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A Survey on Downtime Cost of Equipment Used in a Construction Industry

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ABSTRACT: This paper performed by conducting a web-based survey within Indian firms that have at least 200 employees. The main results obtained from the investigation show that the estimated downtime cost constitutes about 23.9 % from the total manufacturing cost ratio, and 13.3 % from planned production time mechanism. Focusly, the hourly cost of downtime, whether it mayplan or unplanned activities, is relatively high. However, there is a shortage of systematic models that capable to trace the individual cost imposed by downtime scenarios. This lack was shown apparently whilst 83 % of surveyed companies they do not have any complete analysis adapted for quantifying their downtime costs strategy. Generally, only few companies develop their cost accounting methods such as, activitybased costing (ABC) and resource consumption accounting (RCA) to assimilate and reveal the real costs that collaborate with planned and unplanned stoppages. Still, the general pattern of downtime cost calculation mechanism allocated to direct labor and lost capacity cost in each scenarios. Alternatively, the attempts of decreasing downtime events and thus costs were based on schedule maintenance tactics that supported by overall equipment effectiveness (OEE) tool, as an indicator for affirming improvements. Generally, the analysis indicates the need for optimized maintenance tactics by incorporating reliability centered maintenance (RCM) and total productive maintenance (TPM) into companies maintenance systems. The maintenance role of reducing downtime impacts not highly recognized. Furthermore, the same analysis shows the requirement for better results of performance measurement systems is by implementing total equipment effectiveness performance tool (TEEP). The advantage of such tool is to provide the impact index of planned stoppages in equipment utilization factor. Finally, the lack of fully integrated models for assessing the downtime costs and frameworks for distinguishing the difference between planned and unplanned stoppages are the main reasons behind the continuation of cost in ascending form. Due to that, the improvements will emphasize on areas with less cost saving opportunities. As a result, this will affect the production efficiency and effectiveness which in return has its influence on costs and thereby profits margin.

KEYWORDS: Downtime cost, planned stoppage, Maintenance optimization, Performance measurement systems, and Indian manufacturing companies.

1. INTRODUCTION

The opening chapter mainly displays the motivation factors behind the thesis topic and the intention of approaching such a subject. Further, the introduction context enclosed by different constituent elements namely background, problem discussion, objective, research questions, delimitations, limitations, and finally a chapter summary. The report structure consists of eight chapters, and at the end of the first three chapters brief summary will be provided. The purpose is to facilitate the process of idea flow and content coherence; especially the first three chapters addresses the theoretical background of this study. Consequently, the overall goal of this chapter is to furnish the reader with a general understanding about the proposed topic.

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1.1 Background

In today's competitive manufacturing market, production efficiency and effectiveness are among top business priorities. Thus, production equipment becoming the central focus of interest as it is the backbone of the manufacturing process and key performance indicator of productivity. The requirements of outstanding performance force companies to substantially consider reducing their machines downtime frequency and its consequential costs [1]. Equipment downtime occurs due to planned or unplanned stops. However, the unplanned stops caused by failures and disturbances occurrence are the most common unexpected factors that have the non-trivial influence on the overall productivity. Also, this interrelation between downtime events and productivity lies in gist of economic connotation, in which cost and profit variables are inversely proportional by means of decreasing downtime cost and thereby increasing production profit [1]. To this end, in order to decrease the downtime cost, suitable and developed costing methods are needed to calculate and trace every single cost disbursed during the stoppage juncture. All activities and resources that have depleted whilst retrieving the production equipment function should be allocated based on their real costs. The primary role of costing method is to highlight areas with high cost savings, and of which managers proceed to implement improvements. For instance, one explicit trade off is between costing methods and maintenance applications. Productive maintenance strives for minimizing downtime events and hence cost. On the other hand, proper costing method can be of much beneficial to maintenance managers through assessing the efficiency of the adopted maintenance policy. Moreover, it allows the use of series mathematical modeling and simulation as an input to optimizing maintenance strategy, in particular, the preventive maintenance strategy [2]. Thereupon, a real case study is very urgent in approaching this topic in a logical manner. According to that, Indian manufacturing industry was chosen for this issue as it has perceived vast technological progress within production facilities. Moreover, the infrastructure of such development was based on the installation of robotic systems. Nevertheless, these sophisticated and complex systems exposed to frequent stoppages wherein are some of these stoppages has a significant impact on production outage and so lost profit [3]. The case of malfunctioning equipment and its restoration is very costly and requires many resources and budget expenses. For those mentioned reasons, Indian manufacturing industry is considered a good option to investigate especially the issues that related to downtime cost and reduction analysis.

II. LITERATURE SURVEY

1. **Mali Pritam A. "Effect of Construction Equipment On Production In Building Construction Project". International Journal Of Engineering Sciences & Research Technology June 2015 ISSN: 2277-9655 (I2OR), Publication Impact Factor: 3.785**

From This Paper I Refer-

The temporary worker's hardware approach and gear administration framework greatly affect the benefit of a firm, particularly for contractual workers with vast interest in gear. The cost of hardware in structural designing development tasks can run from 25-40% of the aggregate venture cost. In this paper data given about how the arranged and appropriate upkeep is imperative for development gear for better creation. The information given is month to month gear use nearby and different purposes behind misfortunes in development hardware creation. Appropriate arranging, choice, acquirement, establishment, operation and upkeep of development hardware assume essential part underway in development ventures.

2. **Prasannasangeetha.A "Equipment Management In Construction Sector" International Journal Of Science And Engineering Research (IJSER), Vol 3 Issue 6 June -2015**

From This Paper Refer-

Development gear assumes awesome critical part in development industry, costs as high as 36% of the aggregate development extend cost, be that as it may, the hardware support has not been given proper consideration and this add to around 40% of aggregate development extend cost overwhelm. The goal of this examination is to guarantee that development specialists acknowledge and hold fast to appropriate gear upkeep methodology as successful part of

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development venture productivity. For assessment of elements a few polls has been readied utilizing this data and circulated between development experts. Point of this paper is to decrease downtime, accomplish ideal gear usage and increment generation at least cost.

3. **Amir H. B. “Simulation-Based Evaluation Offuel Consumption In Heavy Construction Projects By Monitoring Equipment Idle Times” Proceedings Of The 2013 Winter SimulationConference R. Pasupathy, S.-H. Kim, A. Tolk, R. Hill, And M. E. Kudl, EDS**

From This Paper Refer-

A systematic approach to idle time reduction can significantly boost the efficiency of construction equipment during their lifetime, result in higher overall productivity, and ultimately protect public health and the environment. Towards this goal, this paper describes research aimed at designing a framework for estimating heavy equipment idle times during a construction project. A distributed sensor network is deployed to communicate and present metrics about idle times and production rates and inform project managers and field operators when idle time thresholds are exceeded. The designed user interface includes a graphical representation of the site layout to visualize the status of equipment in real time in sup-port of project management and decision-making tasks. Collected data will be also used to determine energy consumption and CO2 emission levels as the project makes progress. Using simulation modeling, various operational strategies are evaluated from the point of view of equipment emission and idle times.

4. **Rickey A. Cook “A Crane And Heavy EquipmentMaintenance Plan For Improving Safety And Efficiency” The Graduate College University Of Wisconsin-Stout December 1999**

From This Paper Refer-

The objective of this review was to build up a crane and overwhelming hardware upkeep get ready for enhancing wellbeing and productivity. XYZ Construction does not have a methodical strategy for keeping up its cranes and substantial hardware. Their way to deal with hardware upkeep could make dangers to specialists and property. This organization understands the potential for misfortune and thinks enhancing their upkeep plan will help relieve this issue. So as to finish this, the paper utilized three stages to build up a support plan.

5. **IliasNaskoudakis “A Thematic Review Of The Main Research On Construction Equipment Over Recent Years” 47(2), PP. 110-118, 2016 DOI: 10.3311/PPAR.10384 Creative Commons Attribution.**

From This Paper Refer-

An extensive collection of writing has been devoted to research contemplates on development hardware. Numerous themes were talked about and dissected, and different conclusions have been accounted for. Nonetheless, inquire about papers distributed with respect to construction hardware, are profoundly differentiated, and there is an absence of precise examination and arrangement. Subsequently, an entire comprehension of the subject is unrealistic, nor is the assessment of any future research bearing. A meta investigation of the most recent diary papers committed to development apparatus would not just portray the fields the scholastic research was focused on however would furthermore uncover potential crevices for future research. In the ebb and flow examine, through a precise survey of the scholastic writing distributed in the course of the most recent decade, primarily distinguished by means of online databases, principle look into topics, for example, enhancement, support/downtime, efficiency, mechanical autonomy and computerization, administrator ability, development, and environment are resolved and talked about, with future research headings recommended. The result of this paper will encourage future scientists to build up an assortment of learning of advance on development hardware and its potential capacities and provide future research headings on this issue.

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6. **D.G. Proverbs, G. D. Holt And H. Y. Cheok “Construction Industry Problems: The Views Of Uk Construction Directors” Built Environment Research Unit, School Of Engineering And The Built Environment, University Of Wolverhampton, West Midlands, Uk, Wv1 1SB, Uk.**

From This Paper Refer-

Taking after a nitty gritty writing audit, eighteen common issues confronting the UK development industry are recognized. The seriousness of these issues as opined by experienced UK development organization executives, gotten through a poll review, is consequently displayed. Discoveries uncover that the two severest issues are thought to be the poor picture and notoriety of the business, aligned with a dominance of 'cattle rustler manufacturers'. Configuration changes are positioned third, trailed by late installments, time restrictions and dependence on focused offering methodology. In light of these perspectives it is prescribed that the business' need ought to be towards nullifying corrupt firms in the residential repair, upkeep and change area, in this manner driving towards the advancement of a more expert picture. This ought to be consolidated with an endeavor by all development members to annihilate the current antagonistic nature of the business. A long haul vital arrangement is required if such non specific extensive issues are to be tended to adequately in the new millennium.

7. **Urmila A Mahadik “Cost Reduction In Construction Project” International Journal Of Engineering Technology, Management And Applied Science www.ijetmas.com September 2015, Volume 3, Special Issue, ISSN 2349-4476**

From This Paper Refer-

The development venture can fluctuate from to a great degree gainful to scarcely justified, despite all the trouble and here and there wind up costing the contractual worker more than what he or she is getting paid to finish it. In development industry the point of venture control is to guarantee the undertakings complete on time, inside spending plan and accomplishing other venture exercises. Time and cost are two fundamental concerns which increment significance of cost diminishment strategies. Diminishment of cost of development is a consistent objective for development industry. One method for decreasing development cost is to create imaginative innovations and also philosophies to expand profitability. This paper takes care of sorts of expense, elements influencing expense of ventures and additionally exchange on accomplishment of acceptable consequences of time and cost by applying cost decrease techniques.

8. **Tsado, Theophilus Yisa Equipment Maintenance: An Effective Aspect Of Enhancing Construction Project Profitability” International Journal Of Engineering Science Invention [Issn \(Online\): 2319 – 6734, ISSN: 2319 – 6726 www.ijesi.org](http://www.ijesi.org) Volume 3 Issue 4 April 2014 PP.34-41**

From This Paper Refer-

Development hardware assumes extraordinary noteworthy part in development industry, costs as high as 36% of the aggregate development extend cost, notwithstanding, the gear support has not been given suitable consideration and this add to around 40% of aggregate development extend cost overwhelm. The goal of this examination is to guarantee that development professionals acknowledge and stick to legitimate hardware support methodology as powerful part of development venture benefit. The review evaluated this target using Investigatory Survey Research Approach (ISRA) strategy. Five (5) distinctive basic, however firmly related indispensable methodologies of compelling development gear administration were distinguished. An aggregate number of sixty-five (65) very much organized polls were managed to eight diverse development organizations with character of A, B, C, D, E, F, G and H to gather quantitative and subjective information on how gear support has been taken care of in some haphazardly chose development organizations situated in Abuja, Minas and their environs. The contextual investigation regions were chosen as a result of their center overwhelming development ventures exercises. Fifty-seven (57) which speaks to 87.7% of the aggregate polls were recovered and broke down. The information gathered was subjected to recurrence investigation technique.

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The review uncovered that 51.5% of the development organizations surveyed don't append high need to gear upkeep and this contributed significantly to development extend cost invade coming about because of hardware breakdown. Dependability of development gear incredibly relies on upon the support. It is suggested that development experts bear the cost of the chance of gear upkeep technique as a major aspect of development venture administration. This will help lessen costs, likelihood of unforeseen disappointment, upgrade use and limit hardware downtime, which will consequently build the general development ventures profitability.

9. D. B. Phadatare “Impact Of Construction Equipments On Building Site Productivity” International Journal Of Civil Engineering And Technology (ijciet) Volume7, Issue 4, July-August 2016

From This Paper Refer-

The hardware administration framework and gear arrangement dependably hugely affects the gainfulness of the temporary workers with greater interest in gear. In structural designing development extends, the cost of hardware can differ from 25-40% of the aggregate venture cost. The target of this venture was to study that how the arranged and appropriate support is critical for development gear for better generation. The information investigation here is month to month hardware usage on location and different explanations behind misfortunes in development gear generation. It is important to assess if extra development hardware is conveyed to the development site then whether a venture can be done in a given period. The principle motivation behind this review is to assess the general activity stream of development hardware which impacts the effectiveness of development operations. This paper will review the goals and benefits of implementing Total Productive Maintenance and it will also focusing on calculating the overall equipment effectiveness in construction equipments. In construction operations on a large scale require the standard Equipments for Effective operations especially in the area of infrastructural development. This is the true picture of large construction companies whose physical successful activities depends on men, materials and sophisticated machineries that will produce output of operations during a particular period use. Thus, the effectiveness of construction machineries is a major factor that differentiates construction companies in terms of heavy construction and light construction. In the today's era of intense global competition, construction industries are determined to improve and optimize their productivity in order to remain competitive. Overall Equipment Effectiveness (OEE) of a machine plays an important role where performance and quality of the product are of key importance to the company. The OEE intended at minimizing the breakdowns, increasing performance and quality rate and thus improving the effectiveness of the machine. The availability rate of the machine, performance rate of the machine and quality rate of the products are considered as parameters while maximizing the Overall Equipment Effectiveness (OEE) of a production system. The objective of the work is to enhance the overall equipment effectiveness (OEE) at a construction company.

10. Mr. NileshAyane “Review Study On Improvement Of Overall“Equipment Effectiveness In Construction Equipment” 2015 Ijedr | Volume 3, Issue 2 | ISSN: 2321-9939

From This Paper Refer-

This paper will review the goals and benefits of implementing Total Productive Maintenance and it will also focusing on calculating the overall equipment effectiveness in construction equipments. In construction operations on a large scale require the standard Equipments for Effective operations especially in the area of infrastructural development. This is the true picture of large construction companies whose physical successful activities depends on men, materials and sophisticated machineries that will produce output of operations during a particular period use. Thus, the effectiveness of construction machineries is a major factor that differentiates construction companies in terms of heavy construction and light construction. In the today's era of intense global competition, construction industries are determined to improve and optimize their productivity in order to remain competitive. Overall Equipment Effectiveness (OEE) of a machine plays an important role where performance and quality of the product are of key importance to the company. The OEE intended at minimizing the breakdowns, increasing performance and quality rate and thus improving the effectiveness of the machine. The availability rate of the machine, performance rate of the machine and quality rate of the products are considered as parameters while maximizing the Overall Equipment Effectiveness (OEE)

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of a production system. The objective of the work is to enhance the overall equipment effectiveness (OEE) at a construction company.

11. Prajeesh. V. P “Management Of Equipment & Machinery In Construction” Ijiset - International Journal Of Innovative Science, Engineering & Technology, Vol 3 Issue 5, May 2016.

From This Paper Refer-

Construction equipment is a major resource in the building process for a construction project. When equipment is owned by a contractor, it forms a sizable portion of his assets requiring proper management practices. Good project management in construction must vigorously pursue the efficient utilization of labor, material and equipment. The use of new equipment and innovative methods has made possible wholesale changes in construction technologies in recent decades. The selection of the appropriate type and size of construction equipment often affects the required amount of time and effort and thus the job site productivity of a project. It is therefore important for site managers and construction planners to be familiar with the characteristics of the major types of equipment most commonly used in construction. This thesis is to study the management of equipments practices in Construction Industry and to present the most popular practices of the contractors and to compare the equipment management policies with a Case study of a construction industry. The needed data were collected via a structured questionnaire. The contractors were divided into three grades based on their annual work volumes. The collected data were analyzed using the SPSS software. The elements of the management policies were cross-tabulated against the grades of contractors for finding possible significant differences in contractors’ practices. Hypotheses on some expected results were tested. Finally, the findings of this study were compared with findings of questionnaire conducted for finding significant commonalities and differences in equipment management practices.

12. Mr. Pratik Desai “Overall Equipment Effectiveness In Construction Equipments” International Research Journal Of Engineering And Technology (irjet) E-Issn: 2395 -0056 Volume: 04 Issue: 01 | Jan -2017 www.irjet.net P Issn: 2395-0072”

From This Paper Refer-

This paper will review the goals and advantage of implementing Total Productive Maintenance and it will also focusing on calculating the overall equipment effectiveness in construction equipments. In construction activities on a immense scale require the standard equipments for effective operations especially in the area of infrastructural development. This is the true picture of large construction companies whose physical lucrative activities lean on men, materials and sophisticated machineries that will produce output of operations during a particular period use. Therefore, the effectiveness of construction machineries is a major consideration that denounces construction companies in terms of heavy construction and light construction. In the today’s period of agonizing global competition, construction industries are determined to progress and amend their productivity in order to remain competitive. Overall Equipment Effectiveness (OEE) of a machine plays a vital role where performance and characteristic of the product are of key relevance to the company. The OEE intended at minimizing the breakdowns, increasing performance and quality rate and thus improving the efficiency of the machine. The availability rate of the machine, performance rate of the machine and quality rate of the products are considered as parameters while escalating the Overall Equipment Effectiveness (OEE) of a management system. The objective of the work is to enhance the overall equipment effectiveness (OEE) at a construction company.

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- 13. Jariwala Siddhartha “A Critical Literature Review On Comparative Analysis Of Construction Equipment – Rent And Buy”. Journal Of International Academic Research For Multidisciplinary Impact Factor 1.625, ISSN: 2320-5083, Volume 2, Issue 12, January 2015**

From This Paper Refer-

The management of heavy construction equipment is a difficult task. Equipment managers are often called upon to make complex economic decisions involving the machines in their charge. These decisions include those concerning acquisitions, maintenance, repairs, rebuilds, replacements, and retirements. The equipment manager must also be able to forecast internal rental rates for their machinery. Repair and maintenance expenditures can have significant impacts on these economic decisions and forecasts. Construction equipment is a high cost of capital investment necessary for the successful existence of a private construction company. The highest impact cost factor other than the initial purchase investment is the expenses related to maintenance and repair. As the equipment ages, the ownership costs decrease and the operating expenses, increase as the maintenance and repair requirements grow. Both private and public entities desire to manage this high capital investment for optimization of a perceived profit. This project recommends a decision support model that can be used by private and public entities alike to determine the best fit acquisition method between rent-buy and guidance for profitability optimization.

- 14. Marie-Claude Nadeau “A Dynamic Process-Based Cost Modeling Approach To Understand Learning Effects In Manufacturing” Engineering Systems Divisions, Massachusetts Institute Of Technology, 77 Massachusetts Avenue, Cambridge, Ma. 02139, USA**

From This Paper Refer-

Across almost every sector of the economy, a defining feature of modern industry is operating in a context of nearly continuous technological change. Nevertheless, despite this context, industrial decision makers must still select and implement technologies whether they are novel materials, processes, or architectures even in the face of known to be incomplete information. Further complicating the picture, the performance, including the economic performance, associated with novel technology options is likely to change over time. Changes can emerge due to a number of mechanisms, including, for example, economies of scale, and changes in the factor prices associated with the technology. Moreover evolution in performance can occur through gains in productivity that develops over time, or through the learning effect. As a consequence, current information likely will not accurately reflect the future economics of a technology, and making decisions on this current data can therefore be misleading. This raises two critical questions for technology decision makers: how can decision makers pull together disparate pieces of information on the dynamics of operational and technological performance to estimate the future economics of a novel technology? Based on this estimate, what strategies will be most effective for driving down the costs of a particular technology.

- 15. Kunal R Ghadge “Construction Equipment Management For Construction Of Dam Site” International Journal Of Science And Research (ijsr) Issn (online): 2319-7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438**

From This Paper Refer-

The dam site engineering and construction works are one of the biggest projects continuing and progressing day by day. Dams are very important structures as it deals with the major irrigation projects and water resource planning the dam site is large and take much area and also require high endeavor for each of its work packages however most important part then remains as the execution of work and handling of large equipments and machineries. The economic dam site is one which is handled with economy of equipments thus here the part of concern is to have proper planning and management of equipments on dam site. Another part of concern is to complete the project on time where time for dam site is most important as the project is planned with proper weather forecasting.

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III. METHODOLOGY

In this chapter, a description of how study was conducted is presented. Moreover, a comprehensive discussion about adopted research method and its strategy is also provided.

1. Research philosophy

The philosophical attitude of qualifying any research work mainly based on arguing the methodology that have been adopted for a particular investigation. The decision of selecting one method rather than another will be assessed individually by researcher's vision, ontologically and epistemologically, that often related to the research questions in hand [9]. The research paradigms referred to conservative philosophical schools, which known as positivism and interpretivism. Both schools have their impacts of constituting the significant evolve of controversial science [10].

Positivism is considered the cofounder of epistemological movement, especially inconnection to social science. The pioneers of this philosophy introduced the argumentative that social world exists externally to researcher, and can be measured directly through observation. This statement implicit properties of which researcher must be restricted. Subjectivity, not any more accepted. Instead, objectivity is the new trend that enables scientific research on a logical basis. In addition, the independence of analysis is neither affected nor affects by the subject of the research [10].

The achievement of state of art research in accordance to positivism requires clear mechanism and structured method. This methodology facilitates the process of collecting observations and further quantifying them statistically [10]. In contrast, interpretivism approached the interrelation between people and their environment. The debate core here contradicts the essence of positivism custom, see table 1. Interpretivism beliefs are based on merging axiomatically entities, the researcher and social world in one mold. The researcher andhis/her social world cannot be separated. For this reason, the criteria of embracing interpretivism values in research work demanding the methods to emphasize on people. For example, the data collection procedure, usually, preferable with qualitative over quantitative data. In this context, the investigator should make interviews to figure out people behavior in a particular phenomenon [11].

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Table 1. The comparison between positivism and interpretivism

	Positivism	Interpretivism
Reality	Objective, External	Subjective, Internal
Type	Survey, Experimental, Quantitative	Phenomenology, Qualitative
Purpose	Generalize, control	Interpret, Understand

Source: Merriam [12]

1.1 Research philosophy of this study

The philosophical discourse on the subject of this study has been taken to a large extent the positivism manner, as a base for approaching downtime costing issues in Indian manufacturing companies. Moreover, this study claims the objectivity through investigating topic problem, i.e., information, data, and all types of obtained results were presented as given without any biased subjective influence. According to positivism, any problem must be taken into considerations of numerical assessment and can be realized throughout customized measurement tool. Therefore, this study utilized web-based survey as a tool for collecting data and further creating a database for content analysis. The enumerated analytic techniques such as, descriptive statistic was adopted to discern the central tendency of population. Furthermore, this type of analysis enables to generalize results and spotlights interrelated factors.

Nevertheless, the distinction between positivism and interpretivism and in relation to best research philosophy is quite difficult. They have interchangeable characteristics in which any separate selection may lead to impairment of research quality. In my opinion, they are somehow linked in one way or another but at different levels and their causality based on the nature of matter that under study. Consequently, this relative relationship between those two concepts will be pointed-out during the display of upcoming chapters, for instance while firms calculate their downtime costs. They exclude the cost of planned stoppages as routine that entrenched to mindset and organizational cultural aspects.

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IV. RESEARCH APPROACH

One of the essential crucial elements in research is to specify which method is being applied. There are two wellknown approaches dedicated to research namely, inductive and deductive. In the inductive approach, the researcher strives for collecting the data that considered relevant to the topic of interest. Then, the next step starts with analyzing these data in purpose of finding patterns, and afterward developing a theory that could interpret such patterns. Hence, if research trending towards the inductive paradigm the driven factors might be attached to set of observations, and indeed must transit from particular experiences to more general set of propositions about those experiences [13].

In a paradox with inductive concepts, deductive approach enforces researcher to start with existing theories and then attempting to tests its inferences with data. In general meaning, deductive characteristics constrained the work procedure to be into scientific investigation category as labelled by positivism. The investigator must review what others have done in the field and that in ease of drawing hypotheses that emerges from studied materials [14].

4.1 Research approach of this study

The scientific approach of this study is deductive in nature and that because the project idea created after wide review of existing theories. Those reviews are the literatures that associated with downtime cost in production systems. For instance, the proposed methods and models to quantify the downtime cost, the difference between planned and unplanned stops, identification of cost drivers, and the maintenance strategies to increase reliability and thereby minimize downtime cost. The study primarily included articles published in prestigious scientific journals, conference proceedings, books, theses and any other relevant reports that may considered important and fulfill the level of scientific research standards. After thought, the step was to formulate research inquiries in the form of research questions from what have been reviewed and then begins with collecting and analyzing the obtained data in order to answer the research questions. Finally, the compiled results and conclusions will either confirm or reject the proposed research hypothesis.

V. RESEARCH METHODS

The best chosen method for gathering data has been disputed between qualitative and quantitative audiences. In general principle, any selected method either quantitative or qualitative based will be considered appropriate as long as it guides the anticipated research. Hence, the nature of given research determines the method that needed to accomplish better results [15]. Qualitative method explores attitudes, behavior and personal vision through interviews or focus groups. It attempts to obtain opinions from specified participants in which few people take part in the research. In a paradox, quantitative method generates statistics through use of survey accompanied by the assistance of questionnaires. This type of methods reaches many participants, and the contact is much quicker than it is in qualitative [15].

The main differences between qualitative and quantitative research methods explained into following points:

- Quantitative data collection is more close ended in comparison with qualitative data collection that is based on more open ended.
- Quantitative data analysis used the statistical theories as background; Qualitative data analysis count on text or image analysis.
- Quantitative reporting has a set structure, as it grounded on mathematical elaboration; Qualitative data reporting is more flexible and may contain additional conscientiousness [6].

5.1 Research method of this study

The study of downtime cost analysis in Indian manufacturing companies required large size of active participants in order to achieve good results. Therefore, a quantitative method based on survey was adopted and considered effective over qualitative because the target is to assimilate many responses in limited duration. Moreover, the acquired data might be easier to standardize in numeric form for later comparison than data obtained through qualitative methods. The choice was not easy though, because topic like downtime cost evaluation it might contain more investigations about

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human and machine interactions. In other meaning, the qualitative analysis could magnify the problem from different angles. However, the proposed survey was included semi structured questionnaires in which allows participants to present their opinions to some extent.

VI. RESEARCH STRATEGY

Research strategy defined as the way that relied on logic and set of procedures with the aim of answering research questions in particular. There are many listed strategies used by research work such as, survey, experiment, case study, grounded theory and so on [7]. In spite of the variety of available strategies, this work feasibly implements the survey strategy as a tool for answering research questions. Thus, the following parts introduce only elements that shaped such strategy and omitted others for its unsuitability to this study.

4.1 Internet-based survey

Survey defined as a measurement process through asking questions, and that in the aim of collecting information from selected group of interest to be representative of a larger population. In fact, this procedure known as a sample survey and its importance allows generalizing results even though not the whole population is tested. There are two types of surveys, questionnaire and interview. The questionnaires mainly handed out through different ways, electronically, by asking online questions and by sending private emails or throughout physical distribution by post. On the other hand, the interview associated with face to face meetings or via phone [8]. According to Cohen et al. [9], internet based survey is becoming commonplace in many branches of science because of its accessibility of features over other methods. Some of those features can be summarized as following listed points:

- Automated data entry
- Lower costs
- Wider distribution
- Faster turnaround times [2]

4.2 Research strategy of this study

The success of this work required an accurate sample from large existing population. Although, the time and expenditure factors also a paramount concern while planning any survey. For this reason, internet based survey was considered a right choice to get fast responses with high rate participants, in addition to the advantages that arise for both surveyor and contributor by flexible data entry. This method has its positive impacts on the planned budget as well, since there is no much work done manually and no paper work included through distributing questionnaires. In the light of these benefits, the environmental facets have been likewise influenced in a safe manner.

VII. DATA COLLECTION TOOL – QUESTIONNAIRE

One of the techniques that commonly used in collecting data is well-defined. This technique namely, questionnaire, it composed of customized and set of standardized questions in which aim for gaining new knowledge from a given subject. There are different types of questions incurred questionnaire layout such as closed-ended, open-ended and combination of both questionnaires. Closed-ended questionnaires, usually, more suitable for quantitative research than other types because it's easier to generate statistics and perform analysis.

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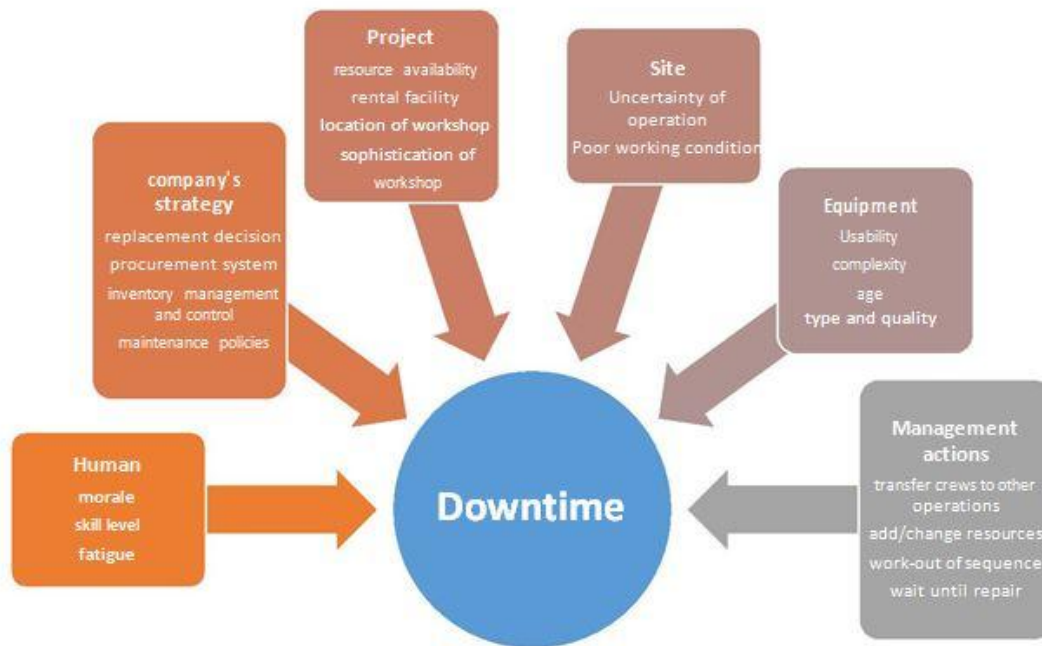


Figure 1. The generic factors and processes that related to Downtime eventSource: Nepal and Park [1]

Downtime occasions are dynamic in nature and however results. Particularly, the downtime that subordinates its events to spontaneous stops, for example, machine breakdown that goes on for developed periods and this machine considered basic in which any characteristic disappointment prompts add up to creation end. In this way, the effect of such occasions are exceptionally serious on the grounds that it disperses the proficiency of the generation procedure, thus make a kind of easygoing circle. For example, once the machine ended up noticeably inaccessible the principal recognizable impact is the asset inaction administrators and gear and along these lines the venture advance (requests satisfaction) log jam in addition to the expanding weight on work routine. In the greatness to this repercussion, the supervisors may ended up noticeably diverted from appropriate control of the circumstance and swing to hurried upkeep. This impedance tends to deliver low nature of upkeep, which on the other hand prompt downtime occasion et cetera, in other significance, making the awful strengthening circle [1]. Another imperative issue is the cost point of view of downtime, as the recurrence of each specified element there is an amassed fetched went with. While Downtime happened, it prompts diminished recuperation of expenses of limit contrasted with a perfect creation volume. Case of limit cost may be an office, apparatus, utilities, and organization or whatever other backhanded capacities related cost. The case here is when machine is down the expenses of limit are still brought about despite the fact that there is no item created. This will brings the cost weight and under such conditions there is less thoughtfulness regarding support work, in which consequently the low nature of upkeep increment the likelihood of downtime occasions [3]. Once in a while, the incessant downtime can interfere with the first succession of work. This interruption may occur in a few routes, for example, changing the work arrangement by presenting new techniques and methodology or by redirecting the impacted assets through downtime term to other site operations. The worry is by occupying the HR to different locales may experience the experience level issues in which required an a lot of learning time conflicting with anticipated techniques. Furthermore, the condition of blockage site close to the sentiments of declined level of experience influences the group assurance and in this manner presented framework to stoppage.

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VIII. CONCLUSION

Indian assembling firms know about the potential effects that hardware downtime creates on their item cost and accordingly benefits. Notwithstanding, the effect that stretch out to creation proficiency and adequacy. For instance, this mindfulness shows up clearly while supervisors assess the downtime cost proportion from aggregate assembling cost. Also, the downtime impact on arranged generate on time, downtime hourly cost, and the requirement for social change and attitudes. These progressions meant to incorporate the arranged stoppage taken a toll into their appraisal strategies, "this kind of cost ought not be ignored". Despite the fact that, the larger part of reviewed organizations (83 %) don't have any efficient model for surveying and following the individual costs that related with arranged and startling stoppages. They legitimize that by the many-sided quality of such models and the time span and noteworthy costs required for usage. For example, the costs that went with preparing and learned individuals. Then again, just couple of organizations receive finish models, for example, action based costing and asset utilization representing measuring downtime costs, yet in low rate of combination, as indicated by poll comes about. Rather, those organizations underscored on the immediate work and lost limit taken a toll as the principle cost related to impromptu stoppage, and calendar upkeep as the primary cost driver for arranged stoppages.

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