DESIGN AND FABRICATION OF A SMALL SCALE ARCHIMEDEAN SCREW HYDRO TURBINE

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Bachelors of Mechanical Engineering

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ABSTRACT

The design and fabrication of a small-scale Archimedean screw turbine is presented in this study. The Archimedean screw turbine is a type of hydrokinetic energy conversion system that harnesses the kinetic energy of flowing water and converts it into mechanical power. This technology offers several advantages, including simplicity, robustness, and the ability to operate in low head and low flow rate conditions.

The objective of this research is to develop a small-scale Archimedean screw turbine suitable for applications in small rivers, streams, or irrigation canals. The design process involves the optimization of various parameters, including the screw pitch, blade angle, and diameter, to maximize power output while considering the limitations of available resources and manufacturing techniques.

Computer-aided design (CAD) software is utilized to model and simulate the turbine's performance under different operating conditions. Computational fluid dynamics (CFD) analysis is employed to evaluate the flow patterns, pressure distribution, and efficiency of the turbine. The results from the simulation are used to refine the design and improve the turbine's performance.

Based on the optimized design, a small-scale prototype of the Archimedean screw turbine is fabricated using readily available materials and manufacturing processes. The construction process involves the assembly of the screw blades, support structure, and power transmission mechanism.

The findings of this study provide valuable insights into the design and fabrication of small-scale Archimedean screw turbines, contributing to the development of sustainable and renewable energy solutions. The future work on this project includes the testing of the prototype under controlled laboratory conditions and in real life location as well, and evaluating its performance in terms of power output, efficiency and stability. The research outcomes can serve as a basis for further optimization and implementation of

these turbines in various small-scale hydrokinetic applications, such as rural electrification, water pumping, and off-grid power generation.

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ABBREVIATIONS

W	Watts
kW	Kilo-Watts
MW	Mega-Watts
mm	Millimeters
m	Meters
m/s^2	Meters per second squared
m^3/s	Cubic meters per second
RPM	Revolutions Per Minute
Rad/s	Radians per second
Nm	Newton meters
AST	Archimedean screw turbine
CAD	Computer Aided Design
CFD	Computational Fluid Dynamics
MRC	Manufacturing Resource Center
TIG	Tungsten Inert Gas welding
2D	Two Dimensional
MS	Mild Steel

NOMENCLATURE

g	Acceleration due to gravity (m^2/s)
ρ	Density of water (kg/m^3)
H	Head (m)
Q	Flow rate (m^3/s)
N	Number of blades
ϑ	Inclination angle (°)
δ	Diameter ratio
λ	Pitch Ratio
K	Slope
L	Length of screw (m)
D_e	External diameter of screw (m)
D_i	Internal diameter of screw (m)
Λ	Pitch of screw (m)
n_{lim}	Upper threshold of turbine speed (RPM)
n	Calculated turbine speed (RPM)
ω	Calculated turbine speed (rad/s)
α	Angle of outer edge of screw blade with runner axis (°)
β	Angle of inner edge of screw blade with runner axis (°)
P_w	Total power acquired by water – hydraulic power (W)
η	Mechanical efficiency factor
P_s	Power transmitted to the shaft (W)
T	Torque acquired by the turbine (Nm)

CHAPTER 1: INTRODUCTION

1.1 Motivation of Work

The electricity sector of Pakistan is still in its developing phase. The problem of power shortage or electricity shortfall is pre-eminent in the history of Pakistan for decades. The roots of Pakistan's energy crisis can be traced back to the 1990s when the country began to experience a significant increase in demand for electricity due to rapid industrialization and population growth. However, the government failed to invest adequately in the power sector to meet this demand, resulting in chronic energy shortages and load shedding. In 2008, the energy crisis worsened, and load shedding became a daily occurrence across the country, lasting for hours and even days in some areas. As of today, according to the facts and figures stated by the Pakistan Economic Survey 2021-2022, it is surprising to note that the total generation capacity of Pakistan is found to be 41,557 MW, while the maximum demand of electricity for residential and industrial sectors stands at about 31,000 MW [1].

Today, load shedding continues to be a significant problem in Pakistan, with frequent power outages that disrupt daily life, hurt the economy, and affect the country's social development. The issue remains a top priority for the government and policymakers, who are working to find long-term solutions to the energy crisis.

1.2 Problem Statement

Although Pakistan has a power generation capacity that surpasses its demand, power outages still occur in the country due to three primary reasons. Firstly, approximately 26% of the population is still not connected to the national grid, and so is devoid of any electricity. Secondly, the country relies heavily on imported fuel to run its power plants, and during the times of dollar shortages, it becomes challenging to pay for the price of fuel. As a result of this, load shedding becomes a necessary step to be taken by the government. Lastly, however efficient may be our energy generation facilities, the line losses due to outdated and inefficient transmission channels are inevitable. This is substantiated by the fact that the transmission and distribution capacity is stalled at 22000 MW.

1.3 Project Objectives

Since hydel power contributes the most percentage share in the renewable energy sector, our prime focus for energy production is on hydroelectricity. Archimedean screws, used as turbines, is relatively a newer technology. The working models of Archimedean screw turbines are installed in United Kingdom, Canada and United State. Our team focuses on the design and fabrication of Archimedean screw turbine, and also takes into account the various factors that affect the efficiency of the turbine.

1.4 Project Management and Deliverables

The project is divided into different phases as shown below:

Figure 1: Different Phases of the Project

In the first phase of the project, comparison between various types of low head hydro-turbines for power generation was made, and the pros and cons of these turbines were considered. Archimedes screw was then selected and various research papers and other literature was studied to understand its design methodology. It also covered the approach used for calculating the design parameters of the turbine, the effect of these parameter on the efficiency of turbine, the material used for the fabrication of small scale existing models and the comparison of the already existing models of the real world. During the second phase, we conducted conceptual design and modeling of the turbine in order to determine the optimal parameters for our prototype. A number of conceptual designs were sketched and the best suit design was selected the final one. This involved considering cost and manufacturing technology constraints to ensure feasibility. In the next phase, CFD Analysis of the screw was carried out using the ANSYS software. The fourth and fifth phase involve the manufacturing of the screw and the assembly of the prototype respectively. The sixth and the last stage included the documentation of the overall project.

The deliverables of the project are shown in the figure below:

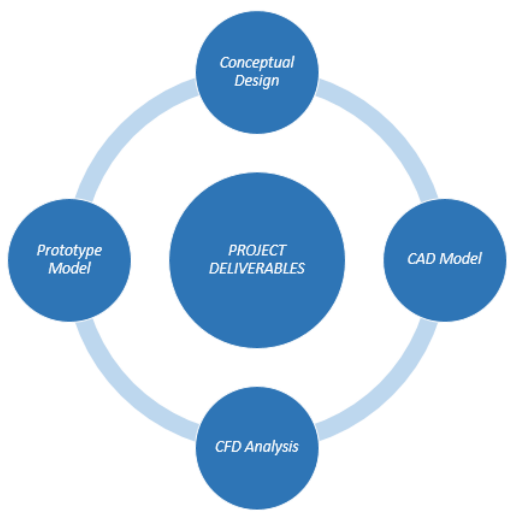


Figure 2: Deliverables of the Project

CHAPTER 2: LITERATURE REVIEW

The literature review section of the thesis provides a comprehensive overview of existing research and knowledge related to reaction turbines, specifically focusing on their comparison. Reaction turbines are widely used in various applications for harnessing hydraulic energy and converting it into mechanical power. They are characterized by their ability to operate under a range of heads and flow rates, making them versatile and suitable for diverse hydropower projects. We also aim to explore and analyze the characteristics of different screw turbines, that have wither been manufactured as prototypes or in real world applications. Each turbine possesses unique design features and operating characteristics that influence their performance, efficiency, and suitability for specific applications. By analyzing the available data from already existing turbines, we can gain valuable insights into their advantages, limitations, and areas of optimal utilization.

2.1 Comparison of Various Reaction Turbines

For the first part of the literature review, the comparison between the various subtypes of the reaction turbines, that are mainly used for lower heads and high flow rates applications, was made. The detailed study about the working conditions of each of the turbine, along with their costs and availability of components led us to select Screw Turbine over all the other types. The detailed comparison as made between the various reaction turbines is summarized in the tabulated form below:

2.1.1 Kaplan Turbine

Figure 3: Real Life Model of Kaplan Turbine

Minimum head requirements used for Kaplan Turbine are in the range of 1.5 to 60 m, however, they are generally used for heads less than 30 m. The power generated by Kaplan turbine ranges from 5 to 200 MW and they have efficiency typically above 90%, but it may be lower for lower head applications. The flow rate required for the operation of Kaplan Turbine ranges from 3 to 30 m^3/s. The maximum operating speeds of these turbines are found to be in the range of 54.5 to 450 RPM. These turbines generally require less space for installation. The unit cost of these turbines range from \$1000 to \$8000. These turbines are easily available and can be manufactured easily. Screw turbines are preferred over these turbines due to the following reasons:

- Kaplan turbines require large flow rates to produce electricity and for its efficient operation.
- Cavitation considerably affects the dynamic stability and the efficiency of these turbines, and reduces its operational life span by inflicting damages and fatigue on the turbine structure due to involved structural vibrations and material erosion.
- Installation of Kaplan turbines is generally harmful for the aquatic life due to its high speed rotation.

- ❖ The design and assembly of Kaplan turbine is generally complicated as compared to the simple and robust design of a screw turbine.

2.1.2 Francis Turbine

Figure 4: Real Life Model of Francis Turbine

Minimum head requirements used for Francis Turbine are in the range of 3 to 600 m, however, they are found to me the most efficient in the range of heads between 100 and 300 m. The power generated by Francis turbine ranges from few kW to 1000 MW and they have efficiency typically ranging between 80 and 95%. Medium to high flow rates are required for the smooth operation of Francis turbine. The maximum operating speeds of these turbines are found to be in the range of 75 to 1000 RPM. These turbines generally require medium space for installation. The unit cost of these turbines range from $700 to $1500. One of the components of these turbines i.e. runner is not readily available. Screw turbines are preferred over these turbines due to the following reasons:

- ❖ Water contaminated with dirt and debris can cause extremely rapid wear and affects the working of the Francis Turbine.

- The casing of the Francis Turbine is stranded, and it is generally hard to dismantle the runner from the turbine.
- The repair and inspection of these turbines are also reasonably harder.
- The phenomenon of cavitation affects the efficiency of the Francis turbine.
- Francis turbines are found to be less efficient for very low head applications.
- Francis turbine affects the aquatic life, especially when installed in environments with fish migration.

2.1.3 Waterwheels

Figure 5: Real Life Model of Waterwheels

Minimum head requirements used for waterwheels are in the range of 3 to 9 m. The power generated by waterwheels ranges from 37 kW to 200 kW and they have efficiency typically up to 60%. Flow rates ranging from 0.5 to 0.6 m^3/s are required for the smooth operation of these turbines. The maximum operating speeds of these turbines are found to be in the range of 5 to 14 RPM. These turbines generally require large space for their installation. The unit cost of these turbines are found to be starting from $1290 per foot diameter. These turbines are the first ever turbines used by the mankind for the generation of electricity, and so are readily available. Screw turbines are preferred over these turbines due to the following reasons:

- ❖ These turbines are generally heavy and require large space for their installation.
- ❖ Losses are incorporated with the overshot wheels due to their height and suspension.
- ❖ High initial torque is required for its smooth operation.
- ❖ Long distance transfer of energy using waterwheels is not possible.
- ❖ Requires expensive hydrological construction measures.
- ❖ Requires large quantities of water for its smooth working.

The generic parameters of the various subtypes of the reaction turbines are summarized in the tabulated form below:

Table 1: Comparison of Various Subtypes of Reaction Turbines

Sr. No:	**Subtypes of Reaction Turbines**	**Kaplan Turbines**	**Francis Turbines**	**Waterwheels**
1.	Minimum Head Requirements	1.5 – 60 m	3 – 600 m	3 – 9 m
2.	Efficiency	Up to 90%	80 – 95%	Up to 60%
3.	Space Requirements	Requires less space	Requires medium space	Requires larger space
4.	Maximum Operating Speed	54.5 – 450 RPM	75 – 1000 RPM	5 – 14 RPM
5.	Cost Analysis	$1000 - $8000	$700 - $1500	$1290/foot diameter

2.2 Archimedes Screw Turbine

An Archimedean screw turbine (AST), also known as Archimedean Screw Generator (ASG) or simply an Archimedean Turbine, is a type of hydroelectric turbine that uses the rotation of a large screw-like device, to generate electricity. Archimedes screw consists of a large screw shaped rotor that is mounted inside a concrete or steel trough. The rotor consists of a central shaft and a series of helical blades that are wrapped around the shaft in a spiral pattern. The screw is then rotated by the flow of water from a river or other water source. As the screw turns, it drives a generator that converts the mechanical energy of the rotating screw into electrical energy.

The Archimedean screw turbine is designed to operate in low-head, ranging from 0.1 to 10m, and high-flow conditions, ranging from 0.01 to 14.5m3/s. The screw can be configured with multiple turns to increase its output, and can be made to operate in either a vertical or horizontal orientation depending on the specific site conditions.

2.2.1 Working

Archimedes screw works on the principle of conservation of energy. Water is introduced into the top of the channel and flows down through the helical blades of the rotor, converting the potential energy stored in the water into its kinetic energy. As the water passes through the blades, it creates a force that rotates the shaft of the turbine, hence this kinetic energy is converted to the rotational mechanical energy of the turbine. The rotational energy of the shaft is then transferred to a generator, which converts the kinetic energy into electrical energy that can be used to power homes and businesses. Occasionally, a gearbox is coupled to the turbine shaft, prior to the generator, to amplify the rotational kinetic energy, which is subsequently transmitted to the generator as an input. By doing so, the efficiency of the turbine is greatly enhanced.

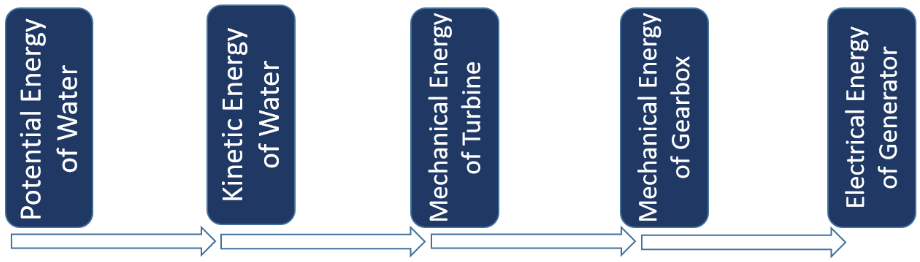


Figure 6: Working Principle of an Archimedean Turbine

2.2.2 Components Required

The main components of an Archimedean turbine are highlighted in the figure below:

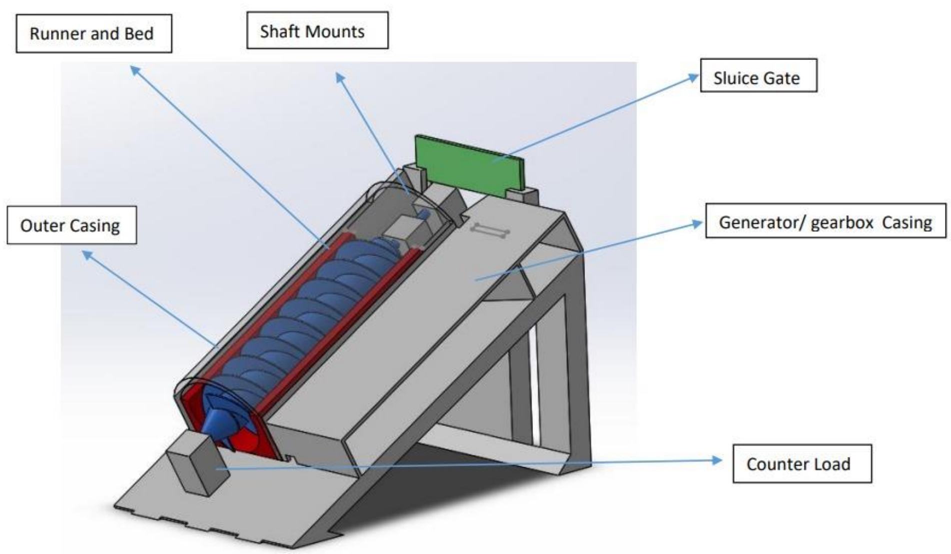


Figure 7: Main Components of an Archimedean Turbine

2.2.3 Advantages

Better Efficiency:

Screw turbines are highly efficient, with a conversion efficiency of up to 90%. This means that they can convert a significant proportion of the energy in the flowing water into electrical energy.

Low Maintenance:

Screw turbines have a simple design, which makes them easy to install and maintain. They also have fewer moving parts compared to other types of hydroelectric turbines, reducing the need for regular maintenance.

Low Environmental Impact:

Screw turbines are a low-impact form of hydroelectric power, as they do not require the construction of large dams or reservoirs. This means that they have a minimal impact on aquatic ecosystems and the surrounding environment.

Versatility:

Screw turbines can be used in a variety of water flow conditions, from low to high flow rates. They can also be used in a range of applications, including small-scale hydropower, wastewater treatment plants, and irrigation systems.

Cost Effectiveness:

Screw turbines are generally more cost-effective than other forms of hydropower, particularly for small-scale applications. This is due to their simple design, low maintenance requirements, and ease of installation.

Debris-Handling Capability:

Screw Turbines use features such as self-cleaning screens or grates to prevent large debris from entering the turbine. Additionally, the slower rotational speed of screw turbines compared to other types of turbines can make them better suited for handling smaller debris, such as leaves and sediment, without significant impact on their efficiency.

Marine Friendly:

Screw turbines have minimal impact on marine life, as they do not require the construction of large concrete structures or dams that can disrupt the natural flow of water or obstruct the movement of marine animals.

2.2.4 Applications

Archimedean screw turbines can be used in a variety of applications, from small-scale installations for individual homes or farms, to larger commercial installations that can generate several megawatts of electricity. The Archimedean screw turbine is designed to operate in low-head, high-flow conditions, which makes it particularly suited for use in rivers and canals where there is a large amount of water flow but not a significant amount of head (vertical drop). They are particularly well-suited for use in remote or rural areas, where they can provide a reliable source of clean energy without the need for expensive transmission lines or other infrastructure.

2.3 Data of Already Existing Models of Archimedes Screw Turbines

The operating conditions of different prototypes and real life models of ASTs are analyzed in detail and their summary is tabulated in the table below.

Table 2: Comparison of Operating Conditions of Different Screw Turbines

Sr. No:	**Reference Papers**	**Head**	**Flow Rate**	**Angle of Inclination**	**Maximum Power Output**
1.	Modelling and Experimental Results of an Archimedes Screw Turbine [2]	1 – 6.5 m	0.25 - 6.5 m^3/s	20° - 32°	1.7 – 300 kW
2.	Modelling the Energy Extraction from Low-Velocity Stream Water by Small Scale Archimedes Screw Turbine [3]	1 m	0.02 – 0.1 m^3/s	30° - 90°	1.54 kW
3.	Design and Performance of Archimedes Single Screw Turbine as Micro Hydro Power Plant with Flow Rate Debit Variations [4]	0.08 – 0.18m	0.003 – 0.02 m^3/s	30°	116.1 W
4.	Micro Hydro Power Plant using Sewage Water of Hayatabad Peshawar [5]	1.5 m	0.24 m^3/s	26°	1963 W

5.	Identification of Archimedes Screw Turbine for Efficient Conversion of Traditional Water Mills (Gharats) into Micro Hydro-power Stations in Western Himalayan Regions of India: An Experimental Analysis [6]	0.56 – 1.25 m	0.001 – 0.004m^3/s	20° - 50°	0.009149 kW
6.	A New Methodology to Design Sustainable Archimedean Screw Turbines as Green Energy Generators – Atlantic Botanic Garden [7]	1.2 m	1.2 m^3/s	22°	1.2 kW
7.	A New Methodology to Design Sustainable Archimedean Screw Turbines as Green Energy Generators – Saja River [7]	1.94 m	2.5 m^3/s	22°	35kW/Turbine

CHAPTER 3: DESIGN METHODOLOGY

In this chapter, the design procedure to calculate the geometric parameters of the Archimedean turbine is discussed in detail. The geometric parameters of the turbine, while keeping the limitations of manufacturing technologies and processes as well as the financial resources, are then optimized. CAD software is used to create a digital representation of the turbine and simulate its performance in various operating scenarios. Computational fluid dynamics (CFD) analysis is employed to assess flow patterns, pressure distribution, and efficiency. The findings from these simulations inform design enhancements aimed at optimizing turbine performance. Using the optimized design, a scaled-down version of the Archimedean screw turbine is fabricated using commonly accessible materials and manufacturing techniques. The construction process entails the assembly of the screw blades, support structure, and power transmission mechanism.

3.1 Design Calculations

The parameters of the screw turbine were calculated empirically using the methodology as referenced in one of the research papers [8]. This process was iterative as the procedure has to be repeated several times in order to get to the values, that made the final design of the turbine compatible to manufacture using the limited technologies and resources available to us.

3.1.1 Assumptions:

Following assumptions were made in order to calculate the geometric parameters of the turbine from the scratch:

- Head, H = 0.5m
- Flow Rate, Q = 0.001 m^3/s
- Number of Blades, N = 1
- Inclination Angle, $\vartheta = 42°$

(The optimum value of angle of inclination for number of screws; N = 1 was found to be of 45° [9].)

3.1.2 Important Findings:

For number of blades, N =1;

- ❖ Optimal Diameter Ratio, δ = 0.5358 [10]
- ❖ Optimal Pitch Ratio, λ = 0.1285 [10]

3.1.3 Formulae Used:

The geometric parameters of the turbine were obtained using the formulae given below:

- ❖ Slope, $K = tan\ \theta$
- ❖ Length of Screw, $L = \frac{H}{\sin\theta}$
- ❖ External Diameter of Screw, $D_e = (\frac{18.63*K*Q}{N\,(1-\delta^3)})^{\frac{3}{7}}$
- ❖ Internal Diameter of Screw, $D_i = \delta * D_e$
- ❖ Pitch of Screw, $\Lambda = \frac{\pi*\lambda*D_e}{K}$
- ❖ Upper Threshold of Turbine Speed in RPMs, $n_{\text{lim}} = \frac{50}{D_e^{\frac{2}{3}}}$
- ❖ Calculated Turbine Speed in RPMs, $n = \frac{931.4*K*Q}{ND_e^3(1-\delta^3)}$
- ❖ Calculated Turbine Speed in rad/s, $\omega = n * \frac{\pi}{30}$
- ❖ Angle of Outer Edge of Screw Blade with Runner Axis, $\alpha = \tan^{-1}(\frac{\pi*D_e}{\Lambda})$
- ❖ Angle of Inner Edge of Screw Blade with Runner Axis, $\beta = \frac{\pi*D_i}{\Lambda}$

3.1.4 Geometric Parameters

The values of the geometric parameters are presented in the tabulated form below.

Table 3: Geometric Parameters of the Prototype Screw Turbine

Sr. No:	Parameters	Dimensions
1.	Slope, K	0.9004
2.	Length of Screw, L	0.75 m
3.	External Diameter of Screw, D_e	0.26 m
4.	Internal Diameter of Screw, D_i	0.14 m
5.	Diameter of Shaft	0.14m
5.	Pitch of Screw, Λ	0.085 m
6.	Angle of Outer Edge of Screw Blade with Runner Axis, α	84.4°
7.	Angle of Inner Edge of Screw Blade with Runner Axis, β	79.64°
8.	Upper Threshold of Turbine Speed in RPMs, n_{lim}	122.7405 RPM
9.	Calculated Turbine Speed in RPMs, n	56.3884 RPM
10.	Calculated Turbine Speed in rad/s, ω	5.905 rad/s

3.2 CAD Model

Once the geometric parameters of the turbine are finalized; the next step is to make the CAD model of the AST. The CAD designing of the turbine is done using the SOLIDWORKS Software.

3.2.1 CAD Model of Screw Runner

The runner of the screw, including the shaft of the turbine as well as the blades of the screw are designed in the first step.

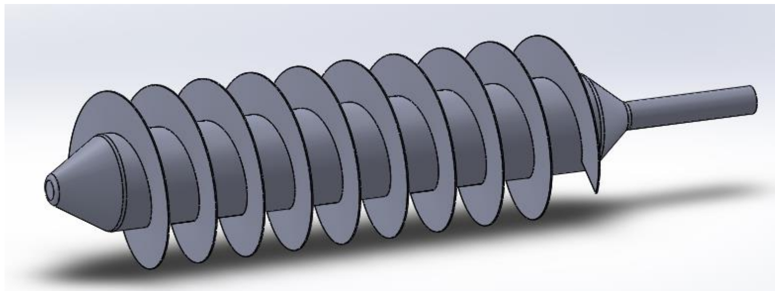


Figure 8: CAD model of Screw Runner

3.2.2 CAD Model of Bed

The bed of the Turbine along with mounts on each of its ends, to hold the runner in its place is then designed in the next step, providing minimalistic clearance for the water to flow in between the blades of the screw.

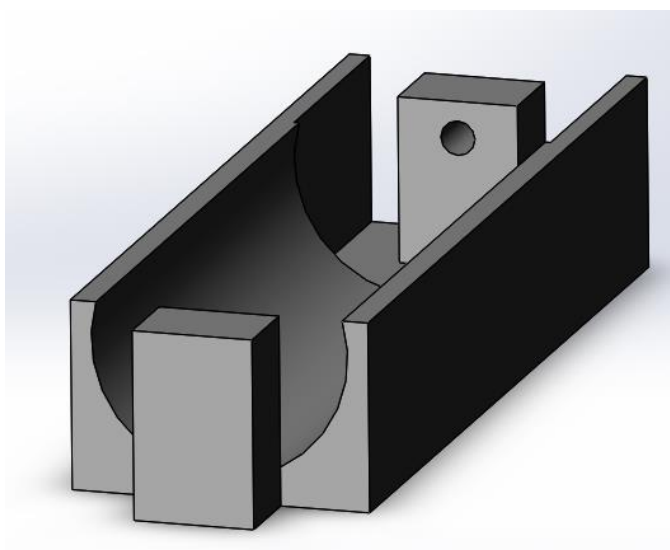


Figure 9: CAD Model of the Trough of the Turbine

3.2.3 CAD Model of Turbine Frame

The frame of the turbine, where the assembly of screw and trough is placed on one side, and the accessories and electronic components to make the turbine operate are attached on the other side, along with sluice gate opening, is designed in the next step.

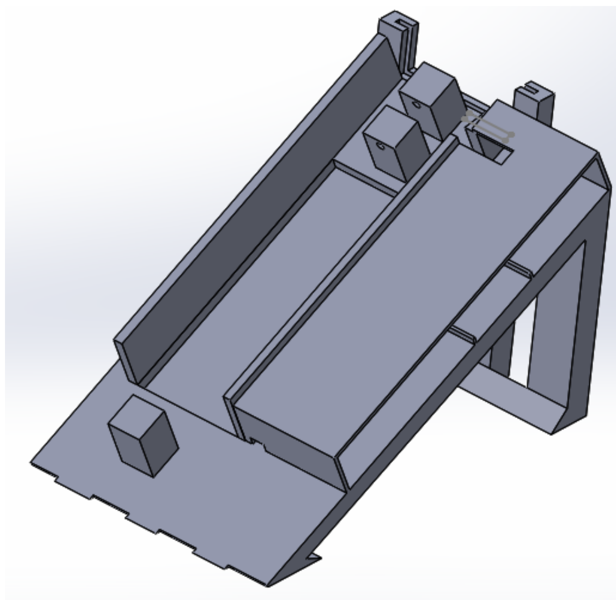


Figure 10: CAD Model of the Turbine Frame

3.2.4 Final Assembly of the Turbine

In the final step of CAD designing, the bed and screw is assembled on to the frame of the turbine using the mating feature. The final assembly of the designed prototype is shown below:

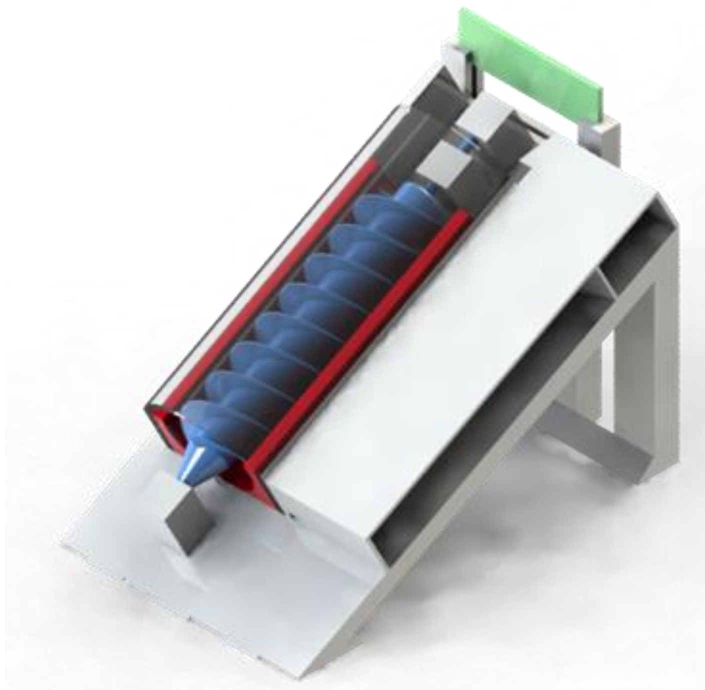


Figure 11: Final CAD Assembly of the AST

3.3 CFD Analysis

After the CAD model of Screw Turbine was complete, CFD analysis was performed on the screw turbine. The CFD analysis was performed using ANSYS Fluent software.

3.3.1 Geometry Definition

The first step in the analysis is the geometry definition. Geometry was defined in Ansys Space Claim. The screw turbine CAD file was loaded, and a hollow cylinder was created around it. The volume extract tool was used to create an enclosed domain around the screw turbine. The screw geometry and the hollow cylinder is no longer required after the volume extract is prepared. The domain was rotated at 42 degrees and the inlet and outlet for water flow were created.

3.3.2 Mesh Generation

Mesh generation is the next step of the analysis. First the Named selections for Inlet, outlet, turbine walls were created. Then the mesh preferences were set namely Physics Preference: CFD, Solver preferences: Fluent. Adaptive sizing was enabled and the mesh resolution was set to Finest (7). The mesh was then generated. The mesh is shown in the figure below:

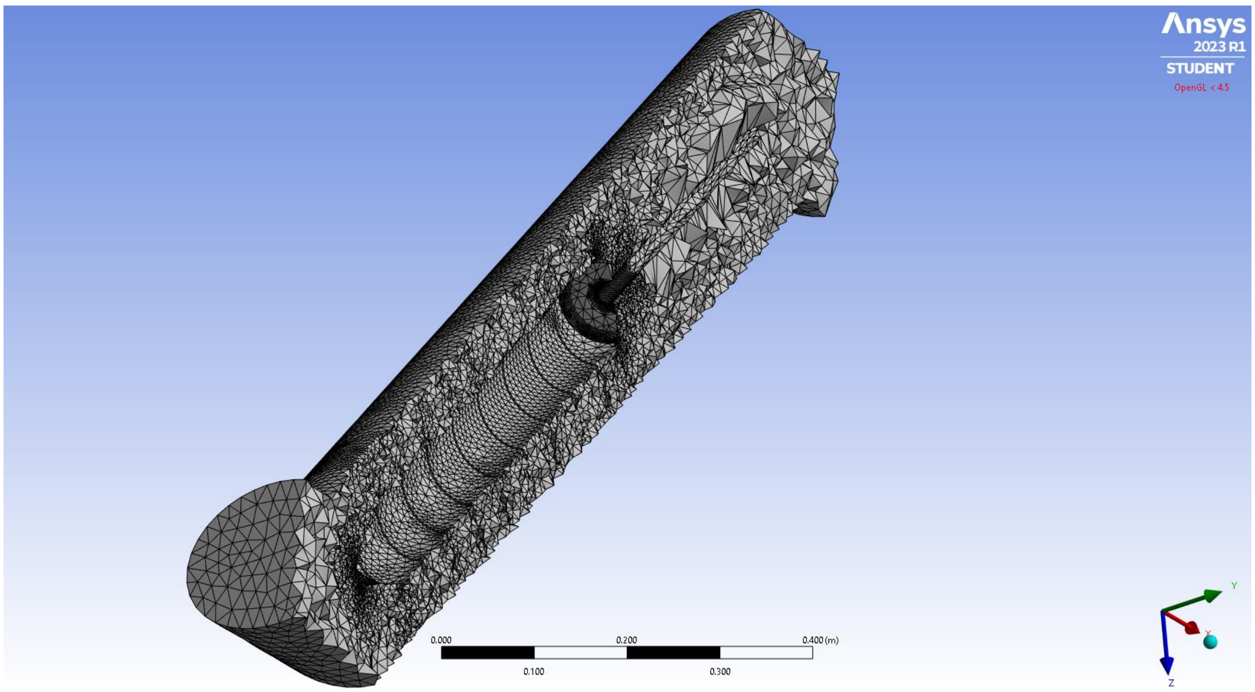


Figure 12: Mesh Generation for CFD Analysis

3.3.3 Turbulence Model

Next step is to select the turbulence model. Viscous (SST K-omega) was used to model turbulence since it is easier to use. It is an extension of the k-omega model that includes additional terms to account for the transport of the turbulent shear stress.

3.3.4 Defining Boundary Conditions

Defining cell zone conditions and boundary conditions is the next step. Water is selected as the fluid throughout the domain. At the inlet velocity-inlet is used and at the outlet, pressure-outlet is used. The turbine walls and the outer walls are defined as the walls with no-slip condition.

Hybrid Initialization was used. The gravity with the acceleration of 9.8 m/s^2 was also defined. Calculations were done for steady state with a time stamp of 0.01 seconds. Total 200 iterations were completed.

Force graph was plotted. Pressure, turbulence, and velocity contours were plotted.

3.4 Prototype Fabrication

We had limited manufacturing resources available to us in MRC, so we outsourced the fabrication process of the screw and bed assembly to a private industry. The manufacturing technologies and the fabrication processes incorporated to manufacture each of the component i.e. the screw and the bed is discussed in detail.

3.4.1 Manufacturing of the Turbine Bed and the Screw Runner

3.4.1.1 Manufacturing of Screw Shaft

Mild Steel of Grade 1040 of thickness 3 mm is chosen to form the shaft of the screw turbine using the following procedure:

- A cylindrical stock of appropriate dimensions, matching the desired final dimensions of the shaft, is selected. The length of the stock is found to be of 0.75m that is the length of the shaft of turbine.
- Six small holes of diameter 5 mm are to be made on the either side of the shaft that is at a distance of 15 mm from either of the edges. A boring tool in the lathe is used to carefully remove material from the internal diameter of the shaft, creating the desired internal features. Precise

measurements are taken and tight tolerances are maintained throughout this operation.

- The stock material is firmly mounted in a lathe chuck or collet, ensuring proper alignment and stability during machining operations.
- A lathe machine equipped with a cutting tool is used to perform the turning operation. The cutting tool removes excess material from the outer diameter of the stock, gradually reducing it to the desired diameter for the shaft of screw turbine i.e. 0.14m. The diameter is continuously measured and monitored using precision instruments to ensure accuracy.
- After the completion of the turning operation, the cutting tool is positioned perpendicular to the end of the shaft. Facing operation is performed to create a smooth and flat surface on the end of the shaft, thus ensuring proper alignment and mating with other components.
- Once the turning, facing and boring operations are completed, a final inspection is performed to ensure all dimensions, surface finishes, and tolerances meet the specified requirements. Additional finishing operations, such as polishing or grinding are also performed to achieve the desired surface quality.
- Quality control checks, including dimensional measurements and surface roughness analysis, are conducted to verify that the shaft meets the required standards.

3.4.1.2 Manufacturing of Screw Blades

Mild Steel of Grade 1040 of thickness 2 mm is chosen to form the blades of the screw turbine using the following procedure:

- A detailed design for the turbine blades, considering factors such as blade shape, size and curvature, is designed. The outer and inner diameter of the blades are designed to be 0.26m and 0.14m respectively. The inner diameter of the blades is the same as the outer diameter of the turbine shaft.

- Gas cutting techniques are used to cut the raw material into rough blade shapes, according to the design specifications. Safety protocols and precision measurements are followed to achieve accurate blade profiles.
- The gas-cut blades are mounted on a lathe machine and are secured firmly. A cutting tool is utilized to perform turning operations on the inside diameter of the blades, removing excess material and achieving the desired internal shape and dimensions.
- After the completion of the inside diameter turning, the turning process is continued on the outside diameter of the blades. The cutting tool is used to shape and refine the external profile, ensuring dimensional accuracy and achieving the desired outer surface finish.
- A pressing operation is employed to create the contours on the blade. This process involves using specialized tools and dies to shape the blades further, enhancing their aerodynamic properties and structural strength.
- The individual blades are assembled together by utilizing arc welding techniques. The blades are aligned according to the turbine design and are secured firmly. Appropriate welding procedures and welding electrodes are employed to perform high quality arc welding, ensuring strong and durable joints.
- Once the welding is completed, a thorough inspection of the blades is performed to detect any surface defects or inconsistencies. Suitable finishing techniques such as grinding, polishing and sandblasting are used to achieve the desired surface smoothness and remove any imperfections.
- Comprehensive quality control checks on the finished turbine blades, involving dimensional measurements, visual inspections and non-destructive testing, is conducted to ensure that the blades meet the required standards.

3.4.1.3 Manufacturing of Shaft Ends

Two Shaft Ends of Aluminum are manufactured and are attached to the either ends of the turbine shaft using the following procedure:

- Cylindrical stock material is selected that matches the desired dimensions of the shaft ends. The length of the shaft cap is found to be of 0.189m. The stock material should be of sufficient length to accommodate the required shaft end size.
- A band saw is used to cut the stock material into sections, corresponding to the length of the shaft ends. Precise measurements are taken and the stock material is aligned properly to achieve accurate cuts.
- The cut sections of the stock material are mounted on a lathe machine, and are secured firmly in a chuck or collet. A cutting tool is used to perform the turning operation on the outer diameter of the shaft ends. The outer and inner diameter of the shaft end is designed to be of 0.134m and 0.12m respectively. Excess material is gradually removed and the outer surface is shaped to meet the desired dimensions and specifications.
- Six small holes of diameter 5 mm are to be made on the either side of the shaft end that is at a distance of 10 mm from either of the edges. A boring tool in the lathe is used to carefully remove material from the internal diameter of the shaft end, creating the desired internal features. Precise measurements are taken and tight tolerances are maintained throughout this operation.
- After the completion of the turning operation, the cutting tool is positioned perpendicular to the end of the shaft. A facing operation is performed to create a smooth and flat surface on the end of each shaft, thus ensuring proper alignment and mating with other components.
- The dimensions of the shaft ends are continuously measured using precision instruments, such as calipers and micrometers, throughout the turning and

facing operations. Adjustments are made as needed to ensure accurate and consistent dimensions.

- Suitable techniques, such as polishing and grinding, are employed to achieve the desired surface finish on the turned and faced shaft ends. This step ensures the proper functioning within the turbine assembly.
- Thorough quality checks are conducted, including dimensional measurements and visual inspections, to verify that the shaft ends meet the required standards. Ensure that they are free from defects or imperfections that could affect their performance and durability.

3.4.1.4 Assembly of the Screw Runner

3.4.1.4.1 Shaft and Shaft Ends Assembly

The manufacturing procedure for assembling the shaft ends with the shaft of the turbine is outlined below:

- Ensure that the shaft ends and the corresponding holes in the shaft ends are accurately prepared for the riveting operation. This involves drilling and machining of holes to accommodate the rivets.
- Suitable rivets are selected based on the material and dimensions of the shaft and the shaft ends. Blind rivets of standard diameter of 6mm are selected for this operation. Factors such as rivet material, size and strength are considered to ensure a secure and durable assembly.
- The holes in the shaft ends are aligned with the corresponding holes in the shaft. The rivets are inserted into the holes and suitable riveting tools, such as a rivet gun, are used to set the rivets. The appropriate riveting techniques are followed; applying sufficient force to deform the rivet and secure the shaft ends firmly to the shaft.
- A thorough inspection of the riveted shaft and shaft end assembly is conducted to verify the integrity of the joints. Ensure that the rivets are

properly formed and the assembly meets the required dimensional and functional specifications.

- Finishing operations such as deburring and polishing are performed to ensure smooth edges and a clean appearance of the assembled components.

3.4.1.4.2 Screw Blades and Shaft assembly

The manufacturing procedure for assembling the blades of the screw with its shaft is outlined below:

- Ensure that the screw turbine blades are properly fabricated and prepared according to the required specifications. This includes accurately shaping and finishing the blades to the desired dimensions and surface quality.
- The screw turbine shaft is prepared by completing all necessary manufacturing operations including turning, facing and finishing the shaft ends.
- The blades with the shaft are aligned, ensuring that they are positioned correctly according to the turbine design. This alignment is crucial for achieving optimal performance and efficiency.
- TIG (Tungsten Inert Gas) welding is used to perform tack welding at strategic points to temporarily secure the blades to the shaft. These tack welds act as temporary joints that hold the blades I place during the final welding process.
- TIG welding is performed to permanently join the blades to the shaft. The appropriate welding procedures are followed, ensuring proper heat control and weld penetration to achieve strong and durable blade-to-shaft connections. Each blade is then welded individually while maintaining alignment and symmetry.

- A thorough inspection of the welded blade and shaft assembly is conducted to detect any defects such as weld discontinuities or structural abnormalities. Non-destructive testing methods, visual inspection and dimensional measurements are used to ensure the assembly meets the required standards.

3.4.1.5 Manufacturing of the Bed

The frame that houses the trough of the turbine is made of aluminum. End plates are also placed at the end of the frame to secure the housing of the turbine. The manufacturing procedure of each of these components is discussed in detail.

- Aluminum is selected for the fabrication of the bed frame, acting as the base, the housing and the end plates of the screw turbine bed. Factors such as strength, corrosion resistance, and compatibility with the operating conditions are kept in mind while selecting this material.
- Detailed designs for the bed frames, trough and end plates are developed, taking into account the dimensions, the structural requirements and integration with other components. Ensure that the designs meet the specified standards as are shown in the 2D drawings in the appendix later.
- Cutting techniques including sawing, shearing, and laser cutting are used to cut the raw material into sections that correspond to the different components of the screw turbine bed. Ensure accurate measurements and straight cuts to achieve proper alignment during assembly.
- Bending equipment, such as a press brake or roll bender, is utilized to shape the cut sections of the material into the required profiles for the base, trough and the end plates of the bed of the turbine. The design specifications are followed, and appropriate bending techniques are employed to achieve the desired curves and contours.
- The locations and dimensions of the hokes, openings and machining features required for mounting components, attaching the screw turbine, and

accommodating other necessary elements, are identified. Drilling machines and machining tools are used to create these holes and internal features. Ensure precise measurements and accurate alignments are maintained.

- The bent and the machined components of the screw bed are assembled using TIG welding. Appropriate welding techniques are employed to achieve strong and durable joints.
- Surface treatments such as painting, powder coating are applied to enhance the appearance and protect the bed frame, trough and the end plates against corrosion.
- Comprehensive quality control checks are conducted throughout the manufacturing process. These include dimensional inspection, visual examinations, and weld quality assessments to ensure that the machined components meet the required standards and specifications.

3.4.1.6 Assembly of the Turbine Bed and the Screw Runner

The procedure for assembling the screw bed with the screw runner of the turbine is outlined below:

- Ensure that all the components including the screw bed, screw runner, bearing post, spacer, pulley and miscellaneous components i.e. screws, washers, nuts and bolts, are clean and free from any debris or damage.
- The bearing post is placed at the top of the screw bed next to one edge of the bed. Ensure that it is aligned correctly and securely fastened using suitable fasteners such as bolts.
- The spacer is placed on the bearing post, ensuring it is properly aligned with the screw bed and the main screw’s intended position. The spacer provides a gap between the bearing post and the pulley, allowing the smooth rotation of the screw runner.

- The pulley is attached onto the main screw, ensuring that it fits securely. The pulley is aligned on the screw bed and fastened using screws and other appropriate fasteners.
- The main screw is inserted into the bearing post, passing it through the spacer and pulley. Ensure that the main screw is centered and properly aligned within the bearing post.
- Washers are placed on each end of the main screw to provide stability and prevent any wobbling and misalignment. The washers should fit snugly against the bearing post.
- The nuts are inserted onto the ends of the main screw and are tightened against the washers. Bolts are used to secure the nuts in place, ensuring a tight and secure connection.
- Ensure that the main screw is properly aligned with the screw bed and there is sufficient clearance between the screw and the bed for smooth operation.
- The main screw is then rotated manually to ensure smooth and unhindered movement. Binding, rubbing or abnormal noise during the rotation is observed. Adjustments are then made to ensure proper functioning.
- A thorough inspection of the assembled components, including checking for proper alignment, tightness of fasteners, and overall integrity. Ensure that all the connections are properly secured and meet the specified requirements.

3.4.2 Manufacturing of the Main Frame of Turbine

The manufacturing procedure of the main frame of turbine, that houses all the accessories and the screw runner of the turbine is outlined below:

- Mild Steel (MS) of 3mm thickness is chosen as the material for the main frame due to its strength and cost effectiveness.

- Angle bars are used for the frame structure, and MS sheets are riveted onto the frame to provide mounting areas for the screw turbine, trough, gearbox and generator.
- The optimal dimensions for the main frame are 1.12m length, 1m height, 0.8m width, with a hypotenuse of 1.5m making an inclination angle of 42°.
- Angle bars are cut to the desired lengths and welded to form the base and slope rectangles of the main frame.
- Arc welding is used to join the angle bars at each corner to create a sturdy structure.
- MS sheets are cut into the desired dimensions using a sheet metal cutter.
- The MS sheets are riveted onto the angle bar structure to complete the fabrication of the main frame.
- The sluice gate, used for controlling water flow, is also made from MS sheets.
- A 0.5m by 0.4m sheet is cut using a sheet metal cutter to serve as the slider sheet.
- Two smaller sheets are cut and bent using a sheet bending machine in the dimensions of 0.5m by 0.1m.
- The two bent sheets are now welded parallel to the ends of the bent sheet (0.4m by 0.1m).
- The slider sheet is inserted into the welded structure to complete the fabrication of the sluice gate.

3.4.3 Final Assembly

The final assembly of the Archimedean Screw Turbine is outlined below:

- All the necessary components are gathered for assembly, including the screw-bed assembly, main frame of the turbine, pulley belt system and alternator. Ensure that all the components are clean, free from damage, and in proper working condition.

- The screw bed assembly is placed onto the main frame of the turbine, aligning it with the designated mounting points. Make sure that the crew bed assembly is securely seated and is leveled on the main frame. suitable fasteners, such as bolts or screws, are used to attach and secure the bed assembly to the main frame.
- The pulleys are then mounted onto their respective shafts. Ensure that the pulleys are aligned properly and securely fastened. The belt is placed around the pulleys, making sure it is properly tensioned.
- The alternator is then attached to the main frame using welding operation, aligning it with the pulley-belt system. The shaft of the alternator is connected to one of the pulleys using a belt drive system. make sure that the connection is secure and properly aligned.
- The position of the pulleys and the tension of the belt is adjusted to ensure proper alignment and tensioning.
- Additional fasteners, brackets and support structures are used to secure and stabilize the pulley belt system, alternator and other components. Ensure that all the connections are tightened and adequately supported to prevent any movement or vibration during operation.
- Before operation, a thorough inspection is conducted of the assembled components. Any loose connections, misalignments or abnormalities are checked. Functional tests are then performed to ensure that the pulley belt system, alternator and electrical system are functioning correctly.

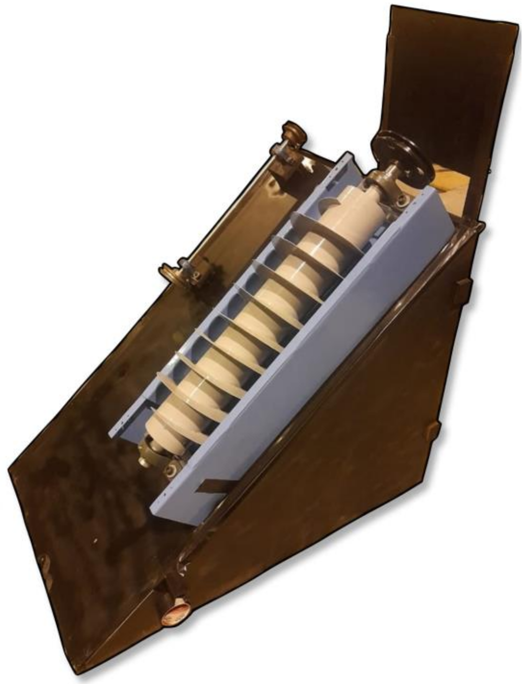


Figure 13: Actual Design of Final Prototype

CHAPTER 4: RESULTS AND DISCUSSIONS

The results and discussions provided in this part of the chapter comprehensively evaluate the performance of the fabricated Archimedean screw turbine. While the turbine has been successfully fabricated, the testing phase is yet to be initiated. Therefore, this analysis aims to empirically examine the turbine's operational efficiency, power generation capacity, and overall performance through rigorous testing procedures. The results obtained from these experiments will provide valuable insights into the turbine's performance characteristics, enabling a better understanding of its potential for renewable energy generation.

4.1 Analytical Results

Keeping in mind the assumptions that were made in the beginning of the fabrication process, following results are empirically obtained, determining the power acquired by the water, power transmitted to the shaft, and the torque acquired by the turbine.

The formulae used to calculate the parameters as mentioned above are given below, and their results are then presented in a tabulated form:

- ❖ Total Power acquired by Water, $P_w = \rho * g * Q * H$
- ❖ Power Transmitted to the Shaft, $P_s = \rho * g * Q * H * \eta$
- ❖ Torque Acquired by the Turbine, $T = \frac{P_s}{\omega}$

Table 4: Analytical Results of Output Power of AST

Sr. No:	Parameters	Results
1.	Total Power acquired by Water, P_w	4.8903 W
2.	Power Transmitted to the Shaft, P_s	2.9342 W
3.	Torque Acquired by the Turbine, T	0.4969 Nm

The power generated by an Archimedean screw turbine (AST) is inherently dependent on the flow rate of water. In the case where the flow rate is very low, as assumed to be $0.001m^3/s$ in our study, the power generation results are expected to be relatively low. However, it is important to note that by enhancing the flow rate of water, the power generation capabilities of the AST can improve significantly. Increasing the flow rate of water through the turbine would lead to a greater volume of water being engaged with the screw, resulting in enhanced rotational force and subsequently higher power output. Therefore, it is anticipated that with a higher flow rate, the results of power generated by the AST would exhibit a substantial improvement, illustrating the direct relationship between flow rate and power generation capacity.

4.2 CFD Analysis Results

The CFD results were promising, and the solutions converged without any abnormalities. Possible improvements to this would be to use the volume of fluid method, dynamic meshing and run the simulation on a rotating model, which would however require higher computing power.

4.2.1 Velocity and Direction of Water

In Computational Fluid Dynamics (CFD) analysis, the path lines depict the velocity and direction of water surrounding the screw in the Archimedean screw hydro turbine. These path lines provide a visual representation of how the water flows around the screw, illustrating the movement and trajectory of individual particles or fluid elements. By analyzing the path lines, we can gain insights into the flow patterns, areas of high and low velocity, regions of turbulence, and the overall efficiency of the turbine. This information is crucial for understanding the fluid dynamics and optimizing the design of the turbine to maximize power generation.

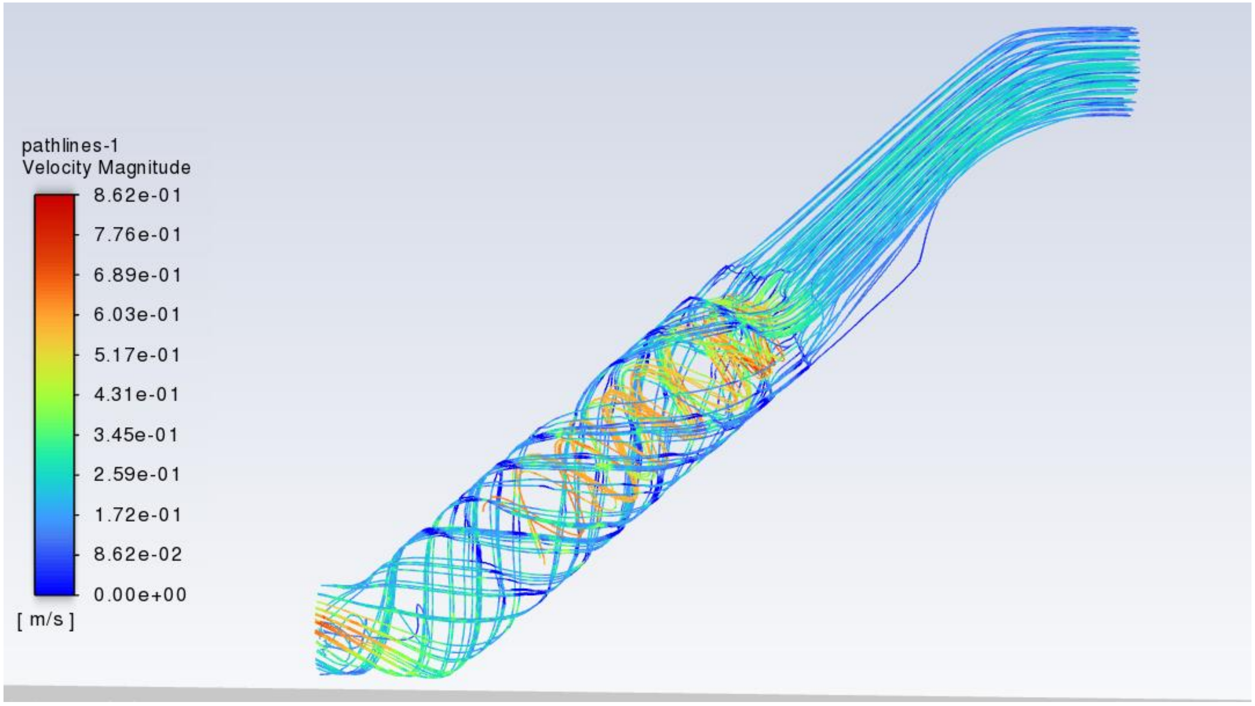


Figure 14: Path lines depicting the velocity and direction of water surrounding the screw

4.2.2 Static Pressure Contours

In Computational Fluid Dynamics (CFD) analysis, the pressure contour at different locations around the screw provides information about the distribution and magnitude of pressure in the fluid surrounding the Archimedean screw hydro turbine. The pressure contour map depicts variations in pressure levels, with different colors representing different pressure values. By examining the pressure contour, we can identify regions of high and low pressure, areas of pressure gradients, and any potential areas of stagnation or flow separation. This data is essential for assessing the efficiency and performance of the turbine, as it helps in understanding the pressure distribution and optimizing the design parameters to achieve optimal power generation and minimize losses due to pressure differentials.

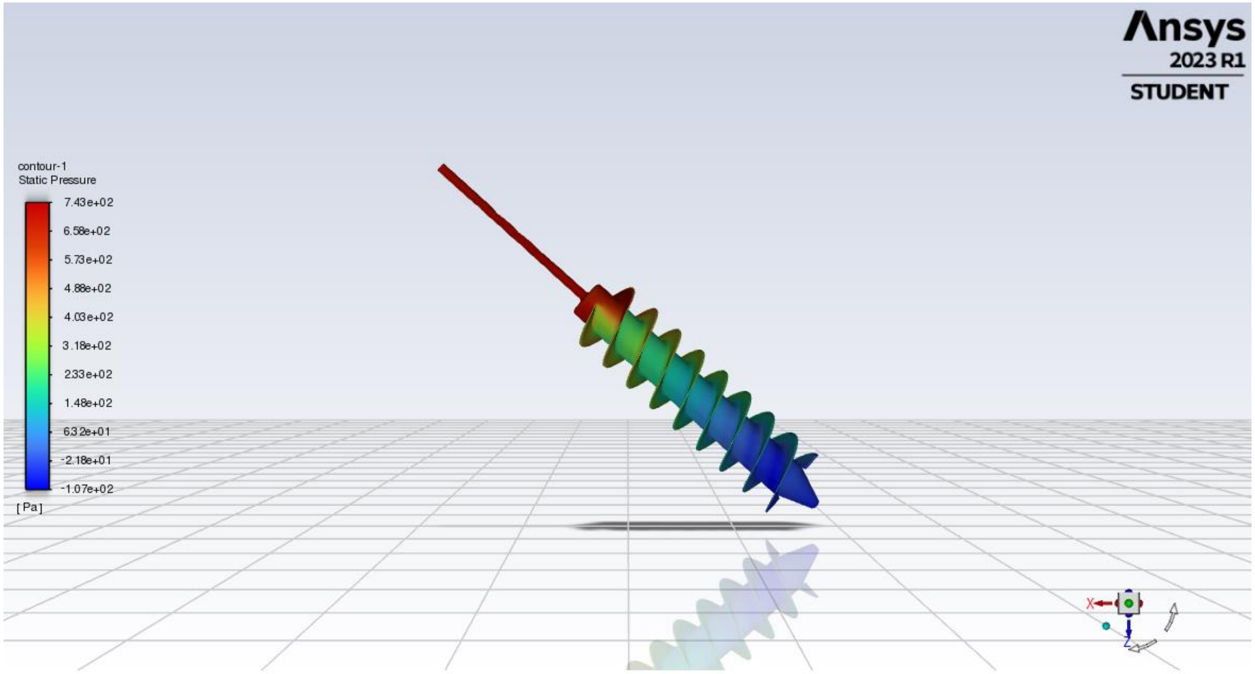


Figure 15: Static Pressure Contours at Different Locations around the Screw

4.2.3 Hydrodynamic Force Convergence

In Computational Fluid Dynamics (CFD) analysis, the hydrodynamic force convergence graph provides insights into the forces exerted on the Archimedean screw hydro turbine due to fluid flow. It plots the convergence of hydrodynamic forces over the iterations of the simulation. The hydrodynamic forces typically include components such as drag, lift, and torque.

The convergence graph indicates how well the simulation is converging towards a stable solution. It helps in assessing the accuracy and reliability of the CFD analysis results. A smooth convergence curve indicates that the solution has reached a steady state, implying that the forces have stabilized and the simulation is providing consistent and reliable data.

The hydrodynamic force convergence graph is important for understanding the impact of fluid forces on the turbine's performance. It can reveal the magnitudes and distributions of forces acting on the screw, helping in the evaluation of structural integrity, power generation capabilities, and overall efficiency. Additionally, it assists in optimizing the design by identifying areas of high force concentration, allowing for adjustments to enhance performance and minimize potential structural issues.

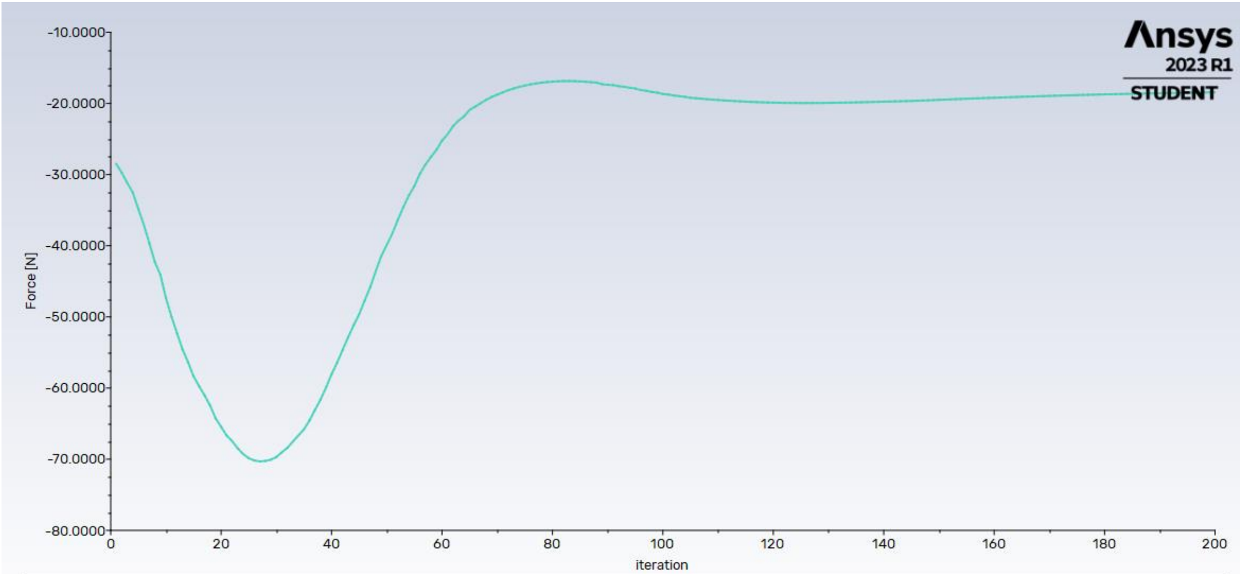


Figure 16: Graph Showing Hydrodynamic Force Convergence of Designed Model

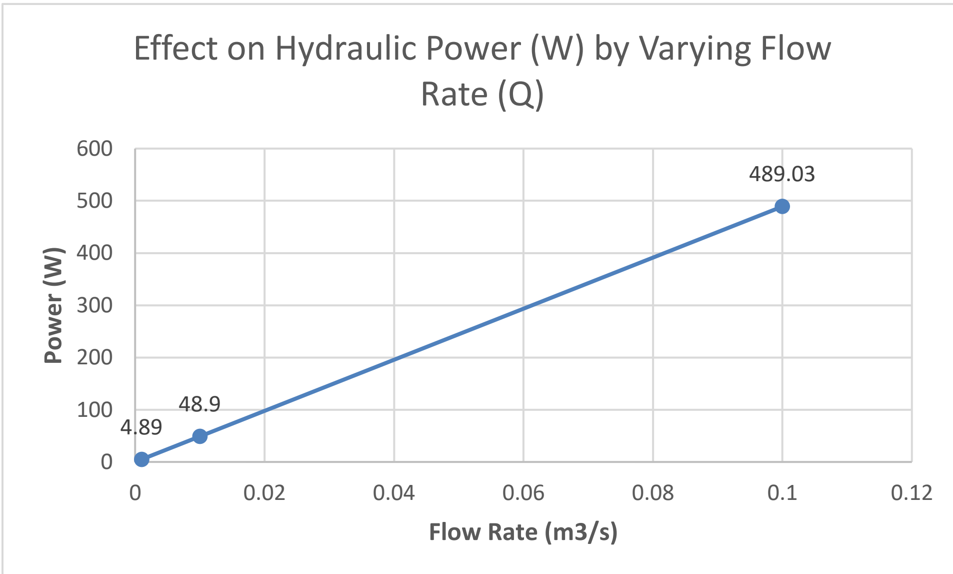
4.3 Empirical Analysis

While keeping the head (H), angle of inclination (ϑ), and number of blades (N) constant and varying the flow rate (Q) in an Archimedean screw turbine (AST), experiments can reveal the relationship between the flow rate and several parameters. Specifically, the following relationships between flow rate (Q) and hydraulic power(P), flow rate (Q) and rotational speed (n), and rotational speed (n) and hydraulic power (P) are depicted empirically.

The flow rate is varied from 0.001m^3/s to 0.01m^3/s and then 0.1m^3/s to evaluate the values of several parameters as output and the results are then plotted on the graph. Keep in mind that since the testing of turbine is yet to be performed, all these results are calculated empirically for analysis.

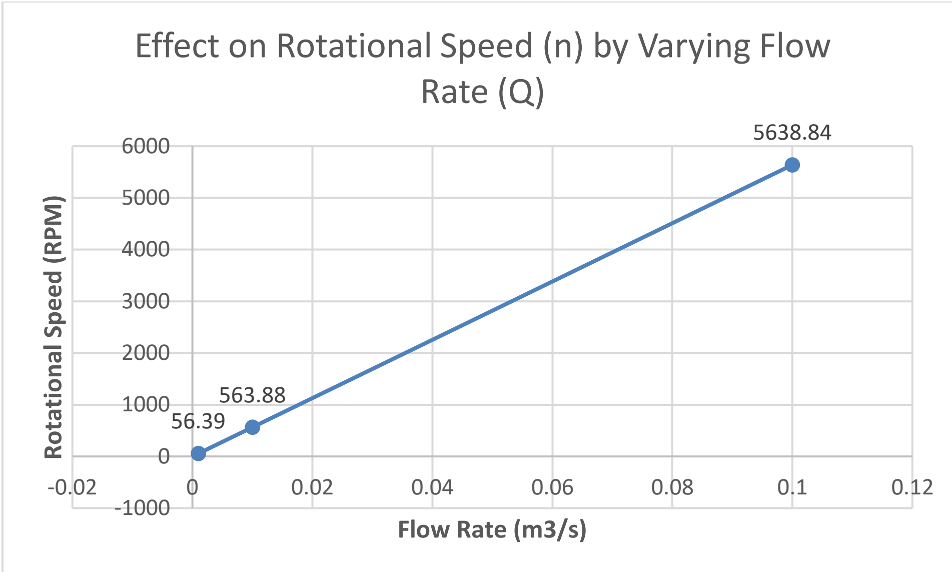
Relationship between Flow Rate (m^3/s) and Hydraulic Power (W)

The hydraulic power generated by the AST is directly proportional to the flow rate. As the flow rate increases, more water engages with the screw, resulting in a greater amount of hydraulic energy available for conversion into power. Therefore, increasing the flow rate typically leads to an increase in hydraulic power output.



Relationship between Flow Rate (m^3/s) and Rotational Speed (RPM)

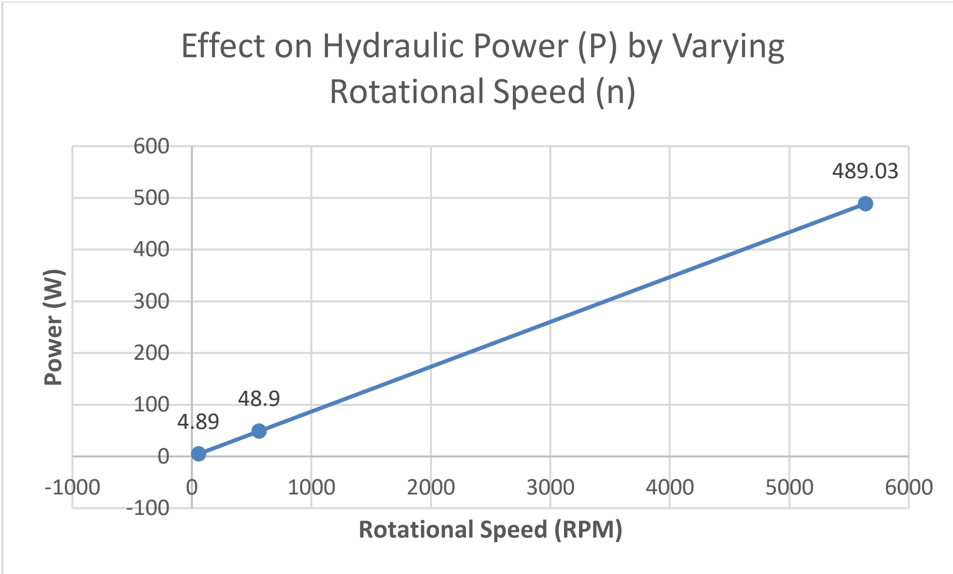
In general, there is a direct relationship between the flow rate of water and the rotational speed of the AST. As the flow rate increases, more water engages with the screw, resulting in a greater force exerted on the blades. This increased force causes the screw to rotate at a higher speed.



However, it is important to note that the relationship may not be linear and can be influenced by various factors, including the design of the turbine, the geometry of the screw, and the efficiency of the system. Additionally, there may be limitations on the maximum rotational speed achievable due to mechanical constraints or optimal operational parameters.

Relationship between Rotational Speed (RPM) and Hydraulic Power (W)

The hydraulic power generated by the AST is directly proportional to the rotational speed. As the rotational speed increases, the screw spins faster, resulting in a higher rate of water engagement and greater torque applied to the screw. This increased torque, when combined with the higher rotational speed, leads to an increase in hydraulic power output.



The relationships between various parameters of the small-scale Archimedean screw hydro turbine (AST) have been obtained theoretically. However, it is important to note that these results are based on analytical calculations and have not been validated through actual testing. The purpose of this study is to provide a theoretical framework and preliminary understanding of the turbine's behavior and performance.

The theoretical analysis has allowed us to establish relationships between the flow rate and hydraulic power, as well as the flow rate and rotational speed of the AST. These relationships have been derived considering constant values for head, angle of inclination, and number of blades, while varying the flow rate. It is anticipated that increasing the flow rate would result in a proportional increase in hydraulic power and rotational speed. However, it is crucial to validate these relationships through empirical testing to account for real-world complexities and factors that may influence the turbine's performance.

4.4 Deviation of Actual Results from Theoretical Results

The deviation between the analytical results and actual testing may occur due to several reasons.

- Firstly, the theoretical analysis assumes idealized conditions and simplifications, such as neglecting friction losses, inefficiencies, and the effects of turbulence. In reality, these factors can significantly impact the performance of the turbine and lead to deviations from the theoretical predictions.
- The accuracy of the analytical results is also contingent on the accuracy of the input data and assumptions made during the calculations.
- The design and fabrication process itself introduces uncertainties that can affect the performance. Variations in material properties, manufacturing tolerances, and imperfections in the geometry of the turbine can all contribute to deviations between the theoretical and actual results. Additionally, factors such as wear and tear, fouling, and environmental conditions can influence the performance during the operation of the turbine.

Given these limitations and potential deviations, it is imperative to conduct actual testing of the small-scale AST to validate the theoretical predictions and provide accurate performance data. The testing phase will involve measuring parameters such as power output, rotational speed, torque, and efficiency under real operating conditions. Through empirical testing, the actual relationship between the flow rate and the turbine's performance can be determined, enabling a more comprehensive understanding of the AST's behavior.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

We conclude the project with some recommendations for the future. In summary, our team has achieved all the project deliverables. We have completed tasks such as literature review, concept design, Computer Aided Modelling, calculations, empirical analysis, and fabrication of a prototype for a small-scale Archimedean screw hydro-turbine.

In this chapter, you can expect a summary of the project's timeline, an exploration of its potential, and suggestions for future improvements to be implemented.

5.1 Summary of the Project

The thesis successfully accomplished all the project deliverables for the design and fabrication of a small scale Archimedean Screw Turbine.

The project deliverables encompassed, in broad terms:

1. The development of the concept design involving the initial hand calculations of the geometric parameters of the turbine.
2. Creation of a Computer Aided Design (CAD) model
3. Performing Computational Fluid Dynamics (CFD) analysis
4. Fabrication of the prototype.

All the deliverables have been documented in this thesis.

The concept design phase involved the formulation of the overall structure of the AST, including the screw, bed, main frame, and other essential components.

The CAD model provided a detailed representation of the turbine's geometry, allowing for visual examination and virtual testing of its performance characteristics.

CFD analysis played a crucial role in evaluating the fluid flow behavior within the AST. This analysis provided valuable insights for further optimization and refinement of the AST's design.

Finally, the successful fabrication of the prototype marked a significant milestone in the project. The construction process involved the assembly of the screw, bed, main frame, and other supporting elements according to the designed specifications. The fabricated prototype served as a tangible manifestation of the theoretical and computational efforts, showcasing the practical application of the developed concepts.

5.2 Potential Improvements of the Project

Considering that the turbine has not been tested yet, there are several potential improvements that can be made to enhance the project. These improvements are based on theoretical considerations and the anticipated performance of the Archimedean screw hydro turbine (AST). Here are some suggestions for making the project better:

Experimental Testing:

Conducting comprehensive experimental testing of the AST is essential to validate the theoretical assumptions and obtain actual performance data. This will provide valuable insights into the turbine's efficiency, power generation capabilities, and hydraulic characteristics. The results obtained from the testing can be used to refine and optimize the design parameters further.

Design Optimization:

Utilize the results of the experimental testing to optimize the AST's design. This can involve adjusting, the number and shape of the blades, the dimensions of the screw, and the configuration of the bed. Optimization techniques such as computational modeling and simulation can also be employed to fine-tune the design parameters for improved performance.

Material Selection and Component Enhancements:

The choice of materials used in the fabrication of the AST can be re-evaluated, and potential upgrades can be identified consequently. Consider utilizing materials with higher strength-to-weight ratios, corrosion resistance, and durability to enhance the turbine's overall performance and longevity. Additionally, innovative manufacturing techniques and component enhancements can be explored to further improve efficiency and reliability.

Efficiency Enhancement:

Methods to increase the efficiency of the AST can also be investigated. This can involve analyzing the fluid dynamics within the turbine to minimize energy losses, reducing frictional losses by optimizing bearing systems, and enhancing the sealing mechanisms to prevent leakage. These improvements can lead to higher power generation and improved overall efficiency.

Cost-Effectiveness:

Opportunities for cost reduction can be explored through material sourcing, manufacturing efficiency, and streamlined assembly processes. The economic feasibility of scaling up the project for larger installations can be accessed to enhance its commercial viability.

By implementing these potential improvements, the project can be enhanced to achieve better performance, efficiency, reliability, and cost-effectiveness. It is important to continuously iterate and refine the design based on the actual experimental results and incorporate feedback from stakeholders to ensure the ongoing improvement of the AST.

5.3 Future Scope of the Project

The implications of the study highlight the significance of ASTs as a renewable energy solution, emphasizing their potential for localized energy production, cost-effectiveness, environmental benefits, technological advancements, and policy considerations. These implications provide a foundation for further research, development, and implementation of ASTs in the pursuit of sustainable energy generation.

Renewable Energy Generation:

ASTs have the potential to contribute significantly to the generation of renewable energy. By harnessing the power of flowing water, ASTs offer a sustainable and environmentally friendly solution for small-scale hydroelectric power generation. The study's findings highlight the feasibility and viability of ASTs as a viable option for renewable energy production.

Localized Energy Production:

ASTs can play a crucial role in providing localized energy solutions, particularly in areas where traditional power grids are inaccessible or unreliable. The outcomes of the study emphasize the importance of considering ASTs as an alternative energy source for remote communities or off-grid locations.

Cost-Effectiveness and Efficiency:

The detailed analysis of the AST's performance and efficiency provides valuable insights into its cost-effectiveness compared to other forms of energy generation. By optimizing the design and operational parameters, ASTs have the potential to offer an economically viable solution for decentralized power generation.

Environmental Impact:

The environmental implications of ASTs are significant. The study's findings can shed light on the positive environmental aspects of ASTs, such as their low carbon footprint and minimal ecological impact compared to conventional power generation methods. These insights can support the adoption of ASTs as a sustainable energy option.

Technological Advancements:

The study's exploration of the design, fabrication, and analysis of ASTs contributes to the advancement of hydro turbine technology. The findings can inspire further research and development in areas such as improving efficiency, enhancing materials, optimizing geometries, and exploring innovative configurations for ASTs.

Policy and Planning Considerations:

The implications of the study extend to policy and planning aspects. The insights gained from the research can inform policymakers, energy planners, and stakeholders in making informed decisions regarding the integration and promotion of ASTs within the broader energy landscape. This can involve developing supportive policies, incentivizing adoption, and integrating ASTs into renewable energy strategies.

The future implications of the study underscore the critical importance of further improvements and optimization of the Archimedean screw hydro turbine (AST) design, with an emphasis on the need for experimental testing to validate its performance and unlock its full potential.

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APPENDIX: ENGINEERING DRAWINGS

Figure below shows the 2D engineering drawing of the shaft of the AST.

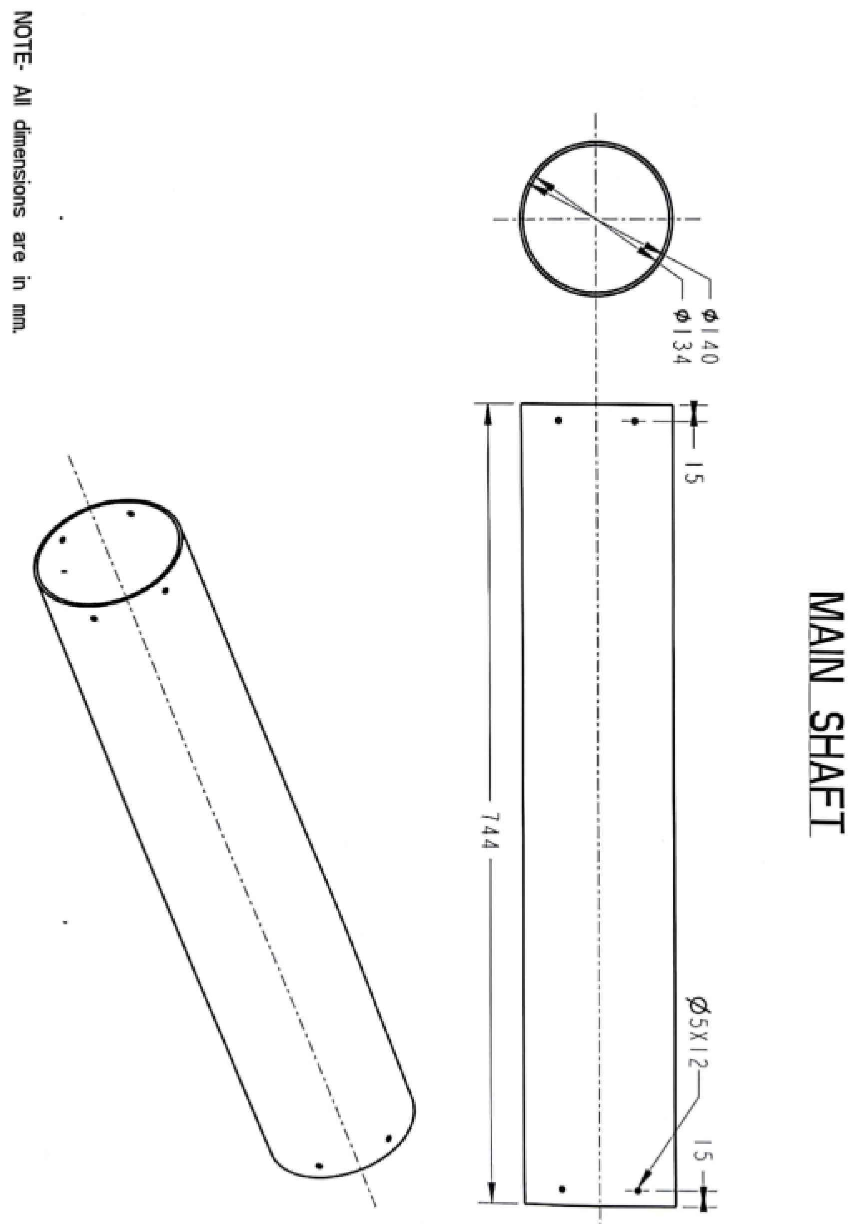

Figure 17: Engineering Drawing of Main Shaft

Figure below shows the 2D engineering drawing of the blades of the screw runner.

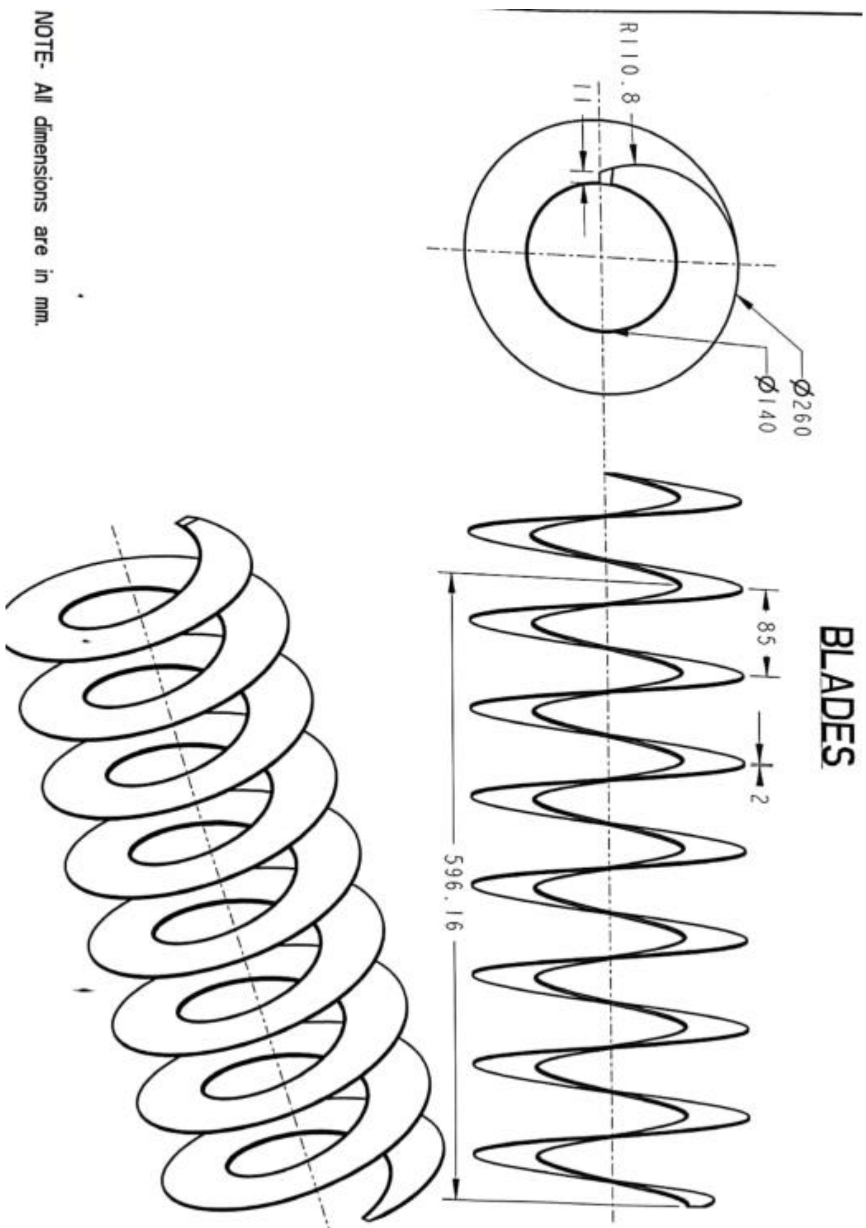

Figure 18: Engineering Drawing of Screw Blades

Figures below show the 2D engineering drawings of the shaft ends of the screw runner shaft.

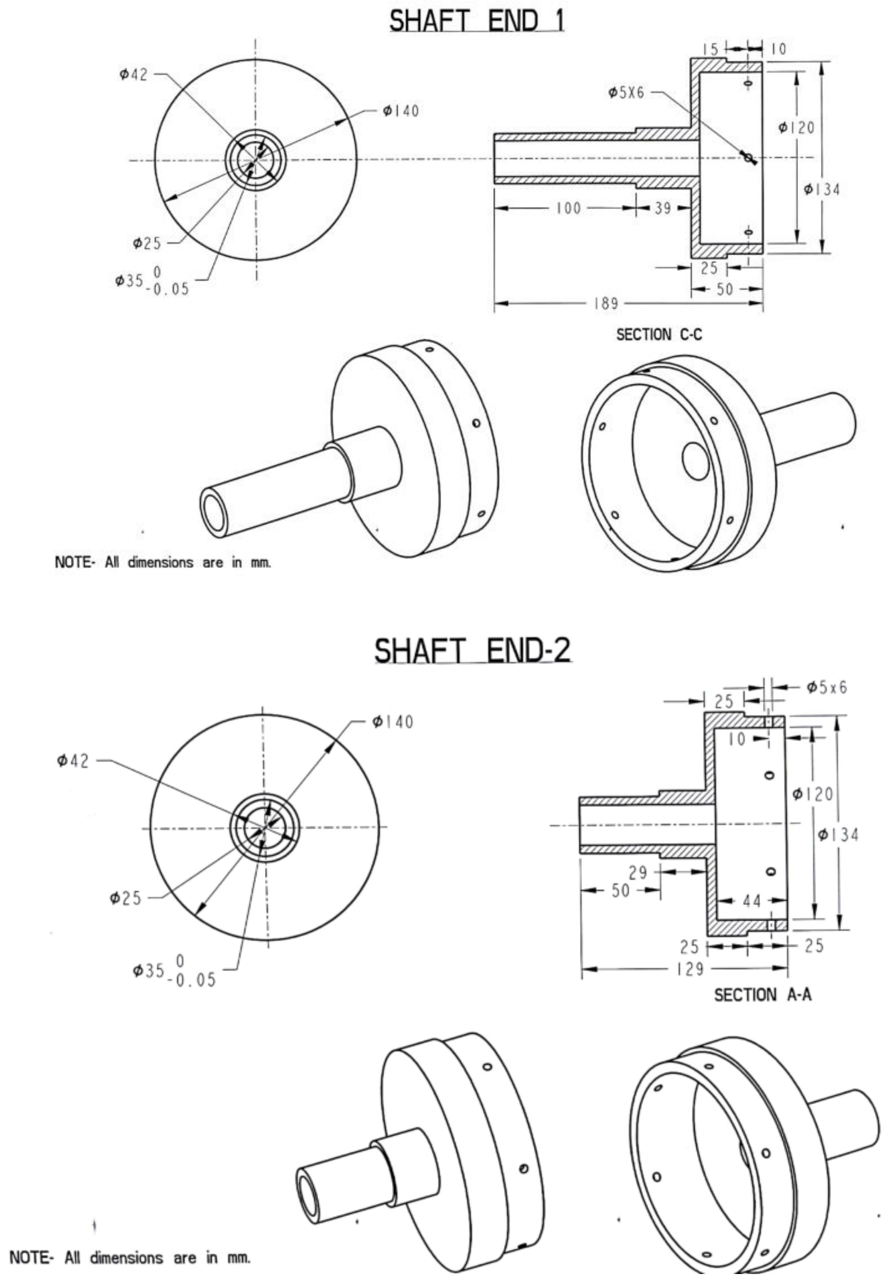

Figure 19: Engineering Drawings of Shaft Ends

Figure below shows the engineering drawing of the screw assembly

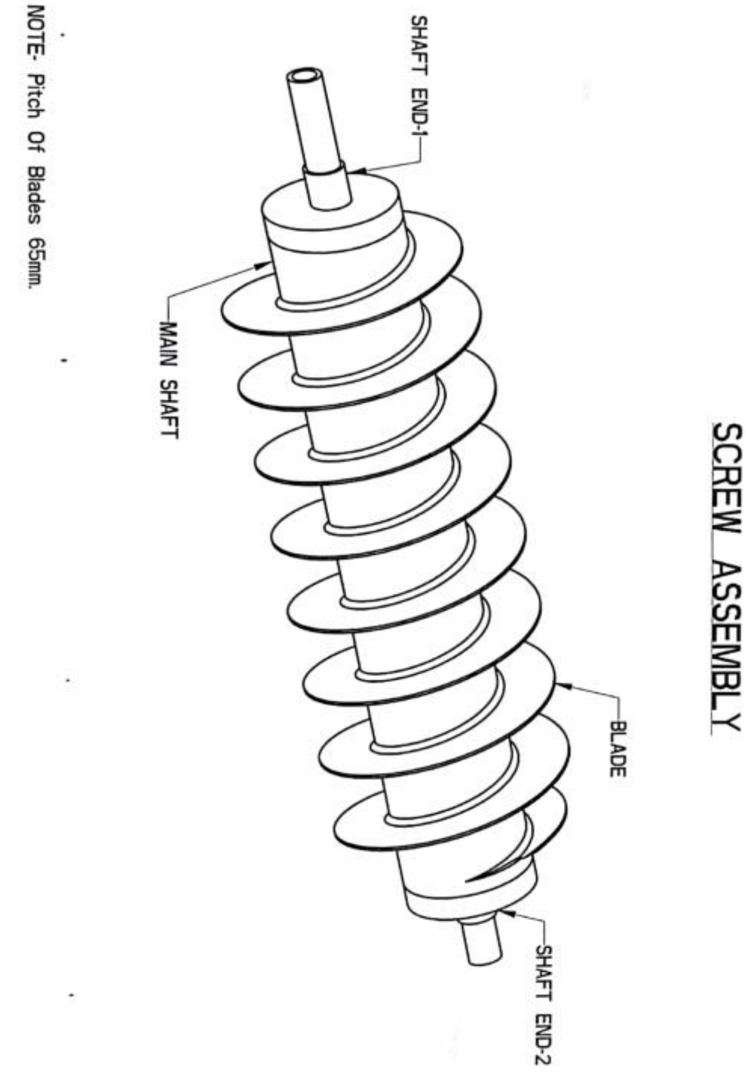

Figure 20: Engineering Drawing of Screw Assembly

Figure below shows the 2D engineering drawing of the frame of the bed of AST.

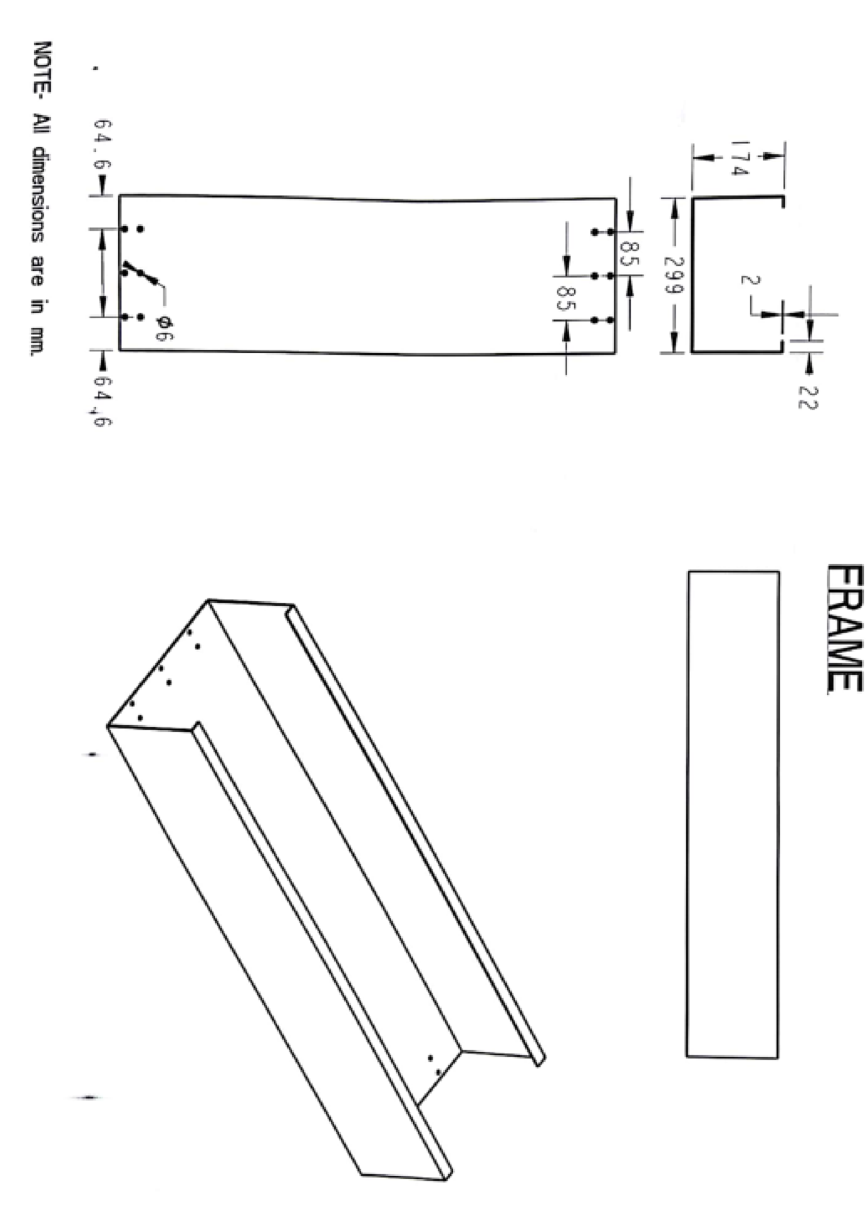

Figure 21: Engineering Drawing of Bed Frame

Figure below shows the 2D engineering drawing of the housing of the bed of AST.

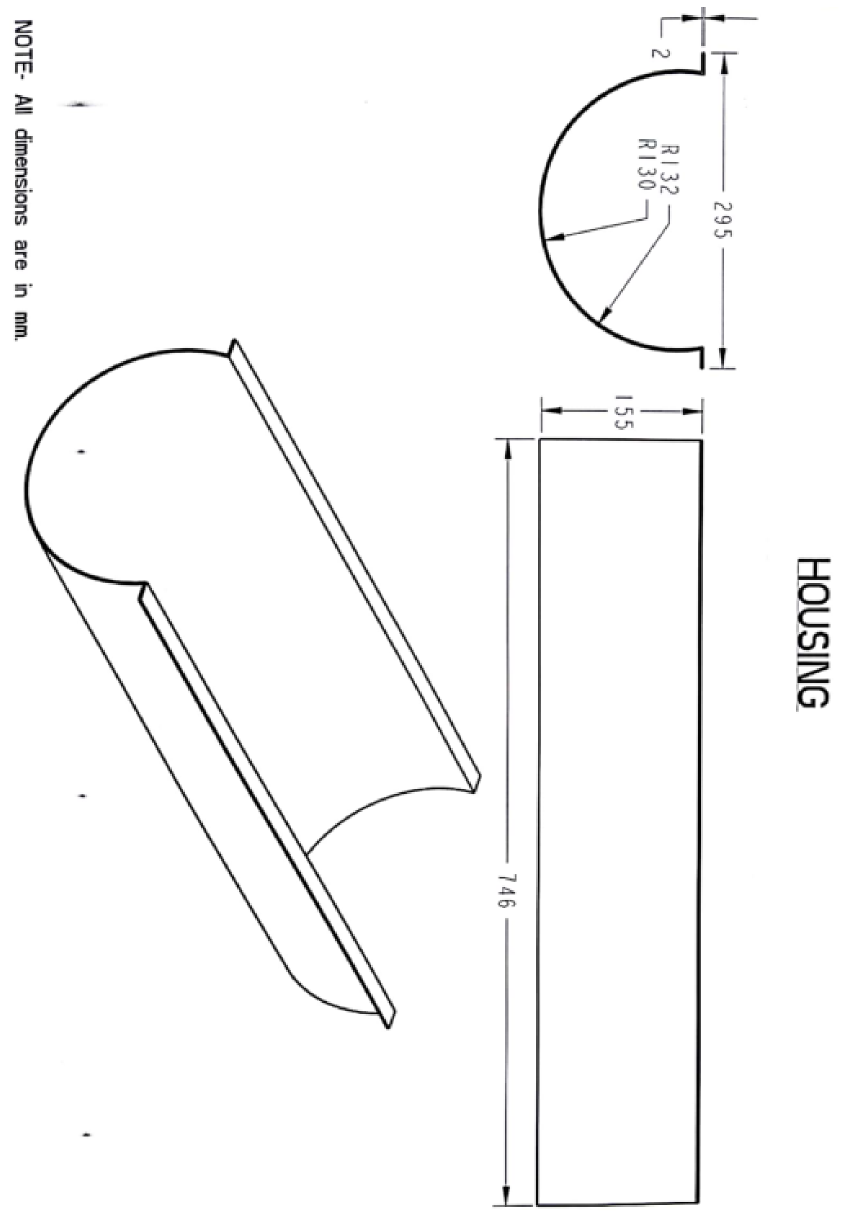

Figure 22: Engineering Drawing of Bed Housing

Figure below shows the 2D engineering drawing of the end plates of the bed of AST.

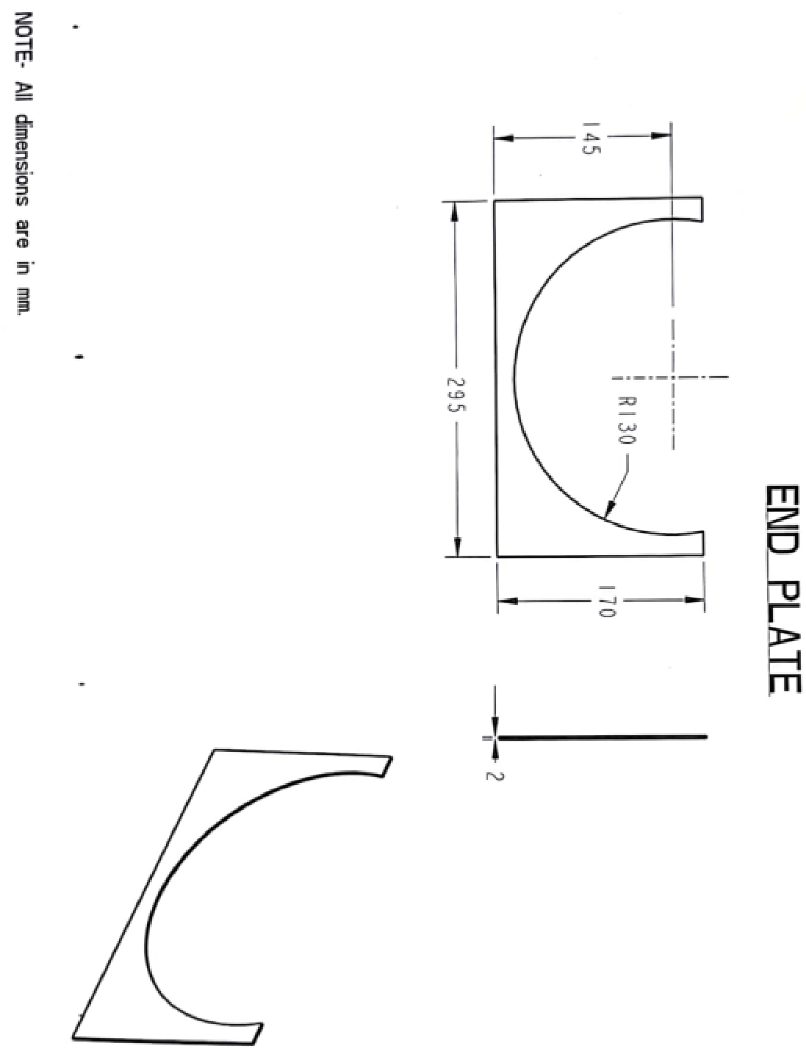

Figure 23: Engineering drawing of End Plates

Figure below shows the 2D engineering drawing of the bearing post to be mounted on the bed of the AST.

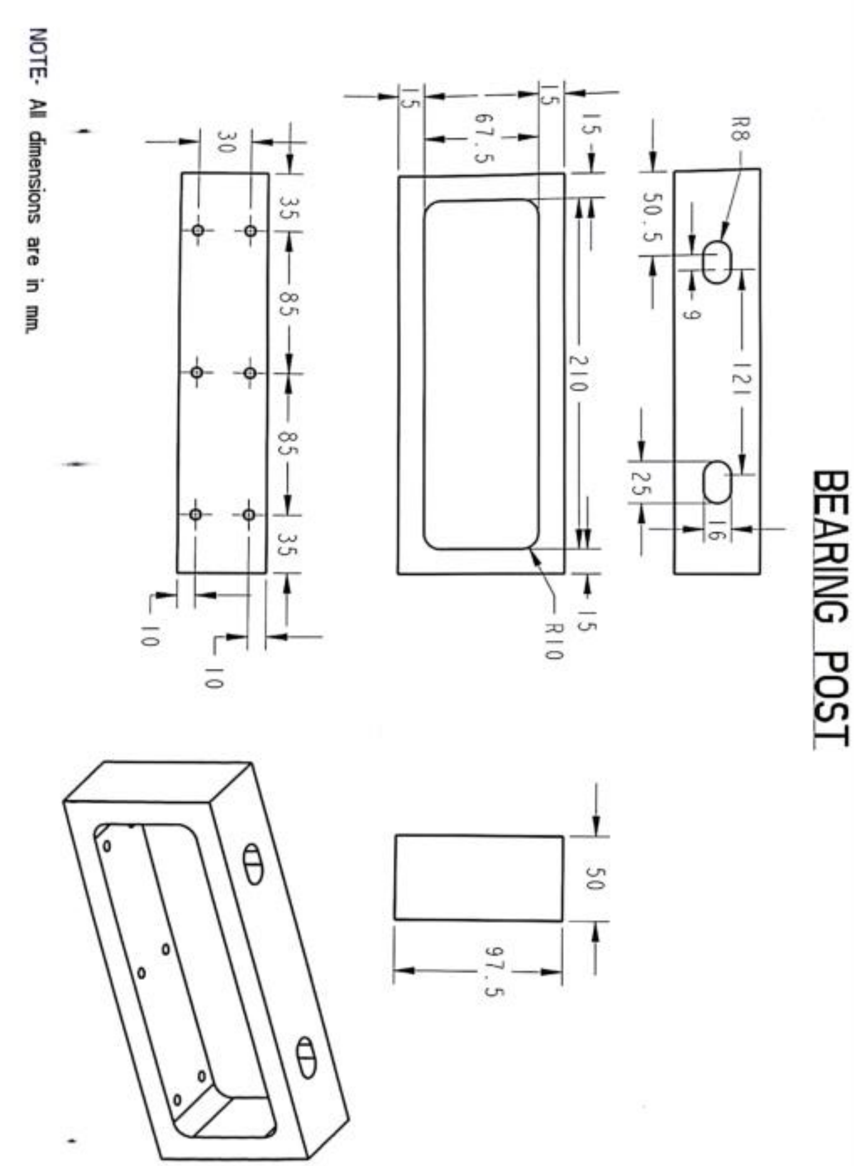

Figure 24: Engineering Drawing of Bearing Post

Figure below shows the 2D engineering drawing of the spacer that is to be mounted on the bed of AST.

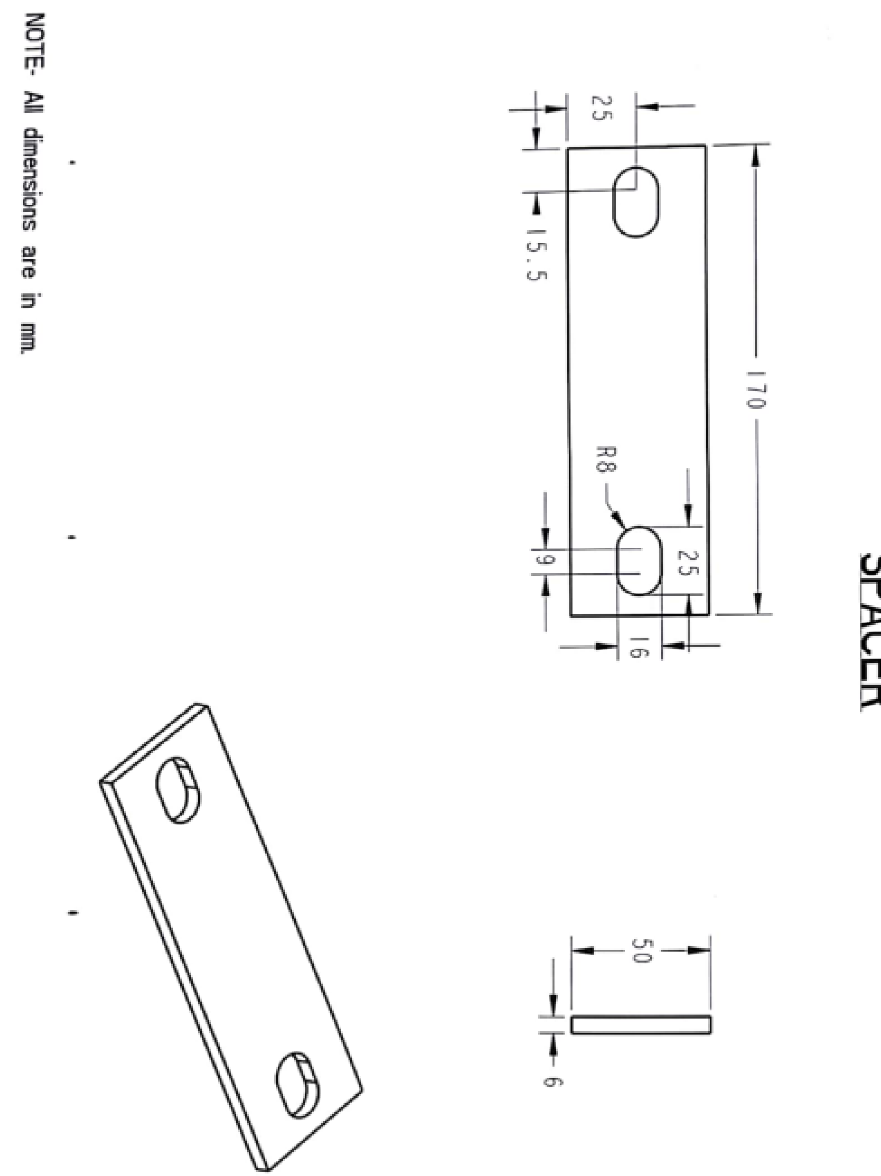

Figure 25: Engineering drawing of Spacer

Figure below shows the 2D engineering drawing of the miscellaneous parts used in the fabrication of AST.

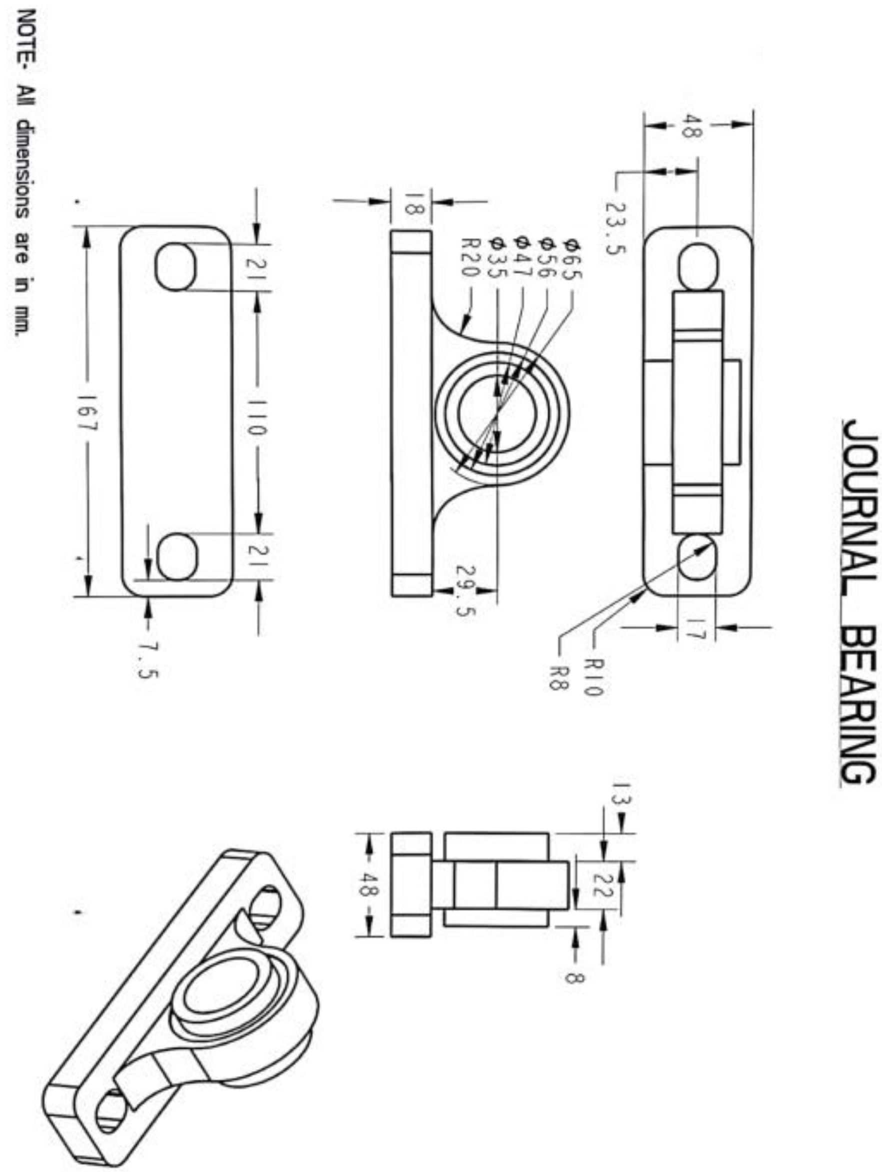

Figure 26: Engineering Drawing of Journal Bearing

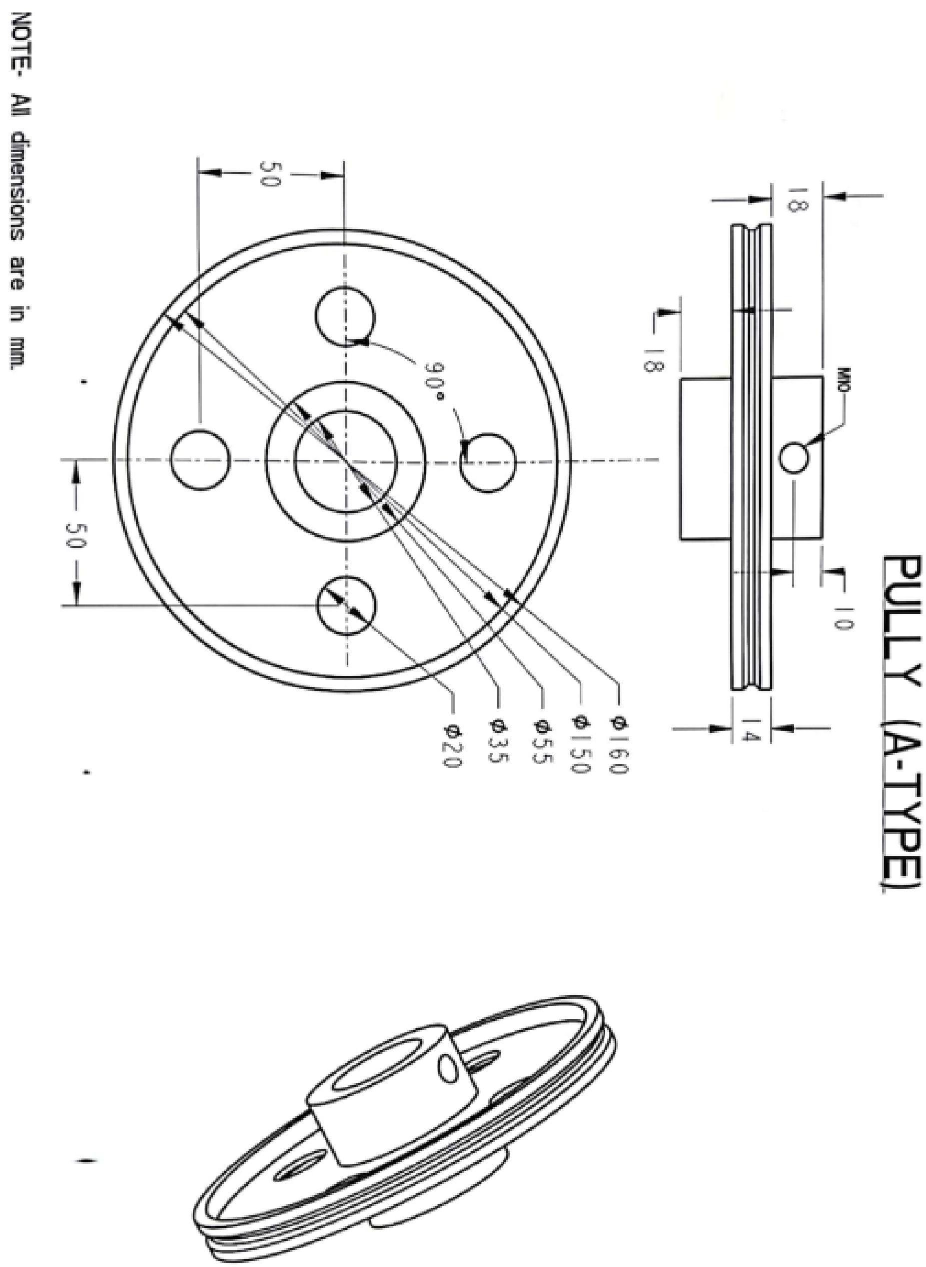

Figure 27: Engineering Drawing of Pulley (A-Type)

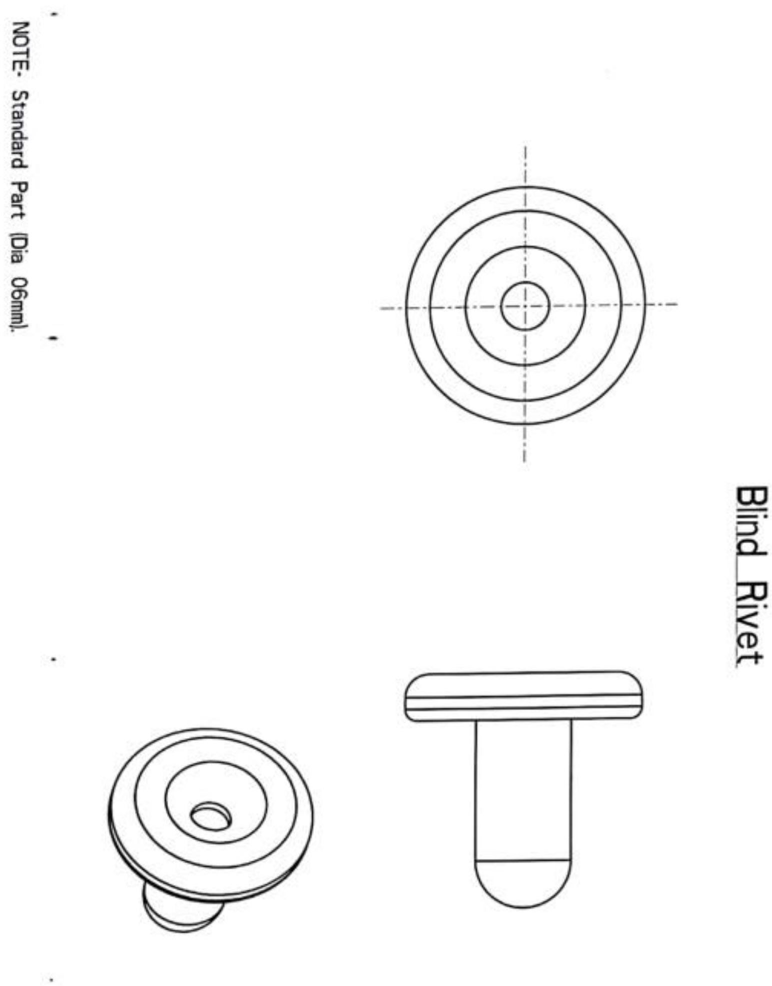

Figure 28: 2D Engineering Drawing of Blind Rivet

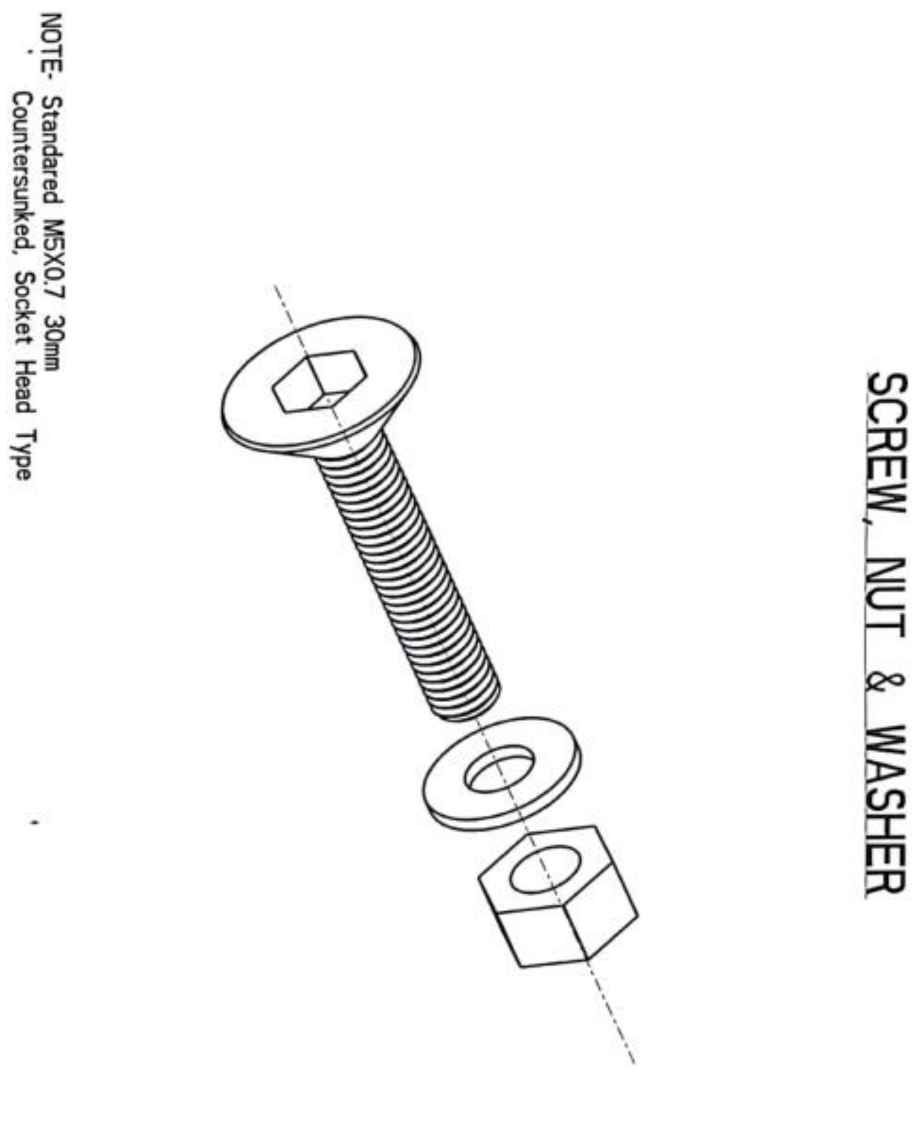

Figure 29 Engineering Drawing of Screw, Nut and Washer

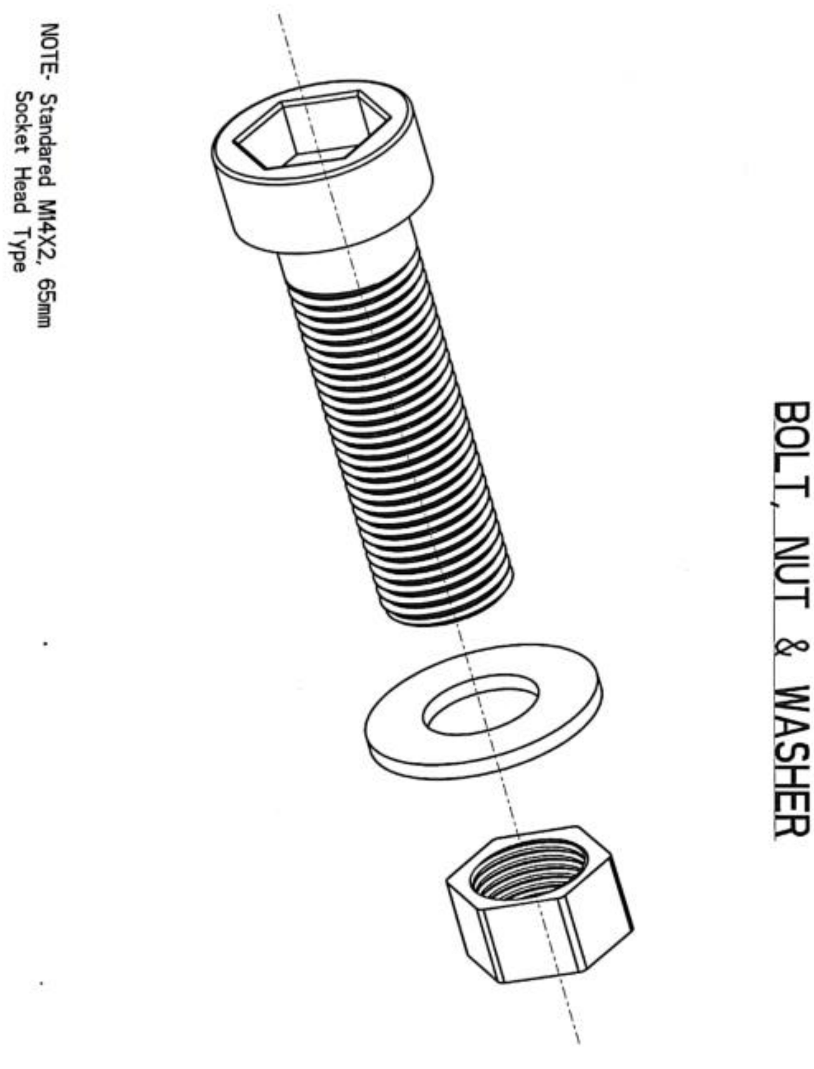

Figure 30: Engineering Drawing of Bolt, Nut and Washer

Figure below shows the complete screw-bed assembly for the fabrication of AST.

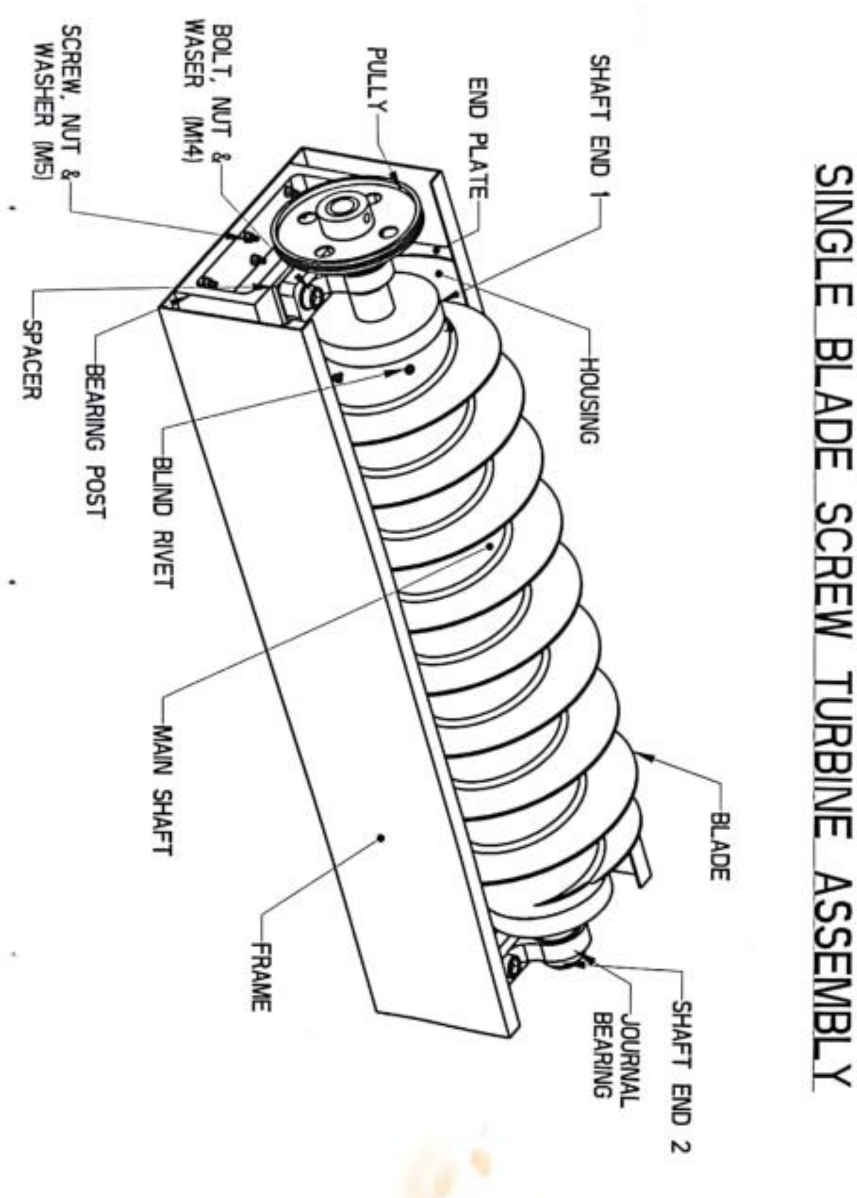

Figure 31: Engineering Drawing of Screw-Bed Assembly