
**IMPACT OF MAINTENANCE MANAGEMENT ON PRODUCTIVITY
IMPROVEMENT AND WORKPLACE MANAGEMENT OF
PRODUCTION SYSTEM IN AN EXPLOSIVE INDUSTRY
(SOLAR INDUSTRIES INDIA LIMITED, NAGPUR)**

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ABSTRACT

The purpose of this research paper is to study the impact of effective maintenance management on improvement of productivity, profitability of production system and effective workplace management in an explosive sector industry (Solar Industries India Limited, Nagpur – A leading explosives industry in India and Asia). As much risk involve in operations of explosive industries it's a challenge for maintenance department to look forward for process improvement, plant-process optimization, effective utilization of available resources, etc. concerning all with the safety. So that it should withstand competitive explosive manufacturing environment with all required accomplishment of industrial goals. This research study also seeks to critically examine the implications of KAIZEN, 5S, TPM, Lean 6 σ , TQM, etc. Implementation of this continuous improvement philosophies in an explosive manufacturing industries not only aims to increasing productivity of production system but also effective workplace management and overall personality development of working individual. The study is carried out in an explosive manufacturing industry which is now facing problem for maintaining machines due to highly acidic atmosphere, lack of effective space utilization, difficulty in establishing processing machines in plant, also to reduce downtime due to hazardous working environment and maintenance issue related with the same.

The research approach is directed in the direction for finding the root cause of the problem due to which maintenance problem rise in a manufacturing of explosives industries. The study includes solving the maintenance issue and plants effective-productive modification by doing root cause analysis (RCA), why-why analysis, of the problem for reducing downtime with zero maintenance requirement, improving productivity ratio of production system, also to implement continuous process improvement tools. The study highlights the contributions of strategic maintenance management initiatives for overall improvement and zero maintenance requirements.

Keywords: Explosives, Maintenance Management, Productivity, Risk, Operations, Safety, KAIZEN, 5S, TPM, 6 σ , TQM, Production System, Why-Why Analysis, RCA, Etc.

I. INTRODUCTION

Growing demand for coal, metals and defence components across various industrial sectors is one of the leading driving factors for the growth of the global industrial explosives market. As per analysis by Persistence Market Research, the global industrial explosives market is estimated to expand at a healthy CAGR of more than 6% over the forecast period of 2021-2031. The global industrial explosives market has been identified as a significantly fragmented market, with the organized sector occupying a major section of the overall industry. As demand for industrial explosives is anticipated to increase substantially growing in mining, defence as well as construction sector due to rapid urbanization and industrialization across the globe. Increasing use of industrial explosives demands for the increase in the productivity of explosives production, which indirectly stressed on plant efficiency and effectiveness which only possible through dedicated and effective Maintenance

Management of an industry. Maintenance Management/Plant maintenance is the complete management of machines and equipment within the factory. It can involve prevention of machine breakdowns through machine lubrication, identifying small faults and replacement of damaged malfunctioned machines, modification of processes for easy accessibility without disturbing process criteria, increasing productivity of production system, optimization of resources and troubleshooting of complicated problem through deep root cause analysis, etc. Also implementation of continuous improvement process tools of maintenance such as KAIZEN, 5S, TPM, TQM, Lean Six Sigma approach, etc. leads to cause effective workplace management in an industrial environment with positive development of individual's personality for lifetime. The integration of maintenance management and continuous improvement tools can lead to high quality and low defect products, safe and secured work environment, increased production speed and the overall improvement of the performance of the plant. The implementation of maintenance management tools has to do with making operators involved with maintaining their own equipment and making sure preventive, predictive, corrective and proactive maintenance will build a foundation for enhanced production (less breakdowns, stoppages and defects). Similarly, Total Quality Management (TQM) which has to do with monitoring and enhancing production and service quality, it emphasizes increase in product efficiency hence low-cost quality production.

II. LITRATURE REVIEW

Maintenance is defined according to the European standard (Alsyouf, 2004) as "the combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to a state in which it can perform the required function". Also in the same vein, maintenance are needed for keeping a system/ product within its life cycle in a functional, operative and condition, or restoring it to a state it can perform the intended function. The performance of the maintenance process is critical for the long term value creation and economic viability of many industries.

Productivity is defined as the ratio of the output to input of a production system. The output of the production system is the products or services delivered while the input consists of various resources like the labor, materials, tools, plant and equipment, also including the cost and effectiveness of maintenance will also plays important role in the productivity and profitability, which used for producing the products or services. (John & Schermerborn, 1993).

Productivity is a function of the production process efficiency and effectiveness. Evaluating maintenance profitability, the impact on other working areas is also measured (e.g. by affirming maintenance role in machine life cycle profit) (Obamwonyi, Martyn, & Aimienrovbiye, 2010). Maintenance improvements in general aim at reducing cost of operation and improving product quality, thus, the cost effectiveness of each improvement action may well be scrutinized through evaluating the relevant cost constraint before and after improvements. Effective maintenance aims to enhance company's profitability and competitiveness through continuous cost-effective improvement of production process efficiency, effectiveness and productivity, which can be achieved via maintaining and improving the quality of all the elements contribute in the production process continuously and cost-effectively (Maletic, Maletic, Al-Nejjar, & Gomiscek, 2012), (Narayan, 2011).

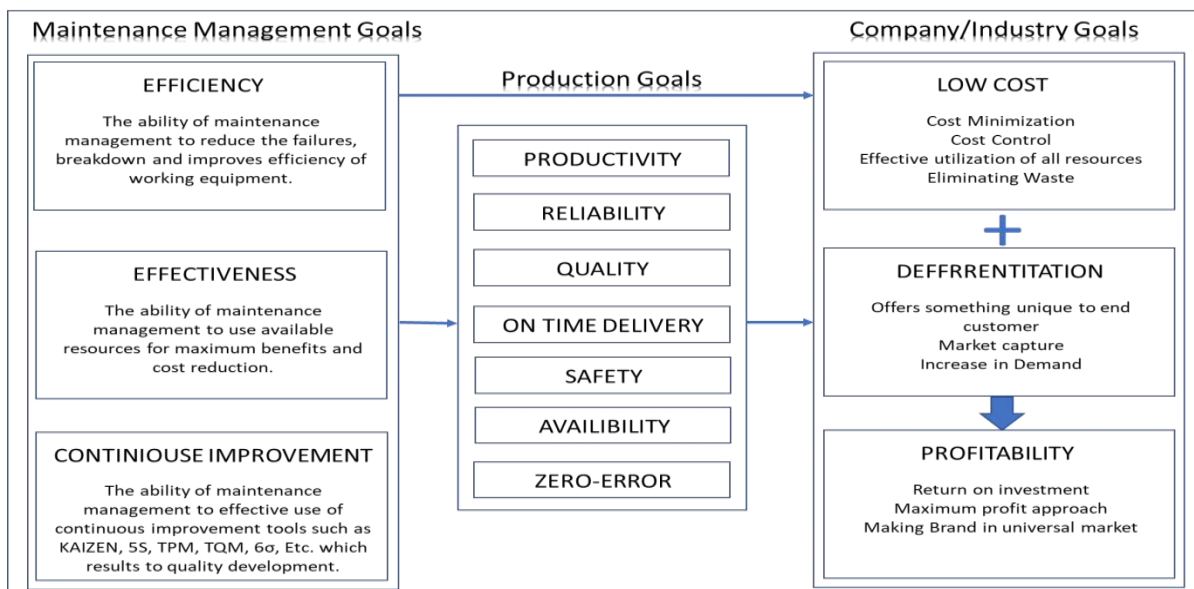
Many researchers and practitioner have emphasized on the total losses caused by maintenance omission or ineffectiveness in maintenance. Nonetheless, maintenance is still considered as a cost center and productivity improvement based on the survey conducted on 118 Swedish manufacturing companies where 70 percent of the respondents consider maintenance as a cost center (Alsyouf, 2007). Maintenance action requires some sets of important inputs e.g. manpower (labor), tools, equipment, management, spare parts and information (Blanchard, 2004).

Evaluating effect of maintenance management on productivity and profitability, the impact on other working areas is also measured (e.g. by affirming maintenance role in machine life cycle profit). Maintenance optimizations/improvements in general aim at reducing cost of operation and improving product quality, productivity, thus, the cost and workplace effectiveness of each improvement action may well be examined through evaluating the relevant cost constraint before and after improvements, a survey performed (Alsyouf, 2004) showed that 70 percent of the respondents considered maintenance as a cost center. Many studies have

emphasized the role of maintenance in improving performance and profitability of manufacturing processes. (Al- Najjar & Alsyouf, 2004).

IMPORTANCE AND SIGNIFICANCE OF RESEARCH STUDY

1. The Indian explosives market is driven by increased spending and activity in the Indian infrastructure segment. The Indian market of civil explosives is pegged at around 0.7 million tonnes worth Rs. 2,750 crore, annually. This accounts for around 5 per cent of the global civil explosive consumption and the local market is growing around 6-7 per cent annually. India is the world's eighth-largest explosive manufacturer and has over two dozen players in the business. So it's been very important to increase the productivity of explosive industrial system through proper material, maintenance and production management.
2. The enhancement of maintenance management in general aims to reduce operational cost and enhancing the quality of the working process equipments which ultimately leads to have increase in productivity, reliability, quality of overall systems. There is a link or rather connection between maintenance, profitability and productivity. Below is the diagram that shows how the two interlink together.



3. Maintenance management tools such as KAIZEN, TPM, 5S, 6σ, etc. might be the only adequate model that identifies the relationship between maintenance, production and quality. So the part or role of maintenance in long-term beneficiary of the organization has been very important, that resulting to researchers and professionals to build maintenance strategies that contribute to company's long-term beneficiary. Profitability and survival of the company might not be maintained without sustaining the quality of the product.
4. Preventative maintenance is the most important part of maintenance management specially in case of explosives sector as minor malfunctioning of any machine or equipment may leads to several critical industrial accident and hence it's very important that in order to maintain safe working condition of machine equipment that should be well maintained which also helps to reduce breakdown of a system. Preventive maintenance is usually performed in prescribed dedicated schedule on a part of equipment/machine to minimize the chances of it failing. It doesn't wait for machine to breakdown instead it is performed while the machines are running so that they don't have to breakdown unexpectedly. Planning is essential for preventative maintenance so that the needed resources are available. And hence preventive maintenance plays vital role in increasing productivity of production system with reducing breakdown time.
5. KAIZEN, TPM, TQM, 5S Management, Lean Six Sigma (6σ), are not only helps in productivity improvement or workplace improvement but it also helps in the development of individuals to gain positive aspects for life development, life improvement.

OBJECTIVES OF RESEARCH STUDY

- To maximizing production, improving productivity and ensuring equipment availability at a lower cost with higher quality with the help of dedicated and scheduled maintenance system.
- To optimizing available maintenance resources, which leads to high rate of production at low cost. Also looking for optimized modifications which cause effortless and safe operating process.
- To compare targets of maintenance with the targets of improvements required in production system.
- To develop a system which not only causes increasing productivity of system but with the maintenance management continuous improvement of working staff and environment.
- To develop a dedicated TPM system, workplace management, social and technical awareness, collaborating with other department for thoughts sharing etc. Which would help to improve working staff development and also being supportive work culture.

III. RESEARCH METHODOLOGY

Development of Instrument for Research Work

Instrument is act as a media of source with required data for ex, questionnaires, survey, personal interview, etc. which will study thoroughly to analyse for research outcome. So some reflections had been made in creating the questionnaire for this research study. Questionnaires were developed in a way that incorporates the whole concept of problem identification in production-process system, preventive maintenance and its scheduling follow-up, total productive maintenance for plant operator and engineer staff, kaizen for maintenance-process improvements, 5s for better workplace management, 6 sigma for improving quality of product through reducing defects, etc. To accomplish this, a detailed study of other literature research had conducted, and pre-testing of the research instrument had performed on the concept matter professionals which includes the company (section) staff, working operators, supervisors, engineers, managers, etc. who are subject expert from maintenance and production department. Also analyzed the process requirement and modifications which helps in detecting some hidden possible areas of enhancement like areas not covered by questionnaires , So that will be covered by the actual problem formulation, rectification and modification by physically engaging workforce at plant. Also, had to go through the questions again to make sure that all the subject of this research can understand the question with ease. However, this made sure that the research instrument meets all the authenticity criteria. According to Schindler, a research instrument is valid if it pleases the content, the related criteria and constructs validity.

- Firstly, the research instrument looked to analyse how effective the basic strategies of maintenance are being applied to reduce downtime in process, optimization of effective sources, etc.
- Secondly, seeks to assess how plant equipment maintenance affects the standard of production in solar industries (explosives industry).
- Seeks to evaluate the effect of plant maintenance on quality production in industry. Also to identify how working operator took the responsibility of plant maintenance and sustained it.
- KAIZEN, 5S, TPM (in the form of workshops practical) concept had be practically implement for easy accessibility of process, and for effective workplace management.
- Research instruments had consisted of TPM, Safety and Technical workshops which will be conducted as a part of safety, productivity awareness.
- According to Cooper and Schindler (2001), the research instrument is used in order to get both Qualitative, Quantitative and Practical data. However, where it's appropriate, unstructured interviews were coordinated to gain detailed insight into responses from the respondents. To obtain leniency and central tendency, some of the questions were rephrased which will result to checks and balances to ensure consistency of the responses through strengthening of questions.

Pre & Post Testing of Research Instrument

The instrument was pretested using a data collection in the form of questionnaire. Which mainly consist of points for process improvement along with easy handling and maintenance of machines and equipment like how it was before work and how it will work after taking required steps for improvement. The answers to the

questions and advice for modification were provided by a group which was mainly consisting of plant operators, shift engineers, maintenance fitter and helpers, managers, etc. Through pre & post testing the research instrument, it can be possible that problem areas are identified before the actual collection of data start. By doing so, it helps to provide the insight and ideas for improving the process and operations of machines equipment's. Also it motivates for future expansion in maintenance-process scope. Another advantage of doing this is that the analysis of the process operation and instruments working can also reveal as to whether the content included by the questions is inclusive of the entire maintenance management concept.

Primary Data:-

Primary data is the kind of data that is collected directly from the data source without going through any existing sources. It is mostly collected specially for a research project and may be shared publicly to be used for other research.

Primary data is often reliable, authentic, and objective in as much as it was collected with the purpose of addressing a particular research problem. For this research work primary data will be directly collected from the Solar Industries India Limited, Nagpur from daily maintenance logbooks, maintenance orders, Plant process log sheets, corporate departmental mails regarding modification requirement, survey with questionnaire, interviewing with plant operators, engineers, managers, etc. So that raised effective information will be get to work on project study.

Secondary Data:-

Secondary data is the data that has been collected in the past by someone else but made available for others to use. Secondary data are usually easily accessible to researchers and individuals because they are mostly shared publicly. For this research work secondary data will be collected from the company profile portals, company website, internal documentations sources, etc. The secondary data had been composed and critically examine for the research work.

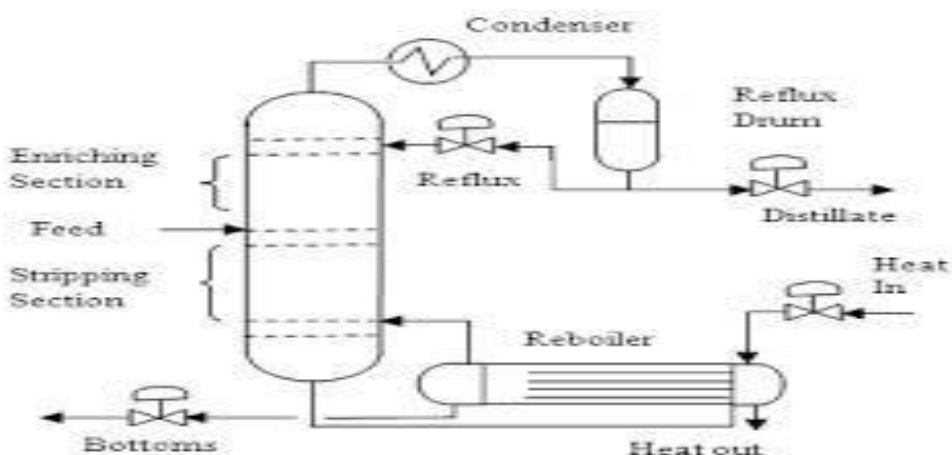
Sampling Technique & Sample Size:-

Sample size in the research had include the surveys, interviews with trained and experienced operators, engineers, managers, etc. At Solar Industries India Limited, Nagpur. The name list from which the sample was taken from was obtained from the head of department. Stratified random sampling/questionnaire was used to get the samples from each process and maintenance department (5/10).

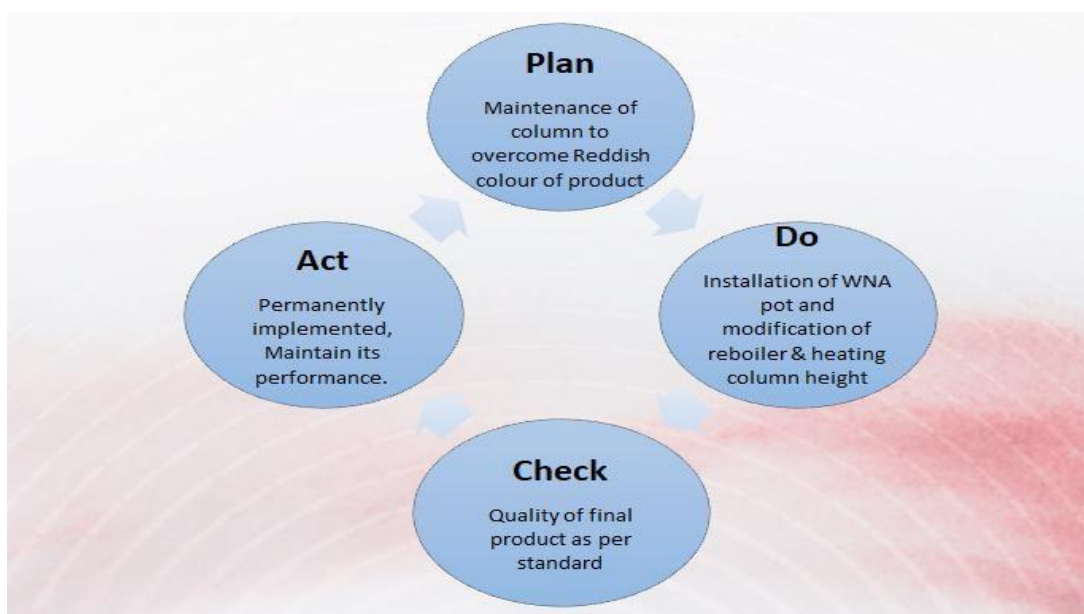
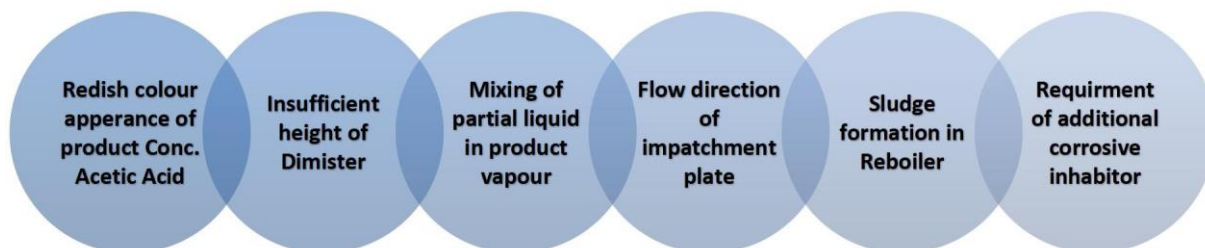
A CRITICAL MAINTENANCE PROBLEM TROUBLESHOOTING BY EFFECTIVE MAINTENANCE MANAGEMENT TOOLS FOR IMPROVED PRODUCTIVITY AND EXCELLENT WORKPLACE MANAGEMENT

#DECOLORIZATION OF CONCENTRATED ACETIC ACID FROM DISTILLATION COLUMN#

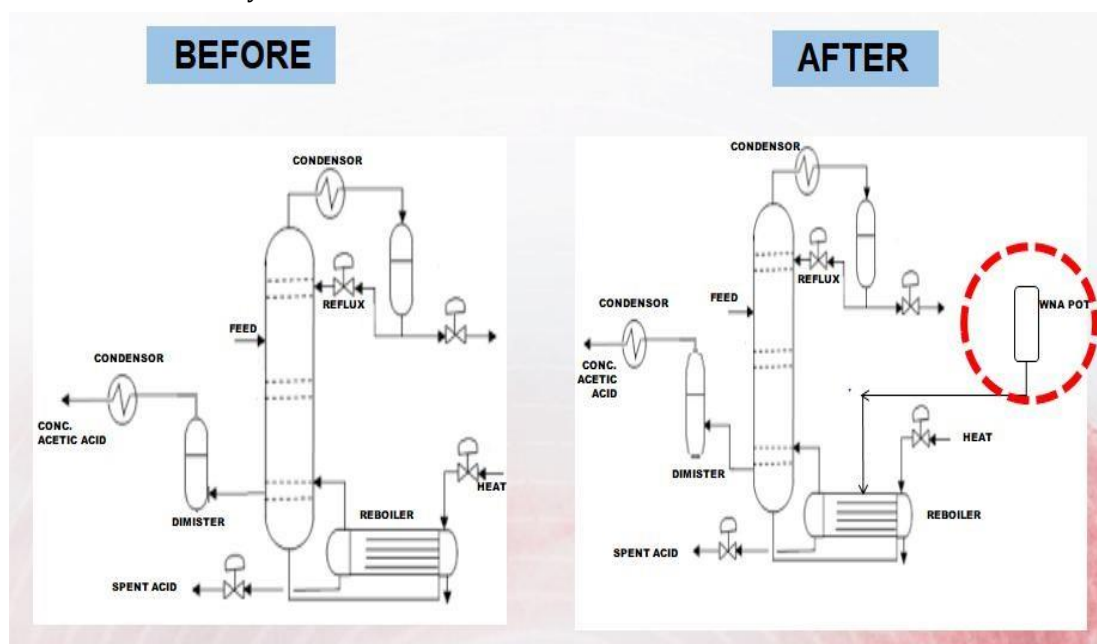
By-product of high energy material (explosives) process plant is Dilute Acetic Acid. The dil. acetic acid need to treat for reuse in main process as raw material Glacial Acetic Acid (conc. >99%). After commissioning of plant i.e. Acetic Acid Distillation Column the finalized products were came out with the impurities and dark color. With the help of proper maintenance of column it's possible to achieve finalized goal of getting required colorless concentrated acetic acid with concentration of 99.90%.



While planning for its maintenance we did its detailed study of problem with the help of RCA (Root Cause Analysis), PCDA Cycle, Why-Why Analysis, etc. so that permanent and effective solution will get. Which is not only helps to improve the quality of product but also to increase rate of production, with a better workplace management and improves overall aspects of system.

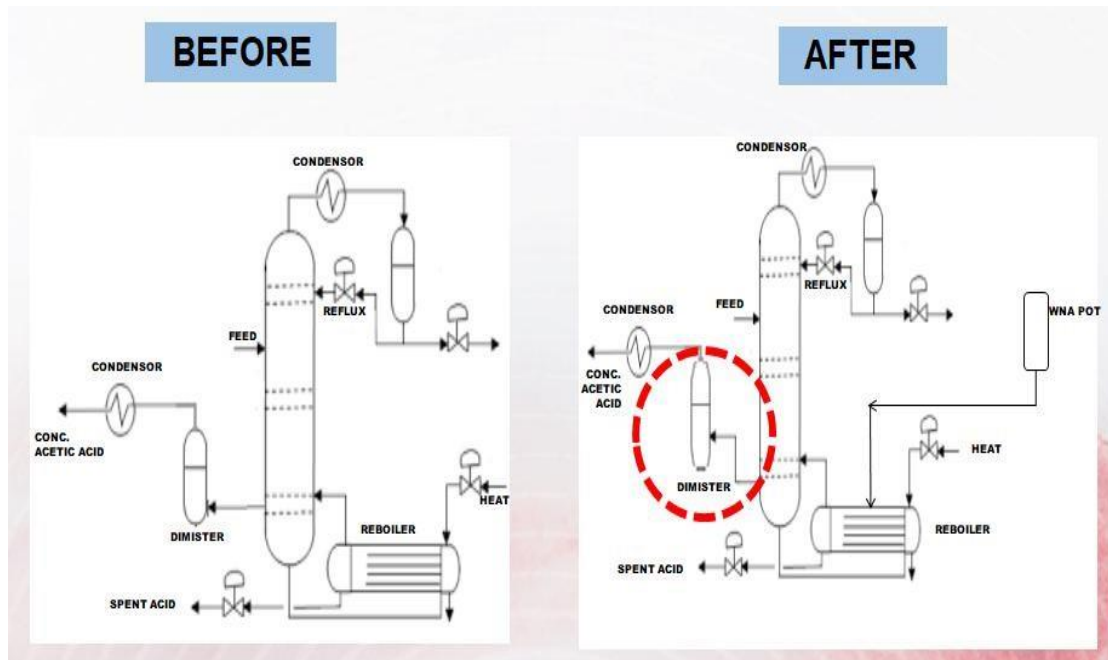


Planned maintenance activity was as follows:-



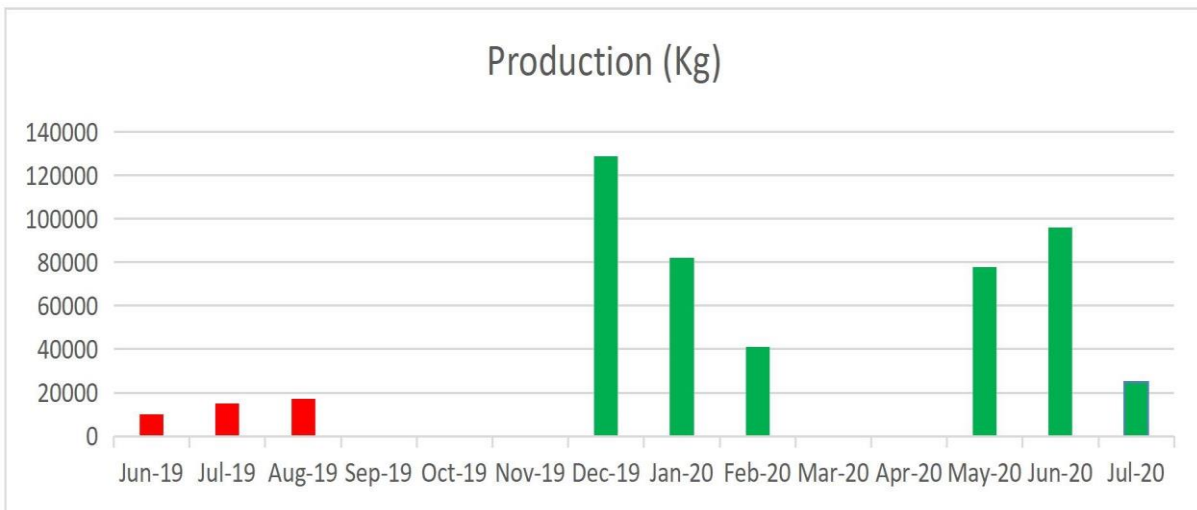
As thoroughly undergo study we found that we need to install intermediate WNA pot which acts as an intermediate anti rusting agent and to increase the height of heating column along with installation of demister

pad which will helps to remove out impurity, also to get the desired result. This all possible by collaborating with process and quality department hence we can say that maintenance management is intermediate performer between production, productivity and quality.

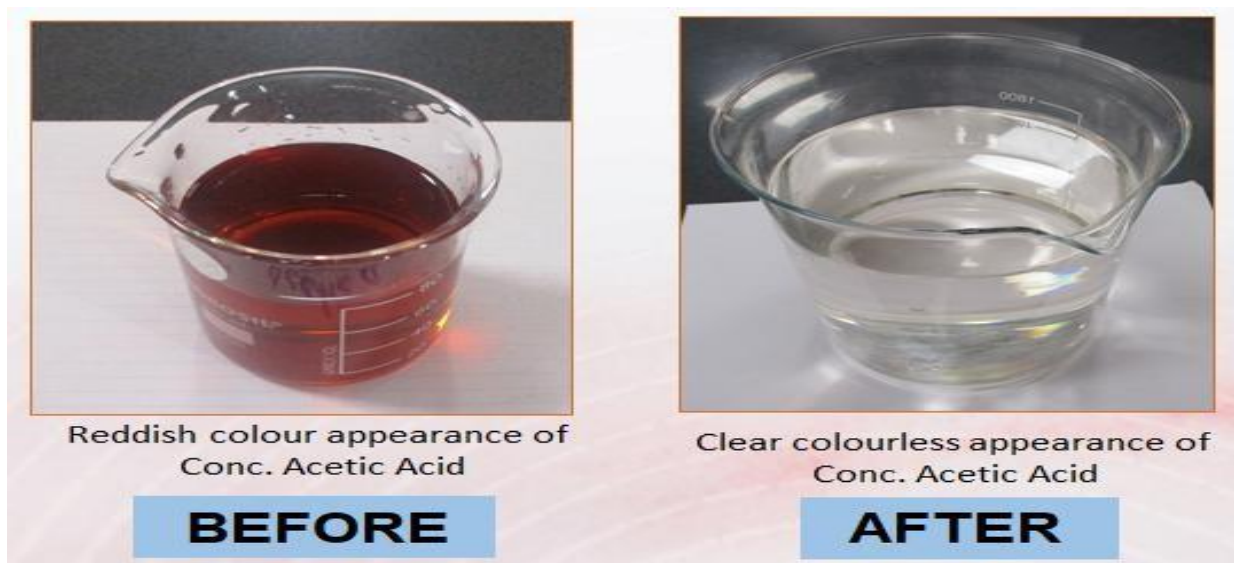


With the effective maintenance of distillation column we were finally achieved the aimed target of decolourizing of acetic acid, increase in the rate of production with minimum inputs and high quality. Following rate of production we got as far:-

Sr. No.	Month	Production (Kg)	Appearance
1	Jun-2019	10000	Reddish Colour
2	Jul-2021	15000	Reddish Colour
3	Aug-2019	17000	Reddish Colour
4	Dec-2020	129000	Clear & Colourless
5	Jan-2020	82000	Clear & Colourless
6	Feb-2020	41000	Clear & Colourless
7	May-2020	78000	Clear & Colourless
8	Jun-2020	96000	Clear & Colourless
9	Jul-2020	25000	Clear & Colourless



With the accomplishment of targeted maintenance plan we had also achieve the increase in the productivity and improved quality of acetic acid. Which proves that effective and planned maintenance of system surely helps to improve the overall productivity, quality and reliability of industries. It also helps in overall development of individual.



#REDUCING THE COST OF MAINTENANCE WHICH DIRECTLY IMPROVES PRODUCTIVITY RATIO#

For this we thoroughly study on silencer system of reciprocating pumps which creates problem in functioning of pumps, also absence of silencer on pump created abnormal sound. In general maintenance practices the only way to attain this issue is replacement of silencer. Due to the issues breakdown time were increases in production system also its replacement cost is much more than cost of maintenance we study it and look for its alternative which helps us to improve the machine/pump effectiveness, reduce the noise of pump and importantly reduce the cost of maintenance.

Solar Industries India Ltd.
 Mechanical Maintenance Hilltop
 Kaizen : New Silencer for AODD Pump

Old Silencer Price	₹3,500.00	New Silencer Price	₹90.00	One Time Modification Cost
		Socket 1/"	₹20.00	
		Hex Nipple 3/4"	₹145.00	
		3/4 " Pipe 175 MM	₹45.00	
Total	₹3,500.00	Total	₹300.00	

Total AODD pumps in PP15	8
Total AODD pumps in PP19	5
Total AODD pumps in CB	3
Total AODD pumps in GB	3
Total M/C in Hilltop	19

Cost Which is Used in 1 Year	Total 24 nos old silencer purchased in one year cost includes ₹84,000.00
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New Silencer cost with modification for all AODD pumps @ 19 Nos	₹5,700.00
One time investment cost for new silencer is	₹3,990.00
Silencer Cost	₹1,710.00

Supposed we will be purchased 24 nos silencer in one year cost is	2160.0
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Total Cost Saved in one Year	₹78,300.00
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#5S MANAGEMENT MAINTENANCE WORK WHICH HELPS TO IMPROVE THE OVERALL PRUCTIVITY OF A SYSTEM ALSO TO HELPS IN WORPLACE MANGEMENT IMPROVEMENT#



KAIZEN						
Unit / Site:	Hilltop	Plant Name / No.:	CB	OPL No:	12	
Machine / Equipment /	Flooring	Circle No.:	26	Date:	16/11/2021	
OPL Classification:	Basic Knowledge	Improvement Case	Trouble Case	Prepared By	Approved By (Manager)	
OPL THEME:	Floor coating of CB process plant done which avoid the falling of grit into the product material, To improve worplace management			Name	sanket Nawghare	Mr. C. G. Tripathi
X (NOT OK)			✓ (OK)			
						
<p style="color: red; font-size: small;">Before:-Flooring of the process plant gets damage so grit falls into the product.</p>			<p style="color: green; font-size: small;">After:-Floor coating done so the falling of the grit into the product avoided.</p>			
Relay Training:	Training date	16/11/2021				
	Trainer	Subhash T				
	Student	Manish D.	Akash C.	Anil D.	Rameshwar M.	Mohan S. Radheshyam N.

IV. CONCLUSION

This study describes the role of effective maintenance management concerning all the safety, process, quality, workforce parameter in an explosives manufacturing industry Solar Industries India Limited, Nagpur as a support function and its impact on increasing production efficiency, increasing productivity of a production system with respect to the reducing the cost of maintenance, modification that stirs smooth driven process, increasing life length and performance of production equipments which is fundamental in achieving production profitability. With the number of kaizens and modification in financial year 2021-22 maintenance department were able to increase 60% more production of explosives with reducing the breakdown time. Maintenance system as a function in a production system/ an organization can increase production efficiency, reduce downtime or unwanted stoppages, improve product quality and consequently, plant profitability which is one of the most significant motivations of company's investment. Implementations of maintenance management tools at plant level at solar industries like, KAIZEN, 5S, TPM, etc. in a production system had really improve production profitability, individual workforce-employee development, effective and safe workplace management, motivates individual to do more for organization which had ultimately help to promote for themselves, also there were numerous improvement had done in production-process-maintenance-safety-quality-management interference as known from post testing of developed research instrument.

In solar industries, explosives manufacturing environment (production system) is a very critical part of system as several malfunctioning of any equipment, lack of knowledge of process, human error will leads to tremendous hazards and major accidents it's a very difficult challenge for maintenance system to work in such critical and hazardous conditions so that it should not hampered any production loss or any kind of accidents during maintenance, modification work, and accomplished it with targeted goals. Production department ensuring that targeted production or products will deliver at the right time with the superior quality and the lowest possible cost which can be attaining by efficient maintenance policy. A proper maintenance practice can keep machines/equipments (that constitute a production system) in a reliable machine condition, thus, minimizing production inefficiency, product defects, downtime, etc. As in the explosives sector continue production will results in improved productivity of a system with effective and efficient maintenance management system. With other working areas in an organization such as quality, production, competence working environment, safety requirement etc. has increased by contributing to the reduction of losses

associated with production and in addition, increasing the quality of the end product, thus, increasing company's return on investment (ROI) and competitive advantage.

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