DEPARTMENT OF MECHANICAL ENGINEERING

POWER GENERATION FROM A SMALL WIND TURBINE

HORIZONTAL AXIS MAGNUS EFFECT TURBINE

PROJECT MEMBERS

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NEED FOR RENEWABLE ENERGY

Environmental Concerns

- Fossil fuels cause air pollution, global warming, and climate change.
- Renewable energy produces **zero greenhouse gas emissions** during operation.

Depletion of Fossil Fuels

- Coal, oil, and natural gas are **finite and rapidly depleting**.
- Energy demand is rising globally.

Cost & Energy Security

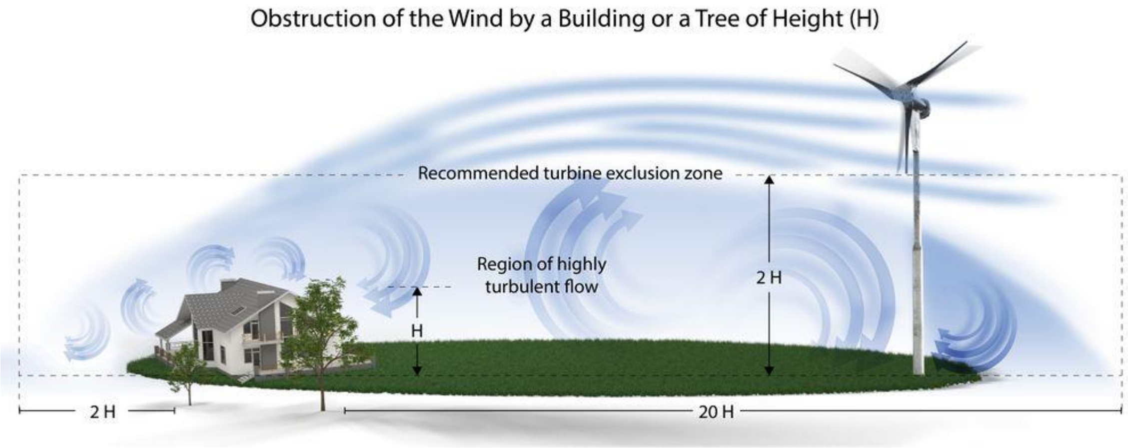
- Fossil fuel prices are **volatile** due to geopolitical and supply chain issues.
- Renewables provide **stable, domestic energy** sources.

Global Shift Toward Clean Energy

- Initiatives like **Mission Innovation**, **Net Zero by 2050**, and **UN SDGs** drive adoption of renewables.

ABSTRACT

- The project focuses on **renewable energy generation** using a **small-scale wind turbine**.
- Aims to harness **wind energy** effectively through a **Magnus-effect-based turbine**.
- Utilizes **rotating cylindrical blades** instead of traditional airfoil blades to improve performance at low wind speeds.
- Designed and analyzed using **Siemens NX** for modeling and **ANSYS Fluent** for CFD simulations.
- The prototype was fabricated and **tested in real wind conditions**, showing promising voltage output even at **low wind speeds.**



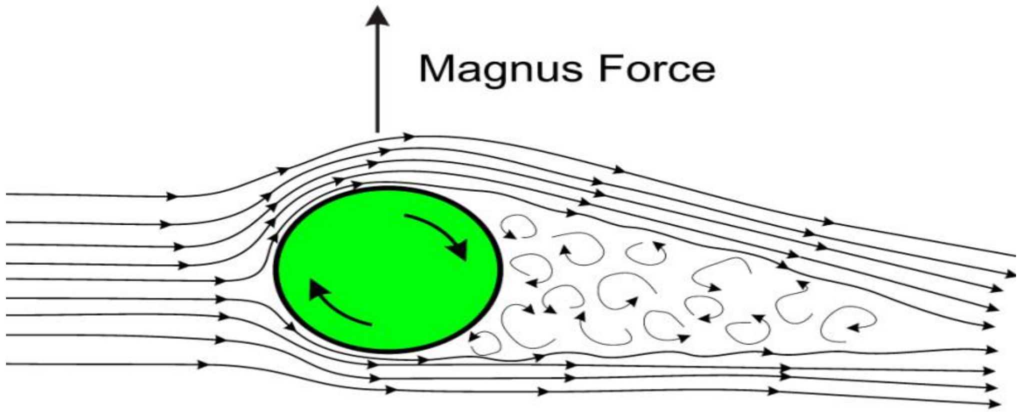
OBJECTIVE

GOALS

- To design and develop a **horizontal axis Magnus wind turbine** for small-scale power generation.
- To **convert wind energy into electrical energy** using the **Magnus effect** with rotating cylindrical blades.
- To **reduce dependency on fossil fuels** and promote the use of **clean, renewable energy sources**.
- To evaluate turbine performance under **low to moderate wind speeds**, making it suitable for rural and urban applications.
- To carry out **CFD analysis** and **field testing** for validating the design efficiency.
- To create a **cost-effective prototype** with potential for future scale-up and real-world implementation.

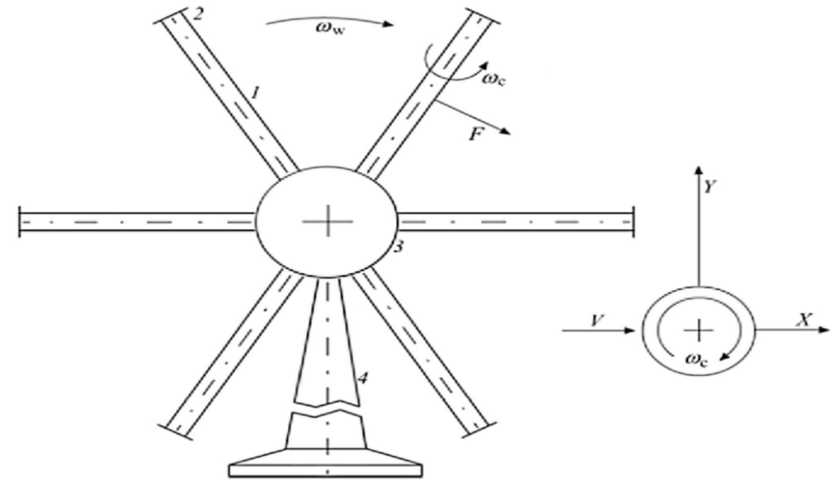
WHAT IS MAGNUS EFFECT ?

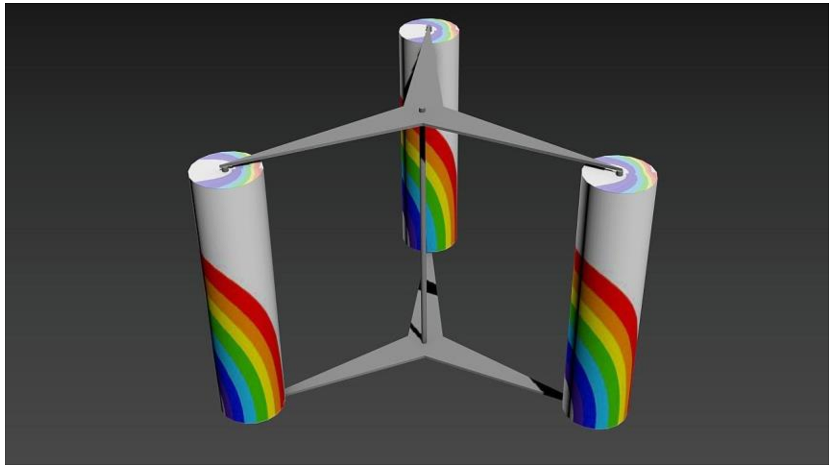
- The **Magnus Effect** is a physical phenomenon where a **spinning object in a fluid** (like air) experiences a **lift force** perpendicular to the direction of flow.
- It occurs due to **pressure differences** created by the variation in flow speed around the rotating surface.
- Common in sports: seen in the curved path of spinning balls (football, baseball, golf).



MAGNUS EFFECT WIND TURBINE

- Replaces traditional **airfoil blades** with **rotating cylindrical blades**.
- These rotating cylinders generate **lift using the Magnus effect**, which creates torque to drive the turbine shaft.
- Particularly effective in **low wind speed** conditions, where traditional turbines struggle.
- Offers potential for **higher efficiency**, lower noise, and better **performance in urban or low-wind regions**.





DESIGN TOOLS USED

1. Siemens NX (CAD Software)

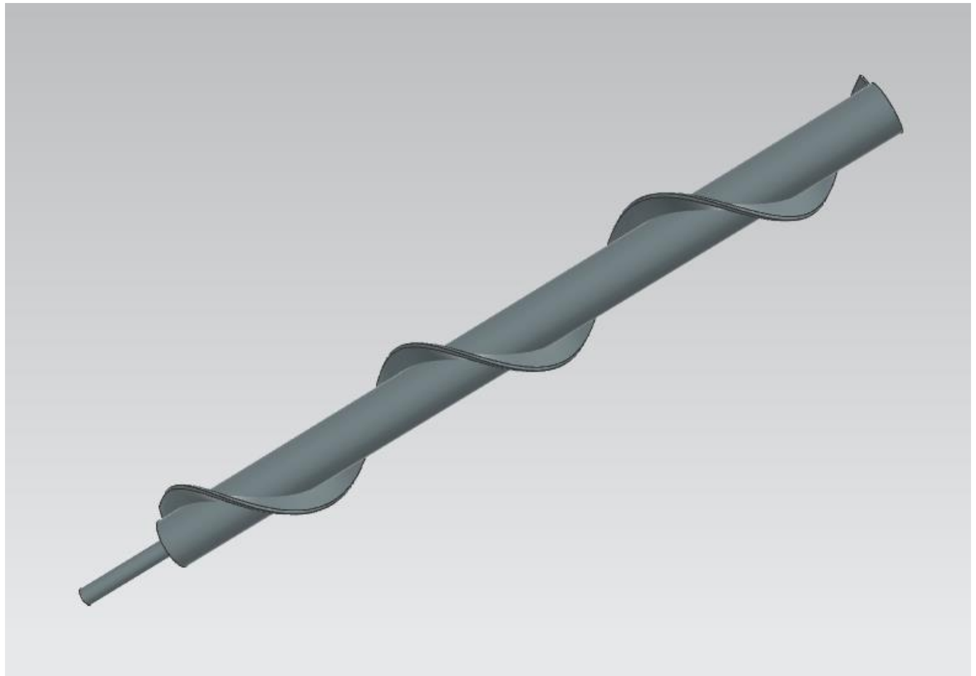
- Used for **3D modeling and assembly** of turbine components.
- Designed parts such as **blades, hub, shaft, and base**.
- Enabled **precise dimensioning** and part alignment.
- Supported **mechanical validation** before fabrication.

2. ANSYS Fluent (CFD Analysis)

- Used for **Computational Fluid Dynamics (CFD)** simulations.
- Analyzed **airflow, pressure distribution**, and **velocity contours**.
- Helped visualize **Magnus effect behavior** on rotating cylinders.
- Ensured design efficiency before physical testing.

TURBINE BLADE DESIGN

- Three **cylindrical blades** made of **PVC** for strength and lightweight.
- **Spiral profile** added using **FRP (Fibre Reinforced Plastic)** to enhance surface roughness and lift via Magnus effect.
- Connected to an 18 mm shaft at each end for rotation and torque transmission.



<u>**Key Dimensions:**</u>

- Blade Length: **750 mm**
- Blade Diameter: **50 mm**
- Diameter with Spiral: **90 mm**
- Spiral Pitch: **90 mm**

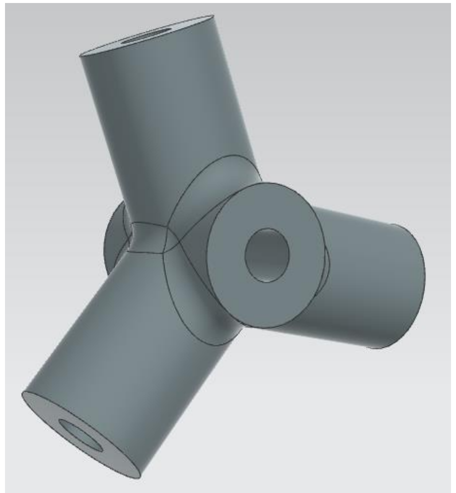
HUB & BASE DESIGN

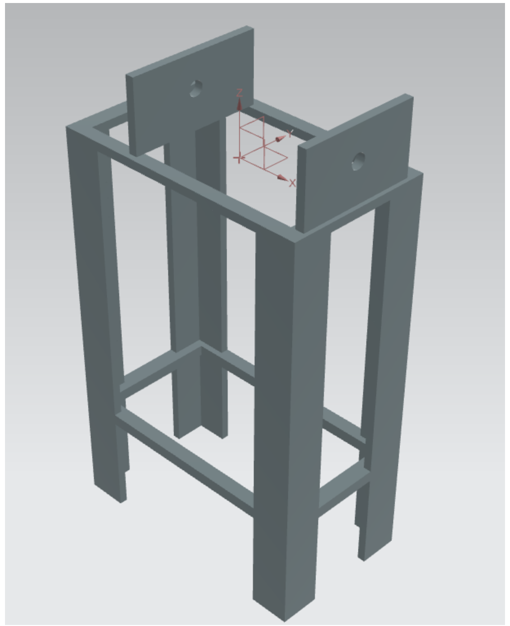
Hub:

- Hub connects all three blades to the **main shaft**.
- Includes **bearings** for smooth rotation and load transfer.
- Precisely machined for **aerodynamic alignment**.

Base:

- **Mild steel base** supports the entire turbine structure.
- Designed for **stability** against wind loads and vibrations.
- Tapered form for better **center of gravity and mounting**.





Base Dimensions:

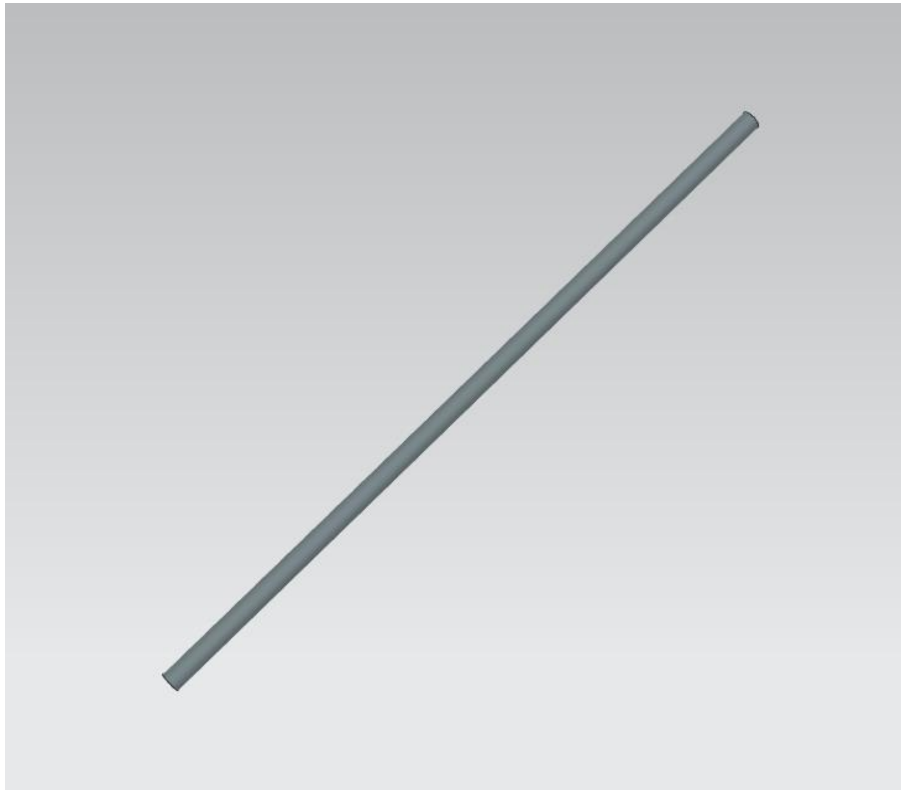
- Height: **1270 mm**
- Top area: **460 mm × 260 mm**
- Bottom area: **460 mm × 520 mm**

SHAFT DESIGN

- Transfers rotational energy from blades to the **Permanent Magnet Generator (PMG)**.
- Made of **Mild Steel (MS)** for strength and durability.
- Connected securely to hub on one end and generator on the other.

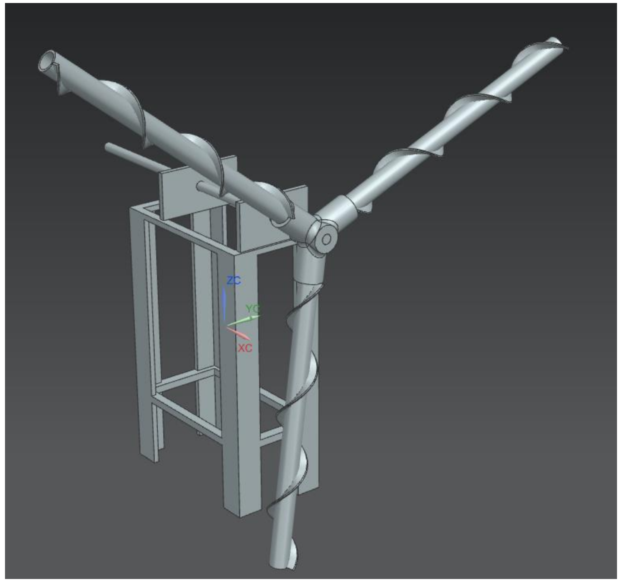
Key Specifications:

- Shaft Diameter: **25 mm**
- Shaft Length: **850 mm**

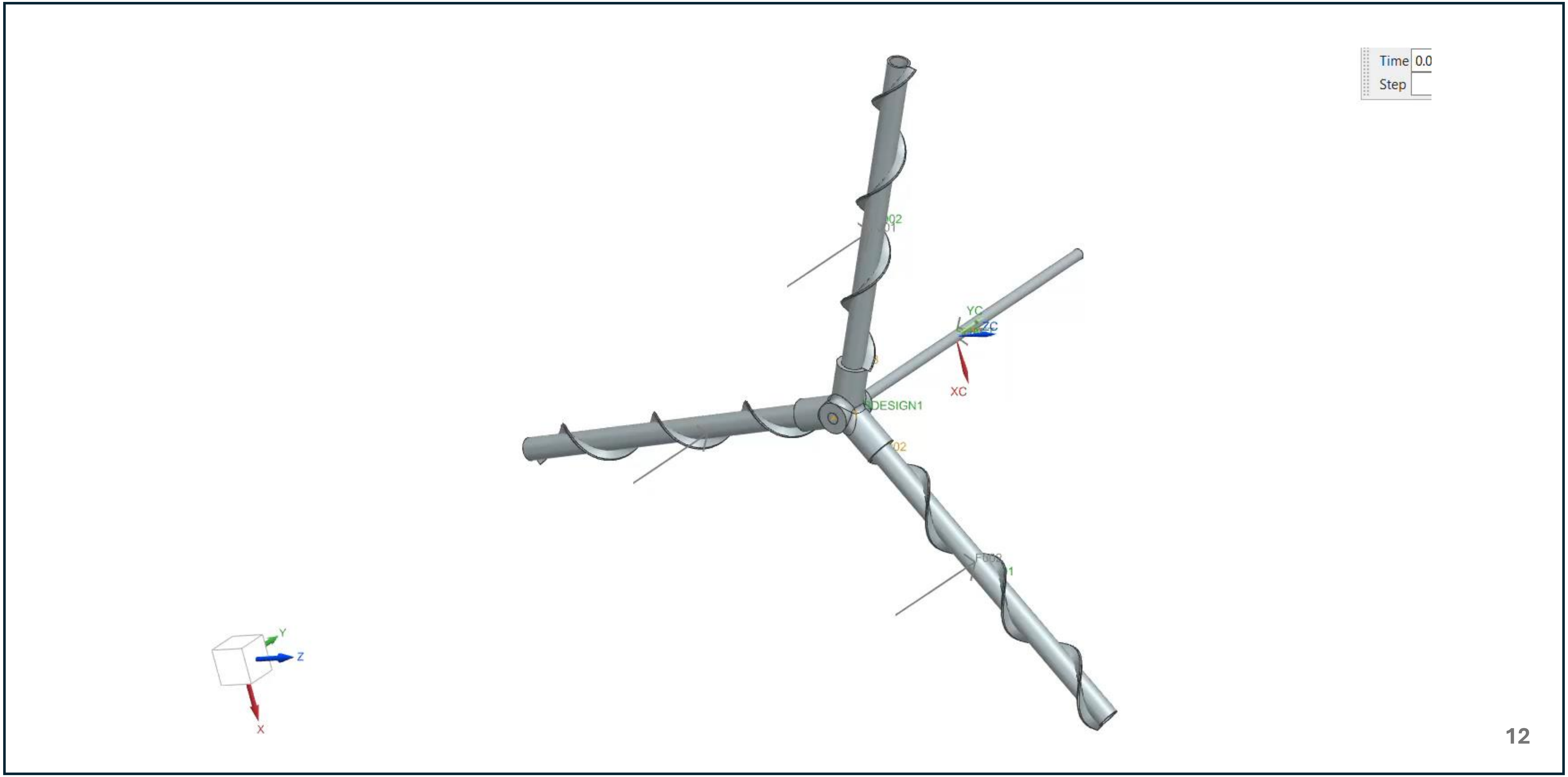


FULL ASSEMBLY

- Complete **3D model designed in Siemens NX**.
- Includes **blades, hub, shaft, base, and generator housing**.
- Ensures **correct alignment and fitment** before fabrication.
- Used as reference during **physical assembly and testing**.

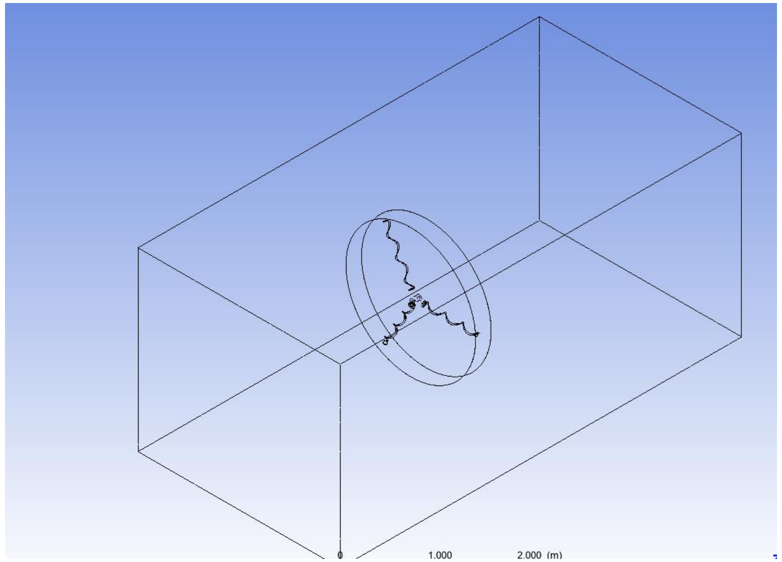


MOTION SIMULATION

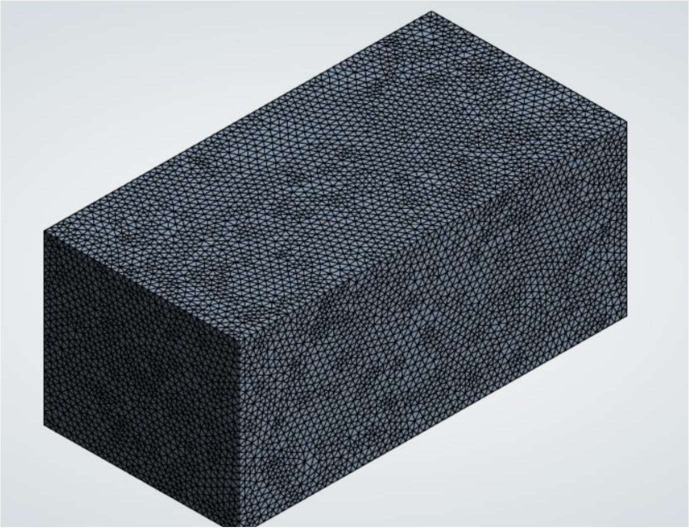


CFD SETUP – GEOMETRY & MESH

- 3D model exported from **Siemens NX** into **ANSYS Fluent**.
- **Fluid domain** created around rotating blades.
- Used **Moving Reference Frame (MRF)** for rotational simulation.
- Fine mesh near blade surface; coarse mesh far from the body.



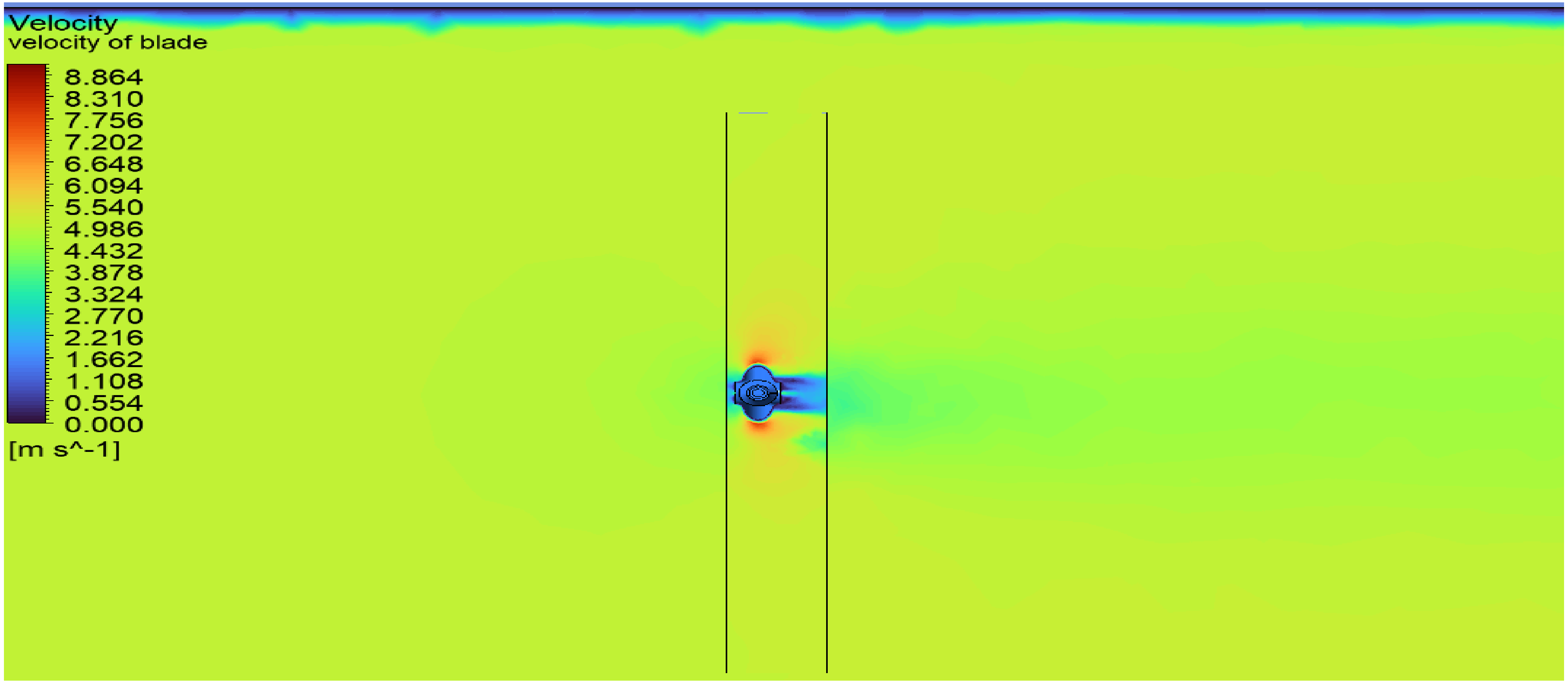
- Boundary Conditions:
- **Inlet**: Wind velocity (5 m/s)
- **Outlet**: Pressure outlet
- **Blade**: Rotating wall (Magnus effect)



CFD RESULTS

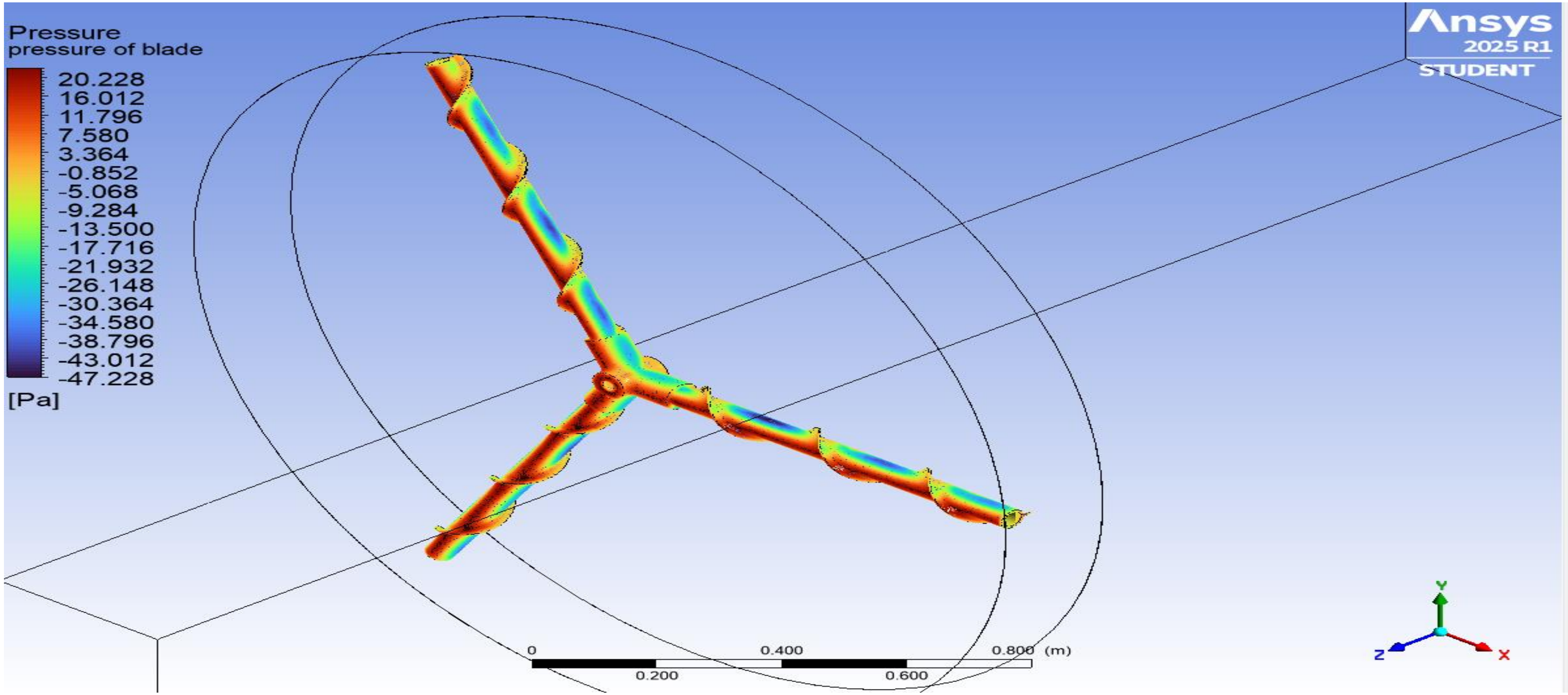
Velocity Contour:

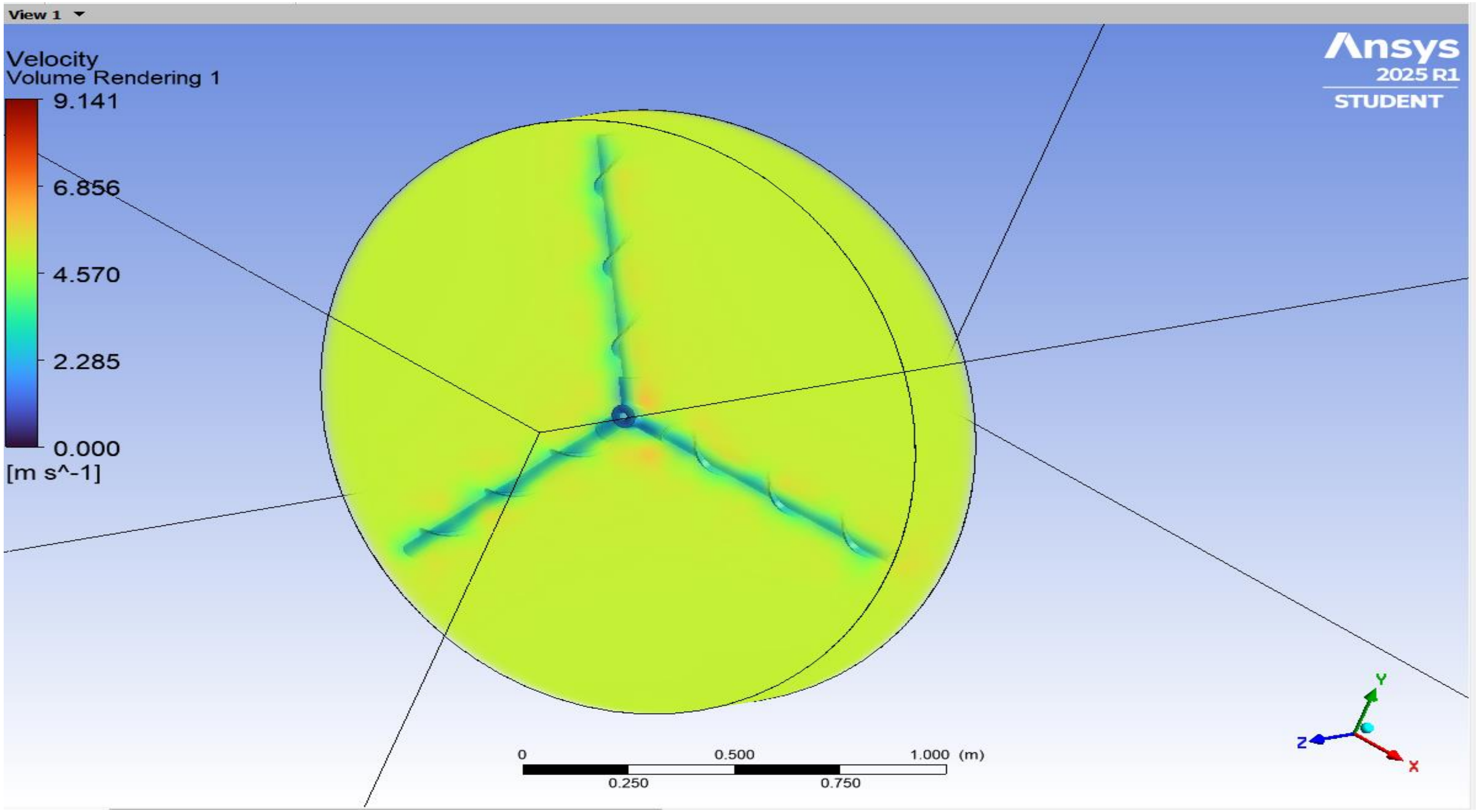
- Shows **higher velocity** on one side of rotating cylinder and lower on the other.
- Confirms **Magnus effect** in action → Lift and torque generated.



Pressure Contour:

- **Low pressure** where flow velocity is high.
- **Pressure difference** across cylinder drives rotation.

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Volume Rendering 1
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4.570
2.285
0.000
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Ansys
2025 R1
STUDENT
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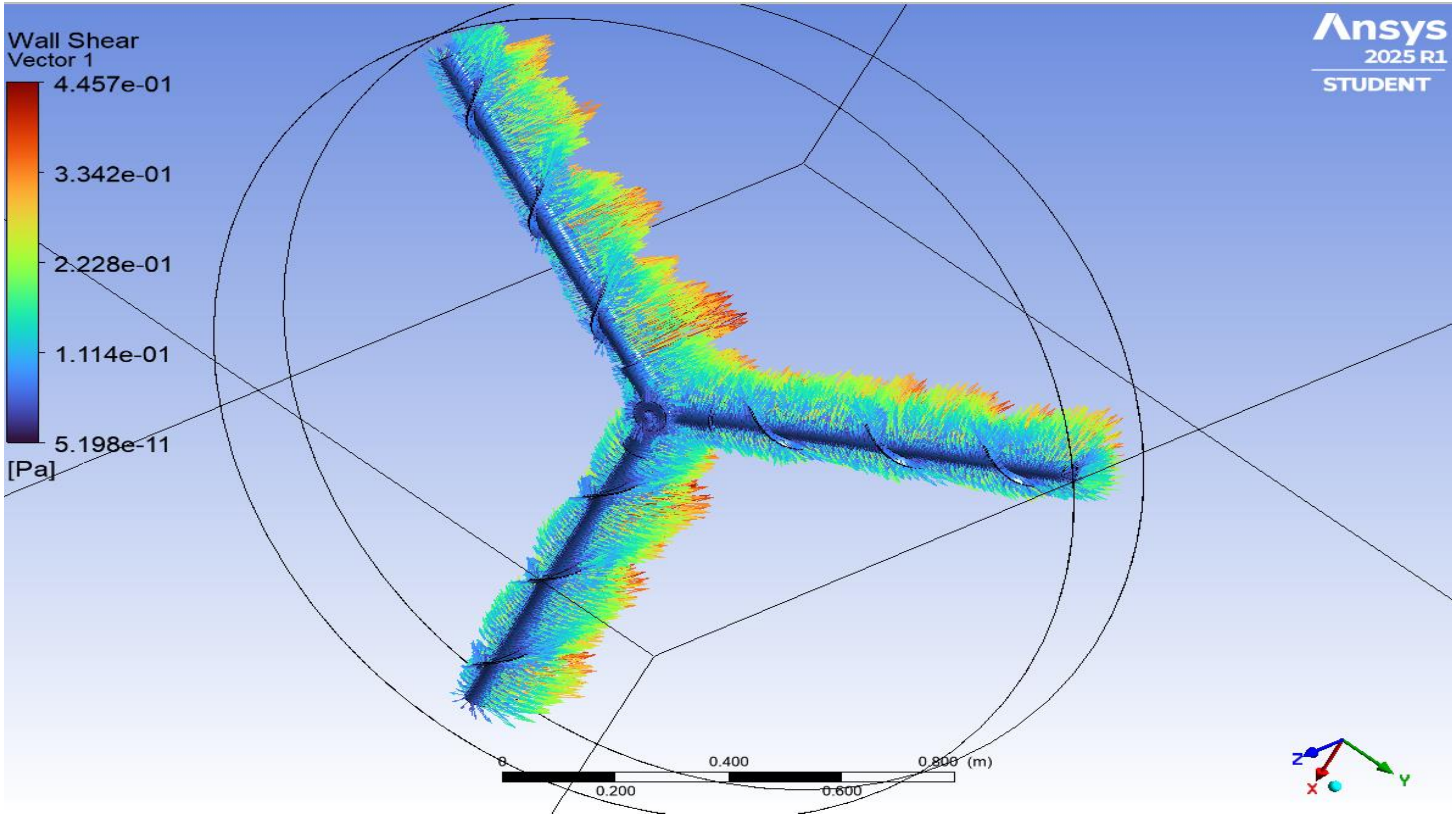
0.500
1.000 (m)
0.250
0.750
Y
Z
X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5.198e-11
[Pa]
Ansys
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STUDENT
0
0.200
0.400
0.600
0.800 (m)
Z
X
Y

FABRICATION PROCESS OVERVIEW

- Fabrication involved **cutting, drilling, welding, and assembly** of components.
- **Main Steps**:
- Helical **cylinder blades** made using PVC and FRP spiral wrapping.
- **Mild steel base** constructed with L-angles for stability.
- **Hub and shaft** machined and aligned using SKF bearings.
- Components were assembled on a **welded support frame**.
- Ensured **proper alignment** for smooth rotation and torque transfer.

FABRICATION PROCESS OVERVIEW

ASSEMBLY

- Final prototype was assembled after **fabricating individual components**.
- All parts were aligned for **smooth rotation and load transfer**.
- Major components in the assembly:
  - **Rotating blades** (PVC + FRP spiral)
  - **Hub** with SKF bearings
  - **Mild steel base frame**
  - **Central shaft** connecting rotor to generator
  - **Permanent Magnet Generator (PMG)** mounted at the rear

MATERIALS USED

Component	Material
Blades	PVC (Cylinder) + FRP (Spiral layer)
Base Frame	Mild Steel (MS)
Shaft	EN8 Steel
Bearings	SKF Bearings
Generator	Neodymium Permanent Magnet Generator (PMG)
Hub	Aluminum rod
Fasteners	Standard steel bolts and nuts

- Converts mechanical rotation into electrical energy.
- Uses **neodymium magnets** for strong, efficient field generation.
- No external power required – **self-exciting** design.
- High efficiency (>90%) and low starting torque (0.1 Nm).

- **Specs**:
- Power: 200W | Voltage: 12V (3-phase)
- Poles: 30 | RPM: 200
- Shaft: EN8 | Material: Cast Iron
- Insulation Class: H | Protection: IP54

Testing & Results – Field Test

- Conducted **open field tests** under natural wind conditions.
- **Instruments used**:
- Anemometer (Wind speed)
- Tachometer (Rotor RPM)
- Voltmeter (DC output)

Wind Speed (m/s)	RPM	Voltage (V)
2.8	120	3.2
3.5	150	4.1
4.2	180	5.0
5.0	210	6.2

CONCLUSION & FUTURE SCOPE

Conclusion:

- Successfully designed, fabricated, and tested a **Magnus-effect-based wind turbine**.
- Demonstrated reliable **low-speed wind energy generation**.
- **CFD analysis validated** aerodynamic efficiency.

Future Scope:

- Integrate **energy storage** or **grid-tie inverter** for real-world use.
- Optimize **blade surface (fins/texture)** for better torque.
- Scale up for **community or rooftop-level installations**.

Q&A / THANK YOU

"Thank you for your attention!"

Any Questions?