MAINTENANCE ASPECTS OF NONCONVENTIONAL MACHINE

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Abstract : Life-cycle maintenance has been an important factor in modern industrial companies' competetiveness and for nonconventional machines operation. The objective of maintenance is to reduce the number of unexpected breakdowns due to failures, which may be catastrophic and may incur huge loss. Many industrial companies have shifted their maintenance programs to condition-based maintenance (CBM), which, if correctly and effectively implemented, can significantly reduce the maintenance cost by cutting down the number of unnecessary scheduled preventive maintenance operations of all nonconventional machines.

Keywords : maintenance, CBM, CMMS, EAM, Life-cycle

1. INTRODUCTION

In the past, maintenance was regarded as repair work. Machines were operated until they broke down. With the development of reliability engineering in the 1950s, the concept of preventive maintenance was advocated, and time-based maintenance (TBM) was introduced. After the limitations of TBM as a means of preventive maintenance were recognized, the concept of condition-based maintenance (CBM) was proposed based on the development of machine diagnostic techniques in the 1970s. In the case of CBM, preventive actions are taken when symptoms of failures are recognized through monitoring or diagnosis. CBM enables taking the proper actions at the right timing to prevent failures, if there is a proper diagnostic technique. However, CBM is not always the best method of maintenance, especially from the perspective of cost effectiveness. When failures of machines or components are not critical, we can allow breakdown maintenance (BM), in which actions are taken after failures are detected. When the lives of machines or components can be estimated precisely, TBM is the most effective means of maintenance. From the latter half of the 1980s, the importance of selecting proper maintenance strategies has been acknowledged. Reliability Centered Maintenance (RCM) and Risk Based Inspection (RBI) or Risk Based Maintenance (RBM) are the most well known methodologies for this purpose. Although maintenance concepts and methodologies have advanced significantly over the past several decades, maintenance still has a negative image because it is regarded as merely a measure against troubles. A maintenance department is usually regarded as a cost-centre, which does not create profits. If we look at the role of maintenance from the perspective of life cycle management the picture is completely different. The purpose of product life cycle management is to control the conditions of products so as to provide the required functionality. There are two reasons why it is necessary to control the conditions of products. One is the change in product conditions due to deterioration. Another is the changing needs of customers. The former is referred to as the product's physical life and the latter as its functional life. In both cases, the measure that should be considered first is maintenance including upgrade, because maintenance generates less environmental load. If maintenance does not work well, next solution should be remanufacturing. Production of new products should be the last measure taken. The perspective of life cycle management for manufacturing has brought about transformation of business models of the manufacturing companies from product providers to service providers [2]. Maintenance could be one of major services associated with product life cycle management. The objectives of industrial maintenance are illustrated in figure 1 [2].

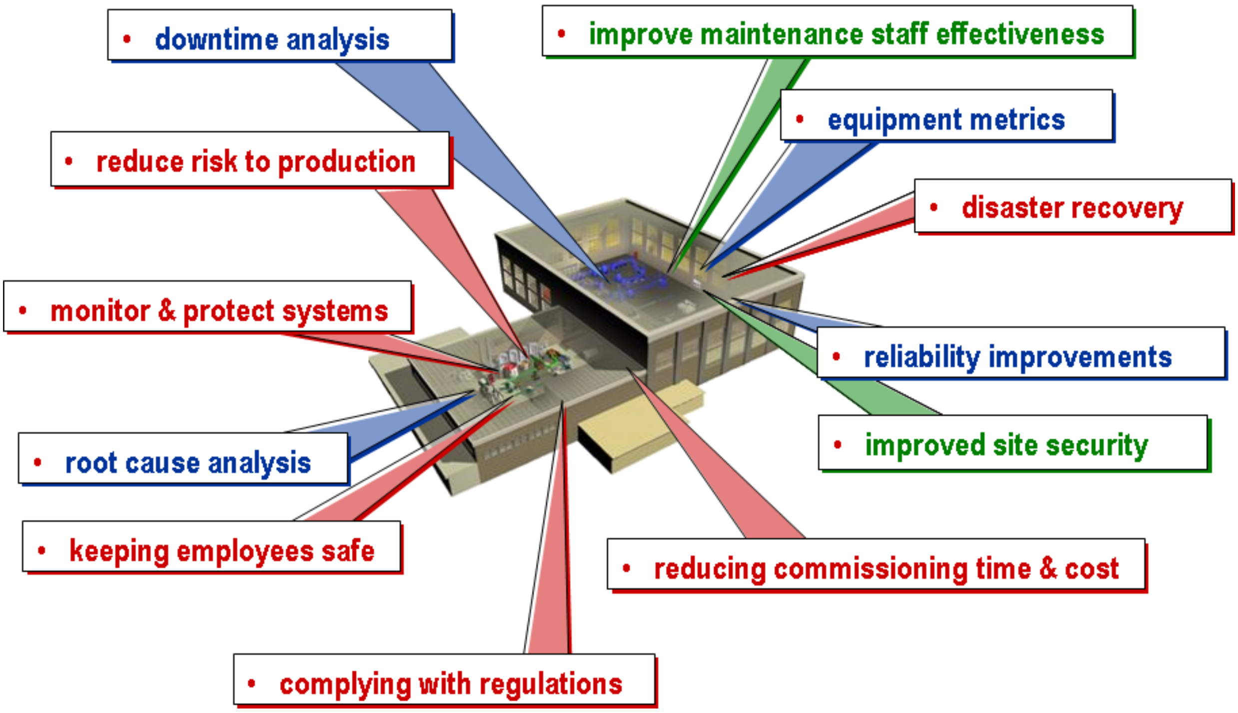

Fig. 1. Maintenance objectives [2]

2. LIFE CYCLE MAINTENANCE MANAGEMENT

For fulfilling the requirements of life cycle maintenance, has been proposed the framework shown in figure 2 [4]. In this framework, maintenance strategy planning plays a key role. This planning involves selecting the strategy of maintenance among various options, such as BM, TBM, and CBM, based on the evaluation of potential problems which could occur during operation, as well as evaluation of failure effects and effectiveness of maintenance technologies. Maintenance strategy planning serves as a bridge between the product development phase and the operation phase. It obtains design data and production records from the development phase, and determines the maintenance strategy for each component of the product. These strategies are passed on to the operation phase, where maintenance tasks are planned in terms of procedures and schedules based on them. After maintenance tasks, which include inspection, monitoring, diagnosis and treatment, are executed, the results are evaluated by comparing between the actual condition of the product and what is anticipated when the maintenance strategy was selected. If there are discrepancies, the information is fed back to the maintenance strategy planning, where the maintenance strategies are revised based on re-evaluation of potential problems taking the actual data into account. If corrective maintenance, i.e., design improvement, is needed, the information is further fed back to the development phase where improvements and modifications of product design are performed.

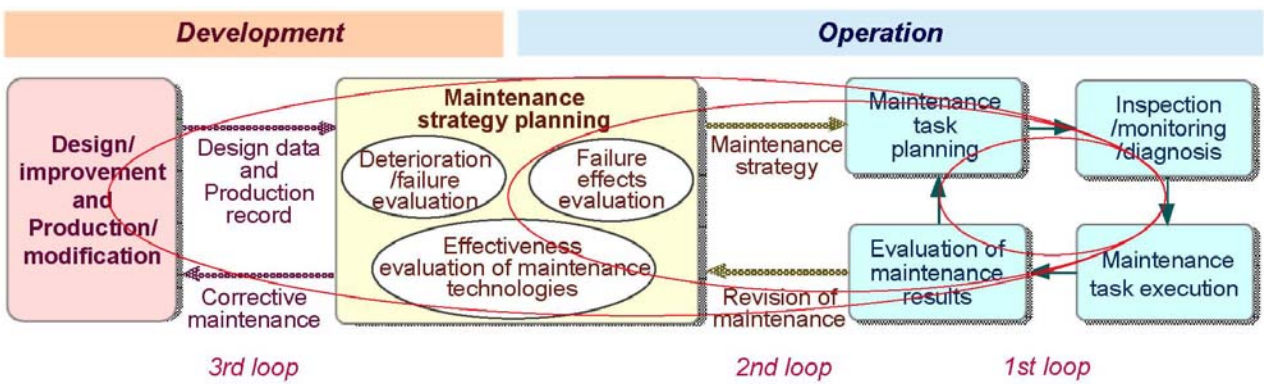

Fig. 2. Framework for life cycle maintenance [4]

As seen in figure 2, there are three feedback loops. The first is the loop of maintenance task management in the operational phase, which consists of maintenance task planning, task execution and assessment of maintenance results. This is the loop for controlling routine maintenance work. The second loop includes maintenance strategy planning. By means of this loop, the maintenance strategies can be improved based on the observation of actual phenomena and knowledge accumulated during the product life cycle. The third loop includes product development. This loop is essential for continuous improvement of the product during the life cycle. These three loops provide effective mechanisms for adapting maintenance strategies to various changes such as those in the operation conditions and environment, and also for continuously improving products.

3. RECENT TECHNOLOGIES IN MAINTENANCE

The development computing technologies enables installation of an intelligent unit on a machine or component to be maintained. The unit, in which sensors and processors as well as communication devises are integrated, can monitor the conditions of machines and carry out prognosis while storing usage data effective for residual life evaluation. An example of such a unit is the so-called Watchdog Agent^{TM} shown in figure 3 [3]. It can assess performance degradation of an observed product by means of embedded sensors, forecast future performance degradation and diagnose the reasons for degradation through trending and statistical modeling of the observed process signatures [3].

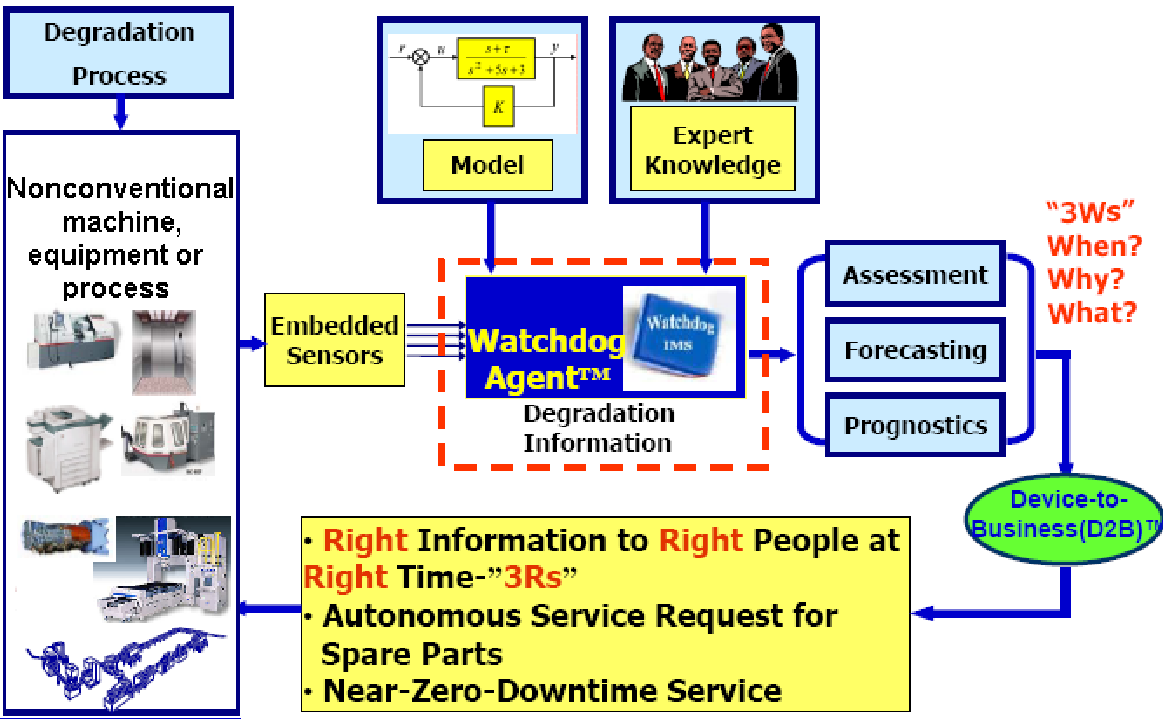

Fig. 3. Watchdog Agent^{TM} [3]

The advancement of communication and network technologies has impacted maintenance with two technologies: remote maintenance and web-based maintenance service. Remote monitoring and diagnosis was discussed considerably in the 1970s, when the technology for data transmission via a telephone line was first developed. Although many machine tool manufacturers offered remote maintenance service at that time, it did not become popular due to the immaturity of the technology. Recent developments in Internet and wireless communication technologies have enabled remote maintenance to be put to practical use. Internet technology makes it possible to provide various maintenance services other than remote monitoring and diagnosis via networks.

Emphasis is placed on providing entire services for life cycle management via a network, such as deterioration and failure analysis, residual life estimation, maintenance strategy planning, maintenance task management, end-of-life treatment and life cycle data management. Figure 4 [4], illustrates a concept of a network-based maintenance system. An intelligent maintenance service platform is proposed to enable easy implementation of a web-based maintenance service system. The platform consists of five layers: interface layer, data transformation layer, data transferring layer, intelligent informatics tools, and synchronization module [1].

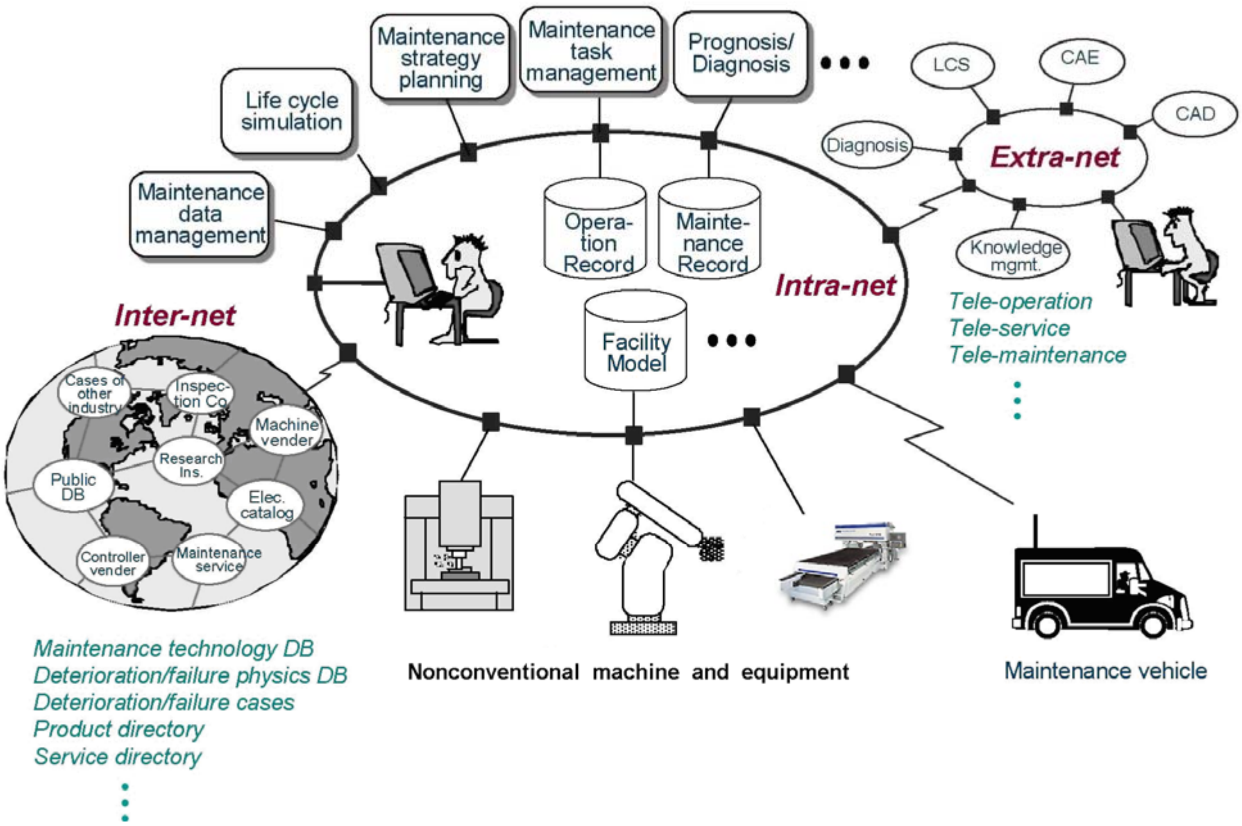

Fig. 4. Concept of a web-based maintenance system [4]

4. SUMMARY

For a sustainable nonconventional manufacturing, we should redefine the role of maintenance as a prime method for life cycle management whose objective is to provide society with required functions through products while minimizing material and energy consumption.

The recent advancement of information and communication technologies could also facilitate the integration of maintenance activities. There are, however, many possibilities to make use of technologies to improve maintenance effectiveness at nonconventional machines.

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