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NEURAL SYSTEM FOR DETECTING CRAKS IN THE WIRE OF THE CONTINUOUS CASTING

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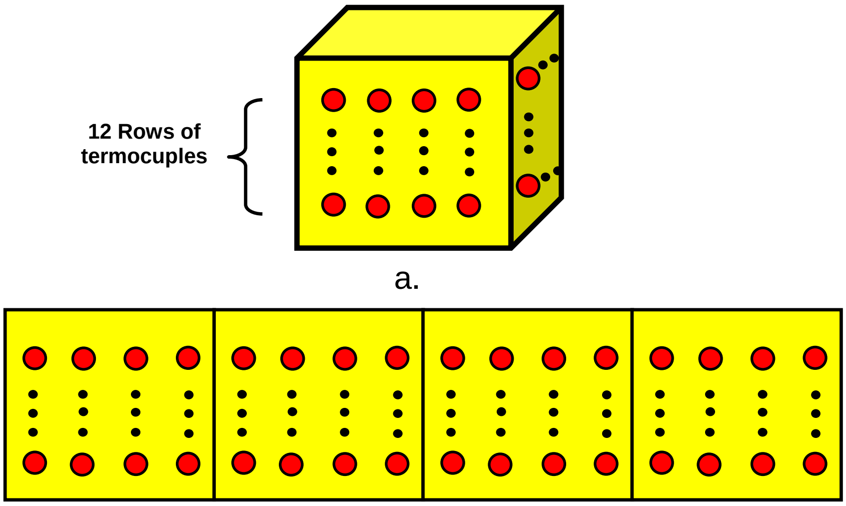
ABSTRACT
In the process of continuous casting, the melted steel from the melting pot is passed, through the intermediary of the distributor, in the water-cooled crystallizer tank. In this way, a crust forms here which is solidified at the exterior, and one of the great problems is its cracking or even its tearing, due to several factors. This phenomenon determines the stopping of the technologic process and significant economic losses. Thus, the conception of a system capable of determining the cracking in the incipient stage imposed itself. The conclusion was reached that a neural system is the optimal solution for predicting the tearing in the wire, in the process of continuous casting.
Keywords: neural system, continous casting, cracks, wire

1. INTRODUCTION
During the casting, the crystallizer tank receives the liquid steel in its upper part in precise conditions of temperature and debit, and, at the lower part, a semi-finished product with solidified crust and liquid core is extracted at constant speed. In the first stage, due to the direct contact between the metal and the water-cooled crystallizer tank, the transmission of heat is very rapid and a low-thickness solid crust forms quickly. As the product goes down in the crystallizer tank, the solid crust shrinks, thus resulting an interstice of air between the semi-finished product and the crystallizer tank, considerably restraining the transmission of heat. In this stage, the piercing of melted metal can occur through the thin crust, especially if the interstice of air does not have a constant thickness on the perimeter of the crystallizer tank. In this case, the efforts due to the ferro-static pressure are maximal in the region where the crust is thin, thus the deformations and tearing being the most frequent in this area. An abnormal process of cooling inside the crystallizer tank can also lead to the appearance of cracks, especially in its upper part.
Another possible factor of apparition of cracks is too high the casting speed, which can lead to forming too thin a crust in the crystallizer, with no sufficient resistance to the ferro-static pressure of the liquid core. Analyzing each of these causes of the apparition of cracks, one can notice that an important role is detained by the mechanic resistance of the newly-formed steel crust in the crystallizer tank, as well as by the size of the forces of friction between the internal wall of the crystallizer and the crust. All these phenomena are hard to be modeled mathematically.

2. BASIC PRINCIPLES FOR DETECTING CRACKS IN THE WIRE
There was established that when a crack occurs, the liquid steel touches the crystallizer's wall, causing an increase in its temperature. That's why, the crack can be detected by means of several heat sensors mounted on the crystallizer's wall both on its width and on the direction of casting. In this way, 12 equidistant rows of sensors will be placed on every wall of the crystallizer, each of them having 4 sensors, fig.1.



b.

Figure 1. Dispose of the termocuples on the crystallizer wall
a) Crystallizer; b) Open crystallizer .● - Termocuple

Not all increases of temperature are cracks in the incipient stage. A real crack has a certain pattern for the temperature, as well as a particularly achieved displacement.

In the figures 2 and 3 were presented the temperature patterns measured by the sensors from a certain row, as well as by the sensors of the very next row. In figure 2, when the crack of the crust reaches the upper row of thermocouples, the temperature registered by them increases. When the crack of the crust reaches the next inferior row of thermocouples, with a certain delay due to the flowing speed, the temperature registered by these thermocouples increases also, following the same pattern of temperature as in the case of the upper row thermocouples.

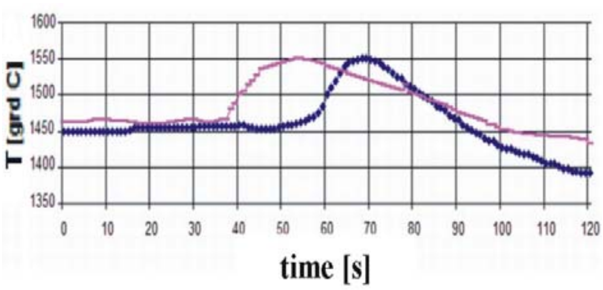


Figure 2. Temperature patterns - the existence of the crack

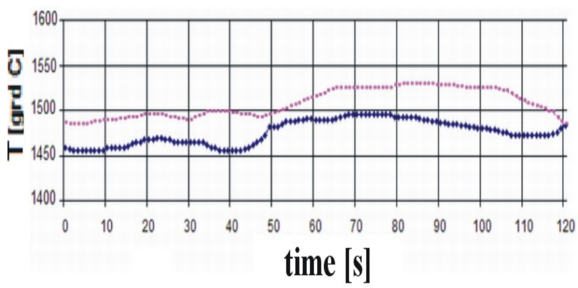


Figure 3. Temperature patterns – no crack

Another similar pattern of temperature is also recognized by the adjacent thermocouples (horizontally).

In the figure 3 are presented the temperature patterns measured by the sensors from a certain row and from the next inferior row, in case the crack did not occur.

The accuracy of the crack detecting system depends both on the pattern recognition and on the displacement performed by the crack.

In this way, a neural system can analyze the signals provided by the sensors mounted on the crystallizer's walls and can recognize the apparition of crack very accurately, and the system managing the process can order the necessary measures to eliminate the crack (e.g.: to reduce the casting speed).

3. ARCHITECTURE FOR PREDICTING THE BREAKING OF THE WIRE

There was established that when a crack occurs, the liquid steel touches the crystallizer's wall, causing an increase in its temperature. Based on that, we are able to make up a system meant for predicting any fissure, by using a number of temperature sensors mounted on the wall of the crystallizing apparatus, and whose signals are analyzed by a system of multi-neurons (Fig. no. 4). This system is able to analyse all the data received from the thermal-couples and give the right answer.

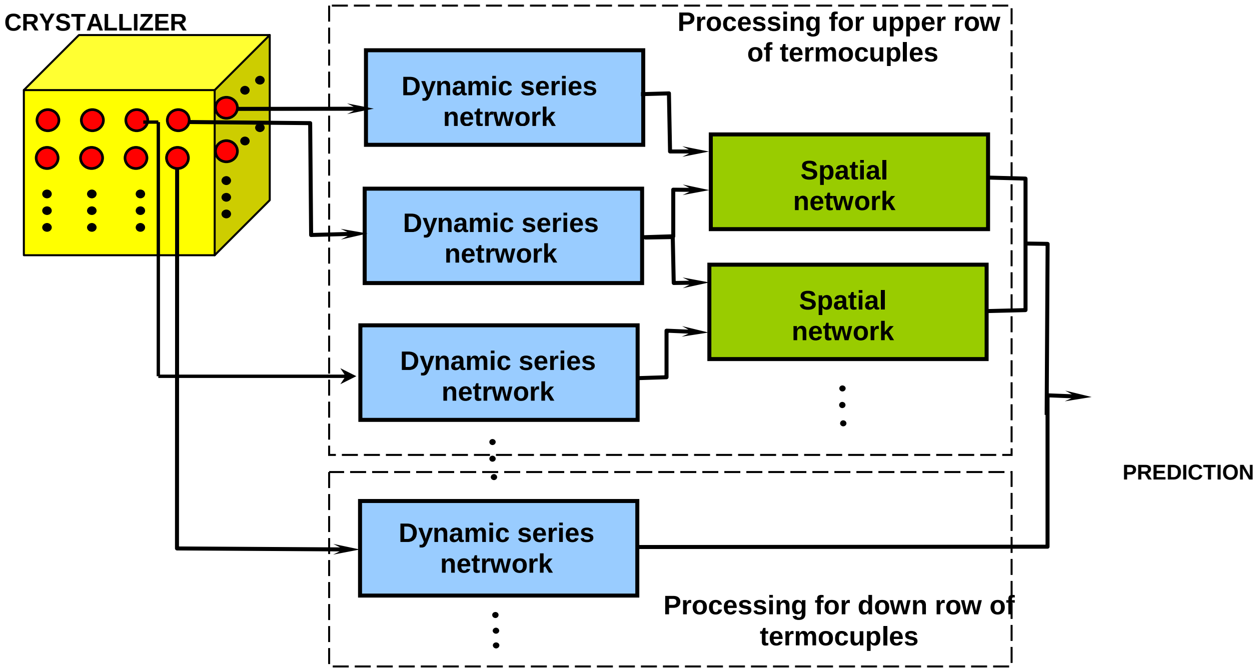


Figure 4. The block scheme of multi-neural network sistem

The phenomenon of apparition of crack is characterized by the dynamic increase and decrease of the temperature recorded by the individual thermocouples (case 1) and by its spatial distribution in the crystallizer (case 2).

In the crystallizer, the temperature can vary, so that, if we take into account only the case 1, its variation can predict the apparition of breaking. In order to achieve a competitive breaking-detection system, the neural networks recognized both case 1 and case 2. In order to cover both cases with a single neural network, this will be very complex and will involve many problems, including the difficulty in learning of the internal coefficients.

In the present case, is presented a solution based on a system composed of several multi-layer neural networks. This system is formed of a neural network receiving as input data the dynamic series of temperature from the individual thermocouples of the upper and lower row, called the dynamic series network and a spatial network, which receives the input data from every pair of adjacent thermocouples from the upper row. These data represent the dynamic series of temperature used to recognize the case 2. To each thermocouple taken aside, both from the upper and the lower row, corresponds a dynamic series network and the spatial networks correspond each taken aside to a pair of adjacent thermocouples from the upper row. The breaking is predicted by the dynamic series network corresponding to the thermocouples of the lower row and by the spatial network in the following stage. It is considered that the solidified crust is non-uniform when the dynamic series network corresponding to the lower row thermocouples record an important modification of the temperature. In order to recognize the case 2, the two adjacent thermocouples for the upper row are used and the corresponding ones of the lower row. In this way, the crack of the wire can be detected early, in the initial stage of its propagation, so that there is enough time to act for preventing the breaking. The structure of the neuronal system used for detecting fissures in case of continuous processing is described in Fig. no. 5.The main features of the system are the following:

- In order to allow the dynamic increase or decrease of temperature inside the thermal-couples, we use a **dynamic series network** who has 10 entries, a hidden level of 8 neurons, and an exit-start button with one neuron.

- In order to allow the space temperature spreading, we use a **spatial network** who has 2 entries, a hidden level made up of 4 neurons, and an exit-start button with one neuron who is able to tell us if there are any fissures (1) or not (0).

Will be placed 12 equidistant rows of sensors will be placed on every wall of the crystallizer, each of them having 4 sensors.

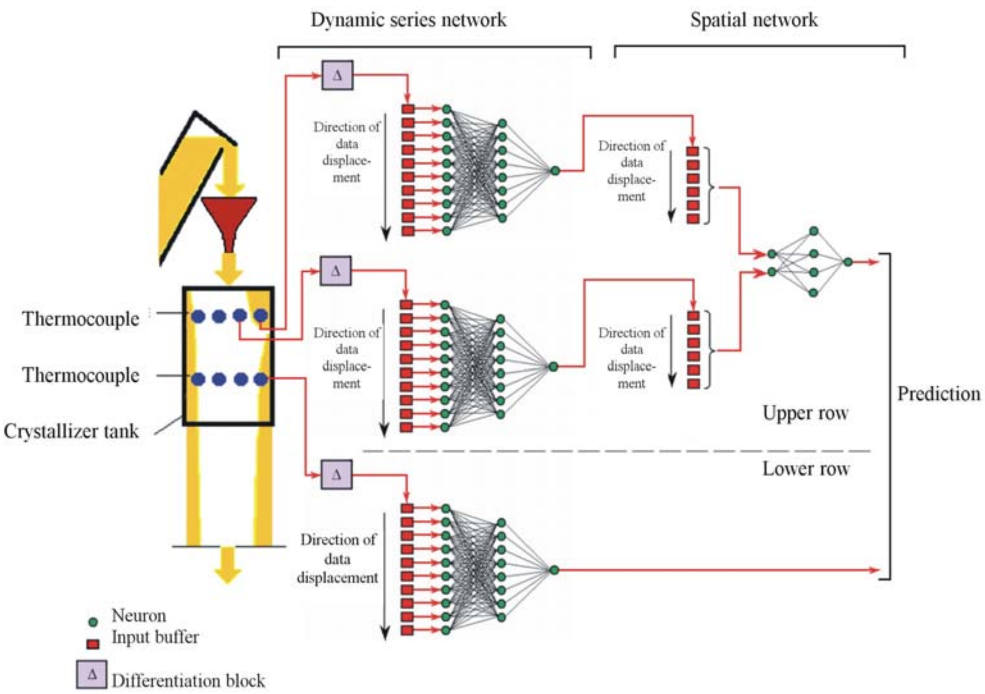


Figure 5. Architecture of the neural system of prediction of break in the wire at continuous casting

4. CONCLUSIONS

We have made up a system for any fissure-prediction by using a number of temperature sensors mounted on the wall of the crystallizing apparatus, and which is meant for detecting the increase of temperature in case of fissure production, when the liquid steel reaches the wall of the crystallizing apparatus. The signals we receive from the temperature sensors are analyzed by a multi-neuron system that can analyze the data received from the thermal-couples and give an answer at the exit. This system is made of:

- **a dynamic series network** – who represents a neuronal net who receives entry-data, which is the dynamic temperature serial number from the individual thermal-couples from the upper and bottom row of the thermal-couples;
- **a spatial network** – who represents a net who receives entry-data from each pair of thermal-couples from the upper row.

This network is a feed forward-type and it is completely connected (it sends the signal before), and it is going to be used for the continuous rolling process.

5. REFERENCES

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