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(54) Titre : PROCÉDE DE RECONNAISSANCE ET DE CLASSIFICATION DE DEFATS DE SURFACE SUR DES  
 BRAMES COULEES EN CONTINU  
 (54) Title: METHOD FOR DETECTING AND CLASSIFYING SURFACE DEFECTS ON CONTINUOUSLY CAST SLABS

(57) **Abrégé/Abstract:**

The invention is directed to a method for the detection and classification of surface defects on continuously cast products using topographical information about the appearance of continuously cast surfaces, wherein defects and/or flaws are determined with respect to their exact position, evaluated with respect to their location and dimensions, and eliminated in accordance with the evaluation prior to further machining of the product, or are prevented by optimizing the process. The aim is a more reliable and only strictly necessary evaluation of defects. This aim is achieved in that, on the one hand, the defects and/or flaws on the slab surface of the continuously cast preliminary product are detected and are stored with respect to their exact position and, on the other hand, a detection of defects and/or flaws on the finished product is carried out and stored with respect to their exact position, and in that the information from the preliminary product is then compared with the information from the surface inspection on the finished product, and only the information which has led to, or can lead to, defects on the finished product is taken into account for the elimination of defects and/or flaws on the preliminary product.



**Abstract**

The invention is directed to a method for the detection and classification of surface defects on continuously cast products using topographical information about the appearance of continuously cast surfaces, wherein defects and/or flaws are determined with respect to their exact position, evaluated with respect to their location and dimensions, and eliminated in accordance with the evaluation prior to further machining of the product, or are prevented by optimizing the process. The aim is a more reliable and only strictly necessary evaluation of defects. This aim is achieved in that, on the one hand, the defects and/or flaws on the slab surface of the continuously cast preliminary product are detected and are stored with respect to their exact position and, on the other hand, a detection of defects and/or flaws on the finished product is carried out and stored with respect to their exact position, and in that the information from the preliminary product is then compared with the information from the surface inspection on the finished product, and only the information which has led to, or can lead to, defects on the finished product is taken into account for the elimination of defects and/or flaws on the preliminary product.

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METHOD FOR DETECTING AND CLASSIFYING SURFACE DEFECTS ON  
CONTINUOUSLY CAST SLABS

The invention is directed to a method for detecting and classifying surface defects on continuously cast products using topographical information about the appearance of continuously cast surfaces in which defects and/or flaws are determined and evaluated with respect to their exact position.

Numerous methods are known for detecting and eliminating surface defects on materials such as continuously cast products. For example, according to EP 0 880 023 A1, surface defects can be detected automatically and are removed subsequently by a grinding machine before further processing, that is, before finish rolling in a roll mill. The grinding machine used for this purpose can operate reversibly so that successive defects or defects which are scattered over large surface areas can be determined by an inspection device arranged in front of and behind the grinding machine and can then be eliminated.

In this method, defects are evaluated on the basis of comparisons with stored models so that the quality of defect detection and, therefore, elimination depends upon the material that has been stored.

Accordingly, superfluous work steps cannot always be avoided.

In principle, only those surface defects which also lead to defects in the rolled product, e.g., hot strip or sheet, should be detected and evaluated. It is not necessary to eliminate all of the other flaws on the slab surface.

Therefore, it is the object of the invention to provide a method by which a more reliable and only strictly necessary evaluation and subsequent elimination of defects can be achieved.

In so doing, the information obtained in this way is used in conformity to the assessment to eliminate the defects before further machining of the product or for timely determination and classification of the possible quality of the finished product.

In a method for the detection and classification of surface defects on continuously cast products using topographical information about the appearance of continuously cast surfaces in which defects and/or flaws are determined with respect to their exact position, evaluated

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with respect to their location and dimensions, and eliminated in accordance with the evaluation prior to further machining of the product, the above-stated object is met in that, on the one hand, the defects and/or flaws on the slab surface of the continuously cast preliminary product are detected and stored with respect to their exact position and, on the other hand, a detection of defects and/or flaws on the finished product is carried out and stored with respect to their exact position, and in that the information from the preliminary product is then compared with the information from the surface inspection on the finished product, and only the information which has led to, or can lead to, defects on the finished product is taken into account for the elimination of defects and/or flaws on the preliminary product.

According to one aspect of the present invention, there is provided a method for the detection and elimination of surface defects on continuously cast products, the method comprising: a) detecting continuously cast defects on a surface of a continuously cast product and evaluating a position and dimension of each of the detected continuously cast defects; b) storing continuously cast defect information including the position and dimension for each of the continuously cast defects; c) processing the continuously cast product to create a finished product; d) detecting finished product defects on the finished product; e) storing the finished product defect information with respect to an exact position of each of the finished product defects on the finished product; f) comparing the detected finished product defects with the detected continuously cast product defects to determine information that can lead to the finished product defects; and g) based at least in part on the information determined by the comparing, eliminating or preventing the finished product defects on subsequently produced finished products.

According to the invention, the surface topography of the continuously cast slabs is determined by suitable methods. Such methods are optical methods operating in the visible or invisible spectrum of light or microwave-based methods. In the visible range, fringe projection methods and stereoscopic methods are used. Laser-based methods are also possible. The information about surface topography acquired by means of one or more of these methods is stored in a location-

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dependent manner, i.e., corresponding to position. The evaluation of detected changes in topography can be carried out by suitable classifying methods, e.g., neural networks, or the like.

According to the invention, the method is characterized by a learning  
5 phase during which the classification methods are optimized so as to distinguish between irrelevant surface flaws and relevant surface defects which lead to, or have led to, surface defects on the finish-rolled products, in this case, hot strip or sheet.

For this purpose, the results of a surface inspection on the finished  
product are linked to the slab inspection system. In particular, the absolute position  
10 of the defects on the finished product is converted to the absolute position on the slab surface. For this purpose, the pass sequence data such as total degree of deformation and ratio of cross rolling to longitudinal rolling are incorporated in the model. The information on the position of a likely surface defect on the slab is stored and compared with the information determined by the inspection system following  
15 finish rolling so that the self-learning effect takes place.

The relationships found by means of the classifying methods, e.g., neural networks, between the topography and the probability of the occurrence of surface defects are then used for a prediction.

The method is able to measure both hot and cold slab surfaces, and either the slab or the measuring device is moved during measurement. The movement can be carried out in discrete increments or continuously.

The topographical information obtained in this way can be stored with its absolute position in accordance with the results of the classification.

As was mentioned above, the decision about whether or not a surface defect exists which can be removed prior to further processing of the slab surface or which leads to a loss of quality on the finished product makes a learning phase necessary. This learning can be carried out manually through inspector guidelines, but is then subject to subjective errors. Therefore, according to the invention, this problem is solved by linking to surface inspection systems on the finished product.

When the method is used in an unlinked installation (slab continuous casting plant and rolling mill) without direct use of the slab or with externally purchased slabs, this learning algorithm must be implemented using a long-term database.

Another possibility consists in the use of this system within the framework of an automated slab inspection. In this case, the defects are marked by a marking robot to facilitate location for repair purposes. The position information can also be forwarded to a machining center for automatic repairs.

The method according to the invention will be described in the following with reference to the drawings.

The drawings show:

- Fig. 1 a sample in which artificial flaws, i.e., defects, have been incorporated;
- Fig. 2 the results of a measurement of the sample by means of a fringe projection method, specifically line 5 in Figure 1;
- Fig. 3 the topographical evaluation of this line;
- Fig. 4 an embodiment example for a measuring device; and
- Fig. 5 the principle of the inspecting and evaluating system according to the invention.

Flaws were artificially created in a sample for illustrating the method. This is shown in Figure 1. The lines are shown on the right-hand side of the illustration. Line 5 is referred to by way of example for the following description.

The sample was measured by means of a fringe projection method and the results for line 5 are shown in Figure 2. The topographical information can be correlated with a punctiform defect as is shown in Figure 3.

Figure 4 shows an example for the arrangement of the measuring device with projector and camera above a table roller serving to transport the slab.

Finally, Figure 5 shows the basic concept, wherein the defects and/or flaws on the preliminary product, i.e., the slab, are detected by the first surface inspection, and a second inspection device then detects defects and/or flaws on the rolled finished product. Based on the comparison that is then carried out, conclusions can be reached concerning which of the defects initially detected have also led to a defect on the finished product so that a learning process can be initiated which leads to an improved evaluation of defects on the preliminary product with the result that only those defects which are disadvantageous for the finished product need be eliminated.

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CLAIMS:

1. A method for the detection and elimination of surface defects on continuously cast products, the method comprising:
  - a) detecting continuously cast defects on a surface of a continuously cast product and evaluating a position and dimension of each of the detected continuously cast defects;
  - b) storing continuously cast defect information including the position and dimension for each of the continuously cast defects;
  - c) processing the continuously cast product to create a finished product;
  - 10 d) detecting finished product defects on the finished product;
  - e) storing the finished product defect information with respect to an exact position of each of the finished product defects on the finished product;
  - f) comparing the detected finished product defects with the detected continuously cast product defects to determine information that can lead to the finished product defects; and
  - 15 g) based at least in part on the information determined by the comparing, eliminating or preventing the finished product defects on subsequently produced finished products.
2. The method according to claim 1, wherein the continuously cast defect information and the finished product defect information comprises topographical information determined by an optical method operating in at least one of a visible or invisible region.
3. The method according to claim 1, wherein the continuously cast defect information and the finished product defect information comprises topographical

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information determined by at least one of a laser-based method and a microwave-based method.

4. The method according to claim 2, wherein the topographical information is obtained by at least one of a projection method and a stereoscopic method.

5 5. The method according to claim 1, wherein the continuously cast defect information and the finished product defect information comprises topographical information determined by at least one of visible and invisible sources of electromagnetic radiation.

6. The method according to claim 1, wherein the continuously cast defects  
10 or the finished product defects are stored in a location-dependent manner and evaluated by a classifying method.

7. The method according to claim 1, wherein steps a. to f. are performed in a learning phase wherein only defects on the continuously cast product surface which lead to surface defects on a finished-rolled product are assessed as defective,  
15 and

wherein the finished-rolled product comprises at least one of a hot strip or sheet.

8. The method according claim 1, wherein the step of comparing comprises converting an absolute position of the finished product defects on the  
20 finished product to an absolute position on the continuously cast product, and

wherein pass sequence data is incorporated in the converting.

9. The method according to claim 6, wherein a relationship between the finished product defects on the finished product and the continuously cast defects on the continuously cast product and a probability of occurrence of surface defects on  
25 the finished product are used for a defect prediction.

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10. The method according to claim 8, wherein topographical information of the finished product defects and continuously cast defects are stored with the absolute positions depending upon results of the comparing.

11. The method according to claim 1, wherein at least one of the finished  
5 product defects on the finished product and the continuously cast defects on the continuously cast product are marked by a marking robot.

12. The method according to claim 1, wherein information obtained from the comparing is forwarded to a machining center for automatic repair of the continuously cast product.

10 13. The method according to claim 6, wherein the classifying method utilizes a neural network.

14. The method according claim 8, wherein the pass sequence data comprises at least one of a total degree of deformation and a ratio of transverse rolling to longitudinal rolling.

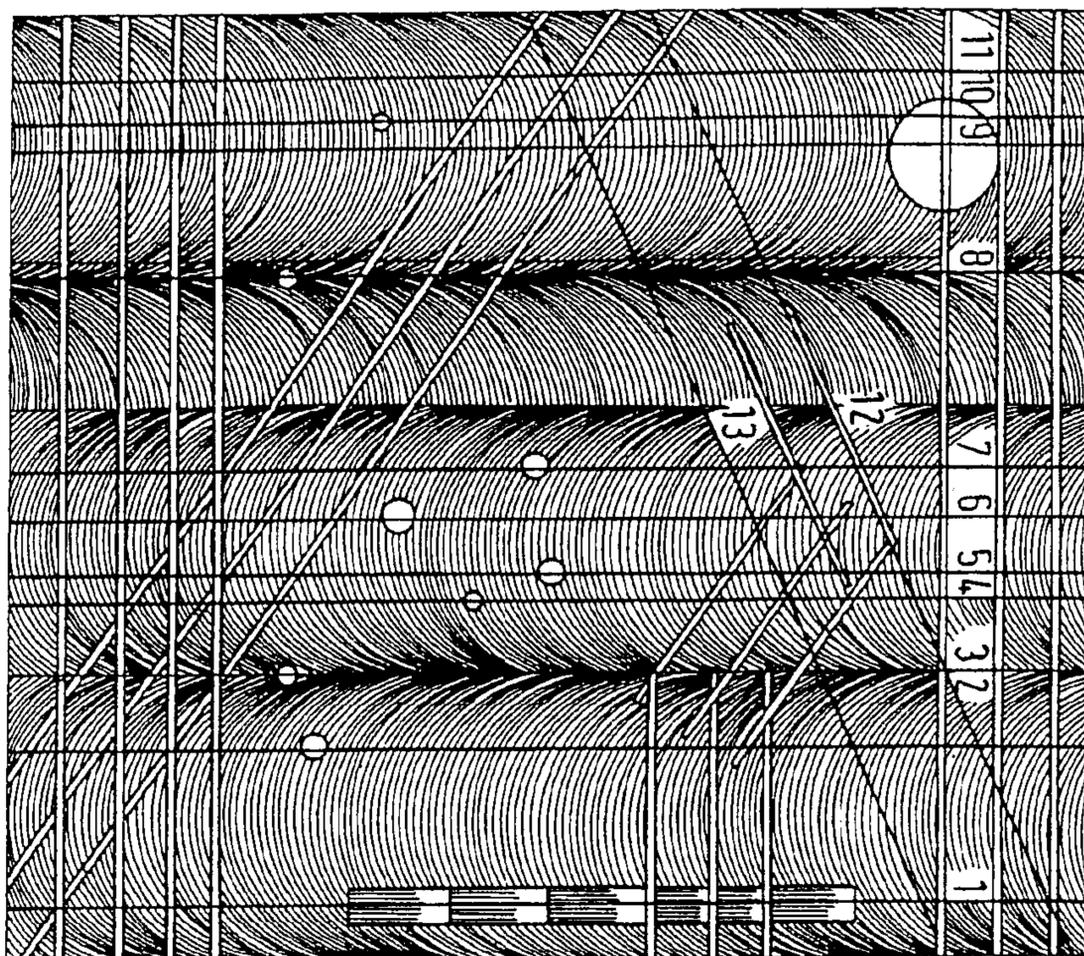


Fig.1

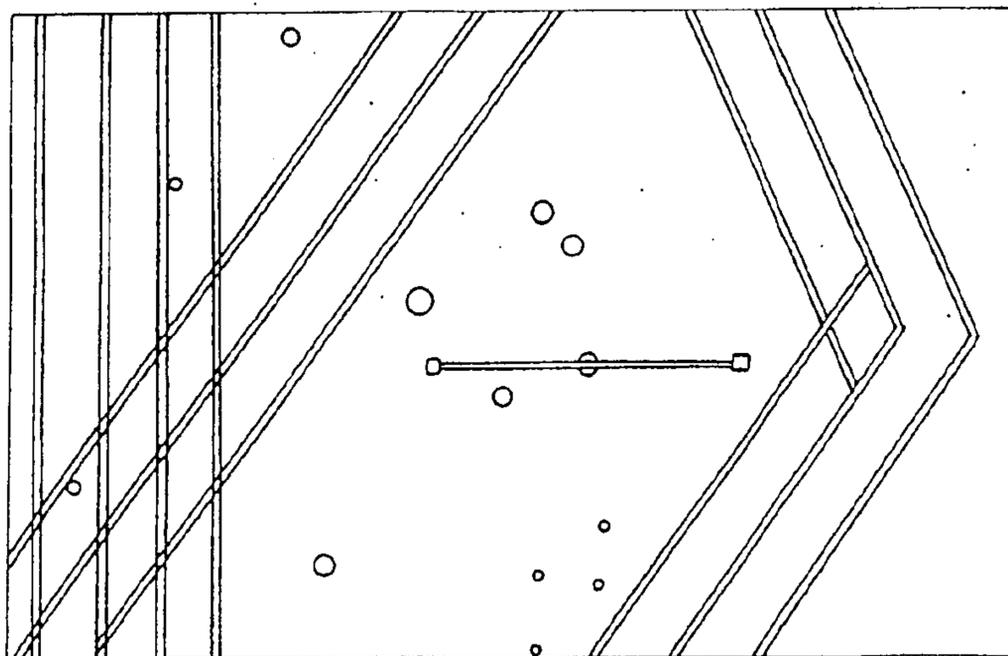


Fig.2

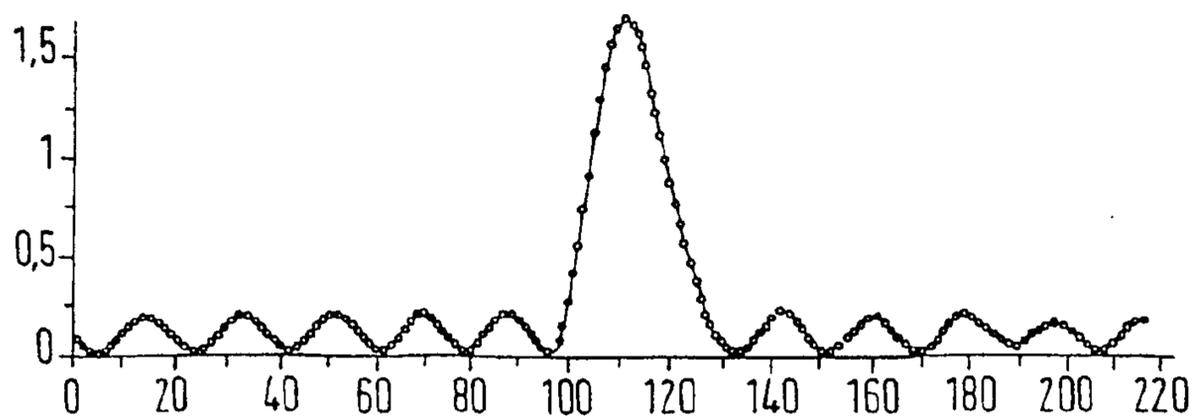


Fig.3

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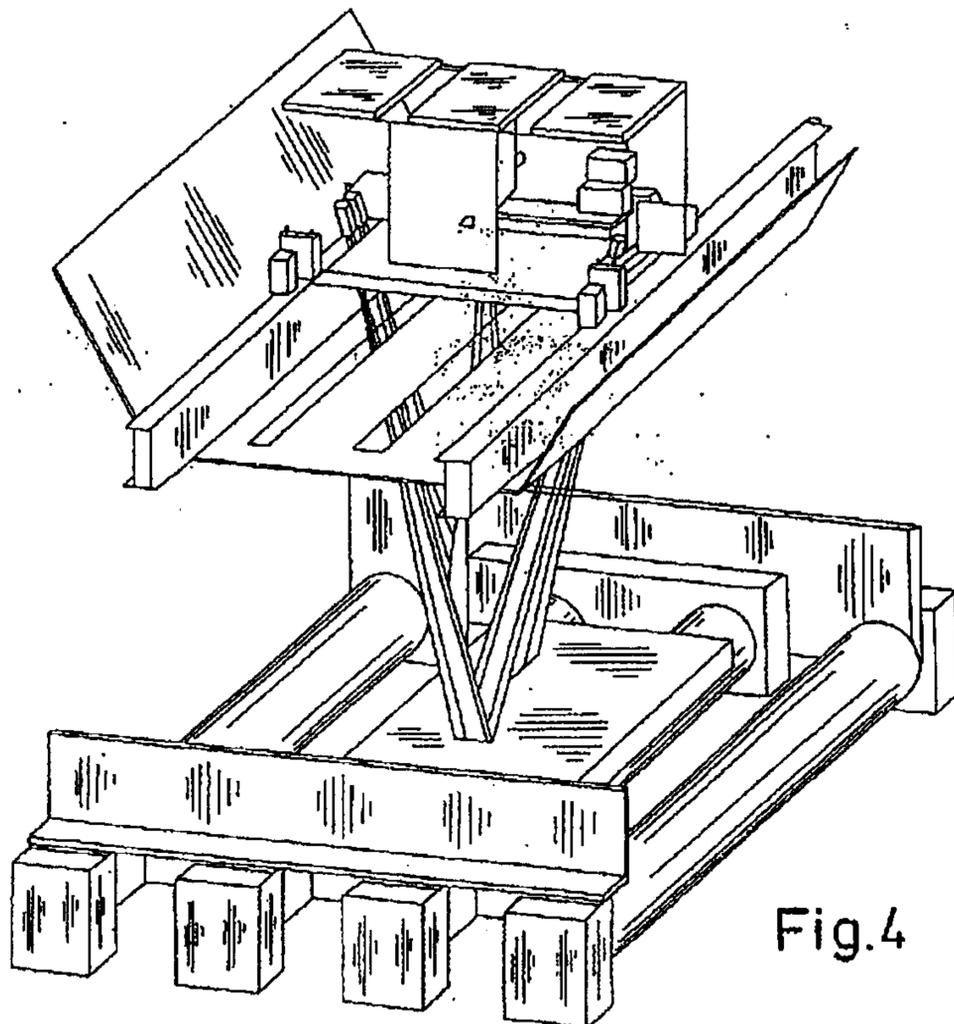


Fig. 4

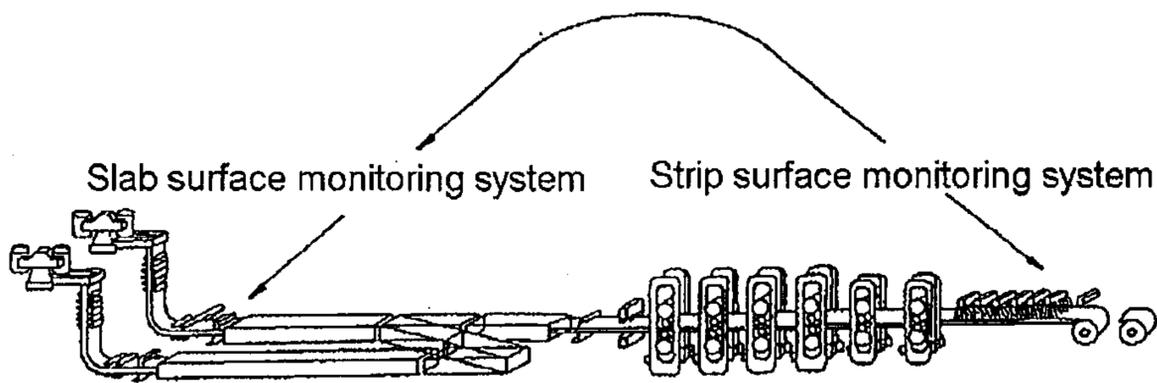


Fig. 5