POSSIBILITIES OF GRAPHICAL SIMULATION OF TECHNOLOGICAL PARAMETERS ON THE MACHINE FOR CONTINUOUS CASTING OF STEEL SLABS

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Abstract:
Authors present possibilities of graphical simulation of technological parameters of individual heats on continuous casting machine (CCM) with use of the model LITIOS, which is used on the slab CCM at EVRAZ VÍTKOVICE STEEL, a.s. This model makes it possible to observe on-line deviations of parameters at casting in individual technological nodes of the slab CCM. This enables prediction of individual types of defects on slabs and afterwards on final products – steel sheets. History of produced sequences may be also controlled and it is possible to model retroactively graphically their course.

Key words:
Continuous casting machine (CCM), graphical simulation, software, prediction, slab.

1. ANALYTICAL SOFTWARE TOOL

Evaluation of slab quality on the continuous casting machine for casting of steel is part of the slab continuous casting machine information system. A complex system for a long-term monitoring of casting parameters and their influence on slab quality was progressively implemented at the EVRAZ VÍTKOVICE STEEL, a.s. and it is part of the system LITIOS. This program system is organically linked to the on-line temperature model (TM), as well as to the on-line module for data acquisition.

The system works with all the data that are available from the CCM process. The system comprises data acquisition and filtration, their sorting and saving into a database system. The data are moreover aggregated and their graphical interpretation is performed. Technological data, which are being measured with a period of 10 seconds, are saved and processed in the temperature model. Temperature model software [1] enters the data directly into the LITIOS system database. The program system LITIOS moreover loads all necessary data information about the sequence from the superior automatic control system of the steel shop, entitled FLS, and it stores in the database system. In this way it is possible to filter the data and perform the necessary aggregations of data. The aggregation is necessary for simplification of work and for handling large volumes of data. It has turned out that it is useful and sufficient to aggregate the data per one meter of the cast length of the strand (slab). The developed software is modular with use of the newest findings from database technology and methods of data analyses [4].

The system offer overviews and it is possible to view data related to a sequence, heat and primary slab. The selected data are interpreted graphically. Functions of data selection are available for analytical methods. User may transform the data into the matrix of causes – measured values and consequences – quality indices. The data thus simplified serve the employees of the steel shop for analyses of the course of casting. The system makes it possible to export the selected data into other statistical programs for more detailed analyses.
2. SYSTEM ARCHITECTURE

Analytic software tool LITIOS is a super-structure over the running sub-systems of the automated control system (hereinafter ACS) in EVRAZ VÍTKOVICE STEEL, a.s.

Acquisition, aggregation and storage of data into the application database are performed by the services of „Import“ and „Re-count“. These services run continuously on the server and their function consists in data updating at the moment of their entering into the sub-systems of technology. In this way the most rapid availability of all functions of the software is ensured. All the data are stored in data warehouse, in which they are accessible with use of the client application of the type client - server from the users’ computers. Fig. 1 presents a conceptual diagram.

![Diagram of creation of the data base for the analytical tool LITIOS](image)

The data stored in the data warehouse can be retroactively searched and displayed and it is thus possible to analyse any realised heat [2].
3. **ALGORITHM OF DATA ASSIGNMENT PER METER OF SLAB ACCORDING TO THE FIELD OF ACTIVITY**

It was necessary to resolve how to store the data, how to aggregate them and assign to the slabs with an accuracy of one meter, and moreover how to file the effect of individual measured parameters from the mould till cutting of the slab on the flame cutter.

Solution of these tasks resulted in optimisation of data storage. Data aggregation has been proposed in a sophisticated manner in such a way that all the data are made available upon the request of the user, and particularly of the steel shop technologist. The data from the temperature model, saved every ten seconds, can be displayed in detail as they were created, and then in relation with the so called field of activity of the given measured value. The filed of activity is a length interval of the strand, where the given quantity influences the course of casting, i.e. where the quantity performs its effect. The monitored field of activity may be different for monitored parameters. It is especially important for casting rate, when technologists needs to know, what was the speed of slab in the mould, in the zone of secondary cooling or even under the selected cooling nozzle (field of activity at single place).

The data are aggregated by the lengths of one meter and statistic characteristics are saved for each section of the field of activity. For statistical purposes related to evaluation of slab quality it is then possible to assign the data to slabs and then to the final products rolled from these slabs.

The data stored in this manner make it possible to simulate in future the course of the slab through the casting curve and to display graphically the selected data. Another possibility of use of the program consists in analysing the data by mathematical and statistical methods. These analyses then serve as a basis for more precise specification of data in the table of causes of defects. Classification of defects is performed directly at the rolling mill by commissional analysis in accordance with the catalogue of defect [4].

4. **GRAPHIC SIMULATION**

During operation of the current system LITIOS very long responses of users accessing the data – typically trends of values of individual measured channels for long period – were registered. For this reason a solution was proposed, which divides the current uniform database to two parts. The first database contains only technological data sent from the temperature model system, the second part contains only aggregated data necessary for the user.

The measured values of technological data are sent every 10 seconds to the database of real-time data, from which they are taken by the service realising aggregation recounts and stored in the database of user data. Both databases contain data always for a period of one year. That's why another database exists, which contains time intervals of data in individual cycles of year and moreover also current setting of channels (technological parameters), which need not be stored in annual data.

Program LITIOS forms also a final table of prediction rules. Moreover some functions were programmed in this program for immediate and retroactive analysis of processes of casting, melting or sequence. It is namely visualisation of selected technological parameters in determined sections and intervals at travel of slab through the continuous casting machine. The application was thus extended by another possibility of viewing the data obtained during the process of slab casting.

This concerns the module „Course of casting“, with use of which it is possible to do visualise in great detail values of selected quantities in relation to the current position during movement of sequence, heat or directly individual slabs in the casting channel. The application uses data of approx. 400 channels, used for calculation of temperature model. Values of these channels are measured at a constant period of 10 seconds. These data are with use of data services of the program LITIOS processed on the application server and data of these channels are here connected with the information from the main database FLS.
Values of channels are thus assigned to heats and individual slabs. Afterwards the results are made accessible with use of the module „Course if casting“ in the user application LITIOS. Function of the module is obvious from Fig. 2.

Overview of function of graphic simulation:

- graphical visualisation of movement of sequence-heat-slab in the casting channel in relation to the whole casting route or only to the selected segment of the route,
- visualisation of the values of selected channels for the whole course of sequence -heats-slab,
- it is possible to regulate the movement in slow or quick steps,

This graphic simulation serves to technologists and researchers and helps them setting of limits of prediction rules and their subsequent correction.

5. CONCLUSIONS
After implementation of the program system LITIOS into industrial practice it serves also for operational control of production (the data and graphs are source for daily meetings of the continuous casting shop
management). In case of analyses of causes of defects on sheets the program is valuable source of data for subsequent statistical analyses. Results of statistical searches enable to make the correction of selected casting parameters which should bring the decrease of the number or even elimination of deficiencies on slabs by selecting optimal values and limits of these parameters.

This program system therefore fulfils the function of a comprehensive analytical software tool for evaluation and optimisation of production on continuous casting machine.

LITERATURE


