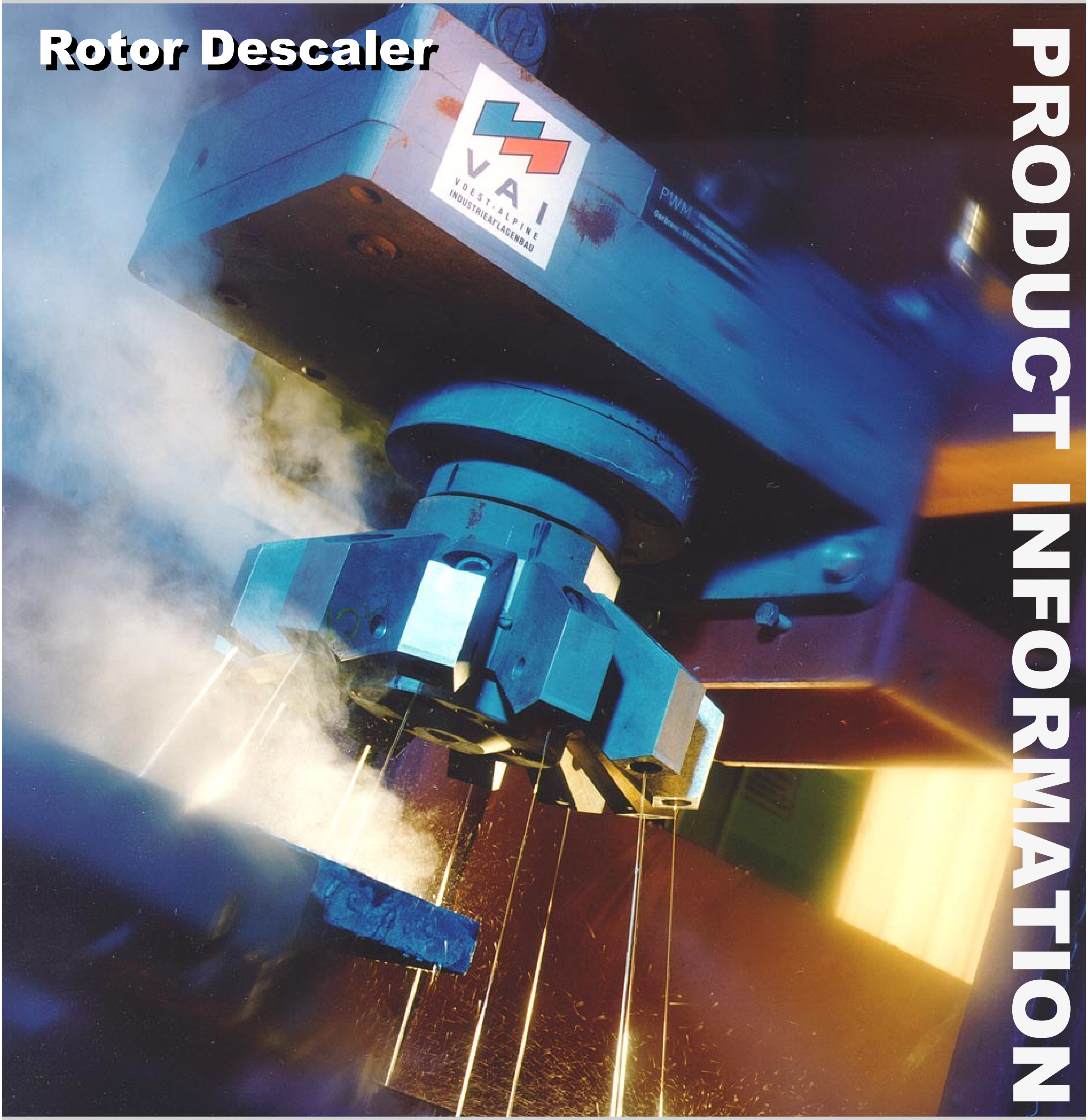
VATECH

VOEST-ALPINE Industrieanlagenbau

Rolling Technology

Rotor Descaler

PRODUCT INFORMATION



Technology is Our Trademark

VAI

VAI Rotor Descaler

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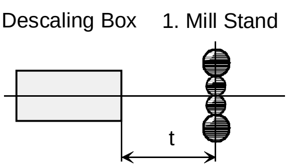
Reasons for Development

Modern descaling units are characterized by reduced water consumption and increased jet pressure and provide the same or even improved descaling results. There is a high demand for descaling quality and optimization of flat (hot and cold) and long products.

One of the main effects of the ever increasing amount of rolling from thin slabs is the low entry speed of the material into the finishing mill. This results in not only an increase in the time ratio between descaling and roll gap entry into the first stand gap, but also an increase in the surface cooling effect on the slab. Figure 1 shows the comparison of plant configurations against time from the descaler to the roll gap of finishing stand F1.

In order to limit secondary scale formation and thus the surface cooling effect, this time ratio must be reduced to as low as possible. The installation of a rotor descaler unit attached directly onto the frame at the entry of F1 reduces the time ratio to a minimum and successfully fulfills both of these requirements. This solution has been patented by VAI.

New technologies must not only meet the objectives of reduced investment and operation costs but also are subject to increasing limitations on industrial water supply. In order to achieve the desired descaling effect using all the parameters of jet pressure, impact pressure on the slab and water quantity available, a low water consumption rate can only be achieved by increasing the impact pressure. Conventional plants are limited in this respect on the basis of the jet type. The flat-jet types have a certain width and depth which limit the number of nozzles that can be arranged across the slab width. For this reason a concept was introduced to allow moveable nozzles. VAI inserted nozzles into a rotating support unit such that the jets, whilst rotating, describe a circular trace on a resting surface. The movement of the jets has proved to have a decisive advantage because solid jet nozzles can be applied in place of flat jet types. The effect of an impacting jet can be concentrated on a small area to achieve very high impact pressures (Figure 2). With these high impact pressures, steels difficult to descale are expected to be effectively descaled with a high-quality surface.



	Distance [m]	Speed [m/s]	Time [s]
Dortmund	4.000	1.50	2.7
Worthington	0.850	0.30	2.8
Linz	3.000	1.00	3.0
Baoshan	4.400	1.20	3.7
Erdemir	3.800	1.00	3.8
Nucor	3.286	0.27	12.3

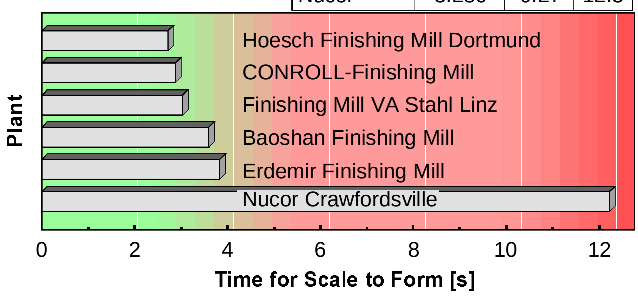


Figure 1: Time from Descaler to Roll Gap

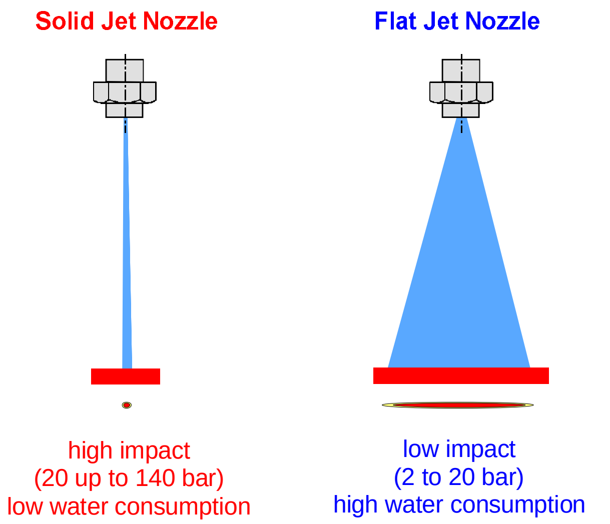


Figure 2: Comparison of Solid Jet Nozzle and Flat Jet Nozzle

Initial Trials on the Hot Strip Mill at VOEST-ALPINE STAHL LINZ

In the course of designing the new descaling unit it was decided to make two of the new conventional spray headers on the existing HSM in Linz interchangeable with rotary units both on the top and on the bottom. 50 slabs have been descaled by means with this new rotor descaler of which half showed a high-quality surface and the others a slight streaky effect with scale residues. This new rotor descaler has also been used as a primary descaler to check its effect on furnace scale.

As a result of the outstanding descaling results achieved with a new conventional descaler unit, the plant operator (VOEST-ALPINE STAHL LINZ) had no particular interest in further developing and optimizing the rotor unit. Further tests, however, were carried out with the assistance of VOEST-ALPINE STAHL LINZ to evaluate the rotor supplied by a hydraulic and pump company. These tests showed that very high friction losses within the rotor were occurring, and a constant number of revolutions could not be guaranteed at the high pressure involved. Figure 3 shows the rotor descaler in use as a primary descaler of slabs. It was decided to employ a new rotor concept with an improved bearing and turning design.

Alternatives to the development activities were sought. Emphasis was placed on laboratory-similar test conditions with trained staff, modern workshops with experience in development and an independent testing facility.

These requirements could only be met by building our VAI-own testing unit in the technical laboratories at VOEST-ALPINE STAHL LINZ.

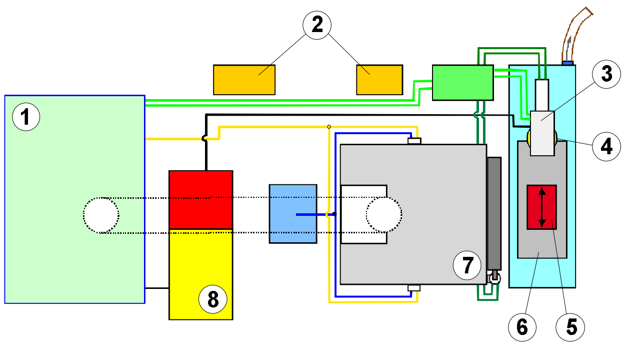
Figure 3: Rotor Descaler Trials at the Hot Strip Mill of VOEST-ALPINE STAHL LINZ

Rotor Descaler Trial Unit

The experimental trial unit, Figure 4, was designed to enable descaling tests under realistic conditions in order to obtain representative information about the influence of the standard parameters such as steel composition, furnace conditions, water pressure, jet type, etc.

The unit consists of a gas-fired furnace, a hydraulic rotor, a box for jet guarding, a scale collector, a hydraulically driven specimen carrier, a high-pressure piston pump and a hydraulic power pack.

The experimental unit was also designed such that all the variable parameters, e.g. the number of revolutions, pump pressure and feeding speed (the speed at which the sample is moved beneath the rotor) are infinitely variable and can be changed as easily as possible. The trials began with the insertion of a sample into the furnace. The heating of the furnace was adapted to correspond to the conditions of a typical reheating furnace. After the sample with scale was heated, it was taken from the furnace with the specimen carrier and passed beneath the rotor descaler. The trials showed an immediate improvement of scale removal with the rotor descaler. Consequently the time between constructive changes and the trials in the laboratory were kept very brief.



1 Hydraulic Power Package
2 Controller
3 Hydraulic Drive and Gear
4 Rotor Descaler
5 Specimen
6 Specimen Carrier
7 Propane Furnace
8 High Pressure Water Pump

Figure 4: VAI Rotor Descaler Trial Unit

Parameter	Maximum values	Typical values
Samples	600 x 450 x 35 mm	
Furnace temperature	1300 °C	up to 1250 °C
Durability of the sample in the furnace	120 min	
Water pressure at the pump	250 bar	240 bar
Number of revolutions of the rotor	1000 /min	250–750 /min
Feeding speed of the sample-sledge	0.1–1.0 m/s	0.1–1.0 m/s
Distance jet - sample	100–250 mm	150 mm
Jet type and size	Full jet < 2.4 mm	Full jet 1.8 / 2.0 mm
Sample-material	Structural steel, high-grade steel, Si steel, austenitic and ferritic stainless steels	

Table 1: Typical Test Parameters

Rotor Descaler Control Concept

The rotor is driven by means of a hydraulic power pack and an intermediate gear unit, which can be seen as one possible drive variant. A hydraulic power pack offers the advantage of simple control, especially for the trial run.
The rotor (Figure 5) consists of a stationary unit with a central inlet pipe and a control disc. The rotor part is fitted around a hollow body shaft and contains the two-stage high-pressure sealing and the inlet supply lines to the jets. The nozzles are inserted in the rotor wing such that they are all arranged along the same diameter. The number of nozzles is selected according to the requirements, but the number of required nozzles is determined by the required feeding speed and water quantity. The actual trial rotor has a jet circle diameter of 480 mm. For this reason wide slabs require three to four rotors arranged side by side.
Pressurized water arrives through the stationary central inlet pipe to the chamber beneath the control disc. Elongated holes are located in the control disc at different radii. As soon as an inlet supply line corresponds to an elongated hole, pressurized water arrives at the nozzle. The nozzles can be switched in groups through the position of the elongated holes on different diameters. Thus it is possible for each group of nozzles to use different nozzle types or nozzles sizes.
This concept allows, through the design of the control disc and the choice of nozzles, the equalization of the uneven water impingement in a lateral direction. A further advantage is that the water impingement on the slab must not be over the full circle. The sample using the current rotor is stroked by only 180° of the jet circle. This principle is comparable with that of a milling machine, where material is only taken off at the front edges. Thus it is possible to save water and to keep the cooling effect of the descaling process low. Figure 6 shows the parameters of the rotor descaler compared with a conventional one.

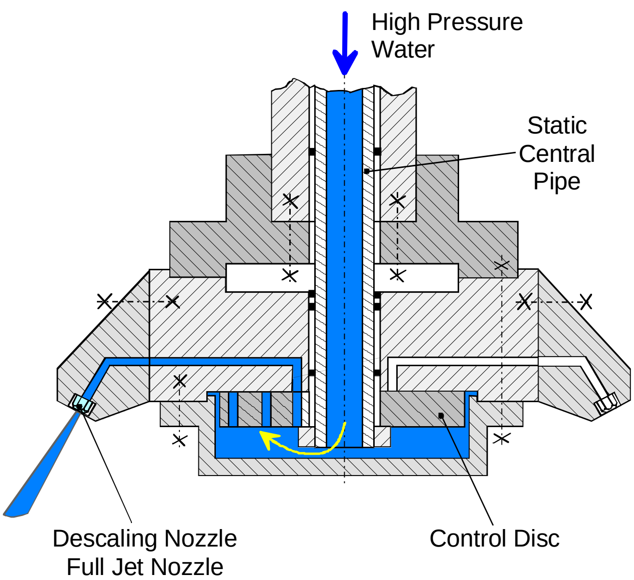


Figure 5: Principle of Rotor and Jet Control

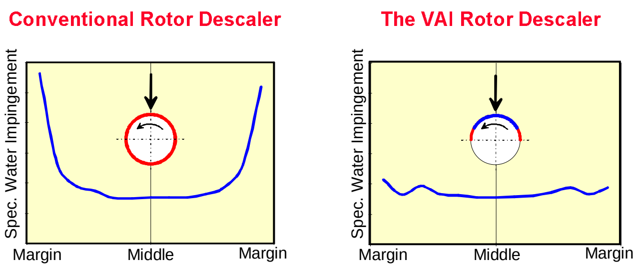


Figure 6: Comparison of a Conventional and the VAI Rotor Descaler

The control concept describes the control of the water jet trace curves on the slab. These are called jet curves. The circular jet curves are distributed by the simultaneous motion of rotor and slab to curves of higher order. The jet circle of stationary circle sectors is arranged through the switching of nozzles in groups. This concept allows the equalization of the uneven water impingement in a lateral direction as achieved with a conventional rotor-descaler (Figure 6).

Depending on the rotor revolution number, the number of nozzles and feeding speed, a pattern of jet curves results on the slab surface. These can be seen in Figure 7.

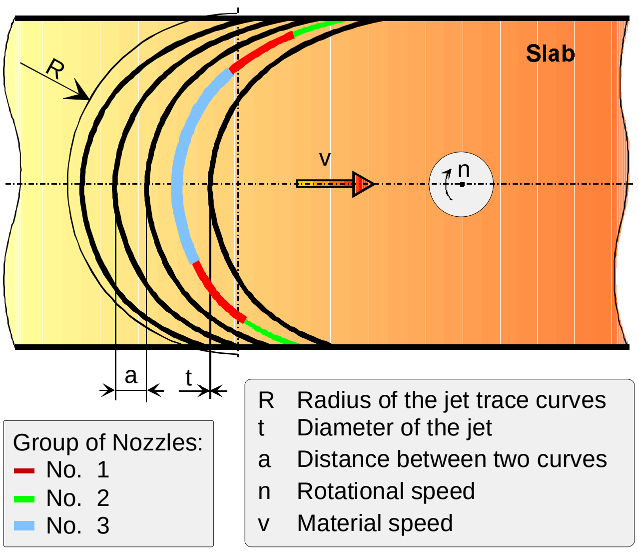


Figure 7: Distribution of Water on the Slab Surface

The jet curves are defined by the jet depth *t* and half the diameter of the jet circle. The interval between two jet curves *a* results from the diameter speed of the jets, the number of jets and the feeding speed *v*. At high feeding speeds and low revolution numbers this interval would be too large, the covering of the surface would be incomplete, so the scale residue would remain between the jet curves.

The revolution number of the rotor has to be selected, independent of the required feeding speed of the slab, so that the interval between two jet curves stays smaller than 30 mm. The distance *a* can also be kept small through a larger jet depth, so that for the same distance *a* at the same feeding speed *v* a smaller revolution number would be required.

The above parameters now fix the water impingement on the slab. The nozzle size and the water pressure are additional influencing factors. The water quantities for each slab surface can be adjusted independently of the parameters. The impact pressure and the water quantity on the slab can be adjusted through variation of these measures, according to the requirements (depending on the steel grade and the adherence of the scale), Figure 8.

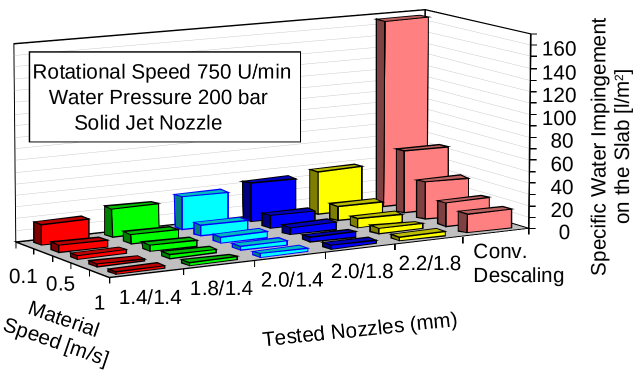


Figure 8: Dependence of the Specific Water Impingement on the Slab of the Feed Rate 'v' and the Diameter 'd' of the Nozzles

Development Phases

The main development phase was the design improvement of the rotor with regard to lifetime. Different material combinations for the control disc and the counter-pressure surface as wearing surfaces were tested, such as hard metal with hard metal, special polymers with steel and nitrated steel. The rates were evaluated and tested as to their accuracy in continuous long-term tests.

During the long term tests under realistic conditions (300 bar, 600 rpm) the combination of hardened steel and high-performance polymer showed the lowest wear and was thus chosen as the material for the control and support disc.

A further focal point represented the technical improvement of the high-pressure inlet supply lines. Due to the high pressures and the high water-flow rate, appropriate design was necessary to keep the pressure drop low. Jet stabilizers are utilized to reduce turbulences in the nozzles. Standard parts offered by jet manufacturers are used.

This stabilization of the water flow plays an important part in the development of the nozzle, as strong vortices increase the jet spread. The impinging jet cross section is enlarged on the sample, and thus the jet pressure is reduced. Stabilizers are able to raise the impact pressure.

The characteristic jet cross sections were determined by a pressure sensitive foil, which changes color under the influence of pressure. It is not an integral pressure but the power of the single drops displayed at the foil. This can also be seen as a qualitative measurement of the power effect of the jet on the slab and is more indicative of the characteristic jet pressure. The pressure distribution of the jet is represented in this way. The jet spread was restricted to less than 2° by means of jet stabilizer so that a strong concentrated jet is possible.

Different nozzle types and sizes were tested in the course of the trials and their jet cross sections were analyzed. The following descaling trials utilized this knowledge.

Descaling Trials

The descaling trials determined the necessary parameter combinations in order to obtain a good descaling effect. Parameter fields were examined, and the dependence of the descaleability on the following has been determined.

- Steel grade
- Furnace temperature and durability
- Water pressure
- Rotor revolution number
- Feeding speed
- Nozzle type and size

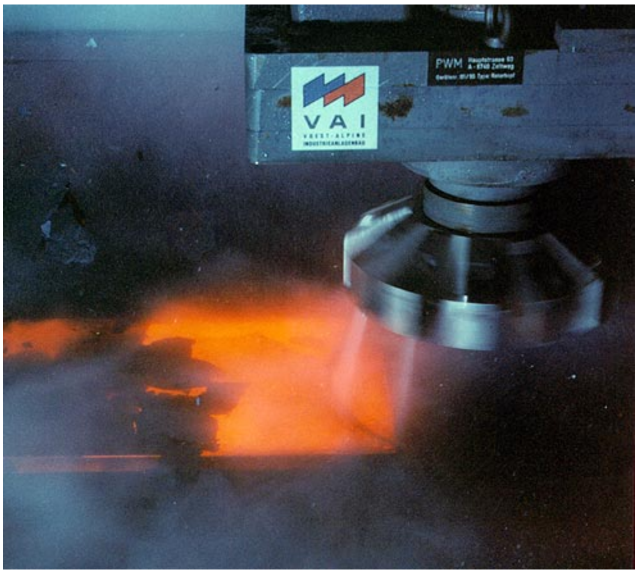


Figure 9: VAI Rotor Descaler

Steel Grade	C	Si	Mn	Cr	Ni	Mo	V	Nb	Cu
AISI 1006	0.03	0.15	0.22	0.09	0.05	0.01	0.003	0.001	0.05
AISI 1055	0.52	0.36	0.65	0.08	0.05	0.01	0.005	0.001	0.05
AISI 1080	0.75	0.28	0.67	0.06	0.04	0.01	0.008	0.001	0.04
QStE380TM	0.05	0.11	0.56	0.1	0.05	0.01	0.005	0.015	0.04
AISI 1551	0.53	0.27	0.98	0.11	0.05	0.01	0.008	0.001	0.04
AISI 4130	0.25	0.29	0.48	1	0.12	0.18	0.008	0.002	0.04
50SiMn7	0.5	1.75	0.72	0.085	0.2	0.05	-	-	0.2
AISI 409	0.01	0.3	0.35	11.3	0.2	0.1	0.01	-	0.2
AISI 430	0.04	0.4	0.425	16.65	0.4	0.35	-	-	0.5
X12CrMoV122	0.12	0.2	0.8	11.6	2.7	1.6	0.3	-	-
X 38 CrMoV 51	0.39	1	0.4	5.1	-	1.3	0.4	-	-

Table 2: Chemical Composition in % of Tested Steel Grades

Results of the Descaling Trials

The tests series showed that structural steel was particularly descaleable even at low pressure (150 bar) with a water savings of up to 80% in comparison to a conventional descaler unit. Higher jet pressures are necessary for intense adherent scale removal, e.g., on X12CrMoV122 but complete descaling is possible at a pump pressure of 240 bar and a feeding speed of 0.8 m/s. High alloyed steel grades can be descaled effectively; however, the specific water impingement must be adjusted. With high alloyed steel grades the reduction in water flow can typically be 50%.
Steels with high silicon content are very problematical because of the intense adherence of scale, which is described in the literature. High impact pressures and higher quantities of water (an intense cooling of the surface) are required for this kind of scale, which can be achieved with a high number of rotor revolutions, a low feeding speed and bigger nozzle diameters.

Short Description of the VAI Rotor Descaling System

The rotor descaling system was designed based on the experimental results and further operational experience. Especially with low material speed (< 0.5 m/s) the rotor descaler offers a unique opportunity to achieve good descaling results and a low temperature drop. The rotor descaler offers the correct solution for each descaling situation.

- The descaling of billets and blooms (ongoing project for the descaling of slabs).
- Rotor head diameter: 250 to 500 mm (for wide strip, rotor heads side by side).
- Hydraulic drive (small and compact unit to keep the rpm constant; important for full impingement of the steel surface).
- Rotational speed: 400 to 700 rpm (dependent on the material speed).
- Water flow rate: Reductions compared to conven-tional descalers up to 60 % depending on the steel grade: adherent scale requires higher specific water impingement and thus higher flow rates).
- Water pressure: 200 to 300 bar (4350 psi); typically 300 bar.
- Full jet nozzles with stabilizers (focused jets with very high impact).
- Number of nozzles: dependent on the material speed (typical 8 nozzles).
- Material speed: up to 0.8 m/s (157 ft/min); with high alloyed steel grades $v \leq 0.5$ m/s (100 ft/min) is recommended.
- Plunger pumps (possible due to lower water flow) and bladder type accumulator or vessel type accumulator. Type of accumulator is dependent on the length of the billet and the gap time.
- Automatic positioning system for the rotor header (required for the descaling of billets and blooms with different dimensions to keep the optimum nozzle to surface distance).
- Automatic system for controlling the descaling period corresponding to the length of the material that must be descaled (no wasted pressurized water) .
- Due to the reduced flow rates a lower temperature drop is achieved. This is of importance with crack sensitive materials e.g. tool steels.

References

- Böhler Edelstahl GmbH, Kapfenberg AUSTRIA, Descaling of Billets and Blooms, high alloyed steel grades
- Huta Baildon, Katowice Poland Descaling of Billets, high alloyed steel grades

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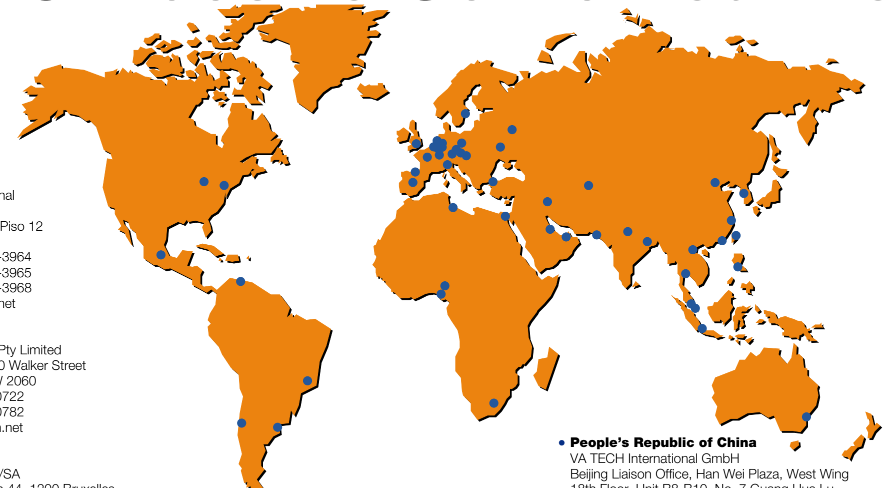

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