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CRYSTALLIZER'S DESKS SURFACE DIAGNOSTICS WITH USAGE OF ROBOTIC SYSTEM

DIAGNOSTYKA POWIERZCHNI PŁYT KRYSTALIZATORA Z ZASTOSOWANIEM SYSTEMU ROBOTYKI (SYSTEMU ZAUTOMATYZOWANEGO)

Discussed problems are solved in Arcelor Mittal Ostrava a.s. company. VSB-TU Ostrava has its share on this solution in the frame of grant project TIP. The project has several goals, which relate with primary cooling system area in CSCD (Continuous Steel Casting Device). One target is concerned about surface quality of crystallizer's desks, also from point of view of its quality evaluation.in terms of project solution was solved a crystallizer's desks defects catalogue and methodology of their evaluation. Also was made methodology for quality evaluation of narrow crystallizer's desks, which are dismantled in maintenance area. There were proposed a laser scanning of the crystallizer's desks surface with usage of Laser sensor. In cooperation with DASFOS CZ, s.r.o. was proposed new method of inner crystallizer's chamber measuring. In this paper are presented partial results of this solution, including first results from prototyped measuring device.

Keywords: steel, casting, crystallizer, quality, laser

Omawiany problem został rozwiązany przez firmę Arcelor Mittal Ostrava. VSB-TV Ostrava posiada swój udział w tym rozwiązaniu będący wynikiem realizacji projektu TIPFR-TI1/319 finansowanego częściowo przez Ministerstwo Handlu i Przemysłu Republiki Czech. Projekt skupia się na kilku celach związanych z maszyną COS (ciągłego odlewania stali). Jeden z celów projektu dotyczy jakości powierzchni płyt krystalizatora z punktu widzenia oceny tej jakości. W rezultacie powstał katalog wad płyt krystalizatora wraz z metodologią ich oceny. Zaproponowana została metoda oceny jakości wąskich płyt krystalizatora zdemontowanych na czas konserwacji. Zaproponowano skanowanie powierzchni płyt krystalizatora z wykorzystaniem czujnika laserowego. We współpracy z DASFOC CZ. S.r.o. została zaproponowana nowa metoda pomiaru wewnętrznej przestrzeni krystalizatora. W pracy przedstawiono wybrane wyniki tego rozwiązania wraz z wstępnymi wynikami uzyskanymi przy pomocy prototypowego urządzenia pomiarowego.

1. Introduction

Grant project of Department of Trade and Industry of CR, in the frame of TIP program, under evidence number FR-TI1/319 „Development of New Progressive Tools and Systems of Dependability Control Support of Primary Cooling on Slab Device of Continuous Casting for Quality Improvement of Demanding Flat Products " is solved in company Arcelor Mittal Ostrava a.s. Co-resolver of this project is VSB-TU Ostrava, FMMI, department of automation and computing in metallurgy. Project results were partly presented in [1-3].

One of the project solution stages, concerning to primary cooling in CSCD is an identification of diagnostics quantities and development of diagnostics system (stage 2). In frame of given stage is also paid attention on problems of crystallizer's desks quality problems. There were made a methods for evaluation of quality of narrow crystallizer's desks by co-resolver of grant project (VSB-TU Ostrava), which are dismantled in the framework of maintenance. For that purpose were designed crystallizer's desks scanning by laser distance sensor. In cooperation DASFOS CZ, s.r.o. was proposed new method of inner crystallizer's chamber measuring. In this paper are presented partial results of this solution, including first results from prototyped measuring device.

2. Methods of crystallizer's desks quality control

The part of the establishment of CSCD in Arcelor Mittal Ostrava a.s. was assignment of documentation for CSCD (supplier S-VAI). In this documentation are presented the ways of repairs, including repairing terms and description of defects limits, such as maximum size (depth) of the crack in the crystallizer's desks. Maintenance crew in CSCD then follows the instructions presented in documentation. With regard to continuous increasing product quality, implementation of new, more rugged steel types, so as with regard to continuous pressure to increase service life of productions process components, while lowering production costs is this documentation insufficient. In other words, it is need to have data and evaluating system with needed analytical methods. With help of this system is able to search connections between qualita-

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tive parameters of the product (blanks) and parameters of the crystallizer's desks service life (occurring of specific described defects on the desks). The last mentioned aspect is solved in cited project in three stages.

2.1. Crystallizer's desks defect catalogue and defect evaluation methodology

The main goal when creating the catalogue was detection and mapping most common defects of the crystallizer's desks. Desks defects are appearing as on narrow desks so on wide desks. In the catalogue are these defects divided on surface defects, under the surface defects and shape defects. Mostly occurring defects are surface defects. Every defect has its own description on the catalogue. There are information about position of the defect on the desks (for of the picture), defect characteristics, probably cause of the defect origin, possible preventive steps of defect origin, possibilities which can fix the defect (in terms of maintenance or renewals of crystallizer's desks surface). Further are mentioned supplementary information, including photos of each defect type. Preview from the catalogue is presented on Figure 1.

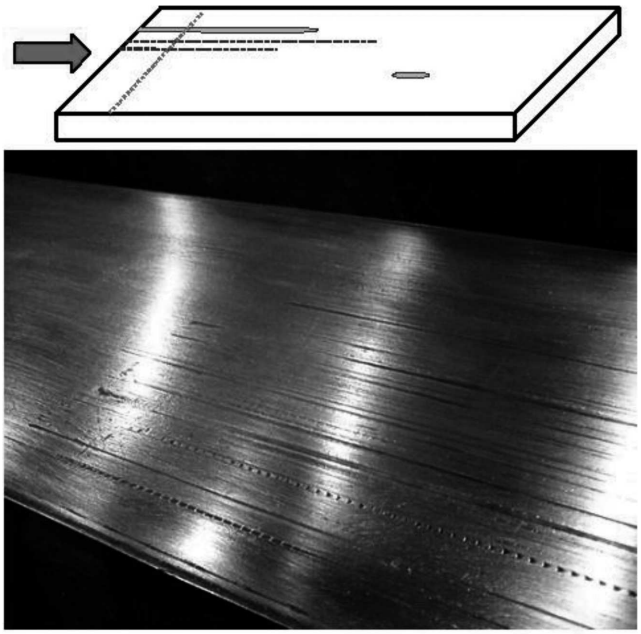

Fig. 1. Preview from the crystallizer's desks defects catalogue [4]

In methodology proposal is mentioned quantitative evaluation of crystallizer's desks defects, whereas is there also mentioned current defect evaluation state. Defects discussed in Crystallizer's desks defect catalogue are in evaluation methodology specified by place of occurrence, by the picture chart, by form of photos. In the methodology evaluation is then presented the table, in which are specified parameters such as maximum length, wide and depth of the defect. In proposed methodology are presented equations, which is need to calculate the quality degree "Q" of current desks with usage of tracked parameters. In present time is planned a verification of proposed methodology for defect evaluation in operational conditions in maintenance department of Arcelor Mittal Ostrava a.s.

3. Narrow desk's surface quality evaluation method development

In terms of above mentioned grant project was in department of automation and computing in metallurgy, VSB-TU Ostrava laboratories developed a method for verification of surface quality of narrow crystallizer's desk on the laser sensor basis. The goal is method and operational device proposal, for visualization and evaluating of the surface of the desk on operational maintenance area in the time, when the crystallizer is dismantled on single pieces. Because in almost all cases this means elimination of the desks, is the goal of the analysis mapping surface quality on the lifetime end and from the results gain other completive information into the developed system. It is not possible to catch and measure all of the dimensional changes by manual way in comparison with original desk's state. [5]

Proposal of the method is in several stages. The solution base is verification of possibilities of laser distance sensor and examination of its fitness. For that purpose was created simple mechanical device for surface scanning, which was verified and on its basis was created new laboratory model, which is able to automatically drive horizontal shift of laser sensor – Figure 2 . At the same time was created software application to visualize gathered data [3].

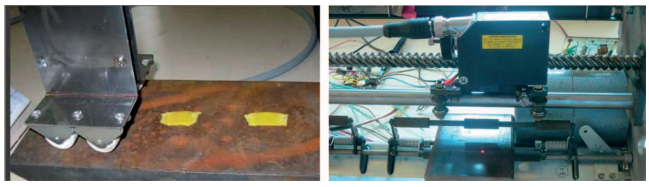

Fig. 2. The look at simple mechanical device for surface scanning and the laboratory model with horizontal shift of distance laser sensor

For operational solution was proposed and made a prototype of robotic device with linear horizontal travel – see in Figure 3. This device is planned to interconnect with measuring computer, which will be recording measured data, visualize and evaluate state of the crystallizer's desk [6].

This device is connected into the measuring computer, which can record measured data, perform its filtration and transform them into proper shape for visualization and evaluate crystallizer's desk state according the classification which is used in Arcelor Mittal Ostrava a.s. company.

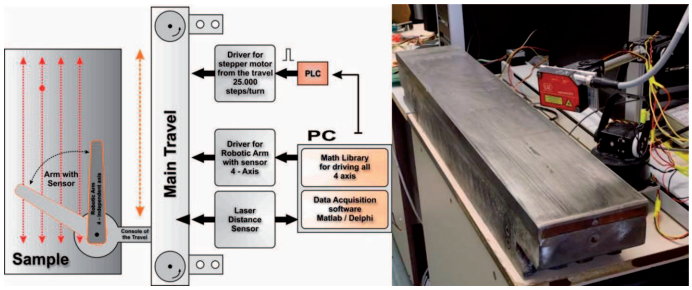

Fig. 3. Prototype device for narrow crystallizer's desk quality evaluation and the photo of prototype device

Diagnostic device

Diagnostic device is based on laser distance sensor OptoNCDT 1302/200 which used special triangular measurement, interconnected with PC through the multifunction A/D card NI PCI 6221.

Laser sensor OptoNCDT 1302/200

The sensor from Micro Epsilon company with measurement range of 200 mm were chose to laboratory testing and to confirm proposed method, can achieve resolution of 500 μm with sampling speed of 750Hz.

Diagnostics measurement through the NI PCI 6221 I/O card

Data acquisition card presented in has a PCI bus interface and it is relatively powerful device, suitable to capturing analog quantities or binary signals. This card is capable to generate digital signals too [3]. Card is mentioned to work with cooperation with Windows OS and Matlab and LabView environment.

To be able to scan surface of the material (crystallizer, metal) with NI PCI 6221 card, we had to correctly set the program Matlab and then measurements were taken.

It was also necessary to choose parameters: of measuring mode between synchronous and asynchronous, the very type of card or other measuring devices installed, set the number of samples captured per second, setting the block size of input type, measurement channel selection and the possibility of setting the output of the block.

To measure, the following settings were chosen with the following parameters: asynchronous signal at a frequency of scanning 10,000 samples per second from the connected channel AI8, the measurement time 8 seconds and a normal type of measurement. These parameters have been set in the window with the Simulink block diagram.

Measurements were performed, which can be seen in the Scope block. File with the time course of values was inserted into the block simout with graphic rendering during the measurement.

3.1. Diagnostics system components testing

The solution base and therefore the proposal were to verify the diagnostic possibilities of laser sensors and assess its suitability. For this purpose it was created simple mechanical device for scanning the metal surface (see Fig. 4).

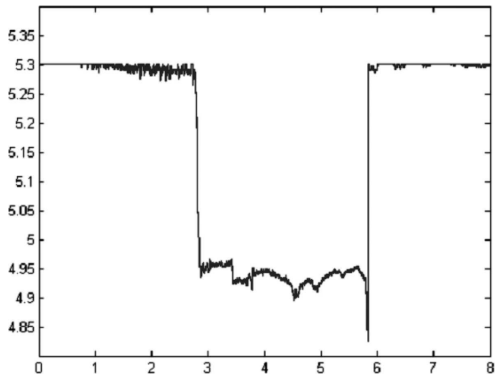

Fig. 4. Captured signal on the surface of the metal ingot

With such proposed equipment experiments were made to verify possibility of basic components of diagnostics system. On (Fig. 5) are graphical results samples presented.

On Figures 5 and 9 are illustrated a sequence of transformation of real crystallizer surface measurement. A robotic system with laser distance sensor measure crystallizer's desks surface (Fig. 5). Then attend to transfer of measured data into the PC. The PC then filter (Fig. 6) them and then perform (Fig. 7, Fig. 8) a transformation of data on visualization map (Fig. 9).

Fig. 5. Crystallizer's desk surface detail with laser dot from laser distance sensor

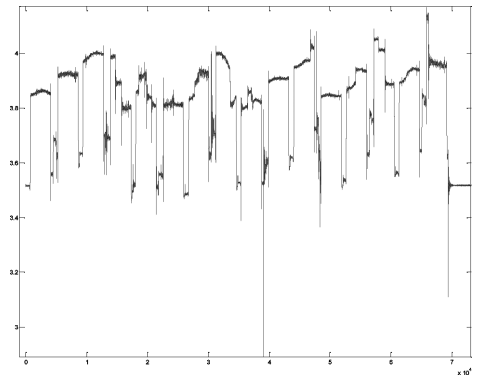

Fig. 6. Data from laser sensor without primary filter

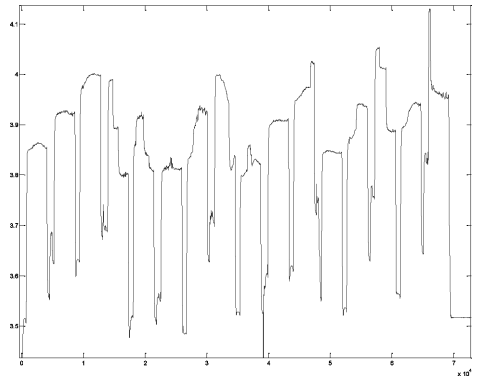

Fig. 7. Laser sensor's output with the basic filter applied

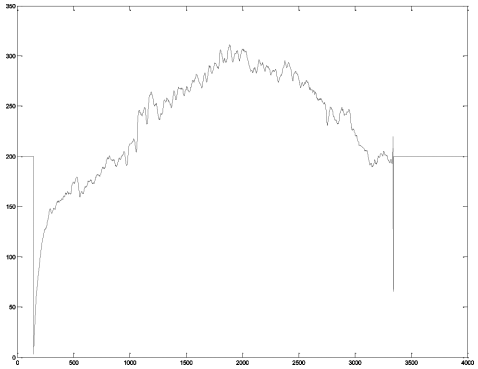

Fig. 8. Detail of one pass through on the desk's surface

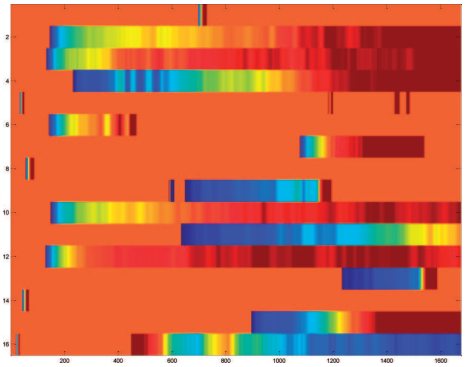

Fig. 9. Testing visualization map with defect height definition

Usage

The focus of the used solution is increasing of advantages of the continuous steel casting device, which can be achieved only by management system's that will minimize undesirable influences on the technological process. Among the significant side effects affecting the efficiency of the process of the continuous steel casting device belong wear of the crystallizer which is causing disturbance and operation disruption. These problems are solved with cooperation with regional metallurgical companies. Proposed method is then used in this companies in test mode to obtain operational feedback. Gained results will be applied into the operational conditions.

4. Conclusion

In this paper is presented part of the results from grant project, which is concern the area of primary cooling in CSCD, especially crystallizer's surface quality. It was presented part results from crystallizer's defect catalogue and Methodology of their evaluation. In terms of this paper was presented a method to evaluate narrow crystallizer's desk qualities, which are dismantled when they are in maintenance department. At the end of this paper are presented information of proposed laser scanning method when scanning inner crystallizer's chamber. This method is developed in term of cooperation with DASFOS CZ, s.r.o. company.

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