

# Control system of water flow and casting speed in continuous steel casting

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**Abstract.** This paper presents the results of research based on real data taken from the installation process at Arcelor Mittal Hunedoara. Using Matlab Simulink an intelligent system is made that takes in data from the process and makes real time adjustments in the rate of flow of the cooling water and the speed of casting that eliminates fissures in the poured material from the secondary cooling of steel. Using Matlab Simulink simulation environment allowed for qualitative analysis for various real world situations. Thus, compared to the old method of approach for the problem of cracks forming in the crust of the steel in the continuous casting, this new method, proposed and developed, brings safety and precision in this complex process, thus removing any doubt on the existence or non-existence of cracks and takes the necessary steps to prevent and correct them.

## 1. Introduction

During the continuous casting of steel, in the secondary cooling stage, the process of crust solidification continues and can develop cracks. In order to detect and remedy cracks that may occur a simulation was made using Matlab Simulink which analyzes the signals from a temperature sensor and provides the necessary corrections. Thus, compared to the old methods of tackling the problem of crust cracks in the continuous casting of steel, such as technological methods (requiring a certain speed, adjusting the composition and quantity of powders, etc.), the new method proposed and developed, brings safety and precision in this complex process.

The output of the proposed system is used as input to a fuzzy decision system, which aims to change the parameters of the technological process to eliminate cracks.

The necessity of manufacturing using continuous casting of some products of high quality and in the same time competitive can be made only by thorough knowledge of the phenomena and the complex processes which take place on the technological development and casting [1], [2].

A very important component of the continuous casting installation is the secondary cooling zone. The secondary cooling zone has the role to continue the wire cooling after it has emerged from the crystallizing and to assure the total solidification of the semi – product. It is considered “the heart” of a continuous casting and has the role of ensuring the quality of the material, the material surface shape



and has to ensure a homogeneous cooling and a uniform repartition of the water on the materials surface [3], [4].

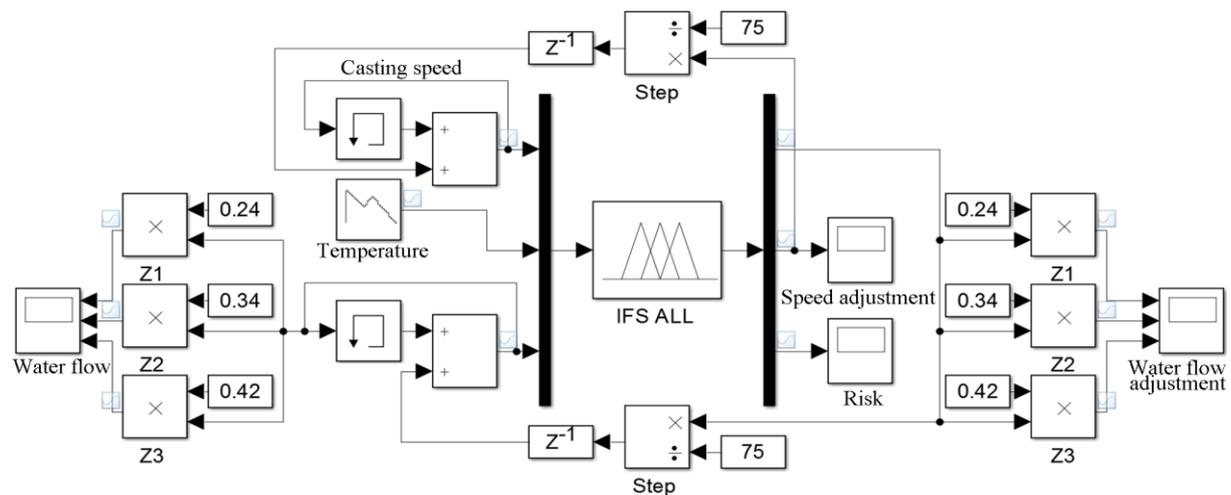
In most cases the crust doesn't offer sufficient mechanical resistance to the action of Ferro static pressure. To complete solidification and guidance in good conditions of the wire it is created the secondary cooling zone. This cooling is achieved by direct spraying pressurized water, through nozzles, it is able to cross the steam layer formed by evaporation and ensure continuous water-metal contact [5], [6].

The secondary cooling can be made in different cooling environments. In practice, the water is used especially as cooling agent that is sprayed through nozzles (circular conical, conical ring and slot). In special cases it is added to the water compressed air for optimizing the automation sprayed water [7].

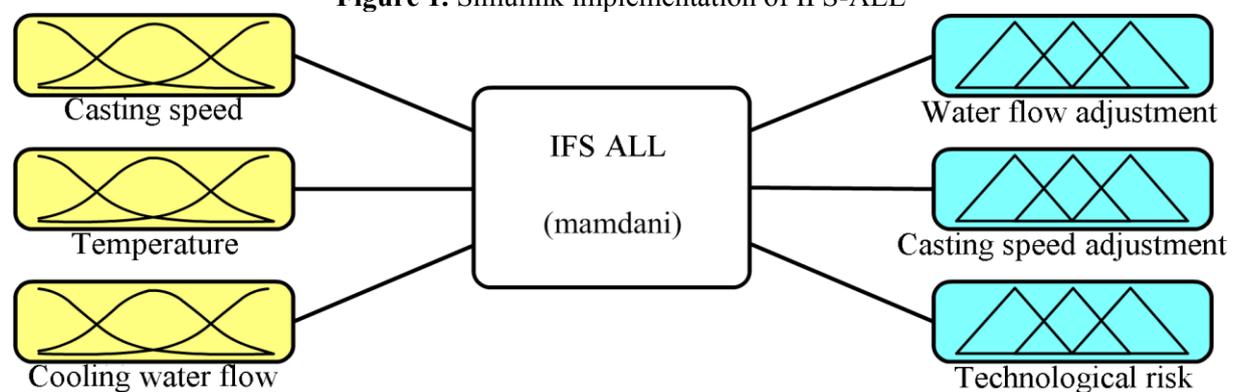
**2. Structure of the control system**

Figure 1 shows the implementation of intelligent fuzzy system (IFS) in Matlab Simulink. Temperature reading is simulated by using data reads from the continuous casting process. To begin the simulation the starting casting speed and water flow is entered, the program corrects these values using a loop that connects the output adjustment and adds it to the input data. The running time of the simulation is 1000 seconds. Also Figure 1 shows the repartition of water flow for all the cooling zones, 0.24% of the total water pressure for the first zone, 0.34% for zone two and 0.42% on zone three.

Using Matlab Simulink environment IFS allowed for qualitative analysis of its various real world situations, resulting in an IFS that meets all the requirements mentioned above.



**Figure 1.** Simulink implementation of IFS-ALL

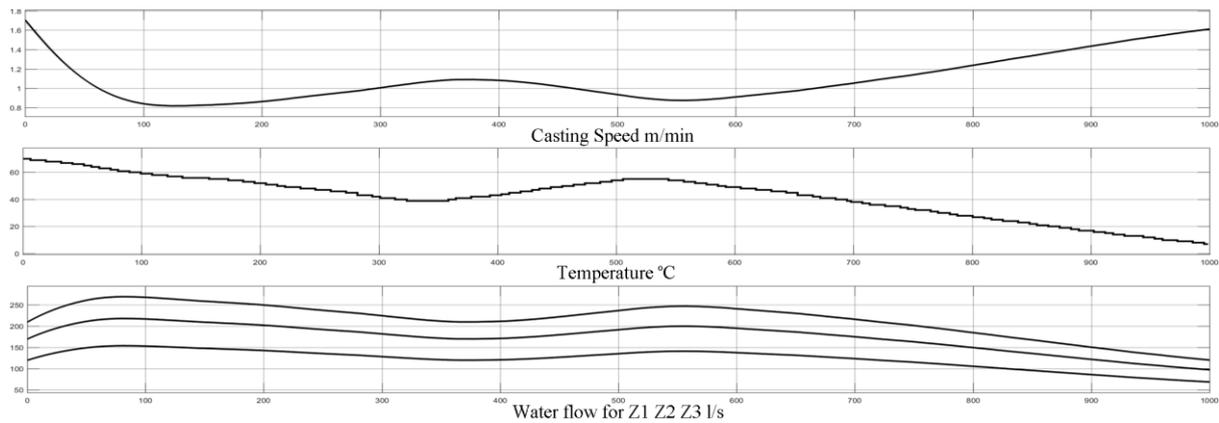


**Figure 2.** Fuzzy implementation of IFS-ALL

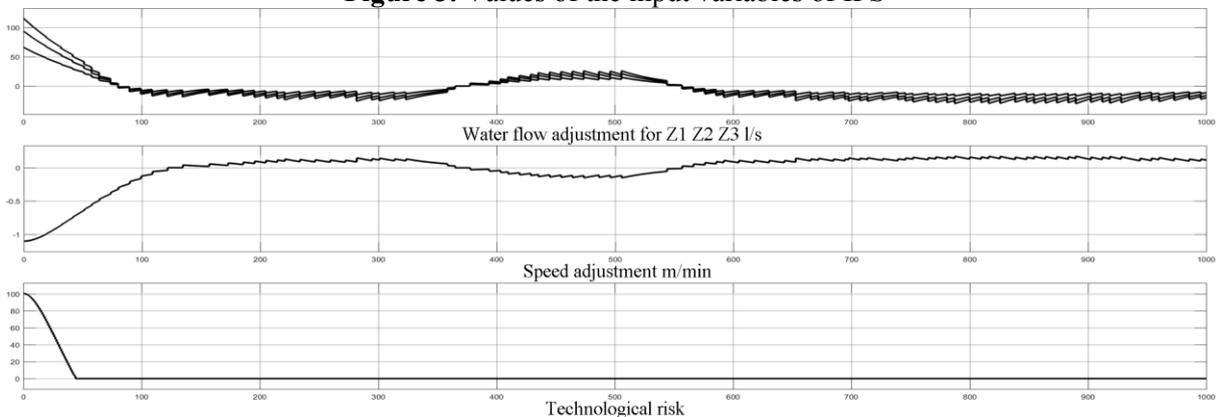
For the IFS seen in Figure 2 a simulation using MATLAB - Simulink environment is used. Figure 2 shows the fuzzy implementation in which we can see the 3 inputs, Casting speed, Temperature, Cooling water flow and the 3 outputs of the system named Water flow adjustment, Casting speed adjustment and Technological risk.

### 3. Data obtained from the system

A very important component of the continuous casting installation is the secondary cooling zone. The secondary cooling zone has the role to continue the wire cooling after it has emerged from the crystallizing and to assure the total solidification of the product.



**Figure 3.** Values of the input variables of IFS



**Figure 4.** Values of the output variables of IFS

It is considered “the heart” of a continuous casting and has the role of ensuring the quality of the material, the material surface shape and has to ensure a homogeneous cooling and a uniform repartition of the water on the materials surface [3], [4].

Temperature variables are obtained from the process and the starting value for the casting speed is 1.5 m/sec and 168l/min flow of cooling water, we chose these values with high risk factor the risk dropped down to 0% in the first 30 seconds of simulation that can be seen in Figure 4.

Analyzing the simulation results shows that regardless of the values generated the system develops the necessary corrections in casting speed and cooling water flow, which confirms the validity of system operation.

The steels heat is partially removed by heating the cooling water, but the most heat is extracted by water evaporation, even if the evaporation percentage of the sprayed water on the wires surface is in general lower than 20%. All the unevaporated water which flows from the wires surface are collected filtered and reused [5], [7].

#### 4. Conclusions

The goal of the Simulink system is to improve this classical adjustment system.

Technological risk in all cases dropped to 0 after the first few seconds of simulation and was kept constant throughout the simulation.

The simulation has shown accurate results and in future this system can be put into practice and implemented in a programmable logic controller.

A major benefit is that the only input needed is the temperature reading to control the water flow to all areas of the secondary cooling.

#### Acknowledgment

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