ESP thin-slab casting/continuous rolling lines is composed as follows. A thin-slab caster featuring liquid core reduction is followed by rolling in a directly linked reduction mill positioned at the exit of the continuous caster. The temperature of the intermediate strip is heated in an induction heater according to finishing rolling requirements. The finishing mill and cooling line are designed to allow the strip to be rolled to thicknesses between 0.8 mm and 12.7 mm at maximum strip width and are directly followed by a high-speed shear and downcoilers. Advanced automation systems ensure that all production and product quality parameters are satisfied.

DECISIVE ADVANTAGES

The unique design and plant configuration of an ESP facility, particularly the high casting speeds that are possible, allow continuous, endless rolling of high-quality strip. Due to the highly compact ESP line arrangement with a total length of only 180 m and the direct linkage of casting and rolling, lower investment and operating costs are incurred compared with conventional thin-slab casters and direct-rolling plants.

PROFITABLE STRIP PRODUCTION

Because the line is capable of producing hot-rolled thin strip, subsequent cold rolling is not necessary for many strip applications. This results in noteworthy operational cost savings. Thanks to the precise dimensional characteristics of ESP thin strip, it can also be rolled in a compact tandem cold-rolling mill with fewer required rolling stands. This means lower investment and conversion costs. Thanks to endless rolling operations, the production of strip with uniform and repeatable mechanical properties is achieved along the entire strip width and length. Installation of integrated automation systems, the latest process optimization models and advanced technological packages is the basis for overall plant reliability, superior products and high line performance.

DID YOU KNOW...

Highly attractive ultra-thin gauges can be produced on Arvedi ESP plants at maximum productivity and at maximum strip width?

Arvedi ESP is a new generation of casting/rolling plants that produce a wide range of high-quality and ultra-thin steel products in an endless casting-rolling process that meet the changing and challenging market demands.

ADVANTAGES OF ARVEDI ESP

- Economical production – of hot-rolled thin strip, substituting cold-rolled strip for many applications
- Significant cost savings – due to the short line length (180 m) and direct linkage of casting and rolling
- Production of high-quality coils – with precise dimensions and uniform mechanical properties
- Fully integrated production facility – incorporating advanced technological packages for overall plant reliability, superior products and a high line output
- Environmentally friendly operation – due to lower energy consumption and reduced emissions
- Leading technology – the world's most compact thin slab casting and direct-rolling process

ARVEDI ESP

THE WAY TO PRODUCE A PERFECTLY ROLLED PRODUCT

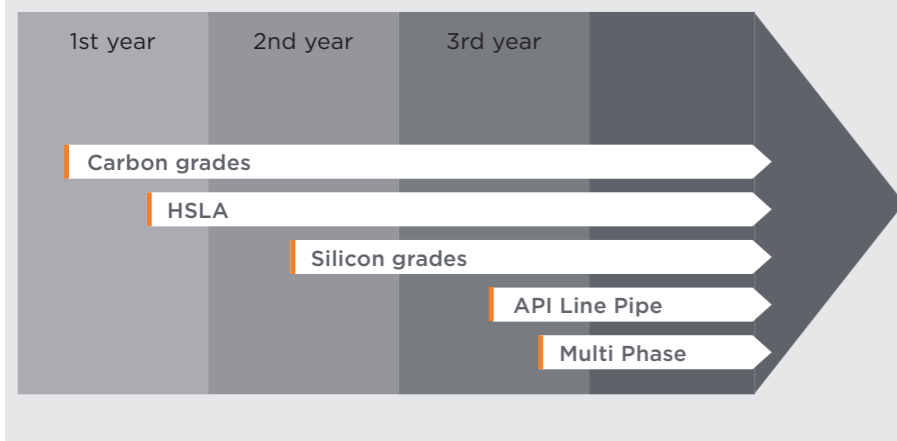
The market for ultra-thin gauge hot-rolled strip is ideally met with Arvedi ESP technology. Overall production efficiency and product yield are far higher compared to alternative processes due to the unique features of Arvedi ESP lines.

More than 50% of the entire product mix can be produced at strip thicknesses less than 1.5 mm at full plant productivity. Furthermore, the Arvedi ESP line is capable of producing the complete spectrum of carbon steel strips in addition to advanced steels such as HSLA, pipe grades up to API X80, HSS and AHSS grades, DP & multi-phase steel grades as well as silicon steel.

THE ESP PRODUCT SPECTRUM

- Complete range of ultra low- to high-carbon steel
- High Strength Low Alloyed steel (HSLA)
- Pipe grades up to API X80
- Advanced High Strength Steel (AHSS)
- Dualphase & multi-phase steel grades
- Silicon steel

ARVEDI ESP, CREMONA - DEVELOPMENT OF STEEL GRADES SINCE START-UP IN 2009

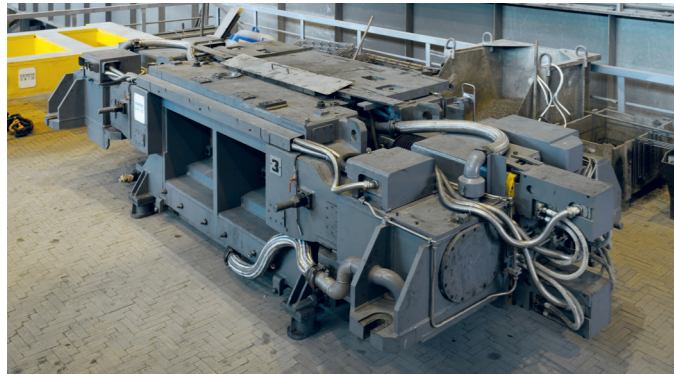


Due to extremely exact temperature guidance and stable process parameters product development is achieved in shortest possible time.



EQUIPMENT AND COMPONENTS

The success of the whole depends on its parts. Arvedi ESP consists of modular technological packages, engineered and constructed to meet your individual requirements. Most reliable components of best quality ensure highest efficiency throughout the entire process chain.



Smart Mold



High-reduction mill



Pendulum shear



Plate pusher and piler

MOLD FOR HIGH-SPEED CASTING

The solidification process commences in the mold and therefore the mold design is particularly crucial for casting small strand sections at high mass flow rates. Mold thicknesses of 90-110 mm assure stable mold conditions and a reduced breakout rate. Proven Primetals Technologies mold technology is enhanced with the following important features:

- Proven and well-established funnel-shaped copper plates
- Intensive mold cooling up to 4 MW/m² heat removal rates
- Hydraulic narrow-face adjustment for taper- and width adaptations during casting
- Instantaneous process feedback with Mold Expert

STRAND CONTAINMENT AND SPRAY COOLING

Liquid core reduction has a positive influence on the strand quality. Less macro segregation, finer grains and better surface quality improve the material properties. Additionally it allows larger mold openings contributing to more stable operating conditions.

Besides mold process and roll gap profile the spray cooling performance is of high importance for stable casting at high steel throughput. Therefore a powerful cooling up to 4 l/kg global cooling rate was designed.

Special wide spraying water nozzles are spaced closely to strand surface and ensure high cooling efficiency. In lower part of machine, from straightener to last segment, air-mist cooling at standard pressure and flow rates enables a wide operation range, predominantly to provide a strand of enough heat to the first high reduction mill stand.

HIGH-REDUCTION MILL

The high-reduction mill consists of three four-high rolling stands. The main emphasis in the design of this equipment is placed on reliability to allow up to 12 hours of continuous trouble-free operation. To control the profile of the strip, a positive and negative work-roll bending system is implemented to take advantage of the possibilities offered by the inverse temperature profile unique to the ESP process:

- Soft core forming leads to better crown and wedge adjustment as well as to improved microstructure
- Energy is saved during rolling due to the hot and soft core of the strand

PENDULUM SHEAR

The pendulum shear is used to disconnect the dummy bar from the cast strand, to cut the transfer bar into plates for removal by means of the pusher/piler equipment, to cut samples when required and for emergency cutting in case of temporary stoppage of the finishing mill/downcoiler area. The shear is designed to cut a wide range of thicknesses (110 mm to 10 mm).

PLATE PUSHER AND PILER

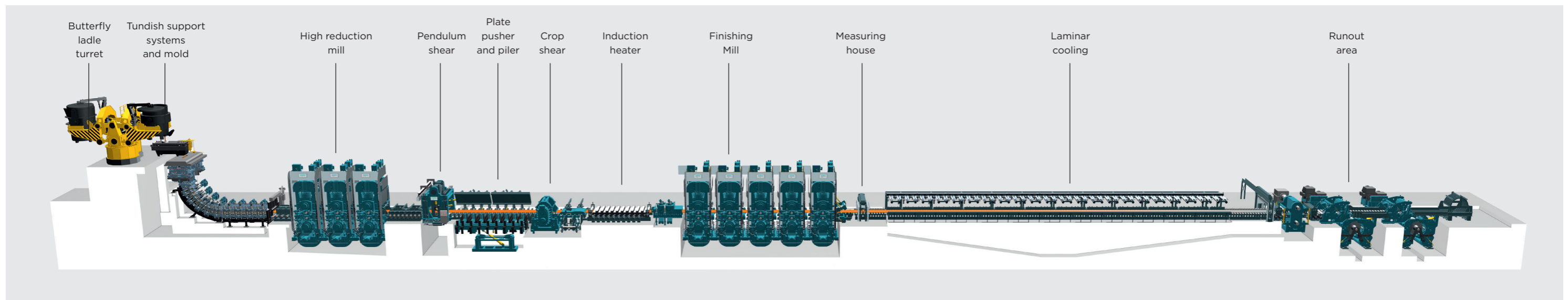
This facility, located downstream of the pendulum shear, fulfills the following functions:

- Dummy bar removal
- Material piling in plate-production mode
- Allows higher availability of the line with continued production during short downstream stoppages

CROP SHEAR AND STRIP LIFTER

The crop shear is positioned directly in front of the strip lifter. This unit is also utilized to:

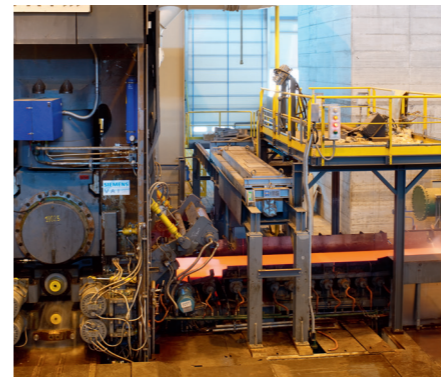
- Cut samples
- Enables tension control between high-reduction mill and finishing mill
- Empty the pusher/piler area in cases of downstream interruptions



Induction heater



5-stand finishing mill



Measuring house with Planicim roll



Laminar cooling section



Runout area

INDUCTION HEATER

The induction heater is characterized by its short length of only 10 m, which is a decisive factor for reduced scale losses compared to long tunnel furnaces. There are no energy costs during furnace idle time. Maintenance periods and costs are also reduced compared to tunnel furnaces. Optimized control of the end-rolling temperature for finishing rolling is ensured by the installed modules of the induction heater.

DESCALER AND FINISHING MILL

A special designed high pressure descaler ensures perfect surface quality. The finishing mill rolls the product to its final thickness while ensuring that the target product dimensions (thickness, profile and flatness) are met. The mill is equipped with all modern actuators, i.e., hydraulic AGC (automatic gauge control), work-roll bending/ work-roll shifting with SmartCrown®, wear compensation, dynamic work-roll cooling, fast vertical hydraulic loopers, an accurate drive system and a roll-gap lubrication system.

In this way a wide range of strip thicknesses can be endlessly rolled at narrow tolerances and at maximum design width, including hard steel grades. Conventional work-roll contours installed in the final mill stands allow wear-compensation measures to be applied, thus reducing operational costs.

MEASURING HOUSE

The measuring house is equipped with standard gauges for thickness, profile and temperature measurements. Additionally, a Hot Planicim roll is installed after the finishing mill in the ESP line to provide accurate flatness readings and control even when the strip is under tension. In this way, potential surface-flatness defects, such as quarter buckles, can be detected online during rolling and rectification measures initiated upstream.

LAMINAR COOLING

The cooling section is equipped with individually controlled tilting headers, providing capabilities for the necessary cooling strategies to produce different products and steel grades. Application of the latest cooling models take into account the phase composition of the material to ensure an optimum and consistent strip quality. Continuous operation of the cooling line due to endless production is the basis for maximum line performance.

RUNOUT AREA

This section consists of a high-speed shear and downcoilers where the strip is coiled. The integration of advanced technological packages and automation systems from Primetals Technologies ensures reliable operation. Contrary to batch processes where the line capacity is limited by the exit speed, the increased risk of cobbling by flying strip heads with decreasing strip thicknesses is eliminated in the Arvedi ESP process.

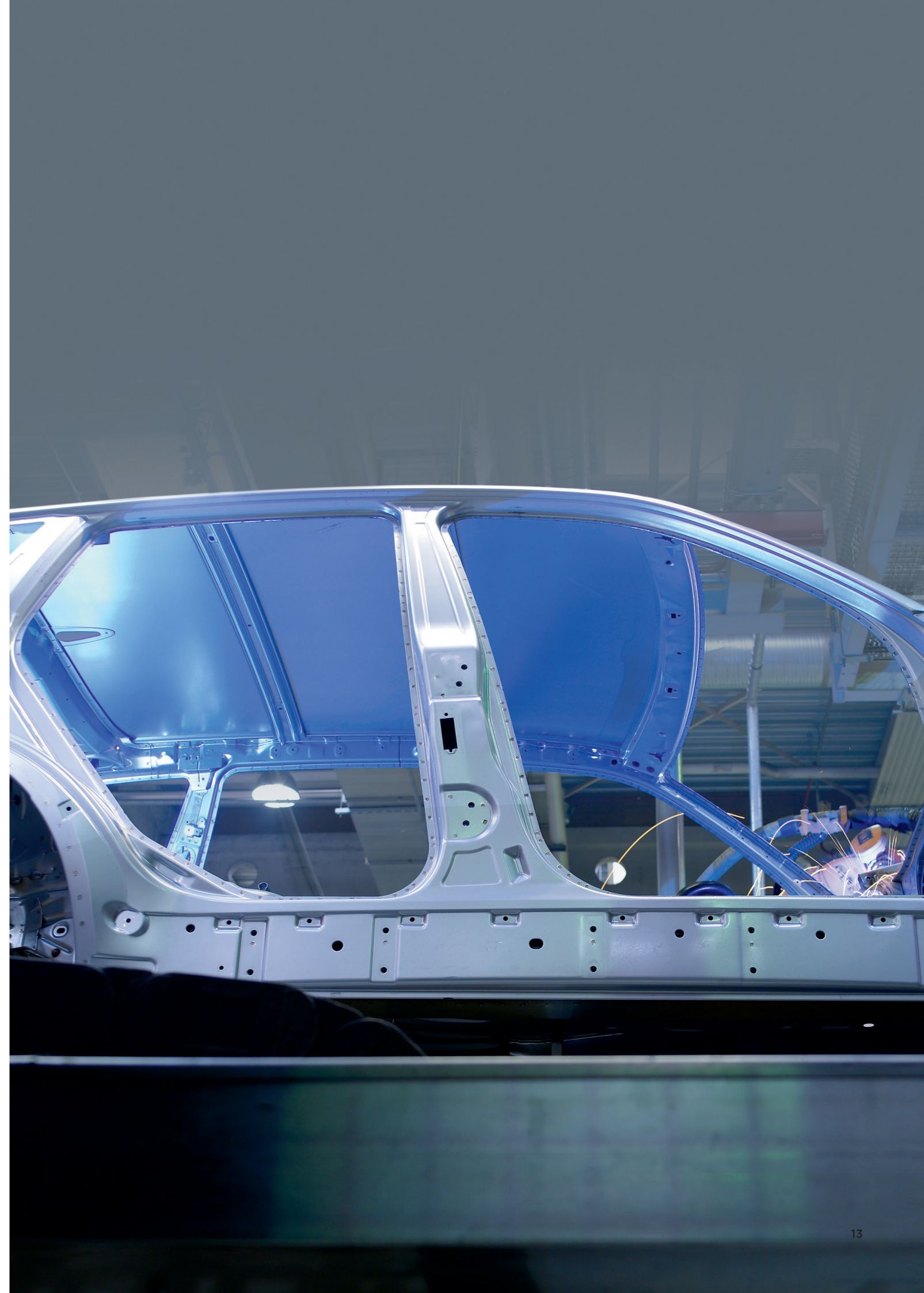
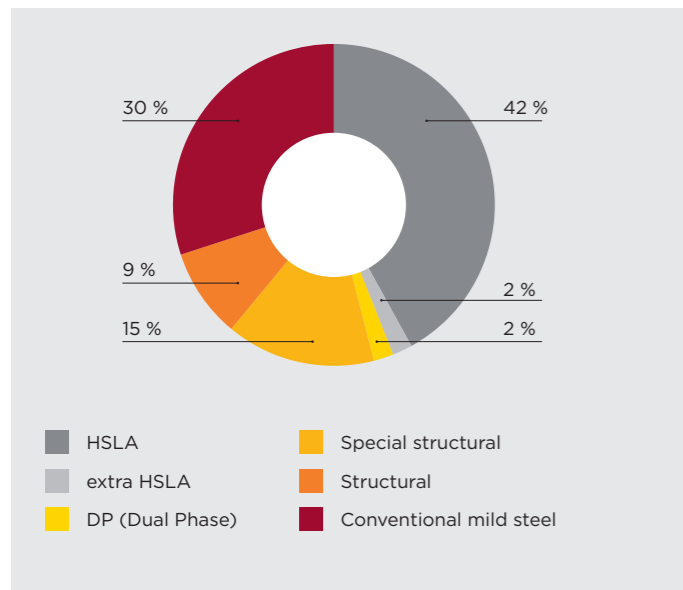
PRODUCTS OF THE HIGHEST QUALITY

Arvedi ESP is the new key technology for successful growth in the high-quality steel segment. The broad range of products gives steelproducingcompanies the independence and flexibility to serve different industries and create new business opportunities.

A complete range of low- to high-carbon steel grades can be produced in an Arvedi ESP plant, including alloyed steel grades. Also pipe grades up to API X80, AHSS grades, DP & multi-phase steel grades as well as silicon steel allow to diversify on the market.

A large portion of thin-gauge strip (0.8 -1 mm) produced in an Arvedi ESP line can substitute cold-rolled products for many applications. This is because the problems associated with threading of the strip into the finishing rolling stands are avoided in the endless rolling process. Properties of steels produced at Acciaieria Arvedi S.p.A. (examples):

- 1 mm thick steel with yield limits up to 315 MPa
- 1.2 mm thick steels with yield limits up to 420 MPa
- < 2 mm thick high-strength steels with yield limits up to 700/800 MPa
- 1.4 mm for DP 600



COST AND ENERGY SAVINGS

The new Arvedi ESP line concept achieves the world's best energy balance for the production of hot-rolled coils from liquid steel. Because the strip is rolled while the center is still hot and soft, the energy required for deformation is drastically reduced.

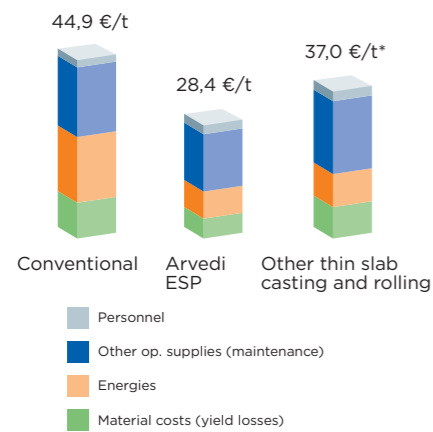
Unlike other thin-slab casting and rolling processes, Arvedi ESP requires less energy when the casting speed – and thus the production output – is increased. In certain cases for certain steel grades induction heating is not necessary at all prior to finish rolling.

The use of thin-gauge hot-rolled strip substituting coldrolled strip saves the energy required for cold rolling, annealing and skin passing. The high-quality thin gauges produced in the endless strip production process will contribute to an increased acceptance of thin-gauge hotrolled strip on the market.

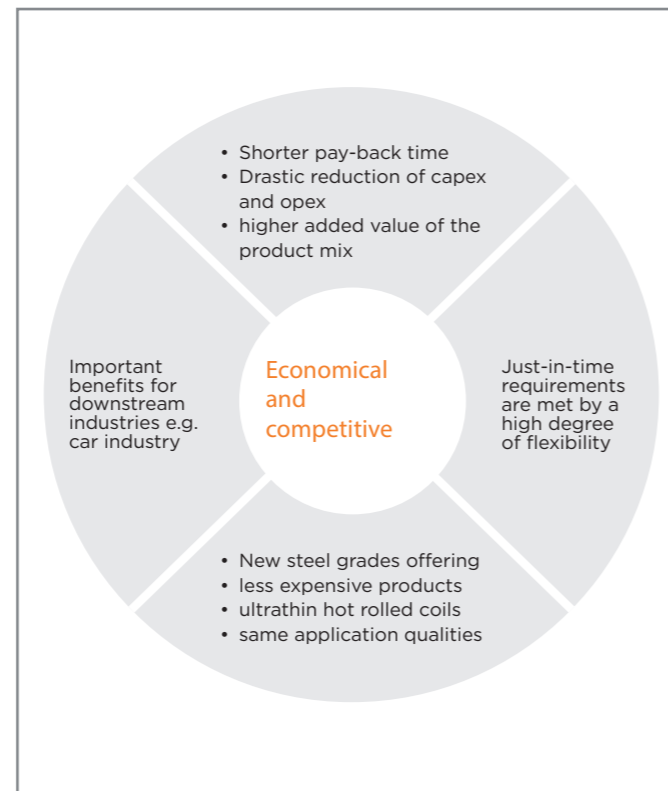
Thin hot-rolled strip produced in Arvedi ESP lines is characterized by its excellent precision, dimensional and flatness features. With a reduced number of cold-rolling steps, strip gauges down to 0.3 and 0.2 mm can be rolled at lower investment and processing costs.

Direct processing costs are highlighted by a lower energy consumption (about 45% lower than in conventional hotstrip mills), lower costs for consumables (mold, rolling cylinders, etc.) and improved liquid steel yield (up to 97%).

OPEX comparison - cash conversion costs from liquid steel to coil:



*) Compare world steel dynamics 2009

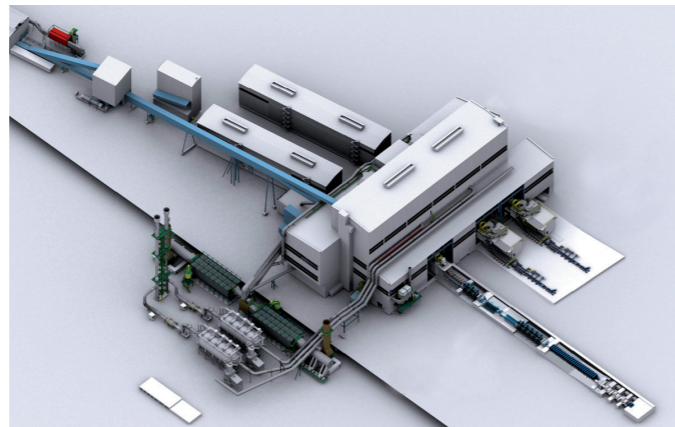
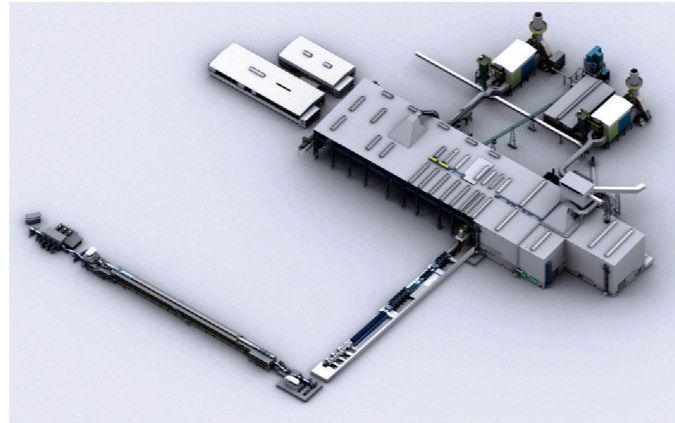


STEELWORKS INTEGRATION

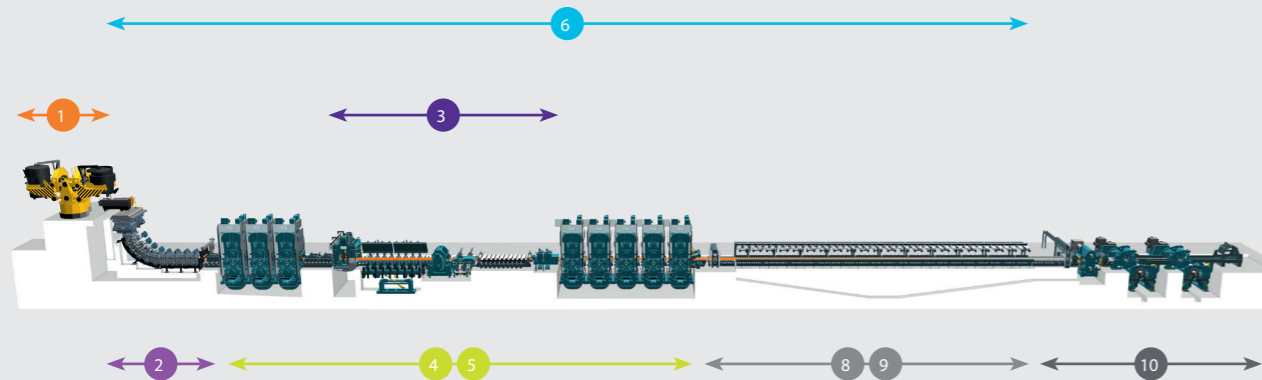
An Arvedi ESP line is not only limited to minimills, it can also be installed in an integrated steelworks as part of an extension project.

The compactness and flexibility of Arvedi ESP lines offers newcomers and owners of minimill plants a perfect opportunity to enter the high-quality flat-steel segment with the production of ultra-thin hotrolled strip.

- Installation of an Arvedi ESP line in an integrated steelworks would allow the production of sophisticated steel grades - typically ultra-thin gauges, silicon steels and high-strength steels - to be shifted from the hot-strip mill to the Arvedi ESP line. The product mix of the existing hotstrip mill could then be optimized to operate at a higher output level with no or only minor additional investments.



ADVANCED AUTOMATION



1 MACHINE HEAD

- Mold expert models (breakout detection, friction, heatflux etc.)
- Mold level control
- Width control
- Hydraulic oscillation model and control

2 STRAND CONTAINMENT

- Cooling control
- Drive control
- Core reduction gap control

3 PASS CALCULATION

- Comprising rolling and strip temperature model
- Taper calculation and setup

4 ROLLING MODEL

- Mechanical model
- Yield stress model
- Friction model
- Adaptation

5 PROFILE & FLATNESS CONTROL

- Roll bending model
- Roll thermal crown / wear model
- Material flow model
- Roll flattening model
- Roll shifting

6 STRIP TEMPERATURE AND MASS FLOW MODEL

- Heat transfer model
- Temperature monitor
- Phase transformation model
- Temperature controller
- Adaptation
- Strip tracking

7 MACHINE HEAD

- HAGC incl. fuzzy logic for stable operation
- Looper tension with tension leveller
- Thickness monitor feed forward to speed control
- Taper rolling

8 COOLING SECTION

- Heat transfer model
- Temperature monitor
- Phase transformation model
- Temperature controller
- Adaptation

9 MICRO STRUCTURE MONITOR

- (Observer mode, Online optimizer, Offline mode)
- Recrystallisation model
- Phase transformation model

10 CUTTING AND COILING

- Flying shear control
- Step control



With the introduction of endless strip production, new control features were implemented from the caster to the coiler. These are based on an integrated automation system using SIMATIC components throughout the entire plant, the well proven SIMETAL and SIROLL software solutions modified to the requirements of endless strip production, and a unified HMI (human machine interface). Examples of process models and technological packages are listed in the following.

DYNAGAP

DynaGap, in conjunction with SMART Segments, provides fully dynamic strand-taper control resulting in:

- Substantial internal product-quality improvements as a result of reduced center segregation
- Automatic determination of the target roller gap profile on the basis of online strand condition modeling

PATENTED FLYING GAUGE CHANGES IN ENDLESS STRIP PRODUCTION*

Precise and rapid application of HGC (hydraulic gauge control) in the mill stands is vital for ensuring the required strip-thickness changes and to avoid excessive transition lengths.

Tension-free cut at the high-speed shear At the end of the endless strip production line, it is necessary to cut the endless strip into discrete lengths for coiling. The high-speed shear positioned in front of the coiler has two key challenges to meet:

- Precise cutting at the position between two coils
- Tension-free cutting to ensure smooth and continuous rolling operations

PROFILE AND FLATNESS

Excellent strip profile and flatness is ensured by the installed SmartCrown® variable crown system, the rollbending system, dynamic work-roll cooling and profile and flatness models.

DRIVES AND MOTORS FOR FAST DYNAMIC CHANGES

The ESP plant is equipped with non-salient-type motors for the main drives and the latest generation of voltage source converters to provide the power and the precision necessary for all dynamic speed changes. High unit availability is a key factor for a high production output in an endless production process.

BIDIRECTIONAL MASS FLOW CONTROL

Since an ESP plant must be able to roll in the standard batch mode as well as in the endless mode in which the entire mill is coupled to the mass flow of the caster, the automation provides modes in which the mass flow is controlled in forward or backward mode and ensure a seamless switchover between the two modes. These functions are supported by a highly precise materialtracking system implemented in the automation system.

MICROSTRUCTURE TARGET CONTROL

Besides the geometrical quality, it is also essential to control the phase composition of the strip at the end of the plant, since this is where the mechanical quality is defined. With the latest cooling model from Primetals Technologies, it is possible to calculate and control online the cooling temperature as well as the phase composition of the strip. With the optional Microstructure Monitor, the mechanical properties can be calculated online and are available along the complete strip length immediately after production.

HUMAN MACHINE INTERFACE

The modern WINCC machine interface provides the operator with a twin terminal for more display area, and thus easy and fast diagnostics with an ergonomic user interface. With masks available for the caster to the coiler a unified and elegant interface is provided for the user.

EXPERTISE FROM EXPERIENCE

These are the results with which our customers can measure their success - and ours as well. Take a closer look, and you can judge us by the following examples.

ITALY ISP Plant Cremona 1

Type of system

ISP Generation 1

Technical features

Upgrade to a high speed caster including DynaWidth mold-width adjustment, liquid-core reduction, dynamic soft reduction and advanced secondary cooling system

Production capacity

1.2 million tons per year

Steel grades

Carbon steels, high-strength low alloyed (HSLA) grades, dual phase steels and silicon grades

Product dimensions

Widths of up to 1,260 mm and thicknesses down to 1.0 mm

Benefits

- Stable high casting speeds
- Increased production from original design capacity of 550,000 tons per year to a current average production figure of about 1,200,000 tons per year
- Increase of segment roller life time

ITALY ESP Plant Cremona 2

Type of system

Arvedi ESP plant

Technical features

Installation of world's first real Endless Strip Production line with a thin-slab casting machine directly connected to a specially designed continuous roughing mill, followed by an inductive heater, finishing mill and run-out area

Maximum plant production capacity

Up to 2.3 million tons per year

Steel grades

Carbon steels, high-strength low alloyed (HSLA) grades, API grades, dual phase steels and silicon grades

Product dimensions

Widths of up to 1,570 mm and thicknesses down to 0.8 mm

Benefits

- Yield from liquid to coil over 98%
- World's best performance in lowest breakout rate on thin slab casters
- Homogeneous product properties
- Lowest energy consumption and operation costs per year Increase of segment roller life time



SELECTED SUCCESS STORIES WITH ARVEDI ESP TECHNOLOGIES



CHINA | ESP PLANT RIZHAO 1

Type of mill. Arvedi ESP Plant.

Technical features. China's first real Endless Strip Production line with a thin-slab casting machine directly connected to a specially designed high reduction mill, followed by an inductive heater, finishing mill and run-out area. Liquid steel supply from a new 300 t converter melt shop.

Production capacity. 2.55 million tons per year.

Steel grades. Carbon steels, high-strength low alloyed (HSLA) grades and dual phase steels grades.

Product dimensions. Widths up to 1,600 mm and thicknesses down to 0.8 mm.



CHINA | ESP PLANT RIZHAO 2

Type of mill. Arvedi ESP Plant.

Technical features. Endless Strip Production line with a thin-slab casting machine directly connected to a specially designed high reduction mill, followed by an inductive heater, finishing mill and run-out area. Liquid steel supply from new a 300 t converter melt shop.

Production capacity. 2.55 million tons per year.

Steel grades. Carbon steels, high-strength low alloyed (HSLA) grades, API grades, dual phase steels and silicon grades.

Product dimensions. Widths up to 1,600 mm and thicknesses down to 0.8 mm.



CHINA | ESP PLANT RIZHAO 3

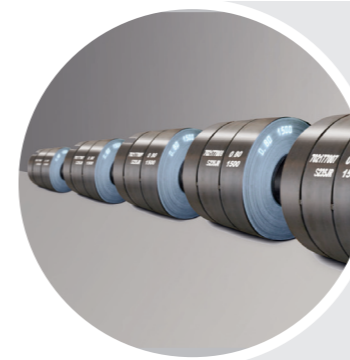
Type of mill. Arvedi ESP Plant.

Technical features. Endless Strip Production line with a thin-slab casting machine directly connected to a specially designed high reduction mill, followed by an inductive heater, finishing mill and run-out area. Liquid steel supply from a new 300 t converter melt shop.

Production capacity. 2.55 million tons per year.

Steel grades. Carbon steels, high-strength low alloyed (HSLA) grades, API grades, dual phase steels and silicon grades.

Product dimensions. Widths up to 1,600 mm and thicknesses down to 0.8 mm..



CHINA | ESP PLANT RIZHAO 4

Type of mill. Arvedi ESP Plant.

Technical features. Endless Strip Production line with a thin-slab casting machine directly connected to a specially designed high reduction mill, followed by an inductive heater, finishing mill and run-out area. Liquid steel supply from an existing 63 t converter melt shop.

Production capacity. 1.7 million tons per year.

Steel grades. Carbon steels and high-strength low alloyed (HSLA) grades.

Product dimensions. Widths up to 1,300 mm and thicknesses down to 0.8 mm.



CHINA | ESP PLANT RIZHAO 2

Type of mill. Arvedi ESP Plant.

Technical features. Endless Strip Production line with a thin-slab casting machine directly connected to a specially designed high reduction mill, followed by an inductive heater, finishing mill and run-out area. Liquid steel from existing 63 t converter melt shop.

Production capacity. 1.7 million tons per year.

Steel grades. Carbon steels and high-strength low alloyed (HSLA) grades.

Product dimensions. Widths up to 1,300 mm and thicknesses down to 0.8 mm.

Primetals Technologies Austria GmbH

A Group Company of Mitsubishi Heavy Industries

Turmstrasse 44
4031 Linz
Austria

[primetals.com](https://www.primetals.com)

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