



PQF® SEAMLESS TUBE PLANTS

Key technology for success





THE SMS GROUP IS A GROUP OF GLOBALLY OPERATING COMPANIES IN PLANT AND MACHINERY CONSTRUCTION FOR STEEL AND NON-FERROUS METALS PROCESSING. WE COVER EVERYTHING FROM PIG IRON PRODUCTION TO METALLURGICAL PLANT, ROLLING MILLS TO STRIP PROCESSING LINES, TUBE MILLS TO THERMAL TECHNOLOGY – COMPLETE WITH ELECTRICS AND AUTOMATION AS WELL AS SERVICE.



PRODUCT RANGE



IRON MAKING



TUBE AND PIPE PLANTS



LONG PRODUCTS PLANTS



ELECTRICAL AND AUTOMATION SYSTEMS



PRODUCTION



METALLURGY PLANTS AND ENVIRONMENTAL TECHNOLOGY



FLAT ROLLING PLANTS



STRIP PROCESSING LINES AND FURNACE TECHNOLOGY



FORGING PLANTS

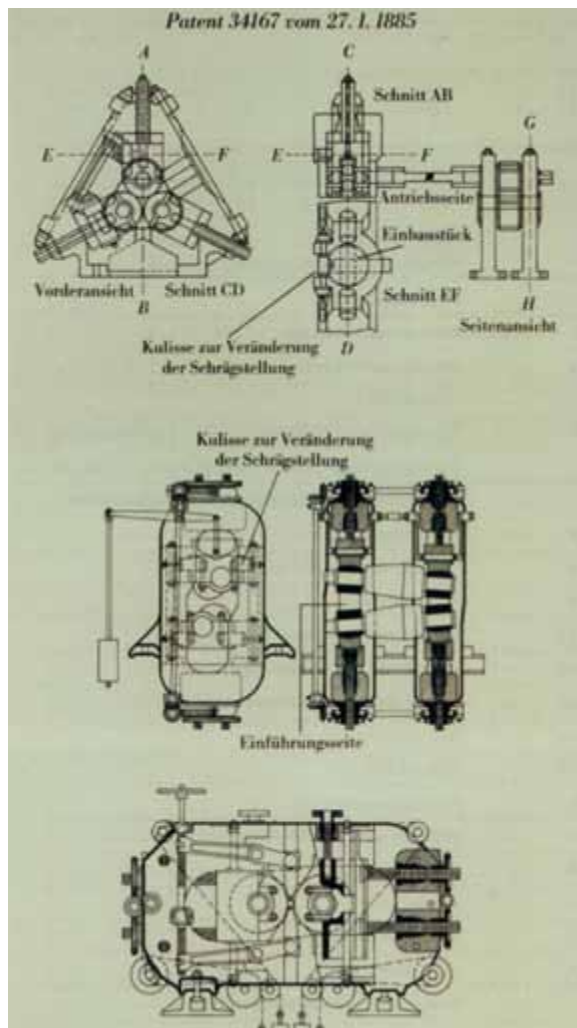


TECHNICAL SERVICE

SMS  group

A PIONEER IN SEAMLESS TUBE PLANTS

Innovative solutions for ever increasing demands



Seamless steel tubes are an integral part of modern life. The oil and gas industry, the construction and mechanical engineering sectors and car manufacturers demand ever better tubes: higher steel grades, closer tolerances, new dimensions. The pressure from competition is also increasing among tube producers: only those who can operate as efficiently as possible and react flexibly to new market trends can stay ahead in the long term.

BENEFITTING FROM 100 YEARS OF EXPERIENCE

SMS group seamless tube plants are tailored to meet these high demands. SMS already has more than 125 years of experience in the production of seamless tubes: Its roots go back as far as 1885, when brothers Reinhard and Max Mannesmann obtained the first patent for the manufacture of seamless tubes – a pioneering invention. In the decades to follow the company continuously developed its technology further, launching innovative products on the market.

SAFEGUARDING YOUR COMPETITIVE EDGE WITH NEW TECHNOLOGIES

The continuous rolling process – using mandrel mills – has been successfully used as a method of producing seamless steel tubes since the 1970s. SMS group customers use plants from three stages of development: conventional mandrel mills, Multistand Pipe Mills (MPM) and state-of-the-art PQF® (Premium Quality Finishing) technology, which, since its market launch in 2003, has established itself worldwide as the new standard in seamless tube production. Today it remains the benchmark for quality and cost efficiency.

Both mandrel mills and MPMs (Multistand Pipe Mills) are used primarily for the production of oil field and boiler tubes with a dimensional range of up to 16 3/4". By contrast with mandrel mills, the mandrel bar in the case of the MPM method is retained and



moved in a controlled manner during the rolling process. A further development in the MPM process now means that the rolls can be positioned hydraulically during rolling. As a result, tube manufacturers are able to achieve better results and thus increase output.

With the development of PQF® (Premium Quality Finishing) technology, SMS group succeeded in making a huge leap forward in mandrel mill innovation: the process uses hydraulically adjustable stands with three rolls instead of just two. Tubes with outside diameters of up to 20" can be rolled on PQF® mills. Tube producers benefit from even higher production capacities with high product quality and efficiency at the same time. What's more, the process enables them to cut production costs, improve output and increase their flexibility in terms of the rollable dimensions and material grades.

CUSTOMER CONFIDENCE IN NUMEROUS REFERENCE PROJECTS

In the past 50 years alone SMS group has implemented over 2000 seamless tube plant projects. Satisfied customers can be found all over the world – and their success on the market speaks for itself. Our commitment to our business partners goes

FROM THE CUSTOMER'S VIEWPOINT

"The companies within the SMS group are extremely reliable partners. We have found the best possible supplier to meet our quality requirements and the team also worked side by side with us throughout the plant construction phase. This is just what I expect of a good business partner."

Christiano Caldeira, Pipe Mill General Manager,
Vallourec & Sumitomo Tubos do Brasil Ltda,
Brasil

way beyond successful commissioning of the plant: SMS provides expert advice, offers reliable support throughout the erection and commissioning and continues to support you with our extensive service range decades after the order has been completed. Whether it's spare parts, maintenance or modernization: you can rely on SMS group.

SEAMLESS PROCESS CHAIN

Customized solutions to meet all your needs

SMS group supplies all the plants for the production of PQF® seamless tubes from a single source. In practice this means harmonized interfaces for a smooth production flow with high plant availability and productivity. Together with the customer our experts choose a solution which best meets the customer's needs. At the same time we focus on the entire process chain, from the pierced billet to the finished tube.



CONE-TYPE PIERCER: EFFICIENT FROM THE START

The piercing process is at the top of the process chain, which starts with the solid steel billet and ends with the seamless tube. High-performance cone-type piercers from SMS are particularly cost-effective here: They produce very thin-walled hollows. This brings with it advantages during the subsequent processing stages in the production of seamless tubes.



PQF® MILL: THE CENTREPIECE OF TOP QUALITY

The hollows are stretched to shells on the retained, travelling mandrel bar within the hydraulically adjustable 3-roll stands of the PQF® mill. The result is consistently high product quality. The shell is gently removed from the mandrel bar immediately after the rolling process.



STRETCH-REDUCING AND SIZING MILL: NO COMPROMISE WITH TOLERANCES

In the last stage the seamless tubes are rolled to the desired outside diameters in a multi-stand sizing mill/ stretch-reducing mill. SMS group offers stands with adjustable rolls, enabling the closest tolerances to be reliably produced.

AUTOMATION: FOR EFFICIENT PROCESS MANAGEMENT

We combine the individual process stages to create complete integrated plants. Furnaces, saws and machines for inside and outside descaling are just as much a part of our range as transportation and handling equipment or cooling beds.

With our CARTA® and LASUS® measurement and control systems, SMS offers reliable tools for managing the quality of the rolling process and products. In this way customers can achieve the closest tolerances and optimize the cost efficiency of their production processes. SMS group Technical Service experts help plant owners to utilize the potential of their systems and machinery fully.

PROCESS CHAIN IN A MODERN PQF® MILL



- ▶ Billet starting material
- ▶ Billet saws
- ▶ Rotary hearth furnace
- ▶ **Cross-rolling mill with Diescher disks**
- ▶ Hollow descaling unit
- ▶ Hollow inside deoxidation
- ▶ **Multistand PQF® mill**
- ▶ Extracting mill
- ▶ Reheating furnace
- ▶ High-pressure water descaling unit
- ▶ **Stretch-reducing / sizing mill**
- ▶ Cooling bed
- ▶ Batch saws

PQF® Seamless tube plants, examples of dimensions

	7" PQF®	10 ¾" PQF®	18" (20") PQF®
Billet			
Diameter [mm]	210	200–280	270–500
Hollow			
Diameter [mm]	230	224–324	301–510 (577)
Shell (PQF®)			
Diameter [mm]	195	194–291	254–477 (530)
Shell (extracting mill)			
Diameter [mm]	185	185–281	245–465 (510)
Finished tube			
Diameter [mm]	48.3–177.8	60.3–278	177.8–457 (508)
Wall thickness [mm]	3.2–22.0	3.9–34.0	5.5–45
Nominal annual production [tonnes]	> 350,000	> 450,000	> 500,000

PRECISE ROLLING PROCESS

Precision control for perfect results

Whether it's high-alloy steels or particularly thin-walled precision tubes – with PQF® technology manufacturers can produce even the highest-quality products efficiently and reliably. Less material is required than with conventional solutions and output is improved. As a result, tool costs remain low, with energy savings also made thanks to the low reheating requirements during the rolling process.

UNIFORM APPLICATION OF FORCE

A PQF® mill consists of up to six stands, with three driven rolls each. The force is therefore applied more uniformly across the circumference of the rolls than it is with MPM technology featuring a conventional 2-roll arrangement. The advantage of this is lower tolerance deviations in the roll gap, lower material strain during rolling and fewer negative influences during the rolling process.



PQF® stand with three rolls





EFFICIENT ROLL DRESSING

With the PQF® roll dressing machine from SMS the rolls of the PQF® stands can be remachined quickly and precisely. This helps plants owners to reduce stand machining costs over the long term.

STABLE AND MANAGEABLE WITH ANY WALL THICKNESS

Each individual roll has a hydraulic adjustment system. This allows tube manufacturers to adjust the roll gap precisely within fractions of a second during the rolling process. Specific tolerance targets can therefore be met and peak loads for the rolls and mandrel bars supported. Computer-aided settings and adjustments are performed using the CARTA® PQF® technology system. For mill operators state-of-the-art technology means tube production is even more stable and easier to manage and control. The lower material strain means that the product mix can be extended to include even thinner walls and higher alloy steel grades.

PQF® plants today produce seamless tubes with diameters of between ½" and 20" and wall thicknesses from 2 to over 40 mm. Depending on the product mix, annual outputs of more than 600,000 tons can be achieved. The tubes are used predominantly in the oil field and energy sectors.

THE BENEFITS OF THE PQF® PROCESS AT A GLANCE

- Lower mandrel bar wear
- More uniform temperature distribution in the shell after the rolling process
- Reduced "finning" at the shell ends and thus lower crop end losses
- Closer wall thickness tolerances

For tube mill owners this means:

- Considerably improved tube quality
- Improved rolling characteristics for high-alloy steels
- Efficient, stable production of thin-walled precision tubes
- Increased output
- Reduced tool costs
- Energy savings thanks to reduced reheating requirements



FROM THE CUSTOMER'S VIEWPOINT

"The PQF® process offers wider scope for forming. As a result, we can operate more flexibly, i.e. react better to our customers' needs. What's more, the process improves the quality of the tubes, which of course suits us perfectly as a premium producer."

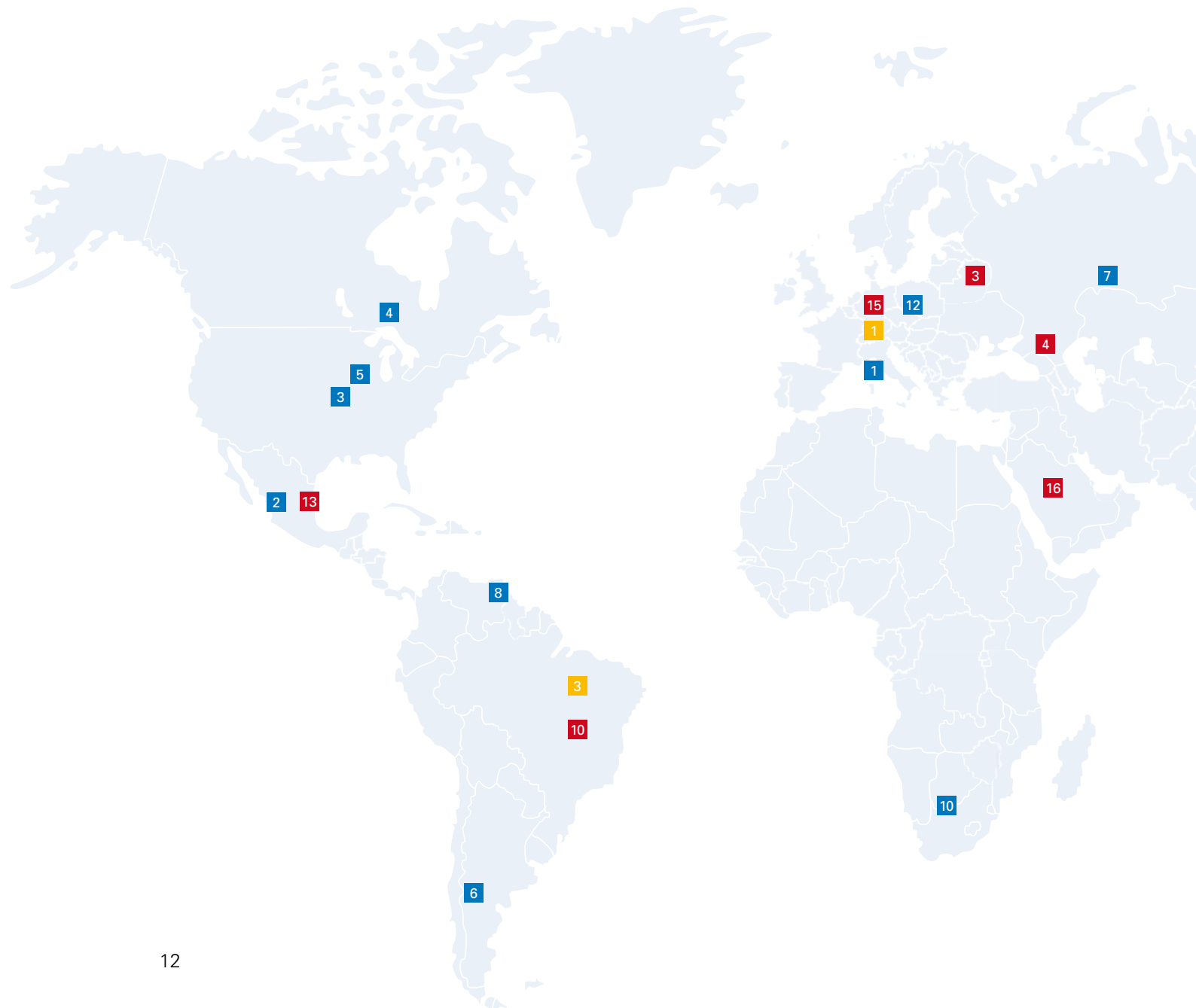
Dr. Christoph Prasser, CTO, Vallourec & Mannesmann Tubes, France

GLOBAL REFERENCES

Over 40 continuous mills since 1972

Since 1972 SMS group has been setting standards in the quality of seamless tubes with its continuous rolling plants. Leading seamless tube producers were quickly convinced of the benefits of the new PQF® technology: SMS has received over 20 orders for PQF® plants within the first 10 years already. These

mills are being successfully used as replacements for pilger mills and are also operated in parallel with Assel mills. The largest PQF® mills can produce a tube diameter of 20" (508 mm). A record: such sizes were previously impossible with the 3-roll continuous rolling process – a real leap in innovation.



MANDREL MILLS

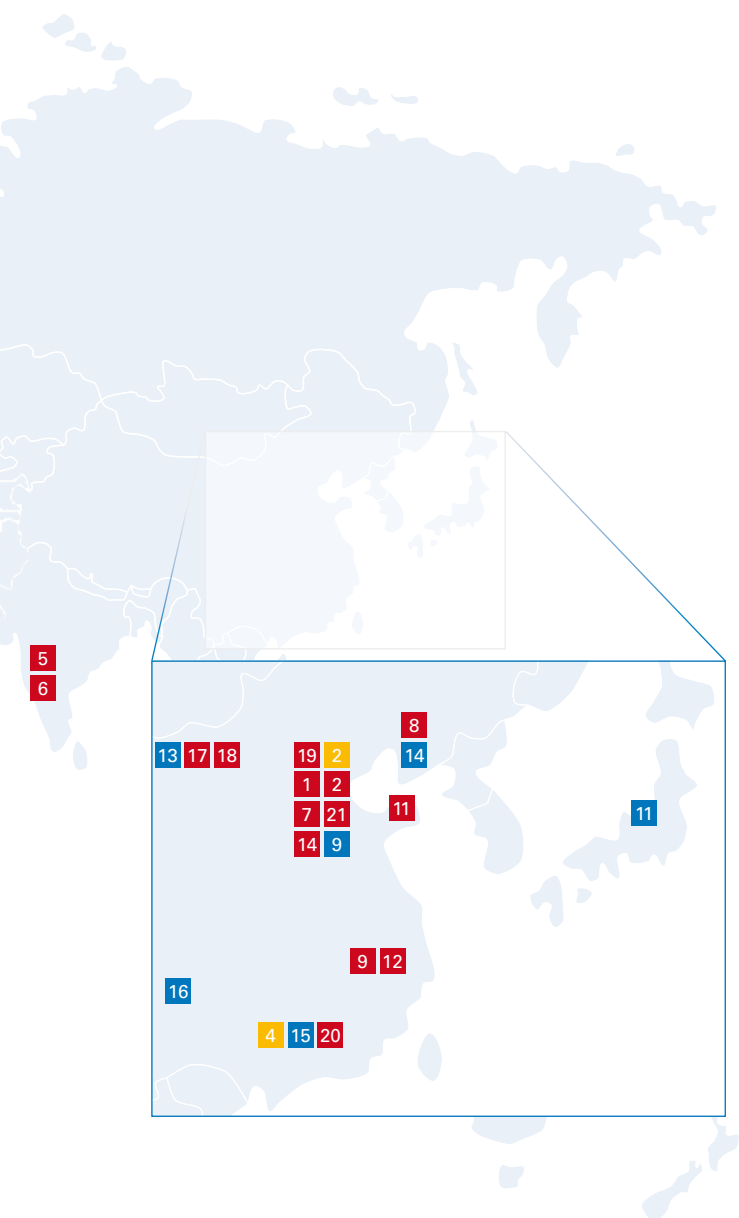
1	7"	V&M Mühlheim	1972
2	7"	Baosteel	1979
3	7"	V&M Belo Horizonte	1995
4	4"	Hengyang Valin Steel Tube	1997

MPM – MULTISTAND PIPE MILL

1	16"	Tenaris Dalmine	1978
2	13 3/8"	Tenaris Tamsa	1983
3	9 5/8"	US Steel Fairfield	1983
4	7"	Tenaris Algoma	1986
5	10 3/4"	V&M Star	1987
6	10 3/4"	Tenaris Siderca	1988
7	16 3/4"	TMK-Volzhsky	1989
8	9 5/8"	EBS de Tubos Acero Sin Costura (Sidor)	1990
9	14"	TPCO	1992
10	6 5/8"	ArcelorMittal South Africa	1993
11	16 3/4"	Sumitomo Metal Industries	1997
12	6 1/4"	W R Jednosc	1999
13	9 5/8"	Baotou Steel (Group)	2000
14	6 1/4"	Angang New Iron and Steel	2001
15	13 3/8"	Hengyang Valin Steel Tube	2002
16	14"	Chengdu (Pangang Group)	2003

PQF® - PREMIUM QUALITY FINISHING

1	6 5/8"	TPCO	2001
2	18"	TPCO	2005
3	6 5/8"	BMZ	2005
4	10 3/4"	TMK Tagmet	2006
5	7"	Jindal Saw Ltd.	2006
6	6 5/8"	ISMT	2006
7	9 5/8"	TPCO	2006
8	7"	Angang New Iron and Steel	2006
9	10 3/4"	Anhui Tianda Oil Pipe Co. Ltd.	2007
10	16"	Vallourec & Sumitomo	2007
11	18"	Yantai Baosteel	2008
12	10 3/4"	Jiangsu Xigang Group	2008
13	7"	Tenaris Tamsa	2008
14	14"	Tianjin Tianxin	2008
15	4"	V&M Riesa	2008
16	16"	ArcelorMittal Tubular Products Jubail Co.	2009
17	18"	Baotou Steel (Group)	2009
18	6 1/4"	Baotou Steel (Group)	2009
19	20"	Jiangsu Tianhuai Pipe	2009
20	7"	Hengyang Valin Steel Tube	2010
21	5 1/2"	TPCO	2011



PQF® MILL DESIGNS

Intelligent design for quick roll changes

In addition to quality, cost efficiency in production is crucial for success in the tube market. High plant availability is essential. PQF® mills from SMS group are designed such that owners can service the plants easily and change the rolls quickly. In this way they are able to react flexibly to customers' needs. Depending on requirements, SMS builds the mills according to the ACO (Axial Change-Over), LCO (Lateral Change-Over) or BCO (Bilateral Change-Over) design:

ACO: **YEARS OF SUCCESSFUL OPERATION**

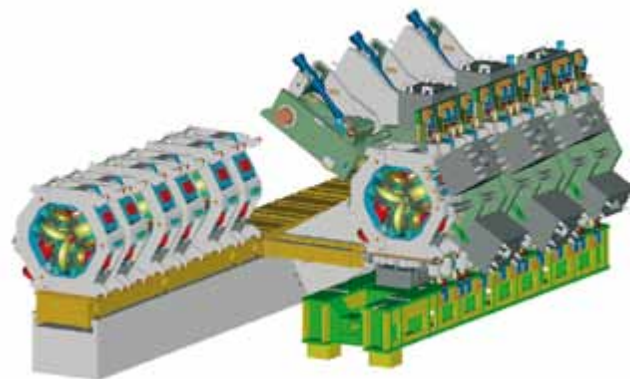
The ACO design is a well-established tunnel design which mill owners have been using successfully for years now. The mill stands are changed in line.



ACO design – rolls stands changed inline

LCO: QUICK STAND CHANGE, EASY MAINTENANCE

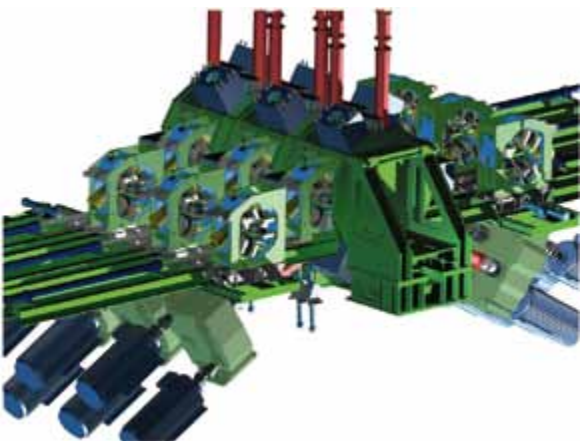
With the LCO (Lateral Change-Over) design the individual stands are changed from the side. This system is already known from SMS group's stretch-reducing and sizing mills. Plant owners can switch to other formats in no time at all, and the plant itself is particularly easy to maintain and operate – as a result, the plant availability increases and even small batch sizes can be produced cost-effectively. Each stand is equipped with three levers. These hold the chocks and rolls. The lever system enables the rolls to be swung out of the stand such that they can be changed within a short period of time. At the same time the levers ensure precise guidance of the rolls during adjustment, thereby guaranteeing optimum quality.



LCO design – roll stands changed from the side

BCO: FOR GREATER EFFICIENCY IN TUBE PRODUCTION

With the new BCO (Bilateral Change-Over) design variant the stands are changed on both sides of the mill. The rolling forces are therefore distributed symmetrically across the mill. The hydraulic capsules are rigidly connected to the mill stand frame. The compact and easily accessible design enhances the user-friendliness of the plant. The drive concept is simpler – there are no bevel gear stages. Such features improve the efficiency and flexibility of the tube production process.



BCO design – roll stands changed on both sides



CARTA[®], LASUS[®] AND QAS[®]

Top quality, automatically

With the CARTA[®] (Computer Aided Rolling Technology Application) planning and control system from SMS group mill owners can optimize their seamless tube production. This is where the process-related advantages of PQF[®] technology really take effect. However, the conventional MPM (Multistand Pipe Mill) process and MM (Mandrel Mill) process with 2-roll arrangement are also areas where CARTA[®] contributes substantially towards increasing quality and productivity. It also provides reliable support for process planning as well as process and tool management.

CREATION OF TECHNOLOGICALLY OPTIMIZED STANDARDS

CARTA[®] creates the rolling schedules based on production data, process models and computation methods – including roll positioning, speed adjustment, throughput and material consumption.

TECHNOLOGICAL SUPPORT WITH PRODUCTION PLANNING

CARTA[®] helps plant owners optimize the preparation and organization of PQF[®] tube production. The advantage: plant owners minimize changing times and standstill periods – thanks to, for example, the intelligent sequencing of rolling operations or the optimized provision of tools and change stands.

OPTIMIZATION OF ONGOING PRODUCTION IN REAL TIME

CARTA[®] adapts the process management of the PQF[®] mill in such a way that deviations between the set-points and actual values are minimized. Here CARTA[®] controls the hydraulic quick roll positioning system, among other things, and ensures there is a uniform shell wall thickness throughout the process.

TECHNOLOGICAL SUPPORT FOR QUALITY CONTROL AND ASSURANCE

CARTA[®] collects information such as sensor signals, measurement data and operator inputs for automatic evaluation. The data is used for tube certification and process optimization.

USE OF PRODUCTION EXPERIENCE

All data which CARTA[®] collects during production is automatically stored in an empirical database. The values can be analyzed later using various methods, allowing plant owners to learn from experience and specifically optimize planning and production. As a result, even small batches can be produced to close wall thickness and diameter tolerances.

KEY BENEFITS

- Higher output
- Improved tube quality
- Optimal mill utilization thanks to a standardized, intuitive control concept
- Solutions for the entire seamless tube production line



GEARED FOR QUALITY WITH CARTA® AND QAS

A quality assurance system (QAS) tailored to each individual seamless tube plant records all measurement parameters during the production process. In conjunction with CARTA®, this data is processed to keep the process within the required tolerance range and optimize tube production. The result is a consistently high product quality, from the billet through to the finished tube, as well as high plant availability and increased output. Furthermore, QAS assigns the measurement data to each individual tube to allow continuous material tracking.

PRECISE WALL THICKNESS MEASUREMENTS WITH LASUS®

An essential measurement parameter for the quality of seamless tubes is the wall thickness. The LASUS® system (Laser Ultrasonic hot wall thickness measuring system) from SMS group provides reliable high-resolution wall thickness measurements. The measuring principle is based on contact-free ultrasound technology, tried and tested over decades. The ultrasonic pulses are excited by a high-performance pulsed laser and recorded by a CW laser. As a result, plant owners can obtain reliable readings already during tube production – even at tube temperatures of over 1200 degrees Celsius.

LASUS® MULTI-SCAN: MAXIMUM RESOLUTION

With the LASUS® system the measuring head is particularly compact. In addition to the proven 1-channel system, variants with a pivoting device are therefore also possible: LASUS® Multi-Scan can accommodate several pivoting heads, with the result that tube structures in a fixed, stationary position can also be measured. The system provides wall thickness measurements with a high local resolution and can even be used wherever a tool (mandrel bar) is used in the tube.



Lasus® Multi-Scan equipped with three measuring heads

SERVICE – ESPECIALLY FOR PQF® PLANTS

Utilizing the full potential of modern technology

Reliable erection and commissioning services for each PQF® plant go without saying at SMS group – as does our comprehensive service after the start-up of production. For PQF® mill owners SMS also offers a series of special service packages, which help to utilize the full potential of modern technology quickly and over the long term.

CARTA® SERVICE PACKAGE: PERFECT RESULTS RIGHT FROM THE START

To ensure the CARTA® technology system delivers the best results right from the start, SMS group tailors the functionality and design of the user interface to customers' individual requirements. SMS group experts provide staff on site with all the knowledge required to operate the system. They also assist with the analysis and evaluation of the process data recorded by CARTA®. They can identify and solve problems at an early stage and advise mill owners on how to further improve the production and automation process. What's more, to ensure the CARTA® system is always up to date, SMS group regularly

updates the software, integrates new functions and upgrades the technical components.

LASUS® SERVICE PACKAGE: LONG-TERM RELIABILITY

Those who use the LASUS® system want to benefit quickly from its advantages. That's why our experts at SMS group are on hand during the start-up phase at the owner's premises. They share their knowledge with the staff and show them how to best operate the system. If necessary, our experts will update the system software. In this way users can benefit from all improvements, as well as upgrade the existing technology easily – for example to the multi-channel LASUS® Multi-Scan.

Even after long period of use mill owners need to be sure that their LASUS® system is still providing reliable measurements. SMS group Technical Service experts inspect the technology – on a weekly, monthly or annual basis, depending on customers' needs. They check the data collected, evaluate the device



parameters and test all system components via remote control. And when you need help quickly, our experts can always be reached: they will reply within 24 hours and come directly to your plant if required.

HCCS SERVICE PACKAGE: PRODUCT QUALITY ASSURED

Within PQF® plants the hydraulic capsules in the rolls are considered key components. SMS group assists customers with the regular overhaul and replacement of these. If necessary, our Service experts will come to your plant directly, offering comprehensive advice and completing all maintenance work to established SMS quality standards.

The hydraulic capsules are controlled by the Hydraulic Capsule Control System (HCCS). In the event of faults, SMS can access this system via remote service – it's quick, flexible and more cost-effective than a deployment of personnel on site. Software updates can also be downloaded via remote access. As a result your plant is always right up to date.

KEY BENEFITS OF OUR SERVICE PACKAGES

- Optimal setting and adjustment of the technology
- Regular updates
- Consistently high product quality
- Long-term reliable plant operation



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