OPERATIVE CONTROL WITH STRUCTURED DATA PROCESSES IN STEEL OPERATIONS ENVIRONMENT

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Abstract

The paper goal is to familiarize with problems of operative control computing support in steel works. In the introduction, there is characterized operative control from the basic function parts point of view with focus on product scheduling data support and maintenance support. The basic proposal is realization of the operational data acquisition system from the steel works. It acts as specific maintenance and technological data, which will represent the key information about operational states and mainly for issue solving support incurred on specific technological places. It is obvious the accuracy of the support model is given not only by the quality, but by the quantity of this data too. It is necessary to create a database so-called “data warehouse”. This database should be not only able to save the data and to search in them, but also should be able to spread. The tool for data conversion from the information system into the data warehouse is a “data pump”. This allows to transform the data from various sources and to save them into a central data warehouse. The data warehouse becomes a powerful part of an expert support, which is on such basis provide production scheduling support and maintenance control. This type of operation control support provides imminent concurrence of all operations in the steel making frame. So the furnace melting, secondary metallurgy processing and processing on the continuous steel casting device.

Keywords: operative control, computing support, steel works

1. INTRODUCTION

Attention of companies in a constant effort to increase the competitiveness now focuses to sphere of operative control. The aim of operative production control is optimal fulfillment of the requirements to a given time interval in the production sector (up to level period schedules operations on individual technological units). As an objects of control is here many manufacturing segments, which are represented the many parameter systems (e.g. production machine) with serial and parallel flows of raw materials and semi-finished products. There are complex issues of spatial and temporal coordination that must be addressed by the combination of economic and technological criteria. The most serious criteria usually include production costs, minimize downtime, shorten production lead time, and compliance with the plan under the influence of random disturbances.

Does this solve production problems such as the undelivered or defective input material, operator errors, equipment failures, permeability traffic routes, backlogs of, unforeseen situations, problems related of productions, etc., and must be able to flexibly adapt to the situation in a very short time horizon. Operative control is very much influenced by the character the production, which is given by primarily to the type of products.

Character of production is determined by the type of products and is therefore not easy the operative production control successfully automated. Production in many companies is established the knowledge and experience the lowest levels of production management - production managers, dispatchers and foremen and their ability on the experience quickly and correctly decide and implement their decisions.

Computer support is in many businesses in the area to a minimum. The consequence of this situation is the production, which can be characterized as reliable regarding the fulfillment of delivery deadlines, but with considerable reserves in efficiency. The dependability is very often achieved at expense of a larger volume of work in progress and excess inventory at the distribution warehouse. Due to the downward pressure on stocks on the one hand and changeability demand on the other the production management is at the limit of its possibilities. For higher management level then production appears to be non-transparent and fully dependent on specific people.

By the realization of tasks operative production control can the automation and computer technology to perform a variety of functions no direct participation of operator. By a certain extent it is possible to automate some control interventions and preparing decisions. Own decision-making task (e.g., when the alternatives) remains man.

Information and management systems that aim to support operative productive control should in particular:

- enable transparency and controllability of the production process
- guarantee the fulfillment of the terms of contracts
- optimize the production in progress and of all warehouses
- support the achieve and maintain the necessary work productivity
- shorten transit time from production to the minimum necessary
- provide a means for rapid response to the immediate situation
- ensure quality monitoring, archiving of important data and feedback proof of the production process
- reducing the cost of material handling in production
- automate administrative tasks

1.1 Operative control of the steel plant

Under term operative production control of the steel plant are currently included mainly the following activities:

a) control of its own production of steel in steel furnace - the aim is to produce steel of the required quantity and quality [6], [7], [8]:
   1) calculation of parameters batch according to the static model
   2) control automaton of preparation and transport batch
   3) control automaton for controlling the position of the oxygen nozzle above the molten batch
   4) control and regulation of the amount of oxygen for the blowing out
   5) control plant for the purification of gas
   6) control during melting in the furnace of the steel dynamic model
   7) communication with the laboratory for evaluation the samples of pig iron and steel
   8) collection, views, storage and assessment of data on the status and progress of the technological process
   9) solution of emergency situations incurred during the melting

b) control of technological process in other aggregates of steel mills with aim to manage sub-technological process to achieve quality steel [1], [4], [5]:
   1) calculation and control no remnant ingot casting
   2) control of technological process of continuous casting of steel - control of level height of steel on the crystallizer - control the speed dragging of continuously cast billet - control of cooling sections
   3) control no remnant continuously cast billet cutting
   4) control of technological process vacuum
   5) traffic control and control of ingredients in the tray in a steel plant
   6) collection, evaluation, display and record the details of during the process
   7) solution of emergency situations in the various technological sections

c) control of steel production in a steel plant with aim to produce in the steel plant planned quantity amount of planned quality of steel in the desired rhythm with maximum efficiency [10]:
   1) processing of short-term production plans (day-week)

2) processing of production schedule with respect the main production devices and aggregates of the individual working shift
3) monitoring the flow of material and energy production in the field of steel plant
4) solution of emergency situations in the production
5) statistics, evidence and balancing
6) printing of production records
7) coordination and linkage to co-managing systems blast furnaces, rolling mills, transport, energy and communication with the master control system of the company and - Level 1 and - Level 2

2. DATA SUPPORT

Necessary basis for the operative control is the area of data collection. An interface through which they come into the system the data and records intended for the production unit. Data are in manufacturing operation continuously collected manually, or automatically. Behind data collection can be declared the production shift for every day, but this method does not give the opportunity to respond to fluctuations in production. Data collection can be different according to the type of production and can be differently costly. In modern automated production parts it is often just a matter of connecting. On the other hand, for example data collection is expensive for purely handmade production and, moreover, largely burdened "the human factor", but even here you can collect data under certain conditions meaningfully applied.

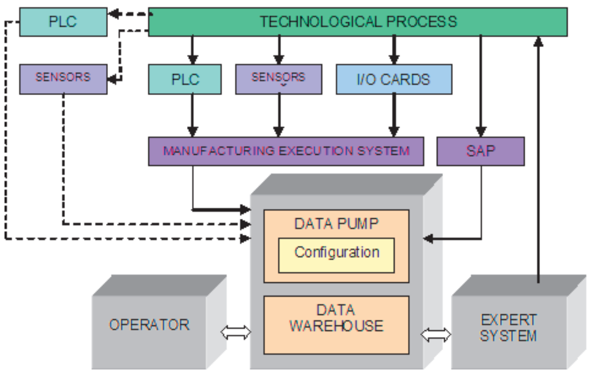

Fig. 1 Integration of data warehouse into a technological process

Basic work with technological data is "operational information system" (often called OLTP On-Line Transaction Processing). The main purpose of operating systems is to support elementary daily operations and activities of the organization and ensure information consistency and integration between different parts or areas of activity. In addition, the system must to store and manage the quantities of various elementary data from different parts must also be capable of such elementary data quickly and efficiently perform relatively simple transactions, such as search records according to specified criteria, insert new records, repair of existing records or deletion. A well-designed operational information system usually keeps its data in a relational database, whose scheme of the data meets all or some of the normal form of relational data storage.

Operational information system in most cases keeps only the current data for the last period, which works directly and no historical data, which would require too much space and wasted power. The data storage is very useful just for simple elementary operations, but it is quite unsuitable for complex queries asking for the creation of various surveillance and statistical reports. For this purpose are produced the so-called data warehouses. A data warehouse is characterized de-normalized data schema, where the same information is kept in several different places. This allows for quick answers to complex analytical queries. Additionally, when loading data from primary systems into the data warehouse is the data cleaning and fixing errors in the data.

Each users group has typically specialized in data warehouse data mart (see **Fig. 1**), which are prepared simply and precisely the information that these users need. Above these data are used OLAP tools, reports, and other options is just data mining. In a typical data warehouse architecture can still find the Operational Data Store (ODS), which serves as a data base of current data with no history of contact for CRM, a staging area or the zero layer of the data warehouse, which is purely technical and is used for efficient transfer of data to the data warehouse. For data warehouses containing, among other things technological (operational) data from the continuous production (under the influence of English often use the Czech language foreign designation "process data", "processing industry", etc.) has become common abbreviation PDW (Process Data Warehouse).

3. SYSTEMS FOR OPERATIVE CONTROL SUPPORT AT STEELWORKS

Data collection and its interpretation are necessary especially for data using solution tasks at steelworks with (see **Fig. 2**):

- sequences planning
- stabilization of continuous steel casting process - hold sequence producing
- classification of technical conditions of plants and planning their preventive maintenance

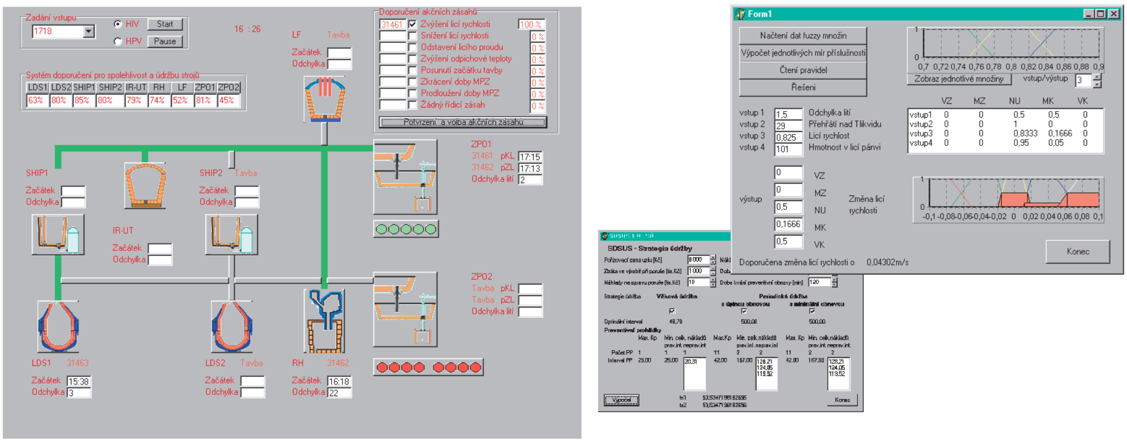

Fig. 2 Systems for operative control support at steelworks

Sequences planning

Current planning methods mostly are based on setting of “casting time plans”. There are determined on based of technical state units, available time, charging stock level, concerted oxygen taking, electrical power, load of steel etc. Consequently delivery times are calculated on the following technological units and a plan sequence casting. From a logistical point of view, this procedure presents the push principle, where the aim is to quickly "push" the material through the production chain.

However, real situation in term of material flows at steelwork is managed the pull principle from a logistical point of view, at which the material is "pulled" by flow inducing end link chain, than to be pushed forward the orders of the plan. In terms of the real situation at steelworks, this means that the flow of material (smelting) is driven by the needs of continuous casting of steel. The approach will then create "plans sequence”.

It follows that production scheduling on the continuous casting is a complex issue, which includes a lot of influences that are determined to technological parameters and the parameters of commercial character.

The calculation is performed in the created software application SAZO (Clustering Algorithm of Steel Brands), where steel brands are divided using clustering methods into clusters. These resulting clusters are used in the design of the algorithm for scheduling of the sequence heats and further reviewed using fuzzy clustering methods for maximizing of capacity utilization one sequence.

The stabilization of continuous steel casting process

The main task of operative control is to ensure the continuous and effective pass of smelting from steelwork's input to the continuous steel casting process according to the predetermined plan. Production and processing of steel is provided by many technological operations. Process of each of these operations is precisely defined in DTP. For time-technological model are important such data about time periods of each technological operation and measurement results of technological quantities provided through the operation durations, as are raw iron chemical composition, steel when main blowing, steel during second blowing, steel when finishing smelting, steel on SHIP, steel on LF, steel on DH, temperature measurement and measurement of smelting weight on CSCD, casting speed on each stream and so on. The operation's start, respectively its end and results of these analyses and measurement are considered as events, which influence the process state on steelworks. Time - technological model serve to prediction time period of technological operation and come out from performed process state analyses. It can be create [3]:

- as mathematical model of technological process coming out from material and thermal statements of smelting
- as a statistical model created on the processed result bases which has been achieved in passed smelting

Both these approaches reveal as not so much effective for creation of quick and precise model, which can be used for control processes support system.

Proposed model is based on time-technological actualization plan of material flow and is able to determine total production times of n-th steel smelting in steelworks furnaces and secondary metallurgical plant and total casting time of (n-1)-th steel smelting on CSCD. These time periods are necessary for calculation of demanded time and estimated time of real smelting preparing in CSCD. If we subtract them we obtained a value, which is called time casting deviation.

Time deviation size determine time reserve, respectively loss, which the current production has for fulfilment of its primary function, which is maintain steel casting running. The target is minimization of this deviation that way, to be maintain technological production order without sequences interrupting. Minimization of this time deviation is so the control goal and so it is the way out for the choice and subsequent quantification of action interference recommendation to the operator.

Maintenance

The results of operative control of production processes are also highly dependent on reliability of technological system or device. For the first it is necessity to avoid such failures and accidents, which can threaten health and life of device's staff or environment. In metallurgical industry are that issues more serious, because economical loses from unexpected production failure are enormous, especially when operation of whole production complex is stoped by one device failure. This enforces the maintenance staff to gather earlier answers on three questions: where can the failure occur, with how probability and with how consequences.

One of the options how to precede those type of failures and so unplanned failures in production process is to implementation of parallel technical state evaluation. This evaluation provide basic input information to determine probability time moment, in which the failure occur and will be necessary renew the operational state of the device (renewal realization, maintenance or reparation). Knowing this time point can help to decision when and in which order will be necessary to realize renewal and reduce the impact of imminent failure and which can be achieved by these ways:

- realization of preventive renewal in non-production time and prevent to occurrence of downtime

- realization of preventive renewal, to prevent occurrence of breakdown failures and prevent to arise of consequent failures
- by organizational and technically remove the failure in time

4. OPERATIVE CONTROL ON STEELWORKS AND ARTIFICIAL INTELLIGENCE

The problems of process decision support while operative steelworks control with continuous steel casting device make multidimensional task, which is need to solve with consequent steps, after single partial subsystems, but with regard on existing mutual structure. One of the significant subsystem is the system of monitoring steelwork state and control of material flow through the steelwork. The main goal is to provide continuous and effective flow of smelting from the steelwork's input to the CSCD. [2]

Because of solution of this task by classic operational research methods is low efficient, there are investigate possibilities of application artificial neural intelligence. The example of such approach to the solving method can be technological model of material flow control, which base is calculation of casting time deviation. This solution combines advantages of classical methods with artificial intelligence methods. Artificial intelligence methods are there presented by expert system for specification prediction of each technological operations times, on which basis is calculation of total time duration precising of steel making process. Although suggested expert system use specific simplifying presumptions, the results are uniquely proof the rightness of chosen path. [9], [11]

CONCLUSION

The paper deal with smelting production time scheduling issues on continuous steel casting devices with usage of clustering method and fuzzy logic, which representing modern approaches and tools for industrial system control. There is proposed and described clustering algorithm for steel grades, which purpose is to make smelting time scheduling that way, to be in one sequence makes as much smelting as possible for steels with similar chemical and temperature features the algorithm idea is clustering steel grades into the groups with usage traditional and fuzzy methods of clustering analysis, it means that steel grades, which has similar features are in the same group after the analysis is made. One group represents one smelting sequence.

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