TANGSHAN GUOFENG 1450 MM HOT STRIP MILL (P. R. CHINA) START UP AND FIRST OPERATIONAL RESULTS[1]

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Abstract
Located in Tangshan City, Hebei Province (P. R. China) the semi-continuous hot strip mill complex of Tangshan Guofeng Iron & Steel Co. is designed for a nominal production of 2,000,000 tpy of Hot Rolled Coils. No doubt this is one of the most competitive plants for the production of hot rolled coils starting from a medium slabs thickness, with outstanding surface quality, excellent internal quality and tight dimensional tolerances. The main technological features of the plant, supplied by Danieli, are described with emphasis on the integration of several technological equipment in the production line.
Key words: Configuration; Hot strip mill; Production rate; Strip quality; Performances.

TANGSHAN GUOFENG (P.R. CHINA), LAMINADOR DE TIRAS A QUENTE DE 1450 MM, START UP E PRIMEIROS RESULTADOS OPERACIONAIS

Resumo
Localizado na cidade de Tangshan, Provincia Hebei (China) o complexo laminador de tiras a quente semi-continuo da Tangshan Guofeng Iron & Steel Co. é projetado para uma produção nominal de 2.000.000 tpa de bobinas laminadas a quente. Sem duvida esta é uma das mais competitivas plantas para a produção de bobinas laminadas a quente começando de uma placa de espessura média, com excelente qualidade superficial, excelente qualidade interna e tolerâncias dimensionais estreitas. As principais características tecnológicas da planta, fornecida pela Danieli, estão descritas com ênfase na integração de inúmeros equipamentos tecnológicos na linha de produção.
Palavras-chave: Configuração; Laminador de tiras a quente; Taxa de produção; Qualidade da tira; Performances.

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Introduction

Danieli Wean United (DWU) has installed in Tangshan Guofeng one of the most up-to-date production units according to the latest technology in the field of Hot Strip Mills, for the production of 2,000,000 tpy of hot rolled coils.
The Tangshan Guofeng I.S.Co. mill includes a Reversing Roughing stand with attached Vertical Edger, Coil Box, six Finishing stands, Run-Out table and two Downcoilers.
Danieli was in charge of the technological responsibility and completeness for basic engineering, detail engineering, manufacturing and functionality of the mechanical and hydraulic equipment for the complete rolling line from the descaler before the rougher until the last coil saddle of the exit walking beam.
Erzhong has supplied all other mechanical devices, while instrumentation together with basic automation, level 2 and electric motors have been supplied by Siemens. Erection and general construction planning has been responsibility of MCC, Mechanical and Construction Company.
The contract was signed in January 2004.
In December 2005 the erection of the mill started, while in February 2006 the cold commissioning started and on March 10th the first coil was successfully rolled, after only 240 days since beginning of erection phase.
The plant overcame the acceptance tests and was handed over to the Customer for normal operations.

1 HSM Plant Configuration

The mill (Figures 1 and 2) is composed of two High Pressure Descalers, one Reversing Roughing stand with attached Vertical Edger, Coil Box, Crop Shear, six Finishing stands, Laminar Cooling, two Downcoilers and Coil Handling Area, based on the plant production data reported in Table 1.
The mill features the most modern Danieli technological packages such as edger with HAWC, HAGC, positive bending, WR shifting, RTC system and shaped roll technology to improve the profile and flatness control capability.

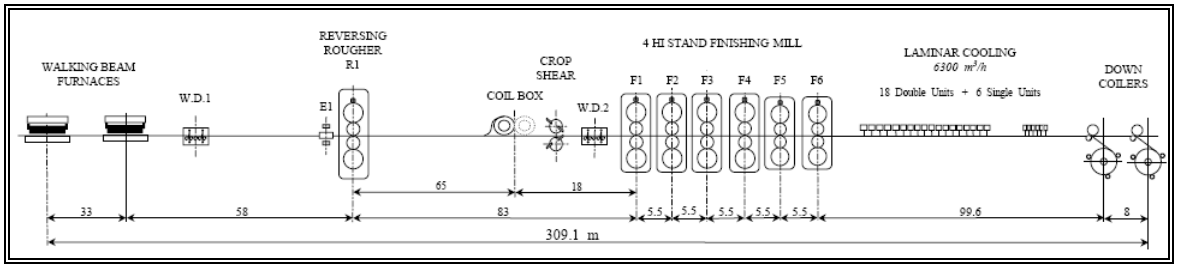


Figure 1 – Tangshan Guofeng I.S.Co., P. R. China

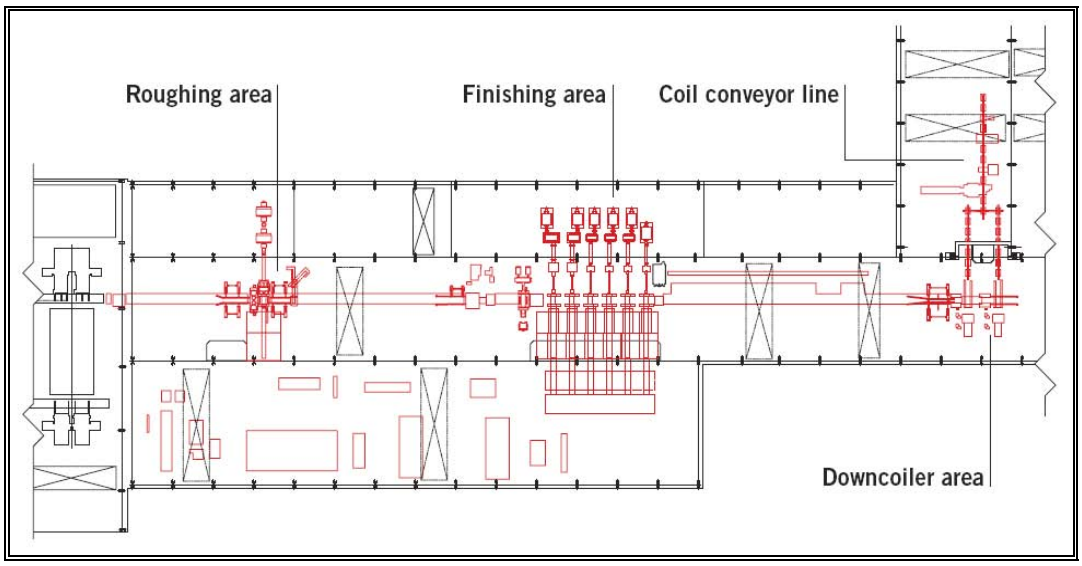


Figure 2 – Plant layout

The layout configuration shows the following key features:

- Powerful high-pressure descaling stations to achieve effective scale removal along the whole plant.
- Vertical edger to keep slabs width within the desired tolerances and to improve edge quality.
- High-speed roughing mill and finishing mill equipped with advanced technological solutions for strip thickness, profile, flatness, width and finishing temperature control, to achieve tight dimensional tolerances and proper mechanical strip characteristics.

Table 1 – Plant production data

Annual Production 1st phase (1 furnace) 2nd phase (2 furnaces)	 1,000,000 tpy 2,000,000 tpy
Slab Thickness	135 mm
Slab Width (min – max)	600 – 1,300 mm
Slab Length (min – max)	8,000 – 15,600 mm
Strip Thickness	1.2 – 12.7 mm
Strip Width (min – max)	600 – 1,300 mm
Max. Coil Weight	21.0 t
Max. Coil Specific Weight	16.0 kg/mm
Steel Grades	Low, Medium and High Carbon, Structural Steel, CQ, DQ, DDQ, HSLA and API grades

2 Plant Main Equipment

Roughing Mill Area

During the delivery of the slabs from the W. B. furnaces to the Roughing Mill, the water descaler No.1 removes the primary scale, using high pressure & low flow rate water to clean completely the slab surface before the slab thickness is reduced at the roughing mill, composed by vertical edger and 4-Hi reversing stand (Figure 3).

Figure 3 – Roughing Mill stand with attached Vertical Edger

The vertical edger is located at the inlet of roughing stand, incorporating fully hydraulic automatic width control (HAWC) and short stroke compensation system on the slab head and tail ends.

The roughing stand has electro-mechanical screw downs in combination with hydraulic capsules.

Descaling headers are provided in front and back of roughing stand for removing secondary scale.

The slab thickness is usually reduced in three reversing passes from 135 mm down to 30-40 mm, according to the final strip thickness, before entering into the coil box, which is running synchronized with the roughing mill. For the longest slabs and the thinner bars, as soon as the tail end leaves the RM, the coil-box begin to accelerate, in order to minimize temperature losses.

In the coil-box there are two possible coil positions: one for the coiling bar and one for the uncoiling bar. Once finished the coiling operation, the coil is moved for recoiling and, at such time, the tail of the transfer bar enters in the finishing mill acting as the new bar head.

Finishing Mill Area

The transfer bar moves to the rotary drum crop shear for cutting non-regular shape ends and, after a further descaling via the high pressure descaler No.2, it enters into the finishing mill. Optimized cutting mode is foreseen.
The chosen equipment for the finishing stands represents DWU global solution to controlling strip profile and flatness and enabling schedule-free rolling (Table 2).

Table 2 – Hot Strip Mill main technical data

Separating Forces	
R1	40,000 kN
F1 ÷ F4	35,000 kN
F5 – F6	30,000 kN
Main Motors	
R1	12,000 kW
F1 ÷ F4	6,000 kW
F5 – F6	5,000 kW
Work Roll Bending Forces (per chock)	
F1 ÷ F6	+ 1,500 kN
Shifting Capacity	
F1 ÷ F6	± 100 mm

The finishing mill consists of six 4-Hi stands (Fig. 4), equipped with fully automatic gauge control system (HAGC) and, in order to obtain tight geometrical properties and high shape quality, also with positive work roll bending system and work roll shifting.
Also the RTC control system is applied in order to control the roll thermal crown.
Furthermore, lower inertia hydraulic loopers are provided between the stands to assure stable and reliable rolling conditions.

Figure 4 – Finishing Mill stands

Run-out Table, Coiling and Storage Area

The strip out of the last stand of finishing mill proceeds through the laminar cooling section, consisting of U-tube headers in the top position and spray headers in the bottom side.

The Run out table is divided in two zones: main zone and trimming section for fast response coiling temperature control (Figure 5).

Figure 5 – Run-out table with U-tube headers

Downstream the ROT the strips are coiled in two hydraulic downcoiler (Figure 6) with pinch roll and three wrapper rolls, hydraulically adjusted for the exact gap between the mandrel and wrapper rolls themselves, according to strip thickness, to operate in automatic jumping control.

Figure 6 – Downcoilers area

The coils are then delivered to the conditioning area by a coil car and a walking beam conveyor.
On the walking beam, the coils are inspected, strapped with circumferential and radial banding machine and then they are weighted and marked by an automatic painting machine.
The coils are finally unloaded by means of a bay crane and handled to pre-pointed area for storing and dispatching.

3 Main Technological Solutions

In order to enable the mill to reach the high and demanding standards of dimensional tolerances on the finished product requested by the market, Danieli installed the most advanced technology available for this equipment.

Fully Hydraulic Automatic Gauge Control (HAGC)

All the stands are foreseen with hydraulic force cylinders. A faster response time and an accurate position control can be achieved with long-stroke hydraulic cylinders (Figure 7).

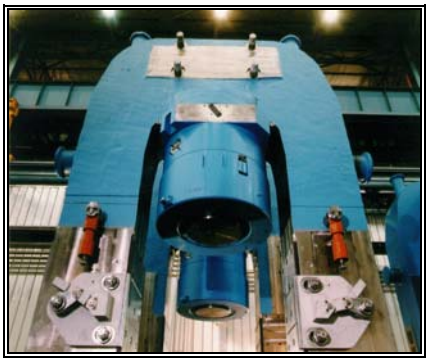


Figure 7 – Hydraulic Automatic Gauge Control (HAGC)

Work Roll Positive Heavy Bending

Positive heavy bending (Danieli Patent) actuators installed in all the finishing stands provide strip crown and flatness control. The high bending force values are possible to be achieved without affecting the bearings life, thanks to the patented solution of the double jack roll bending system (Figure 8).

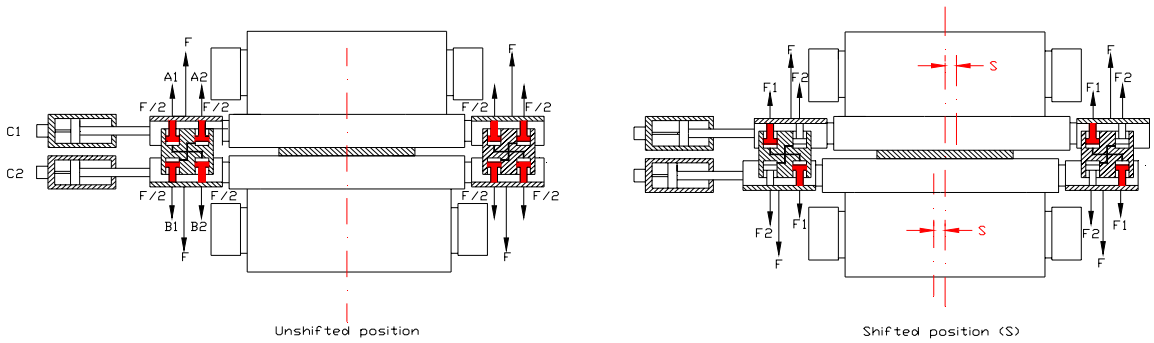


Figure 8 – Double Jack Heavy Bending System

This solution allows to maintain the bending force centered with respect to the bearing centerline, whatever the axial position of the roll, according to the side shifting procedures.

Work Roll Shifting

All the finishing stands are foreseen with Work Roll shifting (Figure 9).
Wide range of side shifting for wear control achievable through double jack bending, allow the schedule-free rolling.

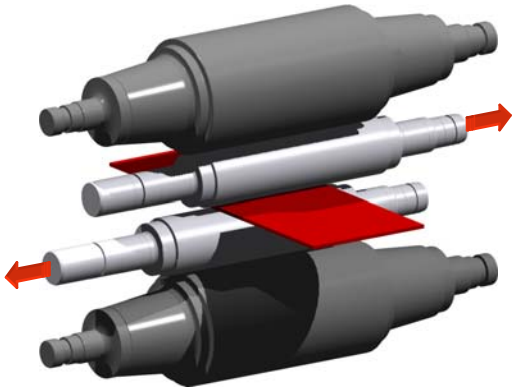


Figure 9 – Work Roll Shifting

RTC (Roll Thermal Crown) Control System

Danieli designs in all the stands the proper cooling system for both work rolls and backup rolls in order to obtain the best cooling efficiency with lower water consumption and to keep the thermal crown of the work rolls under control thereby reducing the need to compensate this effect through roll bending.
In particular, for work roll cooling, the RTC (Roll Thermal Crown – Danieli Patent) control system is installed on all stands to enable a better roll thermal crown control.
The RTC system (Figure 10) controls the work roll thermal crown by varying the cooling efficiency along the roll barrel. The cooling headers are installed at the exit side of both top and bottom work rolls and the nozzles are rather spaced along an arc whose apex is across the middle of the roll face.

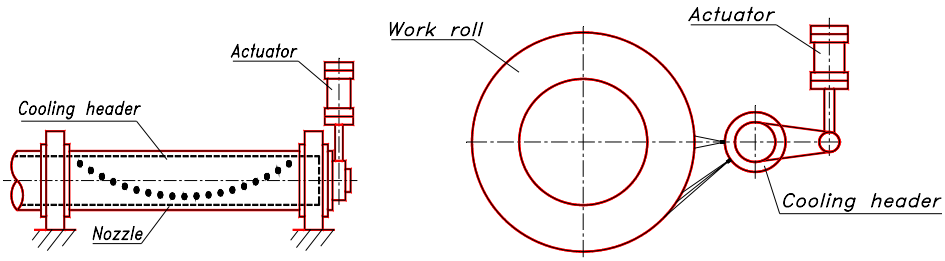


Figure 10 – RTC Cooling Header

In addition, using hydraulic actuators, the angular position of the RTC headers can be adjusted by rotational motion about their axis. The RTC system is based on the fact that cooling efficiency is dependent on the spray angle.

Hydraulic Loopers
Low inertia loopers for a faster mass flow control. One of the specific features of the hydraulic looper type, compared with the electric one, is the direct mechanical coupling between rotary actuator and looper arm. This solution avoids the effects of reduction gear backlash and, at the same time, allows the development of a low inertia looper.

4 Plant Operational Results

The production learning curve had a really ultra-fast growth (Figure 11) since first days production: March production output was in excess of 55,000 t, including thin gauge production down to 2,0 mm.
The target monthly production originally previewed was 83,000 t/month, but since April the full plant productivity was reached, just two months after start-up, with over 90,000 t produced, exceeding the full plant capacity with only one slab reheating furnace in operation.
By the end of July, thus after only 5 months since plant start-up, Guofeng produced almost 500,000 t of hot rolled coils, even with a consistent production of thin gauges, continuously exceeding the monthly target.

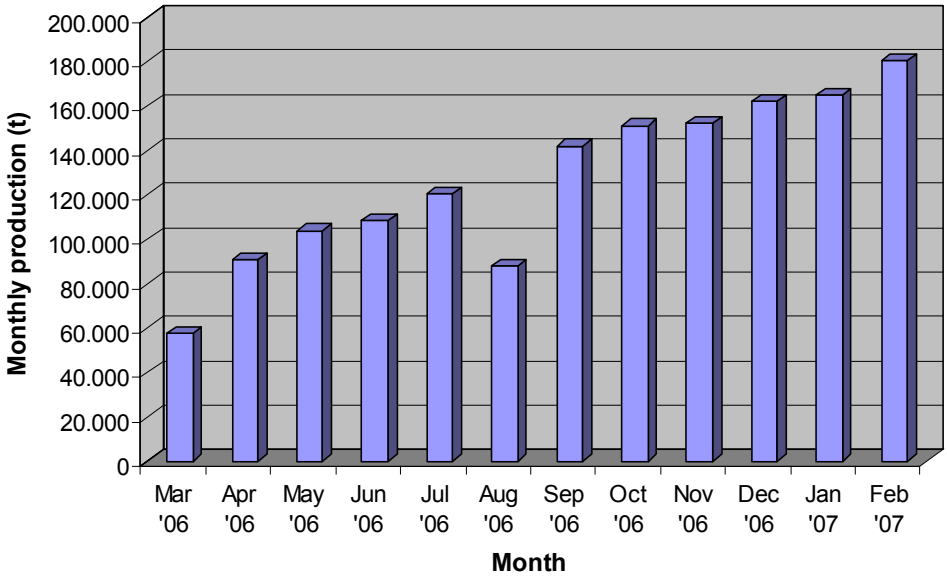


Figure 11 – Production learning curve (March – July 2006)

In 12 months production, from March 2006 to February 2007, the Tangshan Guofeng overall production has been in excess of 1,500,000 t of HRC, with the 2nd reheating furnace commissioned just in January 2007.

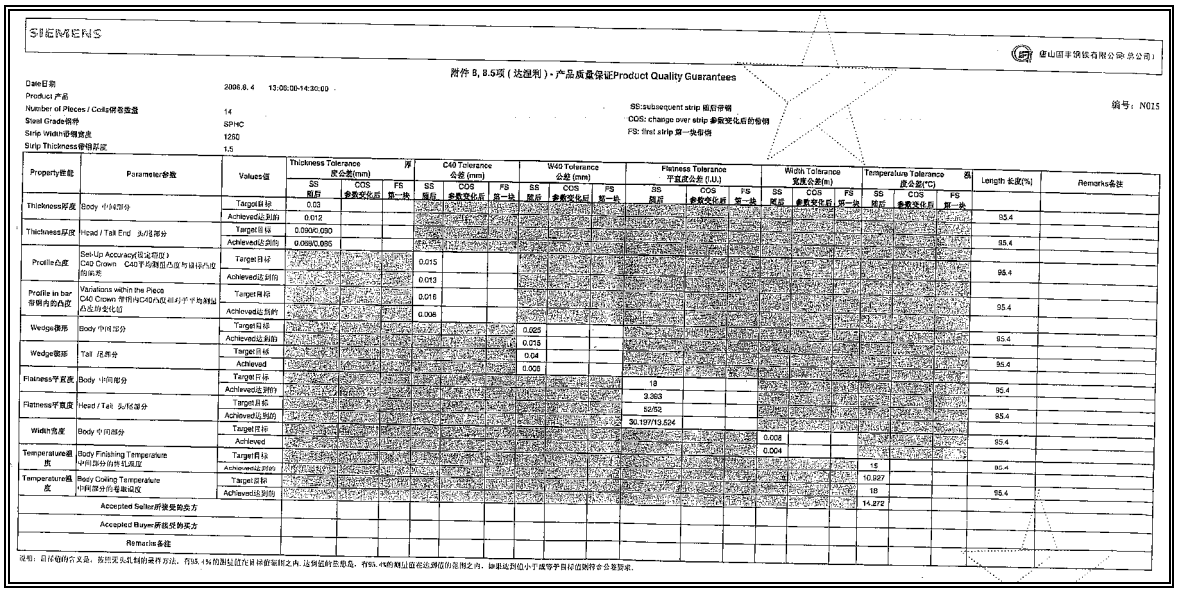
Quality and product mix

Strip geometrical and metallurgical properties fully meet the requirements of national standards and over 95.4% of the strip length have the parameters within the tolerance specified by the relative standards, fully reaching the design performances.
Also the quality of the final product meets the end-user's requirements.

For the performance calculation, as mandatory requirement the in-tolerance percentage of 95,4% of the strip length has been considered. Based on that the minimum tolerance range necessary to respect the condition has been calculated. Here after two representative cases are presented:

First case: SPHC – 1.50 x 1250 mm

Here after are reported the minimum tolerance range achieved in order to respect the condition of the in-tolerance for the 95,4% of the strip length for a low carbon steel grade SPHC, 1.50 x 1250 mm strip format (see Figure 12 for automation report).



SIEMENS

唐山国丰钢铁有限公司(总公司)

附件 8, 8.5项(达到判)-产品质量保证Product Quality Guarantees

Date日期 2008.8.4 13:00:00-14:30:00

Product 产品

Number of Pieces / Coils钢卷数量 14

Steel Grade钢种 SPHC

Strip Width带钢宽度 1250

Strip Thickness带钢厚度 1.5

SS:subsequent strip 顺后带钢

COS: change over strip 参数变化后的带钢

FS: first strip 第一块带钢

编号：N015

Property性能	Parameter参数	Values值	Thickness Tolerance 厚度公差(mm) SS 顺后	COS 参数变化后	FS 第一块	C40 Tolerance 公差 (mm) SS 顺后	COS 参数变化后	FS 第一块	W40 Tolerance 公差 (mm) SS 顺后	COS 参数变化后	FS 第一块	Flatness Tolerance 平直度公差 (I.U.) SS 顺后	COS 参数变化后	FS 第一块	Width Tolerance 宽度公差(m) SS 顺后	COS 参数变化后	FS 第一块	Temperature Tolerance 温度公差(°C) SS 顺后	COS 参数变化后	FS 第一块	Length 长度(%)	Remarks备注
Thickness厚度	Body 中间部分	Target目标	0.03																			
		Achieved达到的	0.012																		95.4	
Thickness厚度	Head / Tail End 头/尾部分	Target目标	0.090/0.090																			
		Achieved达到的	0.088/0.085																		95.4	
Profile凸度	Set-Up Accuracy(设定精度) C40 Crown C40平均测值凸度与目标凸度的偏差	Target目标				0.015																
		Achieved达到的				0.013															95.4	
Profile in bar 带钢内的凸度	Variations within the Piece C40 Crown 带钢内C40凸度相对平均测值凸度的变化值	Target目标				0.016																
		Achieved达到的				0.008															95.4	
Wedge楔形	Body 中间部分	Target目标							0.025													
		Achieved达到的							0.018												95.4	
Wedge楔形	Tail 尾部分	Target目标							0.04													
		Achieved							0.008												95.4	
Flatness平直度	Body 中间部分	Target目标										18										
		Achieved达到的										3.363									95.4	
Flatness平直度	Head / Tail 头/尾部分	Target目标										52/52										
		Achieved达到的										30.197/19.624									95.4	
Width宽度	Body 中间部分	Target目标													0.008							
		Achieved													0.004						95.4	
Temperature温度	Body Finishing Temperature 中间部分的终轧温度	Target目标																15				
		Achieved达到的																10.927			95.4	
Temperature温度	Body Coiling Temperature 中间部分的卷取温度	Target目标																18				
		Achieved达到的																14.272			95.4	
Accepted Seller所接受的卖方																						
Accepted Buyer所接受的买方																						
Remarks备注																						

说明：目标值的含义是，当您买轧制的硬件方法，有95.4%的测量值在目标值范围之内，这个值的意思是，有95.4%的测量值在这个范围之内，如果达到位小于或等于目标值则符合公差要求。

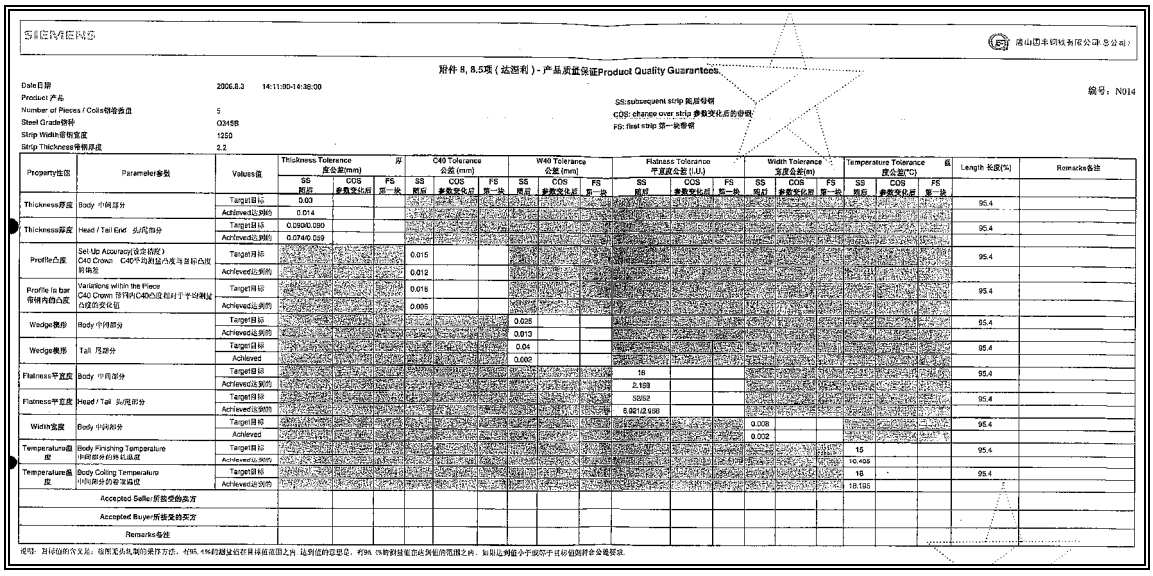
Figure 12 – Strip performance report of SPHC steel grade, 1.50 x 1250 mm strip format

In detail the main parameters performed for the analyzed strip are:

- Strip thickness accuracy within the tolerance range of ± 12 µm for the strip body (target ± 30 µm).
- Strip width accuracy within the tolerance range of –0/+4 mm for all the strip length (target –0/+8 mm).
- Strip profile C40accuracy within the tolerance range of ± 13 µm for the set-up accuracy (target ± 15 µm) and a variation of ± 8 µm within the piece (target ± 16 µm).
- Strip finishing rolling temperature within the tolerance range of ± 11°C (target ± 15°C).
- Strip coiling temperature within the tolerance range of ± 14.3°C (target ± 18°C).

Second case: Q345B – 2.20 x 1250 mm

Here after are reported the minimum tolerance range achieved in order to respect the condition of the in-tolerance for the 95,4% of the strip length for a high carbon steel grade Q345B, 2.20 x 1250 mm strip format (see Figure 13 for automation report).



期件 8, 8.5项（达涅利）- 产品质量保证Product Quality Guarantees.

Property性质	Parameter参数	Values值	Thickness Tolerance 厚度公差(mm) SS 前后	Thickness Tolerance COS 参数变化后	Thickness Tolerance FS 第一块	C40 Tolerance 公差 (mm) SS 前后	C40 Tolerance COS 参数变化后	C40 Tolerance FS 第一块	W40 Tolerance 公差 (mm) SS 前后	W40 Tolerance COS 参数变化后	W40 Tolerance FS 第一块	Flatness Tolerance 平直度公差 (I.U.) SS 前后	Flatness Tolerance COS 参数变化后	Flatness Tolerance FS 第一块	Width Tolerance 宽度公差(m) SS 前后	Width Tolerance COS 参数变化后	Width Tolerance FS 第一块	Temperature Tolerance 温度公差(°C) SS 前后	Temperature Tolerance COS 参数变化后	Temperature Tolerance FS 第一块	Length 长度(%)	Remarks备注
Thickness厚度	Body 中间部分	Target目标	0.03																		95.4	
		Achieved达到的	0.014																			
Thickness厚度	Head / Tail End 头/尾部分	Target目标	0.09/0.090																		95.4	
		Achieved达到的	0.074/0.099																			
Profile凸度	Set Up Accuracy(设定精度) C40 Crown C40中间部位凸度与目标凸度的偏差	Target目标				0.015															95.4	
		Achieved达到的				0.012																
Profile In bar 带钢内的凸度	Variations within the Piece C40 Crown 带钢内C40凸度相对于平均测量凸度的变化值	Target目标				0.016															95.4	
		Achieved达到的				0.006																
Wedge楔形	Body 中间部分	Target目标							0.025												95.4	
		Achieved达到的							0.013													
Wedge楔形	Tail 尾部分	Target目标							0.04												95.4	
		Achieved							0.022													
Flatness平直度	Body 中间部分	Target目标										16									95.4	
		Achieved达到的										2.199										
Flatness平直度	Head / Tail 头/尾部分	Target目标										30/32									95.4	
		Achieved达到的										6.921/2.986										
Width宽度	Body 中间部分	Target目标													0.008						95.4	
		Achieved													0.002							
Temperature温度	Body Finishing Temperature 中间部分的终轧温度	Target目标																15			95.4	
		Achieved达到的																10.405				
Temperature温度	Body Coiling Temperature 中间部分的卷取温度	Target目标																18			95.4	
		Achieved达到的																18.195				
Accepted Seller所接受的卖方																						
Accepted Buyer所接受的买方																						
Remarks备注																						

Figure 13 – Strip performance report of Q345B steel grade, 2.20 x 1250 mm strip format

In detail the main parameters performed for the analyzed strip are:

- Strip thickness accuracy within the tolerance range of ± 14 µm for the strip body (target ± 30 µm).
- Strip width accuracy within the tolerance range of –0/+2 mm for all the strip length (target –0/+8 mm).
- Strip profile C40accuracy within the tolerance range of ± 12 µm for the set-up accuracy (target ± 15 µm) and a variation of ± 6 µm within the piece (target ± 16 µm).
- Strip finishing rolling temperature within the tolerance range of ± 10°C (target ± 15°C).
- Strip coiling temperature within the tolerance range of ± 18°C (target ± 18°C).

Product mix

The actual situation in terms of coil delivery to the market is as follows:

- 85 % to domestic market.
- 10 % to Asian market (mainly South Korea and Singapore).
- 5 % to Europe market.

5 Conclusions

In order to enable the mill to reach the high and demanding standards of dimensional tolerances on the finished product requested by the market, Danieli installed the most Danieli Wean United know-how in the supply of the most advanced technological solutions for rolling plants comes both from experience and constant innovation.
The project was completed within the contract schedule thanks to the joint and full commitment among the Tangshan Guofeng and Danieli teams.
Strip quality, geometrical and metallurgical properties fully met the international standards requirement as well as the end-user constrains.

The operating results demonstrate that Danieli proven technology, based on the broad experience and innovative solutions achieved through large scale R&D activities, is the front-runner in technological know-how and innovation. Danieli demonstrate the capability to supply sound and reliable state-of-the-art equipment to the steel industry in order to satisfy the most demanding applications.

Acknowledgments

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