INDIAN INSTITUTE OF TECHNOLOGY MANDI
KAMAND , HIMACHAL PRADESH –175005

DESIGN PRACTICUM

IC-202P

A Report on

FILAMENT WINDING SET UP

Presented by

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1) Introduction to the problem statement and its need.

2) Specification to the well define the problem statement.

3) Listing all the possible solutions.

4) Statistical evaluation of the possible solution.

5) Detailed description of the final solutions (with CAD and specification)

3D DIAGRAM

2D DRAWING

6) Benchmarking of the proposed solution.

7) Bill of the material

Abstract

1] INTRODUCTION

A filament winding machine is a specialized piece of equipment used in the manufacturing of composite materials. Composites are materials made from two or more constituent materials with significantly different physical or chemical properties, which when combined, produce a material with characteristics different from the individual components.

The filament winding process involves winding continuous filaments, such as fiberglass or carbon fiber, onto a rotating mandrel. The filaments are impregnated with a resin matrix, which cures to form a solid composite structure. The winding pattern, angle, and tension can be controlled to produce parts with specific mechanical properties.

Filament winding is commonly used in industries such as aerospace, automotive, and sporting goods manufacturing due to its ability to produce lightweight, high-strength components. The process is automated and can be tailored to produce parts of various shapes and sizes, making it a versatile manufacturing method for composite materials.

ADVANTAGES OF FILAMENT WINDING SETUP

The advantages of composite materials and filament winding machines are as

High strength to weight ratio: Composite materials like fiberglass and carbon fiber are ideal for applications that require weight reduction without sacrificing strength

Corrosion resistance: Composite materials are naturally resistant to corrosion and can be used in harsh environments that traditional materials such as steel may not be able to withstand.

Design Flexibility: Unlike traditional manufacturing methods, filament winding can be used to create complex shapes or structures that would otherwise be impossible to create.

Cost-effectiveness: Although filament winding machines require a significant initial investment, the automated process can result in cost savings in the long run.

Consistency and quality: Unlike traditional methods of manufacturing, filament winding machines are able to produce components with uniform quality and properties.

NEED FOR FILAMENT WINDING SETUP

Filament winding machines are used in various industries for manufacturing composite materials, typically by winding fibers such as carbon, glass, or aramid around a rotating mandrel. Here are some common uses:

1] Aerospace: Filament winding is used to manufacture lightweight, high-strength components such as rocket motor casings, pressure vessels, and aircraft fuselage sections.

2] Automotive: In the automotive industry, filament winding is used to produce components like drive shafts, leaf springs, and suspension components, where high strength and light weight are desirable.

3] Piping: Filament winding is used in the manufacture of pipes and tanks for chemical processing, water treatment, and other industries requiring corrosion-resistant materials.

4] Renewable Energy: Filament winding is used in the production of wind turbine blades and other components for renewable energy systems due to the high strength-to-weight ratio of the composite materials.

5] Marine: Filament winding is used in the manufacture of boat hulls, masts, and other marine components due to the corrosion resistance and durability of composite materials.

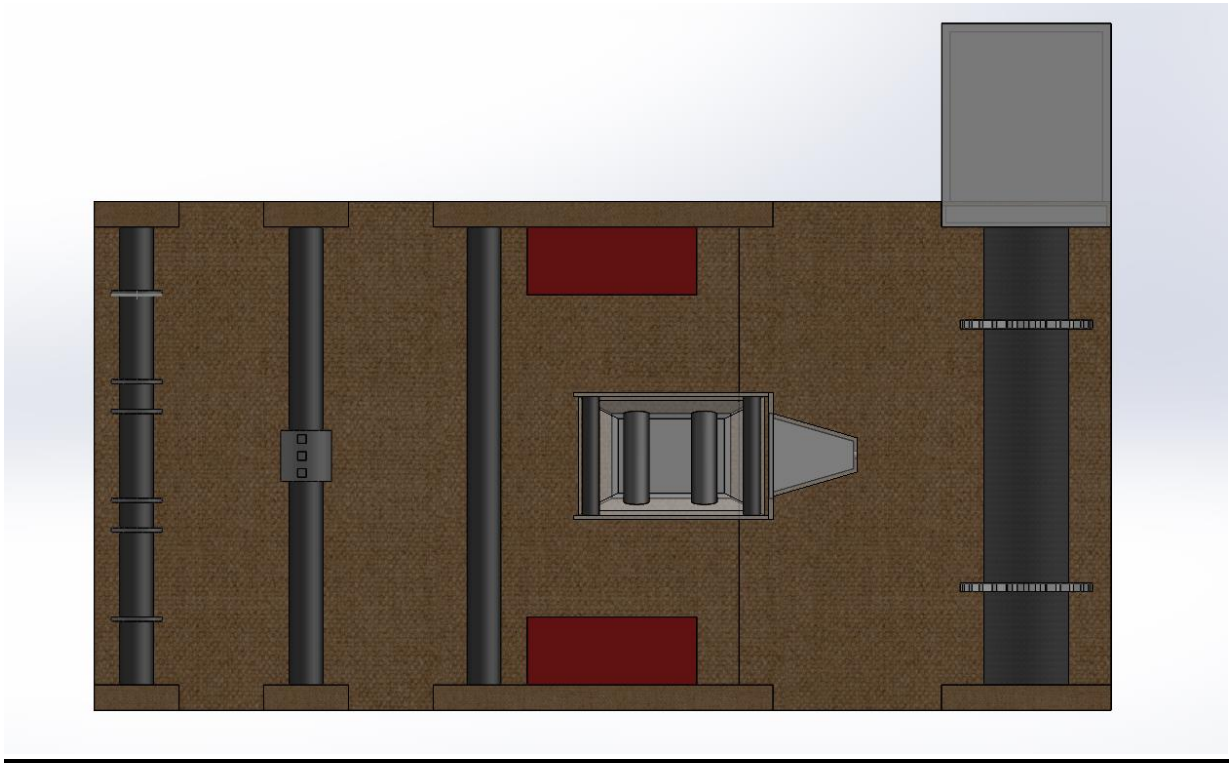
6] Infrastructure: Filament winding is used to manufacture components for infrastructure projects such as bridges, where lightweight, corrosion-resistant materials are required.

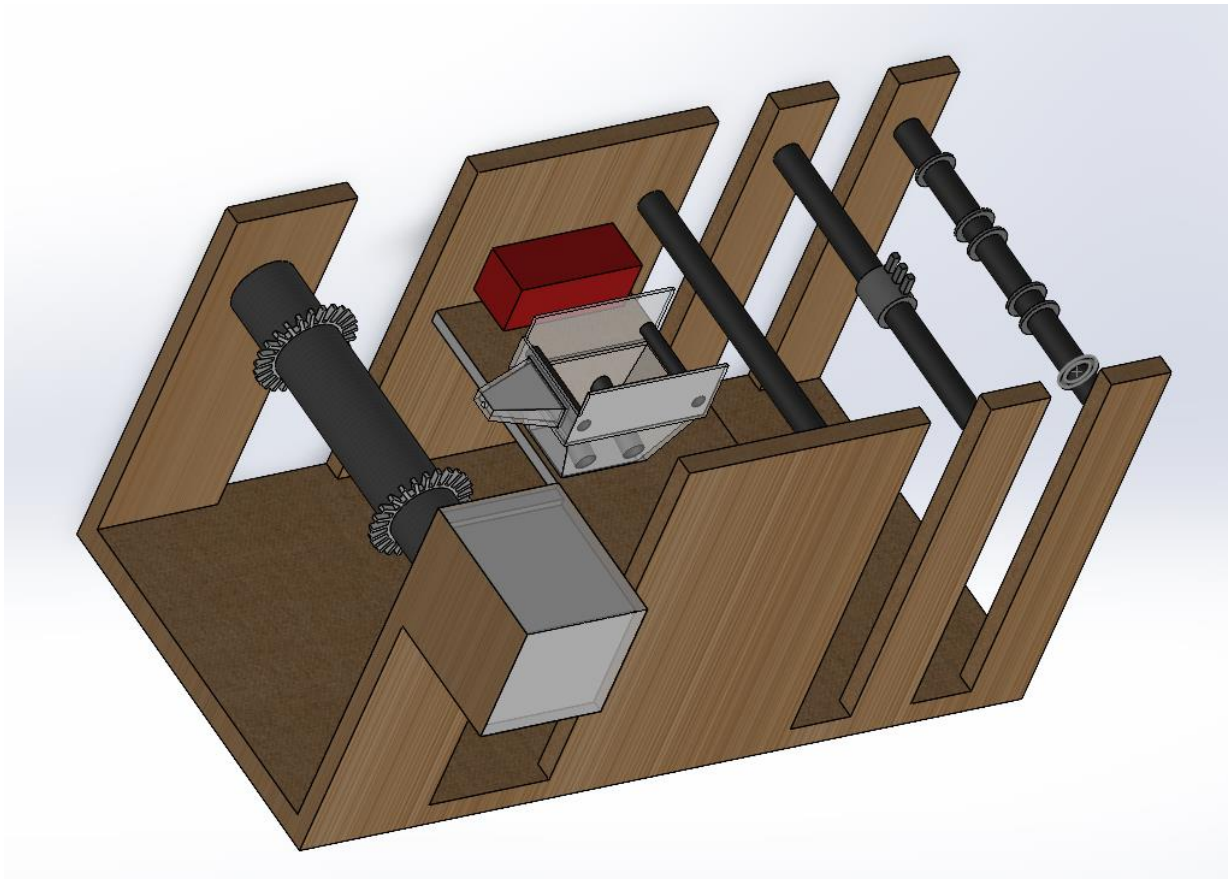
7] Military and Defense: Filament winding is used in the manufacture of military vehicles, armor, and other defense-related components due to the strength and durability of the resulting composite materials.

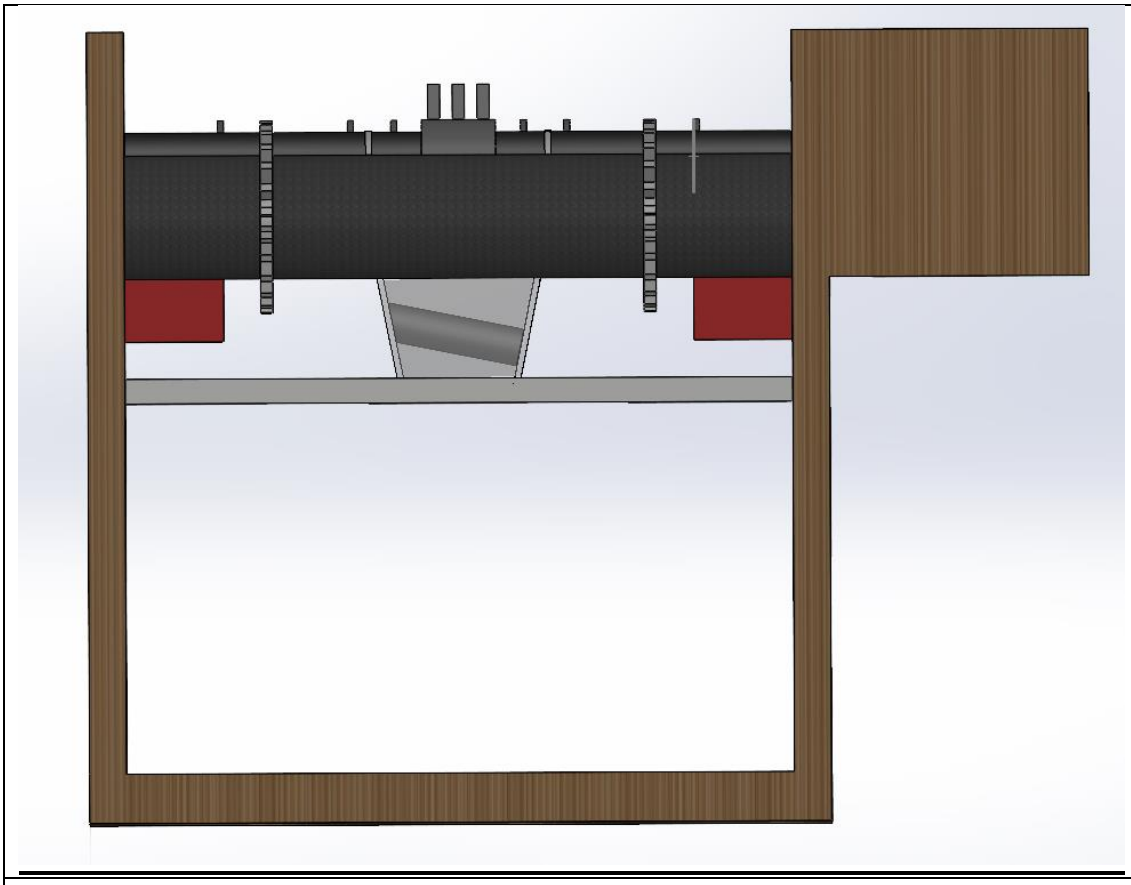
2] PROJECT SPECIFICATIONS

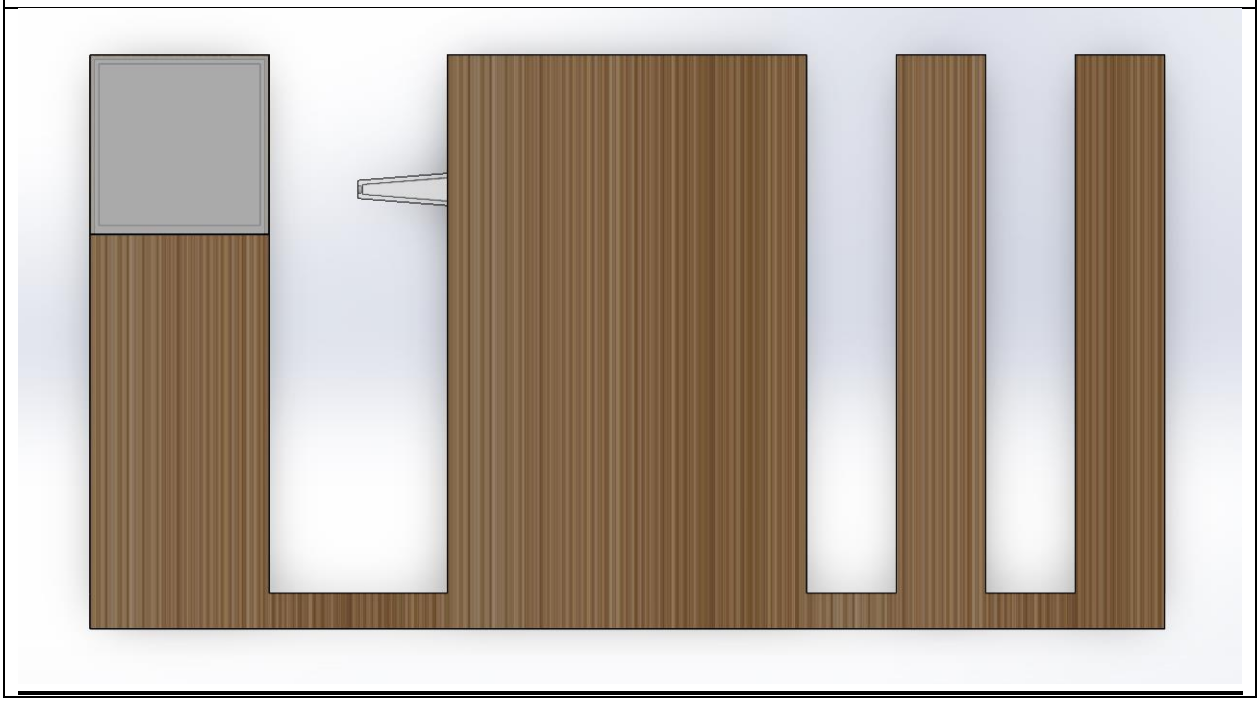
Section	Description
Materials Support	• Support for a variety of materials, like fiberglass, carbon fiber, and other composite materials for winding purposes. • Compatibility with different diameters and characteristics of materials.
Winding Patterns	• Support numerous winding patterns. • Provide multi-axis control to accommodate complex designs.
Automation	• For increased productivity, use cutting-edge automation technologies. • Include material handling and placement capabilities in case of robotic arms.
Monitoring and Control	• Put in place an all-inclusive system for real-time monitoring. • Offer control over speed, tension, and other important variables.
Material handling	• Facilitate smooth and rapid spool changes. • Include automated systems for material replacement.
Quick Changeover	• Reduce downtime during changeovers by facilitating a quick transition between various filament materials and winding patterns.
Energy Efficiency	• Use of energy-efficient components and systems. • Optimisation of power consumption.
Safety	• Follow the guidelines set forth by the industry. • Incorporate safety interlocks and emergency stop systems.
Flexibility	• Facilitate the development of both large-scale constructions and small-scale prototypes by allowing modification of winding parameters to meet a range of industrial needs. • Enable off-site supervision through the use of remote monitoring capabilities. • Put safe access controls in place for remote modifications.
Scalability	• Design a machine that can be prototyped and built in big quantities. • Production volume scalability to be also taken into account.
Cost-effectiveness	• Optimizing the design for economical manufacture without sacrificing the performance.

5] CAD MODEL

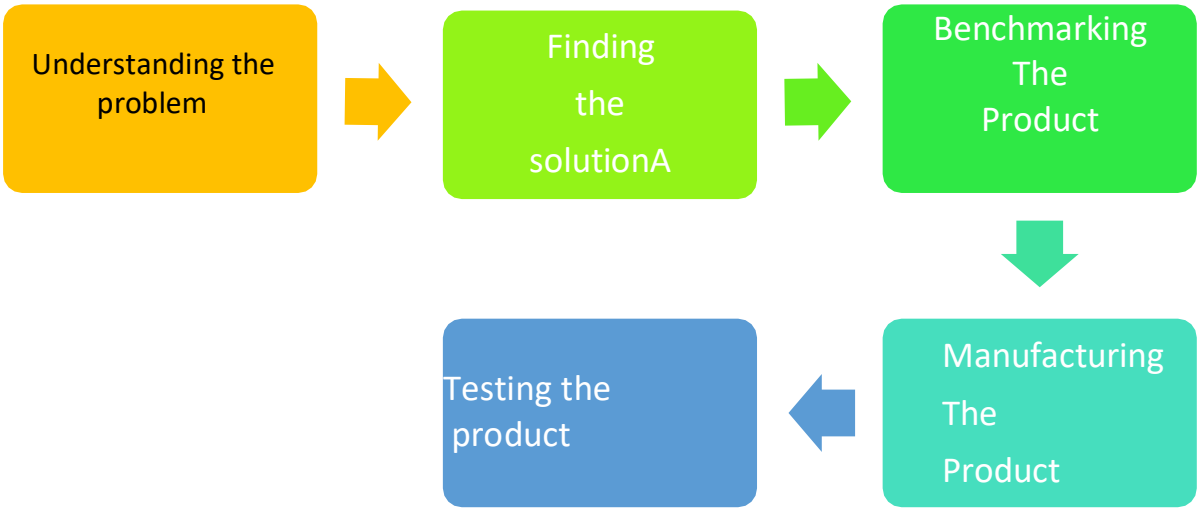








StepsWeFollow



Summary:

Step-1:First,weresearchformanufactureandworkingprinciplesofthe filament winding setup.

Step-2: After research about filament winding setup, we design our model and find the best solution for the setup.

Step-3: After modeling we find benchmarks.

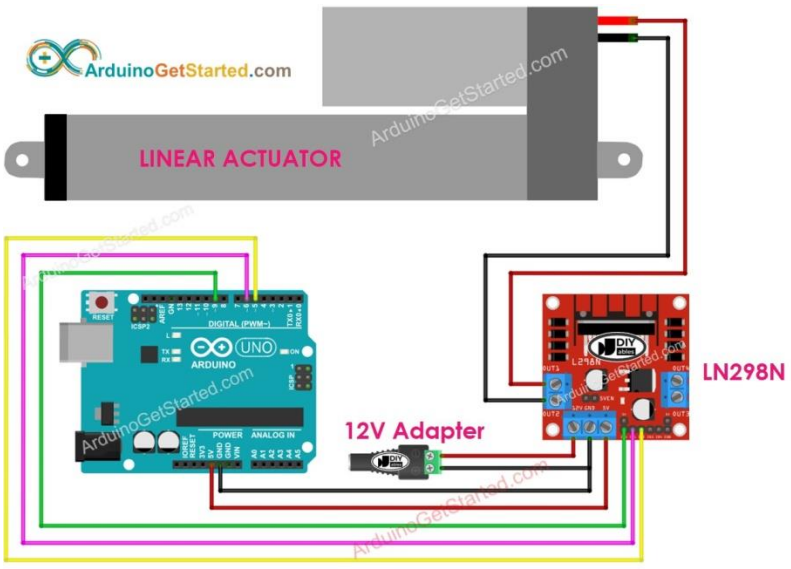
Step-4: After completing the benchmarking of product, we start manufacturing the

Step-5: Finally, we correct our errors ,and our filament winding setup is tested and completed.

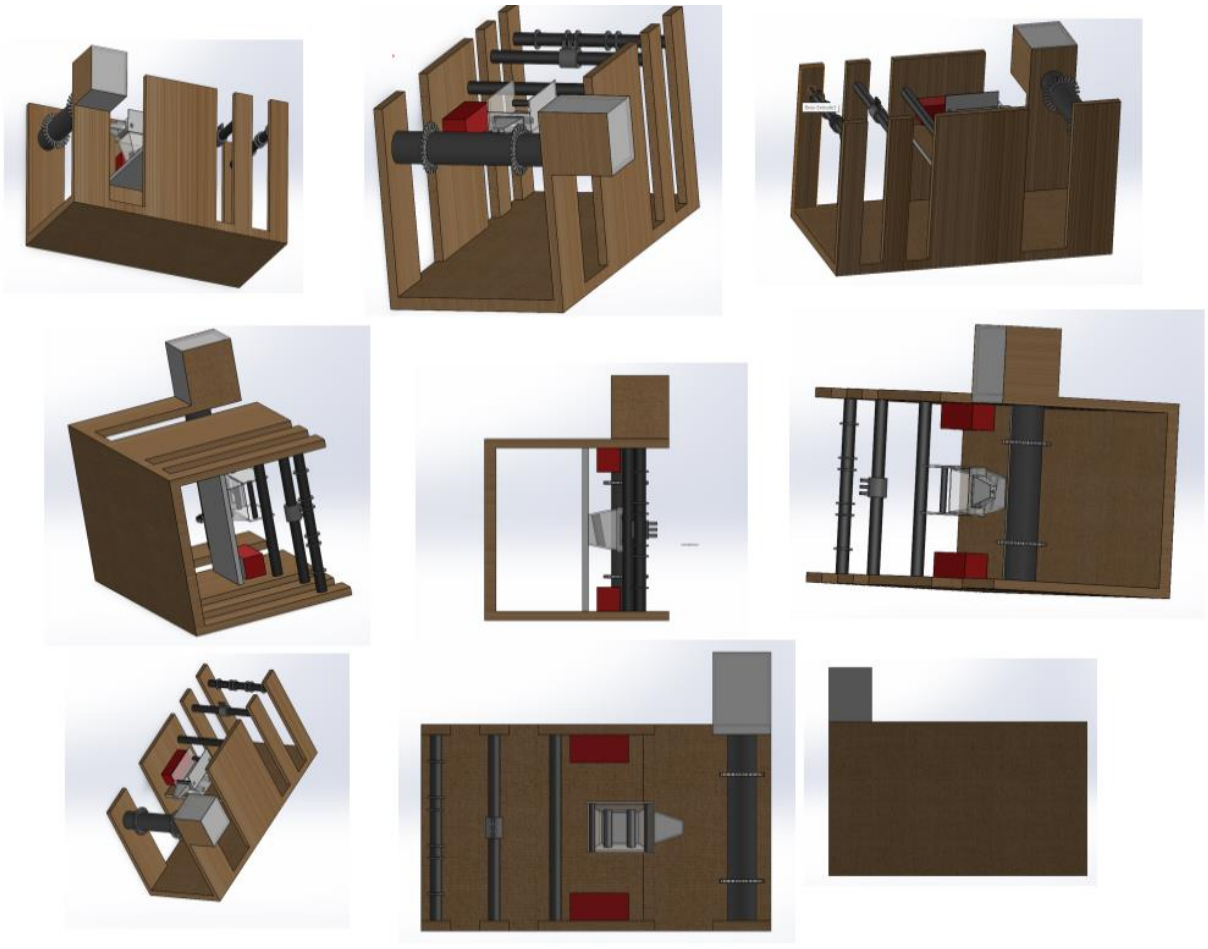
Components List:

S.No.	Item	Quantity
1	Aluminium rods	5
2	Thermostat heater	2
3	Linear motor	2
4	Hot air gun	2
5	wires	1
6	plywood	1
7	Metal sheet	4
8	Ball bearings	1
9	Motor belts	-
10	My1016 250w 24v dc motor	1
11	Switch	1

Connections:

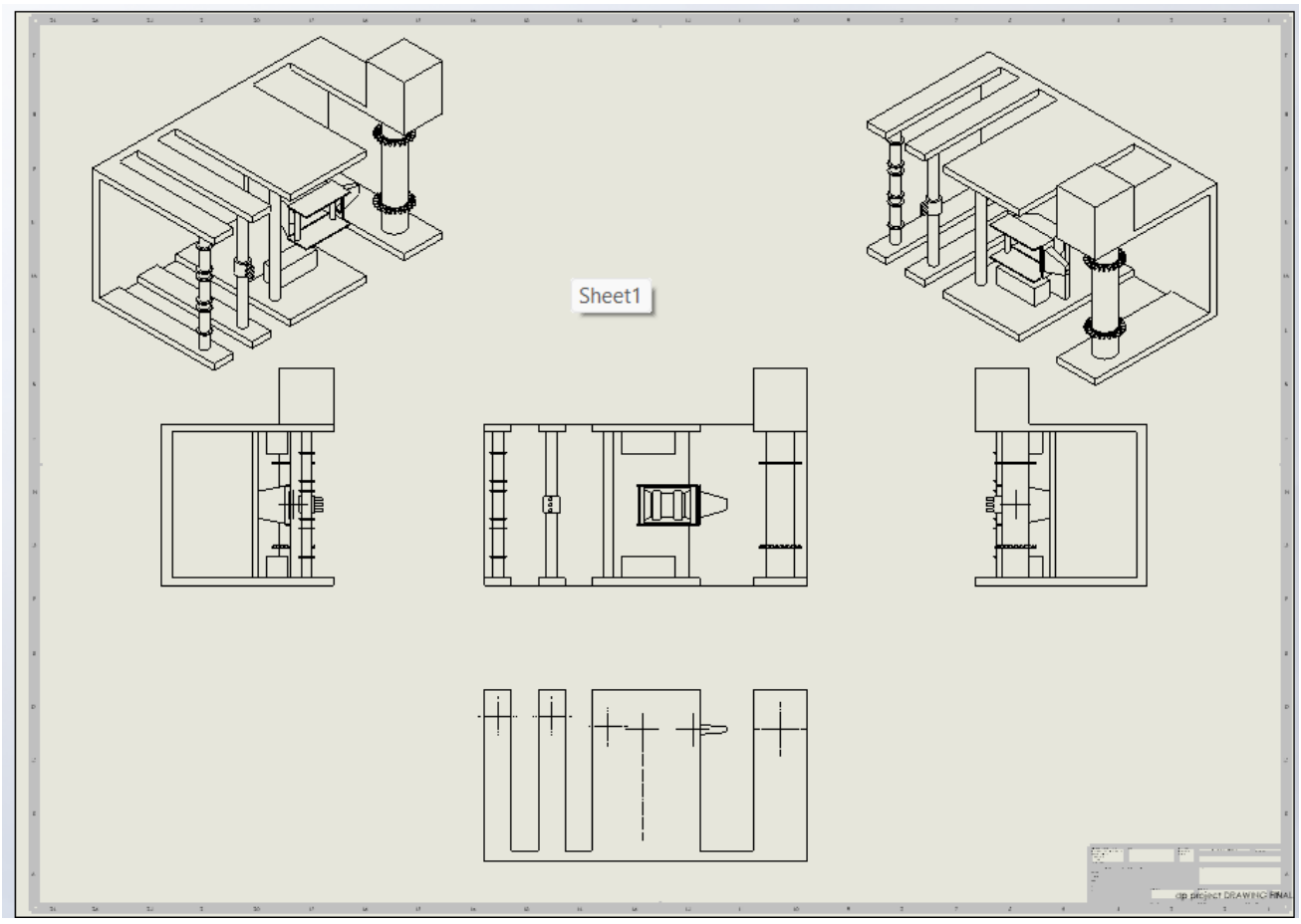


CAD Model



2D Drawing

Model:



DETAILED DESCRIPTION:

- Our project is working on the principle of making composite made of both matrix and reinforcement.
- We are using glass fiber as matrix and epoxy resin.
- In our project we are using 3 big rods, 4 small rods in resin bath and 1 big rod for making final product and to maintain tension in strings and make sure that glass fibers sticks with resin properly.
- Plywood is used as the frame and metal sheet is used to make the resin bath and motor holder.
- To make a winding pattern we are making resin bath to move across the mandrel and a pattern is formed.
- We are using a spike on both side of the mandrel which helps in changing the pattern.

➢ *SPECIFICATION OF OUR PROJECT*

LENGTH OF TOTAL SETUP	60CM
WIDTH OF THE TOTAL SETUP	30CM
HEIGHT OF TOTAL SETUP	30CM
LENGTH OF FINAL PRODUCT	15CM
RADIUS OF PRODUCT	2.5CM
MATRIX	EPOXY
REINFORCEMENT	GLASS FIBER
FRAME MATERIAL	WOOD

3]LIST OF POSSIBLE SOLUTIONS

1. FILAMENT WINDING SETUP WITH (PROBLEM OF MANDREL MOVING TO AND FRO)

In filament winding setups, instead of moving the mandrel back and forth to create a helix winding pattern, an alternative approach involves moving the resin bath. This adjustment can greatly improve the precision and consistency of the winding pattern. By moving the resin bath, operators can achieve more accurate helix winding patterns, reducing the need for manual adjustments and simplifying the process. This change also helps to minimize errors and enhance the reliability of the overall process. Additionally, moving the resin bath provides better control over resin impregnation, ensuring a more uniform distribution throughout the composite part. Overall, this approach can lead to higher-quality products, reduced waste, and increased efficiency in filament winding setups.

2. FILAMENT WINDING SETUP WITH (PROBLEM OF POLYURAETHANE AS RESIN)

Using epoxy resin instead of polyurethane in filament winding setups offers several advantages. Epoxy resins provide improved mechanical properties, including higher strength and stiffness, resulting in stronger and more durable composite parts. They also offer better chemical resistance, making them suitable for applications where exposure to harsh chemicals is a concern. Additionally, epoxy resins have higher temperature resistance, lower shrinkage during curing, and better adhesion to various substrates. These characteristics contribute to easier processing and result in higher-quality composite parts with improved mechanical properties and dimensional stability compared to polyurethane resins.

3. FILAMENT WINDING SETUP WITH (PROBLEM LESS RODS FOR LESS TENSION)

Increasing the number of rods in a filament winding setup can provide several benefits. Firstly, it can enhance tension control during the winding process, ensuring a more uniform and consistent application of the filament. This can lead to improved product quality with fewer defects and inconsistencies.

Additionally, using more rods can help distribute the tension more evenly across the mandrel, reducing the risk of deformation or distortion of the final product. Moreover, increased tension can also improve the resin impregnation process, resulting in better consolidation of the composite material and higher overall strength of the finished part. Overall, incorporating more rods into the filament winding setup can improve process control, product quality, and performance of the final composite parts.

4. FILAMENT WINDING SETUP WITH (PROBLEM OF NO HEATING OF EPOXY)

Using a heater for heating epoxy in filament winding setups offers several benefits. Firstly, it helps to reduce the viscosity of the epoxy, making it easier to impregnate the fibers and ensuring better wetting and adhesion. This results in stronger and more uniform composite parts. Additionally, heating the epoxy can improve the curing process, reducing the overall curing time and increasing production efficiency. It also helps to minimize the risk of voids or air bubbles in the final product, resulting in higher quality components. Overall, the use of a heater for heating epoxy in filament winding setups can improve process control, enhance product quality, and increase production efficiency**.**

5. FILAMENT WINDING SETUP WITH (PROBLEM OF OTHER FIBER THAN GLASS FIBER)

Using glass fiber as a reinforcement in filament winding setups offers several advantages. Glass fiber is known for its high strength-to-weight ratio, making it ideal for producing lightweight yet strong composite parts. It also offers good resistance to heat and chemicals, making it suitable for a wide range of applications in various industries. Additionally, glass fiber is cost-effective and readily available, making it a popular choice for filament winding. By using glass fiber as a reinforcement, manufacturers can produce composite parts that are strong, durable, and resistant to environmental factors, making them suitable for use in aerospace, automotive, marine, and other industries.

6.FILAMENT WINDING SETUP WITH (PROBLEM OF HEATER FOR HEATING RESIN AS UV CURING LAMP)

Using UV curing lamps in filament winding setups offers the advantage of

rapid curing times, leading to increased production efficiency. UV curing enables quick and uniform curing of the resin, reducing the overall processing time and allowing for faster part production. Additionally, UV curing does not require the use of heat, which can be beneficial for heat-sensitive materials or applications where thermal distortion is a concern. However, one of the disadvantages of using UV curing lamps is that they may not penetrate thick or opaque materials effectively, leading to incomplete curing in certain areas. This limitation requires careful consideration of part design and material selection to ensure proper curing throughout the entire composite part.

7. FILAMENT WINDING SETUP WITH (PROBLEM OF USE OF METAL AS FRAME RATHER THAN WOOD)

Using wood as a frame rather than a metal sheet in a small filament winding setup can offer several advantages. Wood is often more cost-effective and readily available than metal, making it a practical choice for smaller-scale setups. Additionally, wood is easier to work with and can be customized to fit specific dimensions and requirements. It also provides good insulation properties, which can be beneficial in filament winding setups where temperature control is important. However, wood may not be as durable or long-lasting as metal, especially in environments where moisture or humidity levels are high. Careful sealing and maintenance may be required to ensure the longevity of the wood frame. Overall, using wood as a frame in a small filament winding setup can be a cost-effective and practical solution, provided that the limitations of wood are taken into consideration.

8. FILAMENT WINDING SETUP WITH (PROBLEM OF ORTHOGONAL WINDING PATTERN)

Using a helix pattern rather than other patterns in filament winding setups offers several advantages. The helix pattern provides excellent strength and stiffness to the final composite part, making it ideal for applications where these properties are crucial, such as in aerospace or automotive components. Additionally, the helix pattern allows for better load distribution along the length of the part, reducing the risk of stress concentrations and potential failure points. Furthermore, the helix pattern can be easily customized to meet specific design requirements, offering flexibility in the manufacturing process. Overall, using a helix pattern in filament winding setups can result in stronger,

more durable, and more customizable composite parts compared to other winding patterns.

9. FILAMENT WINDING SETUP WITH (PROBLEM OF HIGH ROLLING SPEED OF MANDREL)

Using a medium speed for the mandrel in filament winding setups can offer several advantages. Medium speed allows for better control over the winding process, ensuring that the filaments are laid down evenly and consistently. This results in a higher quality finished product with fewer defects. Additionally, medium speed can help to reduce the risk of filament breakage or misalignment, further improving the overall quality of the winding. Furthermore, medium speed can also improve the efficiency of the winding process, allowing for faster production times without compromising on quality. Overall, using a medium speed for the mandrel in filament winding setups can lead to improved product quality, efficiency, and reliability.

10. FILAMENT WINDING SETUP WITH (PROBLEM OF NOT USING PROPER RATIO OF EPOXY AND GLASS FIBER)

Using the proper ratio of epoxy resin to glass fiber in filament winding setups is crucial for producing high-quality composite parts. A balanced ratio ensures that the resin thoroughly wets out the fibers, leading to optimal adhesion and mechanical properties in the finished part. Using too much resin can result in excess weight and reduced strength, while using too little resin can lead to dry spots and weak areas in the composite. By carefully controlling the ratio of epoxy resin to glass fiber, manufacturers can produce composite parts that are strong, lightweight, and have excellent mechanical properties.

11. FILAMENT WINDING SETUP WITH (PROBLEM OF NOT USING MOLD RELEASE AGENTS)

Mold release agents are essential in filament winding setups using aluminum rods with glass fiber and epoxy as reinforcement and matrix materials. These agents help in easy removal of the final product from the mandrel by preventing adhesion between the composite material and the mandrel surface. Silicone-based mold release agents are commonly used due to their ability to provide a smooth and uniform coating on the mandrel, ensuring easy release of the composite part without leaving residue or damaging the surface finish. Proper application and selection of mold release agents are crucial to ensure

the quality and integrity of the filament wound parts.

12. FILAMENT WINDING SETUP WITH (PROBLEM OF NOT USING CYLINDRICAL MANDREL)

Using a cylindrical mandrel rather than square or other shapes in filament winding setups offers several advantages. Cylindrical mandrels provide a uniform surface for winding, allowing for consistent fiber placement and resin distribution. This results in composite parts with uniform mechanical properties and dimensional accuracy. Additionally, cylindrical mandrels are easier to manufacture and handle compared to complex shapes, reducing production costs and setup time. Furthermore, cylindrical mandrels allow for easy removal of the finished part, as there are no sharp corners or edges that could cause damage during extraction. Overall, using a cylindrical mandrel in filament winding setups simplifies the process, improves the quality of the final product, and enhances overall efficiency.

4.STATISTICAL EVALUATION

https://docs.google.com/spreadsheets/d/195-3DbUbeI_2vBb8Ez1Ejsn0DD5S_JF2/edit?usp=drive_link&ouid=105377114002221794193&rtpof=true&sd=true

6]BENCHMARKING OF PROPOSED SOLUTION

This benchmarking report aims to evaluate and compare four prominent filament winding setups : Ultra filament winder , multi-spindle units for high-capacity solutions, mobile filament winder, sc filament winder

Our main objective is to access the performance, reliability and cost-effectiveness of these setups. We select these setups based on their prominence and varied technological features.

Filament winding setup descriptions:

1. Ultra filament winder
   Manufacture: Magnum Venus products
   Model name: ultra filament winder
   Helical and chop/hoop winding system designed for pipe to large diameter tank manufacturing

Specifications:

System Include:

- Automatic computer control
- Roll goods applicator
- Winding glass rack
- Material monitoring
- Pumping system
- Wet bat
- Auto roll out system

Physical equipment specs:

- Mandrel dia: 50.8 m - 5m
- Mandrel length : 6.1 m

Optional

- Electrical requirements : 380/480 volts, 60 amp, three phase, 50/60 Hz

Other options:

- Cantilever mandrel drive assemblies
- Head and tailstock supported drive

Price: 3,50,000 RS

2. Multi-spindle units for high efficiency
   Manufacturer: Mikrosam
   Advance solutions for LPG, CNG, hydrogen tanks and other composite pressure vessels
   Simultaneously winding of up to 5 spindles

Wet and dry winding

Specification :

- Diameter range : 50mm to 800 mm
- Length range : 600mm to 3mm
- Max mandrel weight : 500 kg
- Fiber tension range : 5-80 N
- 5 axes control

Price: 3,00,000 RS

3. Mobile filament winder

Manufacturer: Autonational

This filament winder enables to set up a production facility near the installation site like for large scale projects in infrastructure or renewable energy projects.

Price : 2,00,000 RS

4. Lab-scale winding

Manufacture : engineering technology corp.

Model : SC filament winder

This is a desktop filament winder ideal for R&D, lab or educational use. Compact and accurate, developed specially for school and workplace laboratories.

Specification :

- Max. mandrel diameter : 30.48 cm
- Max. mandrel weight : 22.7 kg
- Number of axes : 2

- Max. fiber tension : 111.2055 N

Price : 1,50,000 RS

Strength

If we use each filament winders at the right place as needed for work then they will be utilized as a best product for manufacturing of composites.
Filament winding offers a high strength-to-weight ratio, ideal for lightweight, strong components. It allows for complex shapes and designs, offering flexibility. The process is cost-effective for large production runs and minimizes material waste. It enables the use of various materials tailored to specific application requirements.

Conclusion

There are many other winders are also present in markets. And they have their strength and weakness which majorly depends on the applications of it.The benchmark conclusion for filament winding setup is that it provides a highly efficient and cost-effective method for producing lightweight, high-strength composite components. It offers excellent design flexibility, enabling the creation of complex shapes and structures. Additionally, filament winding allows for the use of a variety of materials, making it suitable for a wide range of applications across industries such as aerospace, automotive, and marine.

7]BILL OF MATERIALS

Sr no.	COMPONENT NAME	Quantity	PROCUREMENT TYPE	Price of each	Total price
1.	ALUMINIUM RODS HOLLOW (50MM) DIAMETER	1	MANDI	250 RS	250 RS
2.	ALUMINIUM RODS HOLLOW (20MM) DIAMETER	4	MANDI	150 RS	600 RS
3.	THERMOSTAT ADUSTED HEATER	2	MANDI	500 RS	1000 RS
4.	SCREWS AND NUTS	25	MANDI	10 RS	250 RS
5.	STEP MOTOR	1	MANDI	5000 RS	5000 RS
6.	MOTOR BELTS	2	MANDI	250 RS	500 RS
7.	PLYWOOD (2*1) SQF	3	MANDI	400 RS	1200 RS

8.	LINEAR MOTOR (30MM LENGTH)	2	ONLINE	4000 RS	8000 RS
9.	GLASS FIBER ROLL	6	MANDI	150 RS	900 RS
10	ATTACHED BEARING (1 CM DIAMETER)	8	MANDI	100 RS	800 RS
11	ATTACHED BEARINGS (2 CM DIAMETER)	4	MANDI	100 RS	400 RS
12	HOT AIR GUN	2	MANDI	750 RS	1500 RS
13	ALUMINIUM SHEET	2	MANDI	250 RS	500 RS
14	GLUE FOR WOOD	1	MANDI	200 RS	200 RS