HYBRID SYSTEMS IN MAINTENANCE RISK ASSESSMENT

Zdeno Orincák, Ladislav Madarász

Dept. of Cybernetics and Art. Intelligence, Technical University of Košice, Slovak Republic
e-mail: orincak@pobox.sk, ladislav.madarasz@tuke.sk

Abstract: New methodological approaches present integration of Fuzzy Systems with traditional methods and bulk service theory procedures (BST), and the stock control theory (ST) in risk management of maintenance activities in production plant control. The advantage of the targeted integration is the existence of models without defining their exact algorithms, whose objective is to increase the effectiveness, ruggedness and complexity of the observed system. By creating a hybrid system, while at the same time, preserving the above mentioned approaches for the maintenance process, new, non-traditional solutions have been brought – that again become the source of new ideas and improvements .

Key words: *hybrid systems, fuzzy systems, risk management, maintenance of machines and equipment*

1. INTRODUCTION

At present there are almost one thousand different types of machines that differ in their design, operational conditions, the way of operation and intensity of their use [1]. For this reason managers, dispatchers and schedulers(planners) have often to rely on their intuitive methods, that are be effective, but the results of their application can usually be unforeseeable The situation becomes even more complicated, because behind these changes there are usually customers . In large-scale production and small series the managers can get into unenviable situation. They are under constant pressure of delivery completion in required quality and securing production capacities, while taking into account all risks of a production process. The risks, however, have to be known, "well in advance", to enable planning of inspection strategies, maintenance and eventual repairs. Therefore, it is appropriate to use means of technical risks assessment for this purpose.

2. RISKS ASSESSMENT IN TECHNICAL MAINTENANCE

In case of wide variability in production, large number of production equipment, and varieties in orders, the production and scheduling (planning) of production tasks become intricate.

The process of production and its planning is naturally complicated. The process of production ant its planning is naturally complicated in random faults of machines or by lack of operatives. Therefore the effort of managers it is eliminating of these risks.

Identification and assessment of the risk together with the analysis of the risk is a special stage in the process of its judgement. By an appropriate risk analysis in technical maintenance and follow up counter measures it is possible to disclose hidden reserves of an enterprise Various procedures serve this purpose, from the simplest to complicated analytical methods. One of the methods is also represented by targeted linking of enterprise activities, operational management with maintenance management, quality and safety, whose mutual interpenetrating, Fig.1, represents the analysis of global risks of an enterprise.

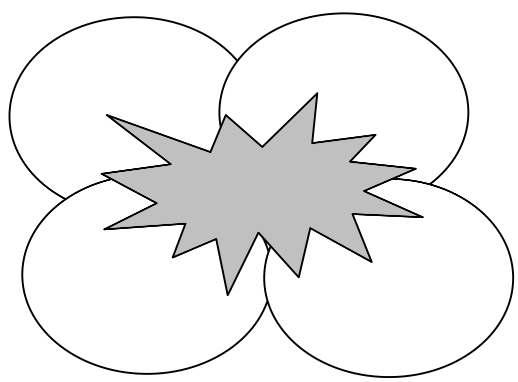

Fig.1 Global Maintenance Risks Assessment

To typical maintenance risks belong [4], [5] :

?? high number of machines and equipment faults

?? high complexity of equipment set up

?? problems with product quality

?? low working moral of employees

- ?? poor information transfer among departments
- ?? excess maintenance warehouse stocks
- ?? stress
- ?? influence of the environment (heat , cold , smell , dirt)

The risk in the maintenance has various forms – economical, quantitative, humane and others, and it consists of probability and consequence. An example of a risk in maintenance process is **downtime** and it means execution of a not planned repair at any equipment during operation.

The downtime, whose chart is in Fig.2, lasts several times longer than the repair itself

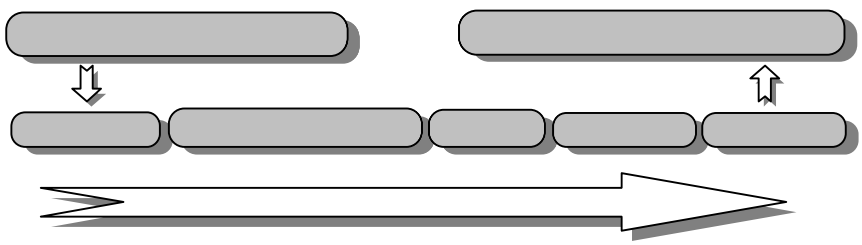

Fig.2 Down time

By assessment and control of maintenance global risks within the framework of hybrid systems the principles of computer aided technical maintenance of an enterprise are observed. The aim of such created hybrid systems is optimizing of global processes in an enterprise**.**

3. HYBRID SYSTEMS

The assessment and control of maintenance risks has a positive influence on the effectiveness increase itself, and consequently on the entire enterprise. Up to now the evaluation and assessment have been carried out partially. A complex analysis result could only be attained in the past based on isolated risks brought into the system. The isolated risks, such as repair time, number of accidents, number of refuses have been transformed to other mainly financial indicators. By the transformation, however, relevant information are lost caused by exchange rate fluctuation, inflation, energy price rise, society social changes, markets change, etc.. To avoid serious information loss, it is necessary to create such a strategy of risk assessment, which will not further transform the defined risks to other forms.

The strategy will be created by targeted integration of proved theories into one compact unit. If this system will be created by the theory of bulk service (TBS), theory of stock control (SC) and the theory of Fuzzy Sets (FS), it is called a hybrid system. Where the TBS-process in the maintenance of an enterprise forms a bounded system without losses [2] and the TSC is a random function of failures [downtimes] and has a discontinuous consumption character then the FS-system implements mutually these theories with the intentions and strategies of top management, mostly presented in words- in linguistic terms. Such a system can then be presented as follows in Fig.3.

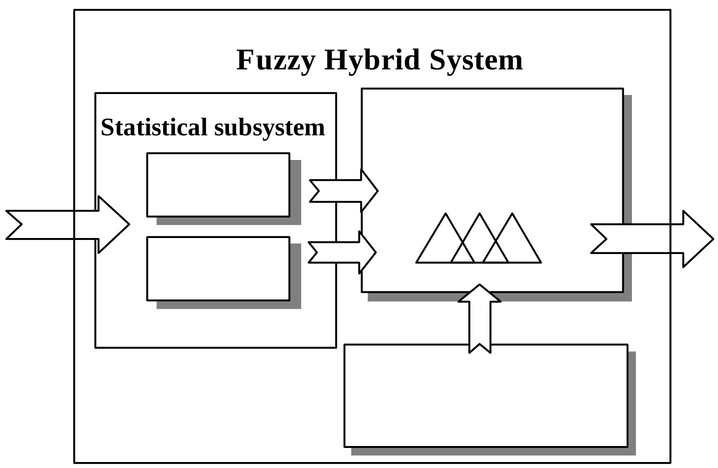

Fig.3: A Schematic Chart of a Hybrid Model

To introduce the system into practice the use of TBS in maintenance at the Division Plant of Hot- Roll- Mill [DP HRM] in US Steel is being considered. The number of equipment and the number of maintenance work force will form the variable in the TBS-module, that is formed by following relations.

The coefficient of a machine downtime :

$$M_2 = \left[\sum_{k=1}^{n} \frac{m!}{(k-1)!(m-k)!} \left(\frac{\lambda}{\mu}\right)^k + \sum_{k=n+1}^{m} \frac{km!}{n^{k-n}n!(m-k)!} \left(\frac{\lambda}{\mu}\right)^k \right] p_0 \qquad (1)$$

The coefficient of worker downtime :

$$\frac{M_3}{n} = \sum_{k=0}^{m} p_k - \frac{1}{n} \sum_{k=0}^{n-1} kp_k \qquad (2)$$

where

?? -? = requirement density in the system

?? -? = average time of requirement service

?? -m = highest possible number of requirements in the system

?? -n = number of servicing stations

?? -p_k = probability of requirement occurrence

The comparison of the results from the considered system is given in the Tables 1 and 2. If we consider ? =4,7% and ? =68 min in the change of the number of maintenance units from two to four and sixteen production units.

After the analysis of the above mentioned tables has been conducted, it can be proclaimed, that maintenance worker number increase will result in equipment downtime decrease from 0,44% (Tab.1) to 0,035% (Tab.2) which means shortening of repair time during the whole year from 38,5 hours to 3,7 hours on average for each piece of equipment. From the economical point of view it presents ca. 15000 US$/year, saved due to improved quality of maintenance organization, compared to 7000US$/year expended on maintenance workforce increase. The shortening of the repair means decrease of the considered risk by the hybrid system, and vice versa, the maintenance workers increase presents the increase of this risk.

Table 1

Number of maintenance units = 2		
Numbers of production units	The coefficient of a machine downtime in %	The coefficient of worker downtime in %
1	0	100
2	0	96,0304
3	0,0006	94,0194
4	0,0025	91,952
5	0,0064	89,7926
6	0,0129	87,4986
7	0,0228	85,017
8	0,0372	82,2827
9	0,0569	79,2146
10	0,083	75,7133
11	0,1165	71,6607
12	0,1587	66,9254
13	0,2108	61,3791

14	0,2739	54,9325
15	0,3498	47,5954
16	0,4411	39,5535

Table 2

Number of maintenance units = 4		
Numbers of production units	The coefficient of a machine downtime in %	The coefficient of worker downtime in %
1	0	100
2	0	100
3	0	100
4	0	100
5	0	95,0379
6	0	94,0445
7	0	93,0486
8	0,0001	92,0463
9	0,0001	91,0291
10	0,0002	89,9782
11	0,0004	88,8515
12	0,0007	87,5513
13	0,0011	85,8451
14	0,0018	83,1708
15	0,0026	78,2161
16	0,0035	68,3986

The hybrid system for maintenance risk assessment thus created follows the optimization objectives of enterprise activities and it is a starting point in the problem solution of information loss .

CONCLUSION

New approaches of risk assessment in maintenance bring satisfactorily results, but the term “technical maintenance” is a complex system with a large number of mutually intertwined elements with a hierarchical structure.

From the above mentioned it results that through elements and methods of computing intelligence integration a system can be created which suggests plan procedures for solution of undesirable situations, and also enables to foresee and detect these statuses.

The described problems of use of the elements, methods and procedures of computing (e.g. artificial) intelligence belong at the Department of Cybernetics and Artificial Intelligence of the Faculty of Electrical Engineering and Informatics in Košice among especially observed fields .

REFERENCES

[1] Cervenka, Z.: Rízení údrrby pomocí pocítace. AT&P journal 8.2001, p.22 ISSN 1335-2237

[2] Madarász, L.: Metodika situacného riadenia a jej aplikácie. University Press, Elfa, TU Košice, 1997 ISBN 80-88786-66-5

[3] Madarász, L., Orincák, Z.,Ottmár, P. Timko, M.: Inteligent Technologies Used in Modeling, Control and Maintaining of Complex Systems. International Symposium of Hungarian Researches on Computional Inteligence. Budapest, November 2-3, 2000, Hungary, pp.185-198, ISBN 963 00 4897 3

[4] Pacaiova, H., Oravec, M.: Aplikácia analýzy rizík na posúdenie technického stavu zdvíhacieho zariadenia. Konferencia Zdvíhacie zariadenia v teórií a praxi. Tatranská Lomnica 2002, pp. 72-77 ISBN 80-7099-801-6

[5] Sinay, J., Pacaiová, H.: Úlohy a ciele manažmentu rizika a manažmentu údržby. Národné fórum údržby 2002, pp.32-37 ISBN 80-7100-961-X

[6] Smrcek, J.,Tuleja, P., Hilovský, M.:Trendy intenzifikácie údržby v automatizovaných výrobných systémoch, zdroj: online http://robot.vsb.cz/konference_2000/_private/Smrcek_2/TRENDY_INTENZIFIKACIE.pdf

[7] Timko, M., Madarász, L.: Computional Inteligence and enterprise modeling. Micro CAD 2001. International Scientific Conference. 1-2 March 2001, University of Miskolc, Hungary.