MAINTENANCE PLANNING

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Abstract

Planning and organization of maintenance activities are the fundamentals of maintenance management and various problems may affect success; especially constructing a maintenance management is highly difficult. Depending on the industrial branch and the type of investment good a variety of reasons may be causative. Referring to Márquez the most frequent reasons will be presented in more detail:

Maintenance is a complex system of activities; the lack of maintenance management models makes the cancellation of complexity difficult. It is not just repair – it is a complex methodology starting with the product design, continuing with planning preventive maintenance activities and ending with shortened down states for repair (product supporting services) in worst case.

Key words: Planning, global markets, maintenance activities

INTRUCTION

Influenced by the requirements of global markets, the competition in high technology branches necessitates permanent operational readiness of technical machinery and equipment. Materials of high quality and reliability-oriented engineering philosophies work against system abrasion, but cannot avoid it completely. Accompanying the introduction and operation of new and existing technologies, many influencing variables need to be considered when maintenance strategies are organized or implemented. A central aspect of maintenance is the failure behavior; but as a result of complex plant structures and solid interlinking of equipment and components, rival goals grow up (e.g. maximization of upstate time with a simultaneous minimization of maintenance costs). Planning maintenance activities is a demanding challenge.

MAINTENANCE TERMINOLOGY

Decreasing reliability and abrasion of heavy stressed parts are indicative for increasing age of technical equipment. It is up to maintenance to constitute and reconstitute absolute operability. According to DIN EN 13306:2010 maintenance is a "combination of all technical administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function". Per definition those items are ascertainable as parts, components, devices, subsystems or systems individually describable and considerable. The main condition of maintenance is maintainability; for stated conditions of use, stated maintenance procedures and resources are defined. Maintainability influences the down time of an object substantially. [1, 2]

The generic term of maintenance combines inspection, preventive maintenance, repair and improvement as basic procedures. [3]

An inspection is a conformity examination; items relevant characteristics are measured, observed or tested. The Inspection is intended to identify and assess the actual condition of objects. [4]

Managed by an inspection plan the activities take place. In addition, to identifying the actual item condition the analysis of generated data is important to initiate future failure prevention. The following tasks are derived from inspection:

- Determining the actual state
- Evaluating the actual state
- Assessing the actual state
- Initiation of further measures

The assessment of the actual state allows monitoring the wear-out of an unit and provides an insight into its reasons. Planning necessary maintenance activities becomes possible this way.

Preventive maintenance unifies all procedures intended to reduce failure probability or functional limitations. They are carried out at defined intervals or according to stated criteria.

Ideally, preventive maintenance activities avoid fault-induced down times of items by retarding the reduction of residual operation time. Concrete goals characterize the predetermined maintenance time frames; goals and time frames are constituted by an operation chart. The available wear-out reserve defines the intensity of preventive maintenance intervals consisting of tasks like cleaning, preserving, adjusting, lubricating, complementing and replacing parts, subsystems and systems. [4]

Repair contains physical activities taken to restore the regular function of a faulty unit. [2]

The goal of repair activities is the compensation of the consumed wear-out reserve by initiated corrective work and item exchanges. Depending on lead time available – planned or unplanned repair – the preparation is more complex compared with preventive maintenance. Only with great efforts down states are avoidable. According to DIN 31051:2003 time schedules, personnel placement and work cycles have to be created before starting repair works. Particularly the unplanned (reactive) maintenance may cause problems; here the time of system failure as well as complexity and flow of actions to initiate are unknown.

Improvement refers to all activities which are intended to ameliorate reliability, maintainability or the safety of parts; the original function is not changed. The traditional maintenance term gets extended by the aspect of perfecting activities.

During the construction process of an object weak spots and safety deficits may creep in. It is the task of improvement to adjust shortcomings by constructive changes, therefore, experiences derived from systems on duty are essential. By establishing a continuous improvement process the latest learning effects inure to the benefit of existing items. Thus, a permanent adjustment to the usual system performance requirements and currently applicable safety requirement has to be realized. [5]

Now defined maintenance procedures are divided into scheduled and reactive maintenance, table 1 provides a structured overview.

Tab.1 Structure of maintenance procedures and classification of mission fields

Maintenance			
Scheduled maintenance			**Reactive maintenance**
Inspection	**Preventive maintenance**	**Improvement**	**Repair**
Determine and assess the actual state of an item.	Keep the target condition of an item.	Restore the target condition of an item.	

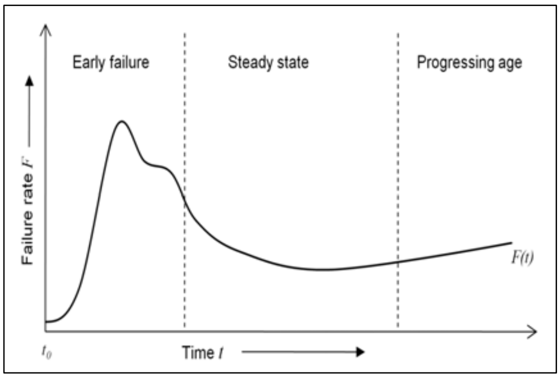
Well-designed maintenance strategies may generate synergetic effects by optimizing the combination of basic procedures; processing efforts in administrative and operative maintenance get reduced. According to the definition of maintenance the aimed target condition of an object is kept for time of usage.

SYSTEMS TYPICAL FAILURE BEHAVIOR

The incidence of a system failure is hard to predict; but the breakdown is guaranteed. Maintenance data analysis reveals part-specific down times which may cause a system failure. This data must be a fundamental part of planning maintenance strategies.

In figure 1 a typical failure rate F(t) is drawn as a function of time. The first bringing into service happens at the moment t0; noticeable is the high error rate at the beginning (early failure). Mostly, quality deficits are identifiable as the cause; they were not recognized during the production process and a high error rate at the beginning is induced. After overcoming initial difficulties the error rate is falling during the steady state before it rises slightly with progressing age of the parts.

Fig.1 Typical failure rate of items



The curve of the function F(t) allows conclusions on quality management structures of part manufacturers, maintenance activities to extend the duration of life and the optimal timing of part or component replacement. In particular, the prediction of parts behavior after steady state operation is difficult.

As soon as machines, which are designed for high reliability, run into age-related wear-out the probability of an error caused breakdown becomes unpredictable; the wear limit of an object is achieved. According to DIN 31051:2003 the reserve of functional performance under specified conditions is defined as wear reserve; the reductions of wear reserve as wear.

For three components n=1, 2, 3 the wear reserve An(t) is drawn as a function of time in figure 2. Corresponding to the technical configuration, different time courses of degradation may result; starting at An(t0). The wear limit is reached at the points An(tAwln); with further exceeding the components finish their functioning at An(t)=0 – failure.

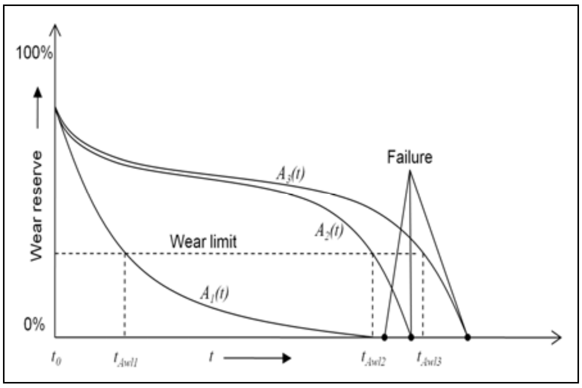


Fig.2 Component specific reduction of wear reserve

An unintended early termination of the system function does not need to result from a complete reduction of the wear reserve. Error-related failures may be caused by dysfunctions which interrupt the normal functioning. Such events are divided into primary and secondary failures; primary failures are caused by the unit itself and secondary failures by an error of peripheral units.

The average operating time interval between two failures of a system is defined as the Mean Time Between Failures (MTBF). Ideally, worn components will be replaced before the expiry of the MTBF (system failure). The average time interval between two preventive component changes is defined as Mean Time Between Replacements (MTBR). [2, 6]

SYSTEM STATES AND REQUIREMENTS OF REACTIVE MAINTENANCE

Disruptions during operation are the reason for the transition from functional to a dysfunctional system state. Further analysis leads to various substates from a functioning system to an external disabled system (secondary failure). Hereafter the two system states with their corresponding substates are presented in detail and classified according to the table 2 in an overall context.

Characteristic for the upstate of a system is the performance of a required function. The following substates are possible:

- Idle state: non-operating item during up state (system is not required)
- Operation state: fulfilling the required function
- Standby: non-operating item during up state (system is required)
- External disabled: the item is in an upstate but there is a lack of required external resources (secondary failure)

Tab.2 States of an item

<table>
<tr><th colspan="4">Upstate</th><th colspan="2">Downstate</th></tr>
<tr><td colspan="3"></td><td colspan="3">Disabled state</td></tr>
<tr><td rowspan="2">Idle</td><td rowspan="2">Operation</td><td rowspan="2">Standby</td><td rowspan="2">External disabled</td><td colspan="2">Internal disabled state</td></tr>
<tr><td>Subject to preventive maintenance</td><td>Fault</td></tr>
</table>

Systems regarded at down state are not able to keep up the required function; causal for those dysfunctions are:

- Faults
- Subjects to preventive maintenance, which force the system to cease its function

Maintenance activities reduce the systems availability. The planning of those activities needs to be well prepared; lead time is mandatory for preventive maintenance. During reactive maintenance the situation is much more complex. In case of damage necessary steps, such as scheduling, personnel approach, staging, etc. cannot be planned. Table 3 shows the course of reactive maintenance, but does not consider a possible logistic delay which can arise through administrative activities, personnel, materials and working space acquisition. [7]

Tab.3 Equipment active corrective times

<table>
<tr><th colspan="4">Active corrective maintenance time</th></tr>
<tr><td>Technical delay</td><td>Troubleshooting</td><td>Fault correction time</td><td>Check-out time</td></tr>
<tr><td></td><td colspan="3">Repair time</td></tr>
</table>

According to systems complexity and cause of reactive maintenance the troubleshooting as well as the approach of time needed can be extended strongly. The removal of cover parts and other technical preparations require additional time before starting fault correction activities. After finishing, there is the technical follow-up; it includes the assembly, function checks and calibration work respectively.

MAINTENANCE MANAGEMENT

Already when designing technical facilities use times are taken as a basis; the wear reserve is the reference value. Technical measures, administrative measures and management activities ensure as parts of maintenance the operation state of a system. According to DIN EN 13006:2010 maintenance management includes: “all activities of the management that determine the maintenance objectives, strategies and responsibilities, and implementation of them by such means as maintenance planning, maintenance control, and the improvement of maintenance activities and economics”.

In an organizational structure the work is distributed to maintenance leadership with responsibility for maintenance management, and maintenance staff; all together are responsible for maintenance processes. Figure 3 illustrates the separation into classical maintenance and management; reliability and economy are the core tasks of maintenance management.

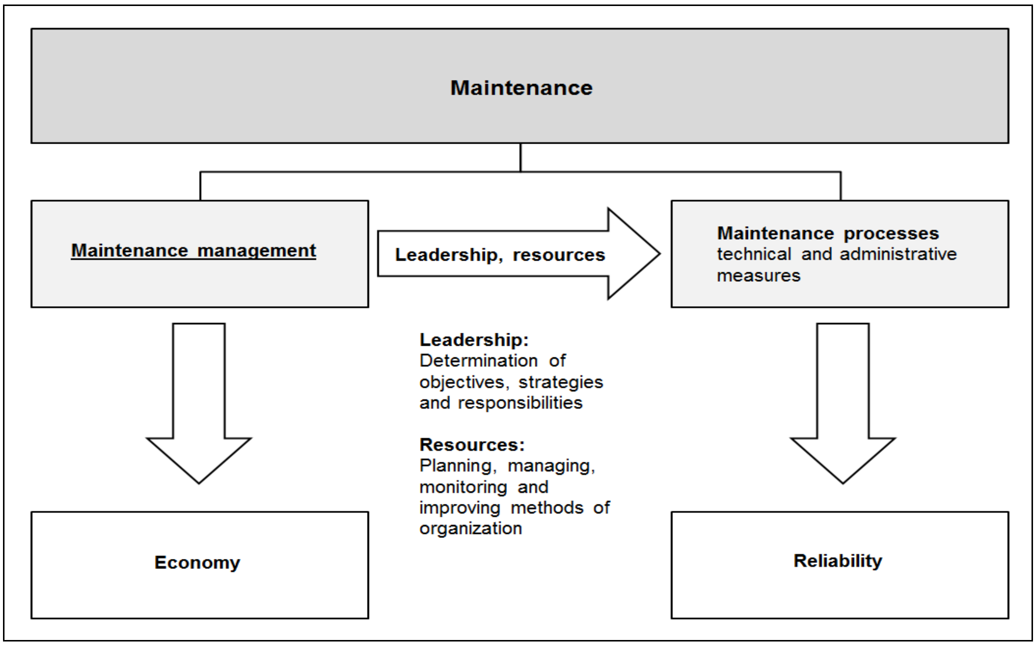


Fig.3 Management and processes in the context of maintenance

Characteristic functions of maintenance management are system procurement, resource allocation and process management. Already during the process of system procurement necessary maintenance measures should be taken into account. It is up to maintenance management to provide the required resources for reducing down state times of existing machinery. Especially in case of reactive maintenance, process management decides on the length of the down state time.

CONCLUSION

The diversification of potential maintenance problems is increasing more and more; administration becomes more difficult. An enormous variety of activities inhibits the implementations of standardized procedures and information support systems. Only in exceptional cases standard recipes are applicable; the demanded customized services require a maintenance management with a maximum of flexibility.

Customized products imply variants – individual maintenance measures are necessary. Building up system-related error knowledge is strongly limited. The permanent further development cuts the time for dedicated problem analysis. Additionally, ad hoc decisions and short term plans undermine maintenance management systems designed for long-term plants availability.

Staff retention and the fear of disruption by maintenance measures restrict the willingness of the top management to support. The increasing improvement of systems efficiency, productivity and complexity makes the implementation of maintenance difficult. As a result of using latest manufacturing technologies and implementing the idea of just-in-time production conditions have changed. Inventory levels have been minimized, throughput increased and the economic efficiency of plants grew as well as the pressure on maintenance. The failure of one component can bring the whole system to a standstill; huge costs are caused at efficiency-optimized systems.

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