

INNOVATION, TECHNOLOGICAL INVESTMENT and COST REDUCTION in ALUMINIUM STRIP and FOIL ROLLING

Axel E. Barten

MARKET REQUIREMENTS

The markets for rolled products of aluminium in transportation, packaging, consumer durables, foil and building construction are worldwide growing with a rate of 2 to 3% per year. Locally we see big differences in the growth rates of the national markets. This increases exports on the short term with a growing demand for plant modernisations in the industrial countries but it also induces the requirement of new installations in developing countries with high growth potentials like China.

Slowly but distinctly the use of aluminium sheet in automobiles is increasing, mainly in the higher price level cars. But energy saving philosophies are going to support the light weight and corrosion resistance advantages of aluminium in cars.

Light gauge aluminium strip and foil is mainly used for packaging purposes. On the market of packaging products a constant substitution process with other materials and different designs and sizes is taking place.

Thinking in the strategic triangle "Producer-Customer-Competitor" every strip and foil producer therefore is forced to offer a product that fulfils the *economic* needs of being competitive in quality and price.

In addition to that all production equipment used has to be more and more *ecologically* sustainable aiming to a generally positive environment and energy balance in favour of the material aluminium. The public opinion, sensitive and critical against waste, is influencing thoughts and actions of producers and equipment suppliers.

The specific requirements for a given market structure are different for every producer according to its own ideas in the realisation of success potentials either by high or low volumes and by wide or narrow product mix ranges. Driven by its sales forecast the producer defines his individual product mix and his production lots. His quality policy defines surface brightness, strip flatness, gauge tolerances and the number of acceptable pinholes in foil.

According to this "Know what" of the producer Achenbach as the only specialised mill builder in the aluminium industry provides the technological "Know how" to fulfil the requirements perfectly and reliably. In selecting the best available modules out of its modular designed mills and putting them together in a smooth way and realising a "Technology for Future Concepts". The quality of all mill modules is directly transferable to the quality of the rolled products. The accurate production philosophy of the machine parts, the right selection of the components and the highest intelligence in the integration of electronic measurement and control technologies into the total rolling operation is important.

“Thinner”, “wider”, “faster” are the productivity driven targets in aluminium strip and foil rolling which have to be reached under the strict conditions of “lowest gauge tolerance”, “best flatness” and “optimum surface brightness”. Additional challenges to limit the investment costs for new and revamped equipment to an acceptable level have to be met in terms of creating universally usable mills rolling small lots with a big product variety without long adaptation steps at the one side and designing mill-lines for bigger productions at the other side.

NEW ROLLING MILLS

Lately Achenbach has introduced a product family of wide and fast rolling mill concepts into the market containing unique modules to fulfil these requirements in a perfect way. They all contain “Technology for Future Concepts” in favour of the customers:



Heavy gauge strip mill

This mill produces 2.100 mm wide strip out of modern strip casters at a gauge range from 6,5 mm down to 0,1 mm with rolling speeds of more than 1.000 m/min.



Light gauge strip mill

This mill produces 2.100 mm wide strip at a gauge range from 2,6 mm down to 0,07 mm with rolling speeds up to 1.800 m/min.



Small production lots in connection with a wide product mix require the “Universal Foil Mill” operational at a number of plants.

This mill produces 2.100 mm wide foil at a gauge range from 0,7 mm down to 2 x 0,006 mm.



“Ligne 2000”

A bigger production capacity can be reached with the installation of a 2-mill-line.

These mills produce 2.150 mm wide foil at a gauge range from 0,6 mm down to 2 x 0,006 mm with rolling speeds up to 2.000 m/min.



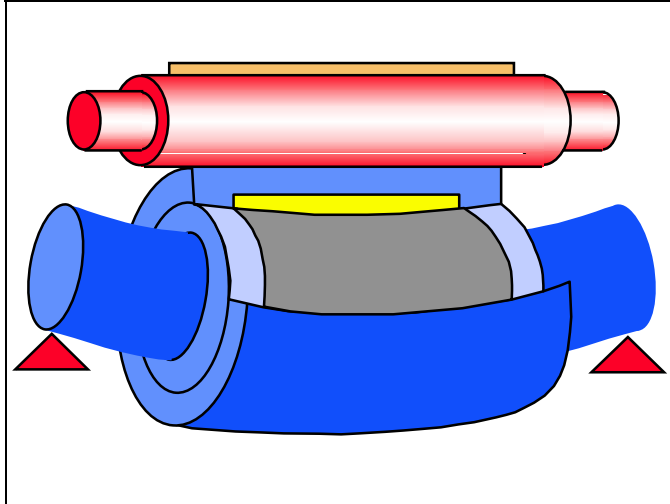
“FOIL 2000”

40.000 tons per year of light gauge foil are produced with this 4-mill-line.

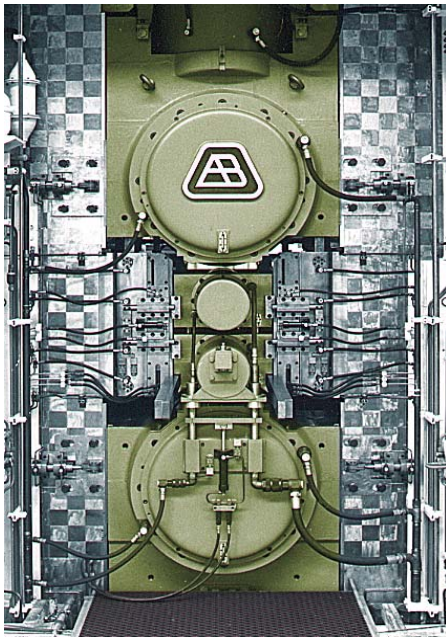
These mills produce 2.100 mm wide foil at a gauge range from 0,75 mm down to 2 x 0,006 mm with rolling speeds up to 2.500 m/min.

Rolling Mill Design Specialities

All rolling mill concepts are containing unique Achenbach modules consisting of mechanical design specialities, control and automation systems, special coil and strip handling devices as well as coolant treatment and fume exhaust cleaning and oil recovery systems. The modular design eases operation and maintenance. Some examples of the most important modules are described in the following:

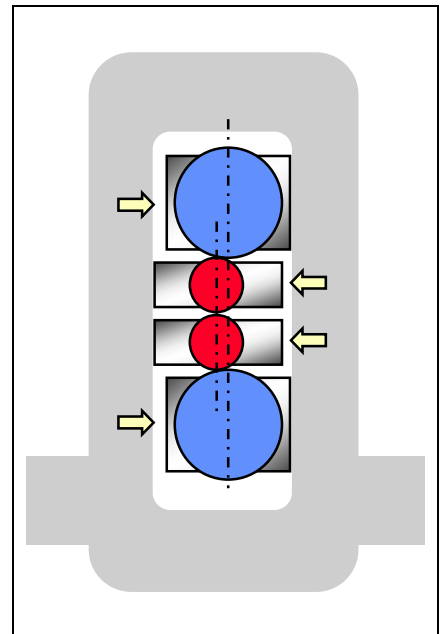


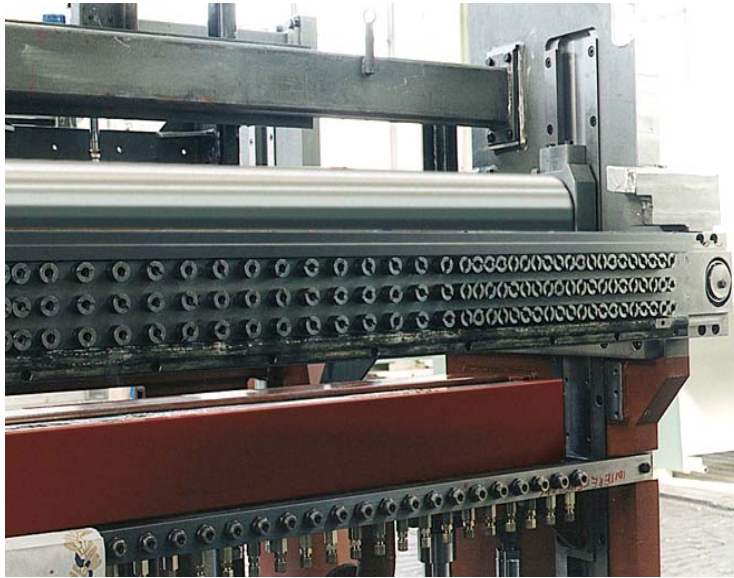
An advanced backup roll design for the correction of the roll stack bending curve by **Variable Crown-Rolls (VC-Rolls)** is standard for wide mills. Originally developed by Sumitomo Metals **VC-Rolls** have been installed in more than 150 rolling mills. Integrated into the control loops of an **OPTIROLL i2® - SFC** System the accuracy of the flatness quality is increased specially during the acceleration and deceleration phases of the rolling process and in the case of frequent rolling width variations.



The other important actuators are the work roll bending cylinders, installed in hydraulic blocks, individually servo-controlled, working in positive and negative directions as a very efficient part of **OPTIROLL i2® - SFC** systems.

The lateral dynamic stability of the roll stack in a rolling mill by still keeping the vertical friction low is provided by a special horizontal roll stabilisation system. Hydraulic cylinders push the backup- and the work roll chocks into opposite directions against the mill stand windows. The chocks are stabilised in defined positions by this method. The risk of chatter even at rolling speeds of more than 1.500 m/min has been reduced drastically.

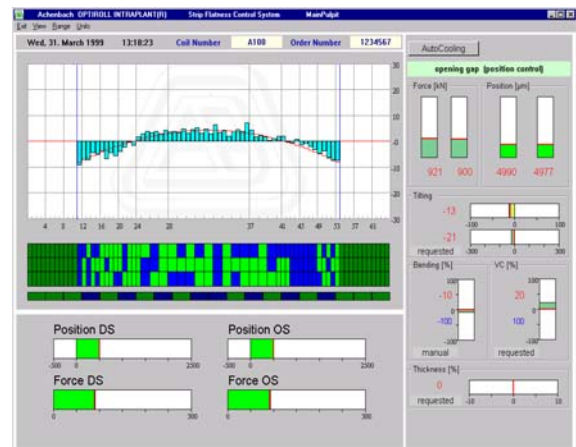




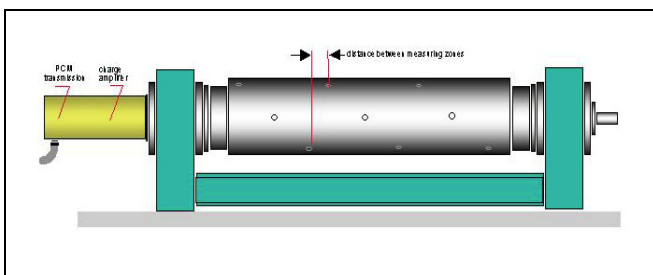
Narrow spacing at the strip edges allow a very accurate indication of loose or tight edge conditions and quarter buckles. Thermal actuators have been developed correcting obvious flatness problems especially at high rolling speeds. Achenbach invented and patented a new coolant spray bar including valves called **WIN Spray® S** using 52 mm and 26 mm wide spray zones adjustable with an accuracy of 13 mm to the actual strip edge.

Rolling Mill Control and Automation

The **OPTIROLL i2®** control system is a lean and powerful mill automation system with the highest possible system efficiency. The consistently realized openness of the system includes data-transmission interfaces as well as software interfaces and functional interfaces to higher-level process control systems. The open, graphic programming in accordance with IEC standards and with simple, universally understandable programming tools is an important system feature. The Man Machine Interface (MMI) is ergonomically installed and simple to understand. Menu driven colour displays provide informations about the process parameters, gauge and flatness control performance, alarm data and coil or shift reports.



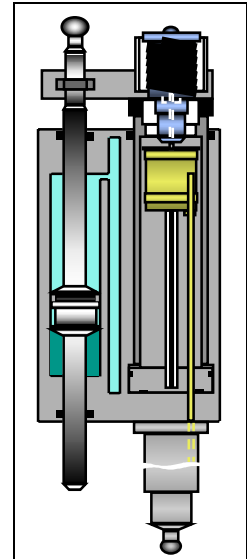
Integrated into the fully digital **OPTIROLL i2®** automation and control system are own sensors and actuators as well as control technology.



The new **SFC** flatness measuring roll, licensed by BFI, is designed as a strong solid roll with peripheral drillings containing the pre-stressed piezo-quartz sensors connected to the transmission box via a drilling in the roll centre. Signal transmission to the computer is done wear free by optical

pulse code modulation. This is the most accurate and reliable flatness measuring roll existing on the market today.

The patented digital **SGC**[®] strip gauge measurement and control system has proven its outstanding performance in many aluminium rolling mills. Using the gap between the backup roll chocks as a reference signal for the inner position control loop of the gauge control system it simulates a stiff mill stand allowing fastest response times. In combination with a roll eccentricity compensation system, feed back and feed forward gauges as well as speed references for mass flow control the best gauge tolerance value are obtained.



The overall systems are not only prepared for world-wide **teleservice** through a conventional modem connection, but also through an integrated router via intranet/Internet and, to ensure data protection, through a virtual private network VPN.

ROLLING MILL DRIVES

The drive systems of all rolling mills are going to change into AC frequency controlled converter technology. Even though this technology is still more expensive than the actual DC drives it offers the big advantage of simpler drive motor designs without brushes containing less risk of failure. It is therefore the preferred system of the future. Achenbach has equipped already 5 foil rolling mills with this advanced technology.

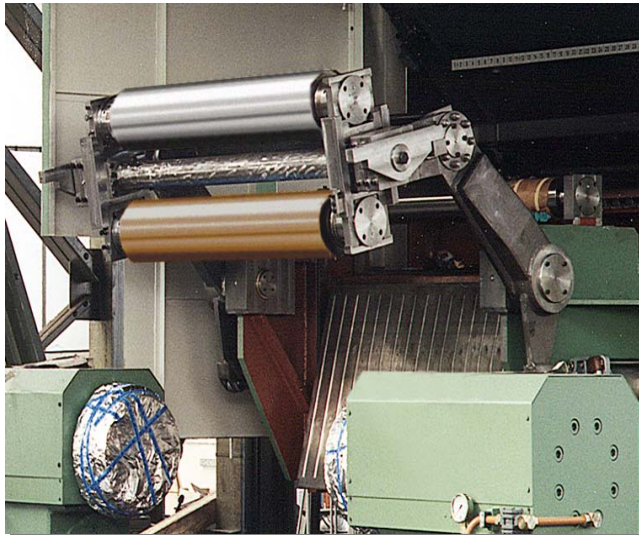
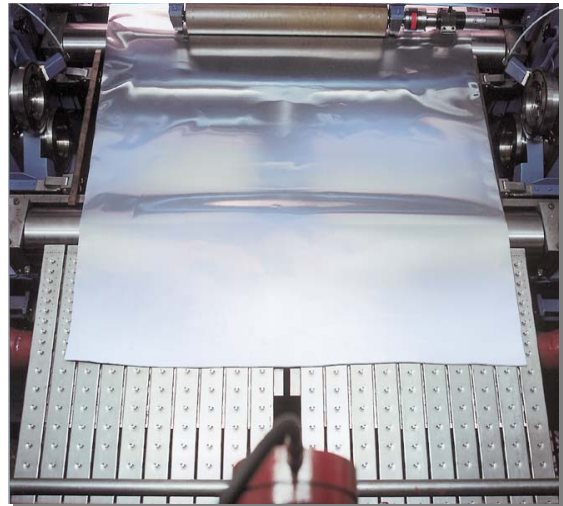
AUTOMATIC COIL and STRIP HANDLING



The strip manipulator helps to reach best productivity by automatically threading the strip nose into the light gauge and foil rolling mill entry side.

Automatic foil threading and the patented FFS Foil Feeding Support system are essential components of a modern superwide foil rolling mill.

Threading of light gauge foil by hand is difficult in a narrow mill but it is impossible in a wide mill. Operators in all plants using Achenbach mills will never work without these supports. Well centred coils on dynamically balanced spools fixed on stub mandrel coilers allow the lowest possible externally influenced strip tension variations. The exact strip tension control of a foil rolling mill is one important parameter on good quality results in terms of gauge tolerances.



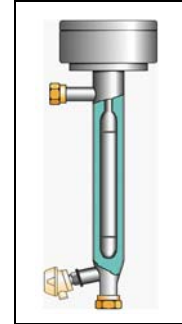
Another limiting factor for high speeds in foil rolling mills can be the design of the ironing roll system on the recoiler. Long experiences and a number of R & D programmes resulted in a unique double ironing roll system. Different vibration frequencies are generated in the recoiler/ironing system at high rolling speeds. They must be damped by the installation of a number of damping elements in the roll arms, in the roll bearings, in the roll coating and in the pneumatical roll balancing system. The balancing system is adjustable to both sides of the strip with small force increments. The

ironing rolls touch down point is not more than 100 mm away from the foil run up point to keep the air off the windings.

ROLL COOLANT TREATMENT



The **SUPERSTACK® II** Horizontal plate filter provides



cleanest rolling oil for bright strip surface and the

prevention of pinholes in the foil. It's unique design allows to operate it automatically **CONDUSENS®**-optimised with hydraulic plate closure as well as oil inlet and outlet without hoses.

FUME EXHAUST CLEANING and ROLLING OIL RECOVERY



Pollution control and recovery of rolling oil is getting more and more importance in all aluminium rolling plants. More than 65 **AIRPURE®** - systems, are in operation world wide today and the number increases year by year. It makes no longer sense to pollute the environment of a modern rolling plant with tons of kerosene per day even though this gas pollution is only recognised by the typical smell in the area. It is worthwhile to recover these tons of rolling oil and recycle them into the coolant system tank.

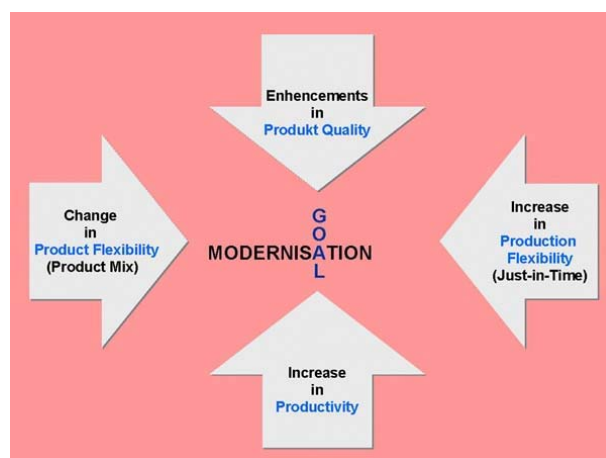
ROLLING MILL MODERNISATION

Changes in the markets for rolled products, as well as advances in manufacturing technology, mean that producers have to consider new factors in development planning, resulting in either new investments or modernisations of existing plants. In any case, the expenditure associated with such changes can be justified only if a specific Return on Investment (ROI) within a predictable time-scale is achieved. The transition between the modernisation of an existing plant and a completely new investment may not be easily distinguishable, if the modernisation is so fundamental that, apart from the heavy mill stands, all elements of the rolling mill will be renewed, and the rolling company will have an essentially new rolling mill after the rebuilding action. The fact that normally the costs of a modernisation are substantially lower than those of a new investment, explains the comparatively higher likelihood of renovation, but it should not be chosen in case of a gap lower than 50%.

Conditions of saturation in certain markets have shown that, fundamentally, modernisation projects should not always exclusively be connected to increases in productivity. In order to be competitive, as well as having or maintaining a high productivity rate, it may be the case that the adaptability of production facilities to the changing demands is the deciding factor. In addition to the two parameters of success, “product quality” and “productivity”, a third “flexibility” has to be added. Flexibility denotes, on the one hand, the spectrum of products which can be rolled on the system -the product-mix-, and on the other hand the production adaptation factor, in regard to a possible “just in time” production.

Hence modernisation, as well as the aim of improved product quality, means, on one extreme, a move into the direction of a “universal machine” in order to be able to service varying requirements within short times, and in this way to strengthen the producer’s position in the market, and on the other extreme, the decrease of “universality” in favour of maximum productivity, in order to fight the pressure of rising prices by minimising costs. New developments in today’s rolling mill technology towards “flexible automation” make it possible connect productivity increases with enhancements in flexibility.

The realistic motivation of modernisation projects lies between the wishes of the producers for **productivity increases**, in order to achieve internal cost reductions, and the attempts of meeting the varying market demands more exactly with **product flexibility**. Modernisations directed towards higher market compliance can be done by an **enhancement in product quality** in terms of strip thickness, strip flatness and surface quality or through an extension or restriction of the product spectrum with respect to thickness, width and coil diameter, and via a time-optimised production. In addition to the individually defined goals, each modernisation project is ultimately limited by minimum shut down times.



ROLLING MILL PRODUCTIVITY

The production of wider and thinner aluminium strip and foil with best quality and high rolling speeds as well as short change times for a high productivity is the key to the success of a growing number of producer's world wide. Advanced machinery, systems, controls and technology specifically developed for aluminium rolling mills is necessary to reach this excessive goal.

A good rolling mill must be equipped with sufficient sensors and actuators and the automatic closed loop controls must permit a stable process even at high rolling speeds. The highest *production output* of an aluminium strip and foil rolling mill can be reached by running continuously high rolling speeds and low downtimes.

The theoretical *production output* is calculated out of a pass schedule taking into consideration the time needed for the number of passes necessary to reach the final thickness, the rolling speeds in the different passes comprising acceleration and deceleration of the mill as well as coil change times.

To determine a practical *production output* at first the rolling time has to be multiplied by a *yield* factor containing deductions for roll change times as well as scheduled and unscheduled process downtimes. The *yield* factor represents the relation between rolling time and utilisation of the mill. It should be not lower than 93%.

The other factor to be considered is the *recovery* factor. Head ends, tail ends, strip breaks and strip trimming provide a certain production scrap rate which is considered in the *recovery* factor. It rises continuously with the number of passes rolled.

Both factors are normally multiplied to a combined production factor of 85% or more. Every mill not reaching this production factor after a reasonable start up time and during its total lifecycle cannot be considered to be "productive". Its initial investment costs are probably 20 to 25% lower but its reduced productivity generates losses of at least 10 to 15% per year of operation.

It is even worse on foil rolling mills if the final gauges of 6 to 7 μm cannot be reached economically caused by gauge variations, strip breaks, pinholes or surface defects. In this case a typical "investment ruin" has been generated which can only be rebuilt by using it for the production of 15 μm household foil with a substantially lower added value and a much longer payback period.

To increase the total rolling time of foil mills by app. 25% the doubling and trimming process for the last pass is normally done on special "doubling machines" outside the mills. One doubling machine can feed up to 3 dedicated finishing mills.

Only the best combination of most advanced components of mechanics, electric's, electronics, engineered by experienced specialists, finally guaranties the necessary safety of a successful operation. Experiments should be done in laboratories and test fields but not on site. Big investments like rolling plants in competitive markets require serious and reliable partners with the complete know-how of the total technical environment.

New dimensions in aluminium light gauge strip and foil rolling at the beginning of a new century are set by the implementation of economically viable equipment today capable to fulfil the quality and productivity requirements of tomorrow.