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OPTIMIZING OVERHAND PUMP ASSEMBLY: A LEAN MANUFACTURING APPROACH

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I. ABSTRACT

This piece of writing examines the significance of lean manufacturing and the kaizen philosophy in enhancing business activities. Despite the established advantages of adopting lean principles, many small and medium-sized enterprises are reluctant to implement them due to concerns about expenses, job security, and inadequate government support. Kaizen culture, which emphasizes continuous improvement and employee involvement, has been effectively applied by both Japanese and Western companies. The article includes a case study on the pump industry, where the hydro-testing of casing and seal chamber required 240 minutes, and potential for a 25-30% reduction was identified through the utilization of a Fish-bone diagram, validation of probable causes, and Why-Why analysis. The article underscores the necessity of a comprehensive and ongoing approach to enhancing business operations.

II. INTRODUCTION

Throughout the years, lean has seen considerable and unprecedented change, and it is now universally recognized as a very useful (Bhamu and Singh Sangwan, 2014). Over time, a number of famous researchers have investigated the diverse range of tools for lean manufacturing (LM), as it has been proven in a wide range of industries, with many successful cases documented in the literature (Pearce et al., 2018). Kat Yamamoto (2019) states that, Lean is a management concept that emerged in the 1990s as a result of Taiichi Ohno's Toyota Production System (TPS).Toyota routinely outsells all other manufacturers, and its vehicles consistently rank first in polls and surveys for quality and dependability. The success of Toyota and Japanese car firms is reason enough to study the true benefits of Lean and how it evolved throughout management history. Lean manufacturing is a comprehensive manufacturing approach that aims to provide value while eliminating waste.

Unfortunately, the majority of small and medium-sized firms (SMEs) have rejected the concept of implementing LM (Bhamu and Singh Sangwan,2014).Despite earlier proof of the benefits of lean adoption, there are a number of impediments to it, including perception, a lack of real rewards, and challenges with shop floor staff. This might be related to:

1) the fear of implementation costs and the subsequent advantages of lean.

2) employees' lack of job security and the possibility of losing their job if it is non-value added.

3) the absence of a supporting corporate culture that allows employees to overcome their fear of failure, change, and retrenchment while accepting more responsibility.

4) a lack of government assistance, which emerged as a critical element in the effectiveness of lean implementation in SMEs.

5) insufficient knowledge or training.

KAIZEN is Key to Japan's Competitive Success (1986), a word that is widely used and has been associated with Japanese management methods as well as being the true key to the success of Japanese firms worldwide. The phrase (kaizen) is made up of two words: (kai) which means reform, change, modify, check, and test in Japanese: and (zen) which denotes noble virtuous and friendliness (Edna Maryani et al.,2020). Some firms have used the notion in the last 20 years through employee engagement in the proposal improvement plan, while others utilize it as a collection of techniques and a tool to decrease waste (Suarez-Barraza et al, 2011).By the close of the twentieth century, Japanese businesses began to practice kaizen. Since then, some western companies, such as Caterpillar (Illinois, USA), Harley Davidson (Wisconsin, USA), Husqvarna (Jönköping, Sweden), and GDM Group & Q-West (Wanganui, New Zealand), have used kaizen to improve production techniques, systematic operation, and seeking more contributions from employees.

The goal of kaizen is to improve three parameters: quality, cost, and submission, sometimes known as QCD (quality, cost, delivery) (Karas et al., 2016). This means that kaizen focuses on improving the quality of goods or services while also attempting to cut expenses at each level of business organizations in order to shorten work time. Kaizen culture goals reflect that continuous improvement must have an ultimate aim in its implementation. In summary, the broad reasoning above may be stated that kaizen culture is a better transformation. As a result, kaizen is applied in a variety of sectors and industrial lines by firms who adopt it. Kaizen regulates and improves the quality of employees in the organisation since the major emphasis of kaizen is the contribution each individual in the firm makes to continual change.

III. PROBLEM IDENTIFICATION

The focus of this project is to use lean manufacturing methods to reduce the assembly time of the Over-hung pump. Lean manufacturing is a systematic approach to identify and eliminate waste in the manufacturing process. The goal is to optimize the manufacturing process and reduce production time while maintaining or improving product quality.

The benefits of implementing lean manufacturing in the pump industry are numerous. The most significant benefit is the reduction in assembly time, which leads to increased productivity, reduced costs, and improved product quality. Other benefits include improved safety, reduced inventory, and increased customer satisfaction.

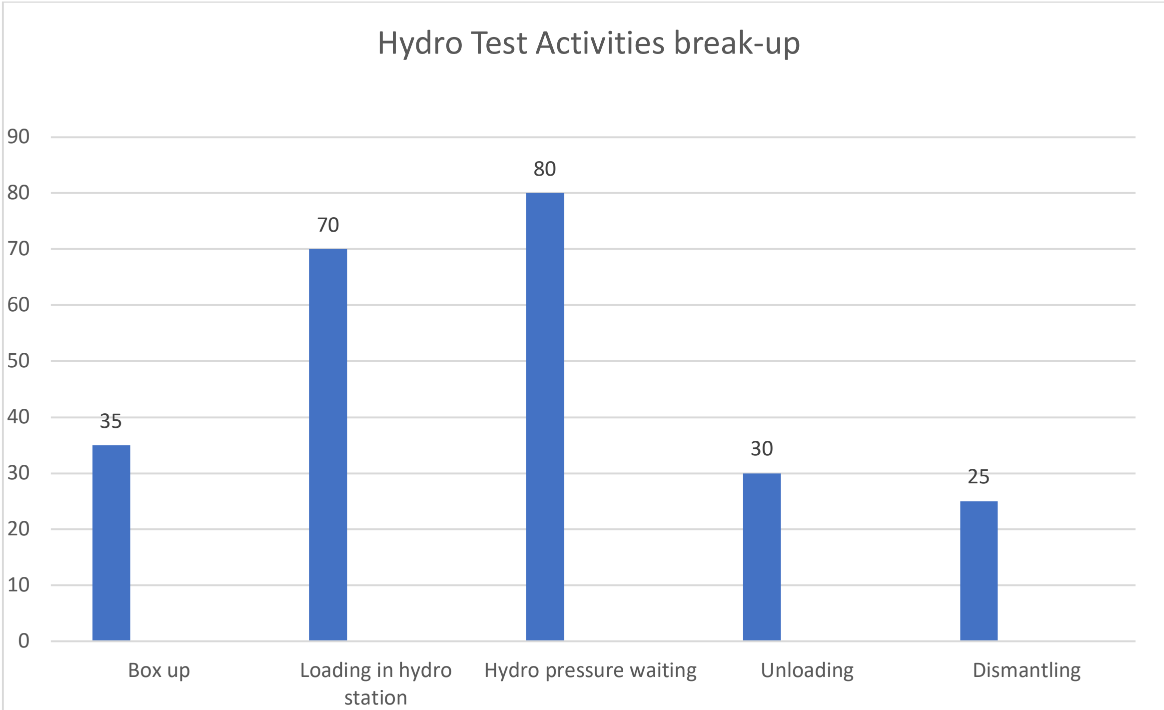
IV. METHODOLOGY

The project at hand involves a comprehensive three-step analysis to identify and address issues related to the overhung-assembly process. The first step is the Fish-bone diagram, which serves as the initial tool for analysis. This diagram is used to visually represent the various factors that could contribute to the problem and helps to identify the root cause of the issue. The second step involves validating the probable causes identified in the Fish-bone diagram to determine their accuracy and relevance to the situation. This is done to ensure that the correct cause of the problem is being addressed, and no unnecessary changes are made that could further complicate the situation. Finally, the third step is the Why-Why analysis of the probable causes, which confirms that the identified causes are valid and provides additional insights into the underlying reasons for the issue.

To facilitate the analysis, a detailed table has been created to document the step-by-step activities involved in the overhung-assembly process, along with the time required for each operation. These times were measured and recorded to determine the average time for each operation. By examining this table and applying the three-step analysis methodology, the project team aims to identify areas for improvement and implement changes that will streamline the overhung-assembly process, reduce the overall time required for completion, and improve the efficiency of the operation.

Assembly Operation	**Time Observation 1**	**Time Observation 2**	**Time Observation 3**	**Average**
Hydro test of casing and seal chamber	236 min	243 min	232 min	240 min
Shaft assembly	27 min	33 min	31 min	30 min
Shot blasting preparation	95 min	102 min	106 min	100 min
Bearing frame assembly	111 min	109 min	112 min	110 min
Pump assembly for testing	132 min	127 min	135 min	130 min
Disassemble of the pump for impeller trim	24 min	26 min	24 min	25 min
Reassembly of the pump	28 min	31 min	33 min	30 min

From the table above we can observe that the hydro-test activity is consuming much time when compared to other activities. The break-up of hydro-test activities is given below.



The Hydro-test process for pumps involves several critical activities that must be completed accurately to ensure that the test is successful. The first step is to box up the casing and seal chamber tightly, ensuring that no water can escape during the test. This is done by placing flanges in the suction and drainage sections of the casing, a process that takes approximately 35 minutes to complete.

Next, the boxed-up casing and seal chamber are loaded onto the fixture, which takes around 70 minutes. The fixture ensures that the casing and seal chamber remain securely in place during the test. Once the fixture is in place, the pressure inside the chamber is gradually increased until it reaches 100 kg per meter square. This pressure is maintained for a waiting period of 80 minutes to ensure that the pressure remains constant.

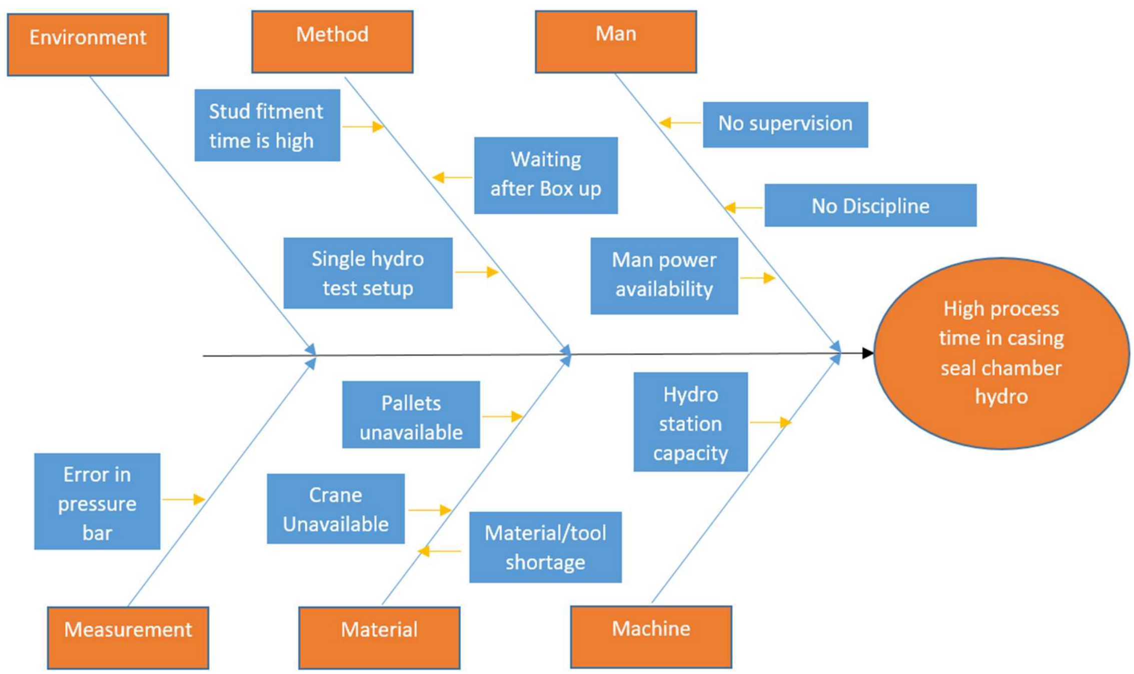
After the waiting period, the casing is checked for any signs of leakage. If there is no leakage detected, the test is considered to be passed. The final steps of the Hydro-test process involve unloading and dismantling the casing and seal chamber. These steps take approximately 30 and 25 minutes, respectively.

By carefully documenting each step of the Hydro-test process and the time required for each activity, the project team can identify areas for improvement and optimize the process to reduce overall testing time, minimize the risk of errors, and increase efficiency. By streamlining the Hydro-test process, the team can ensure that pumps are tested accurately and efficiently, meeting the highest standards of quality and reliability.

V.FISH-BONE OR ISHIKAWA DIAGRAM (ANALYSIS-1)

Once all the necessary data was gathered, the project team proceeded with the first analysis stage, which involved creating a fish-bone diagram or Ishikawa diagram to identify the root cause of the problem - high processing time during casing and seal chamber hydro-test. Six major causes that could be contributing to the time-consuming process were identified and plotted on the diagram. These included environment, method, man, measurement, material, and machine.

The first factor, environment, was eliminated as it was not found to be affecting the process in any way. The second factor, method, had two possible causes: a high stud fitment activity time during hydro-test setup and the unavailability of more than one fixture for casing and seal chamber hydro-test setup. The third factor, man, had several possible causes, including a lack of supervision, discipline among workers, and availability of manpower.Only one cause was identified under the fourth factor, machine, which was the hydro-station capacity. The fifth factor, material, had three possible causes: unavailability of pallets for moving heavy parts between stations, unavailability of a crane to lift heavy parts, and shortage of materials or tools. The final factor, measurement, considered whether there was any issue with the pressure gauge used to measure pressure inside the casing.The completed fish-bone diagram is provided below to better visualize the causes and their relationships.



VI.
VALIDATING THE PROBABLE CAUSES (ANALYSIS-2)

Once the fish-bone diagram was completed, we proceeded to organize the information and summarize it in a more structured manner. We created a table that included all the potential causes identified during the analysis, and we made sure to list them in a clear and concise way. For each probable cause, we recorded the corresponding tests and observations that we conducted to investigate it further.

After gathering all the data, we carefully analyzed each probable cause to determine its validity in the context of the hydro-test situation. This involved assessing whether the cause was directly related to the high processing time in casing and seal chamber hydro-test or if it was irrelevant or only indirectly related to the issue at hand. By applying a rigorous methodology to assess the validity of each probable cause, we aimed to arrive at a reliable and accurate conclusion regarding the root cause of the problem.

The final table that we created captured all the information that we had gathered, and it presented a clear overview of the results of our investigation. The table allowed us to easily identify the probable causes that were valid and those that were invalid, thus helping us to narrow down the possible solutions to the problem.

SN	Probable cause	Probable cause test and observations	Conclusion
1	Waiting after the box up	No waiting after box up activities	Invalid
2	Single pump hydro test setup	Fixture available for single setup	Valid
3	Stud fitting activity time is high	Stud is fitted manually	Valid
4	No supervision	Supervisor have planned activity while operation	Invalid
5	No discipline	Both the operators and supervisors work with discipline and come on time	Invalid
6	Manpower unavailability	Pre planning man power deployment for every process	Invalid
7	Crane unavailability	Each workstation have separate crane	Invalid
8	Pallets Unavailable	Sufficient pallets available	Invalid
9	Material/tool shortage	Designated location for tools and materials and its verified on daily basis by operators	Invalid
10	Hydro station capacity	Area is equipped with sufficient resource	Invalid
11	Pressure gauge not calibrated	All instruments are getting calibrated as per requirement	Invalid

Based on the table provided above, it has been identified that out of the 11 probable causes listed, only two causes are valid for the hydro-test scenario. These two probable causes are number 2 and number 3. The first valid cause is that the hydro-test setup for a single pump restricts the process to only one pair of casing and chamber at a time, as there is only one fixture available for the hydro-test. This limitation results in a longer processing time. The second valid cause is related to the high stud fitment activity during the hydro-test setup, which involves manual stud fitting. The process of manual stud fitting is time-consuming and can be improved by using advanced machinery.The remaining probable causes identified in the fish-bone diagram are invalid, and the reasons for their invalidity are listed in the table above.

VII. WHY-WHY ANALYSIS (ANALYSIS-3)

A Why-Why analysis is a technique used to identify the root cause of a problem by asking a series of "why" questions. It involves repeatedly asking "why" until the underlying cause of the problem is identified. The aim of the analysis is to find a permanent solution to a problem, rather than just addressing its symptoms.

In the case of the hydro-test of casing and seal chamber, we conducted a Why-Why analysis for the two valid probable causes that were identified in the fish-bone diagram. The first probable cause was the limitation of having only one fixture available for hydro-testing, which restricted us to perform hydro-tests of only one pair of casing and chamber at a time. To find out why this was happening, we asked "why" repeatedly until we reached the root cause of the problem. The analysis showed that the root cause of the problem was the unavailability of funds to purchase more fixtures and the lack of space to accommodate them.

The second probable cause was the high stud fitment activity, which involved manual stud fitting and was time-consuming. We asked "why" repeatedly to determine why manual stud fitting was being used instead of using advanced machinery for stud fitting. We found that the root cause of the problem was the lack of investment in advanced machinery for stud fitting.

By conducting the Why-Why analysis, we were able to identify the root causes of the two valid probable causes and come up with permanent solutions to prevent the problems from recurring. In this case, the solutions would be to allocate more funds to purchase additional fixtures and invest in advanced machinery for stud fitting.

Validated Root Causes	**Why**	**Why**	**Action to be taken**
Stud fitment activity time is high	Manual operation of casing seal chamber box up with spanner	No advance tool available for stud fitment	Pneumatic torque gun procurement for stud fitment activity
Single pump hydro test setup	Only one fixture available	Fixture designed for single setup arrangement	Similar Fixture can be setup so that we can hydro test 2 pumps at a time.

After conducting the Why-Why analysis, we gained insight into the necessary actions that need to be taken in order to reduce the time in hydro-test. For the validated root cause (1) which is the stud fitment activity, it is suggested to incorporate the use of a pneumatic torque gun in the process of boxing up and loading the casing and seal chamber onto the hydro-station. This will help to reduce the time consumed during the stud fitment activity as using a pneumatic torque gun is quicker than doing it manually.

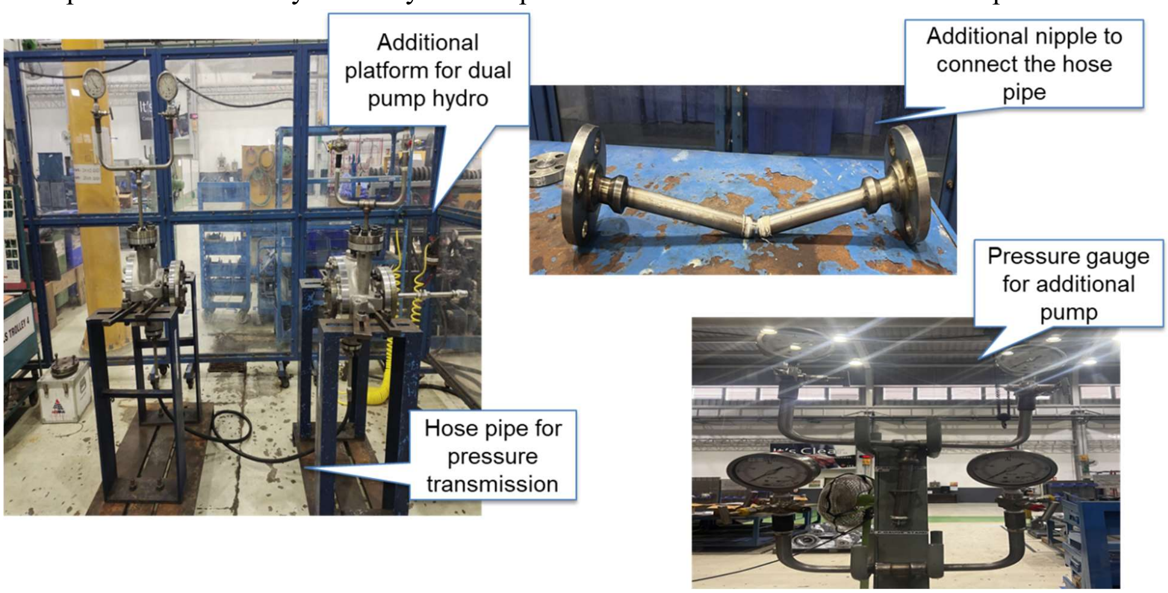
For the validated root cause (2), the Why-Why analysis suggested that adding one more similar fixture to the setup could help us test two pairs of casing and seal chamber at the same time. This would help to reduce the time taken for the entire hydro-test process. By addressing these underlying reasons through the suggested actions, we can effectively prevent the problem from recurring and achieve a more efficient and effective hydro-test process.

VIII. RESULTS AND DISCUSSIONS

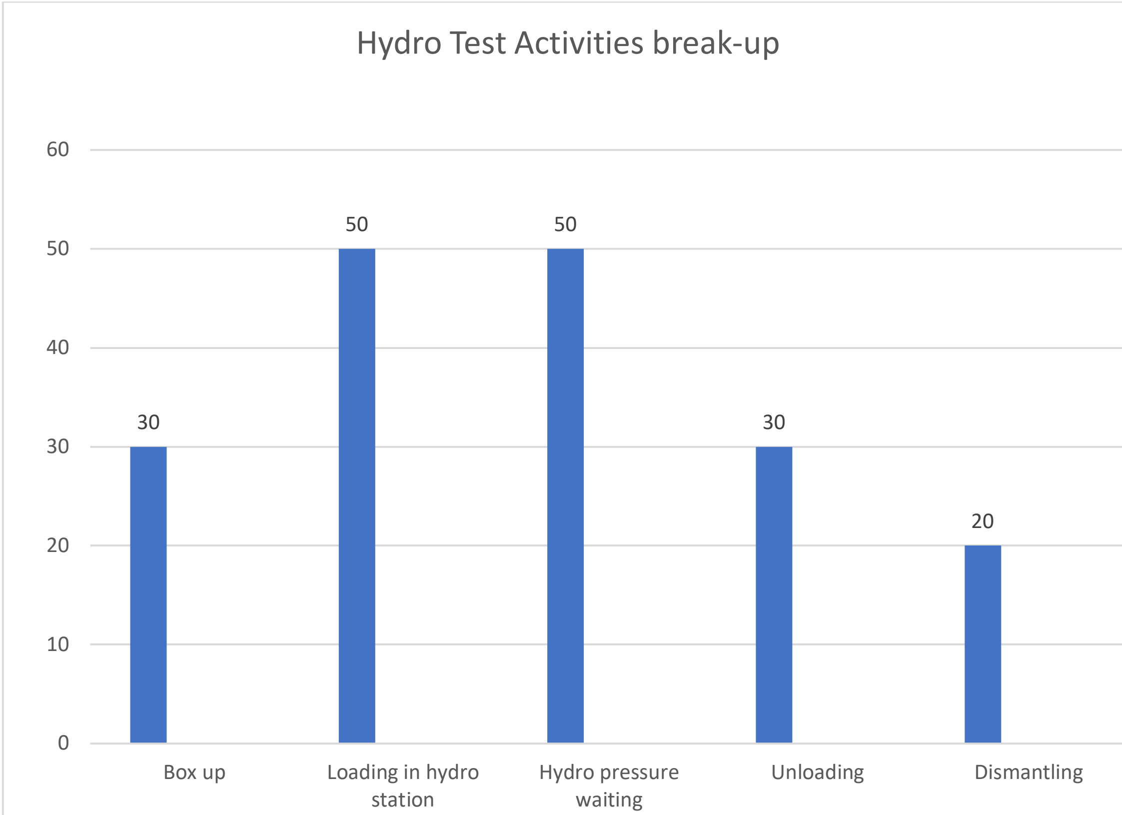
After completing the analysis and identifying the necessary changes, we implemented two solutions to reduce the time of the hydro-test. The first solution involved the installation of a pneumatic torque gun in the hydro-station to reduce the time spent on the stud fitment activity. This new tool allowed us to box up and load the casing and seal chamber onto the fixture in the hydro-station more quickly and efficiently.

For the second solution, we decided to implement an additional fixture beside the existing one. We installed another pair of casing and seal chamber on the new fixture, and connected both casings to a nipple at the drainage section located underneath them. These nipples were then connected via a hose pipe for pressure transmission. With this setup, we could now test two pairs of casing and seal chamber at once using a single hydro-test machine, which significantly reduced the time needed to complete the hydro-test.

The current setup is shown in a diagram below, highlighting the new fixture and the connected casings with the drainage section and the hydro-test machine. These changes have allowed us to improve the efficiency of the hydro-test process and save valuable time in our operations.



The results we got from the above setup is given below, the hydro-test activities break up after improvement is given below.



The graph provided depicts the results of the changes we made to the hydro-testing process. The data clearly shows that the use of a pneumatic torque gun significantly reduced the time required for various activities such as boxing up, loading, unloading and dismantling the casing and seal chamber from the hydro-station. Specifically, the time for each of these activities was reduced by 5 minutes each. This means that the overall time saved by using a pneumatic torque gun was 20 minutes.

Moreover, implementing a new similar fixture was also highly effective in reducing the time of hydro pressure waiting. Prior to the change, the hydro pressure waiting time was approximately 80 minutes. However, after implementing the new fixture, the waiting time was reduced to 50 minutes, resulting in a reduction of 30 minutes. This indicates that the new setup with the two fixtures working simultaneously saved significant time, resulting in a more efficient hydro-testing process overall.

Activities	**Before (minutes)**	**After (minutes)**
Box-Up	35	30
Loading In hydro station	70	50
Hydro pressure waiting	80	50
Unloading	35	30
Dismantling	20	20
Total time	240	180

Before implementing the changes suggested by the Why-Why analysis, the total time required for the hydro-test of casing and seal chamber was 240 minutes. However, after successfully implementing the improvements, we were able to reduce the time to 180 minutes, which represents a 25% reduction in the overall time. This is a significant improvement and has resulted in increased efficiency and productivity in the hydro-test process. The reduction in time has also enabled us to perform more tests in a given period, thereby increasing our capacity to handle more projects and meet tight deadlines. Overall, the successful implementation of the suggested improvements has led to a more streamlined and efficient hydro-test process, which has positively impacted our operations and profitability.

IX. CONCLUSION

The aim of the research project is to shorten the assembly time for an Over-hung pump in the pump industry by applying lean manufacturing methods. The project consists of several stages, such as hydro testing, shaft assembly, bearing frame assembly, pump assembly, disassembling the pump, impeller trim, re-assembly of the pump, and final alignment. The primary objective is to identify and eliminate wasteful activities in the manufacturing process, thereby improving the process and reducing production time while maintaining or enhancing product quality. The implementation of lean manufacturing in the pump industry would result in increased productivity, reduced costs, improved product quality, enhanced safety, lower inventory, and increased customer satisfaction. The study explores the principles of Lean Manufacturing philosophy, which prioritize continuous improvement of quality, cost, and delivery and their applicability to different industrial sectors. Additionally, the project discovered a problem in the hydro-test process for the assembly of Over-hung pumps in the pump industry. By analyzing various assembly operations in a manufacturing process, the study found that the hydro test of the casing and seal chamber took the most extended time, while the shaft assembly took the shortest time. The research can be useful in enhancing overall efficiency and streamlining the time-consuming shot blasting preparation process.

To reduce the hydro-test process time, two changes were made: installing a pneumatic torque gun and adding another fixture to connect two pairs of casing and seal chambers for simultaneous testing. These modifications reduced the total testing time from 240 minutes to 180 minutes, and also significantly reduced employee fatigue with a dual hydro-test setup.

X.REFRENCE

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