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THERM-O-MATIC INSPECTION SYSTEM

A NEW INSPECTION SYSTEM FOR IN-LINE SURFACE INSPECTION OF STEEL BILLETS AND BARS

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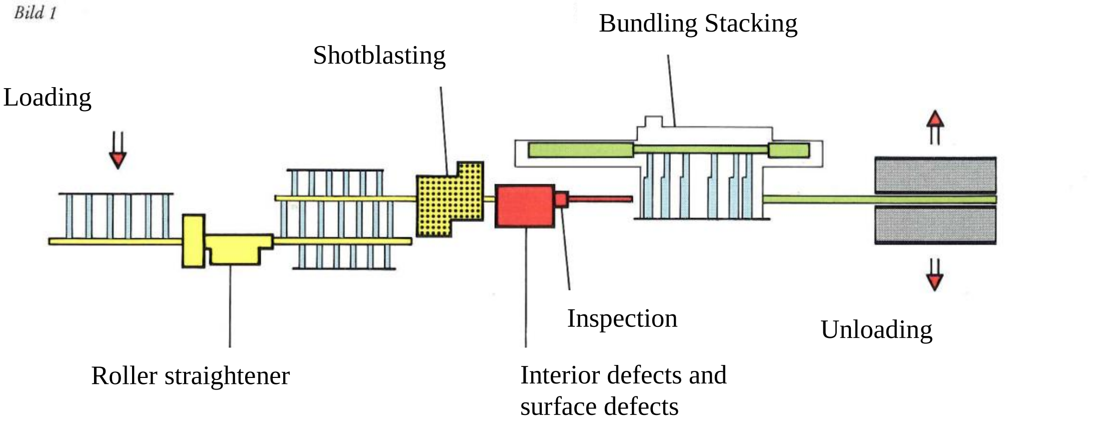
Steel billets and bars are after rolling and additional heat treatment not yet of a quality which is satisfactory to the customer.

The billets must be straightened, mill scale must be removed, and the ends and surface must be further treated in order to meet customer's special requirements.

Straightening, the removal of mill scale and inspection is, for economical reasons, today performed mainly in conditional lines.

Bild 1 illustrates the lay-out of the billet conditioning line at Werk Niederschelden:

Bild 1



Square billets of dimensions from 50x50mm (2"x2") to 130 x 130mm (5"x5"), and round bars from 80mm (3 1/8") diameter to 130mm (5") diameter are first straightened in a straightening machine, then passed through a shotblaster for the removal of mill scale, and then automatically inspected with respect to both surface and interior defects.

Defects which are detected by this in-line inspection are marked on the surface at the exact position where they occur by automatic paint spraying. Billets with surface or interior defects which exceeds the tolerances, can automatically be sorted out for repair. Billets can also be automatically sorted out according to length criteria.

The in-line inspection system for surface defects makes it possible to detect defects with a high degree of accuracy, and with high reliability according to criteria which will vary with the intended final use of the steel. The inspection criteria must be chosen in such a way that the product satisfies the customer's requirements with respect to defect tolerances, bearing in mind that surface in-homogenities without significance for the further preparation of the material, shall not be detected.

This approach has constituted a permanent challenge to the development of new system technology for billet inspection.

With the first magnetography system, which was put in commission at Werk Siegen in the middle 1960's, an inspection system which fulfilled the above mentioned criteria of in-line inspection was for the first time made available. A modern, further developed version of this system is today in operation at Werk Rheinhausen.

In the middle of 1970's a magnetic particle dry flux inspection system was installed at Werk Niederschelden. This inspection method satisfied the requirements to defect detection, but lacked in inspection capacity.

In the spring of 1981, a new billet surface inspection system, Therm-O-Matic, was presented to the industry by the Norwegian concern Elkem a/s.

This system was, because of its design and construction, well suited for implementation in the existing Niederschelden conditioning line.

Comprehensive production tests with a pilot system, which had the ability to inspect one billet face at a time, proved that the Therm-O-Matic method in principle was suitable, and Elkem a/s was given the task of developing and installing the first Therm-O-Matic inspection system for industrial use.

The system was installed in the conditioning line in June 1983 (Bild 2)

Following adjustments and calibration of the system, comprehensive testing of the system's defect detection abilities were performed.

After these tests were concluded, the system was released for normal production use.

The principle of the Therm-O-Matic inspection method is as follows:

A billet is passed through an induction coil. (Bild 3). The coil is fed by induction current of approx. 40 kHz, and current is induced in the billet surface (skin-effct). The induced current elevates the billet surface temperature slightly.

Inhomogeneties in the billet surface cause an un-even temperature distribution across the billet surface. Immediately after the billet has passed through the induction coil, the temperature profile of the billet surface is recorded by high frequency scanning of the surface by highly sensitive infra-red scanners. (Bild 4)

The recorded temperature profiles are analyzed and processed by very high-speed microprocessors in accordance with special algorithms.

Surface defects which according to pre-selected criteria exceeds the tolerances, will immediately after the scanning of the billet surface be exactly marked on the billet surface by means of paint spraying. (Bild 5)

Although the detection method may appear simple in principle, it proved a major task to develop the technological solution. Even short surface defects , with minimum depth down to 0,3mm (12/1000") should reliably, and without pseudo or false markings, be detected on both the billet faces and the billet corners, with a billet speed of up to 60/m/min. (200 ft/min)

With respect to surface temperature values for the momentarily heated billet surface, this means that if the general temperature increases at the surface due to induction is of the order 10°K, then the temperature variation caused by defects will be only about 3°K.
The small temperature differential must be registered by very accurate and sensitive instruments, and must be processed by the microprocessors in only microseconds. This is achieved by highly sensitive infra-red scanners with a temperature resolution of $\leq 0{,}2\ ^{o}$K, And by the most up-to-date microprocessors modules capable to analyze the scanner signals with the required speed. (Bild 6)

The less than 5 m (16½ ft) long Therm-O-Matic system is controlled by a supervisory microprocessor. (Bild 7) the signals from the infra-red scanners are transferred to the four microprocessors which process the data (signals), and the processed data are further transmitted to the supervisory microprocessor.

This supervisory microprocessor is also programmed to automatically correct certain system parameters when allowable variations of the billet speed occurs, and is also programmed with a comprehensive set of alarms and error messages for the system.

If operational problems of any significance to the inspection process occur, the system is automatically shut down.

The operator monitors the inspection process on a VDU, which also displays operational problems.

The Therm-O-Matic system is operated by one person from the control cabin, which is ventilated and soundproof, and with operator consols ergonomically designed. Since almost all system functions are automatic, the operation of the system is without problems.

When the inspection of a batch of billets have been completed, a batch report is printed out.

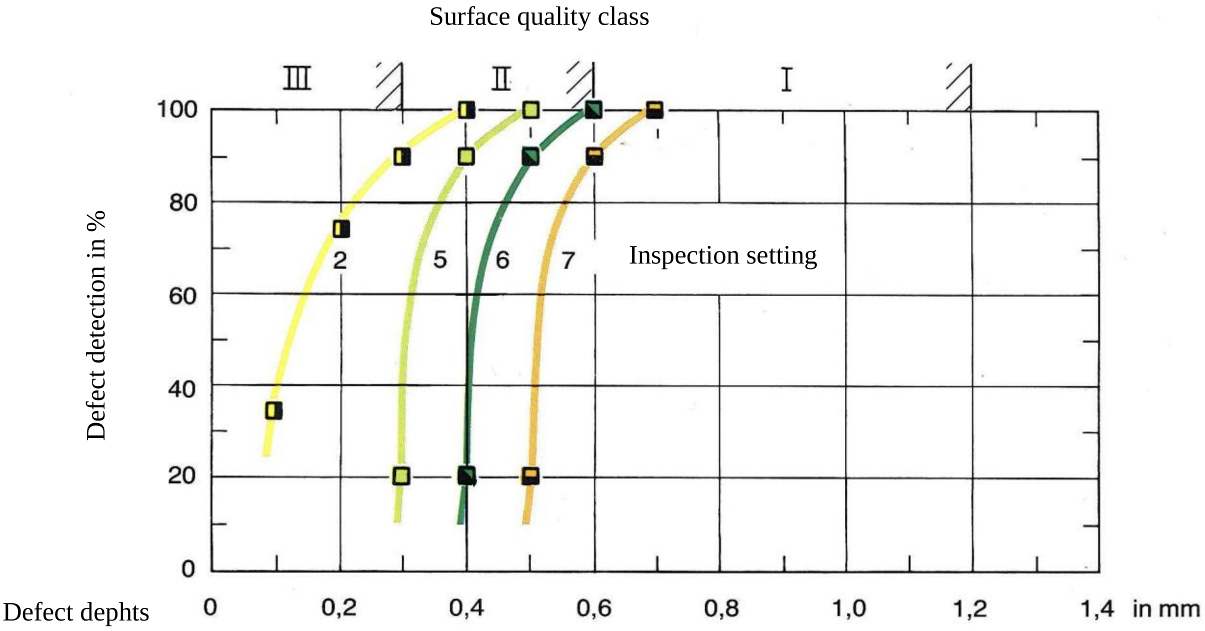
This batch report includes identification data for the billets, as well as information about number of billets tested, inspection parameters and inspection results.

At the end of each work-shift a shift report is printed out with information about all inspected billets and information which is of importance for the next shift.

Another shift report contains documentation of operational problems which may have occurred during the previous shift and their duration.

The crucial test for any inspection system is the system's practical ability to detect defects.

Bild 8 is a graphical representation of inspection results, which have been achieved after numerous tests.



The diagram illustrates the defect detection ability with various inspection parameters, compared to results obtained with a magnetic particle wet flux method.

The diagram clearly illustrates that the Therm-O-Matic system may be set, or adjusted, in such a way that the requirements with respect to the surface quality of rolled steel billets will be met with certainty.

bild. 1	Conditioning line for square billets and round bars
bild. 2	Incorporation of the Therm-O-Matic system in the conditioning hall
bild. 3	A billet passes through the induction coil
bild. 4	Scanning of the billet surface temperature profile
bild. 5	Marking of surface defects by means of paint spray
bild. 6	Analyses of the infra-red signals by means of microprocessors and analog display of the results on monitors
bild. 7	Control of the inspection system
bild. 8	Chosen inspection criteria, or parameters, for various steel quality requirements

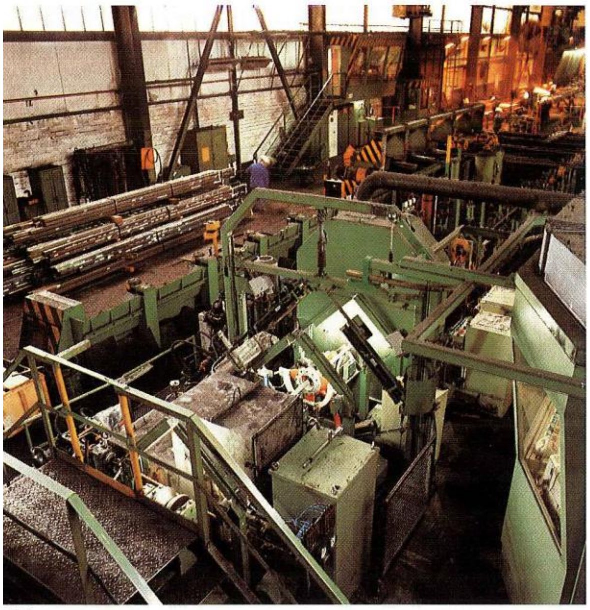


Bild 2

Bild 3

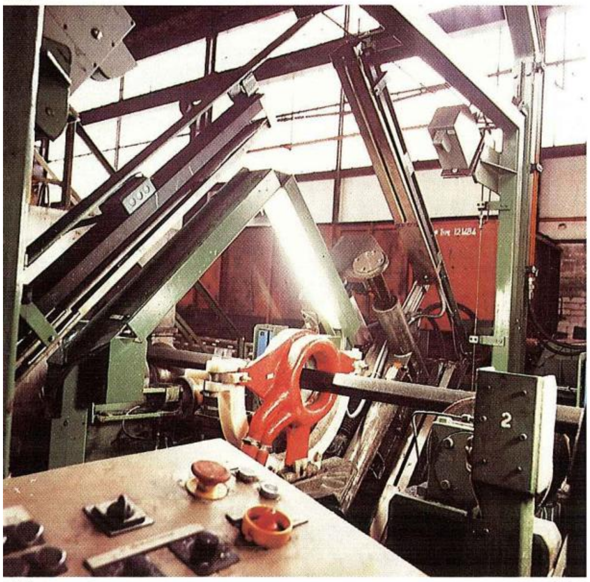
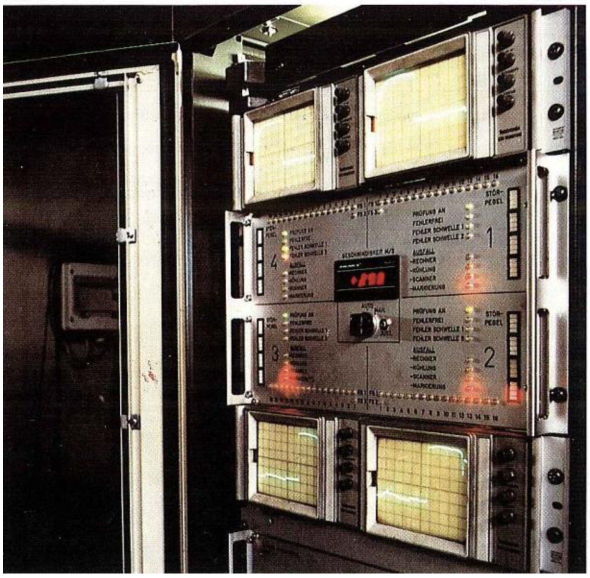


Bild 4

Bild 5

▼ *Bild 6*



▼ *Bild 7*