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IMPROVEMENT IN DYNOMILL MACHINE BY IMPLEMENTATION OF FAILURE MODE EFFECT ANALYSIS (FMEA)

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ABSTRACT

Failure mode and effects analysis (FMEA) is an important method to obtain preventive maintenance and quality assurance. It involves the investigation and assessment of all possible causes and effects of all failure modes on a system. FMEA is widely used in identifying and reducing risks of failure in a system, component or a process. The procedure is made compulsory for devices and installations that attract high initial investments or involve high social risk. Study is focused on conducting FMEA on a milling machine called dynomill to examine all the major components and effects of their failure on the overall performance of the system. Specific outcome of FMEA study is the assessment of a relative indicator called risk priority number (RPN) which is associated to each potential cause or mechanism of failure that are identified during the analytical investigations.

The Aerospace industry uses the term "Failure Modes, Effects and Criticality Analysis" (FMECA), to highlight the criticality factor in the application of FMEA is followed by Criticality analysis by which each potential failure is ranked according to the combined influence of severity and probability of occurrence. It identifies single point failures and ranks each failure according to a severity classification of failure effect, helping to identify weak links of design.

Keywords: Risk Priority Number, Dynomill, Historical Importance, Optimization, Development In Maintenance.

I. INTRODUCTION

The project work is about to a milling machine called Dynomill. Dynomill is used in many chemical, pharmaceutical and mine industry. It is a very important utility system for manufacturing. The purpose of this machine is to mill material in the form of semi-solid, viscous liquids and powder form. The main purpose of it is to decrease the particle size of material. Its machine with effective direct impact on working fluid or material. The more it is easy to use and maintain. We can upgrade the capacity of product as per requirement. It contents a various digital instruments to control and maintain in running condition.

Industry Details

PAX Chem Ltd had a humble beginning when it started as a Chemical trading partnership firm in 1977. In 1983, under a technical arrangement with an International Industrial Biocides supplier, PAX commenced its Biocides manufacturing activities. In 1998, PAX collaborated with one of the World's largest Personal Care Preservatives supplier and started its Preservatives and Hygiene Products operations. PAX presently offers more than 150 Industrial and over 220 Hygiene, Cost -effective and Bio-effective Products. PAX specializes in assisting its Industrial Customers in managing Bio-deterioration, and in keeping its Consumers hale and hearty. PAX Product Performance Assurances are supported by comprehensive Technical Evaluations and Third-Party Certifications.

Dynomill

The DYNO-MILL is an agitator bead mill with horizontal grinding container for dispersion and finest wet grinding in a completely enclosed system. Milling in the stirred media mills is an efficient process for the preparation of ultrafine materials owing to its advantageous features, ease of operation, simple construction, high size reduction rate, and low wear contamination.

The dyno mill (Ball mill) is operated in a recirculation mode. The ground product of purely water soluble organic powder in water is circulated through the grinding chamber which is filled at 75 volume% (bulk volume) with grinding media (0.3, 0.5 or 0.8 mm zirconium oxide, yttrium stabilized beads). The product suspension is drawn out through a 0.1mm gap called gap separator to prevent the grinding medium to exit the

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milling chamber. The system is cooled to keep a constant temperature in the entire system with chilling or cooling water circulation. The inside temperature of Cylinder which also called system temperature is controlled through this circulation system.

The Delivery pump circulates the product in form of slurry in the tank and grinding chamber. The main shaft in the grinding chamber is equipped with blades anti abrasiveness and hardness. The blades drive the grinding media called zirconium Bead inside the grinding chamber to do irregular movements in all direction to put the slurry material under the action of constant collision and friction. At same time , the slurry material are separated from the grinding media by the sieve and keep circulating from the tank to the grinding chamber to obtain smaller particle size, narrower part size range.

Figure 1: DYNOMILL (Actual Photo from Factory, Dt. 7/09/2018, Time 2:06:31 PM)

Depending on screen system centrifugal separation system (gap separator with clearance of 0.2, 0.3, 0.5 mm).The Slurry in fed into the grinding chamber from opposite side of gap separator with help of feed pump to Flows axially through the chamber. The grinding media is radically accelerated on the surface of the grinding blades. A mixing chamber with axial product and grinding media exchange is formed in the active area of the grinding blades. Figure 1 shows a front side view of dynomill. A Name plate with machine number (Z 6) and PE code i.e. Production Equipment Serial no 0138.

Constructional way, an agitator shaft with grinding disks/blades is mounted within horizontally arranged grinding chamber. The grinding media in the grinding chamber is activated by the grinding blades. The product (slurry) flows axially from the inlet through the grinding chamber and is ground by the shearing and impact forces of grinding media.

Figure 2: Dynomill (Actual photo in factory Dt.-7/09/2018 Time- 2:06:44 PM)

The product is separated from the grinding media be screen system at the end of the grinding chamber. Figure 2 gives the auxiliary view of dynomill in which can see portion cut on sheet for ventilation.

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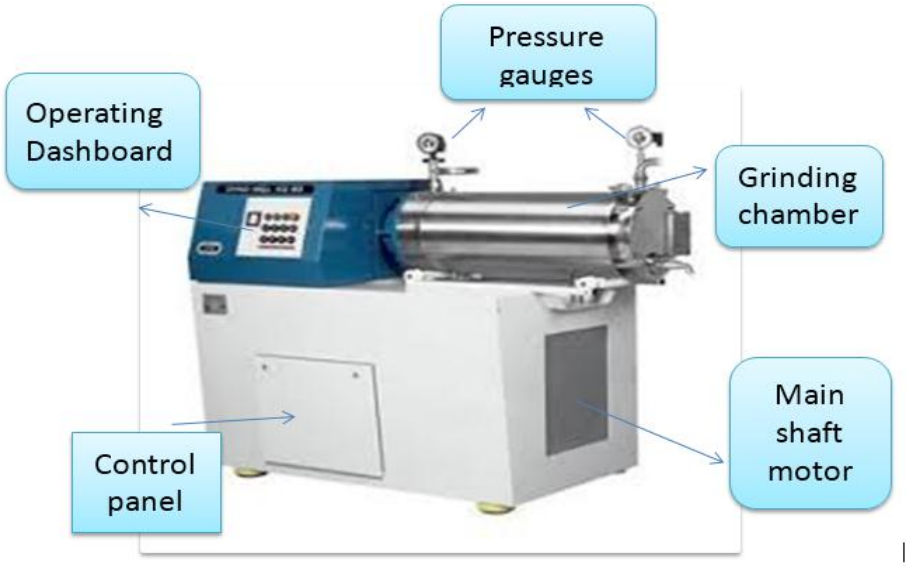

Figure 3: Introductions to Dynomill components

The next figure 3 shows major assembly's in dynomill. Dynomill mainly consist of operating dashboard, pressure gauges, grinding chamber, control panel & main shaft motor. The Operating dashboard includes start – stop push button, temperature gauges. The control panel have various fuse, coils, relays and timer. Then main shaft motor which is the driving pulley, mounded at bottom section of dynomill. It is a belt drive transmission system to grinding chamber shaft. Where the grinding chamber is an enclosed cylinder where product undergoes grinding process. The main shaft having highly sharpened blades on it gives perfect milling to product at high RPM. There are some pressure gauges provided in process lines to know the pressure of flowing fluid. In Grinding chamber there are stainless steel blades of sharp edges mounted on shaft. Motor rotates shaft with blades at high speed which cuts/breaks solid particle from working fluid. Then pressure gauges are used for measure pressure in respective of inlet and outlet to grinding chamber of fluid. In spite of this as per safety concern there is provision of one Non Return Valve (NRV) made. The main purpose of NRV is to resist the flow in reverse direction towards feed pump. While in feeding process of material is likely to flow in direction of chamber. In case of choke or jam in chamber it develops a reverse flow i.e. pressure towards feed pump. This results in slowing down pump speed. This pressure causes a load on feed pump motor and there are chances of early motor winding warn out. The other purpose of NRV is to keep grinding media i.e. bead in only chamber. The bead should not get flown through any reverse flow of material towards feed pump. Because there are chances to mixed beads in material through reverse flow may come in contact with feed pump. Those beads can cause damage to gear teeth & internal pump casing. NRV works as separator between feed pump and grinding chamber to avoid transfer beads. Figure.4 gives an overlook about component where major maintenance issues arises .It Include assembly of both type mechanical as well as electrical component assembly. In Which starts with grinding Chamber, Main Shaft Motor mounted on channel structure frame and feed pump assembly this are the part of dynomill mechanical assembly.

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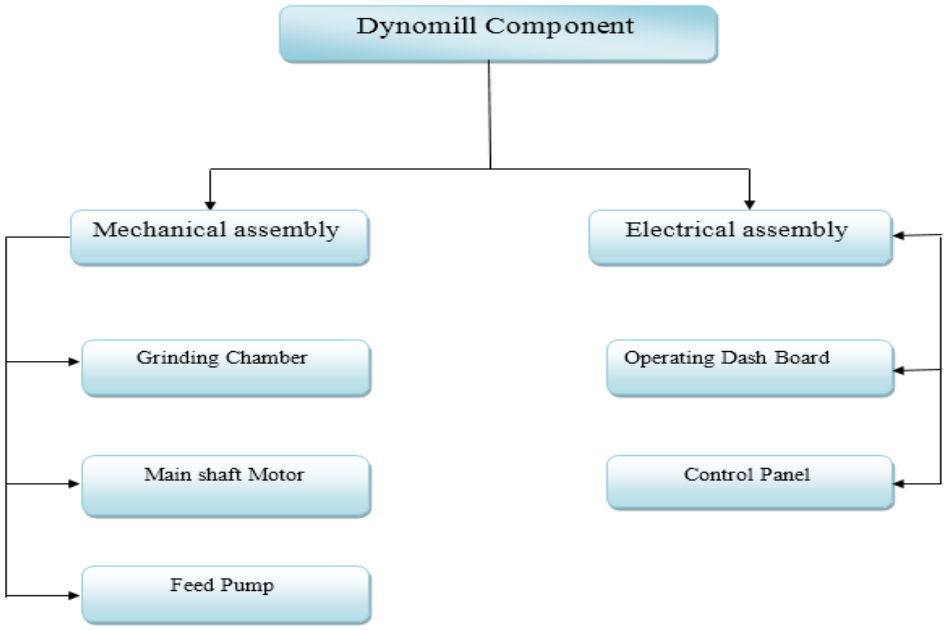

Figure 4: Dynomill machine component structure

Then in electrical assembly it carries operating dash board and main control panel board or box. As maintenance point of view this both departments are very crucial to maintain and overall performance as well as machine life also dependent on this two. As dynomill is a much needed process for manufacturing of system therefore the dynomill maintenance is a big challenge to maintenance team. So further will see this sub part assembly in details. The first in Machanical system is basically consist of three major sub assemblies decribed as follows.

❖ **Mechanical Assembly :-**

A. Grinding Chamber –

In grinding chamber the milling process takes place. This chamber has as shaft in centre of stainless cylinder and a Blades of same material is moundeted on this shaft at equal measured distance which is calculated by designer & the same calculated with the number of blades mounted on a shaft. This blades having sharpen edges with a small hole on each teeth of blade for extra cutting area of product particle. Then Beads are agitated inside the grinding chamber and product particles are ground or dispersed by the collison and shear force of the beads. The Chamber is enclosed by a cooling system on its surface to control temperaure inside it.

B. Main Shaft Motor -

This motor is gives drives to the milling Shaft of grinding chamber. This sytem driven through belt and pulley drive mechanism. V Grooved Pulleys of equal diameter mounted on both the motor shaft and grinding shaft. The grinding chamber and milling shaft is seperated by two components. The first is machanical seal and other is gap seperator in enclosed structure. Before this two a main shaft bearing is placed in bearing hub cylinder.

C. Feed Pump -

The feed pump is used to put product into grinding chamber at a certain reuired pressure. The rate of flow or pump pressure at which product to be milled decides the required final output product particle finerness. Hence feed pump plays an important factor during particle size range setting. The feed pump with spur gear arrangment is used in this unit. An electric motor drives this pump at certain RPM which connected through coupling. The normal rubber seal having good chemical resistance property is used in this pump.

❖ **Electrical Assembly : -**

A. Operating Dash Board –

In Electrical System first will start with opearting dashboard used for operating control on Dynomill. Start and Stop Puch Button are there to Run and Stop the Dynomill operation. Then a Ammeter is placed to check ampere

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rating of Current of Main shaft motor as it is an of type Star Delta Connection.Then comes one of the most important part i.e Temperature Controller.

The purpose of temperature controller is to keep temperature inside of grinding Chamber within Safe range. There are two Pressure gauges which is not a part of Dashboard but they are mounted on inlet and outlet of grinding chamber respectively.

B. Control Panel –

The control panel is a main power supply unit due to which dynomill can operate smoothly. In Control panel includes fuse , reply and timer etc. which does the work as cut off system for dynomill and saves it from a big failures. The control panel takes whole resposibilty of dynomill to run in conrolled manner and get immediate Stop when there will be occurred any uncertain situation like material jam or excess temperature or drop in flow rate etc.

The both mechanical and electrical componets plays their role efficiently. And hence total efficiency of dynomill is depent on these two system. Therefore with FMEA gives a strong Support to these two systems to make them reliable and efficient.

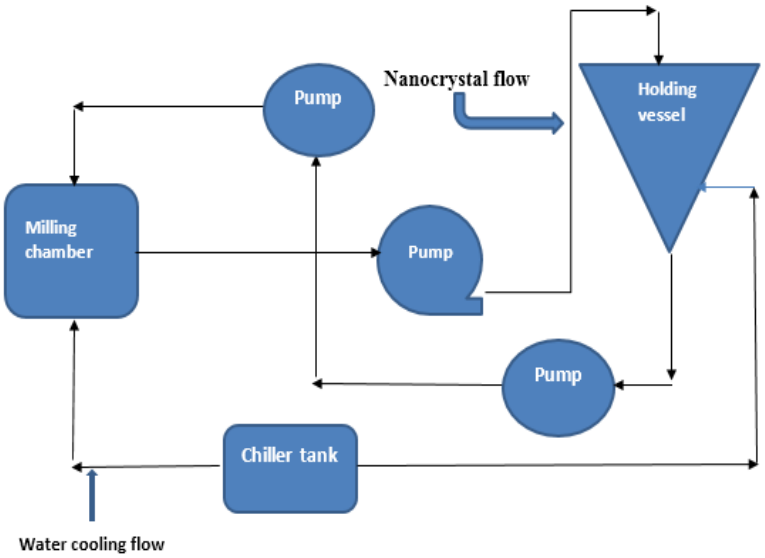

Figure 5: Milling Process/ Operation

Figure 5. Gives brief over view of dynomill process, also called as dyno passing process. Process starts with a rector/vessel contains the viscous fluid of 50-60 micron particle size .This fluid from bottom nozzle of vessel passed in to milling chamber of dynomill through a feed pump. Inside chamber there are present small circular shape metallic ball called as “Beads” made up of zirconium metal. A pump is gear pump having capacity =20 LPM .This pump feed the material in chamber at a pressure.

In Dynomill a mechanical type of seal is used separating bearing housing and chamber plate. During milling process in chamber a heat is generated due to chemical properties of fluid. Also mechanical seal get heated due to friction between seal and rotating shaft. Hence a chilling plant is used for proper cooling of chamber as well as for mechanical seal area. The overall process is quite simple to understand but each sub system makes a bigger impact on actual product output. Therefore to maintain each of elements from this chain is necessity of better quality product. Thus FMEA is tool which makes this effort and keeps focus from root cause to major cause of every element of machine.

Equipment Description:

There are total 6 No’s of dynomill are in operation at factory. Two of them are of 10 Letter capacity and other four are of 30 Liters capacity. The dynomill which is used for this research is among those four of 30 Liters. Describe as follows:

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Name: Dynomill Z6 (PE – 0138)	Feed Pump
Make = Reliance Engineering	Capacity = 20 Liters/ Min
MOC = S.S 316	MOC = S.S 304
Capacity =30 Liters	Manufacturing Year = 2014
Main Shaft Motor – (HP)/ (RPM) = 20 /1480	
Feed Motor Make – Havells Lafert Motor	
RPM = 1400	
Manufacturing Year = 2015	

This Dynomill machine is a newest one among all dynomill hence I have chosen this machine for research due to this reason. I thought the research on most advanced machine would be something more beneficial than with older models. So This Dynomill (Z 6) has Capacity of 1000 Liters / hour in onetime Passing Process.

Product Description:

Though the Product used for dynomill passing is confidential because of which I didn't give any detailed information regarding the product. And not a part of this research also. So basically this is viscous fluid containing a solid particle of 50-100 Micron size.

Therefore to improve the Quality of Final Product it mandatory that the particle size of final product should be range from 1 To 5 Micron. This work of reduction in particle size is done by dynomill machine for final product. Hence Dynomill or Dyno Passing Process is much important for Production.

Figure 6: Grinding media (Zirconium Beads) [Dt.07-09-2018, Time -03:05:00]

Figure.6 shows the media present inside grinding chamber .This Beads are in spherical shaped. Brown in colour. The size i.e. Diameter of bead is ranging from 1.6 to 2 mm. The Quantity of beads in each dynomill are about 45 to 50 kg .It acquires near about 30 % space of actual volume in grinding chamber. Thus the material is crucial, breaking down between beads and rotating blades inside the chamber. **Zirconium beads** are used as grinding media here. This zirconium beads are typically used for fine grinding and ultra-fine grinding process in stirred mills and attritors especially in vertical and horizontal type of bead mills. Generally grinding media has wide range of size and densities.

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This bead has very high chemical and physical resistance properties. Hence these are more likely to be used for chemical grinding applications and are also typical for handling while after use. They have longer life as well in terms of chemical applications. This makes them favourable in such uses.

Significances:

i. Every consumer of dynomill wants there product should get better quality and standards. So particle size should get reduce as much as possible And product becomes finer to improve the quality .it can be possible by dynomill with simple and efficient way.

ii This ultra-valuable equipment's has really proven its performance in the field of dispersion and optimum grinding over the years, and have become a significant part of every industry dealing in the manufacturing of ores, minerals, metals, ceramic and glass, etc.

iii Today, there is no place for conventional mills and their average-speed of service in this modern life, there upon Dynomill are brought to you in a large selection of shapes and sizes for various particular applications.

iv Dyno Mill Machine is an economical mechanical device used broadly in the industrial sector. The primary duty provided by a Dyno-Mill is grinding, cutting and crushing the materials into fine and even sized particles and creating a homogeneous mixture. The materials which consume time to break down into smaller pieces manually or by any other mill are efficiently transformed by Dynomill machine.

Figure 7: Working with dynomill at factory (Date: 6-01-2019, Time: 5:50:14)

II. LITERATURE REVIEW

Over the past few decades, maintenance has become increasingly important for industrial environments resulting in growth in this research area. Effective maintenance is dependent on spare parts availability. So there is always needed to take a serious action in the form of schedule plan or method. Under which it make major improvement for industry. Creating such model, method or action will definitely make it possible to eliminate those factors which can create a serious damages or breakdowns or failure of manufacturing system . Therefore this research going to point out such an important factors and so the industry can find the solution to overcome them.

Waste propriety number:

The Agung Sutrisno, Indra Gunawan and Stenly Tangkuman (**2015**) developed a modified FMEA (Failure Mode and Effect Analysis) as for access the criticality of waste in maintenance operations or services. In an attempted to point out decision makers in appraising the effectiveness of maintenance waste occurrence, an improved model for ranking the risk of maintenance waste mode by using Waste Priority Number (WPN).They proposed a model estimated to know the weight of maintenance waste causes and waste priority number (WPN) as mentioned RPN in conventional FMEA is provided.

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According to researcher the WPN Index is having the similar function like the Risk Priority Number (RPN) in Conventional FMEA. The highest of the WPN score of a failure mode, risk of corresponding waste mode would be more. And hence the analyze WPN is more important to obtain for the effective model. Considering each maintenance waste n system having its own degree of detect ability, probability occurrence, expected cost consequences, and difficulty to rectify, then it's become necessary to find their hierarchy for prioritizing preventative or corrective measure Maintenance causes weight Wwc.

If Wwc represents the weight of the maintenance causes affecting the occurrence of the waste maintenance mode k, then the weight of the waste priority score indicating the rank of the corresponding maintenance waste is given as in equation.

$$Wwc = D_c\, O_c\, R_C\, C_c \qquad \ldots\ldots (I)$$

This model represents some new components to achieve a criticality assessment of different maintenance waste modes. For which they used a modified version of FMEA and it is different from previous works, where they considered the probability of waste effect controllability aspect.

FMEA for mechanical wave energy converter (MWEC):

Chandrasekaran S. and Harender **(2015)** investigated superior method of generating electric power from ocean wave energy using heave motion of a floating buoy. They proposed model for mechanical wave energy converter which examined for its efficient functionality through failure mode and effects analysis (FMEA) to study its reliability and found the better outcomes through their results.

They conducted FMEA on a variable speed, geared drive mechanical wave energy converter (MWEC) and examined all the major components and effects of their failure on the overall performance of the device. Specific outcome of FMEA given the assessment of a relative indicator called risk priority number (RPN) which is associated to each potential cause (root cause) or mechanism of failure that are identified during the analytical investigations. He performed FMEA on mainly two stages i.e. first is Design FMEA and other one is process FMEA .he used Design FMEA methodology to obtain the failures in MVEC.

FMEA for passive magnetic bearing (PMB):

In this research work the researcher applied failure mode and effect analysis (FMEA) process to identify the various possible failure modes of different configurations of passive magnetic bearings (PMB) and obtained the corresponding effects /analysis for these failures on the bearing performance. He identified failure modes of PMBs which facilitated designer to incorporate necessary design features that prevented the occurrence of the failure. For this he has conducted experiment to determine the severity, occurrence and detection of the various failure modes. Followed the standard path in which the Risk Priority Number (RPN) of each failure mode was calculated to identify high risk failures.

According to him, the main objective of an FMEA Process is to identify all the potential modes of failure of a product. The failure of a product is said to occur when it does not function as per the requirements or when the product does not fulfill the required performance objectives.

Optimized photovoltaic maintenance plan based on FMEA:

Mauro Villarini, Vittorio Cesarotti, Lucrezia Alfonsi and Vito Introna **(2017)** described a simplified model of a PV system given by Machine Breakdown Structure (MBS) and the real failure modes obtained from Computerized Maintenance Management System (CMMS) database listed by company. In which CMMS is an organized software database aimed to support the management and maintenance activity. In this paper researcher proposed a maintenance plan over issues related to ground level and the cause of this failure is lack of isolation and sudden over load of system. For which they used an overload measurement device i.e. a Multi meter. This Multi meter likely to test the isolation of modules several times a year.

According to him the criticality using FMEA is defined by the RPN which is the combination of the ratings as follows severity of the effects (S), occurrence (O), and detection (D). The severity related to the seriousness of the end effect of a component failure. The occurrence represented the frequency that a malfunctioning event is likely to occur. The detection is the likelihood of detecting a potential failure situation before it occurs. Each rating was measured on a subjectively defined scale and the assessment based upon the three indicators with reference to this scale. The RPN is obtained by their product.

$$RPN = S\times O\times D \qquad \ldots\ldots II$$

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FMECA (Failure mode effect and criticality analysis) of liner compressor:

A Linear compressor is a positive displacement compressor that uses a piston driven by a linear motor to deliver gases at high pressure. Linear compressor is a new technology used in the domestic refrigeration sector. Basically Liner compressor is advanced technology in refrigeration and cryogenics applications. Therefore it is important to increase the reliability of liner compressor. The Amit Jomde, Virendra Bhojwani (**2016**) has applied FMCEA to Liner Compressor. In which they identified the all possible causes of failures and its effects in designing, manufacturing and assembly process of a Liner Compressor. They developed an interrelationship of different components/ parts of the complete unit. According to the researcher's compressor is complex system in which the failure or breakdown of one part is leads to another adjacent component or part.

FMEA in process industry for asset maintenance:

According to the American Production and Inventory Control Society (APICS), process production is defined as: 'Manufacturing that adds value to by mixing, separating forming, and/or chemical reactions. Structured preventive maintenance, including the use of FMEA, is therefore important for companies in the process industry.

The Process industries are characterized by the need to use complex applications and expensive installations efficiently and safely. Capital investments tend to be high and expenses for downtime tend to be large, which puts pressure on the maintenance function and creates the need for sophisticated maintenance procedures. Thus A.J.J. Braaksma, W. Klingenberg & J. Veldman (**2012**) presented six no .of postulates for explanation to this. Also described the some case studies for practical impact in this study.

Forecasting method for spare part management:

The Liu Shenyang, Huang Zhijie, Zhu Qian and Zhu Chen (2017) developed a model calculate the no of spares to be available in stock. When breakdown takes places so could use the required spare from stock in emergencies. It's really important to keep at least a sufficient stock of critical spares required in factory or manufacturing plant. This can avoid the loss in production time, sometimes production process efficiency .Hence spare part forecasting being introduced in modern industries.

According to authors "If the storage capacity of each spare part is too small, the equipment's successful completion of the training mission cannot be guaranteed; if the storage capacity of each spare parts is too much, it will cause overstock which affects economic benefit of the component". In this paper he took the example of relay from an electrical control board. Then they constructed a model based on its failure timings applied this model and estimated a forecast for relay quantity can be stocked for a year.

Failure mode analysis of Diesel motor crankshaft:

M. Fonte, V. Infante, L. Reis, M. Freitas **(2017)** proposed a detailed study on failure mode analysis of diesel motor crankshaft .In which firstly a diesel motor was disassembled to determine the root cause of its failure, however No defect was detected, but since a suspicion of damage was present, and being this failure recurrent in this type of diesel motor series So again crankshaft was disassembled. Then the crankshaft was subjected to a simple vibration analysis and a preliminary indication of possible existence of a crack was concluded. For an instance the crankshaft was then replaced by a new one, to start motor regular and the old was subjected to a failure analysis for determining the root cause.

In research a crack was found at the crankpin web-fillet and after a complete opening of the crack, the failure analysis showed that fatigue was the dominant failure mechanism. Observations were carried out by optical and Scanning Electronic Microscope equipment. Material defects at the crack initiation zone were not found. The root cause of damage seems to be a misalignment of the main journals and a weakness of design close to the gear at the region where the crack was initiated.

Multi criteria framework in spare part management:

According to researchers classifying the spares has become fundamental for an organizations maintenance department as well as for developing internal, technical and production procedures. Similarly this research work is focused on improving a framework for classify the spare parts. The framework contains grouping of multiple items into different classes according to different inventory policies. Luis Miguel, Isabela maganha, Vanessa magalhas & Maura Almeida **(2018)** presented this framework which based on multi criteria technique for problem solving by using analytic hierarchy process and triangular fuzzy scale.

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In his study spares parts are classified by some criteria, to classify these criteria need to define stock keeping units. This is done by dividing into four main categories which is demand volume & variability, product life cycle & storage properties, consumer attention, time i.e. lead time demand frequency.

Multi criteria Classification for spare part management: a case study

Caterina teixeria, Isabel lopes, Manuel figueiredo **(2017)** presented a research to develop a spare parts classification for integration in a computerized maintenance management system (CMMS) of a manufacturing company. In this they have used firstly classification based on to identify the necessity and importance of spare part regards to maintenance management, then after multi criteria classification using previous maintenance classification model.

In proposed study authors used ABC analysis which is also known as Pareto analysis. As ABC analysis is widely used in industry, but in its traditional form it has some adequacies like it shouldn't be the homogenous. Hence it should include more criteria while classification. After this change a new ABC multicriteria analysis emerged as an alternative for spare management. Further two more techniques has been introduced in simplifying the classification namely as FSN classification and VED Classification. Here CMMS become a one of essential component of many companies for maintenance department which performance role as support system on variety of maintenance activities.it helps to track spare part along requisitions as per necessity.

Sustainable spare part management:

Chiara franciosi, alfredo lambiase and Salvatore Miranda **(2017)** presented a research work focusing on new paradigm for sustainable manufacturing. This mainly seeks to develop sustainable production process, innovative technologies and new upcoming tools in context of economic, environmental and social industrial assets.

The main aim of this study is to provide a periodic preventive maintenance model through which can establish optimal maintenance period for each machine component. This resulted in to reduction of conventional, economical & social cost those generated by maintenance interventions. This presented model gives it potentiality as a decision support system for evaluating the right maintenance policy to adopt in a sustainable manufacturing context. This development in new sustainable quantitative model then could replace conventional ones could be applied in industrial contexts in order to limit the environment and social impacts related to maintenance activities.

Actually here in this model permits to obtain preventive maintenance period which minimize the conventional, environmental and social cost based on maintenance of machine and different types of spare parts used in maintenance interventions for control environmental and social impacts.

III. HISTORICAL REVIEW

FMEA has its origin during the late 1940s for military usage by the US Armed Forces. This is incorporated in the military document MIL-P-1629, dated November 9, 1949, titled Procedures for Performing a Failure Mode, Effects, and Criticality Analysis, and subsequently ratified as MIL-STD-1629A. It was used as Reliability evolution technique to determine the effect of system and equipment failures. The failures were classified according to their impact on mission success and personal or equipment safety.

Its industrial application came during the early 1970s when the Ford Motor company, reeling after the failure of its Pinto car project, introduced FMEA to the automotive industry to improve design, and for safety and regulatory considerations. SAE have documented this as SAE J 1739. First used in the 1960's in the Aerospace industry during the Apollo missions. Its effectiveness in identifying and reducing any unseen problems encouraged its application for space research and design, specifically in the Apollo Space program and in developing the means to put a man on the moon and return him safely to earth. FMEA methodology is now extensively used in a variety of industries, including semiconductor processing, food service, plastics, software, and healthcare.

In starting phase the FMEA was specifically aimed at automotive. But some organizations which demands high levels of reliability. This reliability is extending to white goods and around various electronic products. Therefore for most of the organizations FMEA were becomes a risk analysis tools and to get a solutions over small problems in particular of automotive spares in industry. AIAG was formed in 1982, which later to get

fierce US auto industry competitor to collaborate and agree on standardization use of quality improvement tools like FMEA , Statistical process Control and measurement system analysis. Further In 2019 AIAG - VDA FMEA harmonization project was collaboration between OEMs and tier supplier AIAG and VDA. This joint venture culmination of a three year project revising and improving FMEA Methodology.

Toyota has taken this one step further with its design review based on failure mode (DRBFM) approach. The method is now supported by the American Society for Quality, which provides detailed guides on applying the method. The Aerospace industry uses the term "Failure Modes, Effects and Criticality Analysis" (FMECA), to highlight the criticality factor in the application of FMEA is followed by Criticality analysis by which each potential failure is ranked according to the combined influence of severity and probability of occurrence. It identifies single point failures and ranks each failure according to a severity classification of failure effect, helping to identify weak links of design.

Now this is all about automotive or mechanical industries, but FMEA has now used in health care department to assess risk of failure and harm in processes and identify the most important areas for improvement of process. So FMEA has been used more than hundreds of hospitality in variety of institute for health care improvement programme. Which mainly Include IDMS (Idealized design of medication systems), patient Safety Collaborative and patient safety summit.

IV. RESEARCH PROBLEM AND DEFINATION

The two issues that found mainly related to dynomill machine. In which first one can say common repair work/Breakdown. Another one was spare part arrangement or availability of spare in schedule time Elaborates as below:

Maintenance:

The proper maintenance is necessary for every machine or equipment. If there is no maintenance done to machine then it can be resulted in to breakdown and various failures and if your key machine comes under breakdown while production is at leak then it will going cost you definitely. Hence you needed to be careful and alert for failures and breakdowns. So always keep the machine under monitoring and checkups to avoid such critical situations.

Preventive maintenance is the one of the most used and general method for equipment and machineries. This makes the machine most reliable and effective in production. The dynomill machine is consist of no's of sub-assemblies i.e. most of metallic parts. Each sub assembly or systems have small parts. So each section and sub assembly undergoes failures after a specific time interval or period. As a maintenance engineer for me it's becomes very important to attain and solve all issues and problem with dynomill as soon as possible. And make available for production to production team in quick times. Sometimes there no big worries if you have another same machine for backup. While one machine is repairing the another stand by machine will able to available for production and after machine gets repaired properly with proper trials and again can be used for production. Therefore in this research work I have studied a new advanced method to make less maintenance by firstly identifying and then eliminating those issues. Some of the issue those were not avoidable then at least tried to less its impact on machine. So I used FMEA technique and use of such method on dynomill would be a first time.

Spare management:

Like every other machine, dynomill also required some spares which are less in numbers but sometimes there are key spares can call it as critical spares that must be kept in stock. The Unavailability of any critical part can cause the machine to small issue to some big and serious damages. Hence maintenance team used a forecasting technique to solve this issue. The first one is spare part forecasting and D- classification.

It was not easy to maintain an everyday inventory record for spares. So which requires a separate manpower to do such activity to ensure the spare in stock or not. If not then proceed for their order and similarly for procurement till inventory for the same. Therefore the team needs a master schedule or planning for spare management. Which can gives relief from headache of arranging the right spare required at right time in most economical ways. Hence for quicker response in any sort of maintenance like preventive or breakdown needs such provision of spare management will be advantageous to maintenance team. This can also help the team indirectly to avoid delay in maintenance job especially in some critical cases where a small spare makes effective damage to machine assembly.

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Therefore the spare management plays a vital role in maintenance management. Post FMEA spare management also needs better planning towards maintenance point of view. The coordination of these both FMEA and spare management definitely improve dynomill maintenance programme.

V. AIM & OBJECTIVE

The aim of this study is to identify the way failures occurs in dynomill and then will classify those failures in tabular form then setting a specific preferences to that failures. Initially the failures come from small sections or movable parts.

The main aim is focused on regular breakdowns in dynomill. Either repair or replace the parts in dynomill are not a permanent solution to the maintenance department, because the reliability and quality of maintenance also matters a lot for organization. Why the same things going damage or failure happens regularly in some parts in dynomill. The question is not ends on keeping or doing maintenance when a part gets failed or damaged. For example failure occur in dyno feed pump due to leakage through gland housing. As per action of maintenance the team will replace the gland with new one after then dyno mill runs regular. Thus how the regular practice for maintenance team, but this not an enough job for an engineer to let it go smoothly. I.e. some failures are regularly occurring in dynomill due to part assembly or parts inside their service life. Such things have to be identified and point it out in front of maintenance department. So the aim is very clear & straight of this study to provide best solutions for dynomill while maintenance of it. To improve the preventive maintenance such that the breakdown / failure automatically get reduce of dynomill. This practices not only been applicable for dynomill but can be effective for other machine also of the organization.

The every operators and supervisors those who are complaining , questioning about dynomill i.e. decreased product output rate, leakages , time consumption and other small maintenance issues. For team it's very important to find a corrective and effective solution over these issues. Hence this research aims to improve the efficiency and increase operational life the dynomill. So will try to get a better output through this research work and satisfy company operator while using dynomill. Some of the other objectives enlisted below,

- ♣ Increase the Productivity by dynomill efficiency.
- ♣ Decrease sudden failure and breakdown.
- ♣ Decrease time consumption in dyno passing process.
- ♣ Eliminate some other small mechanical and electrical maintenance issues

To achieve all above objectives need a best planning and execution. Hence the proper study of problems also more important to get output. Some of the issues may looks easy to understand and also to solve them as well. But there should be more focus towards gaining a lifelong solution to such uncertain problems. So that can concentrate on big issues or breakdown in dynomill.

VI. METHODOLOGY

Approaches to FMEA:

Failure Mode is the way in which the component, subassembly, product, input, or process could fail to perform its intended function. Failure modes may be the result of upstream operations or may cause downstream operations to fail. Failure mode and effects analysis (FMEA) is one of the best management tools to analyse the potential failure modes within a system under conditions of uncertainties. Its principle is quite basic and has been practiced since the olden days as the trial and error method. But since learning from each failure is both costly and time-consuming.

It analyses potential reliability problems early in the development cycle, where it is easier to take actions to overcome these issues, thereby, enhancing reliability through design. FMEA should always be done whenever failures would mean potential harm or injury to the user of the end item being designed.

A structured approach to:

i. Identifying the ways in which a product or process can fail.
ii. Estimating risk associated with specific causes
iii. Prioritizing the actions that should be taken to reduce risk
iv. Evaluating design validation plan (design FMEA) or current control plan (process FMEA)

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Procedure:

Step 1 - Failure mode

In the way failure occurs and is observed. The manner in which the fault gets occurred. For a example an Leakage, electrical short-circuiting, corrosion, cracking, or deformation. It may be noted that a failure mode in one component can lead to another failure mode in the same, or another component. When a machine or system has many ways of failing, it has one or multiple modes of failure or competing risk. The more complex a system is, there will be more failure modes are.

Step 2- Failure cause

The failure cause is the most direct reason that something failed .The product or process defects or any other quality imperfections would initiate further deterioration leading to a failure. Some failure modes may have more than one cause or mechanism of failure and each of these shall be listed and analyzed separately.

Failure cause evolves from description of symptoms and outcomes to systematic and relative abstract model that how, when and why failure comes that is exactly cause. Hence it starts of from cause and leading to one particular end effect.

Step 3- Failure effect

Failure effect is the immediate consequences of a failure on operation, function or functionality, or status generally, as perceived or experience by the user. These effects are directly or indirect affect the production process for long time where the immediate maintenance can't possible. The some of the failure effects can be cited as, injury to the user, inoperability of the product or process, deterioration in product quality, no adherence to the specifications, émanation of odur, noise, and etc.

The failures are evaluated in order to assess the failure consequences. This consequences are then categorized in main four types as first is hidden failure consequences, second is safety and environmental then third is operational consequences and last one is non-operational consequences

Step 4 - Severity factor

A symbolic measure of the failure effect is the severity factor, which is the assessment of the seriousness of the effect of the potential failure. It is noteworthy that the severity represents the seriousness of the failure and not the mode of the failure. Here we defined severity scale then need to review the criteria properly when make any judgment in severity column. If the results are shown accurately, the severity can be easily established by reviewing the severity scale criteria.

Step 5- Probability of occurrence

This can be done by looking at the occurrence of failures for similar products or processes, and the failures that have been documented for them in technical terms. Probability of occurrence is the chance that one of the specific failure causes will occur. This recoding of probability of occurrence must be done for every cause indicating the probability of occurrence of that cause.

The Occurrence has relative more importance rather than an absolute value and is determined without regards to severity or either detection. The occurrence scale should be reviewed the criteria column to denote ranking. This assessment of occurrence ranking should be as objective as possible, using past field history of similar items, previous test results, experience with similar system or any other source of information.

Step 6 - Ease of Detection

This is the ability of the inspecting mechanism and/or design control to detect the potential cause or the subsequent failure mode before the component or the subsystem is completed for production. The detection also termed as effectiveness as because numerical subjective estimate of the effectiveness of the controls to prevent or detect the cause or failure mode before failure reaches to customer or item is released to production.

Risk Priority number:

Risk priority number (RPN) is a function of the three parameters discussed above, the severity of the effect of failure, the probability of occurrence, and the ease of detection for each failure model RPN is calculated by multiplying these three numbers as per the formula below,

$$RPN = S * P * D \quad \text{..... (III)}$$

Where,

S - Severity of the effect of failure,

P - Probability of failure, and

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D - Ease of detection.

RPN may not play an important role in the choice of an action against failure modes, but will help in indicating the threshold values for determining the areas of greatest concentration. In other words, a failure mode with a high RPN number should be given the highest priority in the analysis and corrective action.

Relationship between Three forms of FMEA

The relationship between the all three types of FMEA with each other and the type of FMEA used in this research is mentioned. These are general and common type for all manufacturing assembly lines.

To achieve the targeted research goals, in company taken interviews, with maintenance departments meeting and investigating about failures and observed documents from maintenance and operations unit of the company For obtaining relevant data pertaining to how maintenance and operation are practiced in its everyday activities, interview with operators and fitter, operations manager is conducted.

- **Design FMEA : -**

The Design FMEA can be applied to any part or machine before sending to manufacturing department. The product is tested or analyzed in Quality department and then if it approved by them then goes to production team for further processes. This analysis mainly focuses on potential root causes of failure modes. The product with such failures is caused due to the design deficiencies. There it critical to locate those failure modes in final product or in its design phase.

The Design FMEA method is normally carried out at three different levels as system, sub system and finally at component level. This can be used to analyze hardware and operation or combination of both as well.

- **Process FMEA :-**

The other type is Process FMEA which basically used to analyze the potential failures modes those are present within the process.it also identify the severity and frequency of that particular mode of failure during process based on past experience. The process FMEA is normally applied manufacturing and assembly processes to analyzed them on basis of System, sub system and component level. This method mainly focuses on potential mode of failure in the process which having the deficiencies within manufacturing and assembly processes. This kind of analysis develops us to design failure away from those of process system with minimum effort and resource expenses.

VII. DATA ANALYSIS AND EXPERIMENTATION

Preventive maintenance:

Like every other machine in factory dynomill also goes under preventive maintenance check-up and servicing in which all the related issues checked properly as per check list. If any problem found in dynomill then did repair work for that specific part or section. E.g. there was leakage through gear pump gland portion then changed the gland or fit new seal in it. Thus maintain the good preventive record for dynomill in factory

The preventive maintenance strategy used for dynomill is quite effective while taking some important aspect taken into consideration from maintenance point of view. So thus this monthly check-up is essential for us to keep dynomill in healthy condition. While doing it need to keep thing tight and timely so should miss any link or point so it can result in any major issue.

History cards:

The History card is another documented format that used for record the historical breakdown in dynomill. This card helped to trace the historical data and also to find the major issues and changes that taken place in dynomill in past. Sometimes this data can use for analysis or study the equipment in detail. Like preventive checklist the History card also plays an important role in our maintenance planning. Because this record provides some important data used in past over that machine or performed any maintenance work. This data further may useful for making an improvement in particular part or assembly.

Validation / calibration/ testing reports:

Validation report is collected of dynomill at time of its installation in factory. In that report covers all testing and related parameters that essential for starting the dynomill in normal regular state i.e. ready for production.

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Then calibration report contents the record for testing exact functioning of control instruments on dynomill i.e. temperature sensor, temperature indicator / controller, pressure gauge, ammeter etc.

As a point of view of auditors this reports gives a health summery of any equipment. If any machine with uncelebrated or without accuracy then if definitely a major defect of that equipment or machine. This surely makes way for serious failure or breakdown. Without knowing healthy parameter for smooth running of machine you can't get the good reliability of the machine.

The data is collected in form of this record which have weekly and monthly close look on each equipment and machine. For the dynomill also such records are prepared by maintenance team. Keep track of various parameters from temperature controller, pressure indicator, voltmeter / ammeter and rpm meter etc. after getting valuable reading analysis is obtained.

Table 1: The occurrence ranking criteria:

Rank of Occurrence	Description
1	Unlikely failure
2	Remote Probability
3	Occasional Probability
4	Moderate Probability
5	High Probability

Table 1 provides the ranks for occurrences of failures. In this table can see the preferences given to respective numbering with its effectiveness on machine. This starts from low level to end with high level of occurrence. In unlikely failure with rank 1 denotes those failures which have very rarely chance of occurrence may be once in year. Then next is a remote probability with rank 2 it denote failure which are not expected to occur but it possibility cannot be ruled out completely. Again this can also be the rare one but having more chance of occurrence than unlikely one.

The occasional probability with rank 3 it a failure likely to occur definitely in particular time of period but has tendency of occasional one. It don't show any aspect before come into look So will say this rank of failure will happen or occur several times but irrespective of period. The rank 4 moderate probability like its naming, it has average number of times possibility of occurrence. These failures have definite chance of occurrence in a known period of time say every month it under go failure. The last one is high probability with rank 5 which having the most possibility of chances of occurrence.

Table 2: The Detection Ranking criteria:

Rank of Detection	Description
1	Minimal Probability
2	Low probability
3	Moderate Probability
4	High Probability
5	Very high Probability

Table 2 this Provides a ranks for detection i.e. sequence of Minimal probability of detection to very high probability. The detection criteria basically for obtaining that root cause which effect on machine or equipment. The severity number also important factor of this RPN and used for calculating the same. The severity can be labelled based on failure intensity. Whenever failures occurred its impact on machine performance can be showed by severity number. Table 3 gives Rank of severity from minor failure to breakdown state of machine.

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Table 3: The severity Ranking criteria:

Rank of Severity	Description
1	Minor Failure / Hardly detected
2	Failure detected and will cause Machine Performance
3	Failure detected and cause for breakdown
4	Failure easily detected and cause high dissatisfaction
5	Failure will cause non functionality of machine

FMEA chart:

For this research work we will use the FMEA table. In that table we enlist all the possible issues, problem and difficulties related to dynomill. Thus we will collect a form of raw data which can be used for analysis purpose.

Table 4: FMEA Chart for dynomill.

Fault/ Problem detail	Category (mechanical /electrical)	Cause	Effect	Controllability	(D)	(S)	(O)	RPN
Leakage From Feed pump	Mechanical	Gland wear/NRV Chocked	Product loss	Replaced the gland	4	2	4	32
Fuse busted	Electrical	Motor overload	Machine stops working	Replaced fuse / MCB installation	3	3	3	27
V Belt broken down or damaged	Mechanical	High Heat generation /Wear and Tear/ Friction	Increases Vibration / machine under breakdown	Replaced belt /perform checkup for belt condition before use.	4	3	2	24
Connectors having leakage	Mechanical	Cut or damages on nozzle	Cooling system disturbs	Replaced connecters/ Clean Filter Regularly	3	2	1	6

In table no 4 can see faults an i.e. failure occurs in dynomill. In which four of them mainly occurs taken into research. Listed in 1 st column all those failures then in 2 nd column denotes its types of failure they are either mechanical or electrical. In next column can see different cause responsible for these failures or problems. In effect column shows the impact of these failures on dynomill machine.

Then further comes controllability in this provides respective solution for solving this failures or issues. Now comes the main part for research given number for each failure on basis of their criteria and finally get the RPN by appalling formula i.e. product of all three types of observations in dynomill. With very high RPN number to low RPN number. For dynomill a mechanical failure has many occurrences than the electrical failures. As a study point of view has taken most common failures. But each of above failure on has different impact on dynomill. This failure can be repaired or resolved if they get detected during the primary check of dynomill. Also such faults person requires an alertness and good observation for detection.

As a organization always looking for every area to improve the process or system. It can be anticipate and compare the effect of proposed changes like above calculating hypothetical RPNs of different scenarios. But in all of this need to remember that the RPN is measure for comparison within one process only, it is not a measure for comparing risk of between process and systems.

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VIII. RESULT

Finally the results that were aimed at the start of this research work had got after implementing the FMEA method to dynomill. Obtained the major improvement in productivity. Similarly found some healthy reduction in uneven breakdowns with dynomill. Then one of the major objective in focused i.e. time taken by dynomill for milling process have reduced to near about to its original pace.

These results were obtained from FMEA simply applying its steps to machine in right direction and some important factors that accelerated the FMEA process are as follows.

i. Monitored and recorded required parameters to calculate RPN.

ii Prepared a schedule and checked them periodically with basic elements of machine.

iii Configured the issues as per priorities.

iv Then tracked the records to obtain possible solution over those issues.

Problem is difficult but it could be achievable through FMEA. Because the whole production get effected when dynomill have any breakdown and that to be prevented. With normal preventive work it is not going to help to avoid such trouble permanently. And hence we need to step one level up and to obtain some solution to keep machine with very less maintenance always, available for production any time when it needed.

Thus this research will be a way to find some answers for those questions of operators and superiors in factory. Each element of dynomill will be in consideration all the possible small observation which is affecting the dynomill performance. Probably this is something new for dynomill I could say. The method what I will be sing is well known in theoretical world. But if we applied this on dynomill then definitely will get some worth results in its performance. Specially as a mechanical engineer this is I think will be better chance to know and learn it.

IX. OBSERVATION & FUTURE SCOPE

Firstly to see how spare part management could be more supportive for FMEA. The spare availability and unavailability can have variable direct or indirect impact on Post FMEA. The FMEA not going to be disturbed by spare management issues but it may effect in upcoming stages of it. For example, if any design or material change is found after FMEA, it may change the requirement of spares. According to the demand of spares inventory needs to be adjusted. This effect may not be that much critical or worth by any means but it is important one for spare management point of view. Because any spare have their own values and life on basis of which these changes makes their role more effective in purchase process.

The specific outcome need to be observe during these process i.e. performance of dynomill with normal and regular maintenance and that of with FMEA. The belief over the years and some successful researchers those makes the difference in their system after applying FMEA. It always tells us and gives confidence about FMEA simplicity with surety of success in improvement of any machine maintenance.

For Dynomill, automation is a future activity that can add a value in it. Like various sensors, PLC, pressure switches and cut off device etc. such digitalized control element can be introduced in order to prevent dynomill failure in both static and dynamic situations. In field of automation such advanced instrument can be installed easily. Due to this provision dynomill can be used in healthy operation i.e. damages due to failures may get decrease.

The future study can be obtained for solution of failures that taken in this research work .To eliminate or decrease the effectiveness of the failures. Further Set an action plan or schedule or operation manual will be added value in it. Make machine as less maintenance and flexible operations for operators/users.

X. CONCLUSION

After studying and understanding FMEA applied for simplification of the problem. It helped in identifying failures on basis of priorities. So priority used for corrective action during the maintenance or process itself. Right from the days of its conception in the 1940s, it has today become a must for the users. If any unexpected failure shall occurred in dynomill then it result in the poor performance of it, But Now this issue was avoided through the critical examination of FMEA over dynomill. Hence it prepares highly suitable, reliable and most satisfactory level program to dynomill. So for which taken brief information and gone through various research

papers and articles to understand its methodology, process and applications and used to apply over dynomill machine effectively.

This research work mainly aimed over high performance for dynomill .Therefore to achieve this task chosen FMEA among other methods. So Found of new way to segregate failures on basis of level of importance for each. For next level research operating manual can be prepared for dynomill operations. Due to which make user proceed in proper sequence while its operation .and can avoided damages or issues occurs because of wrong operation of handling in dynomill.

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