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INCREASING PRODUCTIVITY AND ROLLING QUALITY THROUGH OPTIMIZED MILL WINDOW GEOMETRY[1]

Jochen Corts[2]

Abstract

For any kind of rolling process, the efficiency, productivity and overall rolling quality is directly dependent on the geometry and surface quality of rolls as well as the 3D-geometry of the mill window. Due to the complexity of the relevant mill components a structured and systematic auditing and 3D-survey of the components is the base. The holistic overview and decision making is only possible through a structured handling of all relevant information. The presented approach generates detailed knowledge about all relevant mill components as well as a detailed understanding of all relevant mill processes and the organizational structure. The presented techno-commercial mill transformation offers the significant optimization of total cost of ownership of any type of rolling mill, the clear increase of mill uptime, reliability, flexibility and consistent product quality. The target is to better align with any kind of market requirement. All collected information and data are available through an overall mill management, maintenance and operation system allowing the systematic performance and lifetime analysis for any relevant mill component. Based on reliable equipment, a far reaching mill management system and the focused organizational transformation it is possible to change from "learning by doing" to "doing what was learned".

Key words: Mill window condition; Process Stability; Productivity; Quality; Profitability

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2 Managing Director, CORTS Engineering GmbH, Industriestr.30 – D-42859 Remscheid (Germany)

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Introduction

During the past 2 years the conditions and requirements of the global steel market have changed significantly. We are facing radical cut-backs in market demand and in the north-western hemisphere as well as in the Americas a clear re-orientation form mass production to focused quality demand in smaller lots.
While the first significant consolidation wave in the steel industry was clearly driven by the visionary approach of Lakshmi N. Mittal, this consolidation was also driven by a demand and hunger for steel never seen before in history. As every surfer knows that the wave breaks, we know this volume driven market wave has definitely broken too.
Today the global steel industry shows the following characteristics:

- oldest assets and equipment is located where the markets are mostly mature
- the requirements of those mature markets changes from mass production to focused, on-time class (quality) production
- in Far East and Asia where the newest assets and equipment is installed the market will still be driven by mass production
- massive M&A investments formed new structures based on aged equipment (ArcelorMittal, Tata-Corus, Severstal, US-Steel to mention a few)
- despite the need for better quality there simply is no cash available for replacing this aged equipment, there is no business model behind the replacement and there is no financial appetite

Seen from today it even could look like everything after Mittal was already slightly too late for a simple “Me Too”-approach.

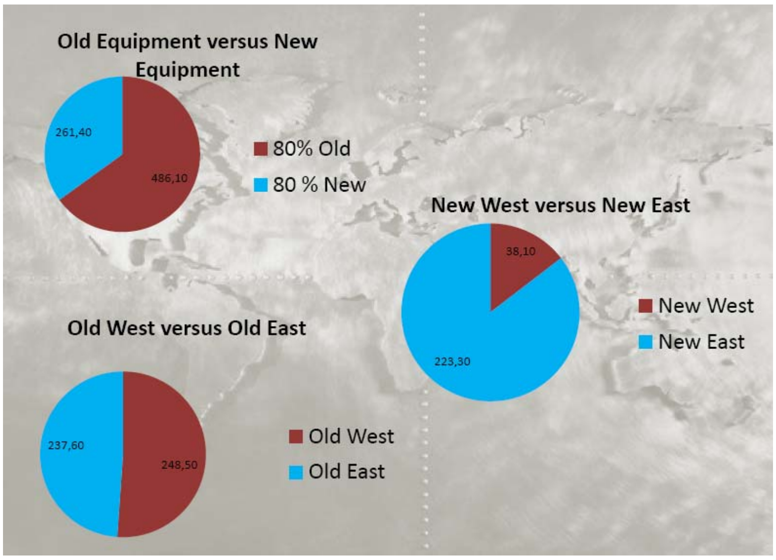

Figure 1. Global distribution of old and new rolling mills.

More than 60% of the global rolling equipment is older than 10-15 years while 50% of this aged equipment is installed in the West. But by far more relevant is that 80% of the new equipment is installed in Middle and Far East.[1]
Consolidation in the steel industry has to go on and will increase. But in the steel industry it will no longer be around quantity, consolidation will be around quality, flexibility and productivity.
So we are definitely facing a paradoxical situation. The biggest players in the most advanced markets spent their cash for “clunkers”. Most M&A money was spent for aged equipment which for the past 10 to 15 years was mostly maintained by quick,

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fire fighting fixes under strict budget limitations. And now as the markets change to focus on quality and the macro economical conditions dictate efficiency there is no cash to replace this aged equipment.

So our opinion: Why replacing what worked before if there is no significant techno-commercial advantage in new technology as is was for example for HYLSA and NUCOR when SMS came up with their really innovative CSP concept.

To make it simple: If you have an airline you have to fly. If you can't afford new planes get the old ones fixed, polished and up in the air…

A great point made in this regard by John P. Surma, CEO of US Steel:[(2)]

If you need a solution, look into the mirror,
not out of the window.

Our mirror is the market to be served by the valuable, installed, aged rolling equipment in the North-Western Hemisphere, the Americas and Australia:

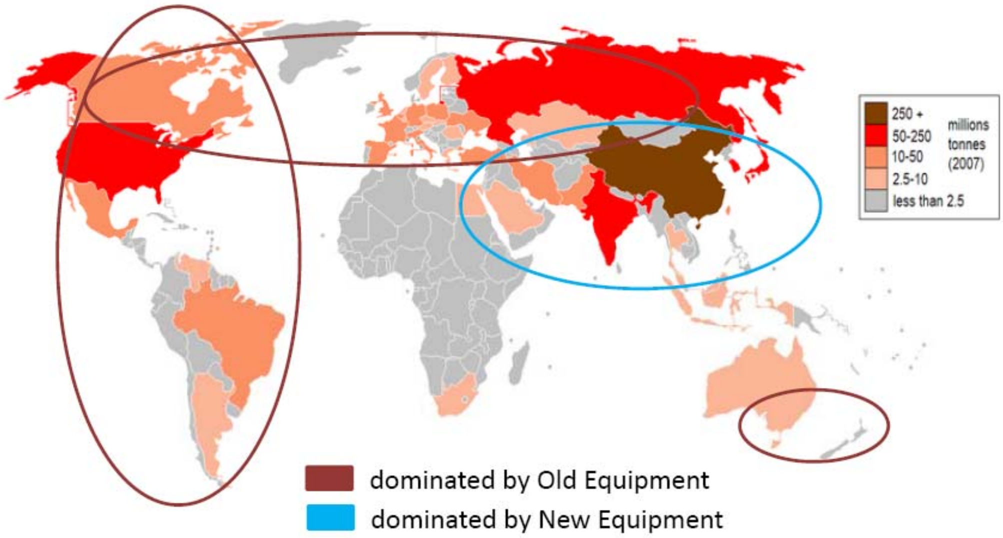

Figure 2. Global production capacity on old and new rolling mills.

That is why Brazil is interesting to focus on because Brazil has been stable enough to make the necessary investments to support its industrial base and avoided falling into a resource-extractive economic pit like many of its South American neighbors.

Market Requirements and Options

If we agree that the market conditions will change than we have to perfectly understand this change. The market is our mirror and we have to understand how we can react to the given and future market requirements.

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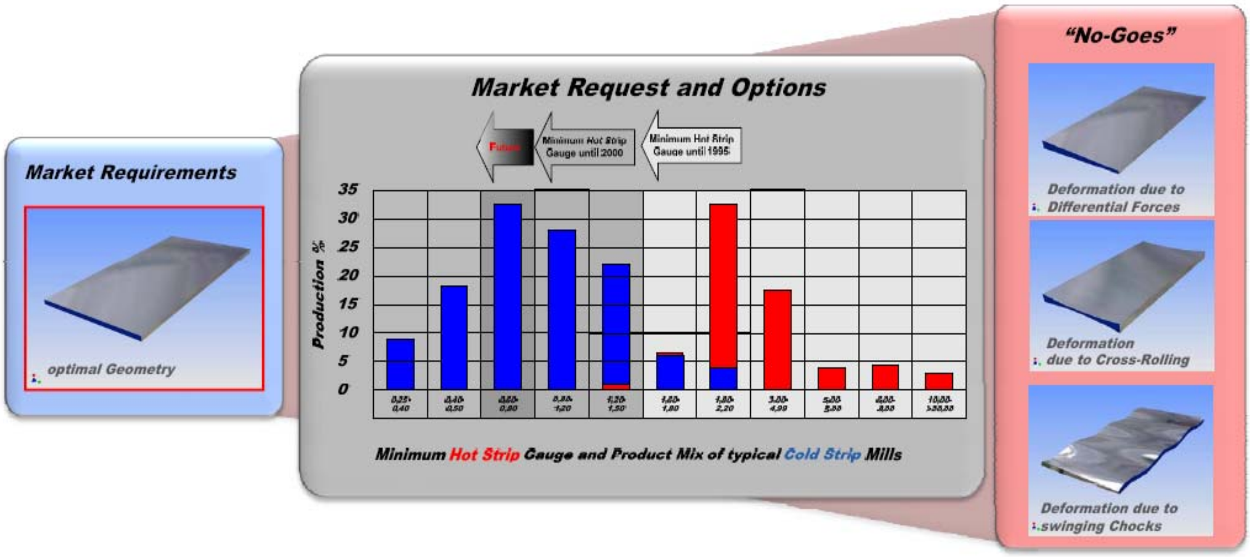

Figure 3. Market opportunities for hot strip and related quality requirements.

The requested quality level will increase while the price pressure will go up. The only way to react is to increase the reliability and efficiency of all related production processes.

We cannot allow extended mill configuration and set-up times. There is no room for trial and error, for unscheduled down-times and unforeseen mill stoppages due to inaccurate and inappropriate overall mill conditions.

Any rolling mill which wants to survive this market change has to be in a technical condition to roll highest quality, consistently and most efficiently. Otherwise the scrap price for the rolling equipment will outperform the commercial results "rolled out" with non appropriate equipment.

In the mature markets of the northern hemisphere, the Americas and Australia there is no room for quality "no-goes" any more. Low quality mass steel is produced and for the time being will be produced in Far East with the newest equipment on lowest cost level. That's what our market mirror face looks like.

Beside basic quality and efficiency requirements especially for hot strip mills there are interesting options. Any rolling mill which is technologically stable with streamlined processes and focused on organizational fitness has the chance to go into new fields like:

- thinner gages
- smaller lots
- special grades
- high strength grades

The markets are there and customers need innovative, flexible high quality suppliers.

Technical Requirements and Options

The rolling process is one of the most capital intensive and complex basic production processes in the industrial field. But when we have a short look to the very basics of the process it is astonishingly simple.

As long as the rolls as basic tools of this process are in place, there where the designers of the rolling equipment originally placed them, this process is stable, reliable and able to roll the quality expected.

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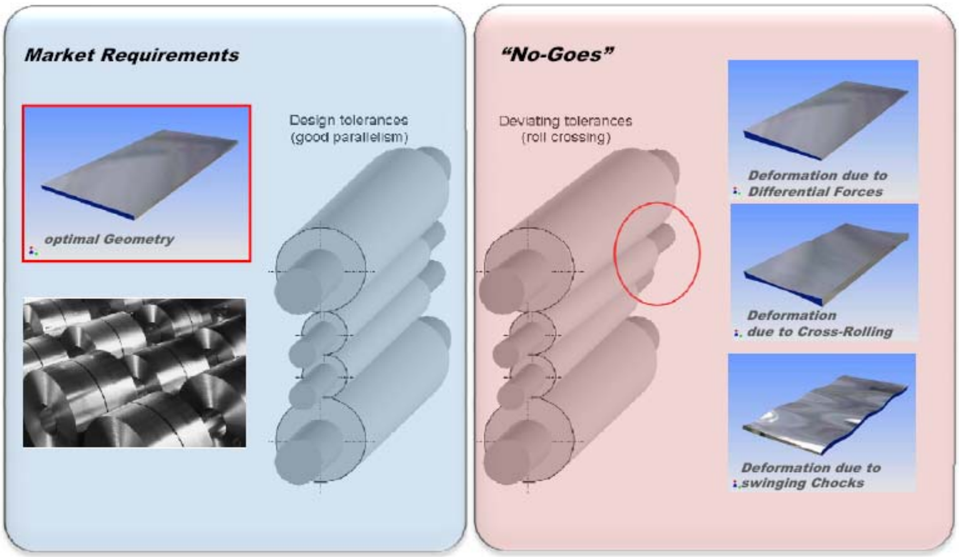

Figure 4. Technological background to fulfill market's quality requirements.

As suppliers for rolling mills are in this market for more than 60 years and in a way it is astonishing and sometimes scaring how easy decisions are made to treat this core of the business like a "greasy step child".
We have been deep enough in the heart of rolling mills to agree that this is not the most fancy place to be. An open heart operation is also not comparable to the body of its owner. But what is the situation of the owner with serious heart problems and do you really think those problems will get fixed the cheapest way possible

Commercial Requirements and Restrictions

A recent survey done by the consulting firm Accenture[3] has shown that 89% of executives agreed that innovation is as important as cost management. What is the given situation in steel?
Here most companies tried to cut down the budgets for necessary repairs and overall maintenance of their core production facilities down to the absolute minimum. A rolling mill is taken like an immortal given which has to run and not cause problems.

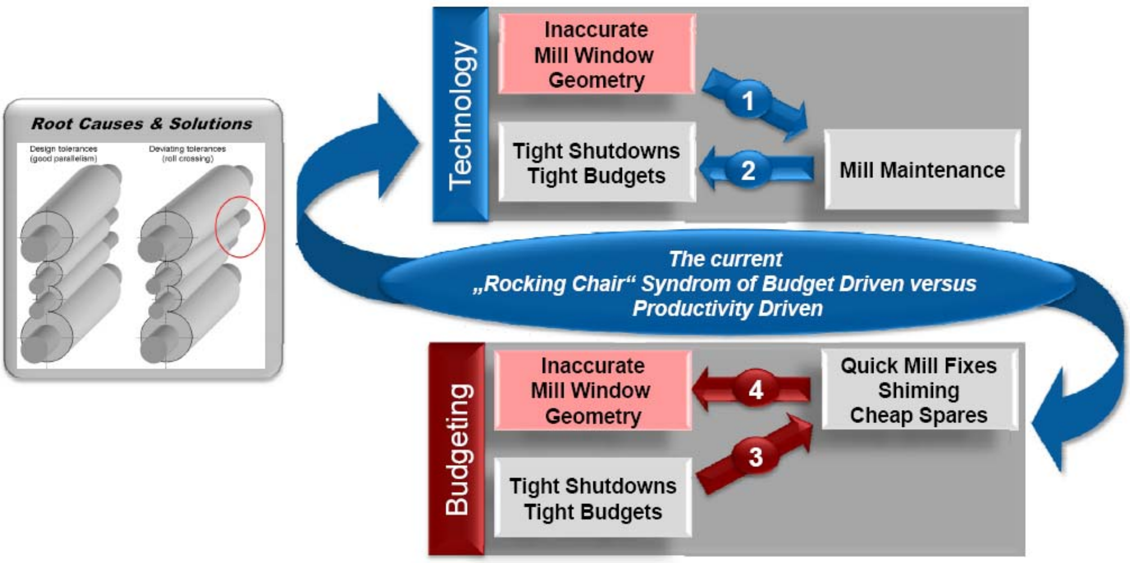

Figure 5. "Rocking Chair Syndrome" of budget limits against cost to guarantee productivity.

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This “Rocking Chair Syndrome”(4) may avoid the decision for innovation and the relate cost for this investment for a while. But is it realistic to expect that things get better on its own? From our point of view consequences are only postponed while the way back to reality gets longer and more expensive.
Over decades technical teams are fighting against commercial teams for basic spare parts, requested revamps and refurbishments. To get at least a bit, the overall system was split into pieces where basic needs can be covered with even smaller budgets. Through an internal “Battle for Funds” also Mill Maintenance and Roll shops were “fighting” against each other….

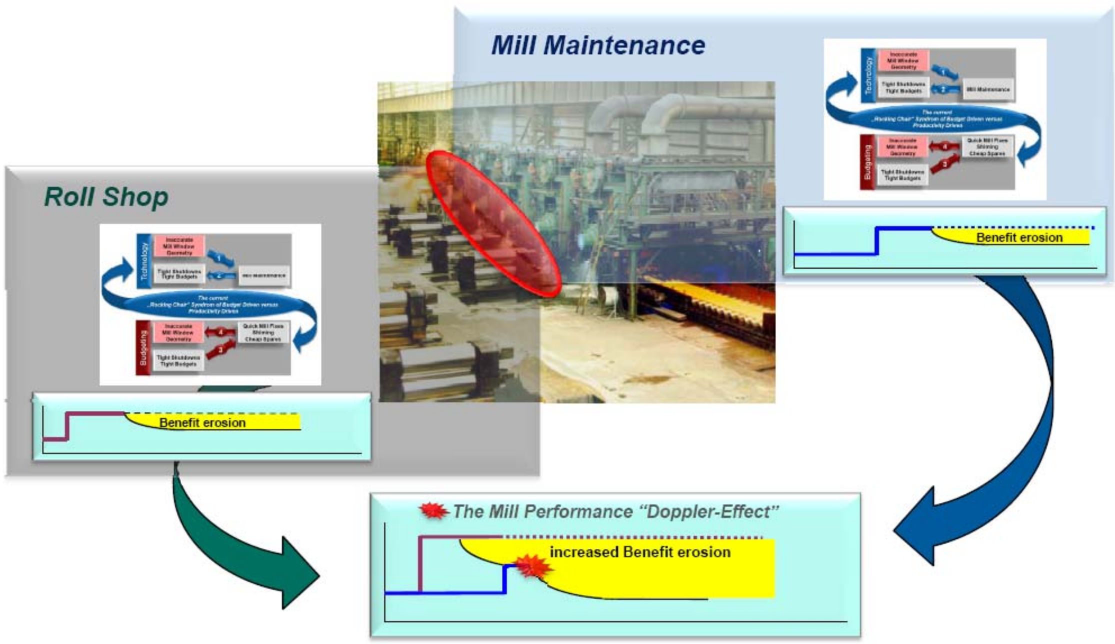

Figure 6. Conflict between mill maintenance and roll shops concerning maintenance budgets.

At the end this procedure only increased the complexity of the system with the consequence that any root cause analysis for quality issues, non reliable processes, system diversions is getting more and more complicate.

The Root Cause Analysis

In essence the root cause analysis is not as complicate as it seems. Going back to that very heart of any rolling mill, the drastic effects of local, short term cost cutting called “optimization” are more than obvious and the long term results are clearly showing the global non-sense which now is the effect.

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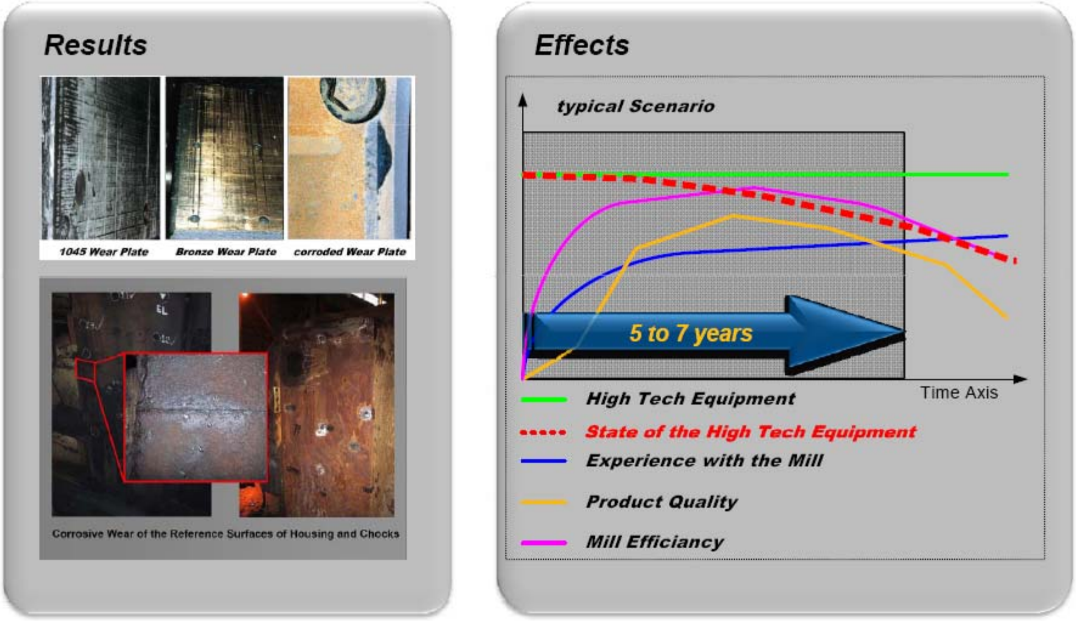

Figure 7. "Cause-and-Effect" of cost cutting in maintenance for housings and chocks.

Only because it takes longer that things are getting to the surface does not mean that things will not happen. A severe heart attack caused by clotted coronal arteries is not happening after one dinner with stuffed goose liver parfait and a good cigar – this happens from "optimized" good living over decades.

In our case cost cutting on basic spare parts and maintenance on equipment level was an easy and comfortable way to generate short term "cost optimization" and superficial "cost efficiency".

But if the basic equipment of a rolling mill is showing drastic, mechanical deviations from the state it was commissioned and if the performance of this mill is showing significant deviations from any new mill for a similar purpose it is most likely that this mill is out of the required specifications.

Under those conditions we have to re-think the given maintenance practice because as simple as it may sound, mill windows which are off tolerance are not the right base for quality rolling. And chock fleets which are not in perfect alignment with the designed roll axis are not reliable.

As consequence the behavior of a rolling mill is not predictable, the rolling process is not reliable. How can we expect a high quality, cost effective rolling product?

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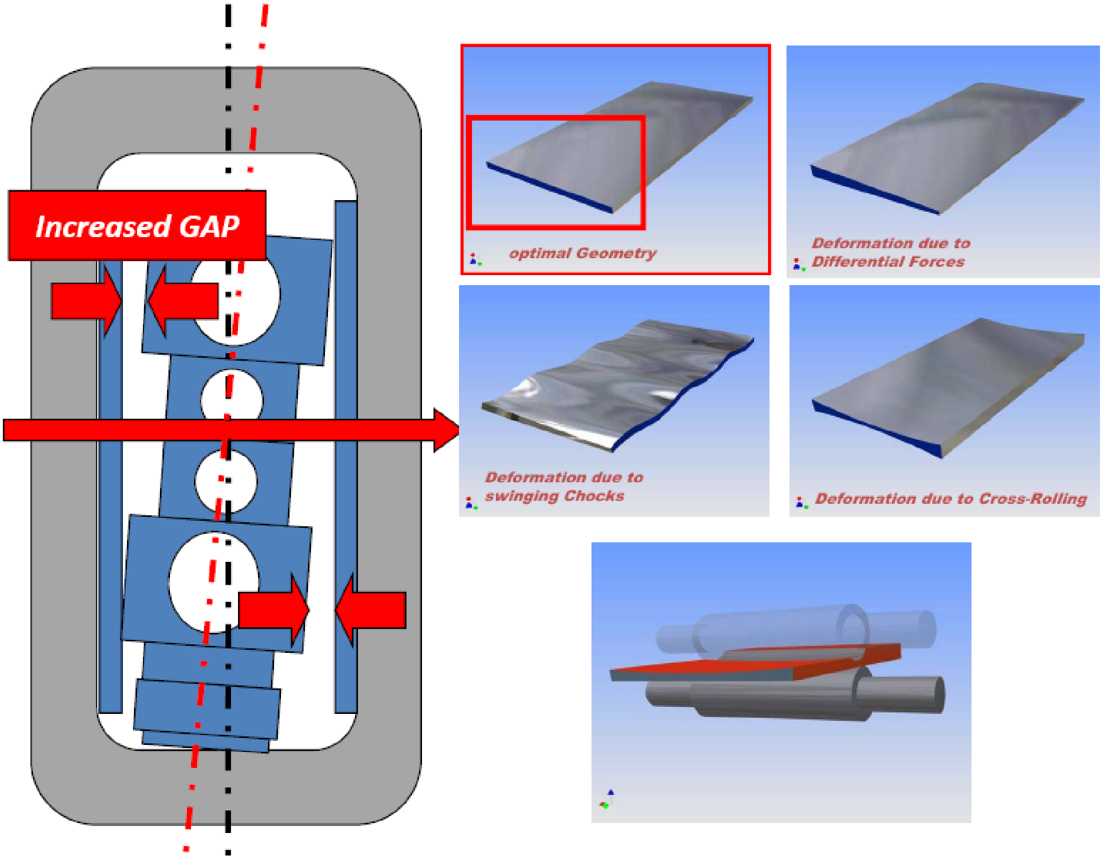

Figure 8. increased GAP - the root cause for problems in quality, mill reliability and diversions.

Rolling mills are simply not reliable if reference and bearing surface are at the upper limit of the defined tolerance fields of far beyond.

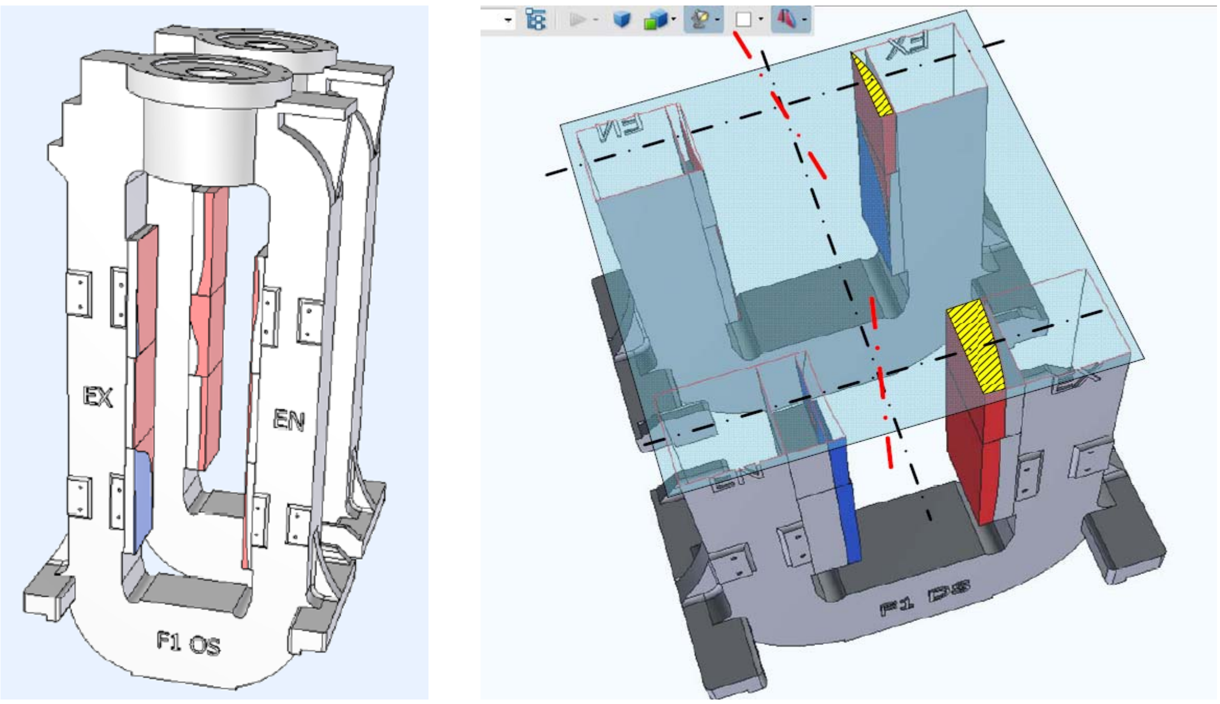

Figure 9. "The Whole Picture" – 3-D GAP-analysis and visualization of mill window conditions.

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The behavior of complex chock fleets, where nobody has a clear understanding of the detailed and precise geometrical conditions is simply not predictable.

Figure 10. Root Cause for Instability - reduced Maintenance + Care in complex Mill Systems

Holistic Solution

As stated at the beginning - if you have an airline you have to fly. If you can't afford new planes get the old ones fixed, polished and up in the air…

If you have a rolling you have to roll. If you can't meet the market requirements and it makes no sense to get a new mill, get the old one inspected, fixed, up and rolling quality steel products following the markets requirements.

One important characteristic of this holistic approach - it has to be a systematic one which starts with the basic mill analysis, the understanding of the given followed by the re-engineering and revamps which are necessary.

Figure 11. holistic Approach to understand, improve and stabilize complex Rolling Mill Systems.

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Based on this investment everything should be done to avoid the well known wear and tear results and effects for the future. So all touched areas should be equipped and optimized with state of the art technologies. That's how we understand mill upgrades and long term durability.

Figure 12. Transformation of Maintenance Cost into Profitability and long term Value

As good as any technical solution can be, the benefits will only be available if there is a *parallel* and *structured* approach and investment in:

- all relevant Mill Areas
- all involved People and Processes
- Monitoring, Control and Care

This can only be guaranteed if the overall mill system is analyzed in detail and the process improvements are delivered, extended and properly aligned across all related areas of the entire operation.

Techno-Commercial Mill Transformation

Over the past years we experienced that it is not done with a local investment in innovation. A rigorous approach for managing the innovation process is absolutely necessary to insure a long lasting and resilient outcome and result.
Our focus is on the technical part of the rolling mill and together with our customers we were able to collect convincing experiences with significant results. At the same time we are perfectly aware that sustainability can only be created if the necessary transformation is going through the entire organization.
To avoid that the transformation on shop floor level fails concerning the realization of the benefits this basic innovations could produce we are able to offer the holistic, techno-commercial mill transformation approaching innovation under three aspects:

- Technology
- Commercials
- Organization & Management

The following case studies are showing some examples from different fields of rolling steel.

Case Studies

Continuous 14-stand Hot Strip Mill – Date of Commissioning 1972

Situation: The last 3 finishing stands of this powerful continuous hot strip mill had been upgraded with MAE-West blocks for roll bending. This upgrade offered the ability of thinner gages and better crown control. After a successful re-start the consumption of tapered work-roll bearings constantly increased to a level of 45 to 50 bearings per year with all related shut-down times and cost.
Procedure: The audition and survey of the mill windows of those stands as well as the related chock fleet showed significant wear of all bearing surfaces as well as a severe deviation of the given geometry from the designed specifications.

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Through a basic revamp the mill window geometry of the housings was corrected. The chock fleet was not only brought back to the original specifications, the mill window gap was minimized to get the mill as tight as possible.
Additionally the base plates and load cell area was brought back to a perfectly perpendicular position.
Results: After the revamp the mill modulus of those these last three finishing stands increased significantly, the axial forces as well as the differential forces were reduced to an absolute minimum and the bearing consumption went down to zero for the third consecutive year after the revamp.

Continuous 14-stand Hot Strip Mill – Date of Commissioning 1972
Situation: The last 3 roughing stands of this powerful continuous hot strip mill were showing significant problems with axial forces and the clamping system for back-up and work rolls was severely damaged through this long term overloads on the entire key-system. Bolts with a diameter of 72 mm were simply sheared off even after repairs and temporary corrections by the extreme forces created during rolling.
Procedure: The audition and survey of the mill windows of those roughing stands as well as the related chock fleet showed significant wear of all bearing surfaces as well as a severe deviation of the given geometry from the designed specifications.
Through a basic revamp the mill window geometry of the housings was corrected. The chock fleet was not only brought back to the original specifications, the mill window gap was minimized to get the mill as tight as possible.
Additionally the base plates and load cell area was brought back to a perfectly perpendicular position.
Results: After the revamp of those these last three roughing stands the axial forces as well as the differential forces were reduced to an absolute minimum and the clamping system is working without any further problems. Not a single bolt is broken since the revamp. The rolling result of this roughing mill is stable and satisfying.

Continuous 7-stand Hot Strip Mill – Date of Commissioning 1966
Situation: The finishing line of this hot strip mill was showing significant problems with axial forces, bearing failures and unscheduled shutdowns. The overall mill availability was going down to 78%.
Procedure: The roll shop management decided for the audition and 3D-survey of the entire finishing mill chock fleet and was shocked by the results. The majority of the chocks was showing significant deviations from the specifications. The basic revamp of the chock fleet was decided and the chocks were equipped with our state of the art linear bearing plates.
Results: Immediately after the first 25-30% of the chocks had been revamped, the mill behavior stabilized. At the end of the project this stabilization was significant and obvious. As result the overall mill availability went up to 86% based on a annual production target of 4 million metric tons.

CSP Hot Strip Mill – Date of Commissioning 1992
Situation: This compact hot strip mill was showing significant instability and the overall mill modulus was not satisfying. The mill was equipped with hard surfaced housing liners and mild steel chock liners on back-up and work-roll chocks.
Procedure: The mill audition showed significant abrasive and corrosive wear of the bearing plates in the housings as well as on the entire chock fleet. Fortunately the mounting surfaces of the bearings plates in the mill window and on the chocks were still in good condition. The basic mill components were with the specifications.

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We replaced all existing bearing plates (wear plates) on housings and the entire back-up and work-roll chock fleet by our abrasion and corrosion resistant compound steel precision flat bearings and upgraded the entire mill window lubrication system.

Results: After the mill window bearing system had been completely changed, the overall coefficient of friction in all mill stands went drastically down and the mill modulus improved equivalently.

The rolling results improved significantly and the mill throughput could be increased step by step to a level that the management decided to talk to mill builder, to increase the slab thickness to be able to get the overall mill capacity up.

At the end the first two mill stands were upgraded to higher rolling forces and roll diameters and the mill capacity could be increased significantly on a very high level of rolling quality and reliability.

Heavy Section Mill – Date of Commissioning 1996

Situation: After the last revamp and upgrade this heavy section mill was showing instability and the product quality was not consistent any more. Heavy H-beams were not properly travelling through the mill and torsion was getting a problem.

Procedure: The detailed mill audit showed significant abrasive and corrosive wear of the bearing plates in the housings as well as on the entire chock fleet. The result of the 3D-survey of mill windows, housings to each other as well as the related chock fleet was significant wear on the mounting surfaces of the bearings plates in the mill window and on the chocks. The basic mill components were off the limit of the original specifications.

After our on-site milling of the entire mill window the geometry was corrected and long term protected against abrasion and corrosion with our compound steel bearing plates. The lubrication system was updated and as first step in the roll shop the chock fleet was rated as base of a more systematic combination and selection of chocks.

Results: As result of this first step the mill was stabilized and the deviations in product quality were eliminated. The next step will be the revamp of the chock fleet with the target of a correction and optimization of the overall mill window geometry and gap.

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