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THE UNI PLUS COILER. A NEW DEVELOPMENT FOR COILING HIGH-STRENGTH STRIP IN LARGE THICKNESSES[1]

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Abstract
The segment for high-strength hot strip holds huge potential on today's market. In particular pipe manufacturers have increasing demand for steel grades like API X70, X80 or X100 in large thicknesses for the production of spiral-welded pipes. The production of these steel grades poses especially high demands on the downcoiler. Therefore SMS Siemag has enhanced its well-proven downcoiler design and developed a more powerful downcoiler, the UNI plus coiler. It was developed with a simulation model, which calculated the complete coiling process and the mechanical and hydraulical movements. Based on these simulations, the new coiler was designed to achieve the required coiling quality and especially a smooth coiling start for the head end of the strip. The paper presents the development of the UNI plus coiler, explains the necessary reinforcement and optimization of the mechanical, hydraulic and electrical design and discusses operational results.
Keywords: Hot strip mill; Downcoiler; High-strength steel; Pipe grades.

A BOBINADEIRA UNI PLUS. UM NOVO DESENVOLVIMENTO PARA A BOBINAGEM DE TIRAS DE ALTA RESISTÊNCIA E GRANDES ESPESSURAS

Resumo
O segmento de tiras de alta resistência laminadas a quente detém um grande potencial no mercado atual. Particularmente os fabricantes de tubos têm uma demanda crescente por qualidades de aço como API X70, X80 ou X100 em grandes espessuras para a produção de tubos soldados em espiral. A produção destas qualidades de aço gera demandas especialmente elevadas sobre a bobinadeira. Por isso a SMS Siemag aperfeiçoou o seu consagrado projeto de bobinadeira e desenvolveu um equipamento ainda mais potente, a bobinadeira UNI plus. Ela foi desenvolvida através de um modelo de simulação no qual o processo completo de bobinagem é calculado com os movimentos mecânicos e hidráulicos. Baseado nestas simulações a nova bobinadeira foi projetada para alcançar a qualidade de bobinagem requerida, especialmente uma partida suave da bobinagem na ponta da tira. O trabalho apresenta o desenvolvimento da bobinadeira UNI plus, explica o reforço necessário e a otimização do projeto mecânico, hidráulico e elétrico realizado, e discute os resultados operacionais.
Palavras-chave: Laminador de tiras a quente; Bobinadeira; Aço de alta resistência; Tipos de tubos.

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ISSN 1983-4764

1 INTRODUCTION

The steel processing industry increasingly demands higher-strength steels with larger strip thicknesses. Above all, two directions of development for hot-rolled steel strip can be stated here. On the one hand, ultra-high strength steel grades are developed with strength levels of more than 1,300 MPa to be used for highly-loaded steel structures or for components particularly resistant to wear. On the other hand, the tube manufacturers' demand for high-strength tube grades rises, as for example API grades X70, X80 and X100 with large final thicknesses of up to 25.4 mm. For meeting these requirements the product range in the hot strip mills must be extended. This leads to an increase of the loads acting on the plants, which applies in particular to the coiler systems.
In order to facilitate the coiling of these high-strength steels with very good quality, the proven universal coiler design was developed further and a new, reinforced coiler, the UNI plus coiler was developed. Apart from the conventional materials and dimensions, the UNI plus coiler is able to coil both ultra-high strength grades at low coiling temperatures and high-strength tube grades with large strip thicknesses. With eleven references for the UNI plus coiler, among which are the strongest coilers currently being operated world-wide, SMS Siemag possesses extensive operating experiences for the coiling of high-strength steel grades.

2 DEVELOPMENT OF NEW COILER

2.1 Boundary Conditions for Design

The demands made on the new coiler mainly result from the coiling of thick, high-strength tube grades. The boundary conditions for the design of the new coiler were:

- Material: X80
- Strip thickness: 25.4 mm
- Strip width: 2,150 mm
- Coiling speed: 2 m/s
- Coiling temperature: 550°C.

The plastic bending torque for this type of strip is by approx. 250 % higher than the maximum plastic bending torque that has been applied by conventional coiling process. Another development target was to enable coiling at constant temperatures from the strip head-end up to the tail-end in order to generate homogenous material characteristics over the entire strip length.

2.2 FE-Analysis

For the further development of the coiler and in order to design it according to the new boundary conditions, the entire coiling process including all movements and the plastic deformation of the strip was simulated. With the aid of the finite element method this simulation was carried out and the process was optimised. The basic design of the model with all plant parts considered is shown in Figure 1.

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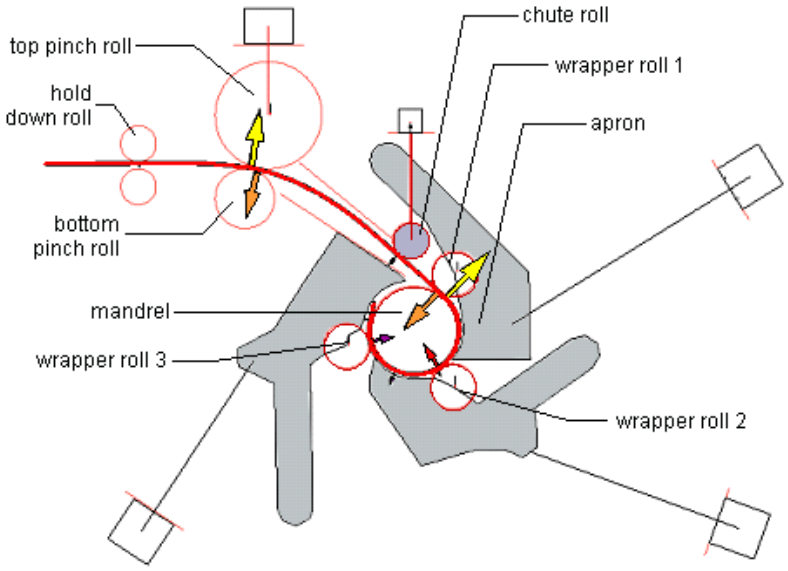

Figure 1: Basic design of the UNI plus coiler.

Figure 2 represents the stress distribution in the strip and the shape of the strip after the first wrap. Building-up the first wrap and coiling round the strip head-end is a critical phase in the coiling process and places high demands on wrapper rolls, mandrel and pinch roll unit.

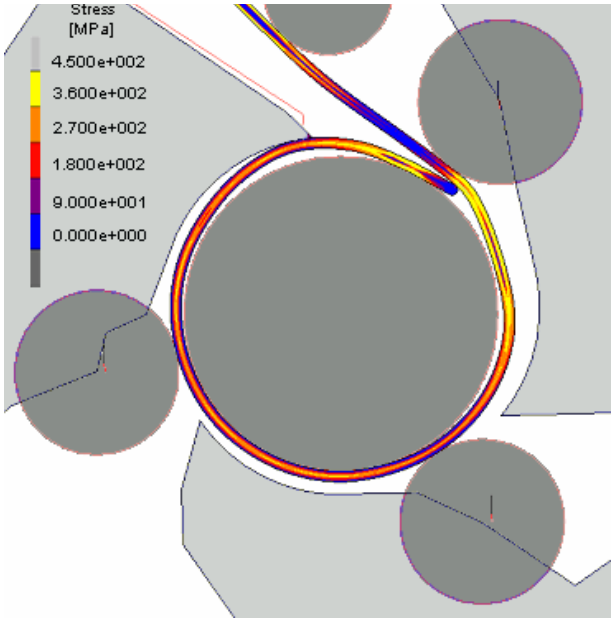

Figure 2: FEM simulation of the coiling process, equivalent stresses in the strip,

In this phase, high forces and torques apply, which essentially determine the design. For this reason, the winding of initial wraps was examined very thoroughly.
In the simulation processes the forces and torques for pinch roll unit, chute plate, wrapper rolls and mandrel were determined that are required for enabling a stable and reproducible coiling process. Furthermore, the kinematics of the wrapper rolls were optimised and the sequence of movement was defined.

ISSN 1983-4764

During further simulation processes, the drives and the hydraulic adjustment system including all control systems were designed and the relevant control parameters were identified.

3 MECHANICAL DESIGN

The main mechanical components of the UNI plus coiler and their functions in the coiling of thick, high-strength strips are briefly described in the following:
Strong hydraulic side guides, mechanically synchronised and with low friction values, ensure tight strip guiding and straight strip flow. An approachable hold-down roll is arranged upstream of the pinch roll unit that keeps the strip between the side guides especially at the strip tail-end.
With the aid of its increased adjustment force as well as its higher drive torque the pinch roll unit ensures safe transport of the strip head-end to the mandrel and sufficient support for winding the initial wrap. During coiling the pinch roll unit maintains the strip tension to the mandrel and generates tightly wound coils.
The chute plate with roll is of great importance as it does not only support the winding of initial wraps but also rests on the strip during the entire coiling process and considerably adds to the coil quality. The reinforced wrapper rolls and curved apron plates guide the strip head-end around the mandrel and form the first wrap, thus ensuring safe winding of initial wraps. Due to the great forces and torques during winding of initial wraps the mandrel's design had to be revised and reinforced.
In addition, a special cooling system was installed for generating tight coils and reducing opening of the last wraps.

Figure 3: UNI plus coiler in operation.

4 TECHNOLOGICAL CONTROL SYSTEMS

The major number of coilers supplied by SMS Siemag is furnished with the SMS Siemag automation system. For the UNI plus coiler these technological control systems and the sequence control system were revised and adapted.
Especially for the winding of initial wraps the Automatic Step Control system was extended in order to optimise the build-up of the first wrap and the coiling round the strip head-end after the first wrap.

ISSN 1983-4764

The chute roll was equipped with a position and force control system. During coiling of thick, high-strength strips the chute roll follows the increasing coil diameter in a position-controlled manner according to a special function for supporting the bending process of the strip and generating a straight-edged coil.
At the strip tail-end the special cooling system and the wrapper rolls are controlled in a way that, in combination with the strapping of the coil strapping machine, a tight coil is produced.

5 RESULTS AND EXPERIENCES

Since its development, SMS Siemag has won eleven orders for the new UNI plus coiler. These are stated in the reference list in Table 1. The coilers are used both for new plants and for the modernisation of existing rolling mills.

Table 1: References for UNI plus coiler

Year of comm.	Customer	No. of UNI plus coilers	Max. strip width	Steel grades
2008	ArcelorMittal Bremen, Germany	1	2,150 mm	Tube grades
2008	ThyssenKrupp Steel Europe, Germany	3	2,030 mm	Tube grades
2008/ 2010	SSAB Tunplåt, Sweden	2	1,650 mm	UHSS*
2010	Bhushan Steel, India	1	1,680 mm	Tube grades
2010	Salzgitter Flachstahl, Germany	1	2,000 mm	UHSS* and tube grades
2010	ThyssenKrupp Steel North America, USA	3	1,890 mm	UHSS* and tube grades

** UHSS = Ultra high-strength steel*

The first UNI plus coiler was commissioned at ArcelorMittal Bremen, Germany in 2008 and is one of the strongest coilers built so far in the world. In 2006, the company decided to have their coiler system modernised. The modernisation included replacing the third coiler by a new UNI plus coiler with four wrapper rolls. This coiler is able to coil high-strength tube grades with a yield point of 750 MPa (at 20°C) up to a thickness of 25.4 mm and a width of 2,150 mm at a coiling temperature of 550°C. Apart from the supply of the new coiler with the complete X-Pact® automation system, SMS Siemag modernised the mechanical and automation systems of the other two coilers.
All key components for this order were manufactured in the SMS Siemag workshop. The entire coiler was preassembled and tested in the workshop in Hilchenbach (Figure 4).

ISSN 1983-4764

Figure 4: Preassembly and functional tests at SMS Siemag workshop.

The automation system, including all control desks and operating elements, was also completely assembled in the SMS Siemag test field and thoroughly tested in an integration test jointly with the customer (Figure 5). In the so-called Plug&Work-tests, the automation system is tested against a real-time simulation of the complete coiling process. The simulation includes the construction data of the coiler, the cinematic behaviour of the drive system and the function of the sensors and reproduces reality as exactly as possible.

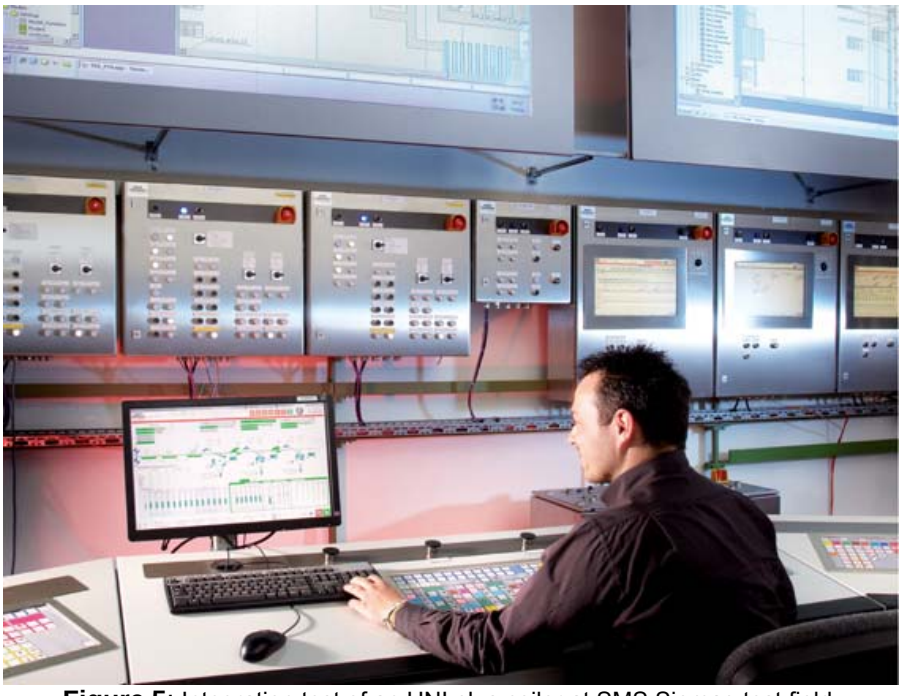

Figure 5: Integration test of an UNI plus coiler at SMS Siemag test field.

Figure 6 shows the first coil of an X70 strip with a thickness of 25 mm at ArcelorMittal Bremen. The first strip already could be produced with excellent quality so that the final optimization of the process could be performed smoothly with small fine-adjustment only. The coiler is designed for even higher-strength API X-grades, which enables ArcelorMittal to meet future demands made by tube manufacturers as well.

ISSN 1983-4764

Figure 6: First X70 coil with a thickness of 25 mm.

At the ThyssenKrupp Steel Europe works in Duisburg-Beeckerwerth (Germany) the complete downcoiler group with three coilers was replaced by UNI plus coilers in 2008. This order included the mechanical components, the utility systems and the complete electrical and automation systems. The fully hydraulic coilers are designed for coiling of tube grades with a maximum thickness of 25.4 mm. They have furthermore proven that also soft steel grades with thicknesses of 1.2 mm can be perfectly coiled with the UNI plus coiler.
SSAB in Borlänge, Sweden, installed in 2008 one UNI plus coiler for coiling ultra-high strength materials at low coiling temperatures (≤ 150°C) in particular. With this investment SSAB takes another step towards facilitating the production of highly-developed steels with special properties in the future as well. The second UNI plus coiler will start production in 2010.
In March 2010, the first UNI plus coiler outside Europe started production at the new hot strip mill of the Indian steelmaker Bhushan Steel. The downcoiler group consists of two units with a universal coiler rated for strips up to 20 mm and the UNI plus coiler for high-strength tube grades with 25.4 mm thickness.
The UNI plus coiler at Salzgitter Flachstahl (Germany) was commissioned in April 2010. Here, the new downcoiler was arranged behind the existing two coilers and enables Salzgitter Flachstahl to extend its supply of high-strength tube grades to thicknesses up to 25.4 mm.

6 CONCLUSION

The UNI plus coiler completes SMS Siemag's portfolio for downcoilers based on today's and future market requirements. Based on the proven universal coiler, it is designed for the coiling of high-strength tube grades and ultra-high strength steel grades with large strip thickness. Nevertheless, it is also appropriate for conventional dimensions. For the producers of hot strip the UNI plus coiler offers the possibility of considerably extending their product range and thus being well prepared also for future market requirements.