DESIGN AND ANALYSIS OF CENTRIFUGAL PUMP BASEPLATE FOR WEIGHT REDUCTION

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Abstract: *The study focuses on the design and analysis of a centrifugal pump baseplate with the primary objective of achieving significant weight reduction without compromising structural integrity or performance. Centrifugal pump baseplates play a crucial role in maintaining precise alignment between the pump and motor while ensuring stable operation under various loading conditions. However, conventional baseplates are often overdesigned, leading to excessive material usage, higher fabrication costs, and increased handling difficulties during installation and maintenance. This project aims to overcome these challenges through optimized structural design and finite element analysis (FEA). The research involves redesigning the baseplate geometry by identifying low-stress regions and reducing unnecessary material, while reinforcing high-stress areas through design modifications such as ribbing, cross-bracing, and optimized support layouts. Advanced 3D modeling and numerical simulations are performed using Siemens NX and ANSYS software to evaluate stress distribution, deformation, and overall stiffness of the optimized baseplate. The goal is to develop a lightweight, cost-efficient, and ergonomically improved baseplate that maintains required safety and performance standards. The outcome of this study is expected to contribute to more sustainable and economical centrifugal pump systems, offering enhanced reliability and ease of maintenance in industrial applications.*

Keywords: *Centrifugal Pump, Baseplate Design, Weight Reduction, Finite Element Analysis (FEA), Structural Optimization, ANSYS, Siemens NX, Material Optimization, Cross-Bracing, Ribbing, Industrial Applications.*

INTRODUCTION

Centrifugal pumps are among the most widely used mechanical devices in modern industries, playing a crucial role in the efficient transportation of fluids such as water, oil, chemicals, and slurries. They are the backbone of many industrial operations, including petrochemical plants, water treatment facilities, power generation units, and manufacturing systems, where reliable fluid handling is essential for smooth operation. The performance, durability, and stability of these pumps, however, depend largely on one key component — the baseplate.

The baseplate serves as the structural foundation of the pump assembly, providing mechanical support and alignment for the pump and motor. It ensures that both components remain rigidly fixed in position, preventing unwanted vibration, misalignment, and structural deformation during operation. A well-designed baseplate not only supports the static load of the pump and motor but also effectively absorbs and distributes dynamic forces generated during high-speed rotation. This helps reduce mechanical stress, extending the lifespan of critical components such as bearings, couplings, and mechanical seals. Improperly designed or weak baseplates, on the other hand, can lead to misalignment, excessive vibration, noise, and premature failure of pump components, resulting in unplanned downtime and maintenance costs. This project aims to address these issues by conducting a comprehensive design and analysis of centrifugal pump baseplates. The focus will be on optimizing the design to reduce weight and material usage, enhance manufacturing efficiency, and improve the ergonomics for workers involved in the production and maintenance processes. By refining the baseplate design, the project seeks to contribute to more cost-effective and sustainable pump systems, ultimately enhancing their performance and reliability in industrial applications.

LITERATURE REVIEW

Christian Jay Uayan (IEOM Society International, June 2024) [1], in this paper authors have took a practical approach to cutting costs in building the foundation and grouting for a centrifugal pump baseplate. By following the international standard API RP 686, the team used a Value Analysis and Engineering method to explore different options. The most significant savings came from deciding to fabricate the baseplate in-house instead of buying it from a supplier. Every modification to the components was carefully considered to ensure they still did their job, kept the structure strong, supported the load, resisted vibrations, and protected the parts in contact. This thorough approach highlighted how Value Engineering and Analysis can significantly improve the foundation and grouting materials. If the four suggested alternatives from the development phase are implemented, over one million pesos could be saved across 100 instances of foundation construction and baseplate installation, with the baseplate modification alone saving Php 1,146,936.00. Furthermore, during the evaluation phase, it was found that switching the anchor bolt to a threaded rod would likely meet the standards for compliance, vibration resistance, strength, cost, and ease of installation.

Xiaohui Luo et. al. (“2021 International Conference on New Energy and Power Engineering”) [2], in this study, the authors studied the vibration behaviour of nuclear centrifugal pump operating at low flow rates. A Simulation model of the pump was developed using ANSYS CFD software to study the occurrence of reverse flow and rotating stall under such operating conditions. The HAZ 50-250 Centrifugal pump was selected as the reference model, and its vibration characteristics were measured using the Enpac2500 analytical instrument. The analysis showed that most vibrations occurred in the low-frequency range, particularly between 0.23 and 0.25 times the rotational frequency. Since the blade-passing frequency of the pump is highly sensitive to hydraulic disturbances at low flow conditions, additional vibrations corresponding to the rotational frequency and twice the rotational frequency were also identified. By studying these vibration responses, the research effectively identified the main causes of hydraulic-induced vibrations in nuclear centrifugal pumps and proposed recommendations for their reduction and performance optimization. These insights serve as valuable guidance for future vibration analysis and centrifugal pump design improvements.

Jonathan Highgate et. al. (European Journal of Mechanics / B Fluids”, 2024, 263–279) [3], in this paper, the authors discussed how energy losses in water pumps play a crucial role in improving urban sustainability and reducing carbon footprints. The study investigates the loss mechanisms in centrifugal pumps by integrating exergy analysis with unsteady Reynolds-Averaged Navier–Stokes (uRANS) simulations. Both a commercially available pump and an idealized pump model with perfectly smooth surfaces were analyzed under different flow conditions. Through this approach, mathematical relationships were developed to describe how exergy destruction rates vary with changing flow rates. These equations provide detailed insight into where and how energy losses occur within the pump and how they shift under different operating conditions. The results revealed that nearly 80% of the total energy losses take place in the impeller, intersection, and volute regions, while secondary flows such as those in the dead zones and leakage paths contribute minimally to overall losses, despite handling significant mass flow. The newly derived exergy destruction equations offer a more accurate and physics-based method for estimating losses compared to traditional semi-empirical approaches. This advancement supports the development of knowledge-driven, energy-efficient, and sustainable centrifugal pump designs in the future.

J.C.W. He et al. ("Journal of Constructional Steel Research", 2023) [4], conducted a detailed study to understand how various factors—such as base plate thickness, anchor rod diameter, axial load, foundation depth, and anchor rod spacing—affect the performance of column base plate connections. As per the New Zealand Steel Structures Standard (NZS 3404), base plate connections in gravity systems are generally treated as pinned joints with limited moment capacity. However, earlier research revealed that these connections often exhibit greater rotational stiffness than assumed, which can lead to higher moment demands and possible yielding at the column base. This excessive stiffness, when combined with continuous axial loading, may cause column shortening, making post-earthquake repairs and maintenance more difficult. To overcome these issues and minimize the risk of base yielding and axial shortening, the researchers performed an extensive numerical analysis. The results indicated that axial load significantly affects both the moment resistance and rotational stiffness of the connection. Furthermore, the measured stiffness was considerably higher than the values suggested by NZS 3404. To better predict the actual behavior under moments and rotations, an analytical model was proposed and validated using numerical simulations and experimental tests. The model closely matched the observed results, providing a more accurate and reliable approach for analyzing and designing gravity column base plate connections in steel structures.

Bonaventura Tagliafierro et al ("Elsevier Thin–Walled Structures", 2024) [5], introduced a novel approach for designing adjustable pallet racks by incorporating experimental testing directly into the design process. The study aimed to gain a deeper understanding of the behavior of floor-to-upright connections in the cross-aisle direction when subjected to dynamic loading. To accomplish this, both monotonic and cyclic loading tests were carried out on baseplate connections at the Steel Structures Laboratory of the National Technical University of Athens (NTUA), Greece. Using the experimental results and existing literature data, the researchers developed and validated a numerical model to simulate the structural performance of the baseplate. The study also compared the dynamic response of two upright frame configurations—one with conventional hinge-type connections and the other with innovative dissipative connections. The results revealed that the proposed design approach significantly improved the ductility of the system and reduced axial forces on the uprights by nearly 50% compared to traditional designs. Additionally, the research provided an open-source computational tool for ground motion selection, along with a supporting database, to facilitate future studies in this field. Overall, the proposed methodology offers a safer, more resilient, and performance-based design strategy for adjustable pallet rack systems operating under dynamic conditions.

Mayuri M. Choundikar (“International Journal of Science and Research”, 2015) [6], focused on the weight optimization of the base frame used in a multistage centrifugal pump. In this study, the factor of safety was adjusted to an appropriate and acceptable level as per design criteria to achieve an efficient structure. The forces and moments acting on the suction and discharge nozzles were thoroughly examined to identify opportunities for weight reduction. A detailed shaft deflection analysis was conducted using ANSYS software to assess the structural behavior under different loading conditions. After optimization, the deflection of the shaft was re-evaluated and found to be within the permissible limits defined by the API 610 standard, confirming that the optimized design satisfied both performance and safety requirements.

D. V. Yadav et al (“International Journal of Latest Technology in Engineering “, 2015) [7], conducted a study to identify and analyze the most commonly used baseplates for API centrifugal pumps, taking into account customer requirements. The structural performance of these baseplates under operational loads was evaluated using the Finite Element Method (FEM). The research also focused on modifying and optimizing the design of a selected centrifugal pump baseplate to achieve weight reduction, which in turn helped lower fabrication costs. Centrifugal pumps are widely used in various industries due to their simple construction, high efficiency, and capability to handle a broad range of flow rates and heads. They operate smoothly and require minimal maintenance, making them suitable for continuous service applications. Similarly, pump baseplates come in different designs, configurations, and styles depending on the pump’s type and size. Regardless of these variations, the main purpose of a baseplate is to provide a stable platform for mounting both the pump and its driver while maintaining precise shaft alignment to ensure reliable and efficient performance.

Ravindra M. Patil et al (“International Journal for Scientific Research & Development”, 2017) [8], In this study, the author investigated the performance of a Floating Production, Storage, and Offloading (FPSO) unit, which is a floating vessel widely used in the offshore oil and gas industry for hydrocarbon processing and oil storage. FPSO vessels are continuously exposed to harsh marine environments, including high sea waves and storm conditions, which can significantly affect the mechanical stability of onboard equipment. Therefore, the pump and drive train components installed on these vessels must be capable of reliable operation under such extreme conditions. The research focused on a multistage Between Bearing (BBS) type centrifugal pump mounted on the FPSO vessel’s structural frame. Since the pump is installed directly on the vessel structure, a non-grouted baseplate design was adopted. To evaluate its mechanical performance, a structural stiffness analysis of the baseplate was performed to determine its ability to resist forces and moments transmitted through the nozzle connections caused by various factors such as piping weight, fluid loads, and thermal expansion or contraction. The study utilized two distinct methods for stiffness evaluation:

1. Finite Element Analysis (FEA) – to numerically assess the deformation and stiffness characteristics of the baseplate.

2. Experimental Testing – to validate the numerical findings through real-world measurements.

The results from both methods were compared in terms of shaft end displacement, following the API 610 guidelines to ensure compliance with allowable limits. In both analytical and experimental evaluations, the baseplate stiffness, represented by the shaft end displacement, was found to be within acceptable limits, confirming that the baseplate design met the necessary structural requirements. The paper provides a detailed description of the FEA modeling approach, experimental setup, and comparative results, demonstrating a strong correlation between theoretical predictions and experimental observations.

Gijoy S et al ("International Journal of Latest Technology in Engineering, Management & Applied Science", 2017) [9], conducted a study in which a three-dimensional (3D) model of a micro electromagnetic pump was developed, followed by comprehensive electromagnetic and mechanical analyses. To improve performance and integration capability, traditional components of the micropump were replaced with MEMS-compatible materials. Additionally, a separate 3D model of the pump diaphragm was created using ANSYS software to study its mechanical response under different electromagnetic forces derived from the electromagnetic simulations. The analysis was performed for two diaphragm materials — Polyimide and Polydimethylsiloxane (PDMS) — to examine how material properties influence pump performance. The resulting diaphragm deflections were compared across different micropump configurations, enabling a clear understanding of how material selection and design variations affect the overall actuation behavior and efficiency of the micro electromagnetic pump.

Mohammad Emal Qazizada et al ("MM Science Journal", 2016) [10], In this paper, the performance characteristics of a centrifugal pump are analyzed to develop its characteristic functional curves, which represent the relationship between specific work, fluid flow rate, and rotational frequency. The study aims to demonstrate how centrifugal pumps can be connected in series or parallel, and how these configurations influence the overall performance map, including the ISO efficiency curve. Through calculation-based analysis, the behavior of the pump's individual characteristic curves was examined to understand how the ISO efficiency curve can be utilized to determine the most efficient operating speed of the pump. Based on these analytical results, guidelines were established for selecting whether pumps should be connected in series (to increase head) or in parallel (to increase flow rate) under various operating conditions.

Amit V. Chavan et al ("International Journal of Engineering Science and Technology", 2011) [11], In this paper, the Experimental and Finite Element Analysis (FEA) of a pump base frame is carried out to evaluate its rigidity as per the requirements of API 610. Ensuring adequate rigidity is essential for all pump base frames used in the petrochemical industry. A well-established rigidity test procedure, based on API 610 clause 6.3.5, was used to determine the structural stiffness of the base frame under various loading conditions. For a standard base frame, the stiffness was measured through actual rigidity tests for multiple load cases to verify compliance with API 610 stiffness standards. The results showed that the existing base frame design did not meet the required stiffness criteria. Therefore, several design modifications were proposed and evaluated through Finite Element Analysis using ANSYS software. The simulation results were analyzed in terms of shaft end deflection at the coupling side, as specified in API 610 guidelines. After comparing all design alternatives, the most feasible optimized design was identified and further validated through experimental testing. The improved design successfully met the API 610 stiffness requirements, confirming its suitability for industrial applications.

Pramod H. Kadam (“International Journal of Engineering Research & Technology”, 2016) [12], carried out a static structural stiffness analysis of an API BB5 type centrifugal pump designed for Floating Production, Storage, and Offloading (FPSO) systems. With offshore oil extraction now accounting for nearly one-third of global oil production and expanding more rapidly than onshore operations, ensuring the structural integrity of pump baseplates in FPSO environments has become increasingly important. In such applications, the absence of cement grouting, foundation bolts, and limited space for piping supports often results in higher nozzle loads and a greater possibility of premature structural failures. Since the non-grouted baseplate design for this particular pump model was being introduced for the first time in FPSO service, a detailed stiffness analysis was essential to confirm adequate rigidity and performance under operating conditions. According to API 610 standards, stiffness verification of pump baseplates is mandatory for pumps used in the Petroleum, Petrochemical, and Natural Gas sectors. Clause 6.3.5 of API 610 specifically outlines the procedure for testing structural stiffness under various nozzle load conditions. This study included an in-depth review of existing baseplate design practices and incorporated necessary design changes to meet the requirements of non-grouted installations and double nozzle load criteria. A theoretical analysis was first performed for selecting suitable structural members, followed by Finite Element Analysis (FEA) using ANSYS software to evaluate stiffness. Minor design refinements were made during FEA to achieve an optimal configuration. Experimental validation was also conducted to confirm the baseplate’s stiffness under different load scenarios. The results, expressed in terms of shaft coupling end displacement, were compared with the allowable limits defined by API 610. Both numerical and experimental outcomes showed good agreement, verifying that the optimized design achieved superior performance and compliance for FPSO applications.

Rushabh Shah et al (“International Journal of Advance Research, Ideas and Innovations in Technology”, 2016) [13], The main objective of this paper is to study and analyze various types of pump baseplates as per the standards defined by the American Petroleum Institute (API 610). A theoretical investigation was conducted to determine the appropriate selection of baseplate structural members, followed by Finite Element Analysis (FEA) using ANSYS software to evaluate the structural stiffness of the baseplate. Baseplates are available in a wide range of designs, configurations, and styles, depending on the specific pump models and their applications. Regardless of the design variation, the primary function of a baseplate is to support and mount the pump and its driver together, while ensuring precise shaft alignment between the two components for smooth and efficient operation.

A.T. Myers et al. (“Journal of Constructional Steel Research”, 2009) [14] conducted six two-thirds scale experimental tests on moment-resisting steel column base plates to evaluate their performance under seismic conditions. The specimens included two types of weld connections between the column and the base plate — Complete Joint Penetration (CJP) and Partial Joint Penetration (PJP) welds. The test results revealed that both connection types exhibited excellent fracture resistance and were capable of sustaining inelastic column hinging up to

story drift ratios between 6% and 9%, which exceeds the 4% drift ratio generally required for seismically detailed special moment frames. In five of the six tests, fractures developed in the Heat Affected Zone (HAZ) along the fusion line between the weld and the column flange, while in one test, the fracture occurred at the inner face of the column flange near the upper edge of the weld access hole in the CJP weld detail. Surprisingly, the specimens with PJP welds showed greater displacement ductility compared to those with CJP welds. This enhanced ductility was primarily due to the fillet reinforcement, which strengthened the PJP welds and enabled them to sustain the stresses and strains necessary for achieving full yield in the column flanges. The experimental findings also supported the design recommendations of FEMA 350, confirming that the required weld strength can be accurately determined using the probable moment demand in combination with a material overstrength factor (Ry = 1.1) and a strain hardening factor (Cpr = 1.2).
Mohamed Abu Waseem R ("International Journal of Engineering Research & Technology", 2019) [15], This paper serves as a foundation for further research on the design and development of rope pumps. The modern rope pump is inspired by the ancient chain pump principle, but it has been improved using modern materials to create a low-cost and efficient water pumping solution for rural communities in developing countries. Owing to its simple working mechanism, easy construction, and low maintenance requirements, the rope pump has proven to be a highly effective alternative to traditional piston and centrifugal pumps. The rope pump can operate efficiently across a wide range of pumping heights and discharge capacities, while also being resistant to silt accumulation and corrosion. Currently, more than 100,000 rope pumps are in operation worldwide, powered by humans, animals, electric motors, fuel engines, or even wind energy. Due to its reliability and affordability, the rope pump has gained recognition as one of the most promising technologies for rural water supply and sanitation. This paper also introduces a hydrodynamic model that accurately describes the fluid behavior within the rope pump. The model shows qualitative agreement with experimental data, explaining the reason behind the pump's light-weight design and efficiency. However, to achieve quantitative validation, additional high-quality experimental data under controlled testing conditions are required.

2.1. Findings from literature survey:

The findings from above literature review are as below:

1. Analysis Techniques: Various studies have successfully analysed centrifugal pump base plates under specific loading conditions using advanced software tools such as Catia and Ansys. These tools were instrumental in accurately modeling the baseplates and simulating their behavior under operational stresses.
2. Welding Concepts: Researchers have explored different welding techniques to enhance the structural integrity of baseplates. One notable conclusion is that welding steel columns onto the baseplate significantly improves its strength. This approach has been shown to effectively reinforce the baseplate, making it more robust and capable of withstanding higher loads.
3. Application-Specific Studies: Some authors have focused on the design and analysis of baseplates for API BB5 type pumps, particularly in FPSO (Floating Production Storage and Offloading) applications. These studies provide valuable insights into the unique requirements and challenges associated with baseplates in this context.

4. Optimization of Pump Components: In addition to baseplate analysis, there has been work on optimizing centrifugal pump designs, particularly in the development of new impeller designs. These optimizations aim to improve the overall efficiency and performance of the pumps, highlighting the potential for integrating similar optimization techniques in baseplate design.

2.2. Scope:

After an extensive review of the literature, it is evident that limited work has been done on the weight optimization of process pump baseplates. While previous studies have primarily focused on the design of baseplates for centrifugal pumps and pumps used in FPSO applications, there is a clear opportunity to explore the optimization of baseplates specifically used in the petroleum, petrochemical, and natural gas industries.

The baseplates for process pumps in these industries are typically large structures, ranging from 3 to 4 meters in length and 2 to 2.5 meters in width, and are generally constructed from mild steel. Given the availability of alternative materials in the market with higher strength and lower weight than mild steel, this project will investigate the potential of using these advanced materials to optimize the baseplate design.

Additionally, the project will explore the incorporation of strengthening design features such as cross bracing and ribbing to enhance the robustness of the baseplate. The existing design will be re-evaluated with a focus on maintaining structural integrity at critical points (hard points) while reducing material usage in areas subjected to lower stress and deformation.

Finite element analysis (FEA) will be conducted to assess the structural performance of the optimized design. Ansys software will be employed for detailed analysis, while Siemens NX will be used for 3D modeling. Through this comprehensive approach, the project aims to achieve a significant reduction in the weight of the baseplate without compromising its strength and durability, ultimately leading to a more efficient and cost-effective design.

PROBLEM STATEMENT AND OBJECTIVES

3.1. Problem Definition

The baseplate of a centrifugal pump is the backbone of the entire system, responsible for supporting the pump and handling all the forces it generates. To ensure the pump operates safely and efficiently, the baseplate must be strong and durable. However, the current approach to manufacturing these baseplates has some significant drawbacks, they are as follows-

1. They are often too heavy, which drives up manufacturing costs and reduces efficiency.
2. Producing these baseplates requires a lot of material, leading to higher expenses and greater resource consumption.
3. Their weight and complexity make them difficult for workers to handle, resulting in increased fatigue during both manufacturing and maintenance.

These challenges highlight the need to generate the new design and analysis of centrifugal pump baseplates. The goal is to create a design that is lighter, uses less material, and is more cost-effective while also being easier for workers to manage.

3.2. Objectives:

1. To study the load, stress and boundary conditions of existing baseplate of process pump. Prepare 3D modelling and analysis for studying the various areas with low stress and low deformation.
2. To study baseplate for weight optimization based on geometric parameters and materialistic properties.
3. Prepare 3D model of optimized system.
4. Stress and deformation analysis using Ansys software and Validation.
5. Comparison of analytical, analysis and experimental report.

DESIGN OF EXISTING SYSTEM

The baseplate serves as a crucial support structure for the centrifugal pump and motor assembly, ensuring their stable and uniform operation. It maintains precise alignment between the pump and motor while absorbing vibrations and operational loads during service. Therefore, the baseplate must be designed to be rigid, robust, and capable of withstanding dynamic and static stresses without deformation or misalignment.

Table no 1: Specification of baseplate

Sr No	Parameters	Specifications
1	Baseplate Dimensions	Length = 5740 mm Width = 2660 mm Height = 1130 mm
2	C section Channel	Total length used = 22250 mm Section Size = 300 × 150 × 10 mm Material = MS
3	Plate used on top of base plate	Thickness = 10 mm Total Area = 10430878 mm^2 Material = MS
4	Total Weight on baseplate	Pump weight = 7000 Kg Motor weight = 9000 Kg Couplings and other materials = 1000 Kg Total load on baseplate = 17000 Kg

Design Proposal 1:

The proposed modifications in this baseplate are as follows:

1. The geometric parameters of the C-channel will be reduced to optimize weight.
2. The upper plate of the baseplate has been removed as it carries very little load.
3. To ensure the baseplate retains sufficient strength after removing the upper plate, ribs have been added at critical high-stress areas.
4. The length and width of the baseplate cannot be reduced, as sufficient support is required for proper mounting of the pump, motor, and other accessories.

The following calculations shows the study of proposal 1:

Table no 2: Specifications of baseplate

Sr No	Parameters	Specifications
1	Baseplate Dimensions	Length = 5740 mm Width = 2660 mm Height = 1130 mm
2	C section Channel	Total length used = 22250 mm Section Size = 300 × 150 × 10 mm Material = MS

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Dimensions of C Channel Ladder
Length = 5740 mm, Width = 2660 mm, Height = 150 mm,
Width of C Channel = 75 mm, Thickness of C Channel = 5 mm
Total weight on the base plate is 17000 Kg
Thus,
Hence if we convert it into N then we get
W = 17000 × 9.81= 166770 N
y = distance of neutral axis = 150/2 = 75 mm
Consider a simply supported beam with ULD acting on system
Maximum Moment (M_{max}) = $W \times L^2 /8$ = 686833 N-mm
Moment of Inertia, I = 12921249659 mm^4
Maximum bending stress is
(σb) = Mmax × Y / I = 4 MPa.
Thus, maximum Deformation is
(Y_{max})= $5 \times W \times L^4/384 \times E \times I$ = 0.00086 mm.
Analytical calculations were performed to evaluate the system, resulting in a bending stress of 4 MPa and a maximum deflection of 0.00086 mm. Subsequently, a 3D model of the system was developed, and finite element analysis (FEA) was conducted to obtain the following results.
The above calculations were done to get the best solution of C channel. Thus, we have performed following iterations
As per above, following iterations was carried out, they are tabulated below.

Table no 3: Iterations of case 1.

Sr no	L	H	C Channel Width	W	C Channel Thickness	Stress (MPa)	Deformation (mm)
1	5740	300	150	2660	10	4.75	0.00052
2	5740	300	150	2660	8	4.94	0.00054
3	5740	300	150	2660	5	5.44	0.00059
4	5740	250	125	2660	10	4.68	0.00061
5	5740	250	125	2660	8	4.85	0.00063
6	5740	250	125	2660	5	5.12	0.00067
7	5740	200	100	2660	10	4.26	0.00070
8	5740	200	100	2660	8	4.32	0.00071
9	5740	200	100	2660	5	4.38	0.00072
10	5740	150	75	2660	10	3.47	0.00076
11	5740	150	75	2660	8	3.70	0.00081
12	5740	150	75	2660	5	3.99	0.00087

From all above study we concluded that the following solution will be best solution:
C Section Dimensions – 150 x 75 x 5 mm
For calculation of above baseplate, we have only reduced the thickness of the c channel and not the plates in between. Now we will remove the plates in between and do the analysis of the baseplate.
After removal of the plates in between the weight of the baseplate is 3420 Kg
Thus, the 3D modeling and analysis results are as follows:

1. 3D modeling of the Optimised baseplate

In this proposal we have selected the best solution of the C channel and removed the central support plates. The 3D modelling was done by using Siemens NX.

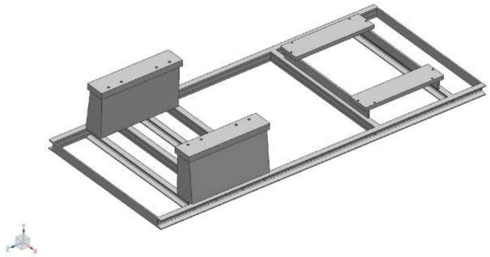

Figure no 1: 3D modeling of Optimised baseplate

2. Stress results:

After applying the total load on the system, the analysis recorded a maximum stress of **10.72 MPa**, highlighted in red, and a minimum stress of **0.0014749 MPa**, highlighted in blue. The obtained stress values are well within the permissible limits, confirming that the design is safe and structurally sound.

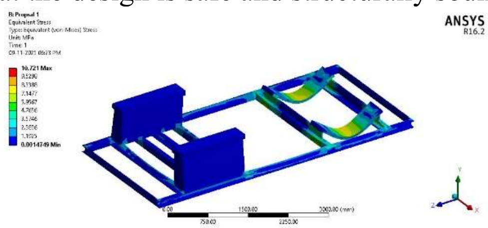

Figure no 2: Stress analysis of Optimised baseplate

3. Deformation results:

After applying the total load on the system, the analysis showed a maximum deformation of 0.1609 mm, represented in red, and a minimum deformation of 0 mm, represented in blue.

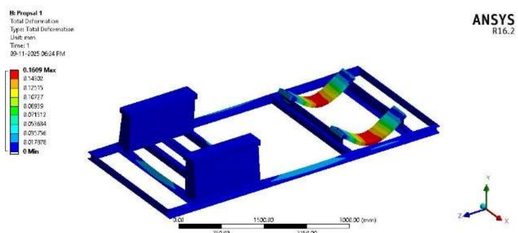

Figure no 3: Deformation of Optimised baseplate

4. Modal analysis

A point mass of **17,000 kg** was applied at the Pump side and motor side mounting faces.

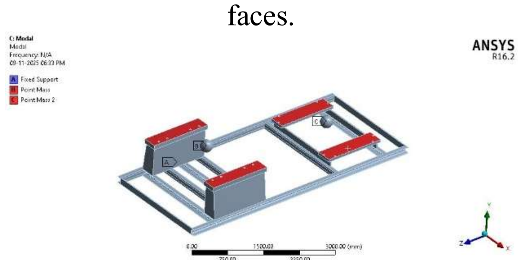

Figure no 4: Modal analysis – Point mass

Mode 1:

After applying the load of 17000 Kg on baseplate, the maximum deformation was 0.56714 mm and maximum frequency was 38.425 Hz.

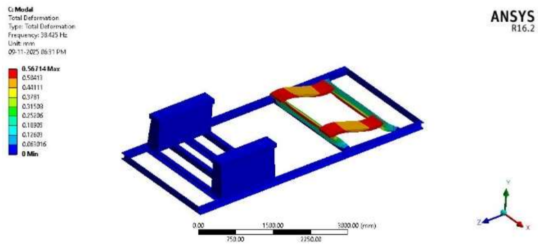

Figure no 5: Modal analysis – Mode 1

Mode 2:

After applying the load of 17000 Kg on baseplate, the maximum deformation was 0.82205 mm and maximum frequency was 48.942 Hz.

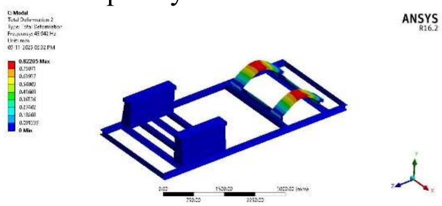

Figure no 6: Modal analysis – Mode 2

Mode 3:

After applying the load of 17000 Kg on baseplate, the maximum deformation was 0.44547 mm and maximum frequency was 51.824 Hz.

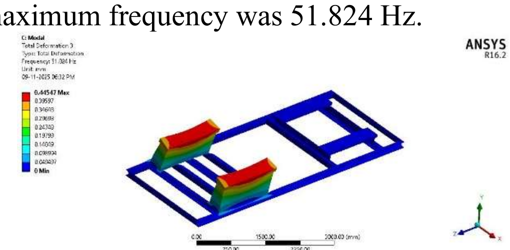

Figure no 7: Modal analysis – Mode 3

Mode 4:

After applying the load of 17000 Kg on baseplate, the maximum deformation was 1.2222 mm and maximum frequency was 91.048 Hz.

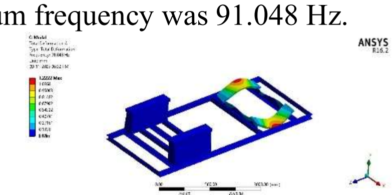

Figure no 8: Modal analysis – Mode 4

Mode 5:

After applying the load of 17000 Kg on baseplate, the maximum deformation was 1.4478 mm and maximum frequency was 109.66 Hz.

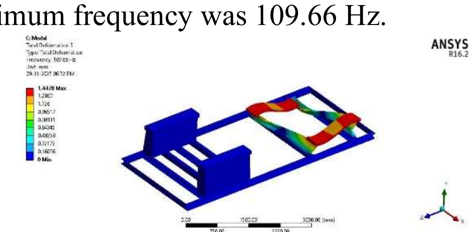

Figure no 9: Modal analysis – Mode 5

Mode 6:

After applying the load of 17000 Kg on baseplate, the maximum deformation was 1.0241 mm and maximum frequency was 120.99 Hz.

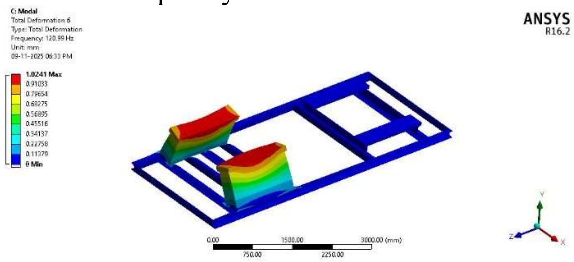

Figure no 10: Modal analysis – Mode 6

Table no 5.3: Mode wise frequency of Optimised baseplate

EXPERIMENTAL SETUP

The objective of project was to reduce the weight of the pump baseplate. Parametric optimization of the pump baseplate by using different materials was done. The validation of this project was done under the UTM machine. It is impossible to test the C channel having such a big length as the Optimised baseplate is. Hence, we have used 400 mm of C channel with dimensions 150 X 75 X 5 mm. The minimum load given on the sample is 1 KN. The setup of the machine is as follows. The total load applied on the baseplate was 166,770 N and total length of C channel used in baseplate was 22250 mm, thus if we calculate then 7.5N load was applied on every single mm. Thus for 400 mm total load applied was 3000 N. Thus, Deformation for 3 KN load was nearly 1.1 mm.

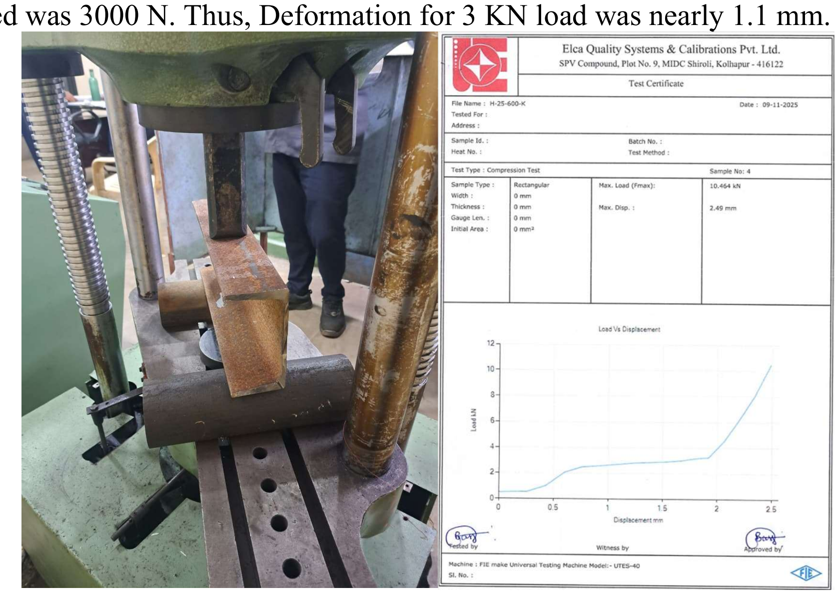

Figure no 11: Experimentation setup and Report

CONCLUSION

The primary objective of this project was to achieve significant weight reduction in the existing pump baseplate while ensuring that the structural integrity and load-bearing capacity of the system were not compromised. The baseplate plays a crucial role in supporting the pump, motor, and associated components; therefore, an optimized design directly contributes to improved system efficiency, easier handling, and reduced manufacturing costs.

A thorough study of the existing baseplate was conducted to identify regions experiencing low stress and minimal load transfer. These observations formed the foundation for redesigning the baseplate geometry.

- Based on the analysis, a new proposal was developed that involved the elimination of the upper plate, since it was found to experience negligible load, and the modification of various geometric parameters such as the dimensions of the C-channel. These changes were carefully made to ensure that the strength of the baseplate remained within the safe limits under all loading conditions.
- Finite Element Analysis (FEA) was performed to evaluate the structural behavior of the modified design under applied loads. The results demonstrated that the stresses and deformations were within the permissible limits, confirming that the redesigned baseplate was both safe and reliable.
- Through this optimization process, a total weight reduction of 2314 kg was achieved compared to the existing design, resulting in a 40.36% saving in material usage. This substantial reduction directly translates to lower material costs, reduced fabrication effort, and easier installation and maintenance. Furthermore, the overall system becomes more efficient due to the decrease in dead weight, which can also contribute to improved vibration characteristics and longer service life.

In conclusion, the redesigned baseplate provides a more economical, lightweight, and structurally efficient solution without compromising performance. The optimization approach adopted in this study demonstrates the potential for future improvements in industrial pump baseplates through geometric refinement, material selection, and advanced simulation techniques. This project successfully achieves the desired balance between weight reduction, cost efficiency, and structural reliability, offering valuable insights for future industrial applications.

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