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Design, Development and Analysis of Double Shaft Pugmill Mixer

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Abstract*: When it comes to mixing bulk solids, few industrial mixers can compete with the double-shaft pugmill mixer. Often chosen for its ability to create a homogeneous mixture from both wet and dry ingredients, the pugmill mixer offers a versatile solution capable of processing everything from sludges to powders, and nearly everything in between. The high torque, combined with the kneading action imparted by the double shafts is especially ideal when it comes to heavy-duty applications. This paper provides an in-depth exploration of the doble shaft pugmill mixer, its design principle, advantages, and application, offering into its role in optimizing industrial logistics and manufacturing processes.*

Keywords: pugmill mixer, costing, Mechatol Engineering Pvt. Ltd

I. INTRODUCTION

When it comes to mixing bulk solids, few industrial mixers can compete with the double-shaft pugmill mixer. Often chosen for its ability to create a homogeneous mixture from both wet and dry ingredients, the pugmill mixer offers a versatile solution capable of processing everything from sludges to powders, and nearly everything in between. The high torque, combined with the kneading action imparted by the double shafts is especially ideal when it comes to heavy-duty applications.

How Does a Double-Shaft Pugmill Mixer Work?

While a single shaft pugmill mixer is occasionally suitable for light-duty mixing applications, this type of industrial mixer falls short in situations where even distribution of ingredients is required, particularly when it comes to the addition of liquids. The design of a double-shaft pugmill mixer, however, is able to create an intimate mixture of materials, even when feedstock consists of both wet and dry ingredients.

Here’s how it works:

Two shafts, affixed with pitched paddles, span the length of a U-shaped trough, and move in a counter- rotating motion at a constant speed. This counter-rotating motion “lifts” material up through the center, and then pulls it back down the sides, creating a kneading and folding-over motion conducive to thorough mixing. When binders or liquid additives are required, a spray system is mounted to the interior of the mixer

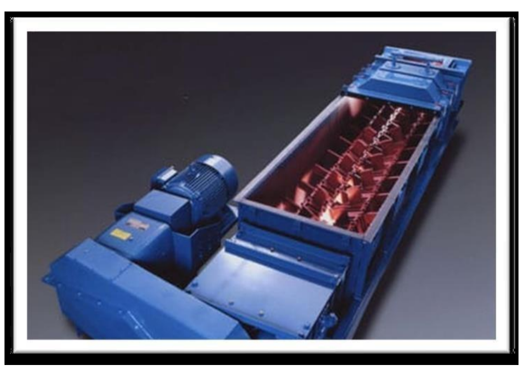

Fig 1.1 Double-Shaft Pugmill Mixer

II. LITERATURE REVIEW

Double Shaft Pugmill Mixer is used to mix homogeneous mixture having wet and dry ingredients. These are some of the literature reviews of the project mentioned below:

V. Kushnir*, N. Gavrilov, S. Kim, Justification of the Design of the Two-shaft Mixer of Forages, International Conference on Industrial Engineering, ICIE 2016, A. Baitursynov Kostanay State University, 47 Baitursynovst, Kostanay, 110000, Kazakhstan. This paper consists of Justification of the use of mixers in the processing of mixtures' feed is given in the article. Some designs of mixers are considered, research of some authors is noted. Existing shortcomings of the mixing process and designs of mixers are revealed. The sound design of a double-shaft mixer with a horizontal shaft and rectangular buildings are given in the article on the basis of a priori review. The experimental feed mixer is designed and manufactured on the basis of objectives and research hypotheses, a description which allows us to understand the essence of the work. In addition, the article reflects the theoretical calculation of the lobed mixer, the technique of the experiments. The experimental results are shown in graphs with the construction of corresponding values, tables, equations. General conclusions reported in this article show the finished work confirming the hypothesis of the research and execution of tasks.[1]

H A Varalakshmi, Pug Mill, International Advanced Research Journal in Science, Engineering and Technology, Vol. 10, Issue 9, September 2023. This paper consists of A pug mill plays a pivotal role in the construction industry, particularly in the context of Wet Mix Macadam (WMM) preparation. This essential equipment is designed to efficiently blend various construction materials such as aggregates, soil, cement, and water to create a uniform and well-mixed WMM base layer. The pug mill's operation involves a continuous process of mixing and homogenizing these components, ensuring that the resulting mixture meets the required specifications for road construction projects. Its ability to precisely control the proportion of each ingredient while maintaining consistency makes the pug mill a cornerstone of WMM production, enhancing the durability and quality of road infrastructure. In summary, the pug mill is an indispensable tool in the construction arsenal, facilitating the creation of robust and dependable WMM layers for road development and maintenance.[2]

Mr. SukhadipChougule, Mr.K.M. Narkar, Analysis of Double Shaft Paddle Mixing Machine shaft, Mechanical Engineering Department, Savitribai Phule Pune University D Y Patil College of Engineering Akurdi, Pune. Raj Process EquipmentsAnd Systems Pvt. Ltd Gat No.373, Kharabwadi, Chakan, Pune. This paper consists of This project deals with analysis of shaft used in double shaft paddle mixer. Paddle mixer consists of several elements- a centrally mounted horizontal shaft that rotates within a cylindrical container, paddles, openings at the top for feeding materials, flush fitting access doors at the front of the mixer, at the bottom of the mixer fitting discharge valve. Paddle mixer is specially designed to lift, shake and to get combined materials in container, which is made of Stainless Steel. This paddle design is perfect for merging the solids or liquid of different kind of particles density, size and viscosity. It is normally used for food, fertilizer and pharmaceutical industries. The overall subject of this paper is the failure analysis of driving shaft of mixer. One end of that shaft is connected to the output of the motor through gear drive. By considering the system pressure acting on the output shaft is determined. Stresses occurring at the failure section are calculated using this pressure. Model is developed into the Pro Software. Analysis is done by using Ansys 13.0. From that we get the stress value for the conditions. After fulfill the needed conditions of required stress we are going to manufacture and test the product for the validation [3].

Jeroen Emmerink, Ahmed Hadi, Jovana Jovanova, Chris Cleven and Dingena L. Schott, Parametric Analysis of a Double Shaft, Batch-Type Paddle Mixer Using the Discrete Element Method (DEM), Department of Maritime and Transport Technology, Faculty of Mechanical Engineering, Delft University of Technology, Mekelweg 2, 2628CD Delft, The Netherlands Dinnissen BV, Horsterweg 66, 5975NB Sevenum, The Netherlands. This paper consists of theories like to improve the understanding of the mixing performance of double shaft, batch-type paddle mixers, the discrete element method (DEM) in combination with a Plackett–Burman design of experiments simulation plan is used to identify factor significance on the system's mixing performance. Effects of several factors, including three material properties (particle size, particle density and composition), three operational conditions (initial filling pattern, fill level and impeller rotational speed) and three geometric parameters (paddle size, paddle angle and paddle number), were quantitatively investigated using the relative standard deviation (RSD). Four key performance indicators (KPIs), namely the mixing quality, mixing time, average mixing power and energy required to reach a steady state, were defined to evaluate the performance of the double paddle mixer [4].

III. EXPERIMENTATION

As per the given specification and inputs by the company, Mechatol Product Engineering Solution Pvt Ltd, the 3D modeling software, SolidWorks, was used to design the parts and whole double shaft pugmill mixer. The 3D model of the different component and the assembly of system is shown below. A pugmill mixer, also known as a pug mill or paddle mixer, is a type of horizontal, continuous mixer used throughout a variety of industries to combine solid and liquid feed components into a homogeneous mixture. Pugmill mixers are chosen for especially demanding settings in which the materials require a tough but thorough mixing action due to consistency, abrasivity, corrosiveness, or other material challenge.

As specified by Company, Mechatol Product Engineering Solutions Pvt. Ltd. The aims were divided into several objectives:

1. To Reduce weight of the frame
2. Increasing Fatigue cycles which Pugmill shafts can endure

The primary objective of a Double Shaft Pugmill Mixer:

1. To mix homogeneous mixture having wet and dry ingredients.
2. To develop a versatile solution capable of processing sludges to powder.

In this research project the double shaft pugmill mixer is constructed using SolidWorks with taking previous design specifications as a reference. ANSYS workbench used for stress and deformation simulation which uses the finite element method approach to the designed frame.

The proposed design will meet the company's requirements, which include a capacity of 2.5ton, material of plain carbon steel, frame weight 190kg to 200kg, and material to be mixed is municipal sludge. The theoretical calculations and empirical data will be used to determine the double shaft pugmill mixer. The selection of proper material selection for shaft and frame will involve a detailed analysis of the mechanical properties.

This chapter gives us immense information about design methodology, considered variable factors, standard references, part level design, assembly level design, costing calculations, welding calculations, and material selection.

Methodology

The procedure commenced with the prioritization of assembly design over design calculations, material selection, and costing calculations. SolidWorks was used for the design of the model.

The project's primary objective was to enhance the performance and efficiency of a double shaft pugmill mixer. The previous system's parameters and values were analyzed to establish guidelines for the work. After identifying the major objectives, a Level-1_Part List of eight components and a detailed Level-2_Part List of eight components were designed. The individual parts were designed, and subsequently assembled into a complete system.

Technical specifications such as the capacity, length, diameter, etc. were listed. During capacity calculation, careful material selection and modification were made to obtain the required capacity with minimum product cost. Based on previous and required specifications guidelines, the material was finalized, and the capacity calculation proceeded. Through numerous iterations, the required capacity was eventually achieved.

The FEA analysis was conducted to obtain interesting results, and modifications were made to factors such as frame during the analysis. The project's scope requirements were met, and the team proceeded to Final Material Costing, Welding Calculations, and Bill of Material. [Figure 3.1]

Every project adheres to a certain procedure flow chart as part of project planning. The flow chart for this project was determined based on the following criteria

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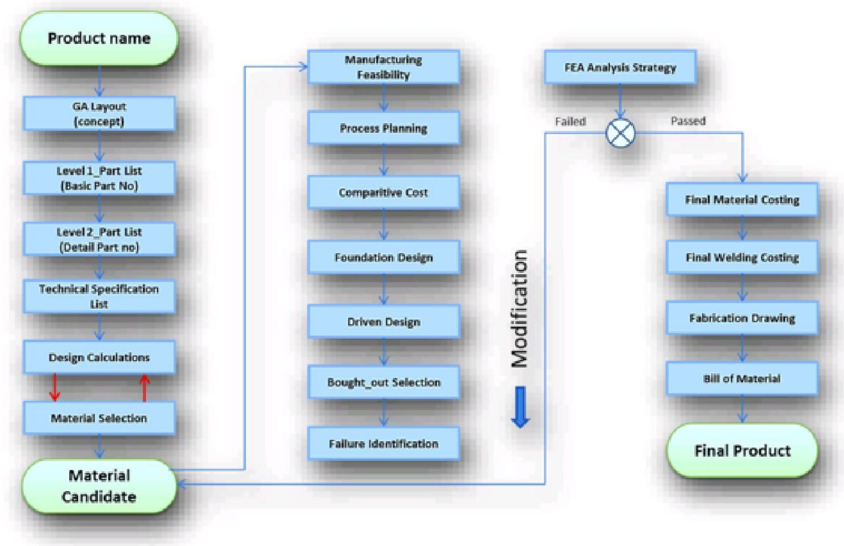

Figure 3.A Project Process Flowchart

Factors consider for analysis:

- Material: plain carbon steel
- Material to be mixed: municipal sludge
- Frame weight Range: 190kg-200kg
- Force considering assembly and material: 4.2 ton

Standard references:

- ASME (American society of mechanical engineering).
- ASTM (American society for testing and materials).
- Granta charts (property charts).

Material selection

Material selection is one of the important aspects of product design and development. Mos of the project objectives related to weight and strength optimization revolves around this important aspect of the project.

Criteria for Material Selection

1. Manufacturing Feasibility:

Analysis and evaluation of a proposed project to determine if it is technically feasible to manufacture the product to meet customer requirements. This includes but is not limited to the following (as applicable): within the estimated costs. and if the necessary resources. facilities, tooling. capacity, software and personnel with required skills including support functions are or are planned to be available.

2. Availability:

Materials that are available conveniently and continuously for the desired period of time are mostly preferred.

3. Relative Cost Comparison:

Comparing the cost of the same as well as each different material from different vendors so as to get them at the lowest rate possible.

4. Chemical composition:

Choosing the material with the appropriate chemical composition so as to avoid issues such as corrosion, failure during operation, etc.

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5. Functioning:
Selection of material according to working criteria and the forces acting on it during application.

Procedure for Material Selection

There are 8 steps that are followed to selecting a material for a given component.

1. Screening-
We had gone through many materials taking old specifications as a reference and did screening of materials on the base of four parameters namely Function to be used, Objectives of work, Variables to be made, and Constraints. After shortlisting the materials, we proceeded further for selecting properties and guidelines.

Following are the Screening of materials for scope of objectives.

Table 3.1 Screening

Double shaft Pugmill Mixer	
Function	To mix the material
Objective	To increase the strength
Variable	Density
Constraint	Geometry

2. Selecting Property Chart-
The family of materials is chosen using ASHBY charts, taking the part's objective into consideration. The property space that each material class takes up is discussed in the material charts. There are three ways you can use them:

To:

a) find rough estimates of material properties.
b) choose materials with specified property profiles.
c) Designing hybrid materials.

In our case, we have selected combinations of graph such as strength vs. density graph for comparison and analysis. On finalizing the materials after screening process, we used ASHBY Charts for refiltering the materials based on the guidelines and the objectives or strength and density.

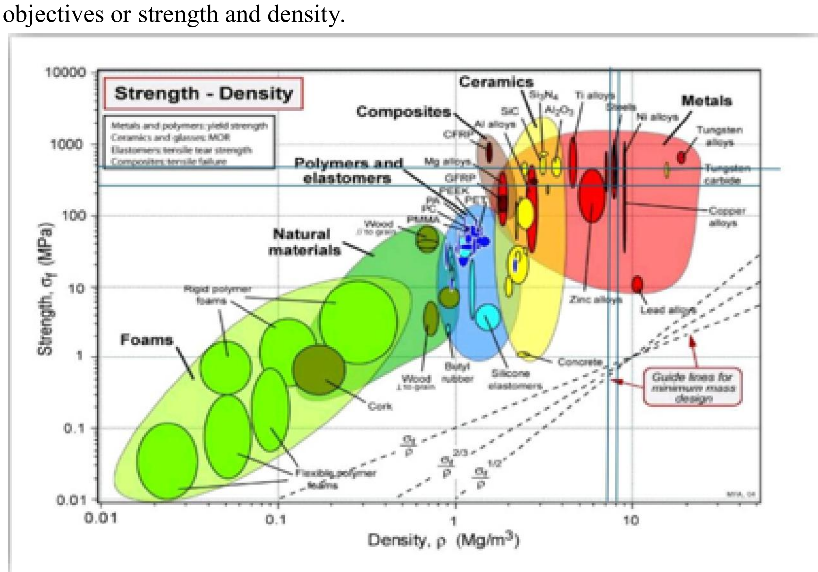

Fig. 3.B ASHBY Chart

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3. Selecting Guideline-
Upon selecting the property chart, it was necessary to adhere to the maximum and minimum condition values while plotting guidelines. The recommendations were there plotted, resulting in a region of material classes. Materials within this region could there be tested for additional criteria
4. Potential Candidate Selected-
Potential candidate materials that meet the specifications of the component can be chosen based on the material class. The materials chosen for the Roller component are as follows:

Component	Double Shaft Pugmill Mixer
Potential candidate materials	IS 2062
	AISI 1010
	AISI 1020

Table 3.2 Potential Candidate Selected

5. Gathering Material properties-
Following are the selected material properties as per the project objectives and scope.
In accordance with the scope of work, properties were listed and the scale value weighing factor, and performance index were calculated to determine the optimal material.

Table 3.3 Material Properties

Properties Material	Yield Strength MPA	Tensile Strength MPA	Density G/cc	Friction coefficient	Youngs Modulus
IS 2062	240	410	7.85	0.43	210
AISI 1010	305	365	7.87	0.40	200
AISI 1020	370	440	7.87	0.43	200

6. Calculating scaled value-
The selected properties had various units, making it necessary to convert them into quantities with fewer units in order to facilitate comparison. The formulas used to translate these properties into equivalent unit values are listed below:
Scaled value (B)
Formula: Numerical value x 100/Max, value in the list
Formula: Min. value in the list x 100/Numerical value
The resulting scaled values were then calculated to facilitate comparison and guide the material selection process.
Scaled values for Roller
The scaled values were calculated using the formulas mentioned above, which utilized the property values.

Table 3.4 Scaled Value

Properties Material	Yield Strength MPA	Tensile Strength MPA	Density G/cc	Friction coefficient	Youngs Modulus
IS 2062	57.14	60.74	100	95.55	100
AISI 1010	72.61	54.02	99.74	88.88	95.23
AISI 1020	88.09	65.18	99.74	95.55	95.23

7. Calculating weighing factor-
In order to make informed decisions, it was necessary to compare the features of the materials. To facilitate comparison, functional importance criteria were utilized. The weighing factor (a) was calculated as follows: Positive decisions/Total PD.

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Table 3.5 Weighing Factor

Properties	Positive Decision	Weighing Factor
Yield Strength	5	0.333
Tensile Strength	1	0.066
density	4	0.266
Friction Coefficient	3	0.2
Youngs Modulus	2	0.133
Total	15	1

8. Calculation of performance index
To select appropriate material for respective components of frame and Sheetmetal performance index is allocated
Formula: - (γ) = Σ=1 βίαι
Where$_1$ = Scaled Value αι=Weighing Factor

Table 3.6 Performance Index

Sr.no		Performance index
1.	IS 2062	82.04
2.	AISI 1010	84.71
3.	AISI 1020	91.94

As Performance Index of AISI 1020 STEEL is highest. Hence, we have selected those material

Design

As per the given specifications and inputs by the company, Mechatol Product Engineering Solutions Pvt Ltd., the 3d modelling software, SolidWorks, was used to design the parts and whole double shaft pugmill mixer assembly. The 3D models of the different component and the assembly of the system is shown below.

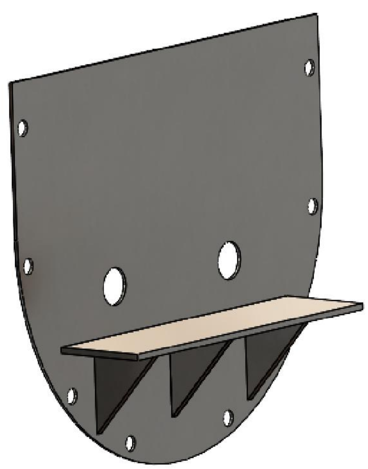

Fig 3.1. Back Plate

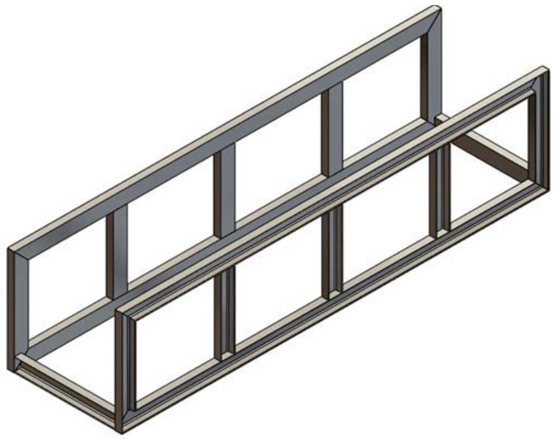

Fig 3.2. Frame

Fig 3.3. Pulley

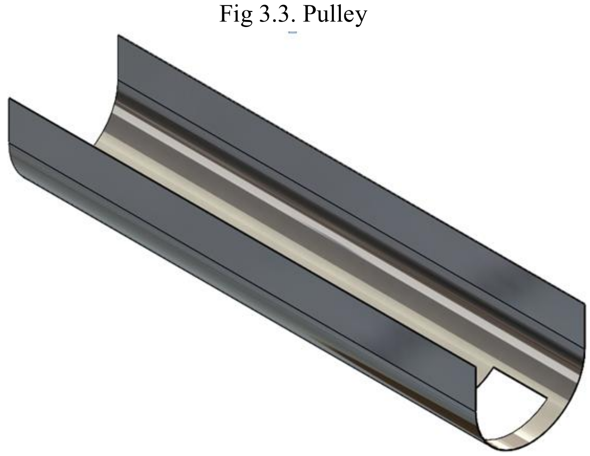

Fig 3.4. Trough

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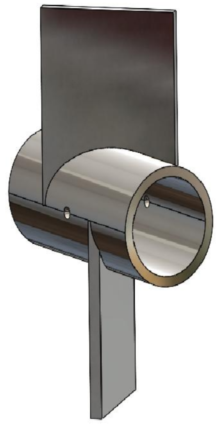

Fig 3.5. Paddle

Fig 3.6. Top Plate

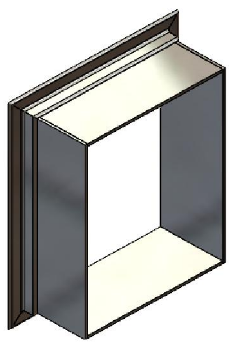

Fig 3.7. Inlet

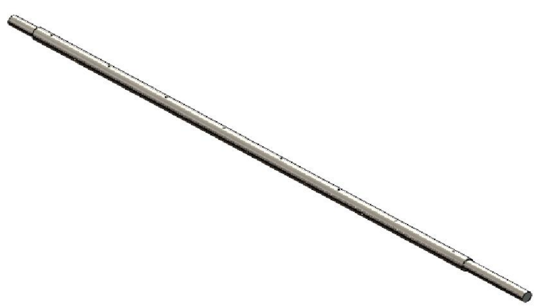

Fig 3.8. Shaft

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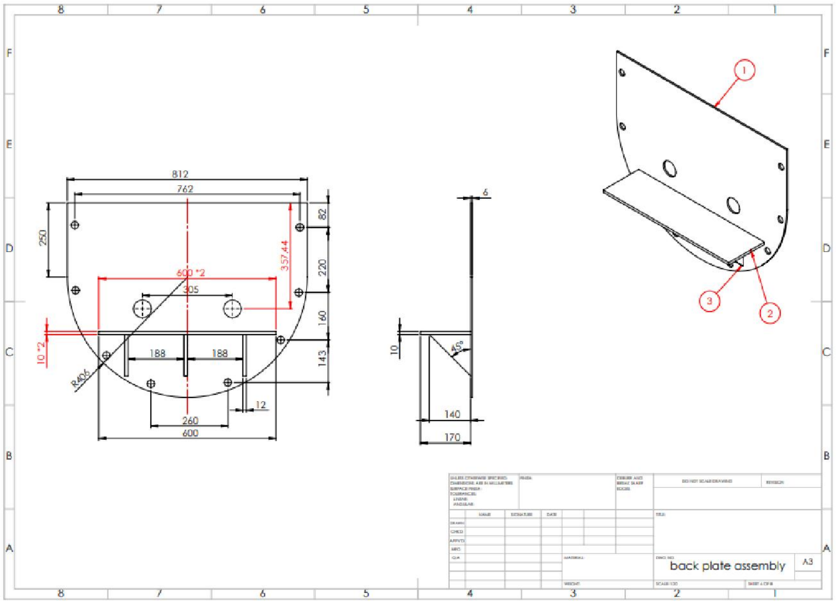

Fig 3.9 back plate

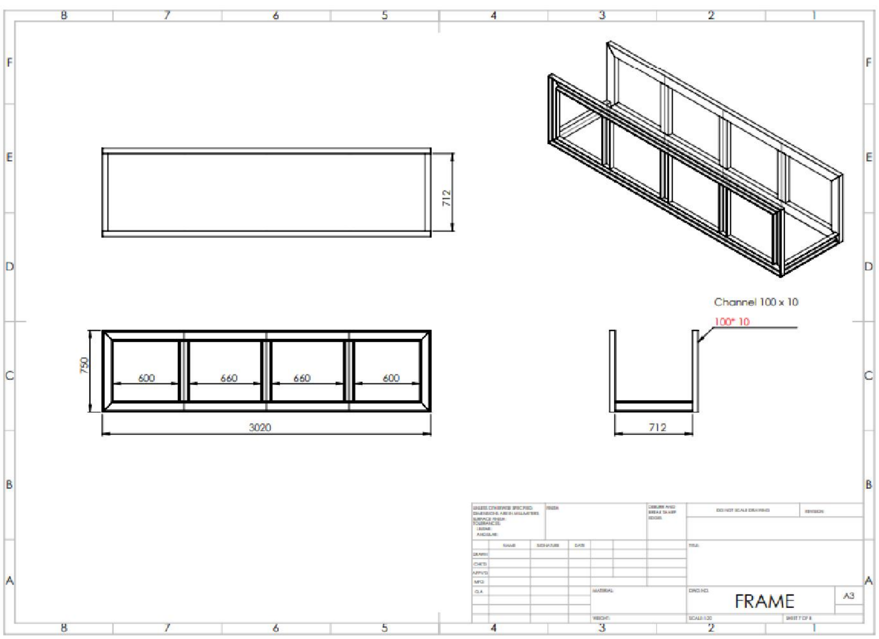

Fig 3.10 frame

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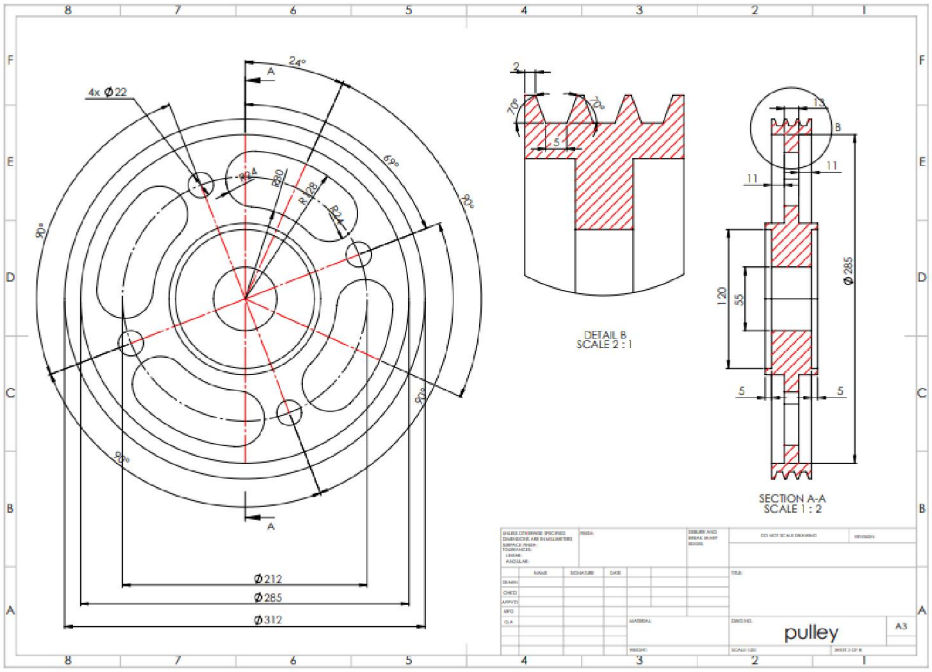

Fig 3.11 pulley

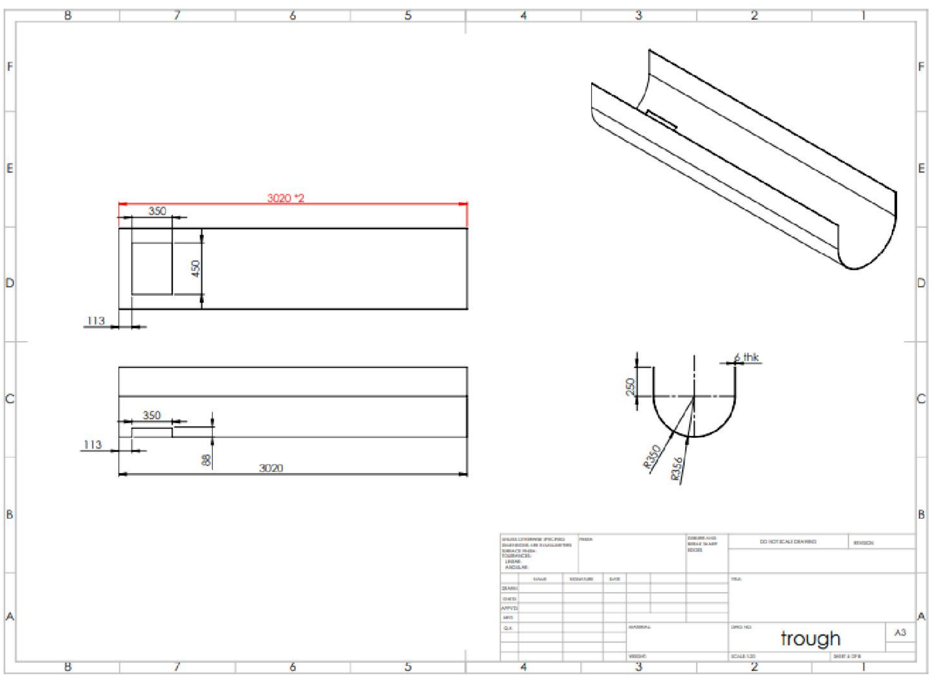

Fig 3.12 trough

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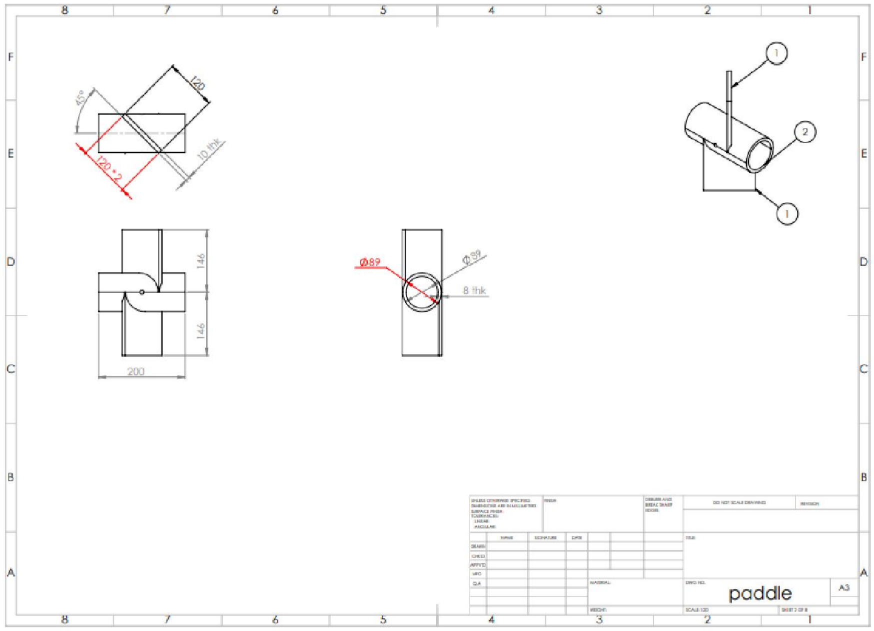

Fig 3.13 paddle

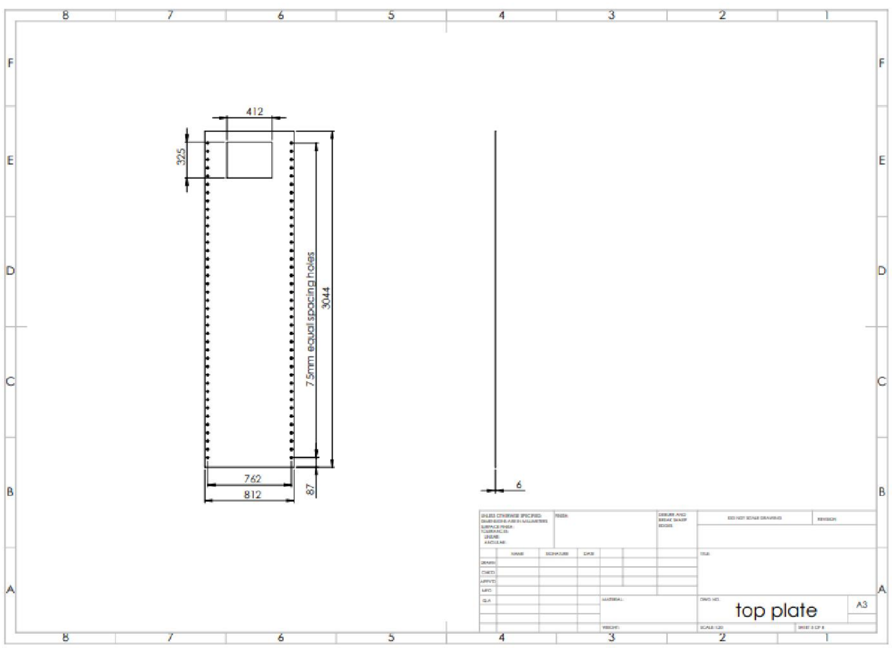

Fig 3.14 top plate

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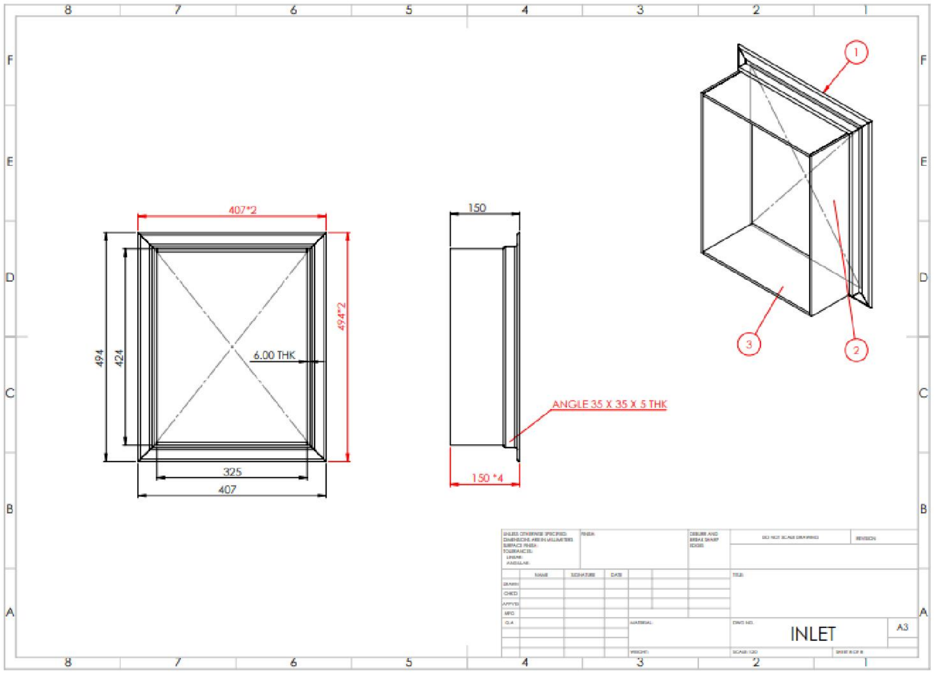

Fig 3.15 inlet

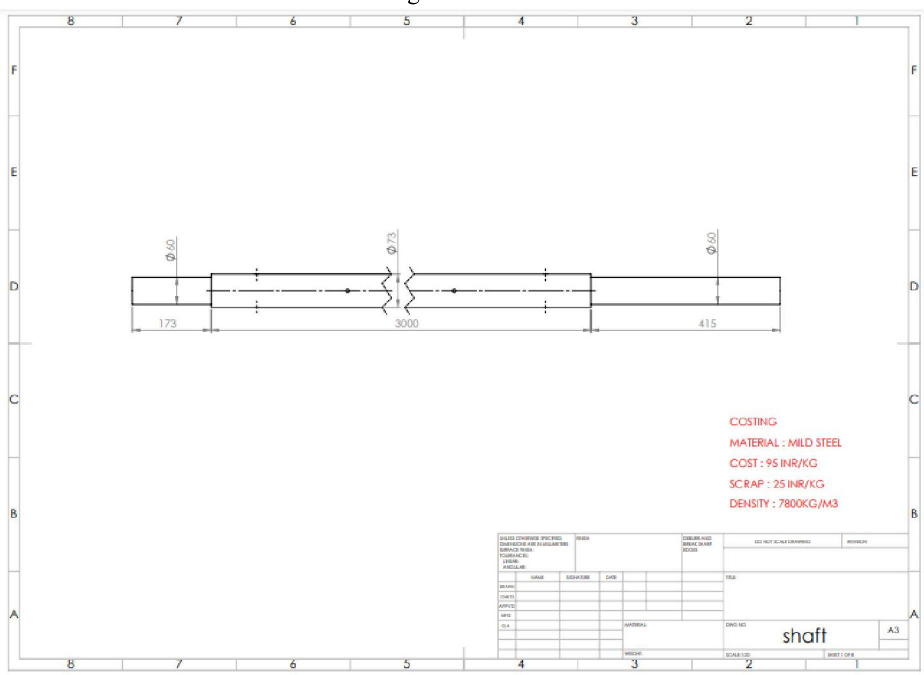

Fig 3.16 shaft

Design Calculations

The design calculations were based on the input data provided by Mechatol Engineering Solution Pvt. Ltd. And CEMA standard were used as reference. Several iterations were carried out to obtain the targeted outputs. After numerous iterations, the desired outputs were achieved. this final calculation was selected from a total of iteration of calculations.

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Table 3.7 Parameter

Sr.no	Parameters	Description
1.	Capacity	2.5 Ton
2.	Material	Plain carbon steel
3.	Density	7.8 kg/m3
4.	Temperature (working)	Ambient
5.	Frame weight Range	190kg-200kg
6.	Operating Type	Electric
7.	Material to be mixed	Municipal Sludge

Costing Estimation Calculations

The price of the materials used to manufacture a product is referred to as the material cost. For certain materials, the expense of scrap and the proceeds from its resale are so negligible that allocating them to the cost of the material is not profitable. The terms "material cost" and "raw material cost" are frequently used the same.

The procedure followed to analyze the cost of the components is as follows: -

1. Calculating raw size of the component.
2. Calculating raw weight of the component
3. Calculating the total scrap weight considering the various mechanical operations that will be performed on the component. For example: drilling, turning, milling, etc.
4. Calculating material cost of the component i.e., Product of raw weight and material cost.
5. Calculating the scrap cost i.e., Product of total scrap weight and scrap return.
6. Calculating Net cost i.e., Difference between Material cost of component and scrap cost.

The following formulas are used for calculating machining cost: -

1. Raw Size = Area x Thickness
2. Raw Weight = (Area-Thickness Density Quantity) 106
3. Raw Material Cost = Raw Weight x Cost/Kg
4. Machining Weight = (area x thickness x density x quantity) / 106
5. Machine Cost = Machine Weight x Cost/Kg
6. Scrap Weight = Raw Weight - Machine Weight
7. Total Scrap = All scrap weight
8. Scrap Cost = Total Scrap x Scrap Cost
9. Net Cost = Machine Cost-Scrap Cost

Input Data –

Material Cost = 110 Rs. / Kg

Scrap Cost = 30 Rs. / Kg

Material = Plain Carbon Steel

Welding Costing

Welding costing of the machinery components is done considering American welding standards. Welding was to be performed on two main components. Le Base Frame and sheet metal components.

The following tables show the of welding costing of all the subassemblies.

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Table 3.8 Welding Costing

INPUT DATA		
DESCRIPTION		UNIT
Cost of Oxygen	15	INR/m3
Cost of Acetylene	60	INR/m3
Cost of Filler rod Material	60	INR/m3
Oxygen Consumption Rate	0.6	m3/hr.
Acetylene Consumption Rate	0.6	m3/hr.
Diameter of filler Rod	4	m
Length of Filler Rod Required per meter of weld	3.4	m
Rate of welding process movement	2.3	m/hr.
Density of Filler Rod	8	g/cm2

The following formulas used for calculating welding cost:
1. Total Consumption of Oxygen Total = Oxygen Consumption Per Hour x Time of Weld
2. Total Consumption of Acetylene = Acetylene Consumption Per Hour x Time of Weld
3. Effective Length of Filler Rod Required = Length of Weld x Length of Filler Rod
4. Volume of Filler Effective = Length of Filler Rod x Cross Section of Filler Rod
5. Cost of Oxygen Consumed = Total Oxygen Consumed X Cost of O2 per m^3
6. Cost of Acetylene Consumed = Total Acetylene Consumed X Cost of Acetylene m^3
7. Cost of Filler Rod Consumed = Volume of Filler Rod x density x Cost of Filler Per Kg / 1000
8. Total Cost of Welding = Cost of Oxygen + Cost of Acetylene + Cost Filler Rod

Shaft

Raw material cost Raw size = 3588 Ø 73

Allowance raw size=3590Ø75

Raw weight
= (Area*Thickness*Density)/106
= 123.709kg

Machined weight
= (Area*Thickness*Density)/106
=117.133kg

Machined weight for 173 length
= (Area*Thickness*Density)/106
=3.8153kg

Machined weight for 3000 length
= (Area*Thickness*Density)/106
=97.9380kg

Machined weight for 415 length
= (Area*Thickness*Density)/106
=9.1524kg

Total Machined Weight = 110.90kg

Raw Material Cost=Raw weight * Machined cost
= 123.709*95
= 11752.355/-INR

Machined Cost = 110.9057*95
=10536.0415/-INR

Scrap weight = Raw Weight -Machined Weight
=12.8033kg

Total Scrap=19.0313kg
Scrap cost = 19.0313*25
= 475.78/-INR

Net Cost=Machined Cost - Scrap cost
=10536.0415/-INR - 475.78/-INR
=10060.261/-INR

Trough

Weld Estimation
Consumption of Oxygen and acetylene=0.6m3/hr.
Diameter Of Filler rod = 3mm
Rate of weld= 3.3mm
Length of fillerrod=3.4mm
Cost of Oxygen= 15/m3
Cost of Acetylene = 60/m3
Density=8g/cm

Time required to weld
=Length of weld /Rate of welding
=(3020*2*10-3)/3.3
=1.8303hr

Total Consumption of Oxygen
=Oxygen consumption per hour*time
=0.6*1.8303
=1.098m3

Total Consumption of acetylene
= Acetylene consumption per hour * time
= 0.6 * 1.8303
= 1.098m3

Effective Length Of filler Rod
= Length of Weld * length of filler required
= (3020*2*10-3) *3.4 = 20.536m

Volume of Filler Rod
= Effective Length of Filler * Cross section area Of Filler Rod
= 20.536 * ((π/4) *0.0032)
= 1.4516* 10^-4 m3

Cost
Oxygen = Total Consumption of Oxygen * Cost of Oxygen
= 16.47/-INR
Acetylene = Total Consumption of acetylene * Cost of acetylene
= 65.88/-INR
Filler Rod = Volume of filler rod * density * 1000 * cost
= 1.4516 * 10-4 * 8 * 1000 *60
=69.6768/-INR

Total Material Cost Of weld
= Cost of oxygen + cost of acetylene + cost of filler rod
=152.068/-INR

Including labour cost
Labour cost = time x Labour rate
= 1.8303 x 50
= 91.515 /- INR

Overhead charges
= 400 % of labour cost
= 366.06 /- INR PRIME COST
= Material + Labour +Overhead
= 884.188 /- INR

Weight of trough = 219.41kg
Cost = 219.41 * 110
=24135/- INR

Inlet
Length of weld = 407 x 2 +494 x 2 + 150 x 4
= 2402 mm

Time required to weld
= Length of weld / Rate of welding = 2402 x 10-3 / 3.3
= 0.7278 hr.

Total Consumption of Oxygen
= Oxygen consumption per hour * time
= 0.6 x 0.7278
= 0.4367

Total Consumption of acetylene = acetylene consumption per hour * time =0.6 x 0.7278
= 0.4367

Effective Length Of filler Rod = Length of Weld * length of filler required= 0.7278 x 3.4
= 2.4745 m

Volume of Filler Rod = Effective Length of Filler * Cross section area Of Filler Rod
= 2.4745 x ((π/4) x0.0032)
= 1.749 x 10-5

Cost
Oxygen = Total Consumption of Oxygen * Cost of Oxygen= 0.4367 x15
= 6.5505/-INR
Acetylene = Total Consumption of acetylene * Cost of acetylene= 0.4367 x 60
= 26.202/-INR
Filler Rod = Volume of filler rod * density * 1000 * cost
= 1.749 * 10-5 * 8 * 1000 *60
= 8.3957/-INR

Total Material Cost Of weld = Cost of oxygen = cost of acetylene + cost of filler rod
= 36.39 /- INR
Including labour cost
Labour cost = time x Labour rate
= 0.7278 x 50
= 145.56 /- INR
Overhead charges
= 400 % of labour cost
= 400 % 36.39
= 145.56 /- INR
Prime Cost
= Material + Labour +Overhead
= 223.0982 /- INR

Weight of inlet = 14.51 kg
Cost = 14.51 * 110
=1596/- INR

Frame
Frame weight=752.6164kg
Cost = Frame weight * 110
= 752.6164 * 110
= 82787.804 INR/-

Top Plate
Top Plate weight = 107.7589 kg
Cost = top plate weight * 110
= 107.7589 * 110
= 118530479 INR/-

Back Plate
Back Plate weight = 31.8919kg
Cost = Back Plate Weight * 110

= 31.8919 * 110
= 3508.109 INR/-

Pulley
Pulley Weight = 14.2139kg
Cost = Pulley Weight * 110
= 14.2139 * 110
= 1563.529 INR/-

Paddle
Paddle Weight = 5.1490kg
Cost = Paddle Weight * 110
=5.1490 * 110
= 566.39 INR/-

Bill of materials

Sr.No.	Description	Qty
1.	Frame	1
2.	Paddle	1
3.	Pulley	1
4.	Trough	1
5.	Back Plate	1
6.	Top Plate	1
7.	Inlet	1
8.	Shaft	2
9.	Motor	1
10.	Bearing	4

Table no. 3.9 Bill of Materials

IV. CONCLUSION

The present study successfully archived the objectives and aims set forth by the company. The results of the study indicated significant improvements in the Double Shaft Pugmill Mixer, while identifying areas for further improvement. The improvements included an increase in the system's capacity, a reduction in the excess weight and an increase in the assembly's service life, while adhering to the relevant standards such as ASTM, ASME, AWS, CEMA, etc.

To accomplish the stated objective, the research team conduct an extensive literature review, reference multiple articles, research paper, and Mechatol company standard to inform the analysis and calculation process.

A double shaft pugmill mixer, it's evident that this equipment offers significant advantages in various industrial processes, particularly in the mixing and blending of materials. Its dual shaft design ensures thorough mixing, homogenization, and consistent output, making it suitable for a wide range of applications including construction, ceramics, and pharmaceuticals.

The design of the double shaft pugmill mixer allows for efficient processing of both wet and dry materials, offering versatility in handling different types of substances. Its robust construction and advanced mixing mechanisms contribute to improved productivity and quality of the final product.

Overall, the double shaft pugmill mixer emerges as a valuable asset for industries seeking enhanced mixing capabilities, consistency, and reliability in their production processes. Its effectiveness in achieving thorough blending and homogenization makes it a preferred choice for manufacturers aiming to optimize their operations and deliver high-quality products consistently

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Future scope :

The future scope of double shaft pugmill mixers is promising, with several potential developments and advancements on the horizon:

1. *Integration of Smart Technologies*: There's a growing trend toward integrating smart technologies such as sensors, data analytics, and automation into industrial equipment. Double shaft pugmill mixers could benefit from these advancements, allowing for real-time monitoring of mixing parameters, predictive maintenance scheduling, and even autonomous operation.
2. Enhanced Customization and Flexibility: Manufacturers are increasingly seeking customizable solutions to meet their specific production requirements. Future double shaft pugmill mixers may offer greater flexibility in terms of mixing configurations, material handling options, and control systems, allowing for tailored solutions to a wider range of applications.
3. Improved Energy Efficiency: Energy efficiency is a key consideration in modern manufacturing processes. Future double shaft pugmill mixers could incorporate design enhancements and energy-saving features to minimize power consumption without compromising mixing performance, thereby reducing operating costs and environmental impact.
4. Advanced Materials and Coating: The development of advanced materials and coatings could enhance the durability, wear resistance, and corrosion resistance of double shaft pugmill mixer components. This could extend equipment lifespan, reduce maintenance requirements, and improve overall reliability in harsh operating environments.
5. Integration with Industry 4.0 Concepts: As manufacturing moves towards Industry 4.0 principles of connectivity, automation, and data exchange, double shaft pugmill mixers may become part of interconnected production systems. Integration with other equipment, process control systems, and enterprise resource planning (ERP) software could enable seamless workflow optimization and resource allocation across the entire manufacturing ecosystem.
6. Focus on Sustainability: With increasing emphasis on sustainability and environmental responsibility, future double shaft pugmill mixers may incorporate features to minimize material waste, reduce emissions, and optimize resource utilization throughout the mixing process. This aligns with broader industry trends towards sustainable manufacturing practices.

Overall, the future scope of double shaft pugmill mixers involves leveraging technological advancements, customization options, energy efficiency improvements, and sustainability initiatives to meet the evolving needs of modern manufacturing industries. By embracing these developments, double shaft pugmill mixers can continue to play a crucial role in facilitating efficient and reliable material mixing processes across a wide range of applications.

The best reading were observed when the temperature of fluid was relatively low.

Result

At the end of this design and development project, this is the compressive discussion on the work results and conclusion.

FEA Analysis

The FEA Analysis help us to simulate an environment to check the endurance of component in extreme situation. In future heavy boxes are going to be used on conveyor so additional weight is considered.

Stress Analysis

Stress analysis is a process used in engineering and materials science to determine the internal forces and stresses within a structure or material under various conditions.

Displacement Plot

A displacement plot shows how much each point in a structure moves or deforms when forces are applied to it. It's like watching how a structure stretches, bends, or twists when you push or pull on it. The plot helps engineers see which parts of the structure move the most and understand how it behaves under different conditions.

Factor of Safety

Factor of safety is the load-carrying capacity of a system beyond what the system actually supports.

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Stress plot

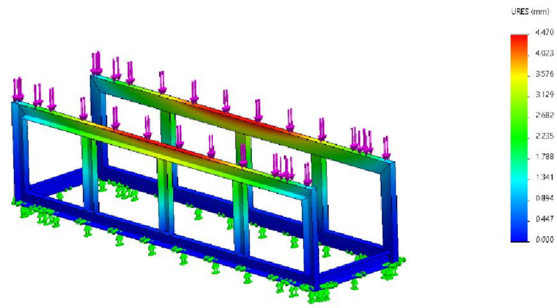

Fig 4.1 stress plot

Displacement plot

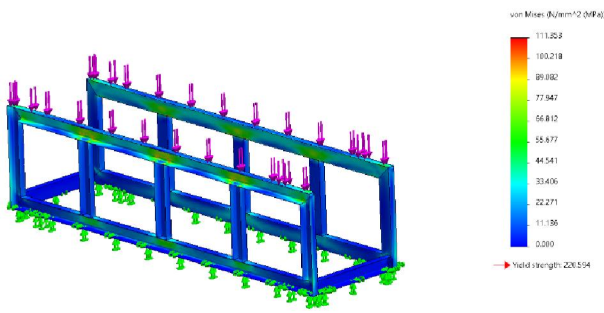

Fig 4.2 displacement plot

Factor of safety Plot

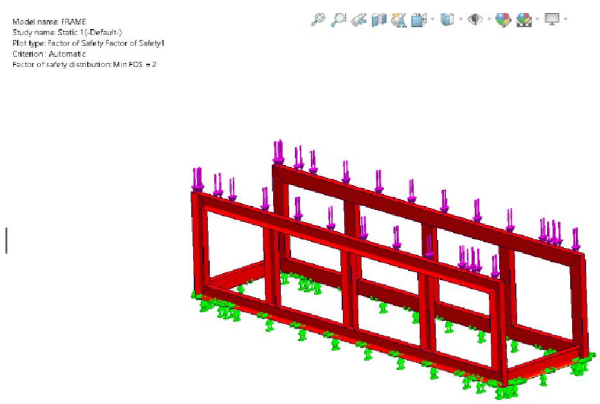

Fig.4.3 factor of safety plot

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Frame Analysis

Size	Stress	Displacement	FOS	Weight
120 x 60 x 5.5	91.56 MPA	3.1 mm	2.402	235.14 Kg
110 x 55 x 5.5	104.56 MPA	3.7 mm	2.104	210.36 Kg
100 x 50 x 5	111 MPA	4.4 mm	2	194.20 Kg
80 x 40 x 5	149.14 MPA	5.6 mm	1.47	176.21 Kg

Table 4.1 frame analysis

Stress Plot

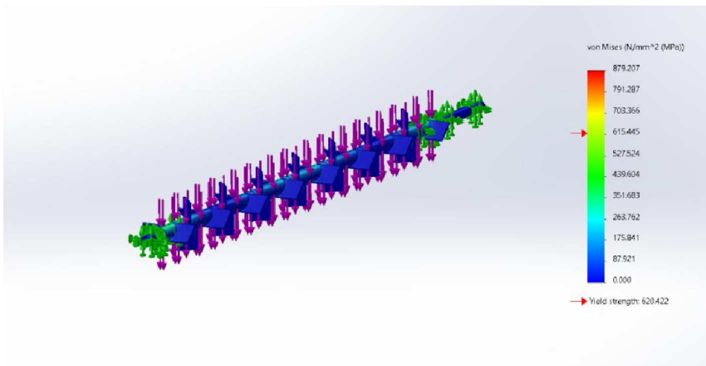

Fig.4.4 Stress plot for shaft

Fatigue Cycle of Shaft

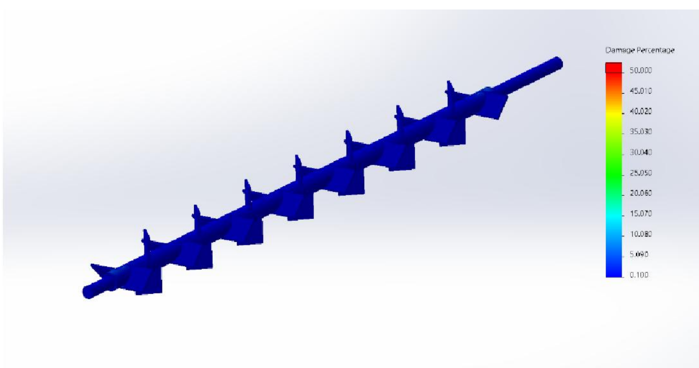

Fig.4.5 Fatigue Cycle of Shaft

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Shaft fatigue analysis (Final)

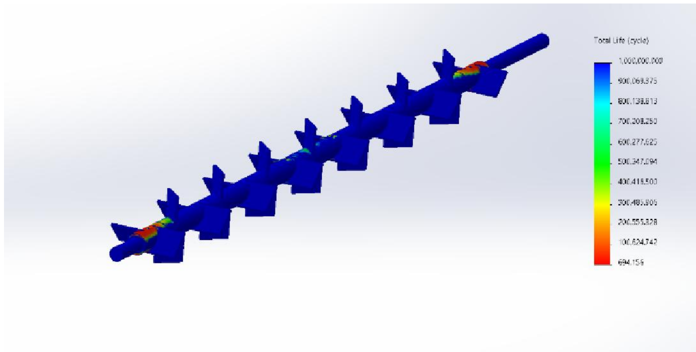

Fig.4.6 Shaft fatigue analysis (Final)

Discussion

Weight of Frame

During the analysis of the part we found out various stress and breakage points. Frame carrys most of the load of the assembly. In order to make the frame load bearable we make the proper selection of the material. The reduction in weight is from 289 kg to 194 kg and reduction in cost from Rs. 31790 to Rs. 21340.

Increase fatigue cycle of shaft

Fatigue life is a term used in fatigue testing and refers to the deformation and failure behavior of materials under cyclic loading.A fatigue life test with constant amplitudes is referred to as S-N test, where the tolerable stress amplitude is determined using the corresponding number of cycles.We increased the fatigue cycle of shaft.

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