MAINTENANCE ADVANCED SOLUTIONS FOR THE ROLLING MILL PLANTS[1]

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Abstract
Production is becoming technologically more complex all the time, the values relating to machinery stocks are increasing and the mastery of plant operations requires an ever more comprehensive degree of knowledge. Complex supply chains with minimal stock-keeping necessitate just in-time production and delivery. This leads to substantially heightened risks to companies in cases of production losses. At the same time, governmental and public demands relating to environment and occupational health and safety are becoming more stringent.
Key words: Availability; Reliability; Advanced solutions.

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AIMS AND REQUIREMENTS OF MAINTENANCE

On regarding it as a product, a principal requirement is made on maintenance: The customer must be satisfied with its performance.

Essentially, three further perspectives can be identified as a function of the customer's wishes. As already mentioned, the main objective is to make available maintenance to a standard which satisfies the customer's wishes (customer perspective). This may be either the internal or the external customer. The purchaser essentially demands good quality at the lowest possible price (cost perspective). For this, maintenance processes have to be represented efficiently (process perspective) and the necessary personnel and equipment (resources and learning perspective) need to be made available (FigURE 1).

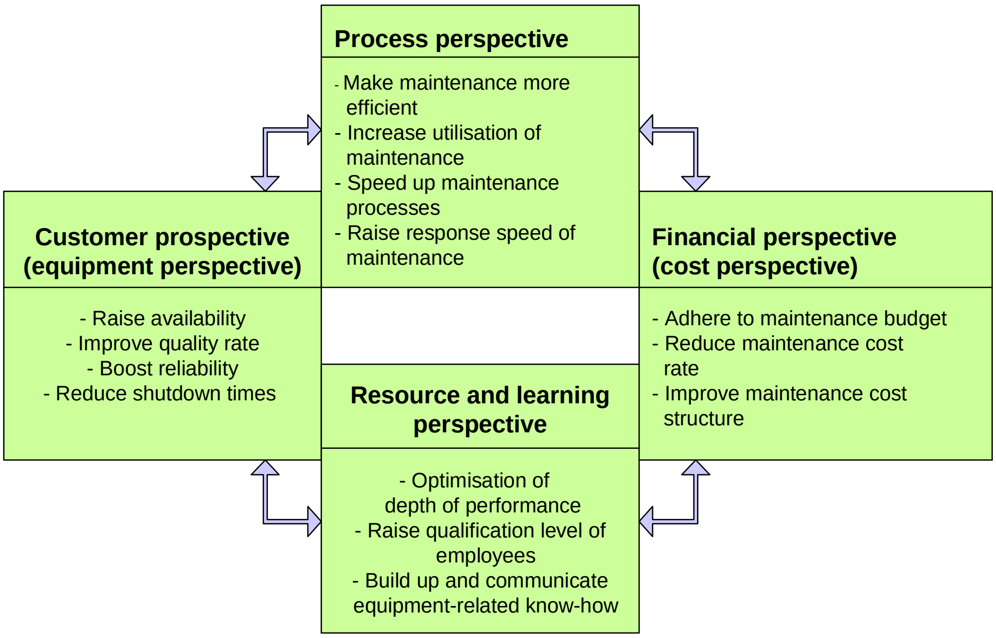

Figure 1: The four main perspectives of maintenance.

FORMS OF MAINTENANCE

Various maintenance strategies have developed over the course of time on the basis of the knowledge and of the respective changes relating to fault patterns and also due to the changing requirements made on plants.

Maintenance in cases of breakage or shutdown – Breakdown maintenance

Breakdown maintenance (Maintenance as and when required) designates the maintenance carried out exclusively when a case of damage occurs which results in failure. It is the simplest form of maintenance, as far as the systems and planning are concerned. The maintenance operative has the nature of a fireman who only goes into action when a case of damage actually occurs (Figure 2).

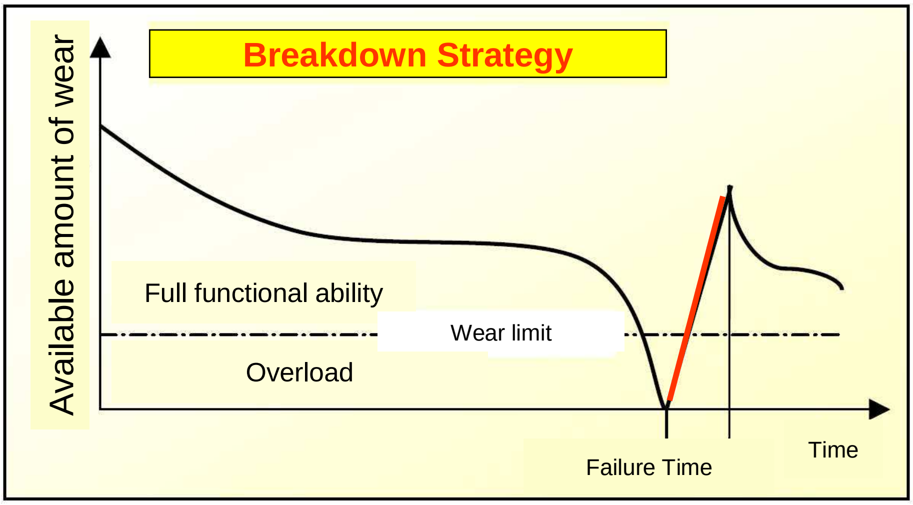

Figure 2: Example of progression for breakdown maintenance.

Time-based maintenance

Time-based maintenance was utilized as the initial method of preventive maintenance, based on the traditional view that downtimes could be calculated. It was introduced in order, on the one hand, to keep the quality level at a constantly high standard and, on the other, to minimize failure times and, accordingly, failure costs. Parts are replaced according to a previously stipulated and calculated utilization time, irrespective of whether a plant part is defective or in whatever condition it is in Figure 3.

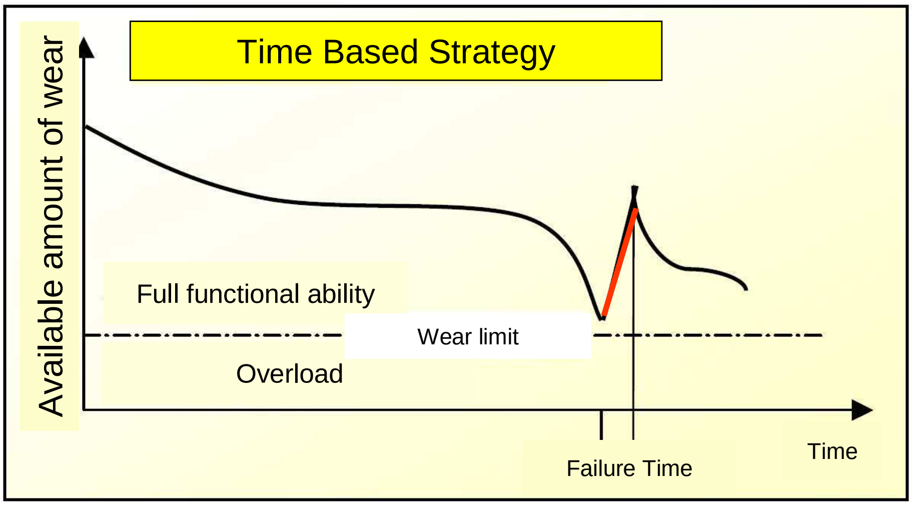

Figure 3: Example of progression for time-based maintenance.

Condition-based maintenance

Condition-based maintenance has become established following the realisation that the causes of defects are to a large extent independent of age and wear. These new findings have brought about a change in many of the existing opinions about age and failure. In complex machines, the correlation between age or operating time and failure is diminishing all the time (Figure 4).

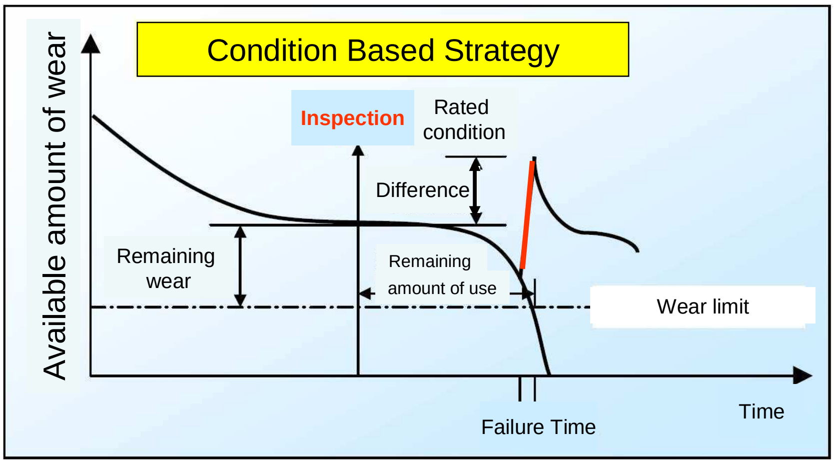

Figure 4: Example of progression for condition-oriented maintenance.

Total Productive Maintenance – TPM

Total Productive Maintenance (TPM) follows the basic philosophy of aligning maintenance towards the needs of production, i.e. fully towards the core activity of the producer firm. Here, as a preventive measure, the efficiency of the plant and of the accessories should be maximised. Through preventive maintenance, failures of all types should be excluded and economic detriment thereby minimised. Maintenance is focussed on optimising the three strategic magnitudes of production., called succes factor a follow:

- enhancement of quality;
- the time aspect;
- costs optimization.

MAINTENANCE ENGINEERING

The main task of the Engineering department is to develop and specify a higher-level maintenance strategy. From the point of view of cost-benefit aspects, the optimum maintenance concept for the respective plant must be developed with a view to optimising the entire process network, increasing the plant availability and thereby achieving an overall rise in plant efficiency.
Process analyses and process improvements have the objective of making the whole process network become more effective. First of all, the relevant maintenance processes need to be identified. It is important to clarify which connections exist between the individual processes. The question also arises as to which types of data need to be collected (output and input data). Thereafter, an analysis must be made as to which preconditions apply for the data management, i.e. what has to be satisfied in order to guarantee the recording and storage of the relevant data. Finally, the data are collected and compiled in a database, and this forms the basis for improvements.
The aim of engineering is to install a scheduled maintenance which recognises faults in a predictive manner and which is oriented towards processes and employees. This finally makes it possible to achieve a continuous improvement of the processes and an optimisation of the customer-supplier relationship (Figure 5).

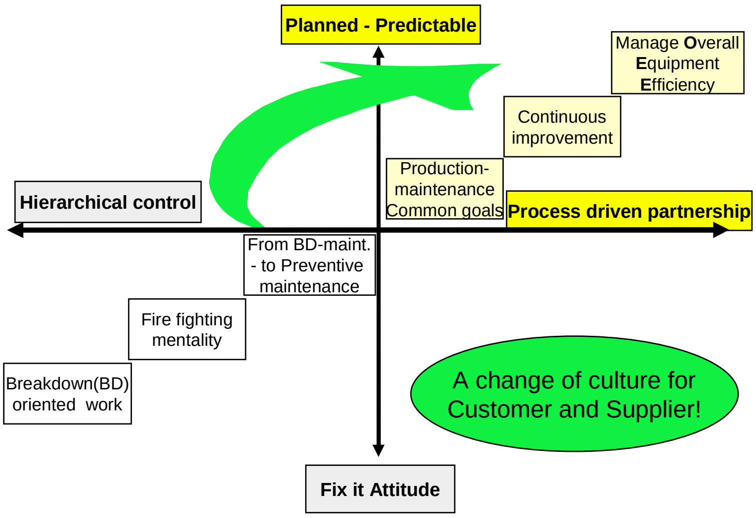

Figure 5: Optimisation of the customer-supplier relationship in maintenance;

MAINTENANCE INDICATORS

The OEE indicator – Overall Equipment Effectiveness

An important indicator for maintenance, from which the entire plant availability is derived, is the OEE indicator. This indicator expresses the purely productive operating time of a plant. It makes it possible to identify how both the degree and the manner of maintenance cause the plant availability to change and thus have an effect on the production (Figure 6).

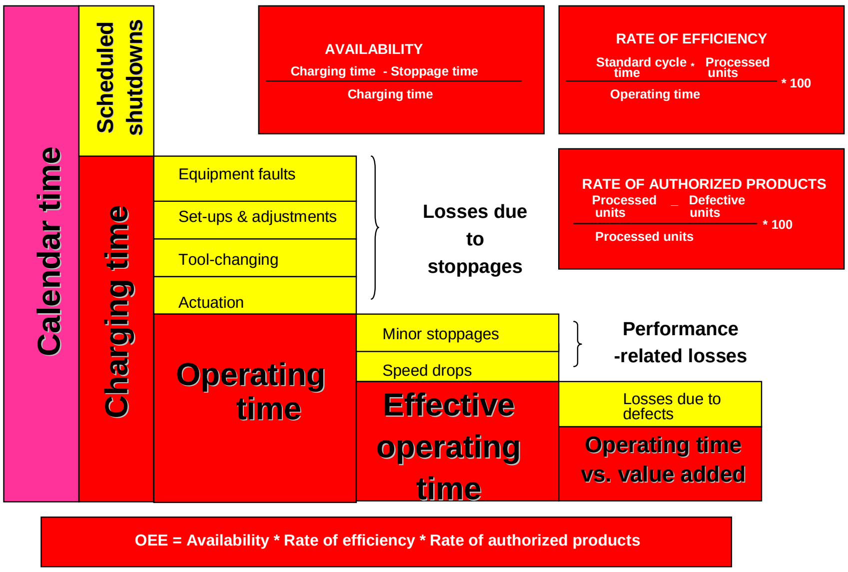

Figure 6: The OEE indicator.

The utilisation of the OEE (Overall Equipment Effectiveness) indicator and its enhancement has the following essential effects:

- High process stability
- Continuous improvement of the existing processes (CIP)
- Implementation of the best and most modern maintenance practices
- Avoidance of unscheduled shutdowns and consequential problems
- Operation of an efficient fault management system

RCM – Reliability Centred Maintenance

In RCM the term “reliability” can be defined as the quality required during a period of time in relation to the requirements made on a product by a customer. Another definition of reliability would be that it is the possibility for a system or a facility to fulfil the requirements made on it in a satisfactory manner under special circumstances during a period of time.
For the application of RCM it is now necessary to define which functions and performances of plant parts and components are needed in order to guarantee the required degree of reliability.
The operation and/or the reliability are potentially at risk when malfunctions arise. Malfunction states are functional disturbances which arise when a plant component is incapable of performing in conformity with the customer’s wishes. RCM is used for identifying which types of malfunction may occur, which circumstances may cause the state of malfunction to arise and which events may trigger the malfunction. The reasons for all types of malfunctions must be identified in detail. Thereafter, the effects must be listed. In RCM predominance is given to the consequences of malfunctions. Causes have to be dealt with, not symptoms (Figure 7).

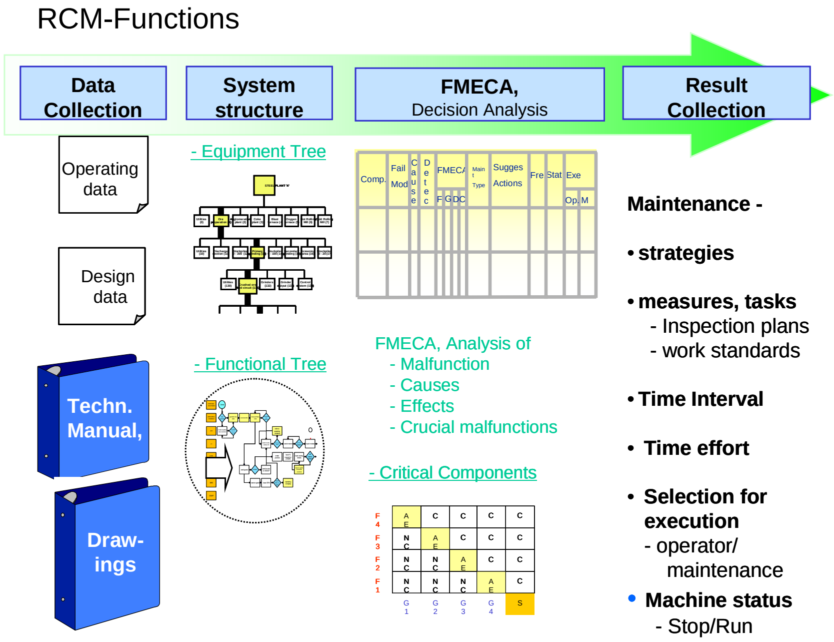

Figure 7: Functions of RCM.

Main advantages of RCM (Figure 8):

- More safety and better environmental protection;
- Higher operating efficiency;
- Improved profitability of maintenance;
- Longer useful life of the more expensive plant components
- Better individual motivation due to employee satisfaction;
- A centralised database and consolidated experience

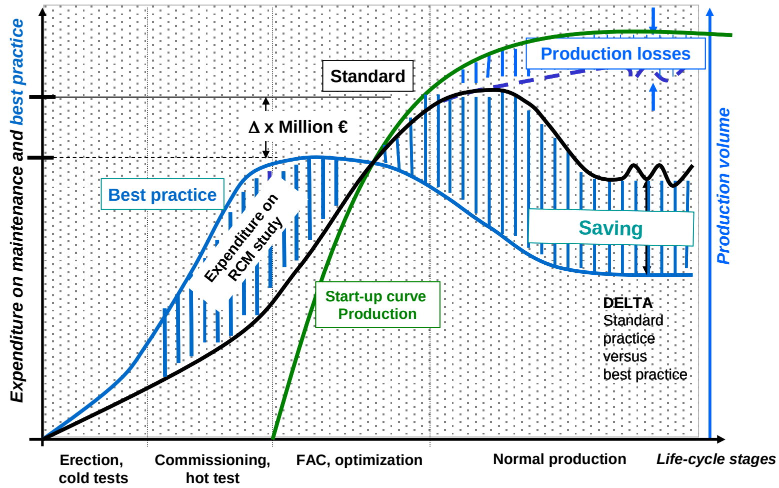

Figure 8: Cost savings through RCM.

Weibull distribution

RCM does not take into account the availability of a plant but its reliability. However, it is not possible to check the reliability 100% because it would then normally be necessary to employ destructive testing. For this reason, statistical methods are utilised based on survival probability (reliability), and therefore the distribution is indicated as R(t):

$$R(t) = e^{-\left(\frac{t}{T}\right)^b} = 1 - G(t)$$

t Lifetime or cycles that are survived by the component.

G(t) Likelihood of failure (distribution function): Expected proportion of those components which fail before t is reached.

R(t) Survival probability (reliability): Proportion expected to survive t.

T Characteristic lifetime:

$G(T) = 1 - e^{-\left(\frac{T}{T}\right)^b} = 1 - e^{-1} = 0{,}632$; time until failure occurs of 63.2% of the components

$R(T) = 1 - 0{,}632 = 0{,}368$; time that is survived by 36.8% of all components

b Models the kind of distribution

µ Average lifetime: $\mu = \left(\frac{1}{b}\right) x T$

λ Fault rate: $R(t) = e^{-t\lambda}$

Example:

an equipment has 3 shutdowns in one year, each one with 2 hours downtime

VALUES OF MTBF (month)	1	2	4	6	8	10	12	24	36	48	60
RELIABILITY (%)	0.0006	0.25	4.98	13.53	22.31	30.12	36.79	60.65	71.65	77.88	81.87

PERÍOD OF 12 MONTHS OF CONTINUOUS OPERATION
(CONSTANT FAILURE RATE)

$R(t) = e^{-t\lambda}$
$= e^{-1x3}$
$= 4{,}98$

Availability = 99,93 %
Reliability = 4,98 %

$R(t) = e^{-12*1/MTBF}$
$= e^{-12/4}$
$= 4{,}98$

Figure 9: Example of calculation of plant reliability.

IMMS® – INTEGRATED MAINTENANCE MANAGEMENT SYSTEM

Based on the philosophy of RCM we provide an information system which processes and makes available datas which are needed for systematic maintenance (Figure 10).

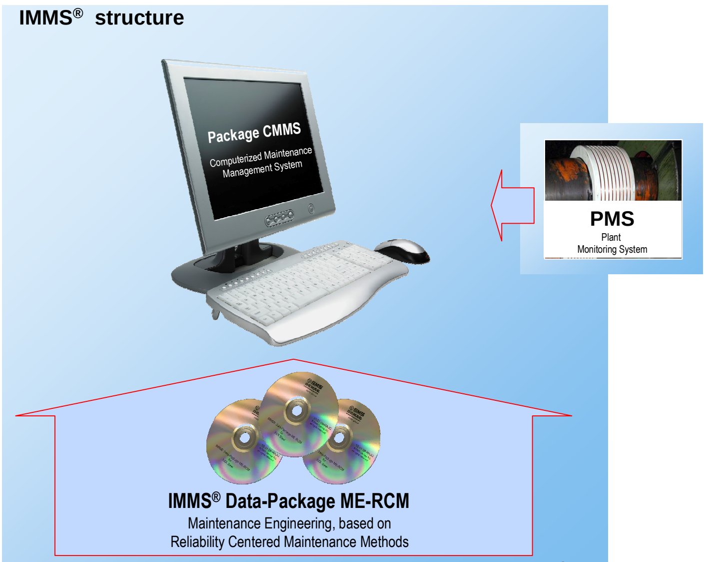

Figure 10: Components of an IMMS®.

MMS comprises a computer-based maintenance management system (CMMS – Computerized Maintenance Management System) including a stock-keeping functionality, an interface with the Maintenance Engineering department, the tasks of which are based on the RCM methods and procedures and the plant monitoring system (PMS).
The computer-based maintenance management system (CMMS), a standard application system, collects all of the relevant data that are important for enabling the Maintenance Engineering department to carry out effective plant management. On an individual basis, starting from a plant tree, CMMS provides information on the erection of equipment and on the plant components. In addition, all relevant technical

data, documentation and drawings as well as fault and maintenance data are made available by CMMS.
Besides the provision of inspection schedules and information on the respective status of maintenance tasks, there is an interface for processing of the cost and controlling data and a connection to the stock-keeping functionality. The procurement of spare parts can thus be optimised and cost savings are made through the reduction of stock-keeping.
Furthermore (fig. 10)., CMMS enables the Maintenance Management and Maintenance Engineering departments to prepare, on the basis of the RCM methods and procedures, those working instructions, work sequences, working hours schedules and work specifications which serve to regulate the resources, materials and tools. The performance of the maintenance activities is coordinated and monitored by the Engineering department with the aid of the data, in order thus to obtain feedback on the effectiveness of the activities.
The effectiveness of maintenance activities can be measured, for example, by continuous monitoring of the plant data, on the one hand by comparing the actual with the desired status and on the other by comparing the data prior to the maintenance activities with those following a maintenance measure. For provision of the data required here, use is made of a Plant Monitoring System (PMS). Sensors measure the individual process parameters like torque, vibration, temperature, flow, which are then monitored and evaluated by the PMS

Advantages gained from the introduction of IMMS®

- The reliability and availability of the plant and equipment are enhanced, along with the obtaining of lengthened inspection intervals, shorter reaction times in the event of shutdowns , lower costs, shorter shutdowns and repair times and, furthermore, there is a positive influence on the incidence of faults.
- An active and efficient flow of information arises, with the correct data becoming available, performance indicators being displayed and comparisons being able to be made with problems that have already occurred.
- Communication and coordination is made easier, particularly in inter-departmental fields (stock-keeping, controlling, production, maintenance by external firms, etc.), and interface problems are reduced.
- The maintenance personnel can be utilised and coordinated more efficiently through improved knowledge concerning the plant and the plant condition.
- A smaller scope of stock-keeping is obtained as a result of enhanced plant transparency, with the relevant machine data from the CMMS being directly available for Spare-Part Management .
- A higher degree of efficiency in the purchase, planning and sale of new plants is achieved through a pool of information relating to similar or identical plants and plant accessories.

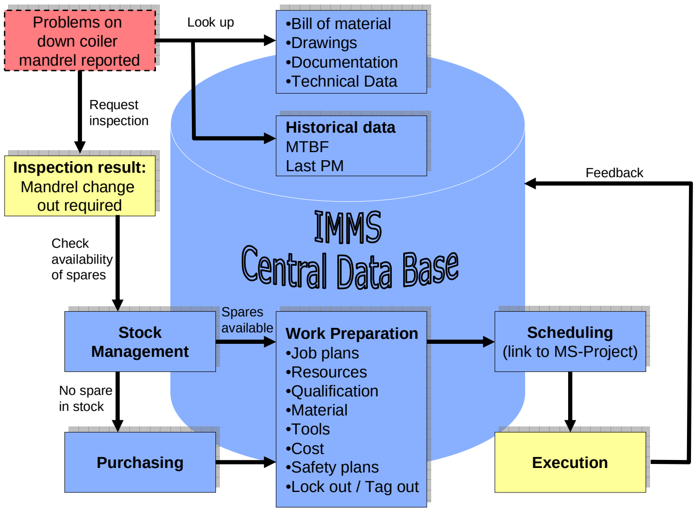

Figure 11: Example of a problem-solving process in combination with IMMS.

MAINTENANCE OUTSOURCING

Outsourcing is an artificial word compiled from the terms “outside”, “resource” and “using”. It refers to the separating-off of certain sub-services or sub-functions of a firm and their being taken over by external suppliers. Fundamentally, this concerns every economic and business-related function. Outsourcing does not normally affect products, but services.
The core objectives of maintenance outsourcing are the separating-off of individual areas with the aim of attaining the improvement in OEE as described in the chapter on Performance Indicators. In addition to the individual maintenance processes, methods and systems, the management and the maintenance organisation are also the subject of an outsourcing procedure.
Positive effects of a financial nature, which are obtained through outsourcing, are the fixed prices which are charged by external firms. These result in fewer fluctuations in the total cost situation and thus in an improved cost-planning capability. A partial risk for the plants is borne by the external firm, leading to lower costs for the user in the event of a case of damage.
From the strategic viewpoint, the advantages obtained will enable the customer to concentrate on the core business, and in the maintenance field he can profit from the knowledge of the external firm, thus causing the process of change to accelerate.

Maintenance audit

A component of the outsourcing process is the auditing of the existing maintenance system by the external supplier. Auditing is essentially performed in three phases.
Within the first phase, the customer is first requested to answer a number of questions. These include the discussion of fundamental subjects such as manufactured products, finances, personnel, strategies and policies. As part of a 1st audit, the structure of the object is examined more closely. This involves, for example, the individual production facilities, the logistics, the infrastructure or the energy supply. At the end of the 1st audit, a report with a cost proposal is drawn up.
At the beginning of the second phase, the customer will have decided to outsource the maintenance areas. First of all, a feasibility study is conducted on the objects to be outsourced. In this study, the question is clarified as to which methods and constituents of the maintenance system can be transferred to the relevant plant. On

this basis, the individual components of the maintenance system are specified as part of the preparation of the master plan. At this point, concrete savings can be indicated for the customer.
The third phase comprises the implementation of the maintenance concept that has been stipulated in cooperation with the customer. Depending on the requirements and wishes of the customer, various areas can be taken over or different types of hardware and software can be applied.

SUMMARY

Insufficient maintenance will definitely result, in the long term, in a deterioration of the plant condition and, at the same time, in heightened expenditure on the care and maintenance of the plant. Conversely, excessive maintenance expenditure or maintenance at the wrong locations will likewise result in greater costs (Figure 12).

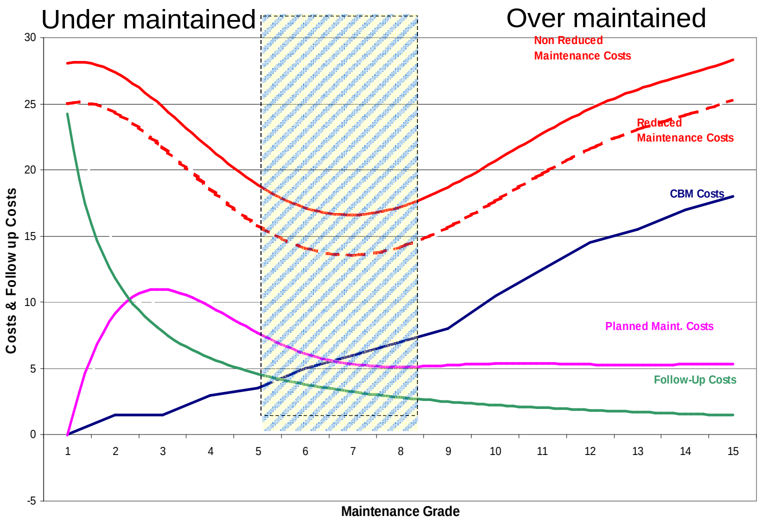

Figure 12: Achievement of a cost-optimised maintenance.

‘The objective of a maintenance system is to optimise the cost-benefit ratio, i.e. to apply the best possible maintenance under consideration of the total costs of a company. In order to achieve the aims of quality improvement and simultaneous lowering of the total costs, the maintenance processes must be represented in an optimum manner, which will enable the ratio of production time to downtimes to be improved (improvement of OEE – Figure 12).

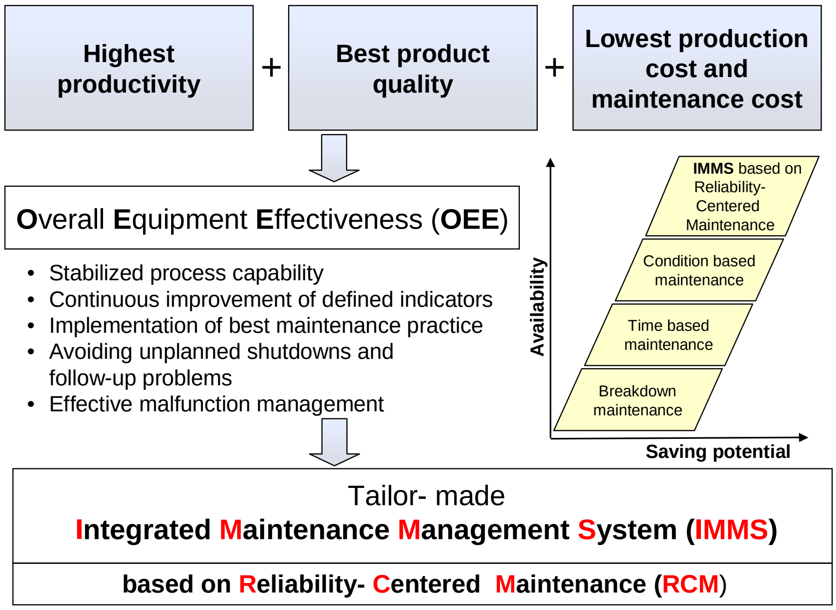

Figure 13: Achievement of the basic objectives of maintenance using IMMS and RCM.

Modern maintenance comprises, on the one hand, the optimum hardware and software (CMMS) and, on the other, a modern system of maintenance (RCM) combined to IMMS®. The potential for savings and the availability of a plant is influenced decisively by the maintenance system applied.

If a modern system of maintenance is implemented in a consistent and uninterrupted manner, this will lead to a continuous improvement process (Figure 14).

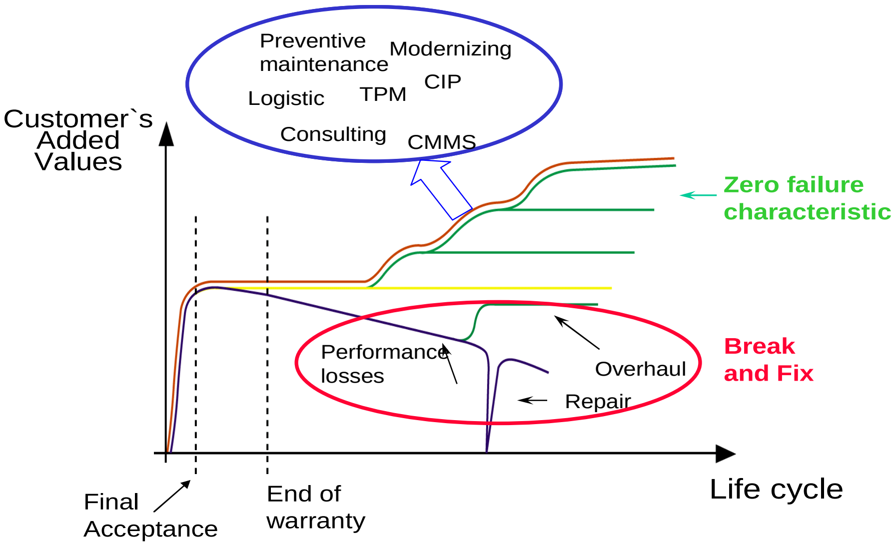

Figure 14: Benefits to the customer and process improvement.