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PROCESS AND CONDITION MONITORING AT A FINISHING MILL[1]

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Abstract

Because of the growing quality demands of hot rolled flat products and in order to improve competitive ability it becomes more and more necessary to use automatic diagnostic tools in order to monitor the condition of the equipment and the rolling process. Main target of torque monitoring is to enable a condition-based maintenance of main drive spindles. In addition it allows to optimise rolling schedules, roll gap lubrication and minmise the risk of overloads. Torque sensor technology presented is specifically designed for rough ambient conditions. A computer based monitoring system is described which uses sensor signals and additional plant data for a rolling mill main drive specific signal analysis. The diagnosis and data mining is supported by a report generator module. Vibration monitoring is described as an effective and essential tool for rolling mill main drives components such as bearings of rolls and motors, reducers and pinion stands. Dynamic loading and speed variation require a high level of monitoring expertise and experience. These tools of a modern monitoring system are explained and illustrated using the example of a finishing mill.

Key words: Roll gap lubrication; Process monitoring; Torque amplification factor; Wear fatigue analysis.

MONITORAMENTO DO PROCESSO E CONDIÇÕES DE UM LAMINADOR ACABADOR

Resumo

Por causa do crescimento na demanda da qualidade dos produtos planos laminados a quente e, de maneira a aprimorar a competitividade, torna-se mais e mais necessário o uso de ferramentos automáticas de diagnóstico para monitorar as condições dos equipamentos e dos processos de laminação. O principal objetivo do monitoramento do torque é capacitar uma manutenção baseada nas condições reais dos principais eixos de acionamento. Além disto, permitir uma otimização do planejamento da laminação, intervalos de lubrificação dos rolos do laminador e minimizar o risco de sobretorques. A tecnologia de sensores de torque apresentada é especificamente projetada para ambientes de condições severas. Um sistema de monitoramento baseado em um computador é introduzido, o qual utiliza sinais de sensores e sinais adicionais da planta para uma análise específica do sinal oriundo do acionamento principal. O diagnóstico e a fonte de informações são auxiliados por um módulo gerador de relatórios. O monitoramento da vibração é visto como uma efetiva e essencial ferramenta para os principais componentes dos acionamentos dos laminadores. tais como mancais de rolos e motores, redutores e caixas de pinhões. Cargas dinâmicas e variações na velocidade requerem um elevado nível de conhecimento e experiência neste monitoramento. Estas ferramentas de um moderno sistema de monitoramento são explicadas e ilustradas através do exemplo de um laminador acabador.

Palavras-chave: intervalo da lubrificação de rolos; Monitoramento de processos; Fator de amplificação do torque; Análise do desgaste.

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1 INTRODUCTION

The ThyssenKrupp Steel Europe AG Hot Strip Mill 3 is located in Bochum. Figure 1 gives a plant overview.

Figure 1. Plant overview.

Due to rising quality requirements on hot strip mill products and for improvement of the competitive ability, it is necessary to use state-of-the-art technical procedures to monitor the current mill condition and rolling processes. Practical experiences show unwanted mill chatter vibrations at the finishing mill caused by rolling of high yield strength steel. Especially at mill stands 2-4 vibrations occur. Amongst others, these vibration effects cause objectionable strip surface quality losses. Further more the risk of damage for the roll equipment gets higher. There is higher wear on the drive spindles or the backup and work rolls, which causes gearbox or bearing defects. From the roll technology point of view, the torque signals bear more benefit in analysing the mill behaviour, than only the roll force signal, because the roll process can be analysed separately for the top and bottom spindle. Using these signals, the mill behaviour can globally be analysed and the mill chatter can be classified and determined.
Modern rolling mills are using roll gap lubrication systems in order to reduce roll force and torque and to optimise the strip surface quality. The optimisation of these processes is only possible by using a functional torque monitoring system.(1)

2 OVERVIEW HSM

The ThyssenKrupp HSM at Bochum is a semi-continuous strip mill and includes four refurnaces, one deep oven, one quarto reversing mill including a pre-edger, one coil-

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box, a seven stand finishing mill and three underfloor winders. Through the following coil store, the products are distributed by train, truck or other transport chains. Figure 2 gives an overview on the HSM components.

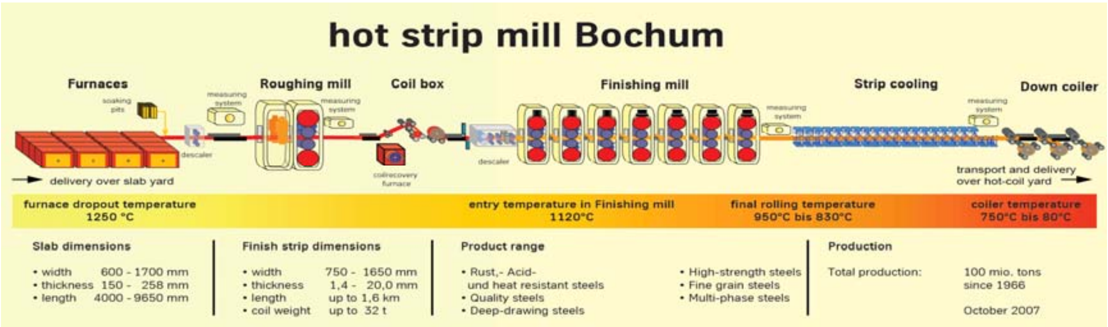

Figure 2. Overview hot strip mill.

The HSM at Bochum processes a large range of modern steels including high-alloyed materials and a range of nonferrous metals (e.g. titan, nickel bases materials). An overview on the product mix gives Figure 3.

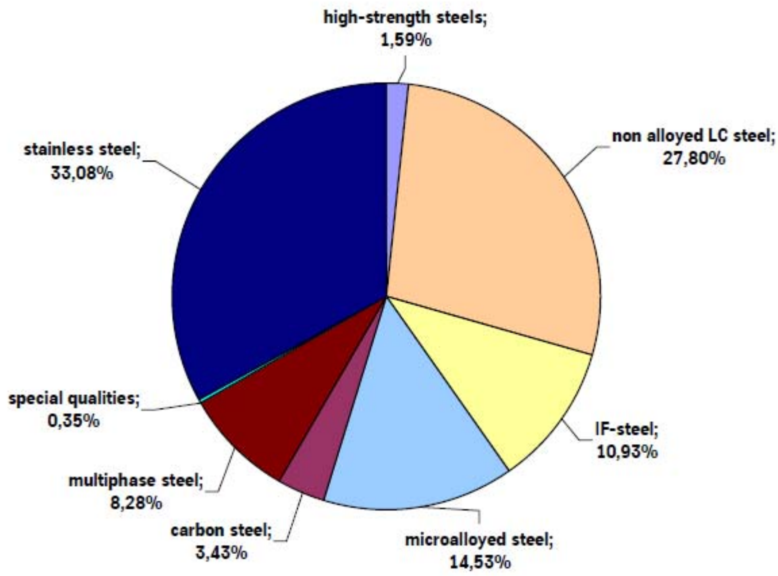

Figure 3. Product mix.

The steel grade processed in Bochum has a wide range and includes severely processable materials with a distinctive nonlinear yield stress behaviour.

3 TECHNICAL LAYOUT

The focus of the investigation is the finishing mill (Figure 4). Basic characteristics are shown in Table 1. In order to get a complete overview, other mill components are shown as well.

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Table 1. Technical data of the HSM Bochum

1. Furnaces:

Type:	Pusher-type	Number:	1
Capacity:	250 t/h	Length:	35 m
Width:	10,3 m	Soak Length:	8,2 m
Type:	Walking beam	Number:	3
Capacity:	310/310/320 t/h	Length:	35/35/36 m
Width:	10,1 m	Soak Length:	7,0/7,5/7,6 m

2. Roughing:

Stand	Roll Dimensions	Motor Power	Speed (max.)
E	1100 mm	2x1800 kW	6 m/s
R (WR)	1000 mm	4x4460 kW	6 m/s
(BUR)	1500 mm		

3. Finishing:

Stand	Roll Dimensions	Motor Power	Speed (max.)
F1	775-700 mm	6760 kW	2 m/s
F2	775-700 mm	9800 kW	3,4 m/s
F3	775-700 mm	9800 kW	5,2 m/s
F4	675-600 mm	9800 kW	7,7 m/s
F5	675-600 mm	9800 kW	10,5 m/s
F6	675-600 mm	9800 kW	13,2 m/s
F7	675-600 mm	6760 kW	15,2 m/s

4. Coiling:

Number:	3	
Number of Wrappers:	3 / 3 / 3	
Mandrel Power:	700/700/700	kW
Step Control:	No / Yes / Yes	

5. Control Features:

Computer: Furnaces, Roughing, Finishing, Coiling, AGC, CTC

Finishing:	F1	F2	F3	F4	F5	F6	F7
Looper Type	HYD	HYD	HYD	HYD	HYD	HYD	HYD
AGC Type	E/M	E/M	E/M	HYD	HYD	HYD	HYD
WR Shift Stroke (mm)	-	-	-	-	-	-	-
max. WR Bend Force (t)	80	80	80	80	80	80	80
max. WR Coolant Flow (m^3/h)	890	870	1025	885	360	285	230

6. Product Capability:

Slab Thickness	130 mm	to	260 mm
Slab Width	600 mm	to	1640 mm
Slab Length	4000 mm	to	9600 mm
Strip Thickness	1,5 mm	to	20 mm
max. Specific Coil Weight	20,3 kg/mm		
Transfer Bar Thickness	30 mm	to	45 mm

7. Standard Roll Change Time: (Finishing Mill) 17 min

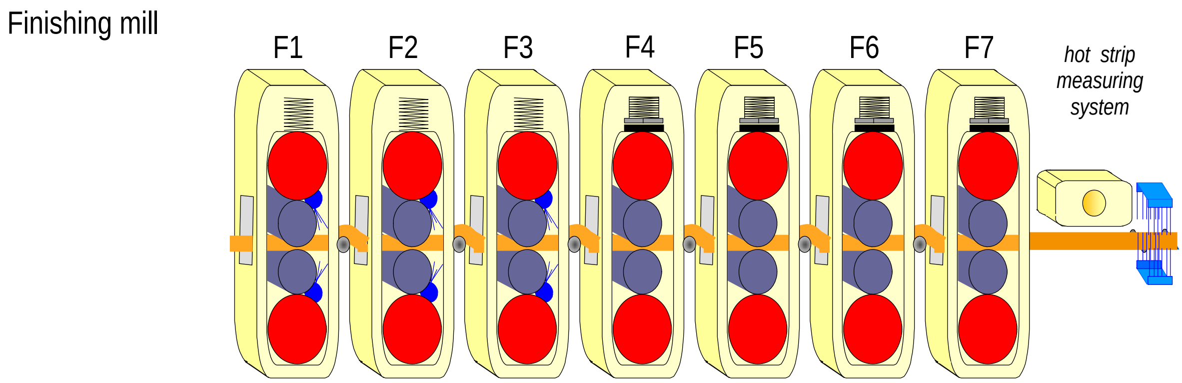

Figure 4. Schematic view on the finishing mill.

Each mill stand of the finishing mill consists of top and bottom roll set (backup and work-roll), the drive trains include a twin drive motor, two spindles and a pinion gearbox transmission respectively speed reduction.

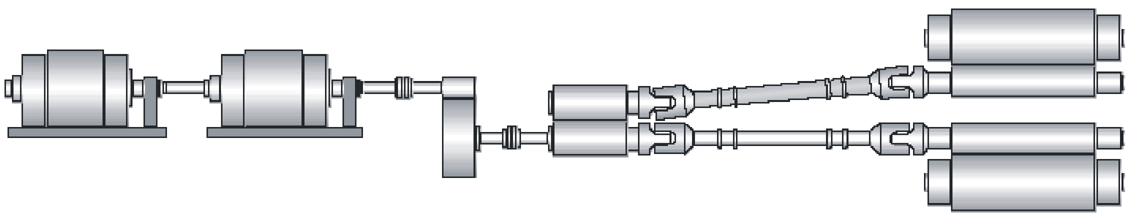

Figure 5. Drivetrain of a finishing mill stand.

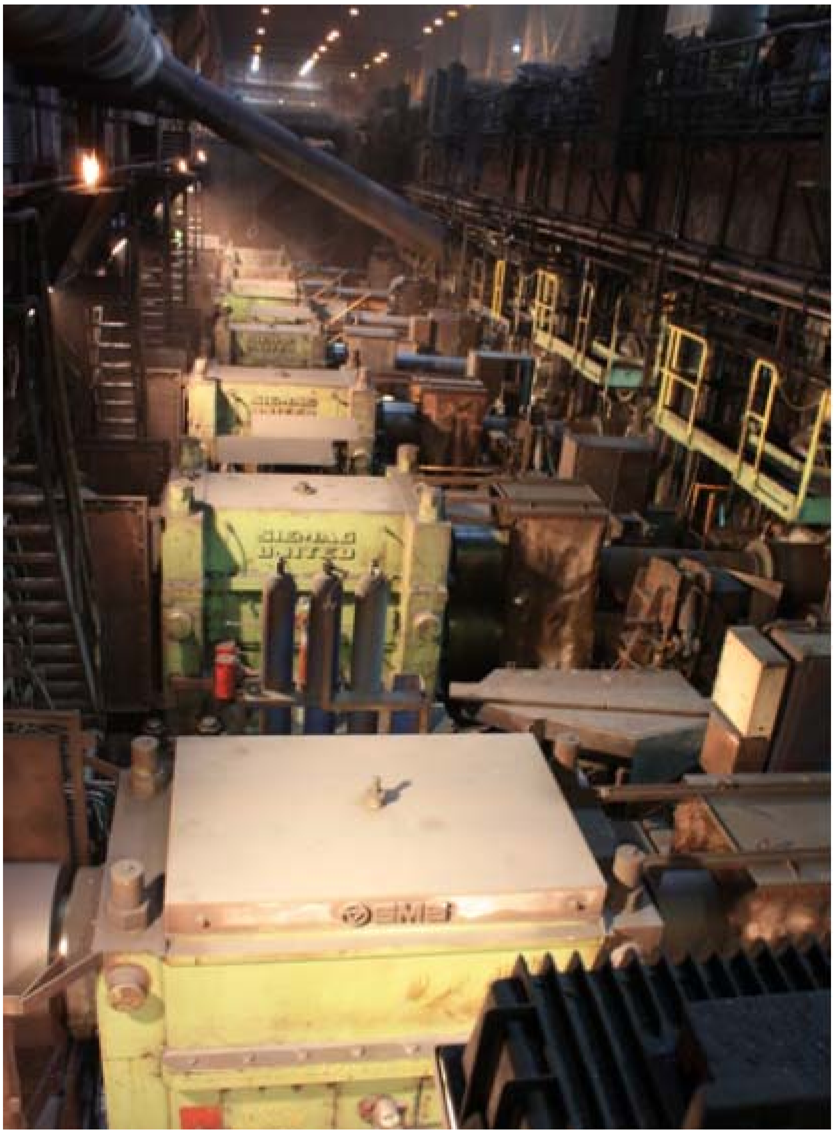

Figure 6. Drive side of finishing mill.

The mill stand / drive train is equal to an oscillatory system due to its complex design. The project aim is to monitor and analyse the system behaviour by using adequate sensors.

4 INSTALLATION OF THE TORQUE SENSORS

F4 was chosen for the first installation of torque sensors, because at this mill stand mill chatter and unwanted roll problems occurred, which is a specific problem at this HSM at Bochum.

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Figure 7: Sensor location at the drive spindles at mill stand 4

The torque signals are monitored together with other relevant process characteristics (process specific data and additional actual values) and are stored into a database to be analysed.

5 MILL STAND VIBRATION DURING ROLLING OF AUSTENITIC STAINLESS STEELS

In order to improve the roll process, typical roll programs including recurring roll phenomena have to be analysed. Therefore the following example shows a roll process with high alloyed austenitic stainless steel. The vibration amplitude was extrapolated from the acceleration sensors DC signal.

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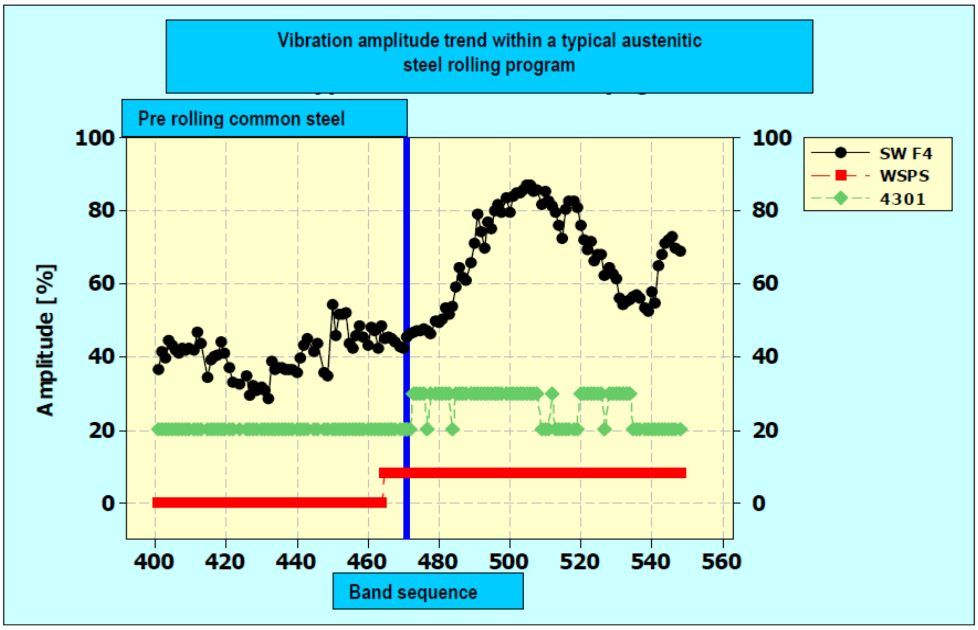

Figure 8. Example for an austenitic roll campaign.

The common steel pre rolling (green curve values 20) process does not show high vibration amplitudes (no mill chatter). Things change by rolling austenitic steel compositions (green curve values 30). In spite of the roll gap lubrication (red curve), the addiction for mill chatter is high because the amplitudes rise continuously. In that case the roll gap lubrication is limited. In addition the work rolls are shaped. This effect does not lead to lower mill chatter by interspersing common steel bands.
Figure 9 shows the relationship between the absolute level of the roll force and the vibration amplitude. The trend says, at lower roll forces, a lower vibration amplitude is detected. The reason for higher vibration amplitudes are the higher roll forces when rolling austenitic steel. Because of the shaping effect of the work rolls high amplitudes occur at the end of the roll program, even at common steel with lower roll forces (blue circles).

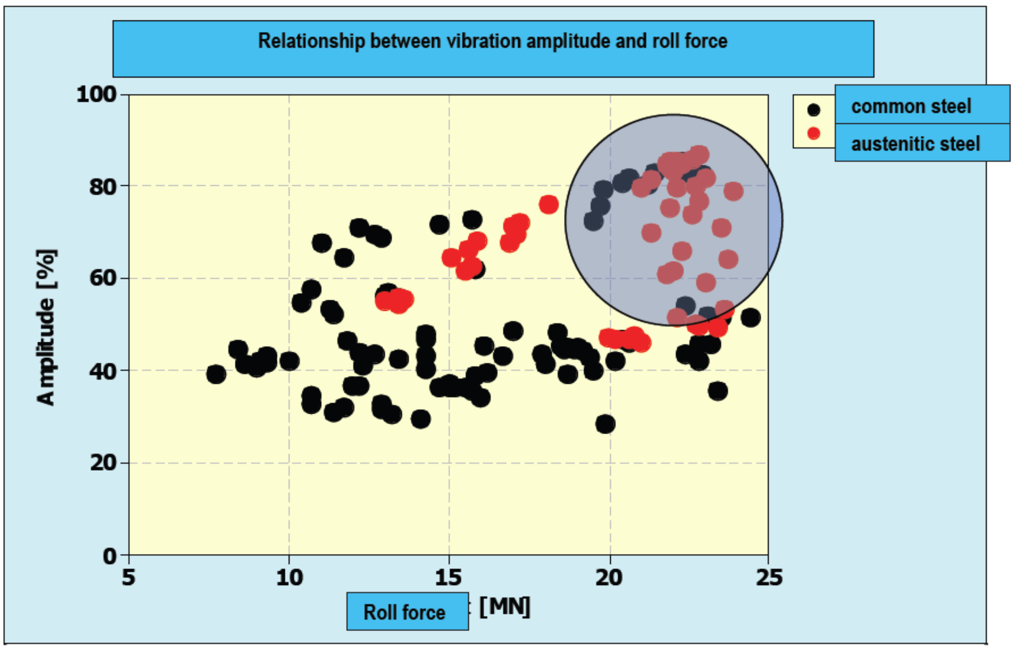

Figure 9. Dimension of the roll force and vibration amplitude during a austenitic roll program.

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The reasons for the mill vibrations respectively mill chatter could determined using torque monitoring.

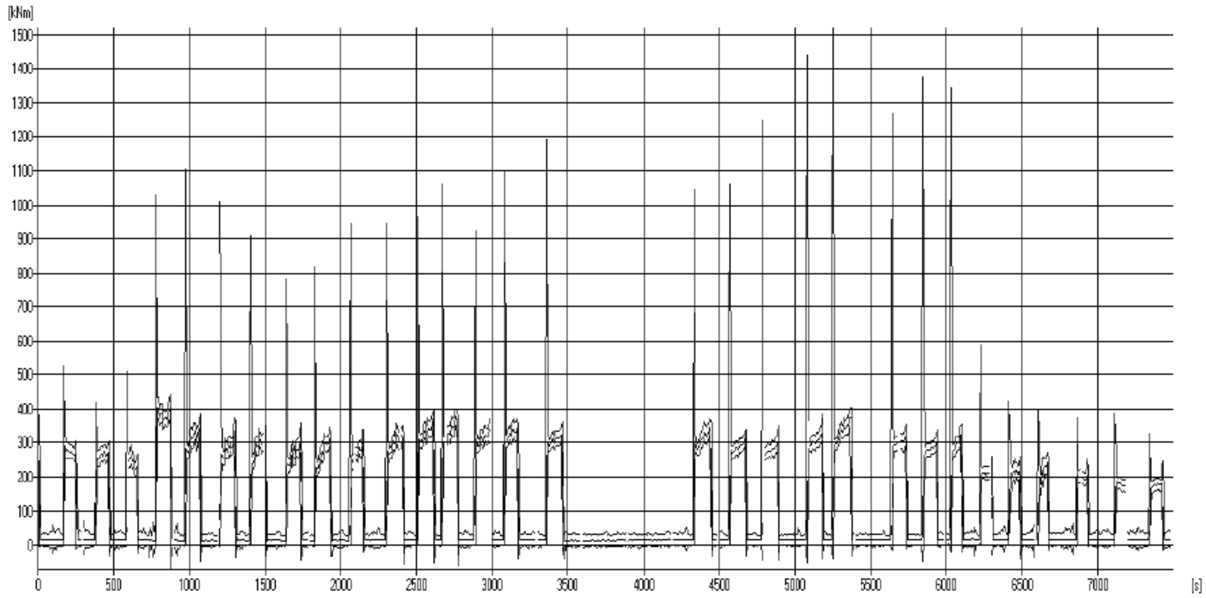

Figure 10. High TAFs at top spindle during rolling of austenitic steel.

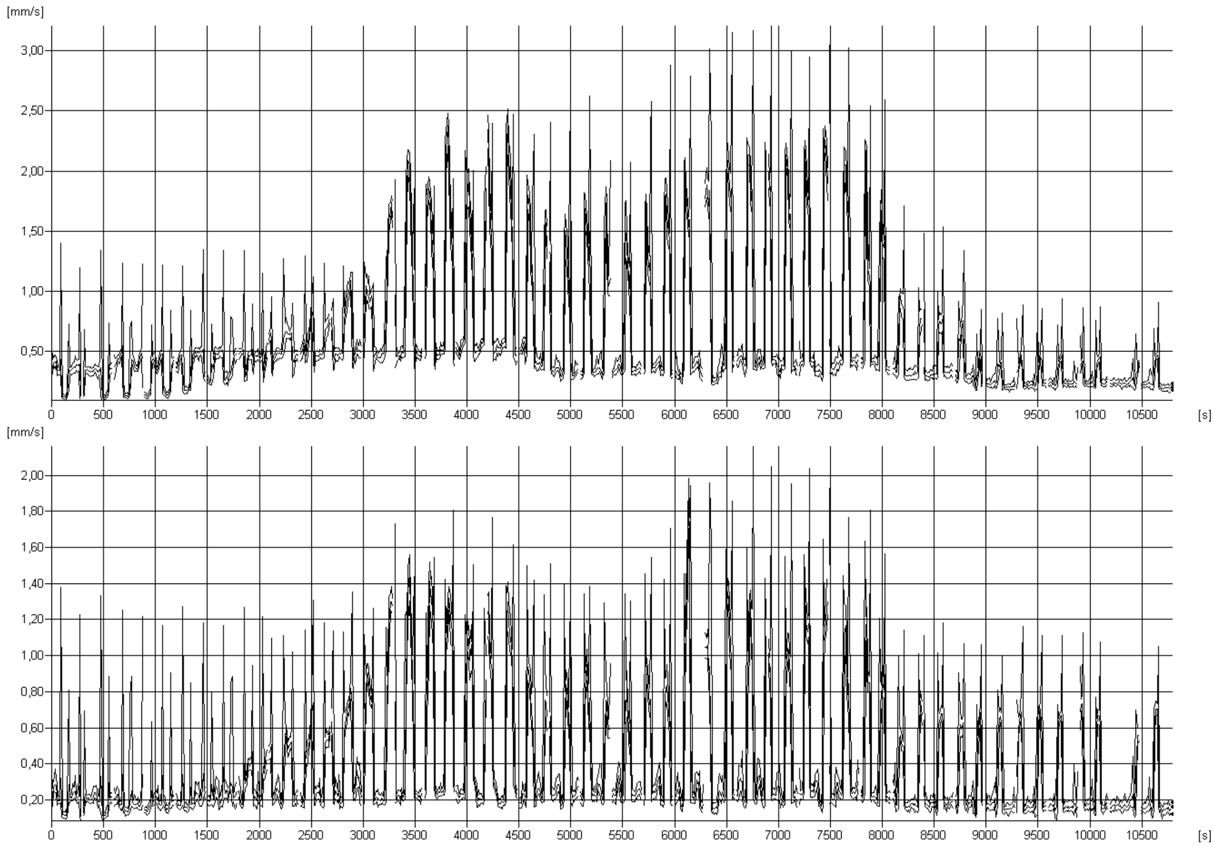

Figure 11. Mill chatter and rising Vrms.

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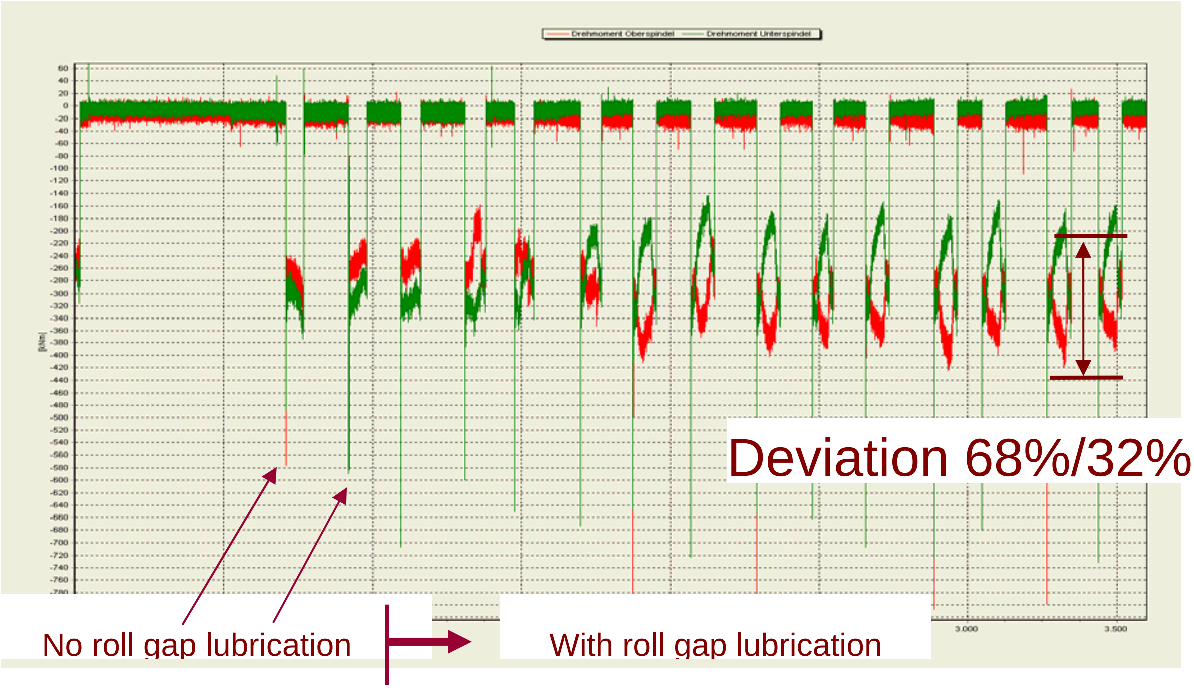

Figure 12. Influence of the roll gap lubrication on the torque distribution.

Figure 12 shows the influence of the roll gap lubrication on the torque deviation of the top and bottom spindle. During the first two passes the roll gap lubrication was switched off. For all following passes the roll gap lubrication was switched on again. The influence can clearly be seen. The torque deviation between top and bottom spindle gets worse. In this case the top spindle has to handle higher loads (red curve).

6 CONCLUSIONS

The torque behaviour of the drivelines in Finishing Mill Stands is completely unforeseeable. Lots of solutions were implemented looking to lower the loads and improve the product quality. However, each machine is single and its features must deeply be investigated.[2]
Voith Turbo Acida has the best solution for torque and vibration monitoring and definitely, for Finishing Mill Stands, the torque is one of the most important features to be analysed offering better understanding of the loads involving your drivetrain and also a good analysis to improve the product quality.

Gratefulness

Our special thanks to ThyssenKrupp steel which supported us during the torque measurements.

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