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SPECIFIC DESIGN OF PINION STAND GEAR UNITS IN ROLLING MILLS[1]

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Abstract
Pinion stand gearboxes are one of the main components in rolling mills. This paper discusses the main points which have to be taken into consideration for the design and production of these specific gear units. This analysis is based on years of experience as well as on the latest results in research. Furthermore this paper includes the choice of the right application factor and the necessary securities on tooth root break, pitting and scoring.
Key words: Gears; Gearboxes; Pinion.

PROJETO ESPECÍFICO DE CAIXA DE PINHÕES PARA LAMINADORES

Resumo
A caixa de pinhões é um dos componentes principais dos laminadores. Este trabalho discute os pontos principais que devem ser levados em consideração para o projeto e fabricação destes específicos redutores. Esta análise é baseada em anos de experiência bem como nos mais recentes resultados em pesquisa. Adicionalmente este trabalho inclui a escolha do fator de aplicação adequado e as seguranças necessárias para quebra na raiz do dente, fadiga e escoriação.
Palavras-chave: Engrenagens; Redutores; Caixa de pinhões.

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1 INTRODUCTION

The steel industry has had a long history of development, yet, despite all the time that has passed it still demonstrates all the sign of longevity. New ideas continue to revolutionise the steel-producing process today as much as they did a hundred years ago. The latest advances – making of “clean” steel, development of the continuous casting process for thin slabs and strip, introduction of the ingenious strip profile and shape control technologies in rolling mills – are only few examples that illustrate the great potential for further innovations and discoveries. It is no wonder that many scientists, specialized companies and engineers from different countries still find the steel industry an exiting field for implementation of their creativity.
As there is a large variety of drive systems for rolling mills and the demand on quality of the rolled products becomes more and more important it is indispensable to know more about the technical details of each drive solution.
In the following paper I will give a short impression of the main point of interest for pinion stand gears in hot rolling mills.

2 GEAR UNITS IN ROLLING MILLS

Figure 1. Pinion stands for horizontal roll shafts.[1]

Figura 2. Pinion stands for vertical roll shafts.[1]

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Table 1. Eisenbeiss Millmaster ®: Standardized program (compact solution, special development for heavy duty in rolling mills)[2]

			Centre distance output pinions [mm]																	
Gear size	Nominal-torque [kNm]	Nominal torque output pinions [kNm]	160	180	200	225	250	280	320	350	400	450	500	565	595	625	660	715	755	800	850
200	12	8	160	180	200																
250	22	15			200	225	250														
280	34	23					250	280													
320	51	34						280	320												
350	67	45							320	350											
400	100	67							320	350	400	450									
450	140	93								350	400	450	500								
500	194	129									400	450	500	565							
565	280	187										450	500	565	595						
595	325	217											500	565	595	625	660				
625	380	253												565	595	625	660				
660	450	300												565	595	625	660				
715	570	380													595	625	660	715	755		
755	660	440														625	660	715	755		
800	800	533															660	715	755	800	850
850	910	607																715	755	800	850

3 DEFINITION OF PARTICULAR REQUIREMENTS

3.1 Gears and Pinions

It becomes more important to have the maximum possible availability of the facilities. So the gears shall offer highest safety considering the quality of materials, tooth root brakes, appearance of pitting and wearing.
Fundamental influence factors on the safety against tooth root brake are frequent reversing load directions, continuous peak loads grinding notches. This kind of requisition should be covered by an appropriate service factor kA and respectively by a sufficient tooth root safety factor sF. According to the place of installation the service factor ranges from 1,25 (moderate shock loads and a few start-ups) to 2,25 (high shocks loads and many start-ups).

Table 2. Service factors according to Operation method[3]

Operation method of engine	Operation method of driven machine			
	uniform	moderate	medium	heavy
uniform	1,00	1,25	1,50	1,75
moderate	1,10	1,35	1,60	1,85
medium	1,25	1,50	1,75	2,00
heavy	1,50	1,75	2,00	2,25

In accordance with DIN 3990[3] the operation of engine has to be considered as follows:

- uniform: electric motor up to 3 start-ups per hour
- moderate: electric motor with 4 to 10 start-ups per hour
- medium: electric motor with 11 to 60 start-ups per hour
  multi-cylinder combustion engine

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- heavy: electric motor with 60 start-ups per hour

In rolling mill application heavy shocks have to be taken into consideration so the application factor is between 1,7 and 2,25.
Development of pitting is a question of continuous overcharge of contact areas. This is mostly caused by an inadequate contact pattern due to bending of shafts or weak grinding quality. Thanks to sophisticated calculation methods the bending of shafts can be considered in the grinding process in order to get a nearly 100% contact pattern under full-load condition. The precision of carburizing and grinding plays a mayor role in this matter as well.

3.2 Bearings

Providing a maximum possible operational availability it is essential to manage the balancing act of highest bearing lifetime and respectively highest safety without over sizing because of cost awareness. The risk of bearing failure should be covered through careful elaboration of bearing types and sizes, as well as high quality products.
Thanks to particular focus on the supply of clean lubricant to the bearings and a well directed evacuation of pollutants and abrasive wear a longer lifetime of the bearings can be achieved.

$L_{nm} = a_1\, a_{23}\, L_{10}$

L_{mn}	rating life, in million revolutions
L_{10}	rating life at 90% reliability, in million revolutions
a_1	life adjustment factor for reliability
a_{23}	life factor for lubrication conditions

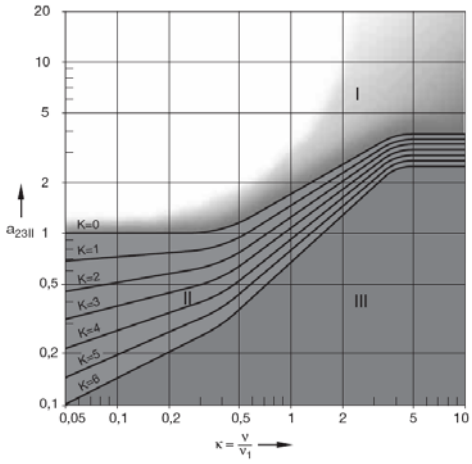

Figure 3. Bearing life time.[4]

3.3 Lubrication

The lubrication in gear units has two responsibilities – on the one hand the sufficient lubrication of gears and bearings and on the other hand the proper cooling on the internals. For the gears it is necessary to consider oil lines with multiple nozzles to ensure the distribution of the oil on the overall width of the gear.

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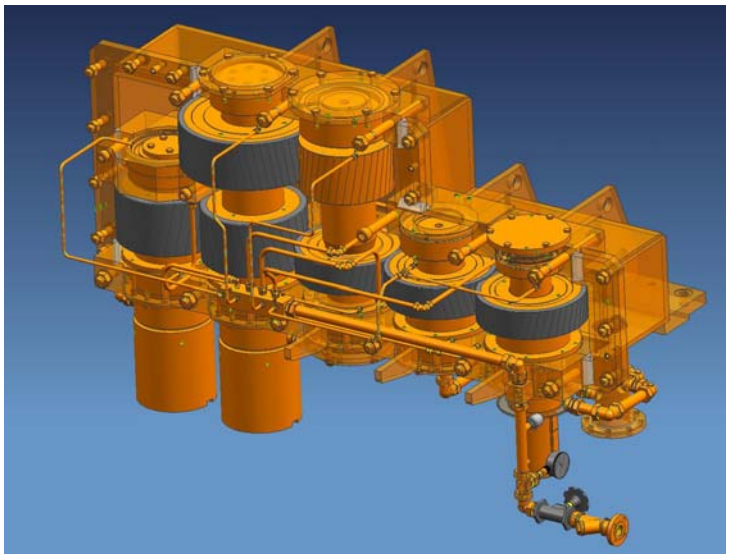

Figure 4. Lubrication system

3.4 Sealing

As the application conditions in rolling mills are challenging (cooling water, dust, heat …) a reliable sealing system with low maintenance efforts is requested. The usage of labyrinth seals has many advantages like absence of friction loss or abrasive wear which make them interesting especially in rolling mills. This kind of seal guarantees the protection of the gear oil and the rotating parts from cooling water as well as from any kind of dirt.

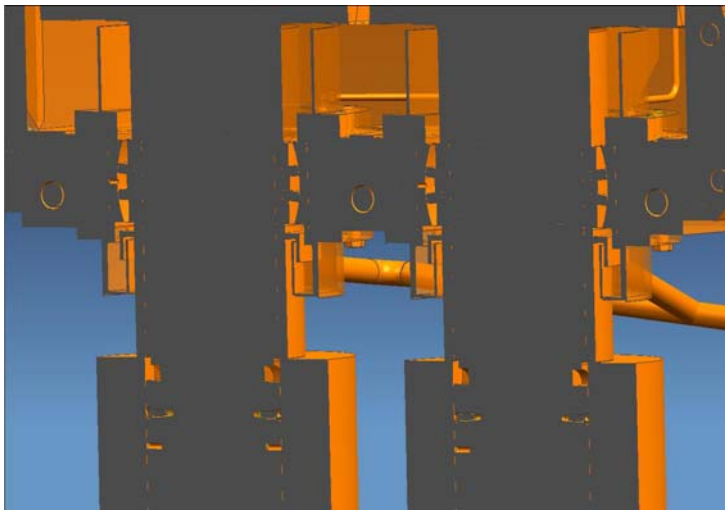

Figure 5. Sealing

4 CONCLUSIONS

We found out, that there is a large number of influencing factors which have to be taken into consideration during the engineering process for gear units in rolling mills. Therefore it is necessary to know the place of installation and whose ambient condition in order to choose the correct minimum and respectively proper safety factors in order to provide highest equipment availability and low maintenance cost.

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