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Automatic Hot Slab Spray Marker in Continuous Casting Lines

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Synopsis :
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The body can be viewed from the next page.

Automatic Hot Slab Spray Marker in Continuous Casting Lines*

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1 Foreword

Marking of identification symbols and numbers on semi-finished products such as slab is an indispensable work for production control and material handling within a steelworks. An effort to automatize this work dates back to some time ago. In fact, the development of stampers and the riveting of a thin steel stencil plate on the slab offered some degree of effective use, but these still required a manual re-touching in white paint on the cooled slabs to get marking identifiable from far distance so as to prevent mixing up of slabs in many places, especially at slab yard, scarfer line and entry side of reheating furnace. Conventional marking by handwriting is an unhealthful work performed within the cooling bed area in high temperatures and humidity, with tendency toward many mis-markings. Recently, as part of energy saving efforts, hot charging has been in wide practice. In this case, workers are placed under a severe working environment where marking has to be made in close distance to hot slabs under high radioactivity.

It was in 1974 that Kawasaki Steel took this matter up as challenge, and after R & D efforts based on a unique concept, came to establish in December 1977 a method to mark clear identification symbols in white paint on the cross-section of red-hot C.C. slabs. The first machine has been making a smooth operation at No. 6 C.C. Plant of Mizushima Works. Another began working at No. 5 C.C. Plant in August 1979. Another is installed at other company in Japan, and one more unit has been now installed in a steelworks in France.

2 Brief Review of Development

In starting the research and development project in 1974, all the demands from the manufacturing site were examined to conclude the method of spraying paint through stencil plate as target since it was considered best in attaining clear marking. The subsequent study and experiments brought into focus the following problems:

(1) Problems in a steel stencil (see **Fig. 1**)
Despite many patent applications, the method of spraying paint through heat-resistant steel stencil does not produce clear marking in practice unless the stencil is closely adhered to red-hot slab. With the stencil closely held onto the red-hot slab, however, paint fuses and piles up on metallic stencil itself, thus making markings unclear gradually. Besides, cleaning of the metallic stencil is not easy, making it less efficient to perform a stable and long-term functioning. Another difficulty is the production of clear marking with sufficient adherence to uneven slab surface.

(2) Problem of paint
Paint for marking hot-rolled slab is required to have various properties; it must not be washed away by water-cooling after marking. It must withstand hot-cracking and flaking during cooling. By the efforts of a certain domestic paint manufacturer, a satisfactory paint has been developed. This paint uses TiO_2 as pigment and bases itself on a material meltable with heat of 250 °C and over.

* Originally made public at AISE 1979 Annual Convention in Cleveland, Ohio
** Mizushima Works

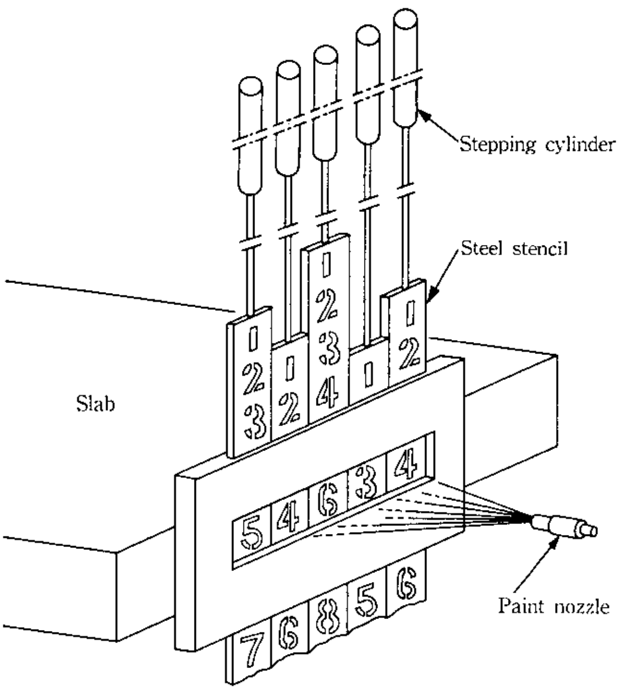


Fig. 1 Example of steel stencil methods

Once fused in a kind of chemical reaction on the scale-free slab surface, the paint will not flake off with slab cooling water, and even functions to in hibit the subsequent generation of scale. However, the following problems occurred when the paint was directly sprayed on red-hot slab.

(a) Paint flakes off with much scale as red-hot slab surface cools off.
(b) Paint sprayed disperses with a hot air flow from red-hot slab surface.
(c) The instance paint touches red-hot slab surface, moisture in the paint evaporates in explosion, causing paint to disperse, leaving hardly any adhered to slab.

(3) Clogging of paint spray nozzle
Clogging of nozzle is always a problem even at room temperature, and in marking red-hot slab, nozzle tends to clog under strong radioactivity. Heat resistant paint for red-hot slab is similar to solid material melted in water, tending to sediment more than organic paint does at room temperature.

2.2 Concept for Solution and Confirmation Through Experiment

2.2.1 Use of paper stencil

Since slab temperature immediately after torch-cutting is usually 700 ~ 900 °C, a preoccupation had formerly prevailed that the stencil should have heat-resistivity. However, based on a new idea, the use of paper stencil was studied. The low cost (¥3 ~ 5/use) paper stencil solves the problem of fusing of paint to stencil as it is expendable. Besides, the paper is so flexible as to stick to uneven surface of slab, contributing to obtaining clear marking. A question was how to stop the burning of paper when it touched red-hot slab. After a number of experiments including wetting and thickening of stencil, the problem was solved as follows.

2.2.2 Temporary water cooling of limited slab surface

Basic idea is not to overcome the difficulty but to remove it temporarily. And a number of studies and experiments were performed and as a result, many problems came to be solved. More specifically the cross section of C.C. slab cut with torch was temporarily cooled for 20 ~ 30 sec., with a 10 ~ 20 kg/cm² (140 ~ 280 psi) water, 250 l/min (66 GPM) to obtain the following results.

(1) Paper stencil starts burning at a about 450 °C, on the other hand C.C. slab temperature with even 1 000 °C on surface once drop down to below 450 °C for 10 and odd sec. by this water cooling method. Then marking is made possible, by having stencil contact the slab during the above period of time and by spraying paint over it.
(2) Since slab surface on which marking is to be made is cooled, hot air flow is subdued, and the dispersion of paint by explosive evaporation is kept down, thereby making most of the paint to adhere to slab surface.
(3) At present, the upper limit temperature of heat-resistance of the developed paint is 850 °C, and the paint slightly disappears if held over one hour at, for instance, 900 °C.
However, when slab surface is once water-cooled as explained above, regenerated temperature will be about 750 °C sufficiently within allowable temperature as shown in **Fig. 2** even when surface temperature before water-cooling is 1 000 °C.

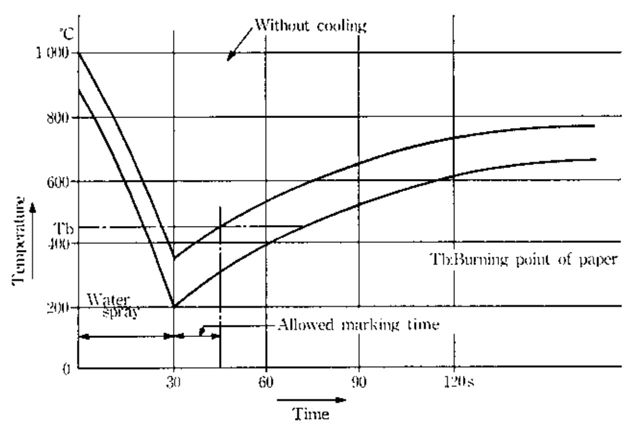


Fig. 2 Slab surface temperature

Actually, it is hardly possible that surface temperature of slab exceeds 950 °C on the table after torch-cutting.

(4) Scale that was generated on red-hot C.C. slab is almost completely removed by the impact of water cooling and heat contraction, making it possible for paint to adhere to clean slab surface, and hardly any flaking takes place in the ordinary subsequent cooling process such as spray water, dipping into water tank, etc.
This paint itself fuses strongly on slab surface, accompanied by a kind of chemical reaction, thus preventing any further generation of scale at that portion. Sometimes, a thick scale can not be removed by this cooling, but it was confirmed that such scale does not flake off any more in the subsequent cooling.

(5) Generation of slab surface defect due to local cooling of red-hot slab surface was feared, but no marking problem has occurred to date on torch-cut surface of ordinary steel, low alloy steel, silicon steel.

2.2.3 Measures against nozzle clogging of paint

Problem of paint nozzle clogging was completely solved by the following measures.

(1) Paint is constantly recirculated through a nozzle by special diaphragm pump, while in stirring. Commercially available nozzle is so remodelled that paint can be recirculated within the nozzle proper.

(2) A needle hole of a nozzle is pierced for each marking. So-called clean-cut needle is used.

3 Construction of Device and Principle of Function

Fig. 3 shows a schematic drawing of marking system, and **Fig. 4** a layout of slab C.C. machine when this marking system is incorporated. A belt-like paper fed out of the stencil reel goes into the stencil puncher in which letters are automatically punched out by the control of microcomputer, and cut into a specified length by the cutter on the stencil table.

Next, the stencil holder of the stencil handling car catches this stencil paper in vacuum and carries it to the table center. As slab makes a stop at a fixed position, the water jetting device acsends from within the table to water-cool for 20 ~ 30 sec. only the portion where marking is to be made on the cross section of slab. When water-cooling is completed and the water-cooling header descends, the stencil holder immediately descends in rotation, with spray nozzle moving horizontally while spraying paint (see **Photo. 1**). At this instance, marking is completed, and slab starts for transfer.

This is followed by disposition of used stencil papers into the used stencil box. The paint recirculates constantly by diaphragm pump from the paint tank to the tank through paint nozzle.

Data for marking covers from Arabic figures to alphabets in English character. **Fig. 5** shows an example of marking. For mechanical limitation and reduction in paint cost, size of a letter is of 50 mm(2″) × 30 mm(1 $^{1}/_{6}$″). This is identifiable from 10 m away. This marking system is fully-automated with the control of microcomputer. For inputting of data, automatic transmission from computer of upper level

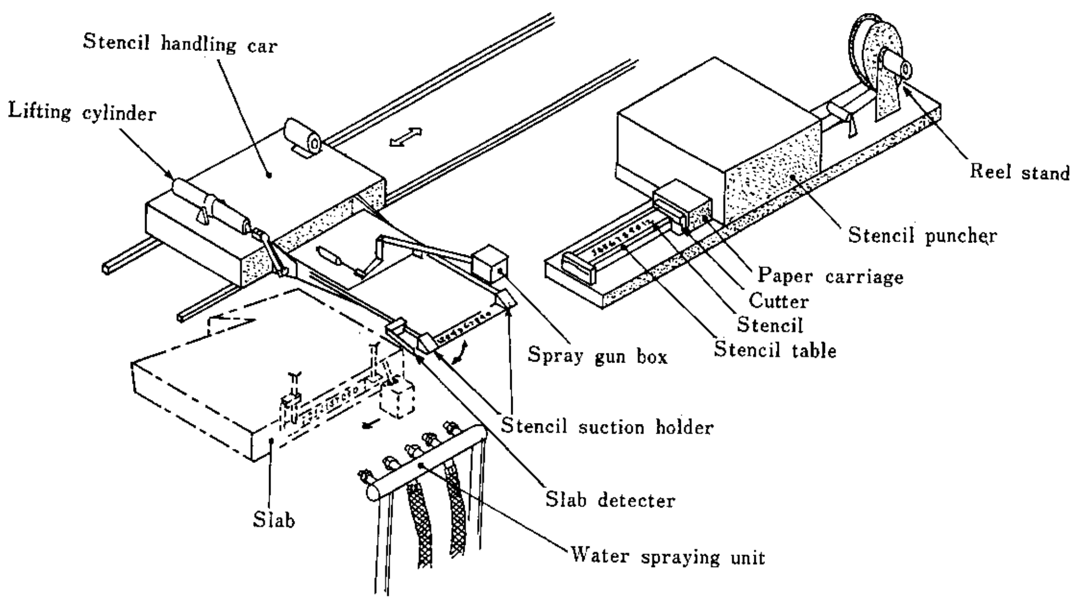
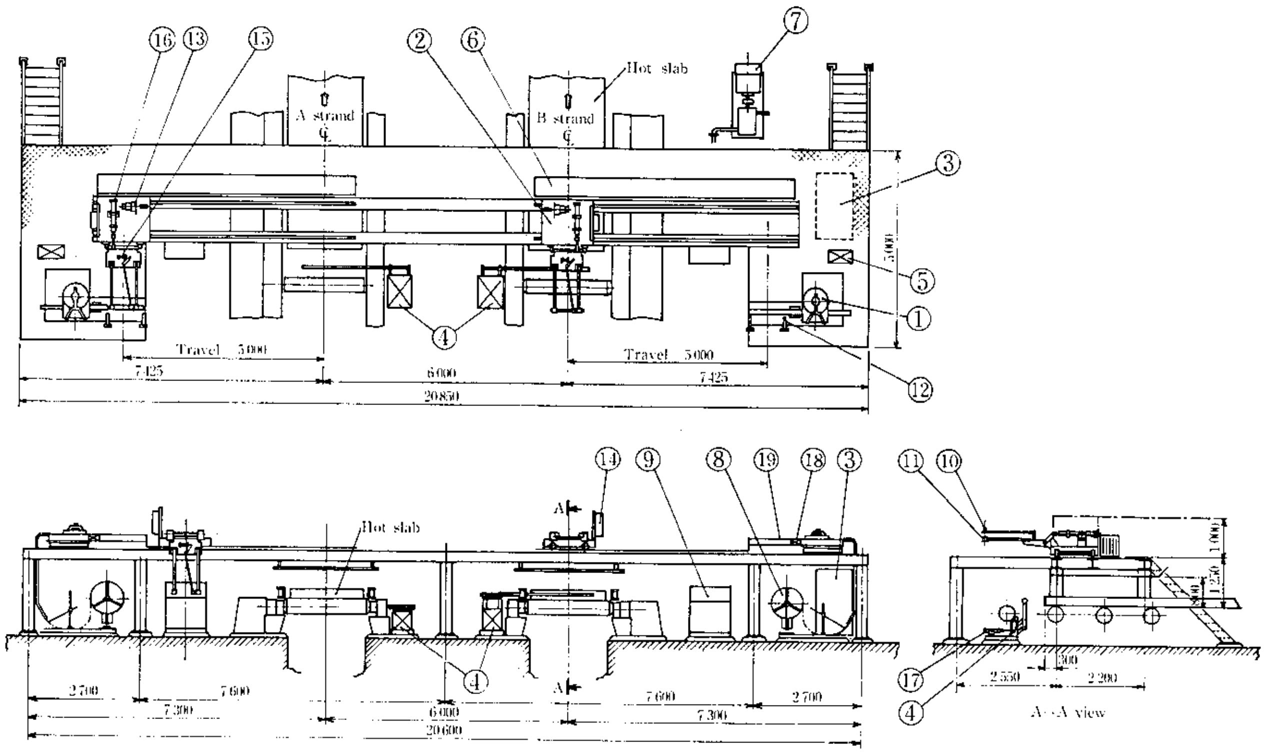


Fig. 3 Schema of the marking machine



① Stencil puncher
② Stencil handling car
③ Paint supply unit
④ Water spraying unit
⑤ Hydraulic servomechanism
⑥ Cable bear
⑦ Water supply unit
⑧ Reel stand
⑨ Disposal box
⑩ Paint spray nozzle
⑪ Stencil sunction holder
⑫ Stencil cutter
⑬ Speed reducer
⑭ Valve stand
⑮ Driving cylinder
⑯⑰ Lifting cylinder
⑱ Paper carriage
⑲ Stencil table

Fig. 4 Installation example of the marking machine

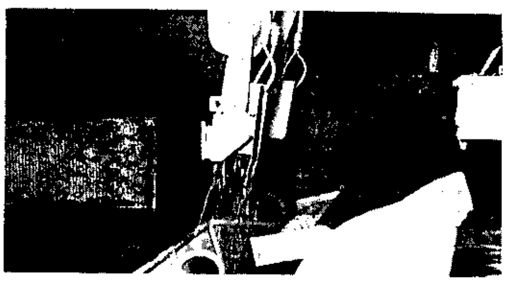


Photo. 1 Paint is sprayed through a stencil touched on a hot slab

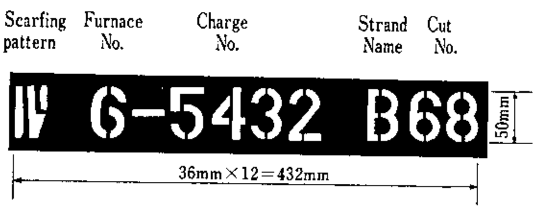


Fig. 5 Marking sample

is possible. It is also possible to input in the memory of microcomputer several charges of data in a lump by keyboard or thumb wheel switch.

3.1 Slab Specifications

Surface temperature of slab at the delivery side of the torch of the slab C.C. machine is from the range of 700 °C to 950 °C, and as shown in **Fig. 2**, regenerated temperature after the temporary water cooling is in the range of 250 to 850 °C which is good enough for the fusion of paint. Therefore, this system is applicable to any slab C.C. machine. As for the surface unevenness, allowable range is markedly wider as compared with stamper.

Marking surface is limited to the torch-cut side according to the actual results to date, but even in the marking test using other sides, flaking caused by scale has not been seen.

The time of slab in stop for marking is 20 ~ 30 sec. for temporary water-cooling (descaling), and 5 ~ 7 sec. for paint spraying. Marking pitch is about 80 sec. at minimum, giving no problem in the case of regular casting pitch of C.C. machine.

3.2 Paint

This paint was developed by a heat-resistant paint manufacturer in Japan, with its main content of TiO_2, calcium salt, clay, and 50 % water. It is non-organic soluble paint which is harmless to skin, not containing harmful organic substance such as thinner. Paint required for one time marking costs about ¥ 20 for a letter of seven digits.

3.3 Paper

Material used as paper stencil is kraft linear widely used for corrugated cardboard. A coil (650 mm in outer diameter, 24 kg in weight) of paper—0.35 mm thick and 100 mm wide—serves for some 1 360 markings for a letter of seven digits, with a cost of ¥3 ~ 4 for one marking.

3.4 Limitation in Application

(1) Type of steel

At Mizushima Works where C.C. ratio exceeds 70 %, two markers are installed in main two slab casters. These Nos. 5 and 6 C.C. machines turn out many kinds of slab for plate, pipe and hot-and cold-rolled steel strip.

No surface defect has ever occurred by temporary water-cooling, and it is judged that no problem exists for normal carbon steel, and low alloy steels. Furthermore, experiments confirm that no problem exists for silicon steel.

In the case of stainless steel, however, thin layer of scale is generated all over the torch-cut surface at low temperature zone even after descaling. The scale turns into small flakes and falls over the entire surface; therefore, marking is considered impracticable.

3.5 Rust Problem

Letters once marked will not be erased or disappear. However, there is one problem in case of inadequate cooling condition after marking; red rust is generated over the surface of slab, covering the marking and degrading the clarity, depending upon the method of cooling at the cooling yard. This phenomenon takes place only when slabs of fairly high temperature are piled up one over the other in more than four layers, and water-cooled slowly in a considerable length of time, without any air-cooling. The problem of red rust does not take place in the case of slabs for air-cooling alone, or not subjected to water, or if slabs are immersed into water tank so as to lower temperature as quickly as possible. Also the red rust problem does not take place since slab surface temperature is lowered to 600 ~ 700 °C when slabs are piled at the cooling yard.

4 Summary

Kawasaki Steel has developed a unique hot slab spray marker. Features of this device can be summarized as follows:

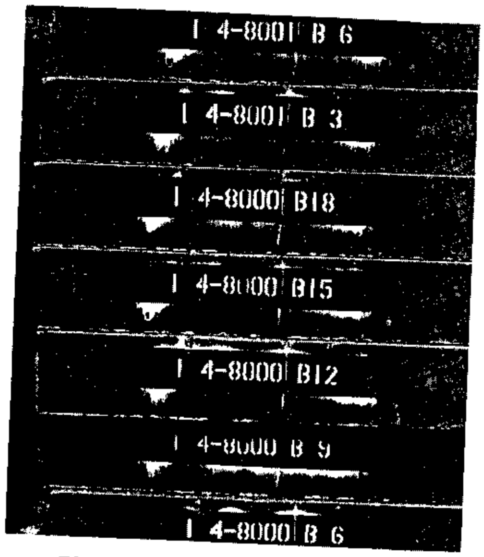


Photo. 2 Piled slabs with marks

(1) Identifiable even from 10 m away because of the clarity of white paint (see **Photo. 2**).
(2) No erasing or disappearing of markings even slab is left outdoors for many months.
(3) Marking is possible on more uneven surface by this device than by a stamper.
(4) Complete unmanned operation is possible, thus contributing to a considerable manpower saving.

For the above reasons, the subject device has almost satisfied demand of production fields. This device is expected to expand its use as an indispensable auxiliary to the slab C.C. machine.