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Leanness and Agility within Maintenance Process

Hassan Soltan
Production Engineering and Mechanical design
Faculty of Engineering, Mansoura University
Mansoura 35516 Egypt

Sherif Mostafa
School of Natural and Built Environments
University of South Australia
Adelaide 5001 Australia

***Abstract*—Maintenance has become a contributor towards achieving the strategic objectives of an organization. The maintenance operation is considered as one of the main pillarsfor improving the overall performance of an organization in today's markets. The principles and practices of lean and agile can be incorporated into maintenance to manage the maintenance processes.Lean and agile maintenance should beconsidered as a prerequisite for any successful application of lean and agile in an organization. This paper proposes a framework to measure the performance of maintenance strategies based on lean and agile factors. The factors of maintenance performance are designedbased on an analogy tolean and agile manufacturing principles. The multi-criteria decision making (MCDM) approach could be followed todistinguishdifferent maintenance strategies with respect to the lean and agile factors.**

Keywords—Maintenance; Lean and agile manufacturing; Performance measurement

I. INTRODUCTION

Maintenance has become a significant contributor towards achieving the strategic objectives of an organization in today's competitive markets [1]. Maintenance involves planned and unplanned actions carried out to retain a system or restore it to acceptable operating condition. Its main objective is to ensure the highest level of availability and efficiency of plant, equipment and buildings in a manner required by production at an economic cost (service cost and downtime cost).The maintenance operation is very important service to production activities as the total cost of production may be greatly reduced. Someorganizationsperceive maintenance as an inevitable risky source of cost. For these organizations, the maintenance operation has a corrective function whichis only executed in emergency conditions. Today, the maintenance operation as an emergency execution is no longer acceptable because of the increase in product quality, production plants safety, and the maintenance department costs (from 15% to 70% of the total production costs) [2-4].

In the changing and increasingly competitive industrial arena, organizations are striving towards the world class competition. This rivalry environment puts maintenance under increasing pressure to improve the availability and reliability of production facilities as well as to reduce total costs and waste. Someorganizationsattempt to reduce the cost of maintenance in the short-term. This might result in serious long-term implications, as the effects of bad maintenance areoften delayed. Maintenance managers should be able to convince the top management not to reduce maintenance costs to the bone. Top management should be aware of the fact that spending more, but wiser, is a sound investment. Maintenance already evolved a lot during the last decades, but still there is the need to rethink the way that maintenance is carried out. This means that the significance of maintenance concept to an organization needs to be addressed [5].

Succinctly, over years of developing maintenance strategies, maintenance has evolved from being breakdown (corrective) into sophisticated strategies. Therefore, the plant managers have to select the best maintenance strategy for each piece of equipment or system from a set of possible alternatives based on performance measurement. Basic categories and their versions, and applications of maintenance can be reviewed from various sources [2, 4, 6]. This paper is a proposal to a measurement framework to the performance of maintenance strategies based on lean and agile paradigms. The factors of maintenance performance are a set ofanalogyto lean and agile manufacturing. The multi-criteria decision making (MCDM) approachcan be subsequently conductedtodistinguishdifferent maintenance strategiesaccording to lean and agile factors.

II. OVERVIEW ON LEAN AND AGILE MANUFACTURING

Manufacturing organizations have pursued performance improvements by adhering to lean and agile manufacturing paradigms. Naylor et al. [7] relate both paradigms to supply chain strategies as leanness means developing a value stream to eliminate all types of waste (non-value added activities), including time, and to ensure a level schedule and agility means using market knowledge and a virtual corporation to exploit profitable opportunities in a volatile market place. A virtual corporation/enterprise means cooperation among many enterprises culminating in a virtual partnership [8]. A major issue in the formation of a virtual enterprise is the rapid integration and reconfiguration of business processes undertaken byparticipating enterprises. Narasimhan et al. [9] stated that lean manufacturing and agile manufacturing are distinct, yet they are overlapping paradigms. Sanchez and Nagi [10] mention that lean and agile are adopted as a top world class manufacturing system. Lean responds to competitive pressures with limited resources. On the other hand, agile manufacturing works with complexity brought by constant change. Lean is a collection of operational techniques focused on productive use (no waste) of resources. Whereas, agile is an overall strategy focused on thriving in an unpredictable market environment (responsiveness).

Lean manufacturing is suitable when demand is relatively stable and product variety is low. On the other hand, the agile manufacturing servesvolatile demand and high product variety. The natureof waste depends on the activities of the organization. Waste classified into three types: unobvious waste, less obvious waste and obvious waste [11]. deTreville and Antonakis [12] identify obvious waste such as inventory, unnecessary production processes, excessive setup times, unreliable machines and rework. They argue that the less obvious waste occurs as a result of variability sources such as process times, delivery times, yield rates, staffing levels and demand rates. Leanness can eliminate the obvious waste and reduce the less obvious waste. Lean operations reflect performance improvements in areas of cost efficiency, conformedquality, and delivery speed and reliability. Notice that delivery speed and reliability are enablers of agility, which shows some overlaps between leanness and agility. The improvements stem from greater resource productivities and utilizations, lower overhead, lower inventories (especially work-in-process) and faster cycle and throughput times [9].

Toyota identified seven major types of waste in manufacturing and business processes [13]. The processes include overproduction, waiting, unnecessary transport, incorrect processing, excess inventory, unnecessary movement and defects. In addition to the seven types of waste, Womack and Jones [14] identifythe eighth waste type which is related to unused employee creativity to improve the processes and practices [15, 16]. The eight types of waste are discussed as following:

- Overproduction: producing too much or too soon, resulting in poor flow of information or goods and excess inventory.
- Defects: frequent errors in paperwork or material/product quality problems resulting in scrap and/or rework, as well as poor delivery performance.
- Unnecessary inventory: excessive storage and delay of information or products, resulting in excess inventory and costs, leading to poor customer service.
- Inappropriate processing: going about work processes using the wrong set of tools, procedures or systems, often when a simpler approach may be more effective.
- Excessive transportation: excessive movement of people, information or goods, resulting in wasted time and cost.
- Waiting: long periods of inactivity for people, information or goods, resulting in poor flow and long lead-times.
- Unnecessary motion: poor workplace organization, resulting in poor ergonomics (e.g., excessive bending or stretching and frequently lost items).
- Underutilized employee: unused employee creativity and skills to improve the processes and practices.

The agile manufacturing concept became popular in 1991. Sharifi and Zhang [17] state that new competitive environment is a key driver tochanges in the manufacturing industry. The competitivecriteria include continuous change, rapid response and quality improvement. Agility is defined as the ability of an organization to respond rapidly to changes in demand in terms of volume and variety [18]. There are different structures for agile supply chains. Agarwal, Shankar [19] state the characteristics that supply chains must have in order to be truly agile (Fig. 1).

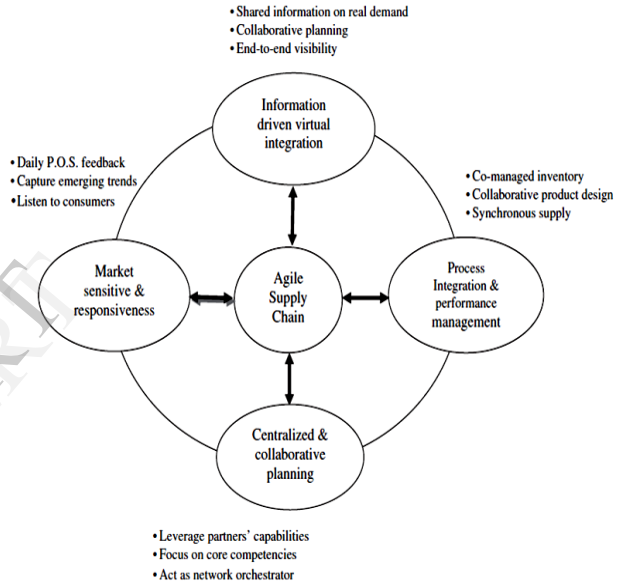

Fig. 1. Structure of agile supply chain.

III. LEAN AND AGILE THINKING IN MAINTENANCE

The maintenance operation must be considered as a pillar that increases the overall performance of an enterprise. Lean and agile thinking can be incorporated into maintenance processes through the application of their principles and practices. Alternatively, lean and agile maintenance could be considered as a prerequisite for lean and agile manufacturing systems. The hierarchy in Fig. 2 shows the maintenance factors in accordance with lean and agile manufacturing.

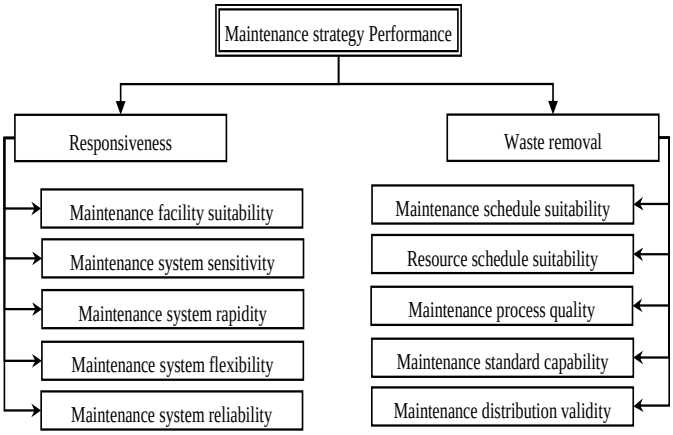

Fig. 2. Lean and agile factors in maintenance operations.

TheMCDM such as Analytic Hierarchy Process (AHP)is suggested to compare/measure the performance of different maintenance strategies (alternatives) in accordance with lean and agile factors (criteria/ sub-criteria). The AHP was developed by Saaty in 1980 [20]. It yields priorities for decision alternatives that compete in multi-criteria decision environment. The AHP ranks the important factors in a descending hierarchic structure. The goal is set at the first level, criteria at the second level and the alternatives (maintenance strategies) are set at the last level. The Expert Choice softwarecan be used to operate the AHP analysis.

IV. CONCLUSION

Maintenance management is a critical issue amongst management activities of manufacturing organization. It has rapidly grown into a very complex undertaking as technologies, competition, and product characteristics evolve. In order to achieve world class performance, the maintenance strategies should be linked to manufacturing strategies such as lean and agile. Selection of an effective maintenance strategy keeps high degree of utilization, reliability, and availability of production facilities, especially in continuous production process. Furthermore, this reduces the scrap of materials, spare parts and equipment. This study has introduced a framework based on lean and agile concepts to measure the performance of available maintenance strategies and compare each other using MCDM such as the AHP. The proposed framework can be applied in both manufacturing and service organizations.

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