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Web Based Survey on Impact of Maintenance Management Practices and Techniques on Maintenance Service Quality and Sustainability of Plant Equipments

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Abstract – Todays' world is highly competitive than ever before. New technologies, machines, human beings are getting increasingly productive to sustain and survive in the world. In todays' globalized world in India's position as manufacturing force is getting noticed. Hence the scale of efficiency has become global benchmark.

Every manufacturing facility wants production system and equipment and operated in reliably. Everyone wants production system or process to work without breakdown and produce consistent quality of products or to operate efficiently and perfectly. There is no ideal world, no physical asset has operated flawlessly forever.

Maintenance of engineering equipment in the field has been a challenge due to size, cost, complexity and competition. Although progress has been made in maintaining equipments in reasonable manner. The professionals are developed specializing in this area as per market driven in a manufacturing or process industry or service suppliers etc. Thus, there is a definite need for effective asset maintenance practices that will positively influence critical success factors such as safety, product quality, speed of innovation, price, profitability, technical obsolesce, and reliable delivery.

In organization where there are surprises and breakdowns, the quality and productivity losses are high.

The huge opportunity to reduce the manufacturing cost especially in a plant where there is a capacity crunch is not appreciated by all." Zero breakdown "is not just a buzz word but reality today and this is zero breakdown concept can bring about huge savings in manufacturing costs. In industrial world the awareness of important function is rapidly increasing. The science of maintenance is ever developing, and it is important to know the latest developments in the field of maintenance in order to sustain the results.

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INTRODUCTION

If we look into the science of maintenance **management practices** it is principally based on management science principles like organisation structure, budgeting, quality, inventory management, scheduling, and so on as described below. There are certain **maintenance techniques** used with some methodology and tools to ascertain about the condition of the assets, machines.

These are the **inputs factors** to be executed by maintenance teams to get the good **Service quality** of asset performance and subsequently **sustenance of plants** to the manufacturer or stake holders.

The significant factors are researched through focus group, expert interviews, available literatures as summarised as below:

Maintenance Management Practices

1. Computerised Maint management Equipment, Results, Analysis
2. Maintenance activities Planning and Scheduling
3. Schedule and Adherence of Preventive Maintenance Program

4. Breakdown Maintenance by Classification of machines
5. Predictive Maintenance methods management
6. Corrective Maintenance by Rebuild, Overhaul, Servicing of machines
7. Machines Spares & Consumables inventory Management
8. Training, Skills Multitasking of workforce
9. Maintenance Organisation structure, Control, Budgets
10. Safety practices in Maintenance Management

Maintenance Techniques

1. Vibration Monitoring Tools utilization
2. Electrical Condition Monitoring tools usage
3. Thermography tools deployment
4. Non-destructive testing methodology
5. Lubrication wear particle analysis techniques
6. Ultrasonic tool testing and utilization
7. Energy consumption and monitoring of equipments
8. Inspection tools, Functional requirement checking,
9. Utilisation of IOT tools and techniques
10. Maintenance problem solving by Kaizen techniques

Appropriate application by maintenance teams of above factors is essential. Depending on type of industry can result in the good quality of **maintenance services** and hence high productivity and **sustenance of assets.** The shortlisted significant factors are as under**.**

Maintenance Services Quality Factors

1. Uptime of Machine - Time in % for which machine is available for manufacturing
2. MTTR (Mean Time to Repair) -Time taken in hrs to repair after a breakdown had occurred
3. Mean Time Between Failure (MTBF) - This is the time in no of days between the two adjacent breakdowns
4. No of Maintenance work orders Closed and Pending during shift
5. Skills and Attitude of Maintenance Staff
6. ISO Certified Maintenance Services procedures
7. Measurement of Customer satisfaction and feedback
8. Availability Tools, Spares, Diagnostic procedures
9. Adherence to Preventive and Predictive plan
10. Accidents, Near miss reports due to Maintenance activities

Sustainability of Plant Equipment Factors

1. Running Costs, Maintenance, Spares, costs of plant Equipment
2. Safety features of Machine/Equipment
3. Ergonomically designed Machine or Equipment
4. Machine Performance results, Alarms on machine/equipment controls
5. Payback period of Plant/equipment (ROCE)
6. Design for maintainability and reliability
7. Generation of, Hazardous material, Waste of equipment
8. Methods of disposing, recycling of wastes of machines
9. Energy efficiency, Energy saving equipment
10. Operating life expectancy of asset

OBJECTIVES OF THE STUDY

The objectives of study are the impact of the Input factors of (Maintenance techniques, Management Practices) resulting in Maintenance Service quality and sustenance of plant equipments. Each factor amongst each group will have different impact and it is objective of study.

LITERATURE REVIEW

Keith Mobley, the editor in chief of Maintenance Engineering handbook (2008), has more than 35 years of direct experience in corporate management, process and equipment design, and reliability-centered maintenance methodologies. Maintenance engineering is a field which, for the most part, hasn't fundamentally changed much over the years. And there aren't many sources for the latest information or best practices. But in recent years, maintenance engineering has, more and more, put an emphasis on true reliability. A business which is asset-intensive, such as manufacturing, relies on a reliability-centered field of engineering to be successful. Hence, reliability engineering itself has become a technology used for the purpose of improving manufacturing capacity, without capital investment. The Maintenance Engineering Handbook has long been regarded as the premier source for expertise on maintenance theory and practices for any industry. This similar text is World **Class Maintenance by N.K Shivananda (2015)** text has been considered invaluable and now, this latest edition defines those practices that are critical to developing an effective reliability engineering function within your business. This edition also focuses on recognized and proven best practices in maintenance, repair, and overhaul (MRO) inventory management, root-cause analysis, and performance management. There is a good text book showing analytics and mathematics of Maintenance science - a text Engineering Management A Modern approach (2006) is also excellent text material. The proceedings of Seminar conducted by **CII on Predictive and Preventive Maintenance in Sept 2015** has described the approach for the topics. The emphasis is on condition monitoring and various tools. The topics are Vibration Analysis, Vibration Signature analysis, Vibration monitoring system in large machines. Ultrasound techniques for the leak detection of flow of liquids and gases. It is mentioned the Oil and Wear Particle analysis. The means of analysis for Viscosity, Contamination, Solids contents, Oxidation, Nitration, Total Acid Number (TAN)Total base number (TBN), Particle count tests, Spectrographic analysis, Oil and Wear particle analysis. These are techniques used to identify the various types of wear as Rubbing wear, Cutting wear, Rolling Fatigue, Severe sliding wear in the mechanical system. The technique as thermography to monitor condition of structures and systems. The areas as hotter or colder can locate and define incipient problems. The special instrumentation is used with infrared technology. Predictive maintenance for motors, Lubrication systems, & Pneumatic systems are discussed, and checkpoints suggested the literature discussed the practical methods about these techniques.

METHODOLOGY

Data Collection

Quantitative and qualitative are used to indicate the methods through which data has been collected and analyzed, as well as the kinds of generalizations and representations obtained from the data. The paperless method used for getting survey done. The Global survey agency "Survey Hero" was vehicle to upload appropriate structure so that participants were able to use paperless method to indicate their choices.

The survey respondents' work experience aggregated together over 1000 man-years! They are professionals from reputed engineering companies in India representing Public sector Undertaking (PSU), Multinational companies (MNC) and big Indian organisations like Bajaj, Godrej and so on.

The responses were triggered at fixed interval if the responses are not found. The responses and results of survey was made available by agency. The aggregate responses were sent to participants to as complimentary copy.

Similarly, the result of responses was statistically analysed and graphically shown by web software.

LIMITATIONS OF STUDY

The study is based on questionnaire's responses by respondent who are carefully selected from Industry known for progressive outlook. The study is limited to general engineering industries and not specific verticals as chemicals, petrochemicals, construction, public utility and so on.

IMPLICATION AND VALUE OF STUDY

The study is to guide maintenance persons to know where to focus their attention and which are factors are impacting. The maintenance persons can understand the suitability to their work area. The case study of manufacturing plant give insight on how to deliver the results

OVERVIEW OF THE SURVEY

The survey gives the web generated automatic results as output as per below mentioned response:

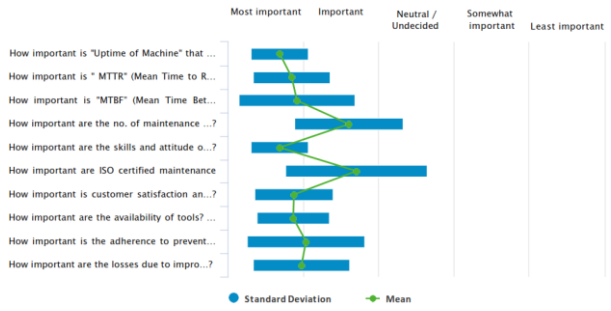
1. Service Quality Factors in five rating scale were rated.

2. Similarly Sustainability Factors in five rating scale were rated

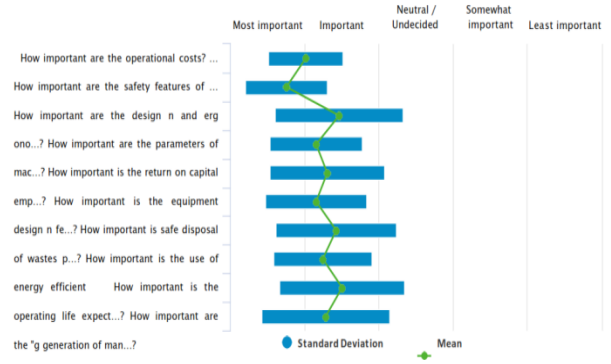
These give clue to Maintenance teams what is expectation. The result is graphically shown on above areas The web survey automatically calculates and graphically below e.g. in Q1. Standard deviation (0.8-1.56) and Mean (1.18) automatically gives information when web cursor is

located there. Similarly, it can be done to all questions as shown in survey result.

Section 1: Maintenance Service quality factors



Section 2: Sustainability factors of plant equipment



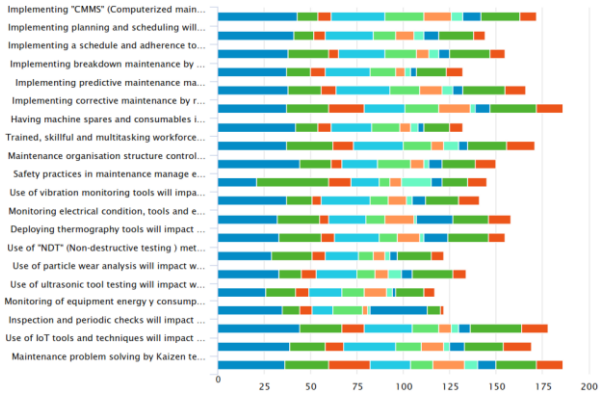
Number of responses: 51

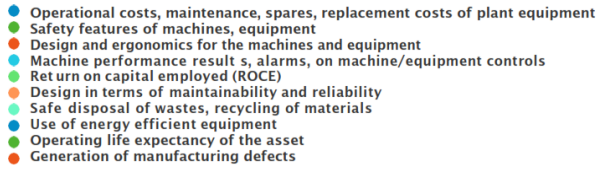
Section 3: Impact of maintenance management practices and Techniques on service quality factors

Number of responses: 51

Section 4: Impact of maintenance management practices and techniques on sustainability factors of plant equipment

Number of responses: 49





The method of web enabled survey enables for giving the graphical representation of the responses shown above.

Section 3,4 there is graph showing the number of responses to each factor. For example, note that "Implementing of CMMS has 43 responses can be seen from the graph. Similarly, all factors and their responses are shown by "Horizontal Histogram"

The entire process is web enabled and gives direct response. The choices are not influence by anybody as it is available web.

RESULT OF IMPACT FROM SURVEY

Maintenance Management Practices and Techniques

- ► Dedicated Computerised Maintenance Management system is most recommended management practices from Survey
- ► It is found from survey that, Implementation of Kaizen system is very much acknowledged as management practice
- ► Implementing of corrective maintenance by rebuild, overhaul and servicing is also high preferred choice as management practices
- ► Inspection and Periodic checks are highly preferred practices

- New technique like IoT is also picked up among top level response as practice.
- Trained and multi skilled workforce is among preferred among highly rated factor.
- The least preferred was among the monitoring the energy consumptions by assets.
- Use of techniques like Ultrasonic testing, non-destructive techniques were among lower preferred practices.
- Moderately impacted factors are Inventory management of spares, Predictive Maintenance techniques from the Survey

Service quality factors and Sustainability of Assets.

- Uptime of machine or asset is most expected service quality by survey
- Similarly, popular Quality factors are MTTR (Mean time to Repair) and MTBF (Mean time between failure) from survey.
- Maintenance work orders closed is also highly rated service quality factor from survey.
- Availability of Tools and Spares are among highly rated service quality factor from Survey.
- Accident reporting and near miss during maintenance are among highly rated service quality factors
- The lower rated factors are ISO certified service quality procedures
- Measurement of customer satisfaction is also among lower ranked from survey popularity.
- Payback period of assets is lower rated factor by respondent maintenance professionals.
- Maintainability, Hazardous waste creation is also among low rated respondents in survey.

SUGGESTIONS

1. It is suggested to have preferred computerised maintenance management (CMMS) practice. The idea is what we can measure we can improve**.**
2. It is suggested that management should invest in skills and multiskilling of workforce.
3. It is also recommended to provide all tools and diagnostic tools to be provided by management as a practice.
4. It is recommended that Kaizens are required to be driven as management practice to motivate employees to improve and maintenance of machines.
5. The importance should be given to IoT tool as maintenance Technique by maintenance teams.
6. It is recommended that the Maintenance Teams should be made aware of the terms like ROCE (Return of Capital employed). Survey indicates the lack of awareness of commercial terms. Ultimately capital saved is capital earned and asset longevity.
7. The condition monitoring practice to be evaluated for the appropriateness as per requirement of assets. This is no so popular amongst the respondents.
8. There is good awareness about the quality parameters about MTTR, MTBF and Uptime of machines is to be monitored regularly to get the benefits.
9. Spares management for maintenance should be implemented based on criticality and cost of spares.
10. It is recommended to take service quality and attitude feedback of the work force as management practice.

CONCLUSIONS

The conclusion can be drawn that there is correctness is saying that there is an Impact of Maintenance Practices and Techniques to get Maintenance Service Quality and Sustenance of Equipments.

Maintenance Management Practices:

Management Practices impacting the Service Quality and Plant Sustainability, are in varying degree as under:

- The prominent impacting factors are 1. Computerised maintenance management system 2. Scheduling and adherence of Preventive Maintenance program 3. Training and multiskilling of workforces and 4. Management controls
- Prominent factor specifically for sustainability of plant equipment are

corrective maintenance by overhaul, rebuild of machine

- The moderately impacting factors are 1. Breakdown maintenance 2. Predictive maintenance 3. Maintaining machinery spares 4. Overhaul and rebuild of machine

- The least impact factors of management practices are 1. Safety practices in maintenance management 2. Inventory management 3. Breakdown maintenance by machine classification.

Maintenance techniques

Maintenance Technique impacting Service quality and sustainability in varying degree are;

- The prominent impacting factors are 1. Use of Inspection tools for Functional 2. Kaizen problem solving.

- The moderately impactful factors in service quality are 1. Vibration Monitoring. Electrical condition monitoring, Use of IoT tools, Thermography techniques

- The least impacting service quality factors are 1. Energy Monitoring 2. Ultrasonic testing 3.NDT testing, 4 Lubrication analysis techniques.

Maintenance Service Quality Factors

It can be seen from survey responses, that the parameters for maintenance service quality in **prominence** are 1. Uptime of machines 2. (MTTR)Mean time to Repair 3. (MTBF) Meantime between failure 4. Maintenance work orders closed 5. Customer feedback. These factors are dominance in response than that of other factors.

Some of the findings can be noted that there are lower choices rating by respondents to factors such as 1. Loss due to maintenance activities, 2. Adherence to preventive maintenance schedule 3. Availability of tools and 4. ISO certified procedures and systems

Plant Equipment sustenance factors

It can be seen from survey responses that the parameters for Plant equipments sustenance in prominence are 1. Safety features of machines 2. Machine performance results on controls of machine 3. Design for maintainability 4. Operating life. These factors are dominance in response that the other factors.

The sustainability factors and maintenance techniques has varied responses. This is possibly due to the industry in which the respondents were working and suitability of that technique for that industry.

Similarly, the lower ratings by respondents to factors like 1. spares cost, 2. ergonomically designed machines,3. Generation &. disposal of wastes, 5. payback period of asset and 6. machines with manufacturing defects

The one way points out that it suggesting the these are not core activities or high impact KPI of maintenance function and respondents.

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