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ENHANCING THE PRACTICES OF SPARE PART MANAGEMENT IN MANUFACTURING INDUSTRY

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Abstract

Spare parts (SPs) are set of extra items that are used for emergency replacements of worn out and defective parts. Maintenance and provision of SPs are the two activities which need to be performed together. Maintenance policy is based on inspection where identified defective items need to be either repaired or replaced. Maintenance activities generate the demand for spare parts. Spare part management (SPM) is an essential concept to be applied in any type of industry, especially in manufacturing industry due to the heavy usage of various types of machineries. Hence, spare part management causes significant impact, positively and negatively on the operations of manufacturing industry. Nevertheless, the applicability of SPM for maintenance in Sri Lanka is comparatively limited and the awareness about SPM is considerably low. There is a dearth of research conducted to identify the impact and to draw the awareness of SPM in Sri Lankan context. Therefore, this study aims to enhance the practice of spare part management for maintenance purposes in manufacturing industry in Sri Lanka. A comprehensive literature analysis was conducted on currently available scientific knowledge through reliable sources in order to realize the current practices of spare part management in other countries and any frameworks used in such countries to enhance the practices. Five case studies covering 5 main types of manufacturing industries in Sri Lanka have been conducted to identify the current practice and impact of SPM. Specially SPM directly related with the maintenance activities and also have the ability to cause direct impact for the production. Priority given for managing SPM is in lover condition. The major reason to have a lacking consideration is the lack of awareness. It increases the cause of negative impact for the organisation. Main six steps to be followed under SPM and the factors to be considered under each step have explained within the study.

Keywords: *Spare parts management, Maintenance, Manufacturing industry*

1. Introduction

Manufacturing industry is the industry which produces different types of products with the help of machineries. Maintenance is a strategy which is carried out by following a set of activities need to restore a system to its required performance state or maintain the equipment to accomplish its designated task towards to each organisation by minimising the failures (Driessen, Arts, Rustenburg, Huisman, & Van Houtum, 2010). Gopalakrishnan and Banergi (1997), stated that, main function of maintenance is to ensure the manufacturing plant and its equipment, to use productively at a minimum cost for scheduled hours with minimum wastages. Satyendra (2014) initiated that, spare parts (SP) are the lifeblood of operational reliability and plant capacity. Plants cannot be operated efficiently without having reliable supply of functional SPs for maintenance. Inefficient management of SPs cause excessive inventory of SPs, non-availability of SPs in case of an emergency breakdown, cause high holding costs and maintenance delay. As per the case studies conducted by Wagner and Lindermann (2008), SP inventory planning for maintenance is not practiced in manufacturing organisations. The applicability of SPM for maintenance in Sri Lanka is limited and the awareness about SPM is considerably low. The aim of the study is to investigate the SPM practices followed in Sri Lanka and identify the impact of SPM for the manufacturing organisation. This paper reviews the concept of SPM for maintenance, its significance, current practices and impact in manufacturing industry based on both primary and secondary data.

2. Literature review

Manufacturing industry is transforming raw materials into a marketable finished product and provide consumable goods to the customers or end users (Levinson, 2018). After identifying the need of low-cost production, industry looked into ways of reducing cost by optimising the maintenance of the organisation by reducing the wastage of costs (Levitt, 2005).

2.1. MAINTENANCE MANAGEMENT IN MANUFACTURING INDUSTRY

Maintenance is one of the major contributors for the cost in manufacturing industry (Porras & Dekker, 2008). Unexpected breakdown of equipment is caused by excessive temperature, faults on electricity supply, excessive force, speed overloading, excessive vibration, defective usage, poor lubrication and contamination (Folger, 2015). Unexpected failures on machines result in reducing the quality and number of outputs which lead to cause tremendous losses on profit (Yang, Zhao, Peng, & Ma, 2018).

Preventive maintenance (PM) and corrective maintenance (CM) are the two main categories of maintenance. (Wang, 2011). PM, which is carried out to keep the equipment in continuous operation condition without breakdown and CM is followed to restore the equipment to its operational state after the failure of the equipment (Doyen & Gaudoin, 2011). ISO/TS 16949:2002(E) standard explains that a manufacturing organisation needs to develop a proper maintenance plan. As the minimum requirement, plan shall include activities of PM on equipment with availability of SPs for key manufacturing equipment to evaluate. The requirement of SPs can be decided with the type of maintenance activities scheduled in ahead of the time period and make them available within the stock. Wang (2011) proved that, PM and provision of SPs are related activities that need to achieve together.

2.2. SPARE PARTS MANAGEMENT

Patterson and Fredendall (2002) defined that the main function of SPs is to assist the maintenance staff to keep the equipment in operational condition. SPM is one of the actions that follows to reduce the risk of uncertainty caused by machine failures (Kang & Subramaniam, 2018). Effective SPM should able to place right parts at the right place in the right time. SPM helps to reduce the downtime of failed equipment (Cavalieri et al., 2008). According to Dyess (2017), the main objective of SPM is to minimise the requirement of inventory while ensuring the timely availability of SPs in case of a failure. But over stocking of SPs cause high overall cost for the organisation (Lanza et al.,2009). Availability of suppliers for some types of SPs are rare and are limited (Cavalieri et al.,2008).

SP planning and controlling is based on the factors like criticality, redundancy, repairability (Driessen et al., 2010), demand pattern, cost of purchase, stock out cost, suppliers (Cavalieri et al., 2008), availability (Kolinska et al., 2017) and specificity (Huiskonen, 2001). Among them Wagner and Lindemann (2008) suggested criticality as the most important component which leads planning and controlling measures. Clear identification of the criticality level of the equipment is the initial level of SPM. To fulfil the requirements of SPM, factors influencing demand forecasting, cost, and the inventory level must be considered. These three factors are further discussed below.

According to Bousdekis et al. (2018), demand for the SPs depends on the type of maintenance action followed by the organisation. Demand forecasting refers for deciding the future requirement of SPs by studying the past demand patterns of SPs. Driessen et al. (2010) mentioned that demand forecasting is conducted based on maintenance policy, price of parts, mean time between failure, data from sensors, historical data, and degradation level.

There are various types of costs incurred on SPM. Initial cost on SP is the acquisition cost or the purchasing cost (Marseguerra, Podofillini, & Zio, 2005). Deviations on SP costs directly or indirectly depend on purchase cost, down time cost, labour cost, inspection cost, replacement cost and breakage cost (Horenbeek et al., 2013). Diallo et al. (2009) mentioned that there are three main types of inventory costs such as, inventory holding cost, stock out cost and ordering cost associated with SPM. Stock out cost occurs due to insufficient inventory levels of SPs. Stock out cost includes cost due to loss of customers, compensation paid for the customers and cost of production loss (Jianfeng et al., 2011). Repairable SPs can save the cost by approximately about 80% than purchasing a new SP (Karsten et al.,2012). But Fleischmann et al. (2003) (as cited in Karsten et al.,2012) argued that the reliability of a used SP is lower than a new one. Therefore, SPM plan or system will help to manage the total costs on SPs effectively.

Managing relevant stocks of SPs in required level fulfils the demand for inventory (Karsten et al.,2012). Poor predictions and poor recommendations of SP inventory cause unexpected failures while low SP inventory and unnecessary ordering cause cost to organisation. Inventory controls for the SPs need to be designed by considering lead time, demand fluctuations, shortage risks and obsolescence (Diallo et al., 2009). Kennedy et al. (2002) mentioned that, SP inventory depends on the maintenance policies and failure rate of machineries. Kyriakidis and Dimitrakos (2006) suggested that impacts caused due to the unexpected breakdowns can minimise by establishing safety stock to fulfil the demands of the PM activities which is called as a buffer stock. Silva (2012) said that the materials must exist closer to the point of usage to reduce the wastages cause from waiting to use. The brief literature review discusses the key features of SPM, which has been analysed primarily in the context of manufacturing industry.

3. Methodology

Due to dearth of research on SPM for the manufacturing industry in Sri Lanka, this research intends to analyse the current practices of SPM in manufacturing industry and its benefits and challenges. Hence, a qualitative approach was considered due to the subjective nature of the research where researcher's judgement played a part as well. In this regard, an in-depth multiple holistic case study approach has been selected to conduct this study where the case study boundary was manufacturing industry in Sri Lanka and the unit of analysis was Spare Part Management (SPM). 5 large scale manufacturing organisations in western province of Sri Lanka with more than 500 employees have been selected for the case study, as the heavy usage of machineries are evident to analyse SPM in such organisations. The details of case studies along with the respondent's profile are shown in Table 1.

Table 1: Overview of case study firms

Case	**Type of industry**	**Number of workers**	**Years of experience of respondents**		
			Maintenance engineer	**Maintenance engineer**	**Maintenance engineer**
A	Garment	560	12	15	5
B	Paint	520	8	16	11
C	Polythene/ plastic	615	17	13	6
D	Food processing	2250	18	12	10
E	Pharmaceutical	535	20	6	8

Fifteen (15) qualitative semi structured interviews with maintenance engineers, supervisors and storekeepers from each case study were used to collect data. Qualitative content analysis that involved data reduction, display and conclusion drawings (Miles and Huberman, 1994) was adopted to analyse the case study interviews. The key findings from the case studies are presented below.

4. Research findings and discussion

4.1 CURRENT SPARE PART MANAGEMENT PRACTICES IN SRI LANKAN MANUFACTURING INDUSTRY

Identifying the current practices of spare part management (SPM) in manufacturing industry is one of the objectives to be fulfilled. One key finding is that, none of the case study organisations have any specific framework for SPM. When considering general overview of the cases, common set of steps are being followed by the factories to address SPM. SP identification, SP planning and controlling, demand forecasting, purchasing, classification and, stock management were the common steps followed under SPM in all the studied cases. Each step described within paragraphs.

According to the view of the respondents, SP identifications leads the SPM process. Two main types of SPs as critical and normal SPs have been identified by them. Critical SPs determine based on parameters such as, parts of critical machines, machine parts that are capable of causing direct shut downs, SPs consumes highest lead time and parts that could cause health and safety issues. Other SPs are non-critical. Identification of criticality has given the priority based on subjective assumptions. All cases used PM schedule, historical data, catalogues, instructions from Original equipment manufacturer (OEM) and experience of technical staff in SP identification. But in addition, case C and D identify SPs required for modification of existing equipment.

Planning and controlling was identified as the second step of SPM process. The factors identified through literature are primarily confirmed with the 5 case study organisations in order to find out their level of considerations as shown in Table 2. The results were based on the experience shared by all 15 interviewees across the 5 case studies.

Table 2, factors for Spare parts planning and controlling

Case / Factors	**Case A**	**Case B**	**Case C**	**Case D**	**Case E**
Criticality	√	√	√	√	√
Repair ability	√				
Redundancy			√		√
Supplier availability	√	√	√	√	√
Availability of SPs in local market	√	√	√	√	√
Brand of SPs	√	√	√	√	√

Based on Table 2, special consideration was given to criticality, supplier availability, market availability and the brand. Quantity to be stored and the quantity to be ordered have decided based on the critical SPs as controlling action. Factories have decided to store identified critical SPs and frequently using SPs as a cost-effective option. With respect to the ideas of the respondents, supplier availability and market availability have considered as one factor. Under planning and controlling, best supplier selection, supplier register preparation and evaluating the supplier are performed within the factories. Reparability of the parts have given low attention in all the cases. Parts which consumes higher cost are repaired and reused, though some of the respondents stated that some repaired SPs have to be replaced for a short period of time. Repair might lead to even higher costs than simply replacing them. The service of the repaired SPs cannot ensure. Redundant items have been considered as a cost for the organisations. As a planning and controlling mechanism, storage of redundant items was reduced by having supplier agreements. Brand of SPs have considered as another major factor in planning and controlling. With respect to the suggestions of the respondents, brand concern only on the identified critical items as a cost-effective mechanism.

Based on the planning and controlling SP demand and forecasting done. All fifteen respondents of the cases have acknowledged, maintenance policy, price of SPs, historical SP consumption records have direct influence on demand forecasting. Case B had separate maintenance history card for each important machine. SPs ordering quantity escalates with the age of machine. Therefore, history cards specify the quantity to be purchased. Demand for the SPs from local suppliers made by considering the price. It is a control measure for the maintenance budget. All cases have highlighted that, regardless of the price, some parts required for machineries have to purchase. Most of them were from OEM. Based on the forecasted demand, purchase was done.

All the factories use similar purchasing and issuing procedure. Interviews revealed that, all factories had two main parties as OEM suppliers and general suppliers for purchases. After handing over the requirement of the SPs, 3 quotations were called to select the most feasible supplier for general supplier selection. Direct purchases have been conducted from OEM suppliers without supplier comparison. For issuing, factories use a combination of manual or electronic procedure. For example, Case A conducts a '5 why analysis' to identify the root cause for the breakdown as manual procedure. Practical application of '5 why analysis" was not seen as a successful method, due to the frequent requisition of the parts. Case E used computerised system for SP issue process. MS excel tool have been used by case A and B to issue SPs. After purchase, SP classification and inventory management has been performed.

Classification of SPs based on their criticality, usage, importance, characteristics and machine based. However, the factories haven't followed any specific classification mechanism for all types of SPs due to different characteristics. Case A and D have considered important items(A), less important items(B) and common items(C) which is known as ABC method, as well as vital(V), essential(E) and desirable(D) method for the classification. All factories classify some of the SPs based on the type of machine specific for the production. But E1 introduced a new classification type as identical, equivalent and substitutional.

Stock management was the last step. Case B, C and E maintains bin card system to determine the existing stock level, record issue and new arrivals. Each stock item was allocated a bin card. Reorder level was decided based on the experience and the past consumption records. It is impossible to classify all SPs based on one classification due to different characteristics.

Above mentioned were the main steps have by the factories as the process of SPM. The method of practice and factors considered have been different from organisation to organisation based on the product.

4.2 BENEFITS AND CHALLENGES OF SPM FOR THE ORGANISATION

SPM affects for the continuity of production and inventory management. Other objective to be discussed is, benefits and challenges of SPM followed by the maintenance in manufacturing industry. Cost reduction is one major challenge of effective SPM. The major costs components associated with SPs are purchase cost, labour cost, inventory maintenance cost, inventory holding cost and downtime costs. Respondents confirmed that, SPM can use for effective costs management. However, the problem is, none of the factories have mechanisms to calculate or monitor the costs associated with SPs. Case B, C and D have agreed that SPM has direct influence for the downtime fluctuations and directly impact for the production continuity. Quality improvement is another impact to be achieved by using SPM. Quality of the product is associated with the fault in production machinery. Low quality products lead to loss of orders, customers, money and reputation. With respect to case D and E, SPs replaced for the machine parts that touches the final product has a possibility to cause defective products. Minimising the time wastage is another impact made by effective SPM. Time consumed for searching relevant SPs on stores, duration of downtime, operation time wastages and waste of effective working time of workers can save by effective SPM. Accuracy of the reorder level and reorder quantity minimises the inventory holding cost and able to get advantages from bulk purchasing. Efficient storage utilization is another benefit of proper SPM. In all 5 cases, it has been identified that enough space for the storage was not allocated. Therefore, it is essential for them to use the available limited space to manage the SPs without affecting the smooth operation and production activities of the organisation. Effective SPM utilizes the limited space allocated for stores effectively to store necessary SPs for the timely use. Space utilisation have not been paid much attention by the factories analysed by the case study.

4.3 DISCUSSION

Based on the findings from the data collection, SPM could define as, "a set of actions followed, to identify, purchase, issue and store extra set of machine parts, that need to reduce the risk of uncertainties cause from machine failures, by balancing the losses cause from over stocking and unavailability of SPs in case of need". SPM directly affect for the maintenance of the factories.

Regardless with the type of product and the size of the organisation, SPs are essential for maintenance activities.

The findings also identified the key areas such as cost, quality, time and space where an effective SPM can make an impact. However, it was clearly evident through the primary data that the factories do not pay much of attention on SPM in order to effectively manage these key areas. Factories mostly focused on the downtime and the quality of products. There were instances where the factories felt negative impacts due to poor SPM, even though they were not quantified or documented. For example, production delays due to delays in SP purchasing and mismatches of purchased SPs. By using different alternatives and replacement of machineries and SPs, factories have managed to provide quality products and complete the targets with some delays. Wastage of products have been reported to be increased, due to malfunctioning of the machines. In such case, the organisations borne the cost of wastage risking their profits rather than risking the customer relations.

The one positive finding is that all the factories have good level consideration to the concept of SPM, despite they fear the barriers such as high initial cost, lack of expertise, lack of awareness, lack of mechanism to reduce cost, time and wastage. If these barriers are addressed, then the concept of SPM can be easily introduced in these large-scale factories. As such how to minimise the barriers in introducing SPM process in large-scale organisations in Sri Lankan manufacturing industry is proposed for further research.

5. Conclusion

This research paper investigated the current practices of SPM practices and their impact on the organisations. Selected factories were large scale well reputed factories in the manufacturing industry of Sri Lanka. The key finding is, the factories in Sri Lanka do not have awareness, knowledge and expertise on the concept of SPM. Hence the discussion on this paper can be related to large-scale factories of manufacturing industry in Sri Lanka despite their types of products produced. As the SPM process, main six steps have identified. They are SP identification, planning and controlling, demand forecasting, purchasing, classification and stock management. Factors to be considered in each step was explained within the content. In conclusion there is a high level of desirability for using SPM in manufacturing organisation whereas there is a low level of readiness to invest on such as new concept of SPM due to the drawbacks and challenges identified in the paper. Further research on how to minimise the barriers is proposed as once the barriers are addressed there is a good chance of benefiting from the concept of SPM.

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