

Machinery Maintenance Yesterday, Today and Tomorrow in the Manufacturing Sector

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Abstract - Maintenance is what is done in machinery to prevent failure or breakdown. In ancient times no proper planning was carried out to do maintenance with the idea behind being simple machines and easy to control. As time progresses people started to find out that it was necessary to safeguard equipment to reduce costs for continuous growth. Maintenance is best divided its phases by world war two due to the fact that everyone wanted to win the war so new ideas were coming from different scholars as to get back their resources and land. Before world war two, everything was done as per suggestions without any standards. In world war two it was order of the day to improve and starting to think outside the box in maintaining the existing machinery and equipment and also lastly nowadays the speed in improvement and advanced type of machinery is always being manufactured at a supersonic speed hence new technology in maintenance as well.¹

Keywords-Maintenance, world war two, machinery

I. INTRODUCTION

Maintenance is the combination of all technical and associated administrative actions intended to retain an item in, or restore it to, a state in which it can perform its required function. Many companies are seeking to gain competitive advantage with respect to cost, quality, service and on-time deliveries (Encyclopaediaofbusiness, 2013). The increasing complexity of advanced machinery, as witnessed by highly advanced and fast processing production produces the rapid growth of manufacturing process automation (Khezzar A, Boucherma M. and Nemmour A.L., 2007), require that more effective and efficient testing and fault diagnosis techniques be developed to improve system reliability (Pacific Northwest National Laboratory, 2010), reduce machine down time, and enhance productivity (Pfeiffer J W and Jones J E, 1972). In this global village it is therefore necessary to work basing in mind the

issues of order winning criteria that is composed of quality, time and cost (Pfeiffer J W and Jones J E, 1972). Basically any machinery should work continuously to avoid loss to the company and producing high quality that can be accepted in society as well as lower cost to attract customers. This therefore has to mean continuous production with minimum machine breakdowns. Tool condition monitoring is crucial to the efficient operation of any machining processes where the cutting tool is in constant or intermittent contact with the work piece material and is subject to continuous wear. It is an important function for unattended operation of Computer Numerical Control (CNC) machine tools and satisfactory operation of flexible machining cells (Wong Y.S, Nee A.Y.C and Li X.Q, 1997). An effective diagnosis mechanism is necessary for the automation of machining processes so that production loss and downtime can be avoided (Aliustaoglu C, Ertunc H.M and Ocak H, 2009, 2009). Goldin and Katz conceives manufacturing as having two distinct stages which are machine-installation and machine-maintenance as well as production and assembly (Goldin Claudia and Katz Larry, 1998).

A. Early stages of maintenance

From the time of Sir Isaac Newton and his laws of motion, the thinking was that once a machinery is manufactured no maintenance would be required basing on what the creator did to the world without anyone to maintain it. That was indeed false considering the ordinary machinery to continue operating (Spangernburg R and Moser D K, 2004). Newton (1642-1727), Descartes (1596-1650), Leibniz (1646-1716) and all of the other major players in the 17th and 18th century development of mechanics were devoutly religious, and as was the custom of the time, they framed their scientific views in harmony with their religious views. Newton felt that this machine would, if unattended, operate somewhat imperfectly. So the hand of the creator was continually required to "tweak the mechanism" now and then and provide maintenance of the machinery. Since Newton had not accounted for all the observed details of the motions of planets, he assumed that these slight "discrepancies" were in fact defects of the machinery, requiring continual adjustment by the maker of the universe (Simanek, 2005, 2009). The British Standard Glossary of terms (3811: 1993) (Islamic University of Gaza - Palestine, 2007) explained

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the phases of maintenance as pre-World War 2, Post World War 2 and period after 1980.

The time before world war two people were only fixing machinery after it fails and knowledge and research progresses as machinery becomes more complicated. In the war people were thinking deeply to come up with very good ammunitions and rifles that work best so as to win. Hence much development arose with great scholars to continue from where the likes of Newton have left. So this paper is about enlightening readers how maintenance started and where it is now.

II. MAINTENANCE PHASES

The maintenance phase involves making changes to hardware, software, and documentation to support its operational effectiveness. It includes making changes to improve a system's performance, correct problems, enhance security, or address user requirements. To ensure modifications do not disrupt operations or degrade a system's performance or security, organizations should establish appropriate change management standards and procedures (The Federal Financial Institution Examination Council (FFIEC), 2012)

Generally maintenance is normally grouped in three stages which are 1G, 2G and 3G where G is for generation and world war two used as a benchmark and border for the development in machinery. 1G represents the first generation; 2G represents the second generation and the last being the third one. Generations of maintenance are put across according to the benchmark of world war two. First generation is for the time before world war two, second generation during world war two and the last one being the post of world war two (blueOxygen, 2003).

The software Life cycle (SLC) is any process model that has specification, development, validation and maintenance phases and these can repeat in cycles so it's sort of the structure of the development processes, software project management considers the practical limits, risks and deadlines and forms a complete plan for the entire project and the maintenance of its progress (Stack Exchange, 2012).

A. Maintenance before world war two

The second Industrial Revolution is usually dated between 1870 and 1914, although a number of its characteristic events can be dated to the 1850s. It is, however, clear that the rapid rate of pathbreaking inventions (macroinventions) slowed down after 1825, and picked up steam again in the last third of the century. This says little about the rate of technological progress as commonly defined in terms of productivity increase and the improvements in product quality, which

depends much more on the smaller, cumulative, anonymous changes known as microinventions. Eventually such activity like everything else runs into diminishing marginal product, unless a major new breakthrough opens new horizons (Mokyr, 1998). No proper maintenance of machinery was carried out since the machinery was so simple and easy to use hence no preventive maintenance required.

Yet it should be stressed that even with rise of giant corporations such as Carnegie Steel, Dupont, Ford Motors, and General Electric in the U.S. and their equivalents in Europe, these firms employed but a small fraction of the labor force and the typical firm in the industrialized West by 1914 remained relatively small, a niche player, often specialized yet flexible and catering more often than not to a localized or specific section of the market (Scranton, P, 1997) and (Kinghorn Janice R. and Nye John V, 1995).

With the onset of World War I (1914–1918), more sophisticated equipment was being developed and the inability of personnel to use such systems led to an increased interest in human capability. Up to this point, the focus of aviation psychology was on the pilot, but as time progressed, the focus shifted onto the aircraft. Of particular concern was the design of the controls and displays, the effects of altitude, and environmental factors on the pilot. The war also brought on the need for aeromedical research and the need for testing and measurement methods. By the end of World War I, two aeronautical labs were established, one at Brooks Air Force Base, Texas, and the other at Wright Field outside of Dayton, Ohio (U. S. Department of Transportation, 2012). Generally the research on improvement was mainly biased towards war and ammunitions.

Before world war people used to manufacture and wait for the machine to develop some problems then start maintenance. Aviation maintenance on the other hand as shown in figure 3 focuses on human factors programs on the people who perform the work and address physical, physiological, psychological, and psychosocial factors. It must focus on individuals, their physical capabilities, and the factors that affect them. It also should consider their mental state, cognitive capacity, and conditions that may affect their interaction with others. In most cases, human factors programs are designed around the people in the company's existing workforce (U. S. Department of Transportation, 2012).

Safety on humans was the core mandate of the aviation maintenance before world war one. Workers were communicating to each other before changing shifts to enable the incoming shift to know what is supposed to be done bearing in mind the danger areas where they can get some harms.

B. Maintenance during world war two

Engineers and engineering students who enlisted in the military were not available for work in factories. Therefore, the United States Office of Education organized several programs, known variously as Engineering, Science and Management Defense Training (ESMDT) or Engineering, Science and Management War Training (ESMWT) or Engineering Defense Training. The university conducted these courses at cost with the Office of Education paying for the instruction, laboratory materials, and maintenance (Napp, 2009).

C. Maintenance after world war two

This is the period of the inception of automation where breakdown of machinery was of major concern and need maintenance. Reliability engineering came into being in 1962 which is usually termed Reliability Centered Maintenance (RCM) and Total Productive Maintenance (TPM) in the 1970s by Japan (Moballeggi M, Makvandi P, Abadshapouri M.H, Ghaseminejad A and Kalantari H.A, 2013). The trend of maintenance increase in plant machinery is raising up the ladder with the concept of *kaizen* a Japanese term meaning continuous improvement.

Maintenance is the fundamental of all machinery for ongoing production without some failures and stoppages hence Just In Time (JIT) systems application. Though nomenclature changes from industry to industry and in many countries, generally there are four basic types of maintenance which are as shown in figure 1 by Mushiri, 2012 (the researcher for this paper).



Figure 1: Four basic types of engineering maintenance (Mushiri, 2012).

As shown in figure 2 all this maintenance is now being renamed and changed as technology is improving. Crisis maintenance is the type which involves traditional way of doing things with many breakdowns and unpredictability. There is also poor utilization of resources through an unpredictable work load, usually accompanied by a large maintenance workforce on standby. Preventive maintenance is also called planned in that an attempt to reduce maintenance effort by carrying out periodic checks to see if equipment is working properly characterized by the ability to plan. The third one is called CBM where you let the machine tell you the condition to be maintained through assessing or a

programmable logic controller. The last one here is the DOM where there is an ability to design machines that do not break down like modifying to replace components that do not withstand the work environment.

From figure 2 it can be seen that though crisis maintenance was used long time back still there are some companies which are failing to come up with a good strategy in their machinery. According to Inman 1999, the first major trend has to do with the impact of artificial intelligence techniques, such as expert systems and neural networks, on the formation of maintenance knowledge in industrial organizations. There is a diverse application of expert systems within the maintenance area.

DOM is now having such branches as TPM and RCM. Ongoing improvement in machinery is done continuously and hence machine breakdowns are eliminated. This is very possible to such complicated machines which need more attention.

The explanations in this research are more inclined to British Standard Glossary of terms (3811: 1993) (Islamic University of Gaza - Palestine, 2007). More names are coming out but this is basically how maintenance has maneuvered from a time before the world war two up to now. Nowadays with the emergence of technology and use of technology and e-commerce there is now e-maintenance. Maintenance is definitely changing everyday though it is still termed the 3G era but my opinion is this e-maintenance must be now in 4G maintenance.

III. CURRENT MAINTENANCE TRENDS

At first because equipment were not mechanized, maintenance was not a focal point. But gradually as equipment became more and more mechanized and also rising if the new competitive markets and the importance of time in a quality product without a breakdown, a need appeared for the maintenance strategy (Moballeggi M, Makvandi P, Abadshapouri M.H, Ghaseminejad A and Kalantari H.A, 2013).

Recently, eMaintenance has reached a high degree of attention within the industry. It has emerged around year 2000 from the integration of other fields that together are now ripe to harvest. These fields are operation & maintenance engineering, software engineering, information systems, business management, and other fields related to the application domains of eMaintenance. Together, they enable a more proactive, effective, efficient, and thereby, more cost-sustainable maintenance of many complex industrial systems (Mouzoune and Taibi, 2014).

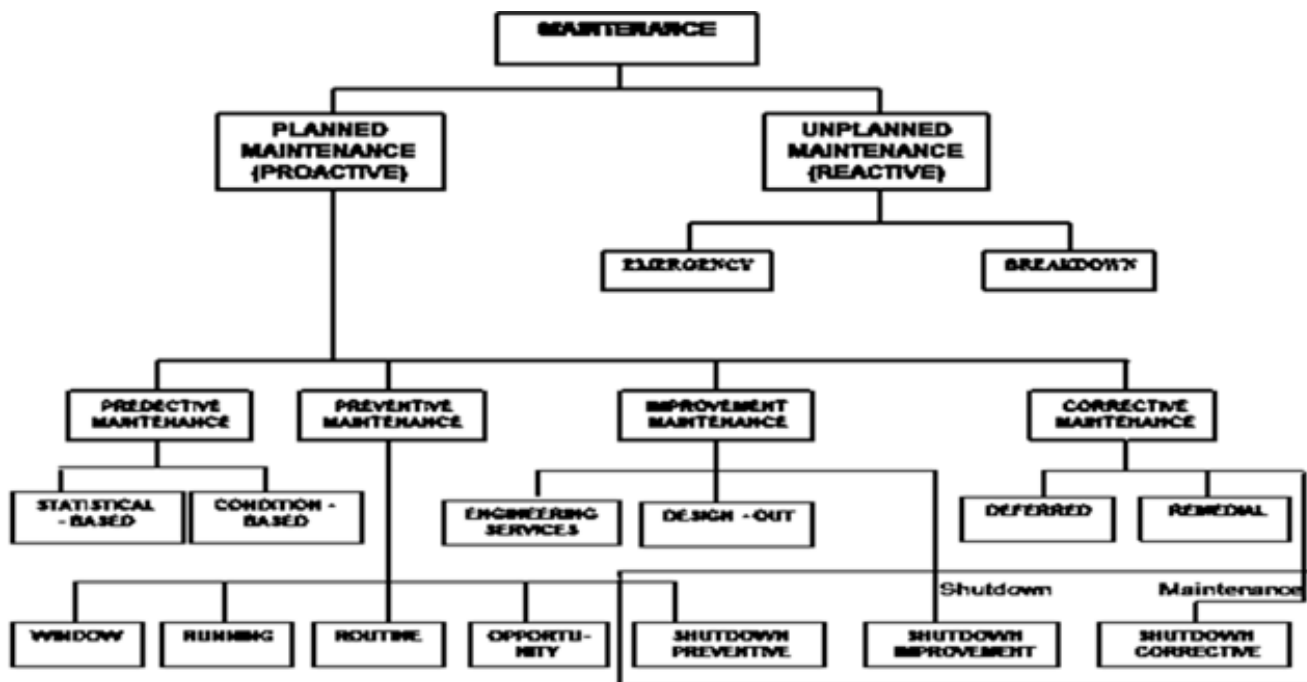


Figure 2: Maintenance types

In e-maintenance the link is from the customer up until the manufacturer hence maintenance is done with what is expected by the customer which is more like Customer Relationship Management (CRM). Al-Najjar (Al-Najjar B, 1996) discussed the importance of maintenance relating it to quality, a new term of CBM emerged which was then termed Total Quality Maintenance where the word total involves everyone from the lowest worker to the highest all fighting for the quality of machinery not to break down. In these recent years Japan and other highly developed countries are developing robots and other advanced machinery which need highly advanced maintenance. It is therefore necessary to shift from traditional ways of looking at things and start using advanced maintenance (Mushiri and Mbohwa, 2014).

IV: CONCLUSION

In a nutshell, maintenance has intensively changed and nowadays it is now a mandatory for machinery to be maintained in a state of the art manner to remain competitive and highly productive of industries in this era of high technology. It is the duty of every company to remain focused and eliminate breakdowns of machinery in a pro-active state.

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