Energy saving and process optimization in a conventional hot strip mill by application of the latest high-efficient descaling technology

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ABSTRACT:

The paper describes the converting to a new generation of descaling nozzles in a conventional hot strip mill for steel. There are descaling stations behind the reheating furnace, on the roughing mill stands and in front of the finishing mill. Before the converting, there had been three high pressure pumps in operation to supply the descaling stations. The new descaling nozzles had been tested first in the finishing mill descaler with good results. There were considerable water savings without compromising the descaling effect and the material surface quality. After a successful test, the remaining descaling stations had been converted accordingly. The overall water savings was approx. 20%, which allowed shutting off one of the three high-pressure pumps. Electrical energy saving amounts to 9,300,000***** kWh/ year. At the current energy costs this is equivalent to 2,100,000 TL / 641,700 EUR******. Additional advantages are seen such as reduced material cooling and the lower wear of the components of the whole high-pressure water hydraulic system.

***** :Daily saving of 30,000 kWh. One year is considered as 310 days.
Data acquired by an energy analyzer at site.
******: Earnings calculated using the cost of electricity as 0.069 Euro / kWh.

Key words: Hot strip mill, hydraulic descaling, centrifugal pumps, high-pressure nozzles, flow stabilizer, nozzle foot print, impact, spray thickness, descaling efficiency, furnace descaler, roughing mill descaler, finishing mill descaler, pressure, flow rate, energy saving, water savings, reduced load and wear of equipment, cost of electricity.

INTRODUCTION

The Hot Strip Mill of Çolakoğlu Metalurji was commissioned in 2010 by SMS Siemag. The mill consists mainly of a single-stand reversing roughing mill with edger, a coil box and a 7-stand finishing mill – see fig.1. Multiple steel grades ranging from HSLA, ultra low carbon, API to conventional steel grades within a thickness range of 1.2-25.4 mm and strip width of 800 to 1,650 mm are being rolled. The mill is designed for a production of 3 Mio t/ year.

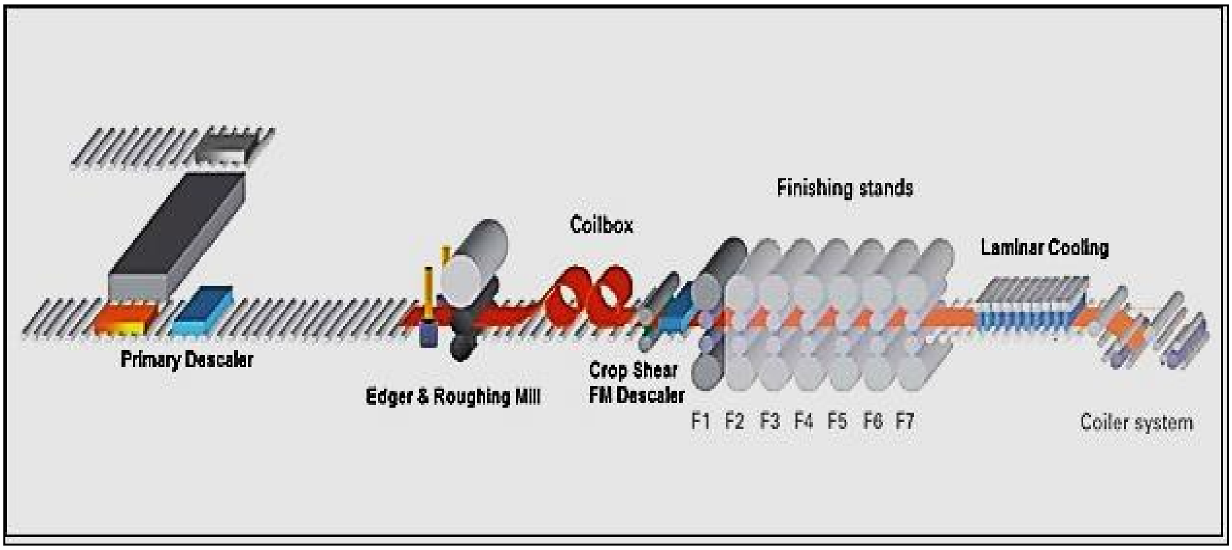

Figure 1 – Process flow diagram of hot strip mill

ENERGY SAVING PROGRAM IN ÇOLAKOĞLU METALURJI

With the increasing competitiveness in the steel market, Colakoglu Metalurji decided that in order to sustain within the market the cost of energy which is the biggest item of the expenditures shall be decreased. And they launched an energy saving program throughout the factories of the plant. Descaling is one of the main energy consumers in the HSM with around 37.000.000 kWh/year with a cost of around 2.550.000 EUR/year. The electrical energy consumption of the descaling pumps is around 15% of the total electrical energy consumption of the mill including the auxiliary facilities. It was a good spot to start with the descaling nozzle conversion, which is one of the biggest energy saving studies in this department along with several others.

HIGH-PRESSURE SUPPLY MACHINE DETAILS

The HSM has 3 running + 1 standby centrifugal descaling pumps having the following data for each of the pumps.

Motor power	: 2,600 kW
Flow	: 250 m^3/h – 69.4 l/s
Discharge pressure	: 245 bar
Suction pressure	: 6 bar
Descaling headers	: Primary zone 2 sets, RM entry & Exit 2 sets + counter descaling, FM box 2 sets (*1 set : top + bottom header)*
Accumulators	: 2 units with a capacity of 10 m^3 each. (One is filled 100% with pressurized air)

DESCALING FLOW DATA BEFORE CONVERSION

Primary Descaler : 240 m³/h (each set)
RM Descaler : 299 m³/h (each set)
FM Descaler : 220 m³/h (each set)
Above data is acquired while the accumulator is shut off.

THEORETICAL CALCULATIONS AND THE VISION FOR SHUTTING OFF ONE PUMP

Since the commissioning of the mill, descaling nozzles type Scalemaster had been installed with good operational results in terms of product surface quality. Nozzle arrangements including spray heights and overlaps were considered to be up to date, as the mill design was fairly new. It was decided to replace the existing descaling nozzles with the newest generation called Scalemaster HP Superior® see fig. 2, which provide a higher efficiency while maintaining the existing spray heights, spray angles and overlaps. The target was to keep the same impact values and at the same time to reduce the flow by using smaller capacity nozzle types.

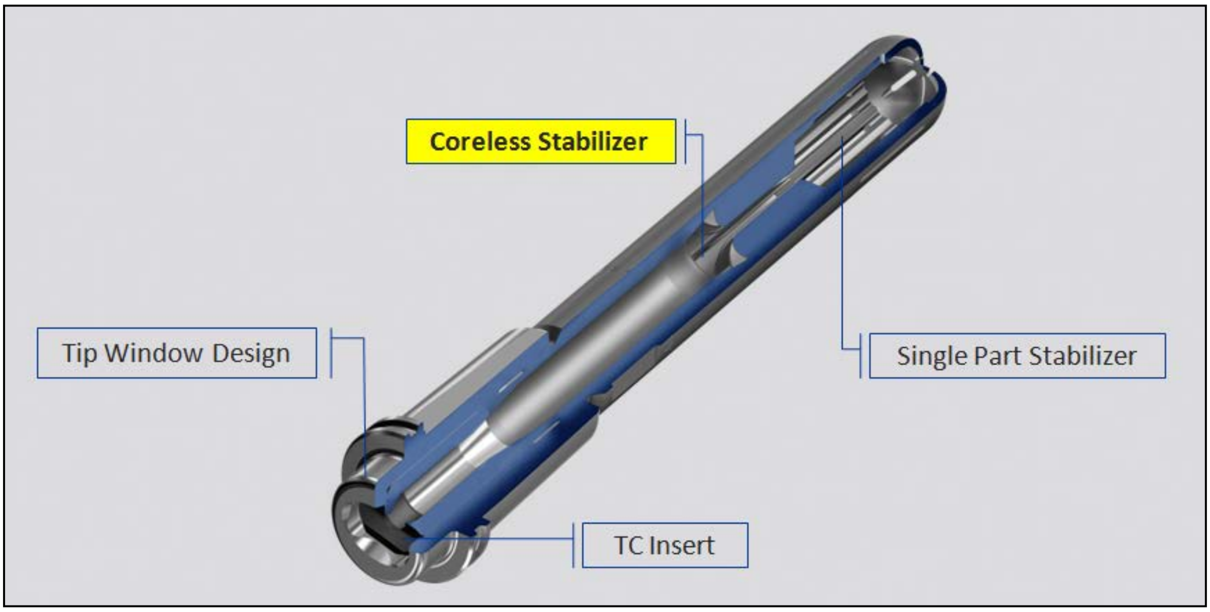

Figure 2 – New descaling nozzle assembly type Scalemaster HP Superior®

At first, theoretical calculations were made using simulation software for the existing and for the new type of nozzles of the Primary Descaler.
At an operation pressure of 190 bar, the flow per header was 1,935 l/min at an average maximum impact of 0.77 N/mm², and the overlap, at the spray height of 142 mm was 26.4 mm, see fig. 3.
Next, a simulation was done at the same boundary conditions, but with the utilization of the new nozzle type, see fig. 4.

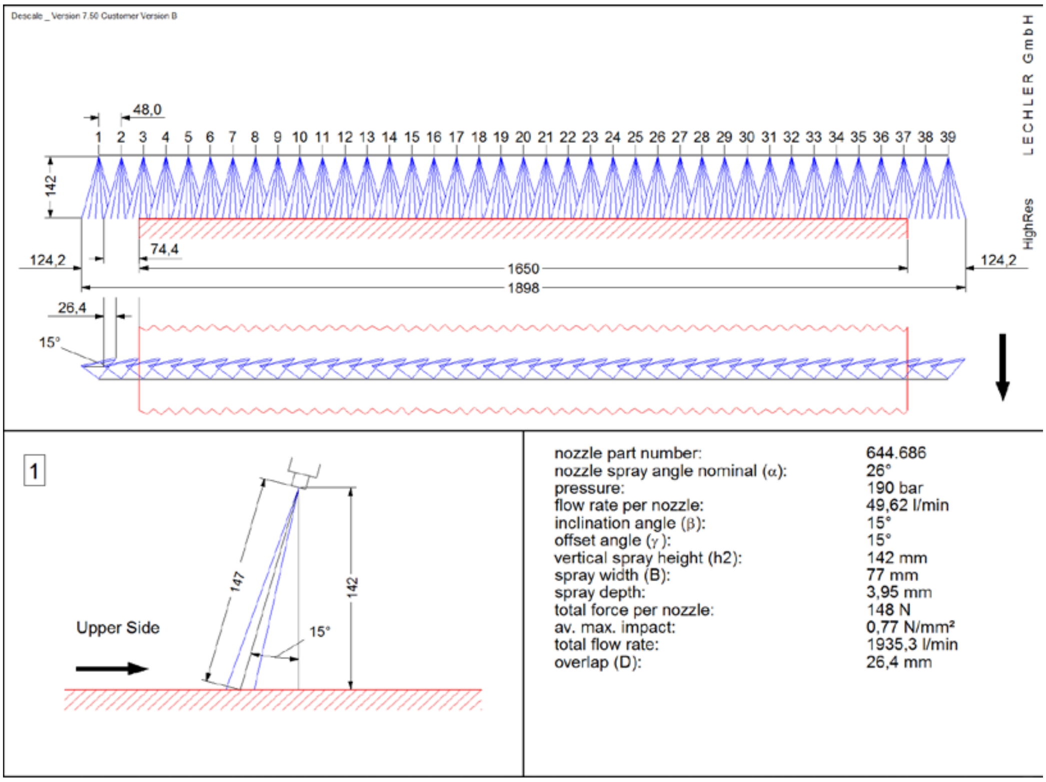

Figure 3 – Existing nozzle configuration Primary Descaler– flow 1,935 l/min – impact 0.77 N/mm²

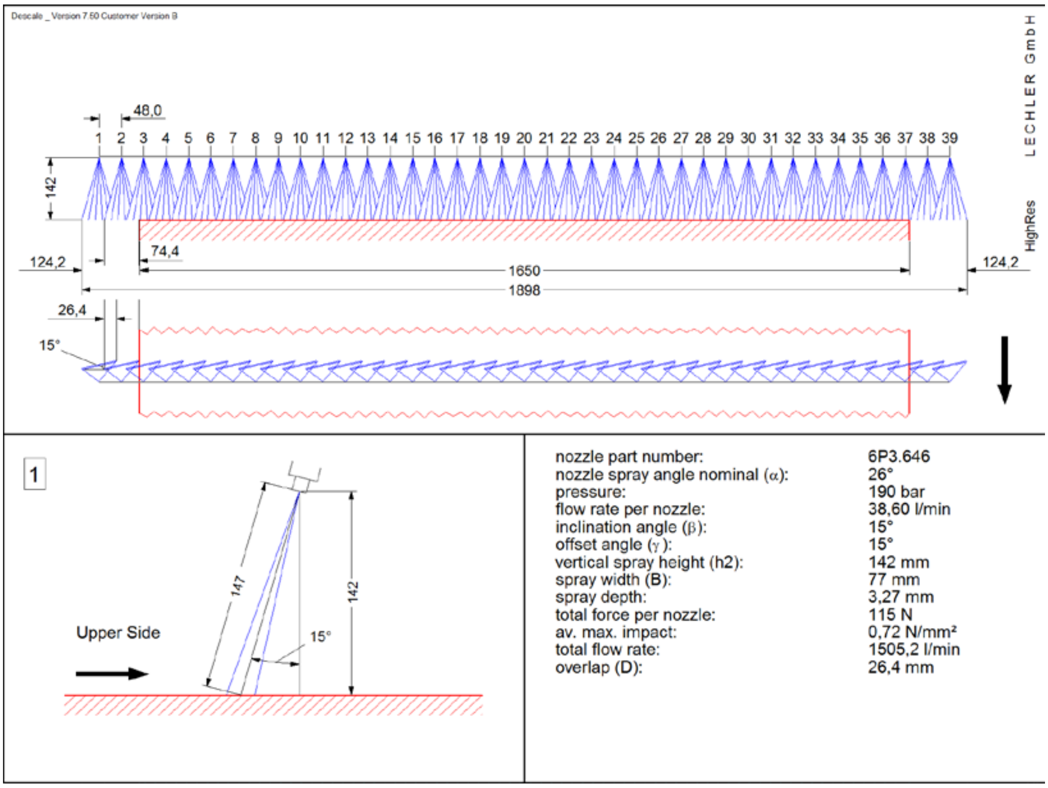

Figure 4 – Revised nozzle configuration Primary Descaler – flow 1,505 l/min – impact 0.72 N/mm²

With the availability of the new nozzle family Scalemaster HP Superior® it was possible to use smaller capacity nozzles. Hence, the water consumption could be reduced by 22% and the average maximum impact values could be kept almost constant (6% lower than before). Simulations for the Roughing Mill followed.

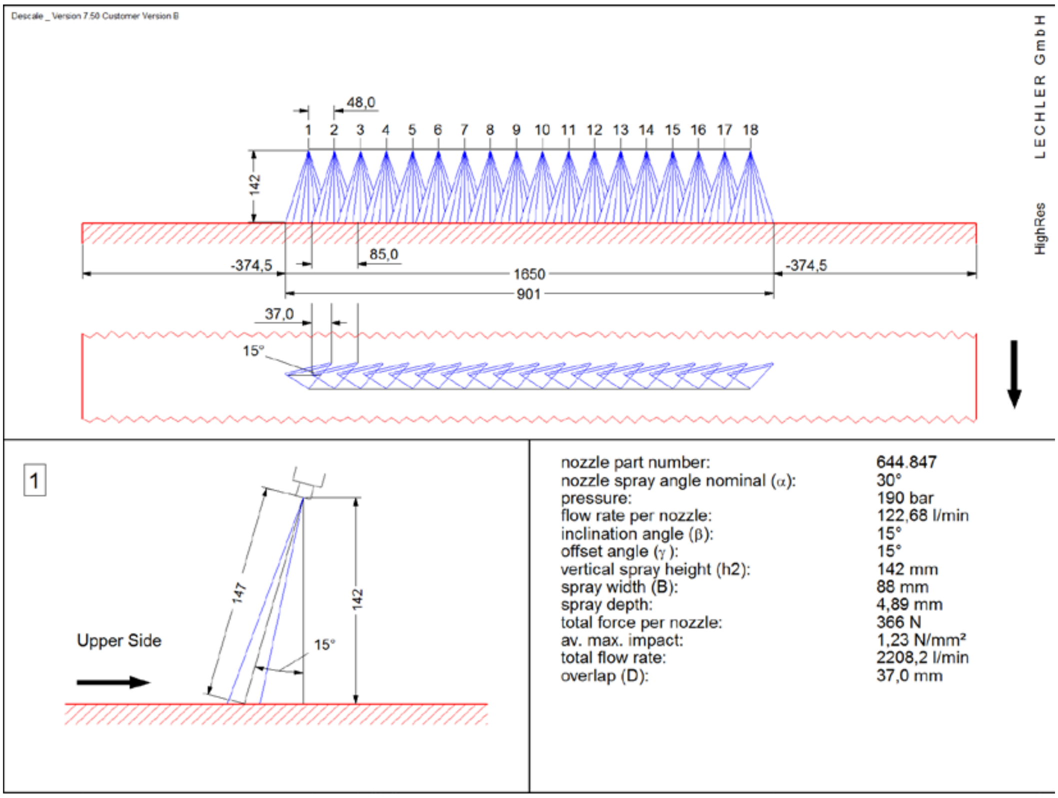

Figure 5 – Existing nozzle configuration Roughing Descaler – flow 2,208 l/min – impact 1.23 N/mm²

The flow per header was calculated with 2,208 l/min at an average maximum impact of 1.23 N/mm², and the overlap, at the spray height of 142 mm was 37.0 mm - fig. 5. Next, a simulation was done at the same boundary conditions, but with the utilization of the new nozzle type - fig. 6.

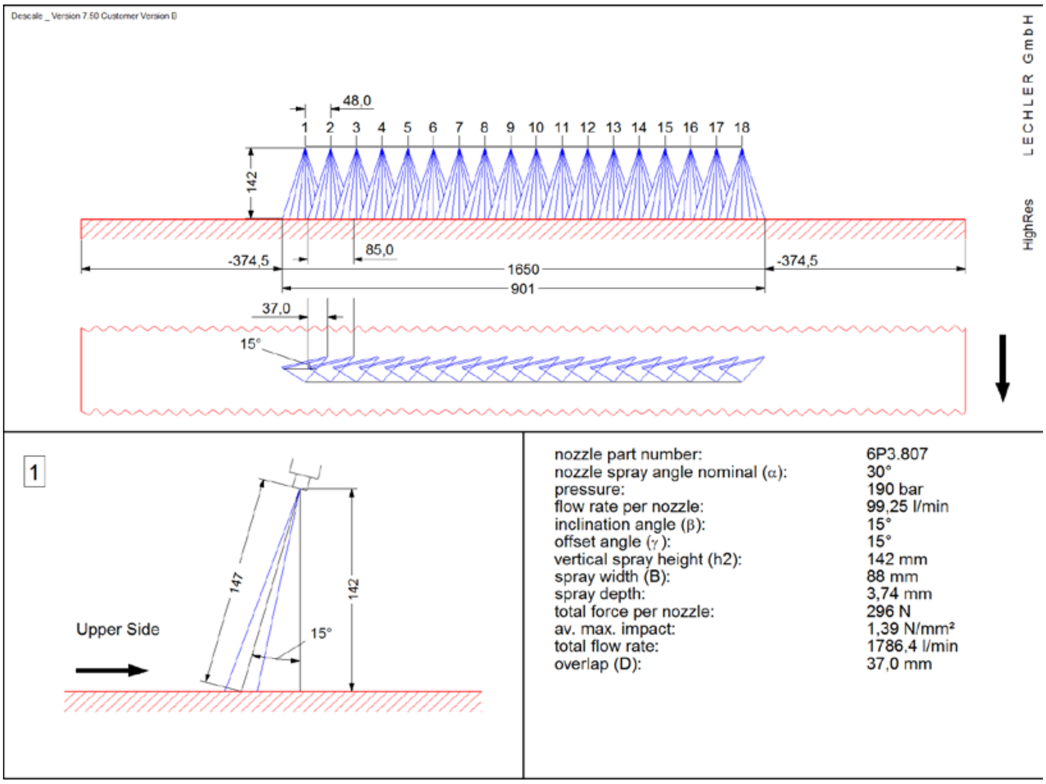

Figure 6 – Revised nozzle configuration Roughing Descaler – flow 1,786 l/min – impact 1.39 N/mm²

Again, smaller capacity nozzles had been selected. In this case, the water consumption could be reduced by 19%, and the average maximum impact values could even be increased by 13%.
Finally, simulations for the Finishing Mill were done. The flow per header was calculated with 1,428 l/min at an average maximum impact of 0.73 N/mm², and the overlap, at the spray height of 110 mm was 14.6 mm, see fig.7.

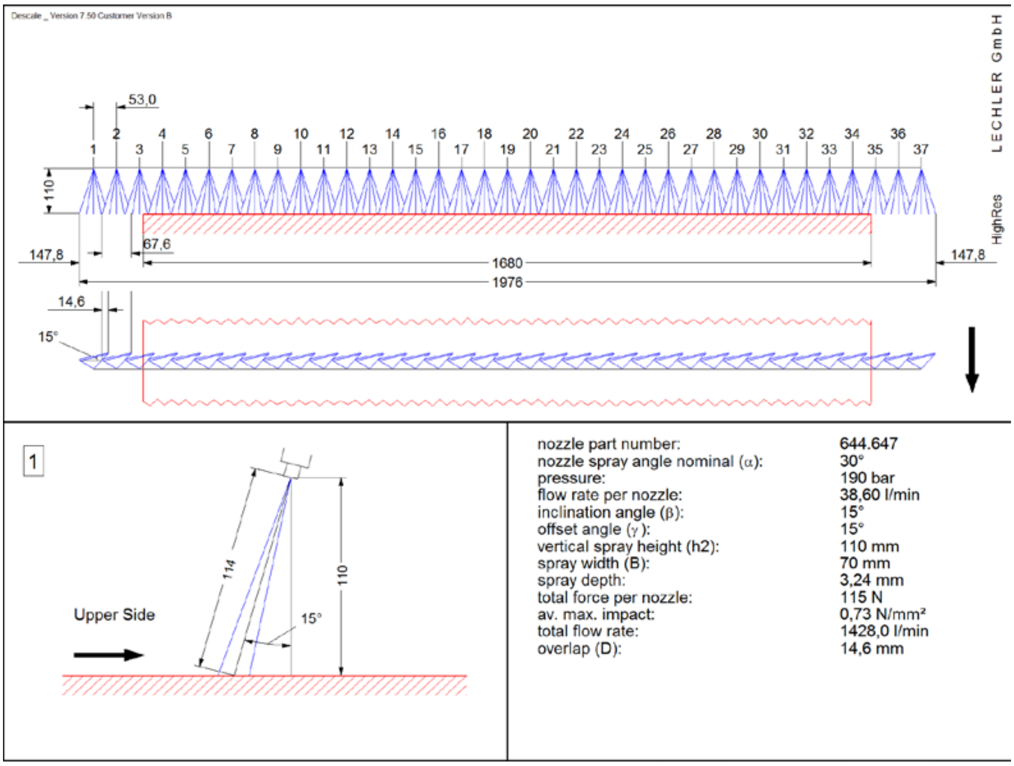

Figure 7 – Existing nozzle configuration Finishing Descaler – flow 1,428 l/min – impact 0.73 N/mm²

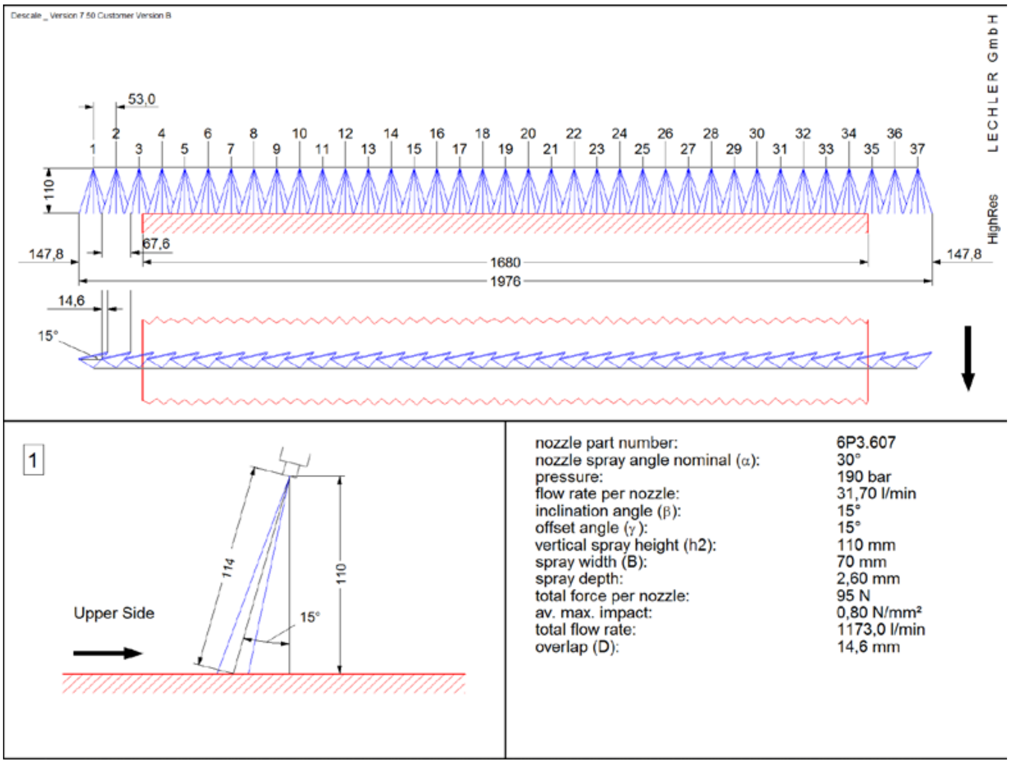

Figure 8 – Revised nozzle configuration Finishing Descaler – flow 1,173 l/min – impact 0.80 N/mm²

The simulation with the same boundary conditions, but with the utilization of the new nozzle type is shown in figure 8.

Also in this case smaller capacity nozzles had been selected. The water consumption could be reduced by 18%, and the average maximum impact values could even be increased by 10%.

During this theoretical calculation phase, it was also noticed that with the sum of the flow decrease, a possibility of shutting off one of the three pumps has arisen. This possibility makes the project even more valuable. Because at first, the earnings would be around 120,000.00 Euro with a 20% decrease in flow, on the other hand shutting one pump would increase the earnings 5 fold.

PILOT TESTING AT FM DESCALING SYSTEM

In order to test these simulations real time, Çolakoğlu Metalurji decided to upgrade one set of FM descaling headers with the new nozzle type. In the end, the results were as expected. As shown in fig. 9, around a 20% decrease in flow was achieved as found in the simulation made before. Reduction in power can also be seen below as 255 kWh (12.5%) for only one set of FM headers (1 set: top + bottom header).

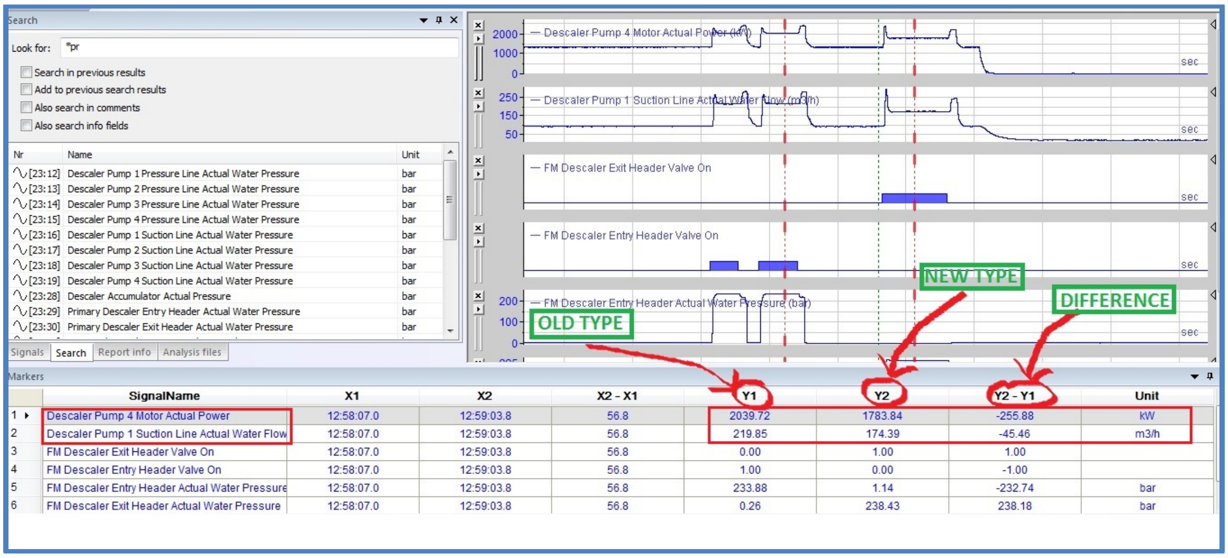

Figure 9 – Pilot test results at FM descaling station

And as a result of this much flow decrease achieved, theory for shutting off one pump seemed very realistic.

CONVERSION OF ALL NOZZLES & DATA AFTER CONVERSION

After the successful pilot testing, nozzles at all of the stations were replaced with the new type. The measured flow results for one set were as follows – fig. 10:

DESCALER DESCRIPTION	FLOW (OLD TYPE) (m^3/h)	FLOW (NEW TYPE) (m^3/h)	FLOW DECREASE (m^3/h)	FLOW DECREASE (- %)
Primary	240	205	35	14.6
RM	299	261	38	12.7
FM	220	175	45	20.5

Figure 10 – Old vs. new type of nozzles at descaling stations

For the maximum need situation the total flow decrease becomes
(35 x 2) + 38 + (45 x 2) = 198 m^3/h

With these values shutting off one pump (capacity 250 m^3/h) seems very realistic. It is tested and confirmed, that the descaling pressures and the coil quality was not affected with running one pump less.
The energy consumption is regularly monitored by an energy analyzer. It was found that the daily total consumption is approx. 30,000 kWh less after the conversation to the new nozzle types. That means 30,000 kWh/ 24 = 1,250 kWh/ h saving.
At 310 days (considered for one year) this amounts to 9,300,000 kWh yearly.
At the current energy costs of 0.069 EUR/ kWh this relates to a cost saving of 641,700.00 EUR/ year.

CONCLUSION

The most important period of the descaling system in terms of capacity usage is the one where all of the descaling headers are open at the same time (Primary 2 sets + RM 1 set + FM 2 sets). It is calculated that with a theoretical flow decrease of 20 % for each descaling station, the total flow decrease would be approx. 239.2 m^3/h at the point of maximum need. That value is nearly equal to the capacity of one pump which is 250 m^3/h. And in actual total decrease was found out to be 198 m^3/h
Another important point is; in times of maximum necessity, the accumulators will have to feed the system meaning that they also have to be refilled at idle times with surplus flow. It is also foreseen that especially with the help of flow decrease in FM descaler, which has the longest opening duration, the system will have more surplus flow and so the accumulators can be re-pressurized more easily. This is one of the main reasons which enabled shutting off one pump.
Impact load simulation: Energy savings with decrease in flow and shutting of one pump is not the only thing that has to be considered. These would mean nothing if the quality of the produced coils are worsened. Because of this, simulations were also done regarding impact values. It was found that, in most cases with the new type of descaling nozzles used, the nozzles can even provide an impact increase of 10 to 13% although the flow was reduced by approx. 20%.
Additional advantages are seen such as reduced material cooling and the lower wear of the components of the whole high-pressure water hydraulic system.

A total of energy saving of approx. 641,700.00 EUR/year was achieved.
The project payback time was as short as 1.5 months, which was a huge success.