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Faculty of Mechanical Engineering*



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# PROCEEDINGS

DEMI 2013



*Banja Luka  
30<sup>th</sup> May – 1<sup>st</sup> June 2013*





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## MAINTANCE MANAGEMENT AND USING BENCHMARKING AS A TOOL IN THE FRAME OF WORLD CLASS INDUSTRIAL SYSTEM

Silvana Angelevska<sup>1</sup>, Ivo Kuzmanov<sup>2</sup>, Zore Angelevski<sup>3</sup>, Vasko Stojanovski<sup>4</sup>

**Summary:** *One of the management tools that is widely spread for companies who wants to be competitive is benchamrking. On the other hand, facilities that produce world class products must be supported by a world class maintance processes. The maintance and productive objectives are inseparable and both needs to be compatible with the basic corporate objectives of the business entity – maximazation of profitability and long term survival on one hand, and on the other continuous improvements.*

*The aim of this paper is to represent some indicators, becnhmarks, whose basic aim is best practice in maintance management.*

**Keywords:** *maintance management, benchmarking, continuous improvements*

### 1. INTRODUCTION

The management of the industrial systems frequently stands to the basic tasks such as: continuous increasements of it's profitability and the dilemma how to achieve the same one [1]. Investment effectiveness is considered from the point of investing in new and andvanced technical systems, and from the point of comparating the aimed profits with the ones from the past. Nowadays the technical systems usage is more and more focused on producing with minimal costs.

In this situation, the maintance activities, especially in R. Macedonia, are seen as an expence. Therefore any kind of maintance savings directly contribute to organizational profits. Having in mind this situation, companies have tried many different organizational structures, usage of outsourcing in terms of maintance, downsizing, employing teams and all of that in attempt for effective and controlled maintance. Yet, the majority of companies have not been able to manage maintance. The two largest factors that directly lead to this situation are the lack of proper measurement and the lack of control systems for maintance. On the other hand the companies that has solved the previously mentioned problems, are known as word class companies.

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## 2. MAINTANCE BASICS

The basic aim of maintenance processes is to sustain the integrity of physical assets by repairing, modifying or replacing them as necessary, taking in consideration the costs (or in other words with minimal costs). Maintenance management as whole must include the following [1]:

- Maintenance department with its objectives, organizational structure, strategy (long term and short term) and maintenance informational systems;
- The linkages, interrelationships and interfaces between the maintenance function and all other sub-systems.

The process of maintenance with its inputs and outputs is presented in the following Figure 1 [1].

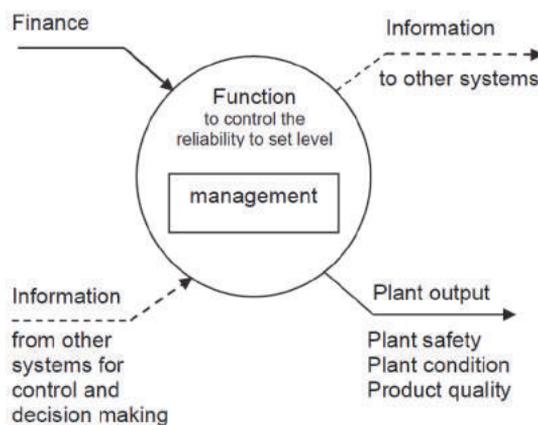


Fig. 1 *The function of the maintenance system*

Maintenance management is a continuous process of managing all of the assets owned by the business entity, based on maximizing the return of investment. A lot of techniques fall under the definition of maintenance management such as: preventive maintenance, predictive maintenance, planning and scheduling, inventory and procurement, work order systems, training programs, computerized maintenance management systems, financial optimization and several advanced techniques and concepts such as: reliability centered maintenance and total productive maintenance.

The typical objectives of maintenance management, in word frames and also in Macedonian frames as well, are the following:

- Maximum production at lowest costs and highest product quality
- Identification and implementation of cost reductions
- Maximum safety standards
- Providing accurate data
- Optimization of the so-called maintenance resources
- Minimizing the inventory on hand

### 3. MAINTANCE BENCHMARKING IN THE FRAME OF WORLD CLASS INDUSTRIAL SYSTEM

In the past few years, the benchmarking is one of the most powerfull tools in the hands of the managers for continuous improvements of the industrial results. Acording to the formal definition, the benchmarking is continuous systematic process of measuring products, services and practices against the toughest competitors (world class business entities). Working definition says that benchmarking is the basic of establishing a rational performance goals, through a process of continuous search for best industry practices and implementation of those experiences in a metter of superior performance. According to Camp (1989), the formal process of benchmarking must have an structured methodology. His recomended benchmarking process is given into Figure 2, in addition [3].

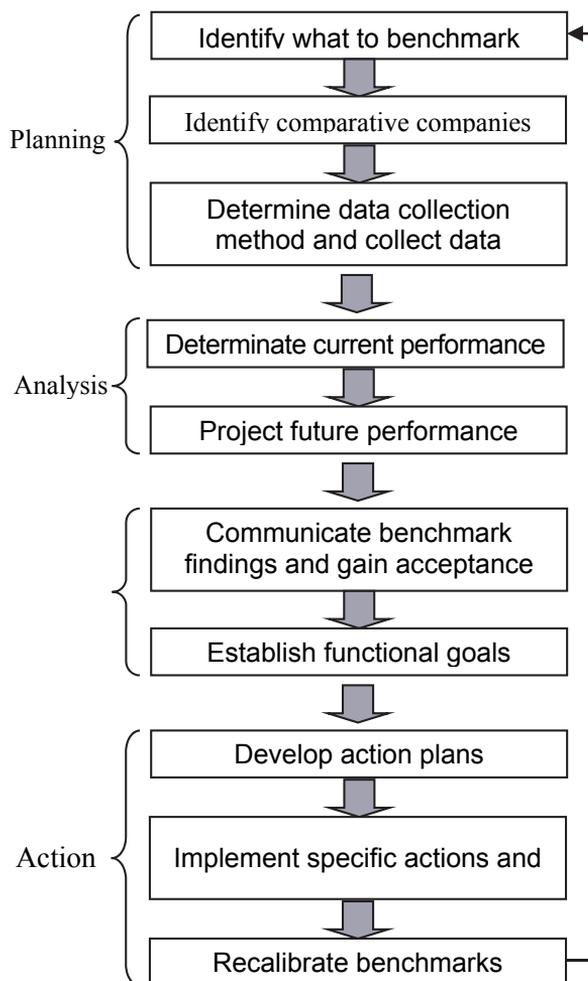


Fig. 2 Benchmarking process acording to Camp

Benchmarking can be performed in several different ways, with a different number of companies, depending on the sort of results that are the wished aim. Considering several authors, there are three different types of benchmarks such as [4]:

- Internal benchmarking
- Competitive benchmarking
- Best practice benchmarking

On the other hand, the benchmarking in maintenance is the ultimate search for the best maintenance practices which will lead to exceptional maintenance performance through the implementation of the best maintenance strategies. Therefore, the objective of benchmarking in maintenance is to compare the maintenance performance with the "best business entities", or the so-called best in class business entities. This enables the company to achieve a higher maintenance performance, as a continuous improvement process.

Although there aren't any kind "magic rules" for achieving world class, there are several key factors that affect this situation such as:

- The organizational structure
- The leadership
- Assets age and the conditions of the systems
- Technical skills of the staff members
- Environmental conditions
- Different attitudes
- Etc.

For the purpose of this paper a set of commonly used best practice benchmarks for different maintenance categories are given. The same one are given in addition:

- Maintenance costs
- Planned maintenance
- Maintenance overtime
- Inventory turns
- Maintenance strategies
- Plant availability
- Training
- Constructors
- Etc.

All of the category benchmarks could vary from one business entity to another, from industry to industry, from time to time, but a general view of the same one is given into the tabular view in Table 1 in addition of the paper.

Table 1 Best practice benchmarks

| Best Practice Benchmarks                                 |           |
|--|-----------|
| Total Maintenance Cost/Total Manufacturing Cost          | < 10-15%  |
| Maintenance costs/RAV of the plant and equipment         | <3%       |
| Hourly maintenance workers as a % of total               | 15%       |
| Planned maintenance/Total maintenance                    | >85%      |
| Planned and scheduled maintenance as a % of hours worked | ~85-95%   |
| Total hours PM/Total maint.hours available               | ~20%      |
| Total hours PDM/ Total mainten. available                | ~50%      |
| Total hours PRM/ Total maint.hours available             | ~20%      |
| Total hours REM/ Total maint.hours available             | ~10%      |
| Turns ration of spare parts                              | >2-3      |
| Stores service level                                     | 95-97%    |
| Training for at least 90% of workers, hrs/Year           | >80 hr/yr |
| Spending on worker training (% of payroll)               | ~4%       |
| Plant availability                                       | >97%      |
| Contractors cost/Total maintenance cost                  | 35-64%    |

#### 4. CONCLUSION

The basic aim of every single industrial system is survival and profit. But on the other hand every single business entity wants to be or to become a world class company. That is a real challenge. Every single company which is recognized as an world class company must be supported by a world class processes, including the maintenance processes.

World class companies can achieve a high maintenance effectiveness standards by using a powerful management tool known as maintenance benchmarking with a combination of various different techniques, such as reliability centered maintenance and total productive maintenance.

#### REFERENCES

- [1] Silvana Angelevska (2007). Benchmarking model for continuous improvements of the maintenance process, Phd thesis, Faculty of Technical Science in Bitola, R. Macedonia
- [2] A. Raouf, M. Ben Daya, Total Maintenance Management: A systematic approach, *Journal of Quality in Maintenance Engineering*, vol. 1, no. 1, pp. 6-14, 1995
- [3] R. Camp (1990), *Benchmarking – the search for industry Best practices that lead to superior performance*, ASQC Quality press.