Inter-IIT Tech Meet 12.0
Solinas: Product Design Challenge
Final Report

Team Number **35**

Abstract

The challenge is to design a retractable and extendable shaft for an agitator mechanism, allowing efficient blending of solid material or waste with liquid substances in tanks up to 5 meters deep. The main hurdles include the lack of flexibility and the considerable weight of the solid shaft, hindering its functionality in deep tanks.

1. Introduction

In the current market, conventional agitator mechanisms rely on rigid solid shafts for blending. These shafts, however, face limitations in deep tanks due to their lack of flexibility and excessive weight. Alternative solutions, such as flexible shafts, lack the required robustness for prolonged use in challenging environments. Moreover, existing options often lack user-friendly features for easy operation.

The primary challenge revolves around the adaptability of the shaft to varying tank depths. The team faces difficulties in achieving a design that allows the shaft to retract to 1 meter and extend to 5 meters seamlessly. Overcoming these challenges is crucial for the effective blending of waste within deep tanks.

Here, we proposed a solution for a retractable shaft covering length from 1m to 5m. Various aspects of the product, such as strength, efficiency, and ease of use. However, a few constraints are ignored due to time and team-size constraints. These majorly include opting for a wireless design, estimating the properties of slurry to be mixed, and cost.

Recognizing the importance of a stable and reliable power source, the team opted for a wired power supply solution. This decision was made to ensure consistent energy delivery, minimizing the risk of power interruptions during critical operations.

While cost implications are generally significant in engineering projects, the assumption is made that cost is not a limiting factor in this scenario. This allows the focus to be solely on achieving an innovative solution without budget constraints.

2. Shaft Design

2.1. Introduction

Shaft is the major component here, several factors must be carefully considered to ensure efficiency, safety, and reliability in shaft design, especially for agitator applications. Shaft load-carrying capacity is one of the major factors, with adequate load support capacity affected by impeller load and dynamic capacity. Material selection is a critical decision, requiring a careful balance of mechanical properties, including strength, durability, and corrosion resistance. In addition, the system must include a reliable self-retracting and locking mechanism for telescopic pole expansion and safe operation. Addressing concerns such as corrosion, water contact, etc., is crucial. Environmental resistance is important, and it can be achieved by proper material selection and coating. Factor in shaft rotation speed, selecting materials and designs capable of resisting centrifugal force and dynamic loads. Finally, the addition of safety features such as emergency stops and overload protection contributes to a complete and robust shaft design.

2.2. Shortcomings of Designs

Some designs were not taken into consideration during ideation because of the evident disadvantages. A few of these are mentioned below.

2.2.1 Single-Bearing Design

This design poses insufficient Load-Bearing capacity, rendering it unable to adequately support loads, leading to deflection. In addition, it has limited resistance to torsional forces, affecting overall stability. Finally, inadequate protection against corrosion and water exposure risks material degradation.

2.2.2 Chain-Driven Design

This design includes a complex mechanical arrangement that affects Load-Bearing Capacity, causing challenges in maintaining load-bearing capacity. It is very susceptible to misalignment and slippage, compromising overall performance. Moreover, the lack of reliable telescopic extension and retraction mechanisms could pose security concerns during operation.

2.2.3 Lock Twisting Mechanism

A lock-twisting design is prone to unexpected unlocking under twisting forces, impacting overall reliability. In addition, lack of resistance to high torsional loads can compromise overall stability.

2.3. Designs Considered

2.3.1 Screw-Driven Design

Advantages: It has a simple mechanical structure, facilitating ease of maintenance. Provides precise control over extension/retraction, ensuring accurate operation. Limited load-bearing capacity, but putting on a double bearing housing with it helps it work more efficiently.

Shortcomings: Requires careful monitoring and maintenance.

2.3.2 Chain-Locking based on lift telescopic shaft Design:

Advantages: Incorporates a mechanical locking mechanism, ensuring stability during operation. Allows for secure and precise positioning. Suitable for applications with intermittent depth requirements, offering versatility.

Shortcomings: Potential for wear and maintenance, necessitating regular inspections. Limited to specific depth ranges, potentially restricting adaptability.

2.4. Analysis of Chosen Designs

1. **Screw-Driven Design: Rationale:** Simple mechanical structure aids in easy maintenance but may limit load-bearing capacity. Precise control over extension/retraction ensures accuracy but requires attention to avoid jamming.

2. **Chain-Locking Design:**

   Rationale: The mechanical locking mechanism enhances stability but introduces wear and maintenance considerations. Versatility in-depth requirements may be compromised due to specific depth limitations.

2.5. Which design Chainlift Vs 6-stage Screw Mechanism?

Drive System: Screw-based systems use a giant steel screw that rotates to move a platform or cabin up or down. Chainlift-based systems use an electromechanical telescopic actuator that extends or retracts a rigid chain to lift or lower a load.

Motor Position: Screw-based systems have the motor at the top of the shaft, while chainlift-based systems have the motor at the bottom or the side of the shaft.

Strength: The screw-based telescopic shaft is generally stronger than the chainlift-based telescopic shaft, as it can withstand higher tensile and shear forces.

Though the strength of the screw-based system is more, it has a lesser load capacity as compared to the chainlift mechanism, where the screw mechanism works for a few thousand pounds effectively, thus it can hold our agitator without any issues. The 6-stage screw-based telescopic shaft is more compact and has a higher degree of precision than the chainlift-based telescopic shaft. It is also more suitable for underwater or sludge storage tanks of 5 meters in depth as it is waterproof and spark-proof. The expansion and retraction processes of the 6-stage screw-based telescopic shaft are user-friendly. On the other hand, the chainlift-based telescopic shaft is more suitable for applications that require high force transmission. However, it is less precise than the 6-stage screw-based telescopic shaft and requires more maintenance.

2.6. Material Selection

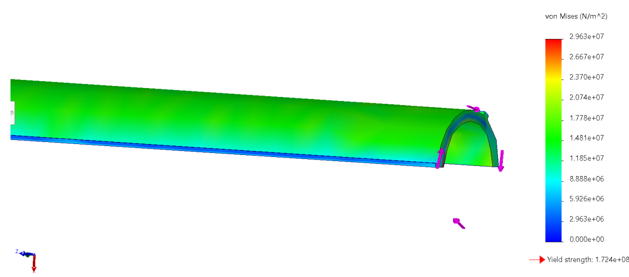

Figure 1. Stress analysis of a telescopic shaft under a 350Nm torque load

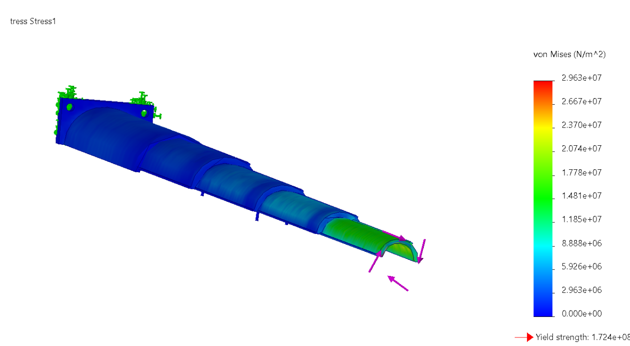

Figure 2. Applied torque at the extreme end

Analysis was run on SolidEdge to decide the material, looking into the stress and the tension values provided. Any other material having yield strength greater than 180 is also

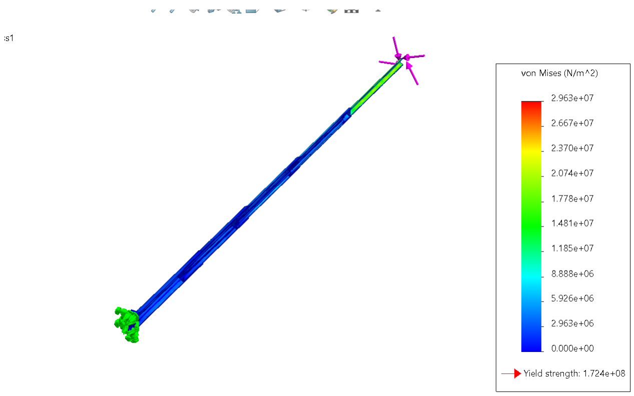

Figure 3. Isometric view of the meshed model,

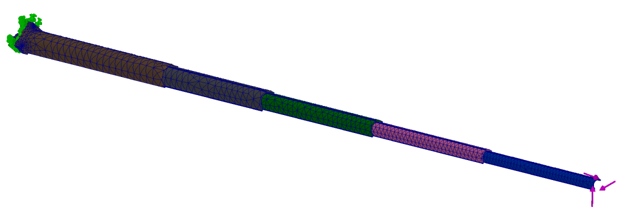

Figure 4. Frontal perspective highlighting stress distribution—color-coded for comprehensive visualization.

suitable. Austenitic grade steels include a face-centered cubic (FCC) crystal lattice and a γ-austenite structure that may dissolve up to 2% C in solid solution. The most appropriate is Type 316 SS's chemical composition and a few mechanical qualities (per ASTM standards).

Property	**Value**
Density	7800 kg/m^3
Poisson's Ratio	0.30
Elastic Modulus	193 GPa
Shear Modulus	86 GPa
Tensile Strength	515 MPa
Yield Strength	205 MPa

Table 1. Material Properties

Mathematically analyzing the material if the property holds.

2.7. Mathematical Calculation

Pull-Out Torque for Motor (M_{pt}):

$$M_{pt} = \text{Factor for Pull-out Torque} \times M'_T$$

Where,
Factor for Pull-out Torque:

- 1.5 for Light Duty
- 2.5 for Heavy Duty

For Heavy Duty:

$$M_{pt} = 2.5 \times 350\,\text{Nm} = 875\,\text{N-m}$$

Stalling Force (F_s):

$$F_s = \frac{8 \cdot M_{pt}}{3D}$$

Where,

- M_{pt} (Pull-Out Torque for Motor): 875 N-m
- D (Length of the Shaft): 5 m

Calculating this gives $F_s \approx 466.6\,\text{N}$.
Bending Moment of Shaft at the Driving End (M_{bc}):

$$M_{bc} = F_s \cdot \text{length} = 2333.33\,\text{Nm}$$

Mass of Agitator (m): 250 kg
Density of Agitator Shaft (ρ): 7800 kg/m^3
Diameter of Agitator Shaft (D): Averaged as 0.06 m
Combined Stress:

$$\text{Combined stress} = \frac{32 \cdot M_{bc}}{\pi D^3} + \frac{4mg}{\pi D^2} + \text{length of shaft} \cdot \rho \cdot g$$

Calculating this gives an approximate value of 140 MPa.
Yield Strength of SS 316 is 210 MPa. Therefore, the material is suitable.

To calculate the minimum shaft diameter required for the agitator, we can use the torsional stress formula and rearrange it to solve for the shaft diameter (d):

$$\tau = \frac{16 \cdot T}{\pi \cdot d^3}$$

Rearrange for d:

$$d = \left(\frac{16 \cdot T}{\pi \cdot \tau}\right)^{1/3}$$

Given parameters:

- Torque (T): 350 Nm
- shear strength (τ): Tensile Strength/ root 3 i.e 120.54 MPa

Now, substitute these values into the formula:

$$d = \left(\frac{16 \cdot 350}{\pi \cdot 120.54 \times 10^6}\right)^{1/3}$$

Calculating this gives $d \approx 0.022\,\text{m}$ or 22 mm.
Therefore, the minimum required shaft diameter for the agitator, based on torsional stress considerations, is approximately 22 mm. We have chosen the diameter to be 28mm, which is perfectly well for the calculations.

Relation between Angle of Rotation and Length of Shaft

From the model of the shaft, the relation between the change in length of the shaft and the angle of rotation of the screw is given by:

$$\Delta\text{length} = \text{N} \times \text{overall pitch}$$
$$= \frac{\theta}{2 \times \pi} \times 8\text{ mm}$$

Hence, in order to expand/contract the shaft from length l_1 to l_2:

$$\text{Angle of rotation} = 2 \times \pi \times \frac{(l_2 - l_1)}{\text{overall pitch}}$$

Using a stepper motor, where 200 steps constitute 1 rotation:

$$\text{Number of steps} = 0.55 \times \text{Angle of rotation}$$

The sign of the number of steps signifies its direction (clockwise or counterclockwise).

Further, open-source libraries like AccelStepper can be used along with a microcontroller to signal the stepper drivers.

Circuitry for the Stepper Motor

The stepper motor can be driven by 24V power and two 5V signals using stepper motor drivers like A4988 and DRV8825.

The circuit diagram for the same is given below:

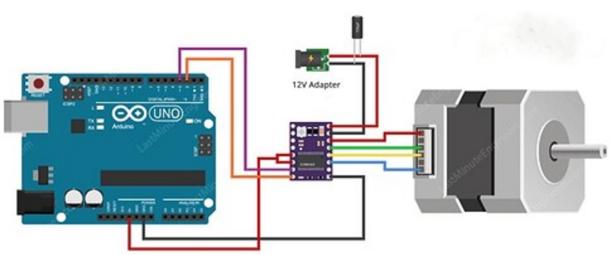

Figure 5. Stepper motor to driver and arduino

3. Impeller design

When opting for an impeller in mixing applications, several critical factors come into play. It is imperative to confirm that the impeller aligns with the viscosity and shear sensitivity of the materials being mixed. Additionally, the selection of the impeller is contingent upon the desired mixing intensity and uniformity within the specific application. Matching the impeller size to the dimensions and shape of the tank is essential for optimizing performance. Evaluation of power consumption, mixing time, and overall efficiency further guides the decision-making process. Equally important considerations involve assessing ease of maintenance, disassembly, and the smoothness of materials for convenient cleaning.

3.1. Design of Impeller considered

Anchor/Gate Impeller: Anchors/Gate type impellers are close-clearance impellers that fit the contour of the vessel. These impeller provide adequate mixing under the laminar flow conditions encountered in high viscosity applications for heat transfer. There are many applications that other type of impellers are integrated with the anchor.

Axial Flow impeller: This class of impellers produces an axial flow pattern. Because the liquid flows parallel to the axis that the impeller revolves around, this pattern is known as an axial flow pattern. Using angled blades, axial flow impellers normally pump the liquid in the tank downward. The contents in the top and bottom of the tank might mix thanks to this downward force on the liquids. Propellers and pitched blade turbines are the most popular axial flow impeller types for low to medium viscosity applications.

Radial Flow Impeller: Along the impeller's radius, radial flow impellers force the liquid out of the tank towards its side. Radial impellers don't have inclined blades as axial impellers do since doing so would drive the liquid downward. While radial flow patterns may be used to various processes, they are particularly helpful for gas-liquid and liquid-liquid dispersion. If radial impellers are not powerful enough to produce sufficient off-bottom suspension, they may leave solid particles on the tank's bottom.

This shows a Problem with the solid property, thus showing that Axial performs better in case for the slurry.

3.2. Chosen Blade design : Pitched Blade Turbine

Medium-High Shear, Low-High Viscosity – Axial Turbine Impeller (45° pitched blade) .The design of the PBT impeller provides a combination of both radial and axial flow, generates higher shear levels for reactions, and provides excellent mixing ability while providing easy cleanup. Because of the simple design, it is also very cost effective in large applications and higher viscosity applications. While useful in most applications, this design excels in aggressive mixing requiring high power input per volume as well as flow. Geometry is industry standard with a blade angle of 45 degrees.

Pitched blades are well-suited for the agitator mechanism in this scenario for several reasons: The pitched blades are designed to efficiently mix solid materials with liquids, making them ideal for creating a pumpable slurry. The pitched design helps prevent clogging by allowing solids to move easily through the blades, enhancing the blending process. Pitched blades can be designed in a way that complements the telescopic shaft, ensuring a compact and streamlined overall structure. Pitched blades are versatile and effective in a variety of substances, making them suitable for blending different types of waste in various environments.

3.3. Why Open Impeller Design?

Open impellers, featuring vanes attached to a central hub on a shaft, excel in preventing gas or fluid recirculation through a slight gap between vane ends and the pump casing. While effective, they demand precise tolerances, making them less suitable for oil and gas applications due to potential sparks from temperature-related shaft diameter changes. Closed impellers sacrifice some efficiency but eliminate the need for meticulous tolerances, using wear rings to prevent media recirculation. Despite being less accessible for maintenance, closed impellers are preferred for long-term cost-effectiveness. Open impellers, with inherently greater efficiency, are chosen for blending solid waste with liquids in deep tanks due to their flexibility and tolerance to solid materials. This design ensures effective handling of heterogeneous waste without clogging, providing smooth operation even in challenging environments like sludge storage tanks. Open impellers also offer practical advantages, including ease of maintenance, adaptability to variable shaft diameters, and enhanced safety by minimizing spark risks, essential for a portable and efficient solution in this application.

3.4. How many Impellers?

In the context of slurry mixing, a single-impeller system has some benefits, but they are outweighed by drawbacks that render it less efficient than a multi-impeller system. Single impellers are appropriate for less complicated applications with lower mixing intensity needs since they are easier to use, more affordable, and consume less energy. But, especially in difficult slurry conditions, they are unable to attain the same thoroughness and uniformity as multi-impeller systems.

One of the main disadvantages of a single-impeller system is its low mixing intensity, which could not be enough for uniform mixing in viscous or difficult slurry mixtures. On the other hand, the multi-impeller system is a more efficient way to achieve consistent and homogenous slurry mixtures because of its capacity to provide increased mixing intensity, better fluid dynamics, and better uniformity—especially in industrial applications where thorough blending and precision are critical. This clearly shows that we need multiple impeller system for our project.

A dual pitched impeller system is a type of pitched-blade impeller that has two sets of blades,each pitched at some angle. The dual pitched impeller system is designed to provide better mixing efficiency than a single pitched-blade impeller system. The two sets of blades work together to create a more uniform flow pattern and reduce dead zones in the tank. Additionally, the dual pitched impeller system can generate higher flow rates and lower power consumption than a single pitched-blade impeller system

In comparison, a flat pitched impeller system has blades that are flat and set at a zero-degree angle. This impeller type is suitable for low viscosity fluids and slurries. It is known for its high flow rate and low power consumption. Based on the problem statement, a dual pitched impeller system seems to be a better option than a flat pitched impeller system. The dual pitched impeller system can provide better mixing efficiency, generate higher flow rates, and lower power consumption. Additionally, it can reduce dead zones in the tank and create a more uniform flow pattern.

Therefore, It is logical to assume that a dual pitched configuration with high top clearance would give the best overall solid-liquid mixing performance.

No. of blades chosen : 4

A pitched blade system for mixing applications typically consists of four blades to balance efficiency and fluid dynamics. This configuration ensures an optimal flow pattern, reduced turbulence, better control over shear rates, balanced torque distribution, uniform suspension of solids, and energy efficiency. It also minimizes stress on the motor and other mechanical components, contributing to the longevity and reliability of the mixing system.

4. User Interface (UI) - Detailed Features:

The User Interface (UI) of the agitator mechanism is designed to be intuitive, user-friendly, and responsive. It includes the following key features:

Mechanical Countdown Timer Switch:

The Mechanical Countdown Timer Switch now operates as a dual-function component, serving as both the ON/OFF switch and the timer-setting mechanism. The timer switch incorporates a straightforward ON/OFF operation, enabling users to easily start and stop the agitator mechanism with a single control.

Figure 6. Mechanical Countdown Timer Switch

In addition to its ON/OFF functionality, the timer switch allows users to set a specific time duration for the operation of the blade motor. This consolidates control options and enhances user convenience. The timer switch is seamlessly integrated with the Arduino, providing the necessary input for both ON/OFF control and time-setting functionalities.

Shaft Length Control: The UI offers control over the retractable and extendable shaft length. Users can adjust the shaft length to suit the specific depth of the tank they are working with. The control mechanism involves a dial, providing a tactile and user-friendly input method. The dial, either in a round or linear form, serves as the input interface. The dial communicates user preferences to the microcontroller, which, in turn, issues commands to the stepper motor responsible for adjusting the shaft length. This design choice is made to enhance user comfort and convenience during operation.

Emergency Stop Button - Cut Power: An essential safety feature included in the UI is the Emergency Stop button. This button is designed to immediately cut power to the agitator mechanism in case of an emergency or if an unsafe condition is detected. It acts as a failsafe mechanism to ensure user and equipment safety.

Conclusion: The comprehensive UI integrates essential features for effective control and operation of the retractable shaft agitator mechanism. These features, including the ON/OFF switch, shaft length adjustment, and emergency stop, collectively provide users with a versatile and secure interface for managing the slurry mixing process. The design prioritizes ease of use, safety, and precision control to meet the project's objectives effectively.

5. Structure

5.1. Components

Motor Design (Stepper + Hydraulic) : The motor system is an integral part of the slurry homogenization process, with special emphasis on the importance of the stepper motor. The stepper motor plays an important role in controlling the cycle of the pitched blade impeller, allowing the slurry to be accurately mixed and controlled Its ability to move in discrete steps ensures precision during mixing operations. Furthermore, a hydraulic motor is used for telescopic movement, and a slip ring mechanism is connected to provide a smooth and continuous electrical current without interruption of the tangled wires this slip ring mechanism permits extension of the telescope shaft into and withdrawn easily without compromising operational reliability.

Shaft Design: The telescopic shaft is carefully manufactured from corrosion resistant stainless steel 316 (SS 316). The design uses a shield with a diameter from 28mm at the smaller shaft up to 120mm at the final stage is included, and provides flexibility and stability during the extension and retraction Being SS 316 material choice not only provides structural integrity but also provides resistance to corrosive elements of water and sludge content is enhanced, ensuring a reliable and robust telescopic shaft for slurry homogenization systems

Blade Design: The impellers are designed with pitched blades to optimize the slurry blending process. The pitched blades enhance fluid movement and promote effective homogenization within the tank. The choice of pitched blades ensures a balance between fluid agitation and energy efficiency, contributing to the overall effectiveness of the slurry mixing process. The diameter of the impellers is carefully calibrated at 80% of the tank diameter to achieve an optimal balance between blade size and tank dimensions.

Tolerance and Waterproofing Considerations: Besides proper telescopic construction, special consideration is given to the shaft surface. Carefully smooth out the inside and outside to minimize the tolerance between the telescope legs. This accuracy is necessary to maximize the strength of the structure. The watertight integrity of the system is not compromised by regular tolerances, even after heavy lubrication. The combination of carefully sanded materials, sealed lines and insulation forms a strong waterproof barrier. Importantly, adjusted tolerances also track maintenance and efficiency issues while the small difference left by the smoothing procedure reduces the chances of contamination or debris Thus two proposals for flexible and waterproof surface materials highlight the promise of reliable and flexible telescopes

5.2. Flow of Control

The operational sequence of the slurry homogenization system commences with the user inputting the desired length of the telescopic shaft, dictating the depth required within the tank for optimal slurry blending. The stepper motor, intelligently positioned near the top, employs precise steps to extend and retract the shaft smoothly, ensuring accurate adjustments. Slip rings come into play to facilitate the rotation of the entire structure, establishing vital electrical connections for the hydraulic motor situated at the uppermost part of the telescopic system. A noteworthy design aspect involves meticulous waterproofing measures, consisting of sealed joints and protective coatings applied to each telescopic stage, preventing water ingress and safeguarding the system's integrity during submersion. With the telescopic shaft securely extended and the hydraulic motor activated through the slip rings, the system seamlessly progresses to the rotational movement of the shaft. Simultaneously, the pitched blade impellers, strategically connected to the last and second last stages, commence their crucial role in mixing the solid material with the liquid to form a pumpable slurry. The combination of waterproofing measures and slip rings ensures the system's re-

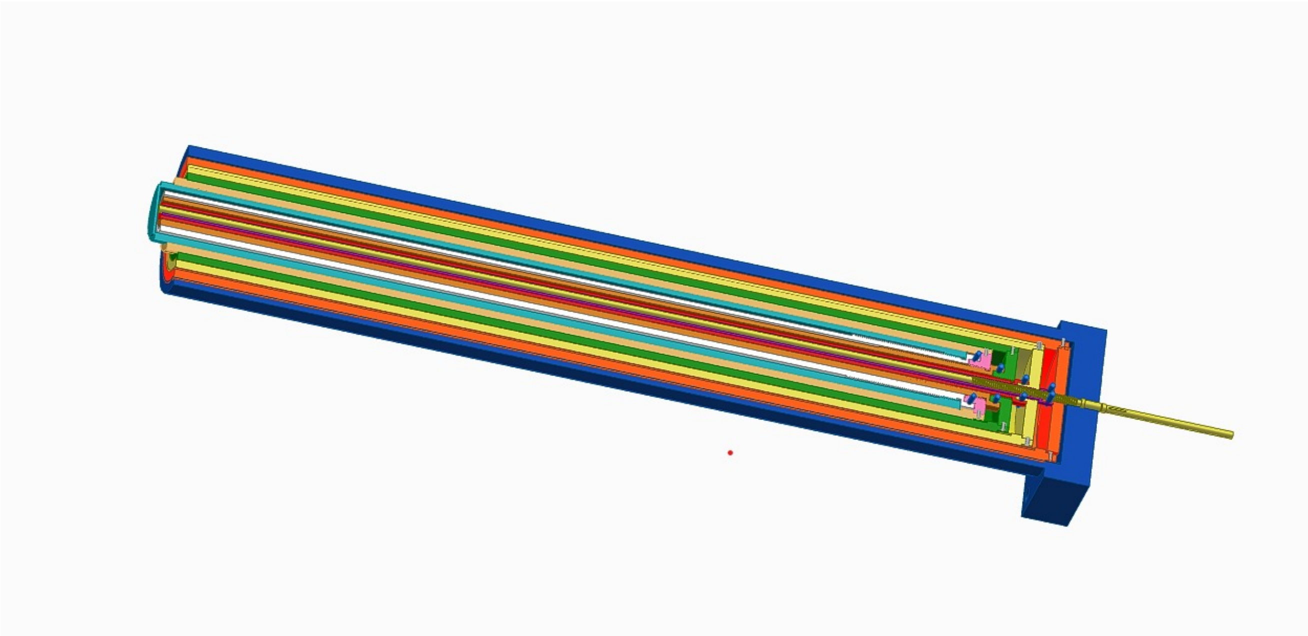

Figure 7. Shaft Structure

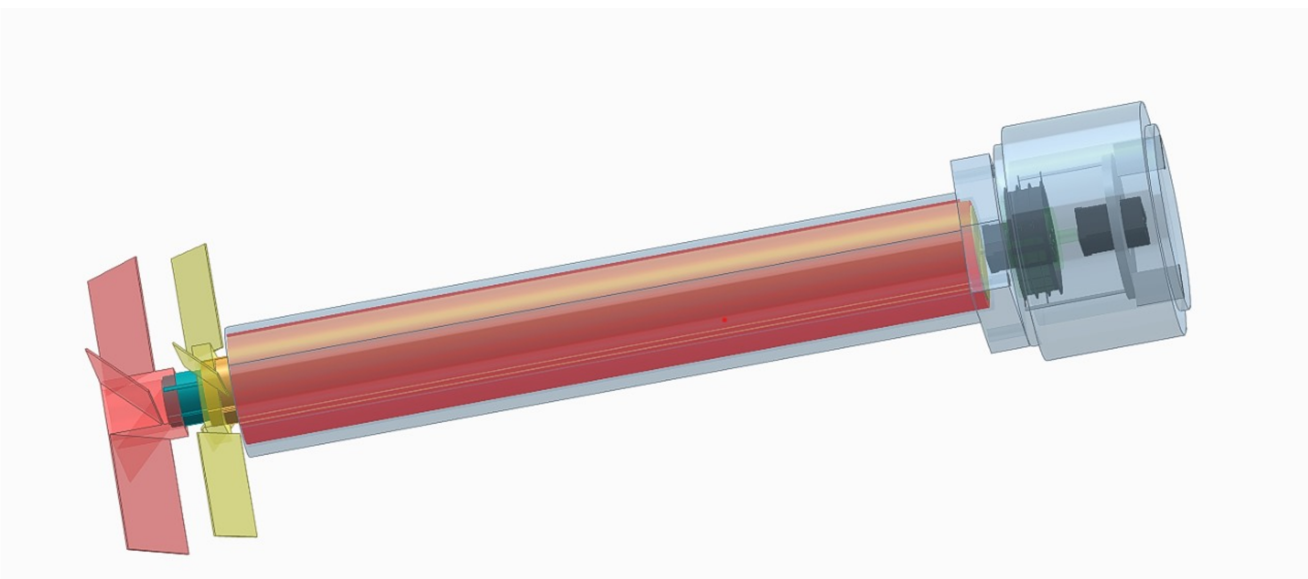

Figure 8. Final Model

silience against water penetration, facilitating efficient operation even in challenging underwater or sludge storage tank environments. The system continues to operate until the user-defined time limit is reached or manually turned off, offering users comprehensive control throughout the blending process.

6. Sequential Development Process

1. Introduction:

Understanding the Problem:

The project aimed to address the challenges faced by a team of engineers tasked with homogenizing solid material or waste with liquid substances in tanks with a depth of 5 meters. The main hurdle was the lack of flexibility and the considerable weight of the solid shaft used in the agitator mechanism. The team sought an innovative solution that would allow the shaft to retract to 1 meter and extend to 5 meters, be easily portable, and be suitable for immersion in deep tanks, considering waterproofing and spark-proofing.

2. Brainstorming and Design Considerations:

Ideation on Shaft Designs:

Brainstorming sessions led to exploring various shaft designs, including single bearing, chain mechanism, and lock-twisting mechanisms. After evaluating the pros and cons of each design, the team settled on a screw-driven design and chain-locking mechanism.

Motor Selection for shaft:

Considering the telescopic nature of the shaft, stepper motors were chosen after a thorough analysis of various motor types. The choice was based on the motor's suitability for the application and ease of integration with the telescopic design. The stepper motors provide precise movement and, hence, better control over the length of the shaft.

3. CAD Modeling and Component Selection:

Telescopic Shaft CAD Design:

The team proceeded to design the CAD model of the telescopic shaft, ensuring it met the criteria of expansion and retraction while being lightweight and portable. Special attention was given to the shaft's structural integrity and material selection.

Blade Design:

Multiple Pitched-blade impellers were chosen for efficient slurry mixing. The team opted for a two-blade system positioned strategically at last and second last stages of the shaft, with the blade motor situated at the top for optimal mixing efficiency.

Component Flow and Arrangement:

Careful consideration was given to the arrangement of components(deciding which component to place at what length) on the shaft to ensure smooth operation during expansion and retraction. The flow of components, including motors, slip rings and blades was optimized for maximum efficiency.

4. Analysis and Material Selection:

Using SolidWorks, the team conducted a comprehensive analysis of the shaft design, considering forces such as torque and stress. Material selection was then performed to strike a balance between weight and portability while ensuring structural integrity.

5. Waterproofing and Spark-Proofing Measures:

To address environmental challenges, protective coatings and sealed joints were implemented to ensure the shaft's waterproofing and spark-proofing, meeting safety standards for immersion in water or sludge storage tanks.

6. User Interface Design and Circuitry:

The team finalized a user-friendly interface featuring an on/off switch, timer, dial for shaft length control, dial for blade speed control, and an emergency stop button. The UI was designed to be intuitive and straightforward.

7. Circuit Design:

The circuit design was developed, specifying connections between components such as Arduino, switches, and dials. This ensured seamless integration of the UI with the telescopic shaft mechanism.

Conclusion

The step-by-step ideation process led to the development of an innovative telescopic shaft capable of expanding up to 5 meters, retracting to 1 meter, and effectively blending waste in deep tanks. The project addressed the challenges posed by the tank's depth, providing a portable and user-friendly solution for slurry mixing in various environments.

7. Future Work

A few ideas were not implemented due to some ideation challenges or hardware design difficulties. These include:

7.1. Speed Control for Impeller

Control over the speed of impellers can increase the utility of the product, allowing the same product to be used in multiple applications. The speed of the hydraulic motor depends on the rate of flow of hydraulic fluid. A tap-like mechanism can be used to vary this rate. However, due to the non-linear nature of the tap-rotation and speed relation, designing an easy-to-use tool is a challenge.

7.2. Sensing the bottom of tank

The proposed solution requires the user to specify the desired length of the shaft, i.e., the depth of the tank. One can automate sensing of this depth. However, the major challenge faced here is distinguishing between the tank's bottom and the semi-solid slurry.

Most common ideas are based on using an emitter-detector array or color detection. Since the slurry is generally thick and colored, setting a threshold for these detection techniques poses a challenge.

7.3. Oscillating Impeller

In the case of highly dense and viscous slurry, where the effect of blades is worn down at a smaller distance, having the impeller oscillate throughout the depth of the slurry can be helpful. However, to maximize the efficiency, one must know both the maximum and the minimum depth at which slurry is present. The current solution takes the maximum depth of slurry, i.e., the depth of the tank as input. However, taking another input from the user will complicate the UI flow and may cause difficulty in use. Hence, this idea was consciously dropped in this interaction. Further research and brainstorming on more input options can resolve this issue.

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