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Ranking of barriers for effective maintenance by using TOPSIS approach

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Abstract

Purpose – In present context of globalization, maintenance of production systems is very important. Many of the organizations are facing a lot of problems in maintenance management. Therefore the purpose of this paper is to identify the main barriers in maintenance management and to rank them for effective maintenance strategies.

Design/methodology/approach – To rank the main barriers in maintenance management, technique for order preference by similarity to ideal solution is used. For giving score to different factors a team of three experts was made. All experts were having more than ten years of experience in area of maintenance management.

Findings – Lack of top management support, lack of measurement of overall equipment effectiveness (OEE) and lack of strategic planning and implementation have emerged as top three barriers in implementation of maintenance systems in industries.

Research limitations/implications – Findings imply that for successful maintenance, top management should be very supportive for taking different initiatives, training programmes, etc. Organizations should try to improve overall performance of machines known as OEE rather than only machines productivity.

Originality/value – These findings will be highly useful for professionals from manufacturing sector in implementing effective maintenance management system.

Keywords Productivity, Maintenance, OEE, Breakdown, Quality, Benchmarking

Paper type Research paper

1. Introduction

Due to the rapidly changing scenario of globalized market, many organizations around the globe are facing problems due to increased number of competitors and volatility in consumer requirements for quality product at the lowest cost (Chandra and Shastry, 1998). In such scenario, many firms are losing their market share to multinational firms (Khanna and Sharma, 2011). Phusavat and Kanchana (2008) and Singh and Sharma (2015) have observed that some factors to achieve competitiveness are: quality, reliability, flexibility, ability to meet demand and delivery requirements. Most of the organizations are working towards improvement of manufacturing flexibility (Singh and Sharma, 2014). Therefore it became crucial for the firms to put focus on effective maintenance systems. Alsyouf (2007) and Ahmed *et al.* (2005) have observed that a common strategy to cut cost is by increasing the level of automation in operations. Automation will have fewer number of employees but due to the complex machinery, the work of maintenance department becomes very important (Ahuja and Khamba, 2008; Garg and Deshmukh, 2006; Hansson and Backlund, 2003). Thus an

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active maintenance management department will be very essential to excel in service and consequently increase the market share. As the technical developments are growing, the influence of productivity and quality, are also moving increasingly from man to machine. The importance of maintenance becomes further important aspect in the industry with the fact that high productivity and quality can be achieved by means of well developed and organized maintenance system. Therefore difficulties faced by the organization should be actively identified, evaluated and managed by the maintenance managers (Mohamed, 2005).

In the era prior to industrial revolution in England near the mid of eighteenth century, maintenance mainly consisted of craftsman such as carpenters, smith, masons for the regular maintenance work, which was usually performed by repairing or making a new part to fit. As there was no concept of dimensional control the maintenance work used to be tedious job. But as the development grew in the maintenance field, Jefferson (1785) noted that the parts were being made accurately enough to be interchangeable. These small but accelerating developments gradually converted the maintenance work to be more diagnostic. Due to high share of maintenance system in operating budget of manufacturing firms, it has been also regarded as "necessary evil" by top management (Cooke, 2003; Eti *et al.*, 2007). But this attitude is increasingly been replaced by the one which regards maintenance as the control of reliability and a strategic issue (Eti *et al.*, 2006). Business leaders are increasingly realizing the importance of maintenance in cost control, to save time and others resources by optimizing their productivity and maximizing the overall equipment effectiveness (OEE). Business leaders are now using this as a competitive weapon or as a contributor to profit (Sherwin, 2000). As the production technology is advancing too quickly, many models have came into existence like the Eindhovn University of Technology model, total productive maintenance (TPM), total quality maintenance, reliability centred maintenance (RCM), condition-based maintenance (CBM). Further the improvements such as fewer defects and errors, reduced waste can be achieved by increasing maintainability of machines (Brah *et al.*, 2002; Hansson and Eriksson, 2002; Hendricks and Singhal, 2001; Kaynak, 2003).

Cholasuke *et al.* (2004) have observed that even after adopting the appropriate maintenance models for achieving productivity goals, the organizations fail to achieve performance targets due to different barriers in implementation of maintenance systems. Cooke (2000) has identified organizational barriers in implementing TPM based on case studies but he has not ranked them. Therefore objectives of this study are to identify major barriers in effective maintenance management and then rank them using the technique for order preferences by similarity to ideal solution (TOPSIS) methodology. Remaining part of the paper is organized as follows: Section 2 deals with literature review for identifying the barriers in maintenance management, Section 3 deals with the methodology used to rank the barriers, i.e. TOPSIS approach, Section 4 presents the findings, finally Section 5 is the concluding remark.

2. Identification of barriers in maintenance management

Now a days all the maintenance operations are within the reach of achieving the world-class level of maintenance delivery, and its credit is awarded to the automation in the industry (Ahmed *et al.*, 2005; O'Sullivan *et al.*, 2011). However, human inputs are still an important factor. Skills beyond the competence of the average maintenance supervisor or worker is required for the automated and technologically advanced equipment, and importantly an appropriate and effective maintenance organization is required to use it effectively (Mohamed, 2005). According to Poduval *et al.* (2015), time, money, manpower, resources and commitment from all the stake holders are required for implementing maintenance work in industries. The organization as a whole should be willing to change its outlook and adapt itself to the new practices and cultural changes that are required for the successful implementation of maintenance models. There are many barriers in implementing effective maintenance in organizations. Major barriers identified from the literature are discussed in following sections and summarized in a framework (Figure 1).

Lack of benchmarking
Benchmarking is a continuous process to move towards best in class by achieving high-maintenance effectiveness standard regularly (Åhrén and Parida, 2009; Raouf and Ben-daya, 1995). The initial benchmarking helps in bridging the gap between the prevailing equipment condition and the desired manufacturing excellence (Ahuja and Khamba, 2007). The main concern for benchmarking from maintenance point of view are unplanned downtime, defects in equipment or degradation in speed of manufacturing equipment (Raouf and Ben-daya, 1995). Effective benchmarking of different processes ensures product quality and customer satisfaction (Singh, 2011). It is possible by measuring ones performance with respect to the "best in class" performer (Hansson and Backlund, 2003). It helps in identifying its strengths and weaknesses and provides a sense of direction for the plan. It is five step process: planning; analysis; integration; action; and implementation and result (Raouf and Ben-Daya, 1995). Lack of benchmarking causes poor maintainability and reliability (Hansson and Backlund, 2003).

Lack of communication and information
Communication and information in an organization implies open and meaningful communication in such a way that information flows laterally thus creating an open

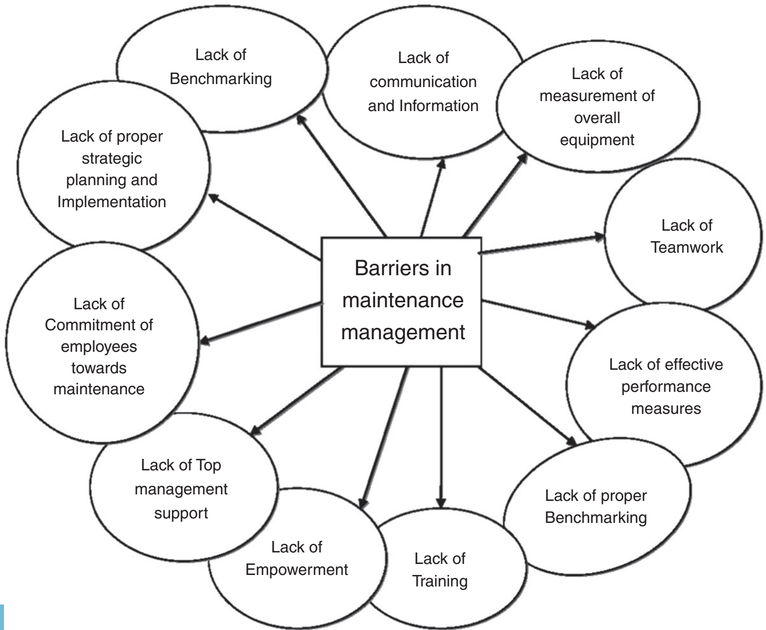

Figure 1.
Barriers in implementation of effective maintenance management

atmosphere in the organization (Mosadeghrad, 2014). It includes informal meetings between management and union representatives to complement formal communications that helps in increasing interest and acceptance. Lad and Kulkarni (2010a) have proposed a mechanism to link operational requirements with machine tool reliability and maintenance parameters. Where employees understanding and involvement could be achieved (Abraham *et al.*, 1999; Pintelon *et al.*, 1999; Tsang and Chan, 2000; Hansson and Backlund, 2003). Due to lack of communication and information not flowing laterally, members of organization are not able to identify and report the sources of maintenance and reliability; and are not able to put their valuable suggestions for improvement (Hansson and Backlund, 2003).

Lack of measurement of OEE

OEE is measure of effectiveness of the equipment or machine or it is a performance indicator (Rolfsen and Langeland, 2012). It depends on three parameters, i.e. system availability rate, performance rate and quality rate. The real goal of maintenance activities is to increase OEE and due to lack of measure of OEE the maintenance activities cannot be implemented properly (Kumar *et al.*, 2014). The progress of the company depends on these three parameters of OEE (Prickett, 1999). System availability refers to the rate of availability of machine tool. Availability depends on the system design which determines the systems reliability, maintainability with the aim that system performs all its functions throughout its life successfully (Lad and Kulkarni, 2008). Performance rate tells us about the losses incurred due to using the machine at low performance rate and the degradation of performance is mainly due to unfulfilled maintenance work (Al-Sultan, 1996). Quality rate refer to the losses occurred due to the low quality, bad quality means more rejections (Prickett, 1999). Elimination of waste such as scrap and rework can be easily achieved by quality improvement which increases productivity and thus leads to reduced cost.

Continuous improvement of these three parameters of OEE should be an important target. The analysis of these factors can be used for improvement of individual tool reliability and importantly to prevent the recurrence of similar type of failures in a machine tool (Prickett, 1999). But if the organizations fail to measure OEE then they are not able to monitor most important factors influencing the system performance. Lad and Kulkarni (2010b) have suggested parameter estimation method for the machine tool reliability analysis to overcome the problem of unavailability of a well-defined failure data collection mechanism.

Lack of teamwork

Team working means involvement of entire organizations to eliminate the defects, i.e. the company wide approach to achieve quality where the role of each and every employee is crucial (Graham *et al.*, 2014; Ledet, 1999). It also helps in achieving better reliability at lower cost (Ledet, 1999). Not only the maintenance department but the entire organization should ensure the reliable and dependable maintenance system (Madu, 2000). Traditional factors of maintenance management like information system, data collection, etc. are still important and are key factors to improve maintainability and reliability. These factors must be coordinated in a cohesive form (Hansson and Backlund, 2003). But many organizations have reported that team working between the production and maintenance department is not only an issue of principle but also an issue of practicability (Cooke, 2000). Many experiments have shown that proper maintenance activities can be performed when the whole business unit works towards a common goal, otherwise sub-optimization will result in unachieved goals (Rolfsen and Langeland, 2012).

Lack of effective performance measures

For maintenance systems effectiveness apart from OEE, other performance measures are also equally important. Due to the substantial cost of maintenance as compared to operational cost, measuring of effective performance becomes very important to become competitive and cost effective. Usually maintenance measures are not part of performance framework. For this structural audits can be carried out to measure productivity and to identify area of improvement (Raouf, 1994; Raouf and Ben-Daya, 1995). To monitor and to take timely decisions, the information about the performance of machine is very important and lack of this information causes ineffective and inefficient maintenance process (Parida and Kumar, 2009).

Lack of commitment of employees towards maintenance

According to Davis (1997), many organizations failed to implement maintenance system properly due to reluctant and demoralized production department, who were in fear of losing job and were unwilling to do stressful work as they do not see the benefits of implementations due to lack of knowledge (Hardwick and Winsor, 2001; Karlsson and Ljungberg, 1995; Shin *et al.*, 1998). This can be overcome by recognizing the employees and visibly showing them the benefits of implementations (Allen and Kilmann, 2001; Hartman, 1992). Since activities are actually implemented by the employees thus the employees who are having lack of positive attitude towards maintenance further increases the cost of maintenance (Hansson and Backlund, 2003). Due to this fewer resources are spent on other aspects of maintenance.

Lack of training

Effective working of maintenance department requires that the managers and employees have the appropriate knowledge, skills and expertise in the field of quality management (Mosadeghrad, 2014). It helps in changing the mind set of employees from traditional maintenance approach to the new and modern approach. It further helps in reducing the maintenance crew and increases the flexibility as the small maintenance works could then be performed by the average maintenance personnel or the shop floor workers (Nembhard, 2014). It also increases the commitment and brings about the positive behavioural changes. Training is required with adequate amount of practical knowledge; otherwise employees tend to forget what they were taught (Hansson and Backlund, 2003). For example a untrained planner would not be able to determine job content, duration, number of workers required, number of spare parts required, etc. (Raouf and Ben-daya, 1995).

Lack of proper strategic planning and Implementation

Strategies set directions for deciding operations functions to ensure competitiveness (Singh *et al.*, 2010). These are the functions that help in integrating the quality requirement with the business activities (Chin *et al.*, 2002). These are the activities to develop and identify the obstacles in achieving the desired goals (Hartman, 1992; Hipkin and Lockett, 1995; Shin *et al.*, 1998). They help in facilitating the follow-ups and monitoring the achievements like involvement of employees and understanding between management and workers by setting goals, and identifying solution (Abraham *et al.*, 1999; Schawn and Khan, 1994). It also links maintenance programme with company's mission, vision and strategies (Bardoel and Sohal, 1999; Riis *et al.*, 1997). It is observed that lack of proper strategic planning and implementation can prove to be a bottleneck due to the unclear picture of benefits to organization from the improvements (Abreu *et al.*, 2013).

Lack of top management support

Atkinson (1990) and Jaehn (2000) have observed that 80 per cent of firms fail due to the lack of top management support. Implementation of maintenance activities in organizations requires major resources like human resources, money and time. Top management is responsible for providing these resources (Shin *et al.*, 1998; Hansson and Backlund, 2003). It has become very important to change traditional methods and organization structure to the new and modern one (Singh *et al.*, 2008). Therefore one of the major job of top management in today's business environment is to reorganize the traditional organization reporting system to obtain the quality maintenance and reliability information on timely basis (Hansson and Backlund, 2003). Major resources need proper implementation and clear understanding of objectiveness and methodologies of maintenance system (Clark, 1991; Hipkin and Lockett, 1995). Real goal of maintenance is to increase OEE and not to reduce the labour count. Asjad *et al.* (2013) have suggested supportability based contract alternatives for operating life of mechanical systems. According to them supportability for a user is the ability of the manufacturer to execute all the support activities that are required for the upkeep of the system, in the most effective, efficient and timely manner throughout the operating life of the product, whenever and wherever needed.

Lack of empowerment

For effective maintenance management, employee empowerment for taking different decisions at owns levels are very important. Empowerment means to develop the teams and to build a matured staff (Mohamed, 2005). Employees should be active participants and satisfied with their job with feeling of ownership (Hansson and Backlund, 2003; Aghazadeh, 2002; Yamashina, 2000). To use maintenance for competitive advantage, organizations should empower employees to adapt processes as per environmental changes (Douglas and Judge, 2001). Lack of empowerment means inactive participation of employees thus there is decrement in efficiency of maintenance programme.

Lack of awareness about safety and health

For the success of any enterprise an important prerequisite is the safety of people, environment and assets (Narayan, 2012). According to survey of European agency for safety and health at work in year 2000, 10-15 per cent of fatal accidents and 15-20 per cent of all accidents were associated with maintenance work. Thus maintenance is usually regarded as critical to operators. They are more exposed to variety of hazards with potential harm to their health (Grusenmeyer, 2010). Therefore one of the main works of the maintenance department should be to create a safe workplace with utmost importance of safety in the plant (Singh *et al.*, 2013). Safety in plant refers to personal safety as well as process safety. Personal safety is important in the industries, but the more important factor is the process safety (Narayan, 2012). Therefore safety and health at workplace should be everyone's concern. Barriers identified based on literature review and experts opinion are summarized Table I.

3. Research methodology

For ranking of different barriers, multi criteria decision making (MCDM) tool, i.e. TOPSIS is applied in this research. MCDM is very important tool to deal with unstructured problems containing multiple and conflicting objectives (Lee and Eom, 1990). Many "MCDM" techniques have been developed, but the TOPSIS approach is the most widely used technique. TOPSIS method was proposed by Hwang and Yoon (1981).

Barriers	References
Lack of benchmarking	Adebanjo *et al.* (2010), Singh (2011), Shaaban and Awni (2014)
Lack of communication and information	Mohamed (2005), Leong *et al.* (2012)
Lack of empowerment	Yongtao *et al.* (2014), Poduval *et al.* (2015)
Lack of teamwork	Rolfsen and Langeland (2012), Aspinwall and Elgharib (2013)
Lack of commitment of employees towards maintenance	Singh and Ahuja (2014), Mosadeghrad (2014)
Lack of training	Singh *et al.* (2013), Mosadeghrad (2014)
Lack of proper strategic planning and implementation	Singh *et al.* (2010), Abreu *et al.* (2013), Mosadeghrad (2014), Ding *et al.* (2014)
Lack of top management support	Kodali *et al.* (2009), Singh *et al.* (2008), Kumar *et al.* (2015)
Lack of awareness about safety and health	Grusenmeyer (2010), Singh *et al.* (2013), Narayan (2012)
Lack of effective performance measurement	Parida and Kumar (2009), Lad and Kulkarni (2010a)
Lack of measurement of OEE	Pophaley and Vyas (2010), Lad and Kulkarni (2010b)

Table I.
Barriers in effective maintenance management

It is considered to give very reliable solution because in TOPSIS poor performance in one criteria can be negated by good performance in other criteria. Therefore many authors have been analyzing their data with the TOPSIS methodology. Jothimani and Sarmah (2014) have used TOPSIS for measuring the supply chain performance in the light of a real life case study. Ramezani and Lu (2014) have used TOPSIS for identifying an optimal maintenance policy that can minimize the failures. Kumar and Singh (2012) have used this approach for evaluating 3PL for global supply chains. Khanna and Sharma (2011) have used TOPSIS for ranking of CSFs for total quality management implementation. Strength of TOPSIS methodology over other MCDM techniques is that the both negative and positive criteria can be simultaneously used in decision making. In addition to this, it is simpler and faster than other methods such as AHP, FDAHP and SAW. In this method two artificial alternatives are hypothesized:

H1. Ideal alternative: the one having the best level for all attributes considered.

H2. Negative ideal alternative: the one having worst attribute values.

TOPSIS selects the alternative that is the closest to the positive ideal solution and farthest from negative ideal alternative. Thus providing a more realistic form of modelling as compared to non-compensatory methods. Major steps in TOPSIS approach are as follows:

Step 1: On the basis of m alternative and n criteria, a matrix with elements x_{ij} is made, where each element denotes the rating of ith decision maker (DM) with respect to jth criteria.

This matrix is known as decision matrix denoted by D:

$$D = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix}$$

$i = 1, 2, 3, \dots, m$ is the number of alternative and $j = 1, 2, 3, \dots, n$ is the number of criteria.

Step 2: Now, the normalized matrix is calculated with elements $r_{ij} = x_{ij}/\sqrt{\sum_{i=1}^{n} x_{ij}^2}$ for $i = 1, 2, \ldots, n$; $j = 1, 2, \ldots, m$. It is denoted by R:

$$R = \begin{bmatrix} r_{11} & r_{12} & \ldots & r_{1n} \\ r_{21} & r_{22} & \ldots & r_{2n} \\ \ldots & \ldots & \ldots & \ldots \\ r_{m1} & r_{m2} & \ldots & r_{mn} \end{bmatrix}$$

Step 3: Construct the weighted normalized matrix with elements $v_{ij} = w_j r_{ij}$, where w_j = weights of different attributes. It is denoted by V:

$$V = \begin{bmatrix} v_{11} & v_{12} & \ldots & v_{1n} \\ v_{21} & v_{22} & \ldots & v_{2n} \\ \ldots & \ldots & \ldots & \ldots \\ v_{m1} & v_{m2} & \ldots & v_{mn} \end{bmatrix}$$

Step 4: Determining the positive ideal solution v_j^+ and negative ideal solution v_j^- by finding the maximum and minimum values of weighted normalized elements in each column in the case of benefit criteria and just reverse for cost criteria.

Step 5: Calculate the Euclidean distance for each alternative.

The Euclidean distance from positive ideal solution is represented by s_i^*:

$$s_i^* = \left[\sum_j \left(v_{ij}^* - v_j^+\right)^2\right]^{1/2}$$

where $i = 1, 2, \ldots, m$; $j = 1, 2, \ldots, n$.

The Euclidean distance from negative ideal solution is represented by $s_i^{'}$:

$$s_i^{'} = \left[\sum_j \left(v_{ij}^{'} - v_j^-\right)^2\right]^{1/2}$$

where $i = 1, 2, \ldots, m$; $j = 1, 2, \ldots, n$

Step 6: Calculate the relative closeness to the ideal solution c_i^*. If it is closest to 1, then it depicts the best solution:

$$c_i^* = \frac{s_i^{'}}{(s_i^* + s_i^{'})}, \text{ where } 0 < c_i^* < 1$$

where s_i^* represents distance from positive ideal solution and, $s_i^{'}$ represents distance from negative ideal solution.

Step 7: Rank the alternatives according to the preference order of closeness ratio c_i^*. The one that have the shortest distance to the ideal solution is the best alternative. Shortest distance to the ideal solution depicts longest distance from negative ideal solution.

4. Results and discussion

A successful maintenance management system plays a crucial role in improving machines productivity and overall performance. It gives an edge to the company over its competitors. To successfully implement the maintenance management, the managers should be aware about the barriers of maintenance management, and should try to overcome them. For obtaining input data, a team of three experts/DMs was made in this study. These three DMs (DM1, DM2 and DM3) are maintenance department heads from top ranked companies in NCR Delhi India, each having experience of more than ten years. These top ranking firms are mainly from manufacturing sectors. On basis of their experience DM1 is given a weightage of "0.5", DM2 a weightage of "0.2" and DM3 a weightage of "0.3". Barriers are given score in scale of 1-10 (1-very low, 10-very high). By using steps 2 and 3, weighted normalized decision matrix is made as given in Table II. By using step 4, positive and negative ideal solutions are determined as given in Table III. By using step 5, separation of each CSF from the positive and negative ideal solution is determined and shown in Tables IV and V. Now, by using step 6, the relative closeness of each barrier to the ideal solution (closeness ratio) is found as given in Table VI and based on closeness ratio, i.e. step 7, relative ranking of these barriers is shown in Table VII.

It is observed that lack of top management support is the biggest barriers in successful implementation of effective maintenance management. Willingness of top management can only bring about the positive changes in the culture and functioning of the company. Usually it is observed that top management especially in SMEs are not very supportive for maintenance initiatives because return is not short term and lot of changes are required (Kumar *et al.*, 2015). It is usually observed that investing in preventive maintenance activities is considered as waste by management in many organizations. They are still following traditional breakdown maintenance systems. Next barrier as per importance is lack of awareness for OEE. As we know that the one of the main goal of maintenance system is to increase OEE therefore lack of awareness for measuring OEE is surely an unhealthy sign for a firm. Lack of OEE can cost a lot to them due to downtime and lost quality (Lad and Kulkarni, 2012). Usually organizations measures machines performance in terms of machines productivity and ignore other factors related with product rejections and speed, thus designating and using OEE helps in identifying causes of losses in manufacturing and helps in keeping a track of factors influencing the overall performance (Prickett, 1999). Next barrier for effective

Table II.
Weighted normalized matrix

Decision makers ⟹	DM1(0.5)	DM2(0.2)	DM3(0.3)
Barriers			
1. Lack of benchmarking	0.051164	0.028834	0.0305
2. Lack of communication	0.153493	0.06728	0.091499
3. Lack of employee empowerment	0.204658	0.038446	0.106749
4. Lack of teamwork	0.102329	0.057668	0.106749
5. Lack of commitment of employee towards maintenance	0.076747	0.057668	0.04575
6. Lack of proper training	0.127911	0.057668	0.076249
7. Lack of strategic planning and implementation	0.204658	0.06728	0.091499
8. Lack of top management support	0.23024	0.06728	0.137249
9. Lack of effective performance measures	0.076747	0.048057	0.076249
10. Lack of awareness about safety and health	0.127911	0.076891	0.04575
11. Lack of measurement of OEE	0.179076	0.076891	0.121999

maintenance is lack of strategic planning and implementation. Organizations usually do not frame exclusive policies and strategies for maintenance which can help in increasing the commitment level of upper management and employees (Hansson and Backlund, 2003). It is the biggest reason for unsuccessful implementation of maintenance system (Newall and Dale, 1991). For successful maintenance systems, employees' empowerment is essential. It promotes involvement of employees, increases job satisfaction and creates a sense of ownership among employees (Aghazadeh, 2002; Yamashina, 2000). Lack of empowerment is the driving factor for the "lack of communication" and "lack of teamwork". Poor communication can lead to decrease in the growth momentum of the organization. To have the high employee morale and productivity, teamwork is an important factor. When the whole organization is working

Table III. +ve and −ve ideal solutions

Positive ideal sol.	0.23024	0.076891	0.137249
Negative ideal sol.	0.051164	0.028834	0.0305

Table IV. Distance from the positive ideal solution (s_i^*)

Decision makers ⟹	DM1(0.5)	DM2(0.2)	DM3(0.3)	Average
Barriers				
1. Lack of benchmarking	0.179076	0.048057	0.106749	0.111294
2. Lack of communication	0.076747	0.009611	0.04575	0.044036
3. Lack of employee empowerment	0.025582	0.038446	0.0305	0.031509
4. Lack of teamwork	0.127911	0.019223	0.0305	0.059211
5. Lack of commitment of employee towards maintenance	0.153493	0.019223	0.091499	0.088072
6. Lack of proper training	0.102329	0.019223	0.060999	0.06085
7. Lack of strategic planning and implementation	0.025582	0.009611	0.04575	0.026981
8. Lack of top management support	0	0.009611	0	0.003204
9. Lack of effective performance measures	0.153493	0.028834	0.060999	0.081109
10. Lack of awareness about safety and health	0.102329	0	0.091499	0.064609
11. Lack of measurement of OEE	0.051164	0	0.01525	0.022138

Table V. Distance from the negative ideal solution (s_i')

Decision makers ⟹	DM1(0.5)	DM2(0.2)	DM3(0.3)	Average
Barriers				
1. Lack of benchmarking	0	0	0	0
2. Lack of communication	0.102329	0.038446	0.060999	0.067258
3. Lack of employee empowerment	0.153493	0.009611	0.076249	0.079785
4. Lack of teamwork	0.051164	0.028834	0.076249	0.052083
5. Lack of commitment of employee towards maintenance	0.025582	0.028834	0.01525	0.023222
6. Lack of proper training	0.076747	0.028834	0.04575	0.050443
7. Lack of strategic planning and implementation	0.153493	0.038446	0.060999	0.084313
8. Lack of top management support	0.179076	0.038446	0.106749	0.10809
9. Lack of effective performance measures	0.025582	0.019223	0.04575	0.030185
10. Lack of awareness about safety and health	0.076747	0.048057	0.01525	0.046684
11. Lack of measurement of OEE	0.127911	0.048057	0.091499	0.089156

Table VI. Summary of closeness ratio

Decision maker ⟹	$c_i^* = s_i'/(s_i^* + s_i')$
Barriers	
1. Lack of benchmarking	0
2. Lack of communication	0.604328
3. Lack of employee empowerment	0.716883
4. Lack of teamwork	0.467974
5. Lack of commitment of employee towards maintenance	0.208656
6. Lack of proper training	0.453246
7. Lack of strategic planning and implementation	0.757569
8. Lack of top management support	0.971213
9. Lack of effective performance measures	0.271218
10. Lack of awareness about safety and health	0.419471
11. Lack of measurement of OEE	0.801084

Table VII. Ranking of barriers in effective maintenance management

Barriers	Ranks
1. Lack of benchmarking	11
2. Lack of communication	5
3. Lack of employee empowerment	4
4. Lack of teamwork	6
5. Lack of commitment of employee towards maintenance	10
6. Lack of proper training	7
7. Lack of strategic planning and implementation	3
8. Lack of top management support	1
9. Lack of effective performance measures	9
10. Lack of awareness about safety and health	8
11. Lack of measurement of OEE	2

as a unit then obviously the chances of getting desirable result would increase. The next major barrier is the lack of proper training which is very important as proper training not only increases the skills of the employees but also their commitment towards the maintenance work. In addition to this for successful maintenance systems, employees should be trained to perform cross-functional work in addition to routine work. Safe and healthy workplace is a prerequisite for a successful maintenance programme. Ignorance of this factors can lead to serious consequences for environment, company and man. The next important barrier is the lack of performance measure as to become cost effective and competitive it's very important to know the areas of improvement. But as the activities are actually implemented by the employees' thus uncommitted staff can become a serious issue for the maintenance work. The last major barrier is the lack of benchmarking. As benchmarking is a tool to keep the goal to be become "best in class" attainable. Thus it is very important to use benchmarking on continuous basis for sustainable competitiveness of any organization.

5. Concluding remarks

As the competition is rising in the world market and local markets around the globe, firms are increasingly realizing the importance of effective maintenance management. It can help to increase the market share by the means of improving product quality, decreasing rejection, reducing cost and by providing superior service to the customers. Many models such as TPM, RCM and CBM are employed in the industry to solve maintenance-related problems. Successful implementation of these models involves many difficulties. This study has identified 11 main barriers in the implementation of effective maintenance management system. These barriers are lack of benchmarking, lack of communication, lack of empowerment, lack of teamwork, lack of commitment of employees towards maintenance, lack of training, lack of proper strategic planning, lack of top management support, lack of awareness about safety and health, lack of effective performance measurement, lack of proper OEE. Managers should address these barriers effectively to have a positive impact of the maintenance system on the performance.

Analysis and findings have shown that lack of top management support, lack of focus on OEE and lack of strategic planning and implementation are the biggest barrier in effective maintenance management. Whereas lack of benchmarking is relatively ranked lower than the other barriers but it cannot be ignored. These barriers can only be overcome by the willingness and strong leadership which really wants to develop a quality-oriented culture in the industry. These findings will help management in formulating maintenance strategies. However, before generalizing these findings, some empirical and case studies may be carried out as future scope of study.

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Further reading

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