

# **AUTOMOTIVE APPLICATIONS**

Trends and solutions for aluminum rolling



# AUTOMOTIVE MARKET TRENDS

The year 2013 marked the breakthrough in aluminum sheet production for the automotive industry. Major car manufacturers announced that new models will see the benefits of the lightweight and durable metal. The new trend is driven by latest European and US legislations which require a substantial reduction of CO<sub>2</sub> emissions and higher fuel efficiency. This will put aluminum cars in a pole position.

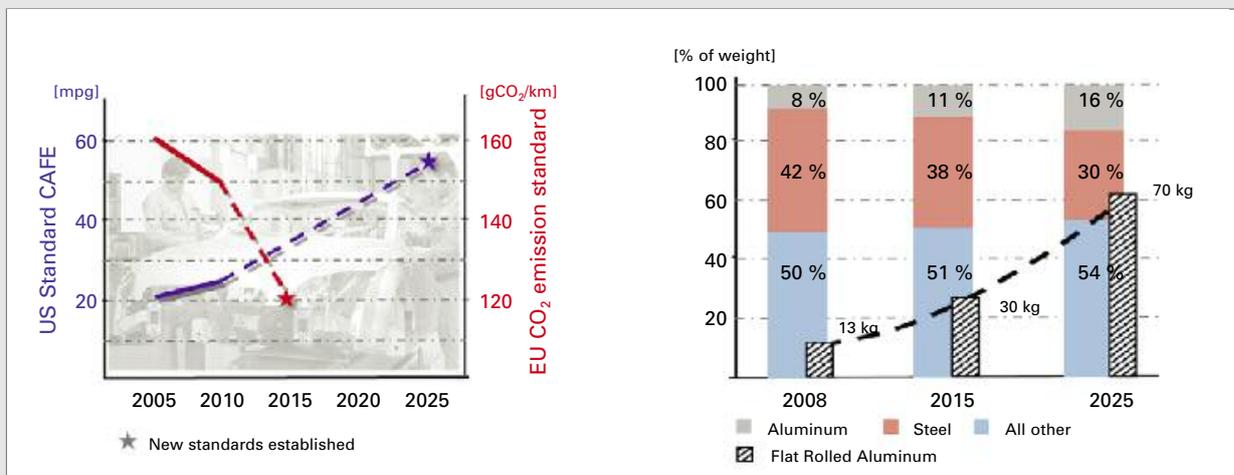
Large volume models like US' best-selling Ford F-150 will use aluminum as their material of choice for body construction to set new standards.

"2014 marks the beginning of dramatic growth for aluminum in the auto sector," Alcoa CEO Klaus Kleinfeld summarizes the expected growth in the US market for aluminum sheet to almost 1 million tons until 2020.

***"By 2020, 65% of our business will be automotive"***

***(Phil Martens, CEO Novelis)***

The global aluminum industry responds to the looming supply shortage of high quality sheet with special properties and perfect surface by announcing new investments in rolling and heat treatment capacity. Established plants must be converted to incorporate the tailored production processes while new facilities enjoy the advantage to focus on the automotive sheet demands right from the design phase.



New cars fuel saving standards.

Material use in new US vehicles.

# STATE-OF-THE-ART CAR CONCEPTS

Innovative and advanced car concepts use cast, extruded and rolled aluminum alloys for parts in the power train (engine block, cylinder head), chassis and heat exchangers.

The car body (body-in-white, hoods/bonnets, doors, etc.) mainly uses work-hardening AlMg(Mn)-alloys of 5xxx series and heat-treatable AlMgSi-alloys of 6xxx series. Sheets of heat-treatable 6xxx alloys like

AA6016 or AA6111 obtain their material strength by a heat treatment process subsequent to rolling.

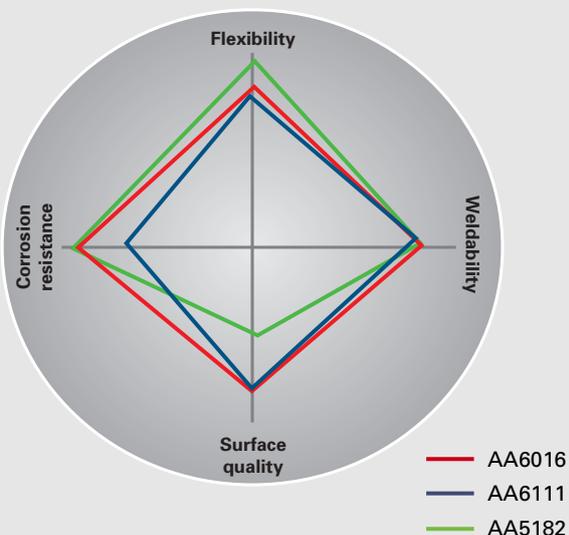
While 5xxx series alloys with high formability are mainly used for non-visible inner parts, 6xxx series alloys with improved bake-hardening and forming characteristics are increasingly used for exposed outer parts.



Aluminum body-in-white.



Perfect surface quality for automotive application.



Material properties of aluminum alloys.

# NO COMPROMISE IN PRODUCT QUALITY

Excellent formability during pressing and a perfect surface appearance after painting are the uncompromising demands to exposed car panels. The European car industry relies on rolled strip surface with an isotropic roughness.

EDT (Electric Discharged Texturing) is a machining process which removes particles from a work roll surface by energy of electric discharges. Such created roughness of the roll barrel is transferred to the strip surface during a final rolling pass.

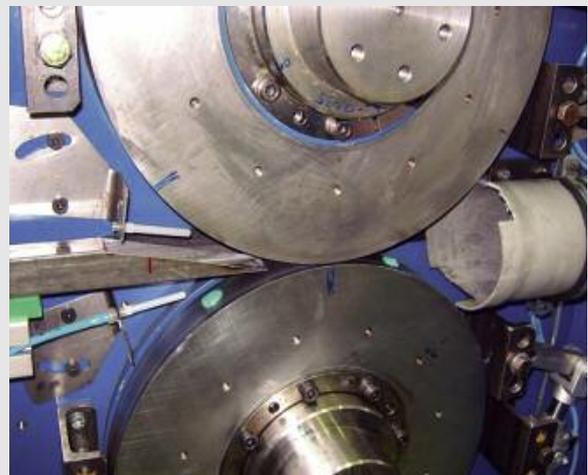
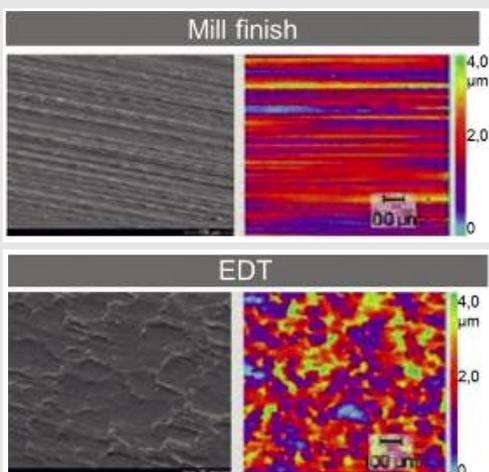
While mill finish sheet shows anisotropic surface appearance with line pattern and a limited roughness of approx.  $0.5 \mu\text{Ra}$ , an EDT rolling process can produce isotropic strip surface with approx.  $1.2 - 1.6 \mu\text{Ra}$ .

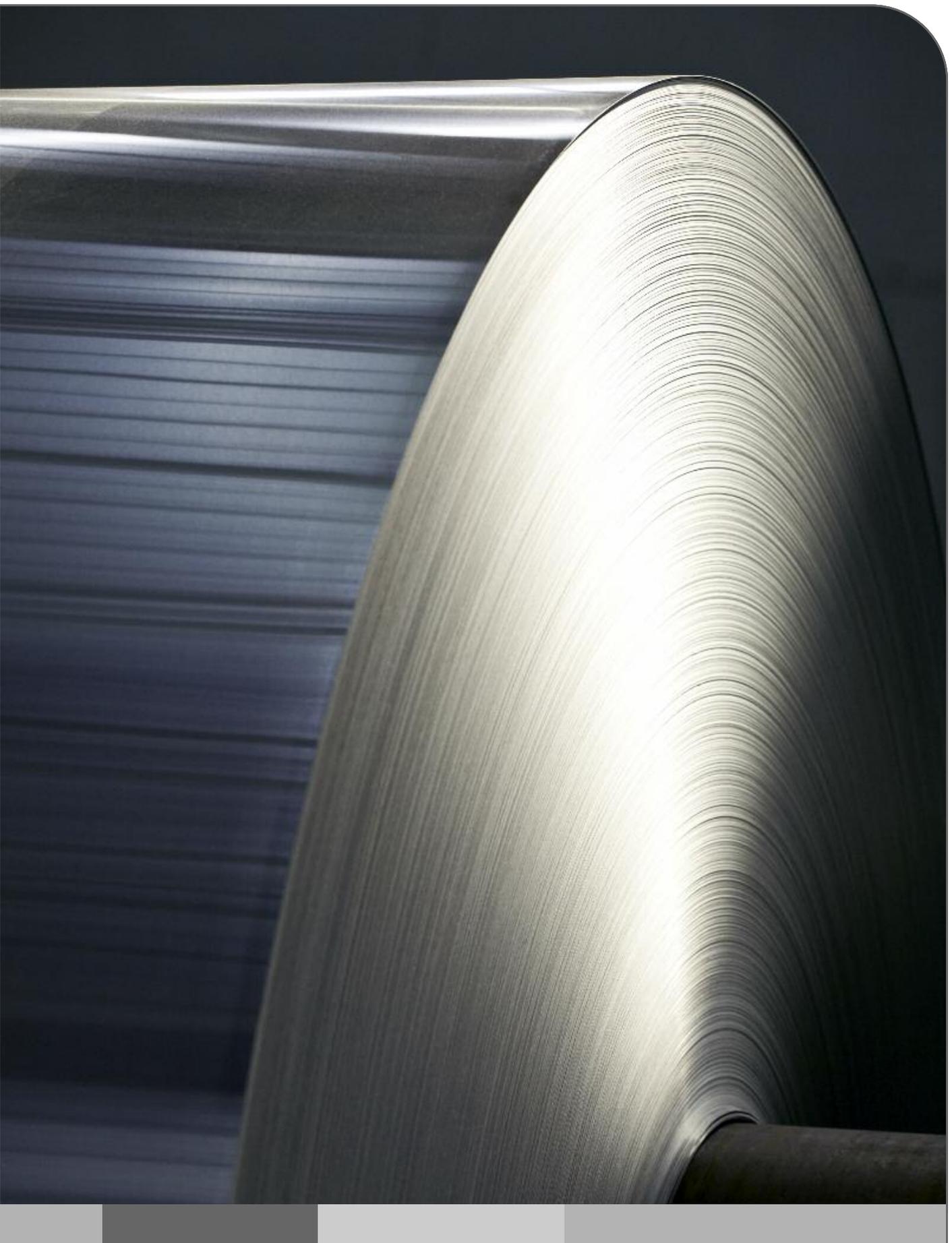
When it comes to first class automotive sheet, SMS Siemag is the partner of choice for the industry. Our unique experience in EDT rolling of automotive steel provides a profound practical knowledge which can



Preparation of EDT roll. Several SMS Siemag service locations all around the world offer EDT treatment of work rolls.

enhance EDT rolling of aluminum. In-house research and testing facilities are used to further investigate and develop EDT rolling. Results are incorporated into our models and the mill design.





# TAILOR-MADE MILL CONCEPTS FOR EDT ROLLING

## EDT ROLLING MILLS

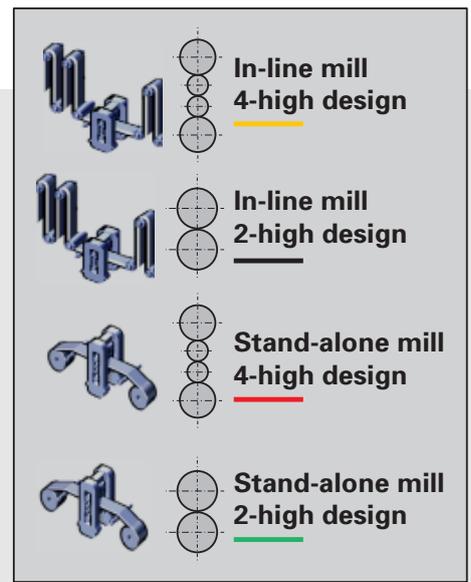
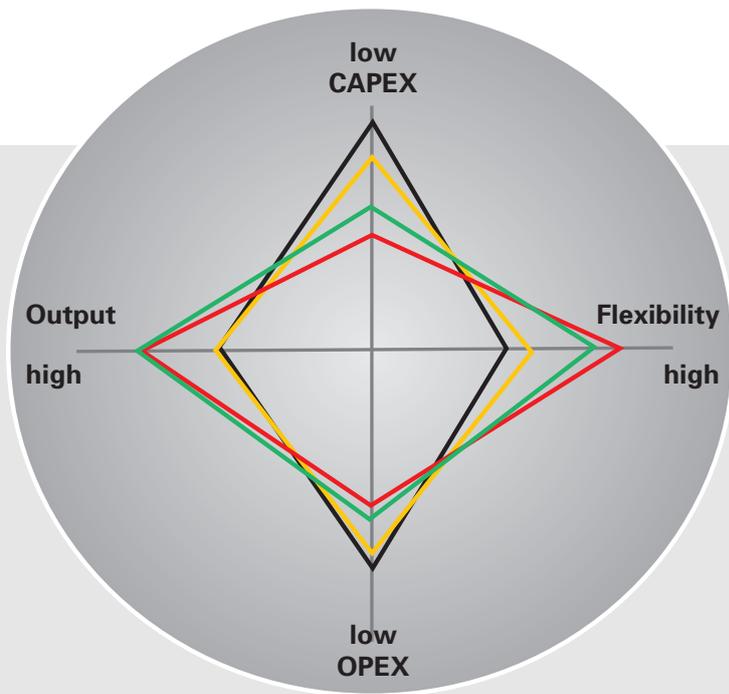
In the course of the strongly increasing demand for EDT rolled automotive sheet and its further growth potential, single purpose EDT rolling mills are becoming economically viable.

The elimination of the reduction mode offers potential to streamline the mill design. Coil logistics, rolling oil system and auxiliary systems can be optimized for the limited requirements.

Mills in conventional 4-high or even 2-high design can be arranged as stand-alone units or as in-line mills integrated into continuous heat and chemical strip processing lines.

The selection of the most suitable EDT rolling mill concept mainly depends on the product mix diversity and the related need for flexibility.

While stand-alone 4-high mills offer high flexibility, the limited capabilities of an in-line 2-high mill can be obtained with low investment and operating costs.



Comparison of EDT mill concepts.

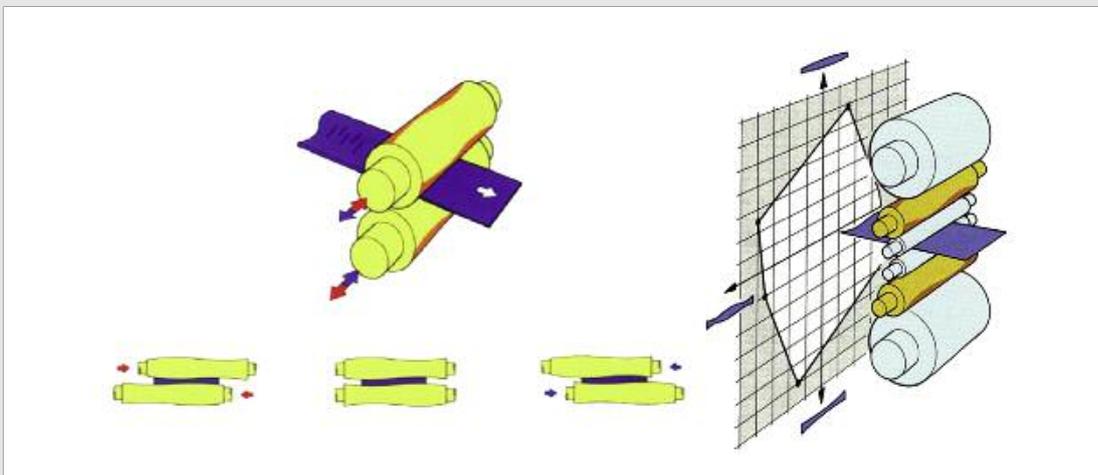
## COMBO REDUCTION & EDT ROLLING MILLS

Today most new aluminum cold rolling mills are requested to provide the flexibility to be operated in heavy force reduction mode as well as in light force EDT mode. Both contrary rolling modes must be effectively performed without compromising on rolled product quality.

Our combo reduction & EDT rolling mills feature CVC® (Continuously Variable Crown) and EBS (Extended Bending System). These unique technologies provide a large mill setting and control range as required to cover all rolling conditions.

The CVC® technology is an outstanding tool to produce strips with excellent flatness. Axial shifting of S-shaped rolls generates roll gap contours of positive, neutral or negative crown matching all needs of incoming strip profiles.

The optimum shifting position of the CVC® rolls is determined by the model-based level 2 control system. By such automatically pre-set and controlled operating conditions, all other flatness actuators like roll bending or spray cooling achieve their highest efficiency.



Working principle of CVC®.

**EXTENDED BENDING SYSTEM (EBS)**

Compared to conventional reduction rolling, EDT rolling is performed with low rolling forces, which might be even lower than the weight force of a back-up roll assembly. The request for an even roughness transfer across and along the entire strip is a challenge which requires special technology, design and dedicated control concepts.

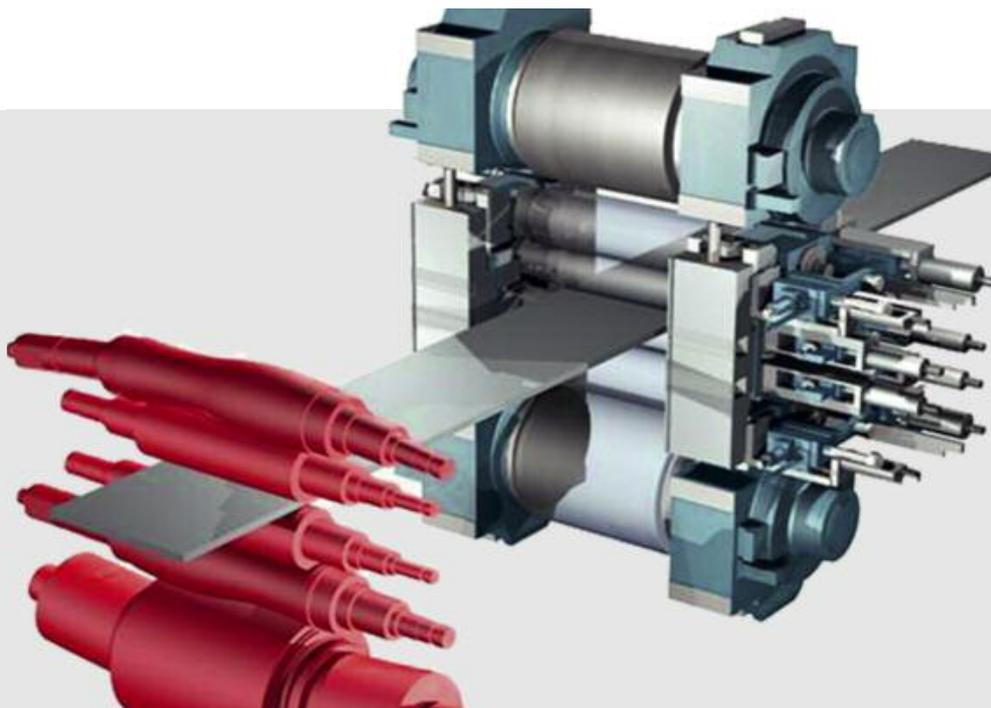
Since similar demanding requirements are well known from the steel industry, we developed the EBS (Extended Bending System) technology for highest accuracy during EDT rolling and adapted it for combo reduction & EDT aluminum rolling mills.

In EBS rolling mode, the upper back-up roll is lifted by the back-up roll balancing cylinders and low rolling force is applied by additional bending cylinders acting

on the top intermediate roll. These additional bending cylinders act in negative bending direction, thus applying the reduction force. If required, also the bottom intermediate roll is equipped with additional bending cylinders acting in positive bending direction to allow for a parallel setting of the roll gap. The hydraulic gap adjustment cylinders are not in use during EDT passes.

Compared to other technical concepts for low-force rolling, EBS improves the control of the rolling process significantly due to reduced mill friction.

When equipped with the Extended Bending System, aluminum rolling mills from SMS Siemag cover a huge operating range from lowest to highest roll forces with excellent dynamic behavior and performance.



Working principle of EBS.

## TECHNOLOGICAL CONTROL STRATEGY WITH EBS

EBS is controlled in force mode like standard bending systems. In addition, the EBS features a position control mode to allow for a gap setting as known from the hydraulic gap adjustment. Set-up is either by a table-based system or by a full model based level 2 system. The model based set-up minimizes in particular the head end losses during and right after threading. During EDT rolling an outer loop elongation control adjusts the force applied by the EBS. Target is an even roughness transfer from the EDT work rolls to the strip along the strip length. The elongation control is based on laser speed measurements located on the entry and exit sides of the mill.



# ROLLING MILL AUTOMATION WITH X-PACT® ALUCONTROL®

Maximum stability, easy maintenance, uncomplicated adaptation and high technological performance are often-stated requirements when it comes to modern automation systems. AluControl® is a part of the X-Pact® automation package from SMS Siemag and is designed to suit the special requirements of aluminum hot and cold rolling processes.

AluControl® offers a full high performance automation package for the rolling of strip qualities according to high demands of the automotive industries. Control strategies for conventional reduction passes are part of the package as well as specialized controls for EDT passes.

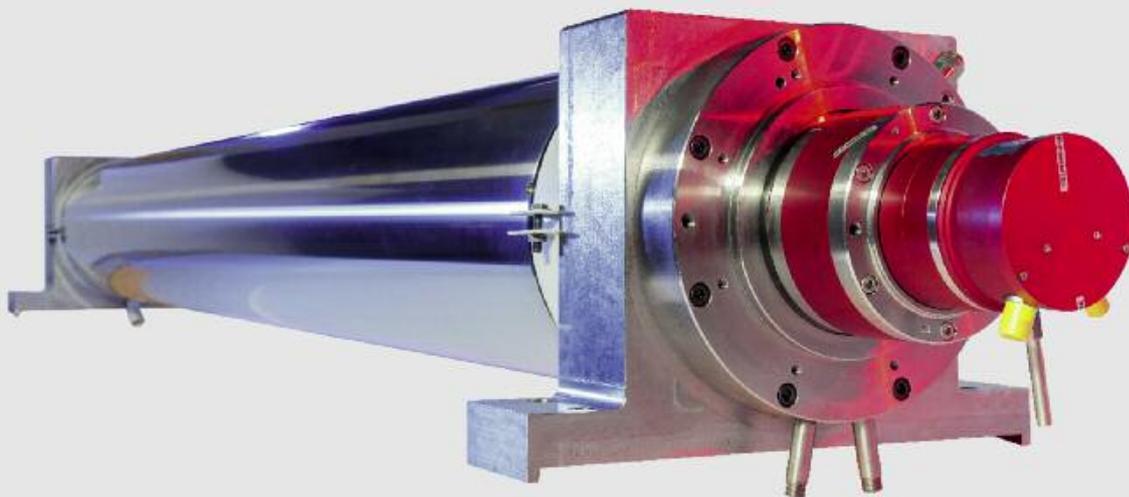
## X-SHAPE FLATNESS MEASUREMENT

A uniform roughness transfer across the strip width is supported by the X-Shape flatness measurement roll located on the exit side of the mill. The roll measures the strip tension distribution across the strip

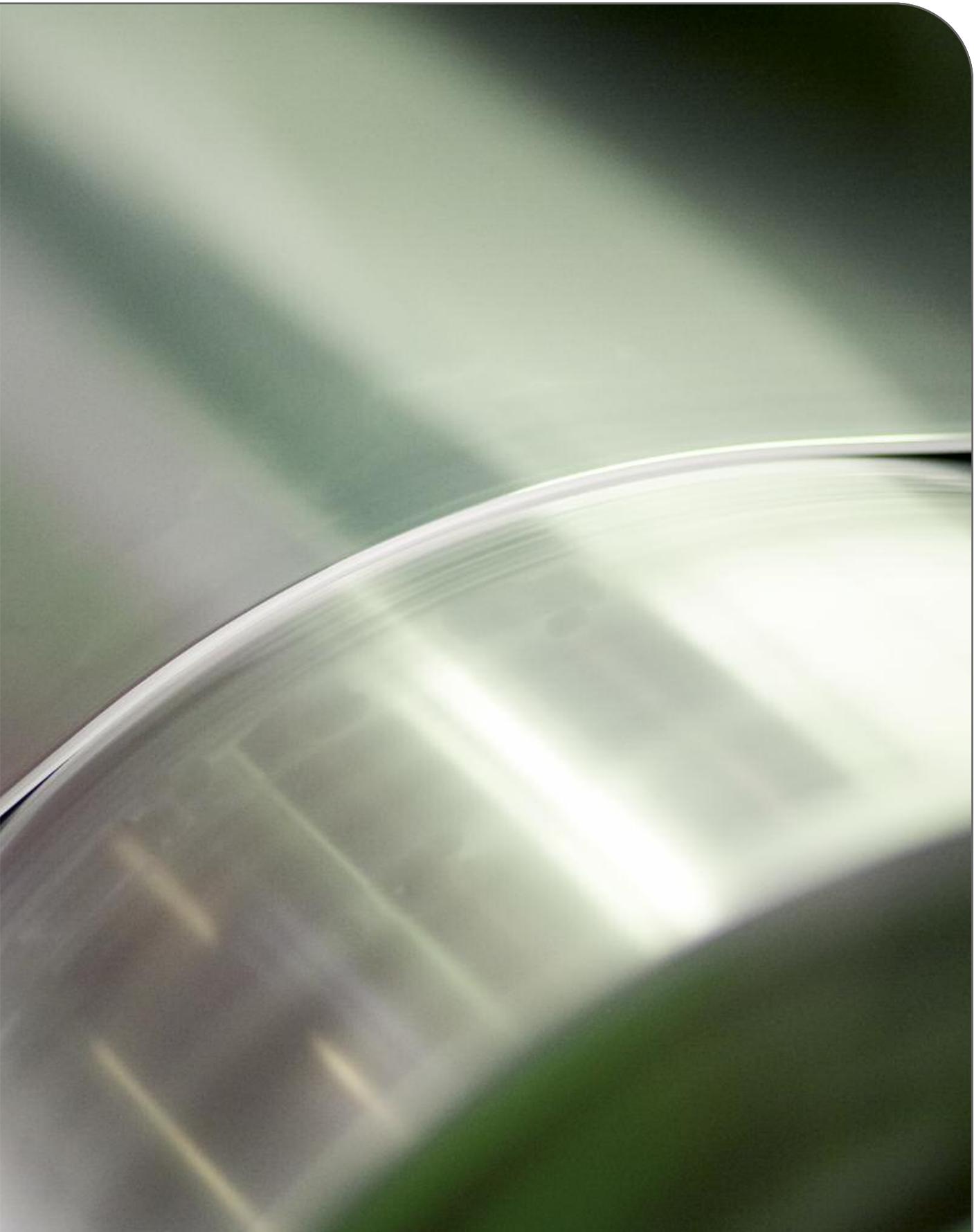
width. The readings are used by the X-Pact® AluControl® to adjust the roll gap by tilting via the EBS and work roll bending.

The X-Shape measurement is based on the BFI principle. Its highly sensitive piezo-sensors are ideal for the detection of even smallest differences in the strip elongation across the strip width. The in-roll signal amplification is adjusted to the actual process needs allowing for an appropriate and high resolution of the measurement.

Optionally, an online strip roughness measurement can be added to the exit side of the mill. Besides quality reporting aspects, the roughness measurement helps prolonging the work roll operating times by adaptation of the elongation control.



Flatness measuring rolls built by SMS Siemag.



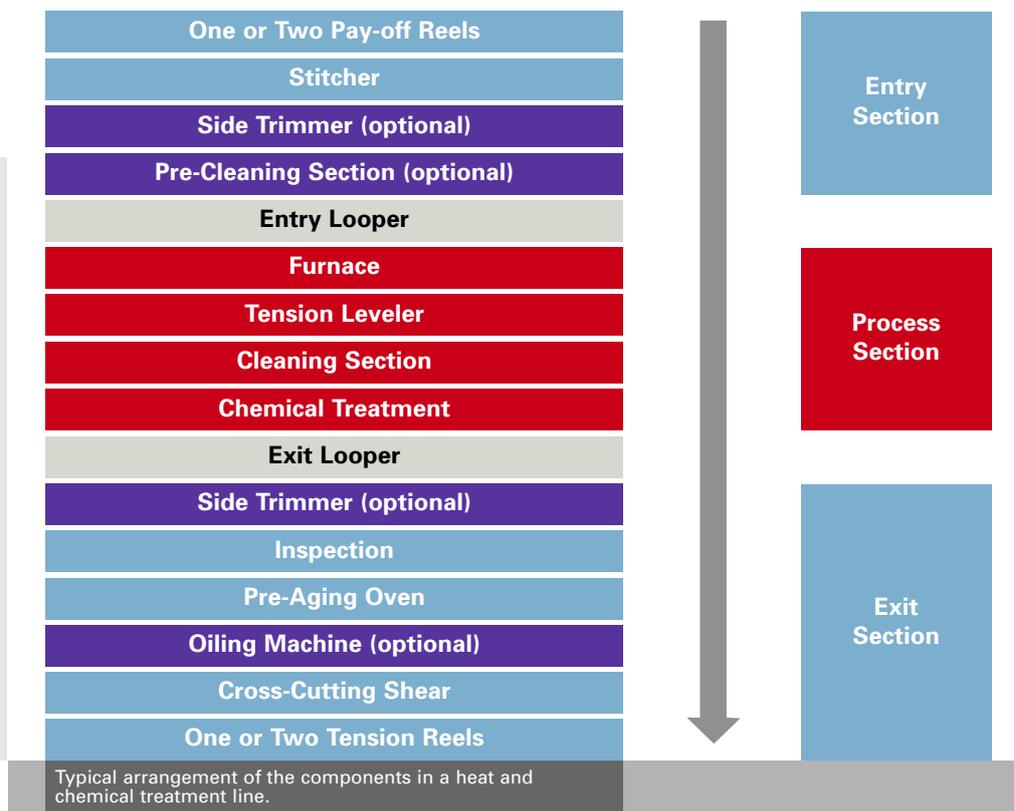
Flatness measuring roll as a deflector roll.

# HEAT AND CHEMICAL TREATMENT OF AUTOMOTIVE ALLOYS

Subsequent to the cold rolling process, the aluminum sheets required by the automotive industries have to undergo special treatments to regain formability as well as the required material strengths, flatness and surface properties. The necessary processes can take place separately in different facilities or combined in a heat and chemical treatment line. One of SMS Siemag's unique features is to supply the required lines completely from one single source including the process components, high-performance and energy-efficient furnace technology, dependable mechanical components as well as electrical and automation systems. This entails clear advantages for the aluminum producers.

## FLOATATION FURNACE AND WATER-QUENCH COOLING

The furnace and cooling technology is the heart of the process. The strip enters a floatation furnace where it is guided sinusoidal in a contactless floating mode. It is heated up and kept at the required strip temperatures in time, so the aluminum-alloy obtains their structure. Especially 6xxx as well as 2xxx and 7xxx alloys require high cooling rates. It is vital in heat treatment lines for those automotive or aerospace materials to achieve up to approximately 400 K/s. The cooling process is executed mainly in a powerful water-quench cooling section. A mathematical model calculates the necessary settings for the annealing and cooling process under consideration of the mechanical properties.



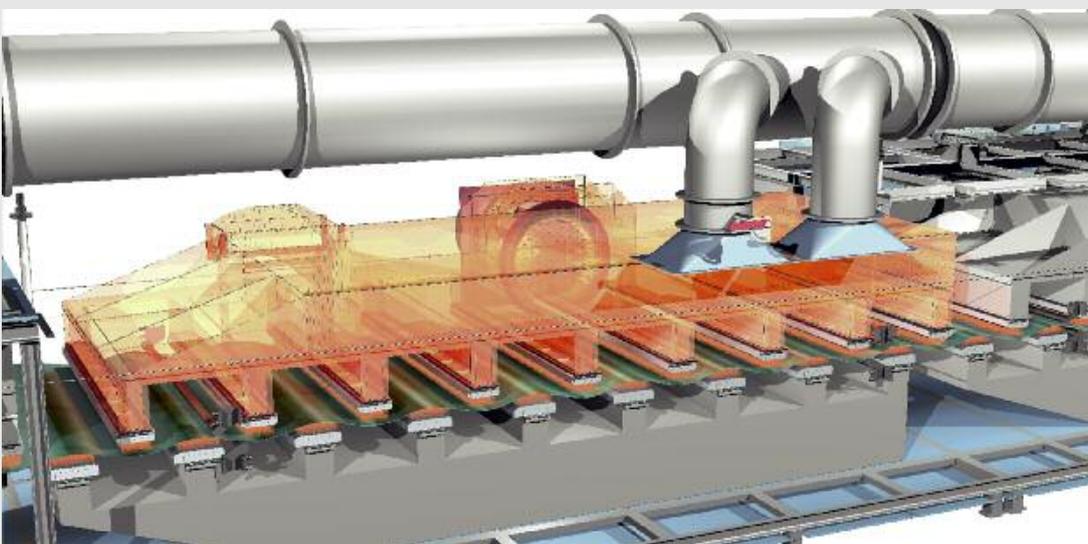
## CLEANING, DE-OXIDATION AND CHEMICAL TREATMENT

The strip surfaces must be cleaned before the chemical treatment. In the spray cleaning process the remaining surface impurities will be removed and the strip surface will be activated. Here special nozzles are used to avoid clogging and the nozzle bars are switchable for higher process flexibility.



Subsequently, a chemical coating is precisely applied onto the strip surface. The strip is coated evenly on each side with predefined surface thicknesses by a vertical or horizontal roll coater. Alternatively, a spray passivation or an immersion bath can be used depending on the media and other frame conditions.

This passivation creates a uniform and dense layer of aluminum oxide on the surface (sealing layer). This layer improves the corrosion protection of the strips to protect them from undesirable corrosion. Moreover it improves the adhesive properties and the weldability of the strips which opens up new opportunities in automobile manufacturing.



Contactless heat treatment in the floatation furnace.

# MANUFACTURING EXCELLENCE

Our key components are manufactured in the SMS Siemag workshop in Hilchenbach, Germany. It occupies about 55,000 square meters and is equipped with more than 70 top-quality machines for mechanical machining.

Prior to delivery the equipment is pre-assembled and functional tests are performed. The fact that at SMS Siemag R&D, design and manufacturing are located under the same roof is a major driving force for the continuous optimization of products.

All manufacturing processes are supported by IT systems as well as special fabrication planning and control software. Additional production process simulation, performed at the test field, minimize production failures and optimize product quality.



Pre-assembly.



Measuring device.



Hydraulic testing stand at SMS Siemag workshop, Hilchenbach.



Gear manufacturing.

# RECORD OF SUCCESS AND EXPERIENCE

Orders since 2005



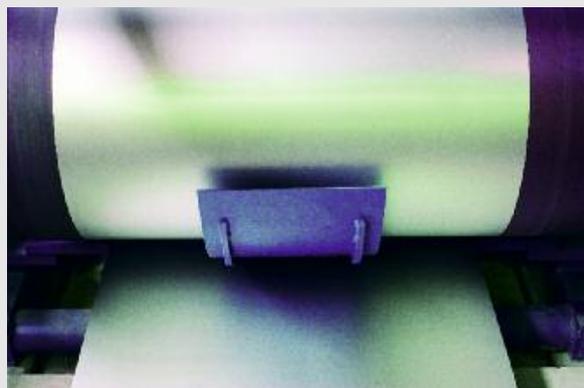
**23**  
Aluminum single-stand cold rolling mills



**15**  
Aluminum cold rolling mill orders for automotive & applications



**11**  
Aluminum tandem cold rolling mills



**21**  
Strip processing lines orders for automotive and aviation grades or can stock

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