AUDITS OF EXISTING HYDRO MECHANICAL DESCALING SYSTEMS IN HOT ROLLING MILLS AS A METHOD TO ENHANCE PRODUCT QUALITY

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Abstract :

Over the life span of a rolling mill the requirements in terms of product quality and the range of steel grades may change significantly. In particular the capability of the installed hydro mechanical descaling systems needs to be investigated as one of the key technology area when it comes to process modifications and surface quality improvements. The introduction of modern strip surface inspection systems has intensified the focus on the optimisation of de-scaling systems, too.

A descaling system audit is a systematic and structured approach to determine how the existing nozzle and header arrangement, operational and maintenance practices and process data influence the surface quality. Typical audit contents are:

- Establishing and benchmarking existing operational and performance data to see where the de-scaling system stands with the existing equipment.
- Diagnosis of the cause of specific processing and equipment problems.
- Proposal and plan describing how to achieve the objectives and new specifications.
- Recommendations on how to implement installation, process, operational, and maintenance improvements.

The paper focuses on the auditing method and its structure. It also shows typical examples of simulations with the problem analysis of two actual system audits followed by some process results. The simulation model and the high impact nozzle measurement method is described as well

Also discussed is how the attentive design of descaling systems, through header arrangement, nozzle layout, nozzle selection can provide the rolling mill with the optimal parameters.

Data Collection and Benchmarking

The complex process of hydro mechanical descaling requires a thorough understanding of the process technology and the environment of a hot rolling mill. Tools such as computer simulation models, a standardized and complete check list (Fig. 1) for data collection and well developed audit procedures are essential for efficient project planning.

Establishing and benchmarking existing operational, performance and quality data is at the heart of the audit and provides the foundation from which recommendations can be made. A site survey can be performed and detailed information is collected to enable a computer aided analysis to be performed. The comprehensive information required for this analysis includes: Existing nozzle configuration with spray heights, nozzle pitches, spray impingement and offset angles. The existing nozzle types with spray angles and flow rates and the operation pressure are also import data to know. Without the dimensions of the product to be descaled and the speed an analysis can not be done. Information about rolling practices and both quality and operational problems completes the initial fact finding process.

Company

Responsible

Address

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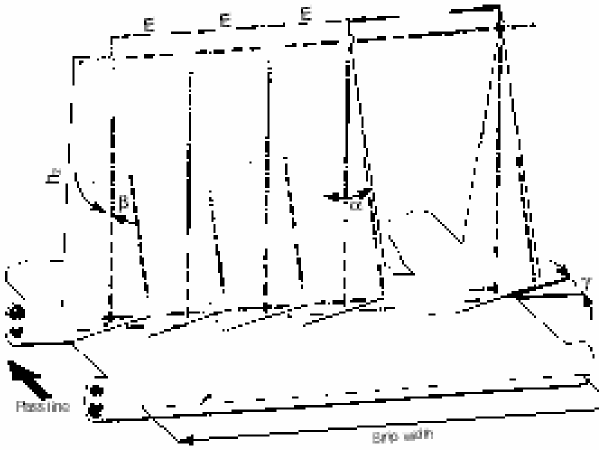

Questionnaire about existing Descaling Nozzle Arrangement

Name Date Department

Location of descaling installation: ☐ Behind the furnace ☐ RSB ☐ FSB ☐ interstand descaling

Format	**Dimensions [mm]**	**Nozzle Data**		
Strip			top	bottom
Slab		Number of headers		
Plate		Nozzle type		
Bloom		Horizontal distance (E)	mm	mm
Billet		Vertical spray height (h_2)	mm	mm
Rounds		Spray angle (α)	°	°
Material speed	m/s	Offset angle (γ)	°	°
Pressure at header	bar	Impingement angle (β)	°	°
Available max. water flow	l/min	Room for sketch:		
	l/h			

Figure 1 - Standardized check list to collect data of existing system

On Site Plant Survey

The initial step of a system audit, before the benchmarking takes place, is to obtain an accurate picture of the real situation by conducting an on site machine survey which includes:

- Physical measurements of existing nozzle positions, pitches and all spray heights of all headers on the mill during a stand still.
- Verification of the nozzles alignment.
- Verification of the maximum available water flows and pressures of every descaling location.
- Investigation of filtration
- Investigation of header pipe dimensions and header water velocities.
- Investigation of internal and external header design with regard to location and number of feed pipes
- Investigation of water hammers

In most cases experience has shown that any existing documented data is not usually reliable since changes and modifications may have been made over the life span of a machine. These changes have often been made without updating the documentation.
Observation of events, unexpected behaviour, minutes from interviews and meetings as well as digital photographic recordings are also a part of the on site survey as shown in Figure 2 showing a descaling header with poorly aligned nozzles.

Figure 2 - Descaling header with poorly aligned nozzles

Off Site Analysis

The next step of the audit is to analyse and further verify the collected data, an action that is performed off site.

Water flows together with their related pressures are always the centre of focus. If documented and measured data contradicts, then potential error sources are identified by specific calculations. These include pressure drops, location of bottlenecks caused by too low accumulator capacities or additional fittings and incorrect pump characteristic curves.

If no data of the existing nozzles from previous measurements are available in the data base of the computer model, than nozzle samples are collected and tested in the laboratory on an impact test bench under identical conditions in terms of vertical spray height and pressure (Fig. 3).

Impact Measurement

The method for measuring the impact force is based on a resistance strain gauge (force transducer) using a transducer that can take force values from every position in the spray.
When performing a measurement the force transducer moves under the spray. The spray is scanned as shown in Figure 4 along the scan path. When starting on the forward left side of the spray the transducer moves along the depth of the spray (Y-axis). At the back side of the spray the transducer stops and moves one sensor width along the width of the spray in X-axis.

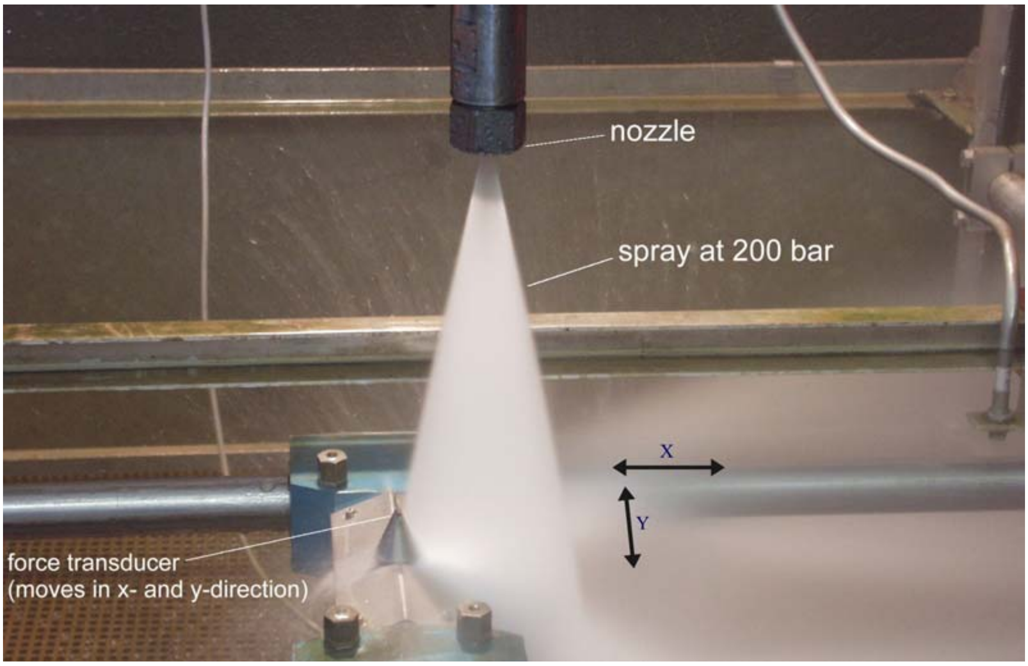

Figure 3 - Test bench to perform impact measurements

The transducer now moves back again through the spray to the forward side. Arriving there this movement of the transducer is repeated until the transducer reaches the end of the spray at the opposite side. During the movements along the depth of the spray in Y-axis the impact force on the transducer is measured continuously and transmitted to the computer.

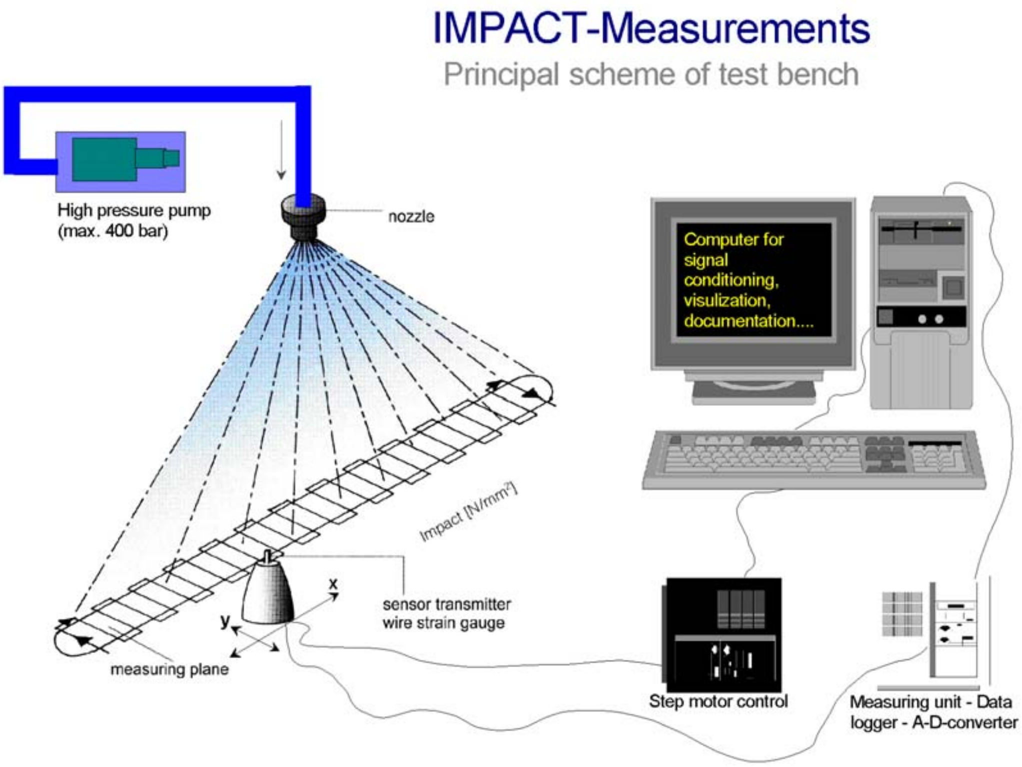

Figure 4 - Set-up of descaling nozzle in test bench for impact measurement.

When analyzing the impact measurements illustrated in Figure 5 one can find that it is necessary to create mathematical functions that describe dependencies of spray angle, spray form and spray depth on pressure, flow rate, nozzle type and some other parameters.

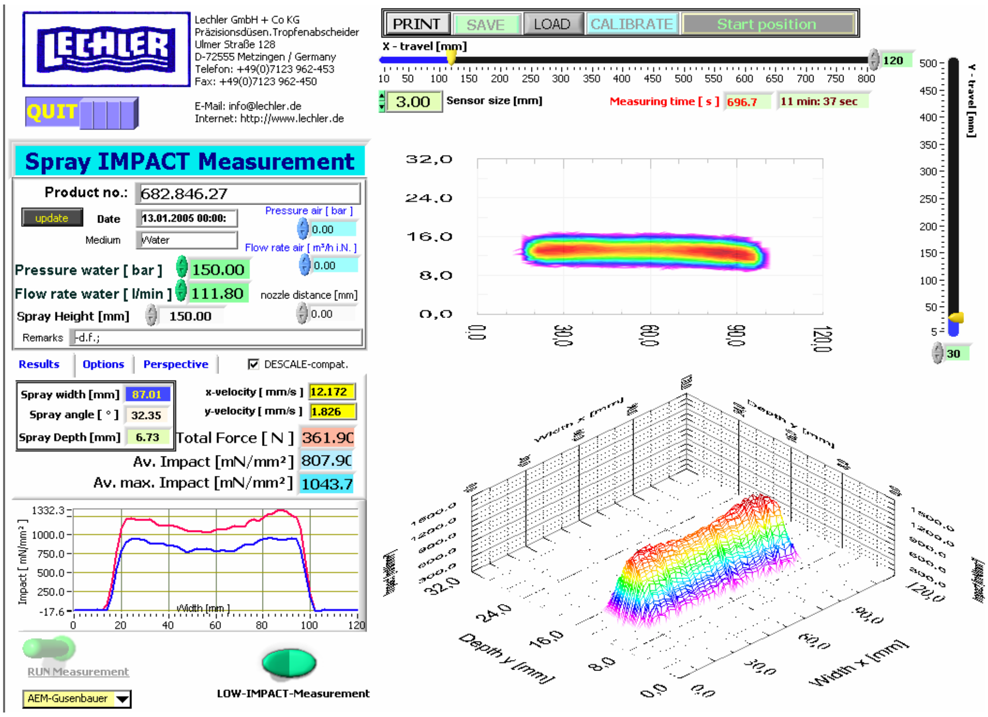

Figure 5 - Documented impact measurement of a descaling nozzle

The utilization of the measured values as a basis for the mathematical functions makes it possible to simulate the impact and spray form of any descaling nozzle at any pressure, flow rate or height with a special computer program called Lechler “DESCALE”.
This analysis based on actual measurements ensures that the computer simulation models give a true representation of the actual descaling system.

Diagnosing Problems

A key to the success and quality of a system audit and the subsequent proposal for improvements is the investigation of the problem areas through benchmarking. Here the input of the operators, the maintenance personnel together with the investigation of metallurgical quality and defects is required.
The benchmarking, in form of a detailed computer analysis of the system performance which is normally performed to identify problems areas and distinguish between defects connected with the existing nozzle layout and header arrangement or those caused by other effects of the system utilities and the overall process.

Typical Examples of Problem Diagnosis

For a uniform descaling over the entire width of the rolled product it is essential to secure also a uniform impact of all jets spraying in one row. The nozzle spacing with the pitches between them is not only directly related to the spray height and spray angle, but also to the overlap of two adjacent spray jets. As illustrated in Figure 5 every descaling nozzle shows a certain unavoidable drop of the impact at both edges of the spray jet. The characteristic of this “Edge Drop” depends mainly on the spray angle, whereas the wider the spray angle the larger the

width of the edge drop. The nozzle manufacturer should maintain one edge drop characteristic throughout all nozzle sizes belonging to one spray angle family.
The width of the overlap of two adjacent spray jets must be equal to the width of the edge drop. Nozzles of different manufacturers, however also show different edge drops with either sharper or softer characteristics. Consequently it is important to define the edge drop for every nozzle respectively nozzle family allowing the header designer to work with this data.
Undescaled stripes on the surface can be caused by excessive overlap. In such a case the spray jet of the nozzle sitting further behind the adjacent one creates a water layer on the surface which reduces the impact in the overlap area drastically (Fig. 6).

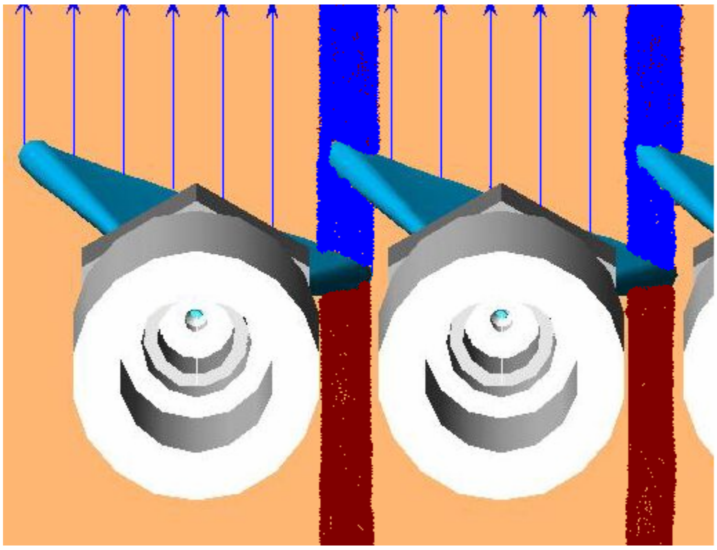

Figure 6 - Water layer effect caused by overlap being too big

This phenomenon can be seen quite often and is shown in Figure 7. No imprint on the lead plate of the front spray jet is visible caused by this effect. In this case the inclination angle was also too big. Undescaled stripes remaining on the surface is the result of such a poor nozzle layout.

Figure 7 - No imprint on lead plate in the excessive overlap area

This situation was confirmed by the result of the computer simulation as shown in Figure 8.

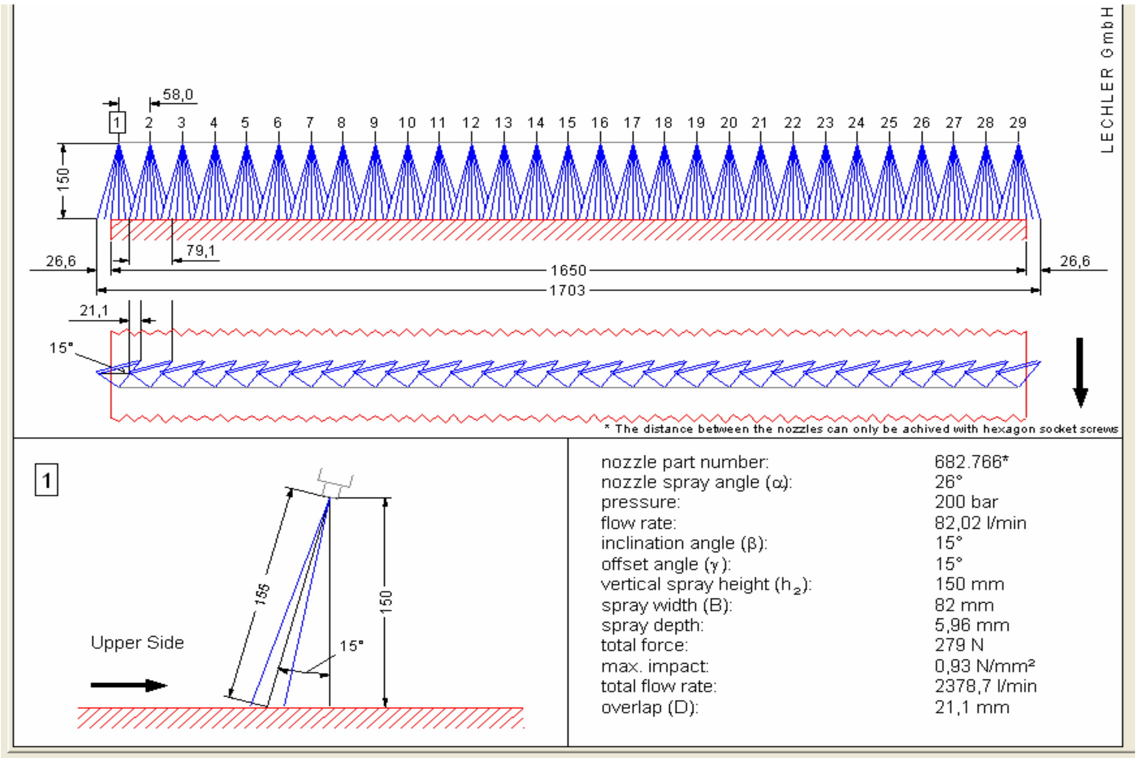

Figure 8 - Example of computer simulation with Lechler "DESCALE" program of existing situation with excessive overlap between adjacent sprays

The nozzle offset angle of 15° against the centre axis of the header pipe is already built into the nozzle tips. This feature prevents that spray jets of one row collide with each other.

If the overlap is too small or if there is a gap where no water impinges directly on the surface, stripes (Fig. 9) of remaining scale will eventually lead to rolled in scale which matches the computer simulation shown in Figure 10.

Figure 9 - Undescaled striping patterns on the surface due to non sufficient spray overlaps

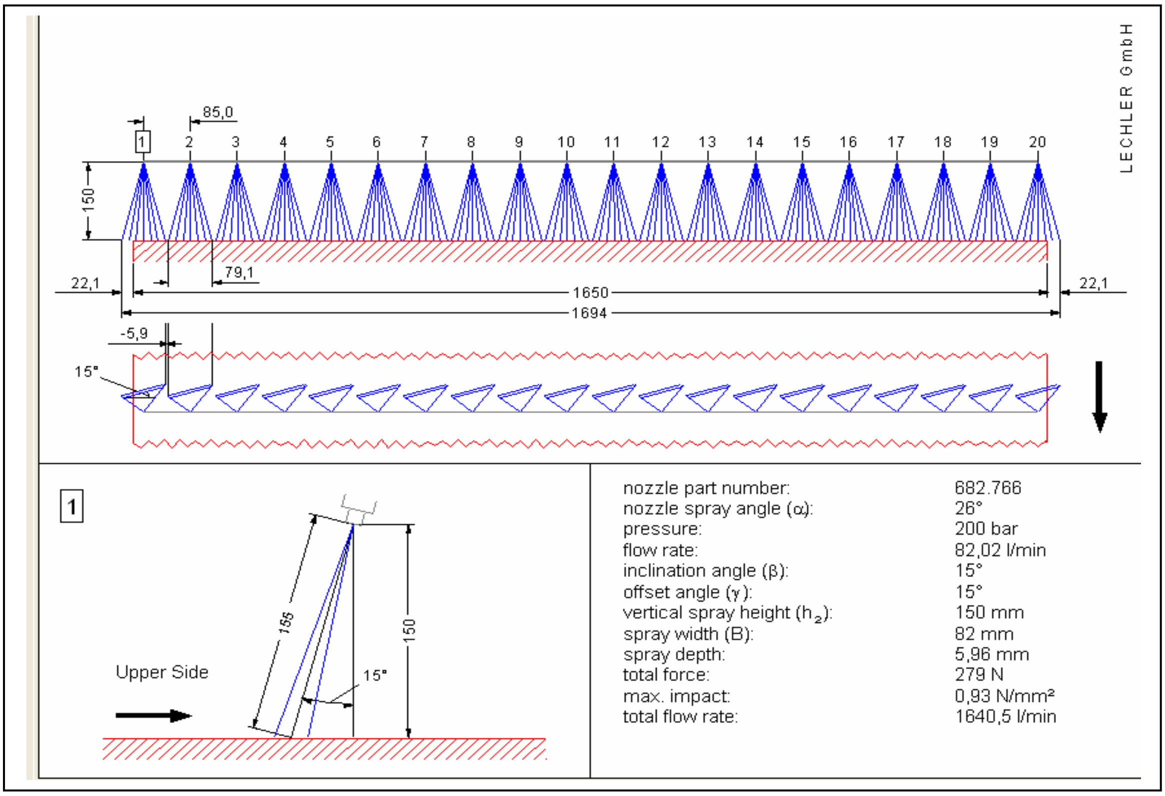

Figure 10 - Example of computer simulation with Lechler "DESCALE" program of existing situation with no overlap between adjacent sprays

The problem of excessive external nozzle wear (Fig. 11) can often be found in older rolling mills when the top and bottom headers are positioned very closely above each other. In such a case the sprays of on header impact on the opposite nozzles and retainer nuts within the short time before and after the rolled product is being descaled.

Figure 11 - Externally worn descaling nozzle tip caused by opposite header

Setting the Objectives for a Revamp

There can be a number of reasons for conducting a detailed descaling system audit. The most common are:

- Identify product quality defects and to eliminate them.
- Improve descaling performance by increasing the impact.
- Improve maintenance friendliness and reduce costs.
- Reduce water flow and hence temperature loss of rolled product.
- Change of product formats and steel grades (product mix).

In most cases it is a combination of all five reasons that determines the objectives for a revamp of the descaling system. It is important that these objectives are clearly defined so as to provide the audit party with a clear focus when preparing the final system audit report and subsequently, the feasibility study for the revamp.

Providing Solutions

Using the previous analysis and the benchmarking as a basis, modifications to the descaling system are proposed. These modifications are aimed at an economical and operable solution with the objective of achieving the new requirements; again computer analysis is applied to ensure the integrity of the modifications. If necessary the proposal can include modifications to the overall system configuration and parameters, the header design and the nozzle layout.

When analysing the existing situation by means actual impact measurements of the nozzles collected at site and with the aid of the DESCALE simulation model the focus is always on the impact and the impact energy of the spray. Benchmarking of the values achieved with the present system allows then a comparison with typical values obtained in similar modern plants, with best industry practices respectively with values established and published of research projects.

The Lechler DESCALE simulation model has proved to be an ideal tool providing the optimal nozzle layout and header configuration to obtain the objectives set for the system audit. It is also the most common software applied by most of the plant and system builders in the industry to design descaling systems.

Proposal and Plan

A comprehensive report is produced and submitted for further discussions and the derivation of an action plan. The report includes:

- Conclusions on existing system conditions.
- Recommendations and observations with regard to the new objectives, together with proposals on the following areas:
  - Header configuration and design.
  - Nozzle layout and arrangements.
  - Water flow rates and pressures.
  - Supply pipe work.
  - Pump and accumulator capacities.
  - Mechanical header and nozzle protection.
  - Filtration
  - Material specification in case of chemical attack

- Conclusions and recommendations on operational and maintenance practices.
- All vital descaling system utilities.

Nozzle Layout

A good nozzle layout is paramount in fulfilling the operational and production requirements of the descaling system. In designing a nozzle layout, it is not only important to consider the specify requirements of the rolling mill but also the behaviour of the nozzles under operational conditions, the mechanical mill design and the roller table configuration. It is essential that nozzle layout produce an even impact distribution across the entire product width.

Plant References

After the Scalemaster descaling nozzle program was introduced in 1992 Lechler has developed and successfully installed new nozzle generations such as the MiniScalemaster, the Scalemaster HP (High Performance) and the MicroScalemaster nozzles. The wide range of nozzles available for each application together with the DESCALE simulation software and the complete program of mounting and maintenance accessories and the experience of more than 50 years in the field descaling, Lechler has been recognized as technology partner in the industry who can bring improvements to a rolling mill with relatively small investments. A large number of rolling mills have benefited from these services around the world including ARCELOR, CORUS, TKS, Mittal Steel, SSAB, POSCO, NUCOR and RIVA to name only a few.

A typical example was the mill audits and the subsequent descaling system revamps performed at the Thyssen Krupp Stahl (TKS) wide hot strip mill in Bochum / Germany.
Between 1992 and 1999 continuous modernisation measures have been carried out on the roughing and finishing descaling systems (Fig. 12). The objective was to increase the impact and hence the descaling efficiency by increasing the impact without changing the water pressure and total system water flow.

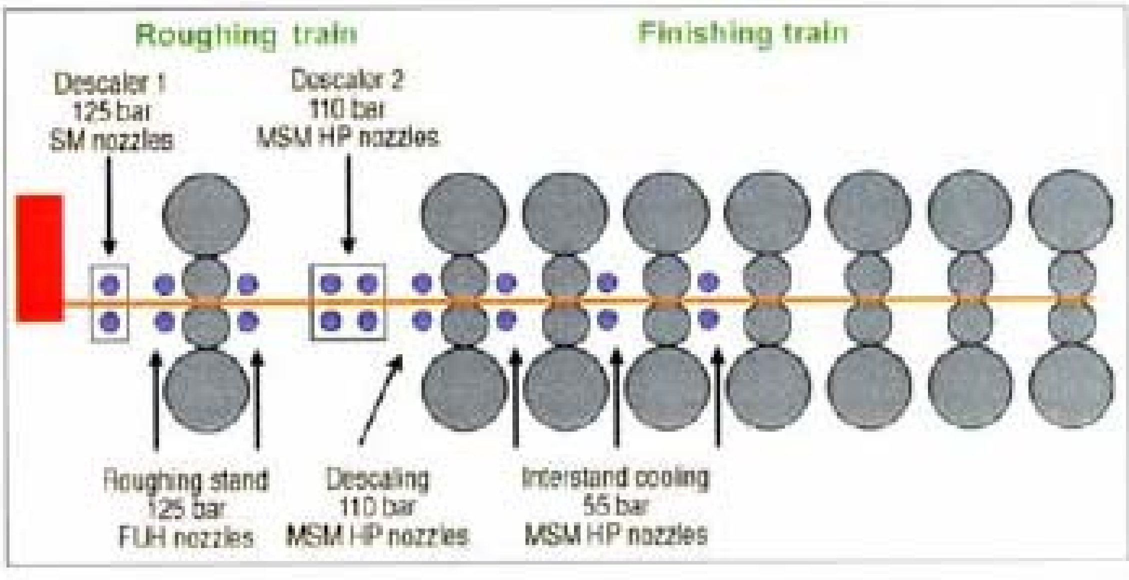

Figure 12 - TKS Bochum wide hot strip mill descaling system overview

Table 1 compares the nozzle layout, header arrangements and the operation parameters during the various modernisation stages. Simply by changing the nozzle type and the vertical spray height it was possible to increase the impact by approximately 35% in the roughing mill descaler and 60% in the descaler in front of the finishing mill.

Descaler 1: Roughing mill Year	1997		1998	
Spray bar top/bottom	Top	Bottom	Top	Bottom
Nozzle type	FUH 666.906.12	FUH 666.887.12	Scalemaster 694.906.27	Scalemaster 694.887.27
Number of headers	1	1	1	1
Number of nozzles per header	30	30	30	30
Flow rate [l/min]	139.75	139.75	139.75	139.75
Spray pressure [bar]	125	125	125	125
Nozzle angle [°]	16	16	16	16
Distance nozzle/strip (index 1997 = 100)	100	100	100	100
Impact (index 1997 = 100)	100	100	133	138
Descaler 2: Finishing mill Year	1992	1993	1998	1999
Nozzle type	FUH4 666.806.12	Scalemaster 694.806.27	Mini Scalemaster 644.807.27 (with adapter)	Mini Scalemaster HP 642.807.27 (with adapter)
Number of headers	2 top / 2 bottom	2 top / 2 bottom	2 top / 2 bottom	2 top / 2 bottom
Number of nozzles per header	24	24	24	24
Flow rate [l/min]	72	72	72	72
Spray pressure [bar]	110	110	110	110
Nozzle angle [°]	15	15	15	15
Distance nozzle / strip (index 1992 = 100)	Top: 100; Bottom: 100	Top: 100; Bottom: 100	Top: 84; Bottom: 90	Top 84; Bottom: 90
Impact (index 1992 = 100)	100	130	145	160

Table 1 - TKS Bochum wide hot strip mill descaling system modernisation steps

As a result the downgrading of hot strip due to rolled in scale was reduced by a total of 55% thanks to the results of the mill audit and the inexpensive revamp (Fig. 13).

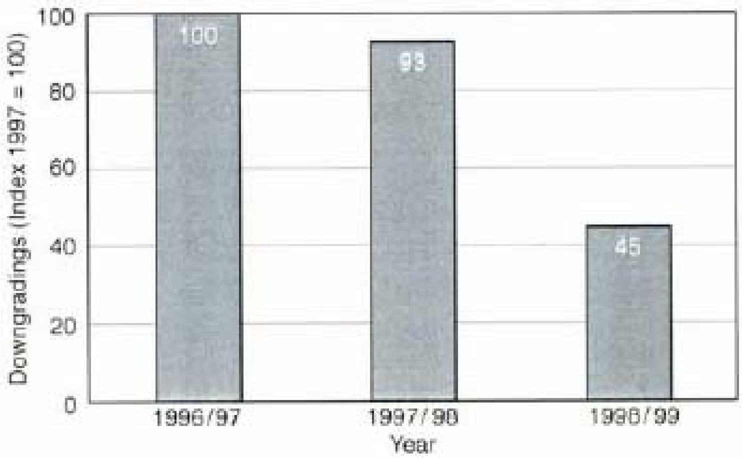

Figure 13 - Development of strip downgradings in TKS Bochum due to rolled in scale

Conclusion

An audit as described and the subsequent feasibility study deliver a wide range of benefits by determining the improvements that can be obtained by an upgraded descaling system with improved operation and maintenance practices. The thoroughly documented final report, containing collected and analysed data and a proposal for future improvements through a system upgrade, forms a comprehensive and indispensable tool for decision making and comparison with other plants. An audit also identifies problems and causes which were previously not recognised. The time, efforts and cost of such work is insignificant in comparison with the potential benefits of a properly executed audit which results in an optimised descaling system.

References :

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