Using of operation analysis models in selected industrial firm

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Operation analysis is scientific system discipline, that at the same time ranking to the praxeology disciplines – science about rational organization of human activity, applied to the area of management in the economy and in the other areas (research, health care, transport, schools, state administration, urbanism, cosmic research, army, etc.). Operation analysis is orientated to the operation of production, transport, division, services, supplying, stocking, renovation, development, conflict solving, etc. Many times we meet in practice with situations; at that it is necessary to solve questions of the preventive control at production equipments or to solve the way damaged segments renovation for production equipments. Goal of the presented article with regard to the higher mentioned facts is to refer to the possibility of mathematical models using for questions solving during optimalization of production equipments renovation in ***mining firm****, to refer to the ways of renovation solving in practice, to evaluate contributions of mathematical modeling in decision process.*

Key words: *Operation analysis, model, optimalization, decision process, information system, controlling.*

Introduction

Using of mathematical modeling during optimalization is today part of every decision process. Managers are deciding not only according their own intuition, expert knowledge or practical experiences, but they use also other forms as supporting tool for decision. Operation analysis is one of such possibilities – it is scientific discipline that is dealing with various optimalization areas. Optimalization process is realized in the frame of beforehand chosen algorithm of steps, that are linked to the individual phases of decision process, that is problem defining, model formulation, alternative stating, choosing of most proper alternative, verification, realization in practice, economical evaluation. It is necessary to secure for effective running of such optimalization process three bases for optimalization and their linking to the firm's management and to the external environment of the firm. (Fig. 1) [3].

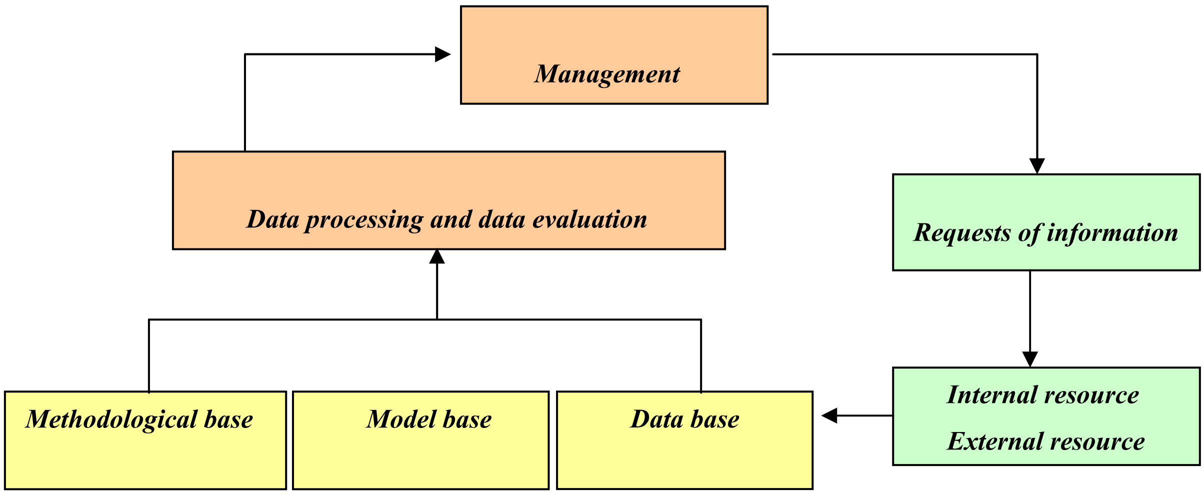

Fig. 1. Information base for modeling.

One of the operation analysis disciplines is also theory of renovation, that solves problems of machines and production equipments renovation in practice. Renovation includes activities, where it belongs repair and maintenance, general repair, simple and extended reproduction, modernization, reconstruction, etc. When we would optimalize such processes, goal of our optimalization should be orientated according III. generation of tools and parameters, that we should achieve in the frame of machines and production equipments renovation. (Fig. 2).

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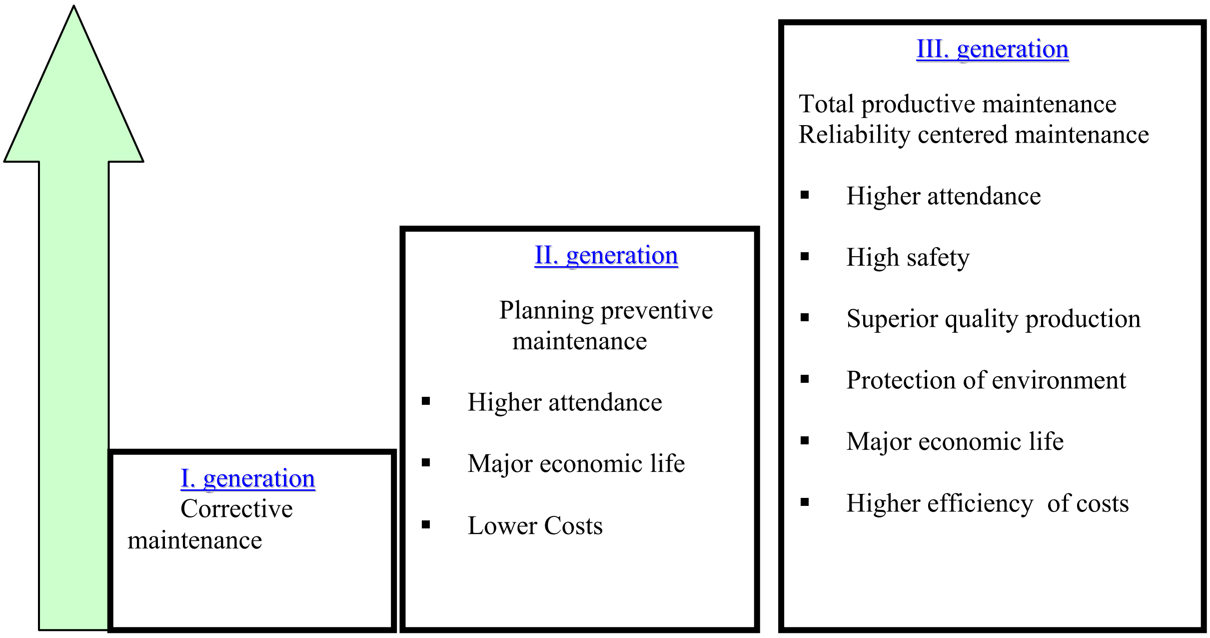

Fig. 2. Demand for optimalization of renovation processes [5].

It is necessary also in the mining firm to deal with question of equipments or machines renovation that lost through their using their functional characteristics, their life period is decreasing; they are wearing out due to the physical or moral influence of internal and external facts. Mathematical models at operation analysis enable to quantify influence of accidental external as well as internal facts through theory of probability, they enable to follow up goals of optimalization by the way of purpose functions, or according certain indexes they state values, that are necessary for optimalization process. Theory of renovation is dealing with finding of optimal time intervals for performing of preventive control or service ability of production equipment through stating of possibility to renew production equipment according decisions, that accept cost in the frame of criteria function stating, stating of time intervals for setting aside of production equipment, stating of the way for segments renovation, respectively parts of production equipment by individual or group way, by stating of life period of production equipment or by optimalization in connection with cost, that exist due to the machines and equipments maintenance.

Analysis of the problem

Subject of the given article is to present several model of renovation theory and their using at the mining firms with orientation to the globular millhouse and its internal elements, resp. its parts, so-called plates, stating of optimal parameters during modeling and their economical interpretation, contribution evaluation for such models in mining firms as supporting tool for decision process in area of economy with production equipments, resp. in area of long – term property of the firm.

Methods of project

First part of the article is dealing with optimalization of time interval for performing of preventive control at globular millhouse in mining firm, during that we will use **model of service ability control of production equipment**. [1].

In second part we will deal with stating of the renovation way of damaged segments for globular millhouse through individual or group change, during that we will use **model of group change of elements in the system**. [1]

Project analysis

We applied using of mathematical models during renovation process in millhouse of mining firm, where we followed up several equipments – globular millhouse and control of their durability. Durability of such equipment is influenced by durability of elements, that exists in given equipment as plates. Durability of such segments is decreased by the influence of physical wearing out and by mechanical influence. Durability increasing of such segments is possible to achieve by the tightening of screws of individual plates and by the change of damaged plates in globular millhouse. Our project was orientated mainly to the stating of optimal characteristics of such equipment – that is globular millhouse and its segments in context of mathematical modeling using.

For achieving of first goal of optimalization we have used model for service ability control of production equipment, mainly **stating of such frequency of production equipment control, that could secure maximalization of time rate per its service ability**. [4]

To solve higher mentioned task we need to have parameters that characterize work of the globular millhouse:

- time interval t, in which we will follow state of globular millhouse t = 9-13 month (in calculation we mark 0-4 due to the calculation simplicity)
- calendar classification t for time interval T, that will represent current plan for maintenance and repair in given system (time interval presents 1 month for globular millhouse using)
- average time t_1, necessary for control of globular millhouse state - $t_1 = 2$ hours = 0,0028 month
- average time t_2, necessary for removing of obtained shortages (slack and damaged segments – plates) $t_2 = 48$ hours = 0,07 month
- value of statistical probability (p) for fact, that globular millhouse will be in time (t) in service state (this value was stated according statistical measuring).

Solution algorithm:

During calculation we apply model for control of service ability of production equipment, where its criteria function state time interval for preventive control performing of production equipment. Optimal time interval is stated according **maximal** value of criteria function. [2]

$$P_t = \frac{1 - p^t}{(1-p)*\left[t + t_1 + \left(t_2 * \left(1 - p^t\right)\right)\right]} \tag{1}$$

(1) – criteria function for stating of optimal interval for preventive control performing at discharging of globular millhouse.

Legend:

t_1	Needed time for control performing of production equipment state
t_2	Needed time for damage removing from production equipment
p	Probability of service ability of production equipment in time t
t	Time interval of production equipment service
P(t)- max	Criteria function for stating of optimal interval of production equipment preventive control

We have decided to use one month time interval for modeling, since it is recommended to use monthly or annual interval for following of production equipments parameters. Probability of service ability for production equipment has been followed in longer time period (in previous period of model calculation) and this probability has been elaborated according statistical data, where we resulted from number of repaired segments in followed monthly period and from probability of globular millhouse damage in followed monthly period. Function, according which we stated optimal time interval of preventive control of globular millhouse is marked as criteria function, resp. purpose function for modeling.

Results of project

According beforehand stated criteria and following the probability of globular millhouse damage we could state basic mathematical parameters for model, that is inputs and to fill data to the purpose function. Every partial calculation is realized in table 1.

Tab. 1. Basic indexes for criteria function calculation.

t_1	0,0028				
t_2	0,07				
p	1	0,99	0,98	0,88	0,6
1-p	0	0,01	0,02	0,12	0,4
t	0	1	2	3	4
p^t	1	0,99	0,9604	0,681472	0,1296
$1-p^t$	0	0,01	0,0396	0,318528	0,8704
$t+t_1+t_2(1-p^t)$	0,0028	1,0035	2,005572	3,025097	4,063728
P(t)- max	0	0,996512	0,98725	0,877459	0,535469

In time interval, where function P(t) has maximal value it will be necessary to make preventive control of globular millhouse. According calculated characteristics optimal solution of this problem is most proper interval for performing of globular millhouse preventive control – mainly **tenth month** of its service. From the view of preventive control it is necessary to state, that every tenth month of globular millhouse service is necessary to perform its control from the view of physical wearing out and from the view of plates (segments) durability, that are part of the globular millhouse and that could cause failure of its function and service ability. Total result of optimalization is at the fig. 3.

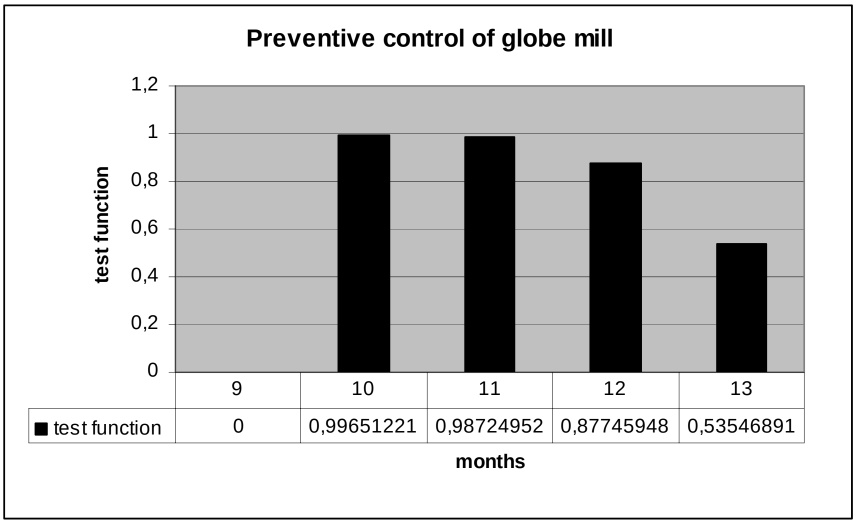

Fig. 3. Preventive control of globular millhouse.

For achieving of second goal of optimalization we have used model for group change of elements, mainly stating optimal way for segments change in globular millhouse with regarding costs for securing of its change by group resp. individual way. Such model is used in power parts of some firms, where there are also such production equipments or technological unit that content certain number of identical, homogenous elements with increasing probability of calling as time function. Probability of their calling depends from the time interval of these elements using in service period. When there is physical wearing out and it is not able to remove it – not repairable elements, or there is damage of one or various elements, that cause decreasing of given production equipment function, but also they cause not its immediate inactivity, in such cases we can use theory of renovation and its model for group change of elements in the system. Following conditions must be fulfilled due to its using:

a, number and age structure of identical elements must represents big group running to the infinity (many same elements),

b, unit price of individually changed element in given system must be much smaller as price of whole system elements,

c, costs connected with change of identical elements need not to be depended from the number of changed elements,

d, when there will be failing of one or more elements in given system, it will decrease quality of the system work, but it will not cause immediate downtime. [1,2].

Goal of the given model is to state **such number of period (n), that will secure, that costs connects with change of identical elements in given system will be minimal**.

Model solution means costs comparison for individual and group change of elements in the system.

1. **when ϕ Ni >ϕ Ns – it is better to make group change of element.**
2. **when ϕ Ni < ϕ Ns - it is better to make individual change of element.**

Due to the solving of such model we must dispose with following information, that is necessary for calculation of optimal model parameters and for comparison.

a, we found out the costs for individual change of segments in globular millhouse calculated per one changed segment by added the costs for segment obtaining, costs for workers wages during one hour of globular millhouse downtime, costs for losses, connected with downtime of globular millhouse. Total value of such costs for individual element change represents **485, 19 €. (We result from accounting and operation evidence of the firm).**

b, we found out the costs for group change of segments in globular millhouse, calculated for one segment by costs sum for change of whole globular millhouse discharging, calculated by number of segments, wages connected with group change, costs for losses during downtime of globular millhouse calculated by number of elements. **Whole value represented 47, 04 €.**

c, **we found out the cost for number of segments, that have been repaired in given month during service of globular millhouse. (table 2).**

d, **we found out probability of segments damage during following period (table 2).**

e, **we found out number of segments in globular millhouse. Total number is 244 segments.**

f, **we stated cycle period, marked as xi for certain service period (month of service) of globular millhouse.**

g, **we used mathematical model for solving of optimalization problem.**

Solution algorithm:

1. Average costs for individual change (€)

$$\phi N_i = \frac{\sum N_{iv} * n_i}{x_i}$$

2. Average costs for group change (€)

$$\phi Ns = \frac{N_{iv} * \sum n_i * p_i + N_{sv} * P_s}{x_i}$$

Legend:

Niv	Costs for individual change (€)
xi	Cycle period for globular millhouse using
t_i	Month of globular millhouse service
n_i	Number of individual changed elements
p_i	Probability of damage (%)
Ps	Number of globular millhouse segments
Nsv	Costs for group change of elements €

According model solution we elaborated and calculated every parameter necessary for calculation of average costs for group and individual change of segments in globular millhouse (tab. 2).

Tab. 2. Calculation of characteristics due to the costs comparison for group and individual change.

Ni- costs for individual change (€)	485,19				
xi-cycle period	0	1	2	3	4
t_i/ month of service	9	10	11	12	13
n_i –number of individually changed elements	0	2	5	30	100
p_i- probability of damage (%)	0	0,80	2,00	12,20	40,10
p_i reduction	0	0,01	0,02	0,12	0,40
ni*pi	0	0,02	0,10	3,66	40,10
Ni- calculated costs for individual change	0	970,38	2425,95	14555,70	48519,00
Costs cumulated - Ni	0	970,38	3396,33	17952,03	66471,03
Average costs -Ni	0	970,38	1698,17	5984,01	16617,76
Costs for group change per 1 segment €	47,04				
Number of segments in globular millhouse	244				
Total costs per group change Nsc	0	11484,30	11525,06	13252,34	30932,66
Average costs - Ns	0	11484,30	5762,53	4417,45	7733,16

Last step of this problem solution was to compare costs for individual and group change. According calculation in table 2 we can state following results:

- Due to the fact, that cost for individual change are lower in 11th month of globular millhouse service, it is better to make individual change of segments (that is plates of globular millhouse) in 12th month of service,
- In 12th month costs for group change are lower than for individual change and therefore it would be better in this month to make whole renovation of globular millhouse discharging, that is group change of every elements of globular millhouse discharging.
- If curves of costs would not overlap in one point – in local minimum, we could exactly state ways of segments renovation in globular millhouse.
- In this case we can state, that renovation depends from the costs and time interval of globular millhouse service.

Figure 4 presents costs comparison and evaluation of possible reproduction.

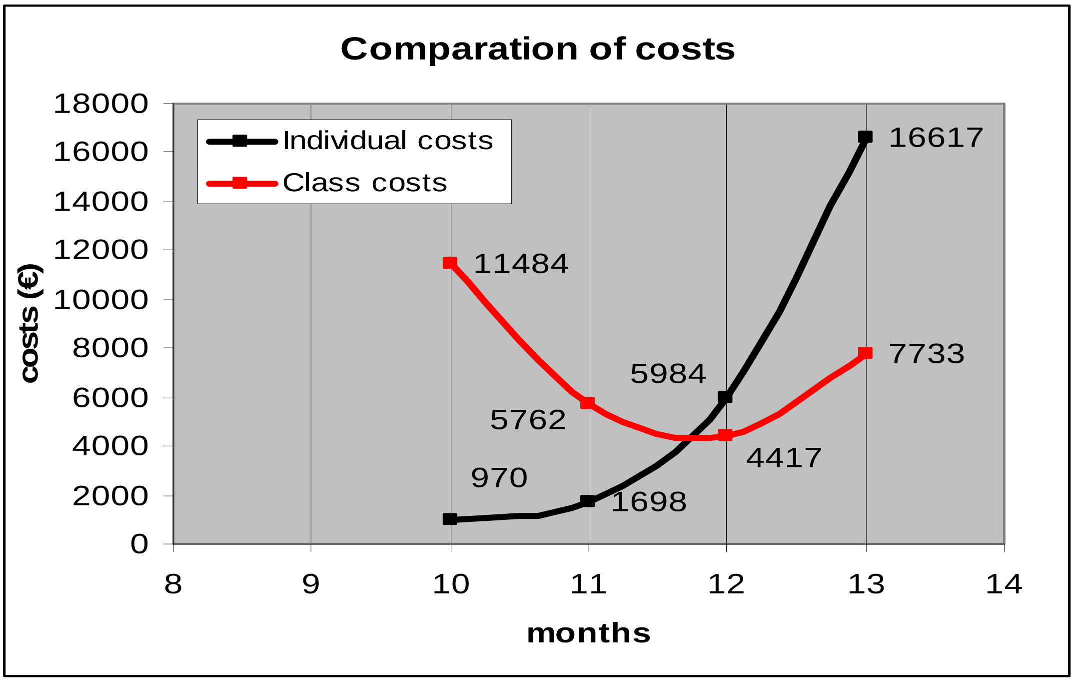

Fig. 4. Costs comparison for group and individual change of elements.

Conclusion

Using of quantitative methods as support for decision process is one of the possibilities how to eliminate risk during decision. Many times managers solve problems, that they know not how to evaluate from the view of expert skills resp. from the view of practical experiences and therefore they use also other tools, as for example statistics application, operation analysis, mathematical modeling. These are methods that exactly quantify results and optimize parameters.

Every such accesses should be rutted to the managerial information system of the firm, since only then results from such models will be distributed to the other departments, where there is necessary to solve given problem. Information elaboration about modeling is necessary not only for firm's management, but also for responsible workers, that solve the problem, but also for interested employees. Output is used also in the frame of firm's controlling, through which it is possible to find impact of such decisions to the total financial situation of the firm and influence of its development in the future. [5] Due to the fact, that mining firm dispose with great amount of long term property, where there are high purchase price and it is not possible to renew it in short time period, we must give attention to its function during its service and to increase level of its durability by the way of permanent maintenance, modernization, etc. When we want to follow state of such property during its durability, we must optimalize time of its preventive renovation, costs for its service and maintenance, costs for maintenance and repairing of its parts, or to create sources for its general repairing, resp. its renovation through new investment. Every such information are disposal for managers mainly through quantitative methods of operation analysis, that solve these problems, connected with long term property.

In the article we have shown to two models, that are connected with solving of production equipments renovation, orientated to the stating of optimal time interval for preventive control and model is orientated to the costs decreasing for repairing resp. change of equipment elements by the way of group or individual change. Except of these models in renovation theory there are existing many other accesses that solve optimalization of renovation parameters. From the view of the mathematical modeling contribution it is necessary to use operation analysis in mining firm, since they enables to increase efficiency of renovation and to plan financial tools for creating of new machinery of the firm.

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