PRACTICAL UTILIZATION OF ANALYTICAL SOFTWARE INSTRUMENTS AT OPTIMISATION OF PRODUCTION OF CONTINUOUSLY CAST SLABS

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Abstract

Production quality control of slabs continuously cast on the continuous casting machine (CCM) forms an integral part of the metallurgical plant information system. The main premise for this process is data collection and archiving of the necessary data for an effective assessment of production and determination of dependencies between the measured and qualitative data. The article describes the proposal of the concept of solution and gives an overview of functions of the software for evaluation of thermal processes at slab casting. The example of such solution is the original software system LITIOS, which together with temperature model provides comfort of services for optimisation of parameters for casting of slabs above standard. The system makes it possible to technologists to analyse the course of casting of heats with use of mathematical and statistical methods. Moreover this software analytical tool gives to CCM operators a possibility not only to evaluate in a complex manner the production process, but also to perform a long-term monitoring and optimisation of production. The article enumerates functions of this software system and describes examples of their use in practice.

Keywords: continuous casting of slabs, production optimisation, software.

1. ANALYTICAL SOFTWARE TOOL LITIOS

Assessment of the quality of slabs on the machine for continuous casting of steel (CCM) forms an integral part of the metallurgical plant information system. For the steelmaking company EVRAZ VÍTKOVICE STEEL Ostrava, a. s. special software was developed for complex long-term observation of casting parameters and of their influence of the quality of slabs. This software was entitled in preliminary manner LITIOS. The software system LITIOS is connected with the temperature model (TM) on-line, as well as with the on-line model of data scanning. The system works with all the data, which are accessible from the process of CCM. The system comprises data recording and filtration, their categorisation, entering into the relational database system, further data aggregation and their graphic interpretation. Technological data measured at the period of 10 seconds are recorded from the temperature model working in the on-line version and they are thus input directly into the database system LITIOS. Furthermore all the necessary data information on the sequence from the superior system of automatic control of operation at the steel works called FLS are fed into this database. At data recording the data are filtrated and their necessary aggregation is made. The aggregation is necessary for simplification of work and for manipulation with large quantities of data. It has been found that it is purposeful and it sufficient to aggregate the data per one metre of the cast length of the casting strand. The software under development is modular and it uses the newest knowledge on database technology and methods of data analysing.
1.1 Architecture of the system

Analytical software tool LITIOS is the superstructure above the operating subsystems of the automated control system. This software is still under development and it will be improved and is extended by other functions. Its conceptual schema is shown in the Figure 1.

Fig. 1. Schema of creating the database for the analytical tool LITIOS

Data collection, aggregation and storing into the application database are ensured by services of the "Import" and the "Recalculate" functions. These services will be permanently in operation on the server and their function will be to update the data in at the moment of their entering into the subsystems of technology. Only in this manner the fastest availability of all functions of the software will be ensured. All the data are archived in the data warehouse, from which they are accessible by means of the application of the type client-server from the users’ computers.

The data filed in the data warehouse can be retrospectively searched and displayed, in order to analyse any realised casting.

1.2 Data structure

Storage of data is performed according to the hierarchy of the origin of defects: data related to each sequence, heat, slab, the measured value, so called channels from the CCM, data on the quality of slabs and products rolled from them, etc.

Data files are divided into items with their attributes. The whole system thus contains thousands of items, and when we add to it the fact that technological parameters, i.e. channels are measured every 10 seconds, a very large amount of data is generated. For example in the year 2008 approx. 700 km of slabs were cast (in case they were laid one after another), which represents approx. 2.1 mil. of records. Each record contains 450 items of parameters. The total volume of the database of the measured data from the temperature model, identification data for individual heats and assessment of the quality of slabs was 8GB. For this reason it is necessary to perform the so called “dilution” of the data, which means to aggregate them and to store them in the data warehouse. Storing of the data is made according to the theory and practice of
relational databases and of creating the data warehouse. Detailed description of the data structure and the procedure of data storing is given in the user's application manual.

![Data model diagram](image)

**Fig. 2.** Data structure – data model diagram

### 1.3 The algorithm of assigning the data per each metre of slab

The aim of the analysis of issues related to processing large volumes of data from the CCM was to find a solution specifying how the data will be stored, aggregated and assigned to the slabs with precision of one meter, and further how to register the activity of the measured parameters beginning from the moulds till the cutting on the flame cutting machine. Solution of these tasks lead to an optimisation of data storage, which is transparently shown in Fig. 3.

It follows from Fig. 3 that data aggregation has been designed in a sophisticated way - so that all the data were made accessible upon the request of the user, especially of the steel shop technologist. The data from the temperature model, stored every ten seconds, can be displayed in details as they were originally obtained, and also in connection with the so called field of activity of the respective measured quantity. The field of activity is the interval of the casting strand, when the respective quantity influences the course of casting, that is i.e. where the respective quantity effects. The monitored field of activity in the observed parameters can be different. It is noticeable especially at the casting speed, when the technologist needs to
know what was the casting speed of the slab in the mould or in the secondary cooling zone, or even under the selected cooling nozzle (the field of activity in one place).

<table>
<thead>
<tr>
<th>1m</th>
<th>400 of filed technological values rate to 32 various spheres of activity on the casting track</th>
</tr>
</thead>
<tbody>
<tr>
<td>e.g. into the field of activity 0-900nm (crystallizer) there rank the most values.</td>
<td></td>
</tr>
</tbody>
</table>

![Casting track - 24m](image)

For every sphere of activity there exists the table with aggregated data on the metre:

<table>
<thead>
<tr>
<th>ID metre</th>
<th>minDT</th>
<th>maxDT</th>
<th>K1 min</th>
<th>K1 avg</th>
<th>K1 max</th>
<th>K2 min</th>
<th>K2 avg</th>
<th>K2 max</th>
</tr>
</thead>
</table>

For every sphere of activity there exists the table with aggregated data on the metre:

<table>
<thead>
<tr>
<th>metre identification</th>
<th>time when the respective metre entered the sphere of activity</th>
<th>time when the respective metre left the sphere of activity</th>
<th>aggregation data of single channels (technological values)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID metru</td>
<td>minDT</td>
<td>maxDT</td>
<td>K1</td>
</tr>
</tbody>
</table>

Relation of aggregation data on the detailed data by means of time marks:

By means of this relation it is possible to realize the view on detailed data of aggregated data.

Tables of values (channels) from the temperature mode of 5 tables, values filed every 10 seconds:

<table>
<thead>
<tr>
<th>ID</th>
<th>DT</th>
<th>K1</th>
<th>K2</th>
<th>K3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21.5.2005 22:01:00</td>
<td>1539</td>
<td>18</td>
<td>0.22</td>
</tr>
<tr>
<td>2</td>
<td>21.5.2005 22:01:10</td>
<td>1540</td>
<td>18</td>
<td>0.21</td>
</tr>
<tr>
<td>3</td>
<td>21.5.2005 22:01:20</td>
<td>1539</td>
<td>19</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Fig. 3. Optimisation of data storage

Data are aggregated by one metre lengths and statistical characteristics are stored for each section of the field of activity. For statistical purposes of quality assessment of slabs it is then possible to assign the data to slabs and to final products rolled from them.

The data stored in this manner in the future can make it possible to simulate retrospectively the passage of the slab through the casting arch and to display graphically the selected data. Another usage of this programme consists in statistical and mathematical analyses of the data.

1.4 Functions of the system

The programme LITIOS contains all usual functions of database applications. Here is an overview of the system functions:

- total overview of casting (records of heats),
- selection of sequences, heats and slabs – adjustment of the filter,
- search by selected criteria,
- data visualisation,
- graphical interpretation of data.
setting of general prediction rules for individual types of slabs,
total overview of casting on the CCM with prediction of defects for the respective heat,
exporting of selected and displayed data into the file of the type xls (csv, html) for further processing.

2. EXAMPLE OF USE OF THE PROGRAMME LITIOS AT EVRAZ VITKOVICE STEEL

At the workplace of the control centre for continuous casting the chief caster makes the regular checks of the state of individual circuits in the programme Litios. He compares individual changes with the previous sequences. In case that he notices any change, which might influence the state of the machine or of the slab, he checks after completion of the sequence the circuit of the respective field of activity of the pertinent parameter.

The example concerns control of the secondary cooling zone, where an increased value of the ratio of water flow and pressure in the secondary circuit (the last circuit before the outlet from the cooling chamber), corresponding to the spraying of the upper surface of the slab, was registered in the sequence - see Fig. 4.

![Fig. 4. Overview of output from the system LITIOS, value of the ratio of water flow and pressure in the secondary cooling zone](image)

After completion of the sequence visual checking of the spray of nozzles was made and clogging of several jets nozzles from the respective section was found out, see Fig. 5. After replacement of these nozzles the values dropped back to the previous level. Each checking requires a time space, which must be devoted to these maintenance works. Clogging of nozzles causes an increase of the ratio flow/pressure. Intensity of cooling is reduced under the clogged nozzles, while it increases under remaining nozzles in the circuit. It may be expected with high probability that this non-uniform cooling will have a negative impact on the final quality of slabs.
3. CONCLUSIONS

The software analytical tool makes it possible to the CCM operators to assess in a complex way the process of production. Together with the temperature model, with which the LITIOS is coupled, it provides an above standard comfort of services for optimisation of parameters for slab casting. The system LITIOS provides overviews of the casting process on CCM for slabs. It makes it possible to display the data for the given sequence, heat and slab. The selected data are graphically interpreted. Functions of data selection are available for the methods of data analyses. The data can be stored into the so-called matrix of causes (measured quantities) and consequences (qualitative indexes). Using such aggregated data makes it possible to perform analysis of the course of casting and also to export the data into other statistical programmes for more detailed analyses. Timely on-line control performed by the system LITIOS enables reduction of scrap factor of produced slabs or sheets made of them, as well as shortening of subsequent process of determination of possible surface defects on the sheets. This analytical tool is also a priceless practical helper at prediction of defects on the continuous casting machine.

LITERATURE

