THE BASIC PRINCIPLES OF THE ANALYSE FOR HEURISTIC MODEL CREATION IN METALURGY

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Abstract

Many activities exist in management practice, which cannot be modeled and solved by mathematical - analytical method, but man is able successfully to solve it. For real solution of the logistic problems in metallurgy, mainly in the field of capacity planning, operative planning and production scheduling models creation, is most frequently applied the heuristic approach. The heuristic approach - method is the creation of an algorithm on the base of experiences, practice, and approximate idea of a man from the solutions of the similar problems. Heuristic approach is established on the modeling of the mental human activities by the solution of the interesting problem. In this papers are described principles and rules for creation of heuristic models in logistics planning and control of metallurgical production.

Keywords: metallurgy, production, heuristic model, analysis, synthesis

1. INTRODUCTION

In the case of concrete problems solution of operative plans development (production scheduling), especially in the case of large size of task (large number of machines, products, time units), and mathematically hardly definable limitations are applied, it is difficult, and sometimes even impossible to create mathematics model. Problem adaptation to some known mathematics model- its idealization leads often to basic properties omission of examined problem, so practical utilization of results, obtained from this model, decreases.

But man is successfully solving these problems, factory produced and fulfilling orders. Previous reasons forced us to develop qualitatively new methods of problem solutions by computers, through modeling of various sides of creative human activities. This approach is called heuristic approach. Heuristic method is method, where heuristic approach is used, i.e. in contrary to accurate- analytic methods it assumes modeling of information processing processes realized by people on different stages of activity and during various tasks solution and development of heuristic models on this principle.

The heuristics from the Greece (heuristikó) is the method for the problems solution, for it´s not exist the method, algorithm. The heuristic approach - method is the creation of the algorithm on the base of experiences, practice, and approximate idea of the man from the solutions of the similar problems. [1]

Vogel define three types of decision making processes: deduction, abduction and induction. Deduction decision making is exactly decision making and abduction and induction has a probably character - it is a heuristic decision making. Heuristic approach is approach with apply the rules created on the base the abduction and induction. [2]

According Perl heuristic is the strategy, which is applied by man and machine for problem solution using available information. [3]

The heuristic method is algorithm witch apply heuristic approach, it means on the opposite of the exactly - analytical methods heuristic algorithm is the based on the modeling of processes witch is realized by the man in individual steps by problem solution. Heuristic algorithm apply the rules - heuristics, i.e. rules created on the abduction and induction thinking, on the base of repeating solution of the man. [4]

Yang defines the category heuristics and metaheuristics. As heuristics means „to find“ or discover the algorithm by „trial and error“, on the elementary rules - heuristics. Solution the problem - optimization problem, can be found as a reasonable solution, but there is no guarantee that optimal solution. Metaheuristc algorithm (model) is further development over the heuristics algorithm. „Meta“ - means bigger level and generally perform better than simple heuristics. [5]

Heuristics is the way - by „trial and error“ to produce acceptable (good) solution to a complex problem in reasonable practical time. [5]

The elementary rules applied in heuristic and metaheuristic methods as are Simulated Annealing, Genetic Algorithms, Tabu Search, Ant Colony Optimization, Neighborhood Search, etc. utilize idea of the selection of the way in the decision tree witch described variant of the problem solution - NP incomplete problem. These rules are applied mechanically for selected way in decision tree from the fact that each production in each factory has original characteristics [6].

The aim of the paper is to generalize the types of rules and principles used for heuristic models creation in metallurgical industry from the solution and application of heuristic models in many real projects.

2. THE RULES AND PROPOSALS FOR HEURISTIC MODEL DESIGN

The advantage heuristic models are when combine the human and artificial Intelligence (see **Fig. 1**).

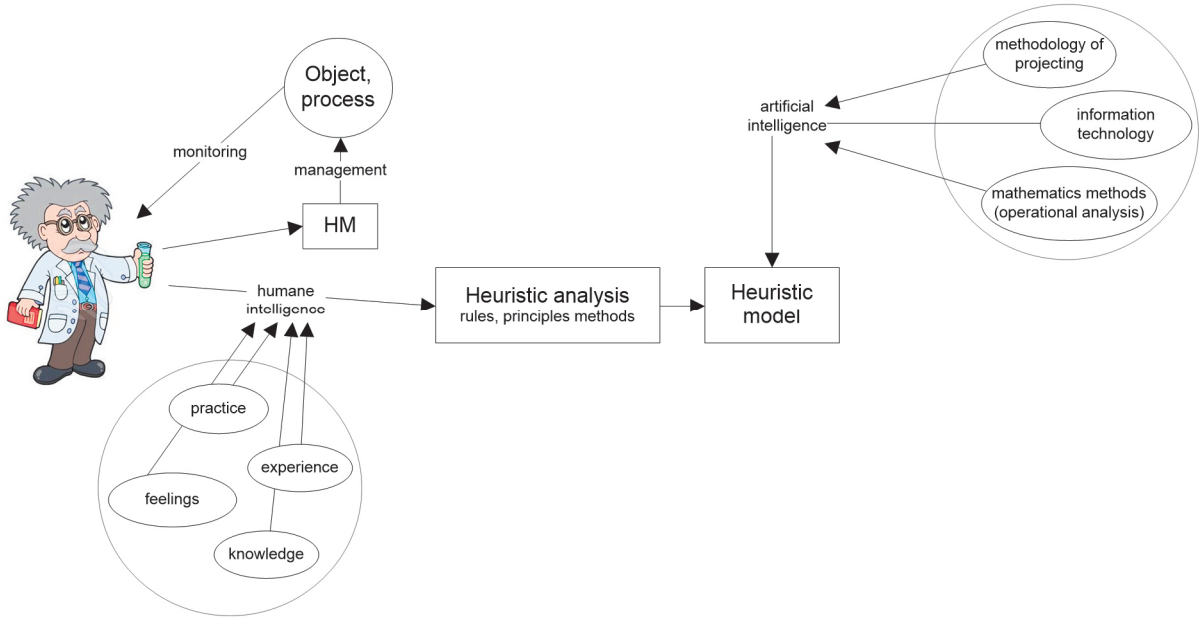

Fig. 1 The application of the human and artificial intelligence for heuristic model

Heuristic analysis should create outlet for heuristic model synthesis. An outlet for decision is a collection - database of information and rules. When we have the input information for such decision process (e.g. heuristic basis of data about product sales), by executing an analysis we will be able to describe algorithms, sequences of steps and rules as executed by a human being during decision making.

The heuristics are rules which are defined on the analogy and induction principles. Definition the set of rules $\bar{R}$ bring to heuristic models, experiences, praxis, intuition because these are expressed in concrete techniques, steps, decisions, situation reactions, etc. that is why the analysis for rule definition initiates from:

- Knowing how people do it.
- Why they do it.

- What rules they apply for particular activity.

Repeated activity execution (during plan preparation) and fact that praxis has verified correctness and success of it means achieving a suitable tool for future control decision making and management.

These conclusions based on repeated analogy and abductive and inductive decision making.

If particular rule R_i was valid for situation S_1, S_2 ... S_n and provided suitable solution y_i, then if situation S_{n+1} is analogical to situations S_1, S_2 ... S_n, rule ($\bar{R}$) is also suitable for its solution (see **Fig. 2**).

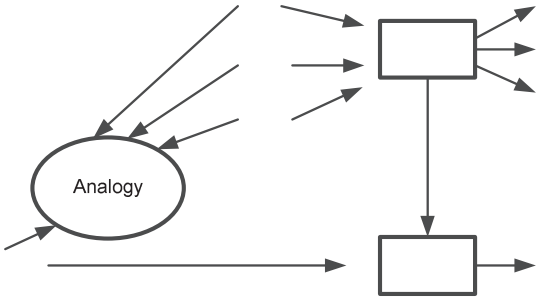

Fig. 2 Induction principle [7]

Heuristic rules are created by induction according to repeated analogy. It is difficult to divide the phase of analysis from synthesis especially in case of heuristic approach. This is a model approach and it has its own specifications.

A rule set {*R*} contains sets of:

- Heuristics - *H*
- Technological rules - *TR*
- Expert rules - *ER*
- Restrictions - *L*
- Optimality criterion - *CO*
- Main optimality criterion - *MCO*
- **{*R*}** ∈ **{*H*, *TR*, *ER*, *L*, *CO*, *MCO*}**

3. MOST COMMONLY APPLIED HEURISTICS IN HEURISTIC MODEL IN METALLURGY

3.1 Have to - Able to - Want to (HAV)

For example, when supplied buffers of the blast furnaces from the storage of the raw materials, the interpolator moves on rails, where is slowly, about 3m/min. Low material solves is long amount 900m. And materials are stored on piles abreast. In the case that the interpolator moves on long distance to the raw material, which have to be loaded, i.e. iron pallets and will go side the pile with lime stone, which have to be loaded next day, “model for supply” define line stone as product “able to do”. And when the interpolator will go side the pile with manganese ore and buffer with this raw material has free capacity, this product “want” to load [4]. Very frequently this heuristic is applied in maintenance model. This heuristic can be applied in the reverse sequence too: “Want to - able to - have to” (WAH).

3.2 Scheduling the product with fewer demands on quality

After replacing parts of equipment, after maintenance, and shutdown of equipment are scheduled product with fewer demands on quality:

- For example, after regularly steel mill maintenance are scheduled sheets with fewer demands on the sizes.
- After replacement of the cylinders of the steel mill are scheduled soft sheets (because the rolls are cold) with average wide (because this wide is most frequently in assortment).

3.3 Pooled heuristics

The individual heuristics and rules can be combine to the one “pooled heuristics”; e.g. for rolling steel sheets are combine individual rules: continually changing of the wide of the slabs; optimal number of the slabs of the same wide in the one sequence; after replacement of the cylinders are scheduled soft slabs; as quickly as from the start go to rolling the widest slabs atc. From the individual rules are created for rolling of the steel sheets typically campaigns, e.g. for construction sheets, sheets for automotive industry, wrapping sheets, dynamo sheets. [1]

3.4 From the cleanest to dirtiest

For the many aggregates, machines, products are arranged to sequence by the rules from the cleanest to dirtiest, e.g.:

- Sequence of the alloys for the fixer furnace from the maintenance contents of iron in aluminum to the maximum (Slovalco Hydra).
- In the brasses production (the content Pb and Sn in Cu).
- The mixing of the materials for the magnesite bricks, fireclay bricks (Ceramics s.r.o. USS).

The reason for application this rules is the rest which remains in facilitate after processing the previous product.

3.5 Technological rules

Technological rules ($\overline{TR}$) are rules defined by technological regularity.

Continually changing of product parameters

For example:

- The wide of the slabs from the maximum to minimum wide in the rolling campaign of the steel mill.
- The continually changing of firing temperature of the bricks in loading process in tunnel furnace.
- The continually changing of the chemical element in compound.

Technology specialization

If the product can be manufactured on more machines is defined the “main technology” and “substituted technology”.

The main technology for this product is optimal technology from the point of criteria cost, profit, quality act. If the main technology is utilized for another product to maximum its capacity in this case product can be processed on substituted technology.

Cumulating of products

From the customer orders on the same product are created - cumulated on the common parameters the group of products - virtual orders. For example the same input material, the same sequence of technological operations, the approximately same processing. The reasons of cumulating the products is manufacturing process are:

- Smaller number of readjusting, minimization of the services, utilization of the automatized processes.

- Technological batch, e.g. one slab is about 20 tons. Therefore from the orders are created batches on this type of steel which are multiple of 20 tons.
- The similar idea is batch of input materials which is traditional in supplier.
- Capacity of the production batch of facilities, aggregates, furnaces; e.g. the batch of the steel conveyor is about 160 tons.

3.6 Constraints

Value of technical, economical, time, capacity and environmental variables, which is bounded the validity of the heuristic model [8].

Technical limitations, e.g.:

- Gradient of the heating slabs in push furnaces.
- Number of the slabs in the batch for rolling.
- Size of the form, which can be allocated to the press.
- Duration of slabs movement in push furnace can´t exceed 120 minutes; if we load it in cold phase, its inner material structure would be disturbed.

Time and capacity limitations, e.g.:

- *DD* - due date defined in the orders (date of delivery for customer).
- SMT_I - shortest manufacturing time for product *I*.
- CM_J - capacity of the machine *J*.
- CS_J - capacity of the store, buffer *J*, etc.

Economical limitations, e.g.:

- The price and cost of the product.
- Repayment period.
- Payment discipline.
- Cost of inputs: material, energy…

Environmental limitations, e.g.:

- Utilization of the energy out of peak energy (the melting of the cement in cement factory).
- Minimization of the scrap (the model for the sheets cutting).
- Minimization of the transition slab (scrap) in continuous casting of the slab, etc.

3.7 Expert rules

Expert rules ($\overline{ER}$) define particular activities deciding to keep in competence of the man after creation and application the heuristic model - planners, logistic manager, dispatcher, because:

- Those activities are not suitable for modeling - and for automation.
- This model is designed as „user friendly“ model and man’s participation is requested.

For example:

a) Assignment the orders or product to operative plan which model capacity cannot be able to process, e.g.: model for production scheduling for steel mill TŠP 1700 in USS is adjusted on maximum batch the same slabs - on 20 pcs of slabs. When is ordered 22 pcs of slabs, the model scheduled only 20 pcs of slabs to schedule and 2 pcs of slabs is remainder. The manufacturing of these 2 slabs in another time is bigger lost as one time processing in TŠP 1700 batch about 22 pcs of slabs.

b) Removal orders of the customer, which don´t keep the payment discipline.

c) Assignment not profitable order to the production schedule from the point of other more profitable orders from the same customer.

3.8 Co-optimization criteria

Innovation, re-engineering of logistic system (LS) in metallurgy has a defined goal implicitly and explicitly - process of system optimization as an entity. LS optimization always leads to a multi-criterion optimization problem. In analysis we have to define main optimization criterion. In synthesis it is necessary to e.g.:

- Maximize profit.
- Minimize production cost and logistic cost.
- Maximize and uniform machine capacity utilization.
- Minimize energy consumption.
- Determine the order - sequence of product manufacturing.
- Optimize production sequence from chemical consistence point of view, dimensions, etc.
- Optimize smoothness of parameter changes.

3.9 The main criterion optimization

The main criterion optimization (MCO) is always the criterion of production cost or profit, because each of the above-mentioned criteria is directly or indirectly supported into expenses.

CONCLUSION

From the practical point of view, analysis is performed by any possible means, such as internet, company's materials, study, study of the theory, research of the company processes, but mostly by a detail exploration of people through interviews and analyses their intellectual activity during decision making and managing, by algorithmization, verbal description.

The main result of analysis for heuristic model creation is set of the rules $\bar{R}$ (see **Fig. 3**).

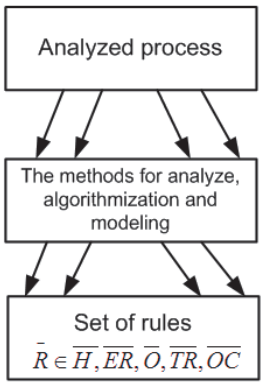

Fig. 3 Principle of rule creation [4]

For example:

- By the situation on market the main criteria optimization can be changed, e.g. to due date or minimum conception of energy.
- Models for capacity planning and scheduling should be created as flexible models, in which main criterion of optimization can be defined by the situation on the market.

The paper described the methodology for the creation the basic rules for design the heuristic model with application to metallurgy. The methodology of definition and creation rules and principles i.e. heuristic, technological rules, expert rules, limitations, criterion optimization was established on induction principle from the solution of the many practical projects by authors in metallurgical industry. The paper describes examples of most frequently applying rules in heuristic model for planning and control in metallurgy manufacturing.

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