RESEARCH ARTICLE OPEN ACCESS

# DESIGN AND ANALYSIS OF COMPOSITE PROPELLER BLADE FOR AIRCRAFT

D. Jagan[1], G. Srikanth[2], R.Rakesh[3], M. Karthikeya[4], Ch. Gayathri
[1] Assistant Professor, Department of Mechanical Engineering, Ace Engineering College
[2, 3,4,5] Students, Department of Mechanical Engineering, Ace Engineering College

## ABSTRACT

This project focuses on designing and analyzing aircraft propeller blade strength, utilizing software like CATIA V5 for complex3Dmodeling. It highlights the benefits ofusingcomposite propellers overmetallic onesandconductsfiniteelementanalysis(FEA)usingANSYSworkbenchsoftware.Thestudycomparesthe strengthofaluminumandcompositepropellerbladesthroughstaticandmodalanalysisformaterialssuchas Aluminum alloy7075, E-glass, and Carbonfiber andalsoby usingMachine learningas prediction tool and comparingtheresultsoftheprojectwewillbeabletoconcludetheeffectivenessofeachmaterialindesignof propeller blades and the use of the blades in aerospace engineering.

## INTRODUCTION

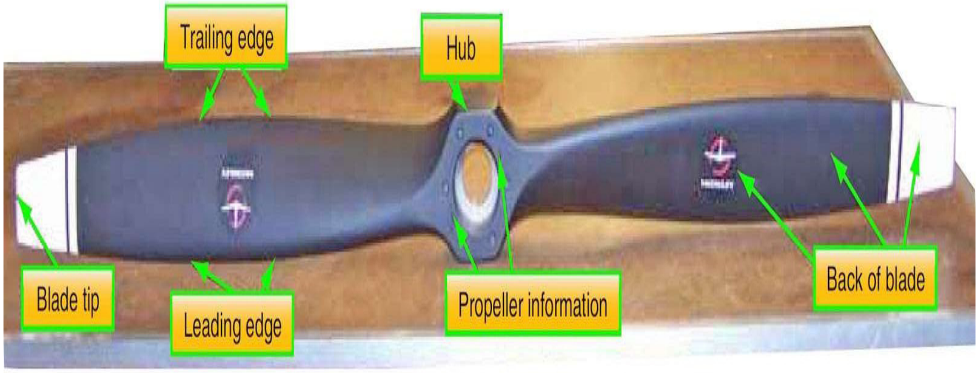
### 1.1 INTRODUCTIONTOAIRCRAFT

Aircraft, since their inception, have been emblematic of human innovation and progress, reshaping global transportation and military capabilities. They are vehicles Designed for atmospheric flight, serving purposes such as transportation, reconnaissance, and combat.Aircraft come in various types, including fixed-wing airplanes, rotary-wing helicopters, and unmanned aerial vehicles (UAVs). These machines consist of components like airframes, propulsion systems, avionics, and control surfaces, working in harmony to ensure safe and efficient operation. Advancements in technology have led to faster, more efficient, and safer aircraft, driving the evolution of air travel and defines capabilities. However, challenges such as environmental sustainability, safety concerns, and technological integration persist. Looking ahead, developments in electric propulsion, autonomous systems, and sustainable aviation fuels hold promise for shaping the future of aviation. Overall, aircraft symbolize humanity's relentless pursuit of exploration, connectivity, and progress.

### 1.2 PROPELLER

Aircraft propellers serve as essential components in aviation, converting engine power into thrust to propel aircraft through the air. They come in various types, including fixed-pitch, variable- pitch, and constant-speed propellers, each offering unique advantages in terms of efficiency and control. Propellers consist of blades, hubs, and spinners, working together to create airflow acceleration and generate forward thrust. The operation of propellers relies on engine power to rotate the blades, which then create pressure differences to produce thrust. Propeller efficiency and performance depend on factors such as blade Design, pitch angle, airspeed, altitude, and engine power. These components find applications across general aviation, commercial airliners, military aircraft, and unmanned aerial vehicles (UAVs). In essence, aircraft propellers play a critical role in aviation by providing reliable propulsion and contributing to the overall performance and efficiency of aircraft operations.

FigureNo.1.1AircraftPropellerBlades



FigureNo.1.2PartsofAircraftPropeller

## 2.1LITERATUREREVIEW

1. **Dr. Y. Seetharama Rao et al**, This work proposes a methodology to Design a propeller with a metal and composite material to analyse its strength and deformation using Ansys software. In order to evaluate the effectiveness of composite over metals, stress analysis is performed on both composite and metal propeller using Ansys. Proposed methodology showed substantial improvements in metal propellers. The mean deflection, normal stress and shear stress werefound for both metallic and composite propeller by usingAnsys. From the results, stress analysis composite propeller is safe resonance phenomenon. In this work effort is made to reduce stress levels so that advantage of weight reduction along with stresses can be obtained.The comparison analysisof metallic and composite propeller was madefor themaximum deformation and normal stresses.

2. **Palle Prasad et al. (2017) and Lanka Bosu Babu**, The work carries out the structural analysisof a CFRP (carbon fibre reinforced plastic) propeller blade which proposed to replace the Aluminium propeller blade. Propeller is subjected to an external hydrostatic pressure on either side of the blades depending on the operating depth and flow around the propeller also result in differential hydrodynamic pressure between face and back surfaces of blades. The propellerblade is modelled and designed such that it can with stand the static load distribution and finding the stresses and deflections for both aluminium and carbon fibre reinforced plastic materials.This work basically deals with the modelling and Design analysis of the propeller blade of a torpedo for its strength. A propeller is complex 3D model geometry. This requires high end modelling CATIA software is used for generating the blade model. This report consists of brief details about fibre Reinforced Plastic materials and the advantages of using composite propeller over the conventional metallic propeller. By

using ANSYS software static structural analysiswere carried out for two different materials.

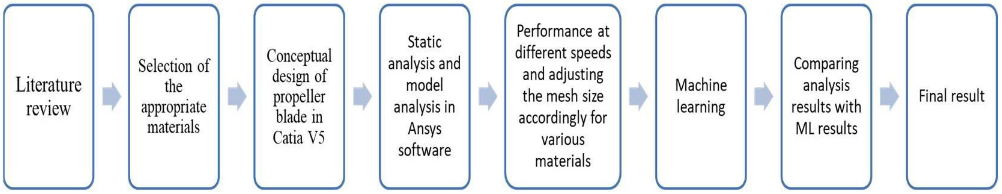
3. **M. Suneetha et al**. (2013) The paper aims at achieving high propulsive efficiency at low levelsof vibration and noise, usually with minimum cavitation. Achieving this aim is difficult with conventional propellers, as ships have become larger and faster propeller diameters haveremained limited by draught and other factors. Surface piercing propeller offers an attractive alternativetohigh-speedcrafts,whichoperateunderlimiteddraught.Theperformanceofthe

   vehicle depends upon the efficiency of the propeller. The geometric shape and its surface finish will decide the efficiency of the propeller. The material used is carbon UD and aluminium. The research basically deals with the modelling and Analysis of the propeller using composite material of a marine vehicle having low draft. A propeller is complex 3D model geometry. CATIAmodellingsoftwareisused for generating theblade model and tool path onthe computer. Sectional data, pitch angle of the propeller are the inputs for the development of propeller model. Finite element analysis was carried out using ABAQUS. The propeller model developed in CATIA is converted in to IGES file and then imported to HYPERMESH for developing fine mesh of the model. As a part of the analysis static structural testing was conducted by varying material properties in pre-processing stage.

4. **D. Gopaiah et al. (2014) and N.Amara Nageshwara Rao**, The thesis deals with modelling and analysing the propeller blade of underwater vehicle for its strength. A propeller is a complex geometry which requires highend modelling software.The solid model of propeller is developed usingCATIAV5 R17.Tetrahedral mesh is generated for the model usingHYPER MESH.Static, Eigen and frequency responses analysis of both aluminium and composite propeller are carried out inANSYS. Inter laminar shear stresses are calculated for composite propeller by varying the number of layers. The stresses obtained are well within the limit of elastic property of the materials. The dynamic analysis of aluminium, composite propeller which is a combination of GFRP(Glass Fibre Reinforced Plastics) and CFRP(Carbon Fiber Reinforced Plastics) materials.

5. **Guanmo Xie et al**. (2011) In this studyAmulti-objective optimization approach is proposed for propeller preliminary Design. A Non-dominated Sorting Genetic Algorithm II (NSGA II) is employed to approximate the set of Pareto solution through an evolutionary optimizationprocess. Then a decision-making approach is adopted to select “best” solution. A B-propeller Design example is conducted to illustrate the analysis process.

## METHODOLOGY



FigureNo.3.1Methodologyflowchart

### 3.1 Selectionoftheappropriatematerials

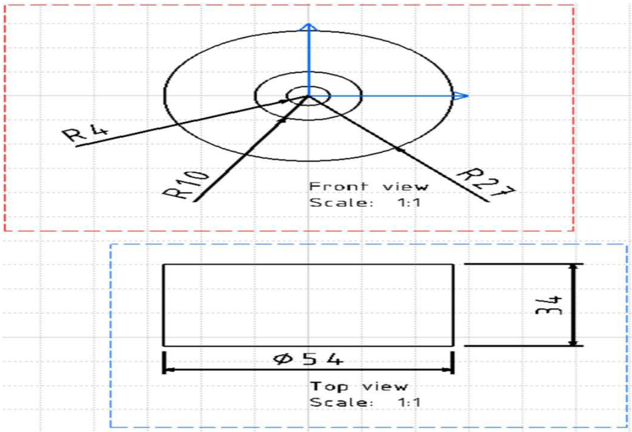
Selecting the appropriate material for composite propeller blades involves considering factorslike strength, weight, fatigue resistance, and aerodynamic performance. Materials like carbon fiber are commonly used due to their high strength-to-weight ratio and fatigue resistance. However, other factors such as cost, manufacturing process, and environmental impact also playa role in the selection process. Conducting thorough analysis and testing is crucial to ensure the chosen material meets the specific requirements of the aircraft application.

1. **Strength and Stiffness:** The material must be strong and stiff enough to withstand the loads experienced during operation, including centrifugal forces, aerodynamic loads, and enginetorque.
2. **Fatigue Resistance:** Composite materials should have good fatigue properties to withstandthe cyclic loading experienced during the propeller's lifespan without developing cracks or failures.

3. **Density and Weight:** Low-density materials help reduce the overall weight of the propeller, which can improve fuel efficiency and performance of the aircraft.
4. **Corrosion Resistance:** Materials should be resistant to corrosion, especially if the propeller will be used in harsh environments or exposed to moisture.
5. **Manufacturability:** Considerations such as ease of manufacturing, compatibility with manufacturingprocesses(suchasfilamentwindingorresintransfermolding),andavailability of materials are important factors.
6. **Environmental Impact:** Environmental considerations, such as recyclability and sustainability of materials, are becoming increasingly important in material selection.
7. **Cost:** Material cost, as well as the cost of manufacturing processes and maintenance, shouldbe evaluated to ensure that the chosen material is cost-effective over the lifetime of the propeller.
8. **Aerodynamic Performance:** The material's properties should not adversely affect the aerodynamic performance of the propeller, including factors such as surface smoothness and dimensional stability.

## 3.2 Conceptualdesignofpropeller bladesincatia V5

Creating a 3D model of an aircraft propeller blade involves several steps. Designers start by conceptualizing the blade's geometry and aerodynamic profile based on performance requirements. Using CAD software, they create a detailed 3D model of the blade, integrating it with the hub and spinner to ensure proper fit and alignment. Details like blade root fillets and leading-edge protection are added for structural strength and aerodynamic performance. Surface refinement techniques are applied to ensure smoothness and continuity, crucial for minimizing drag and improving efficiency. The model undergoes mesh generation for analysis, including structural and aerodynamic simulations. Analysis results inform optimization iterations to improveperformance.ValidatedDesignsaredocumentedformanufacturing,providingpreciseinstructions for fabrication. Throughout the lifecycle, Designs are iteratively improved based on field performance data and regulatory requirements.



FigureNo.3.2DesignofHub

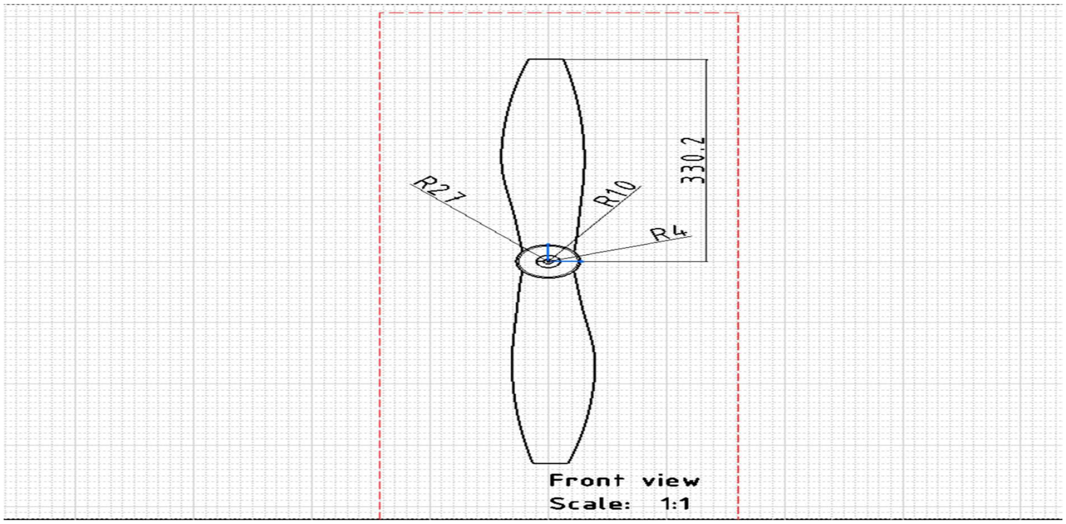
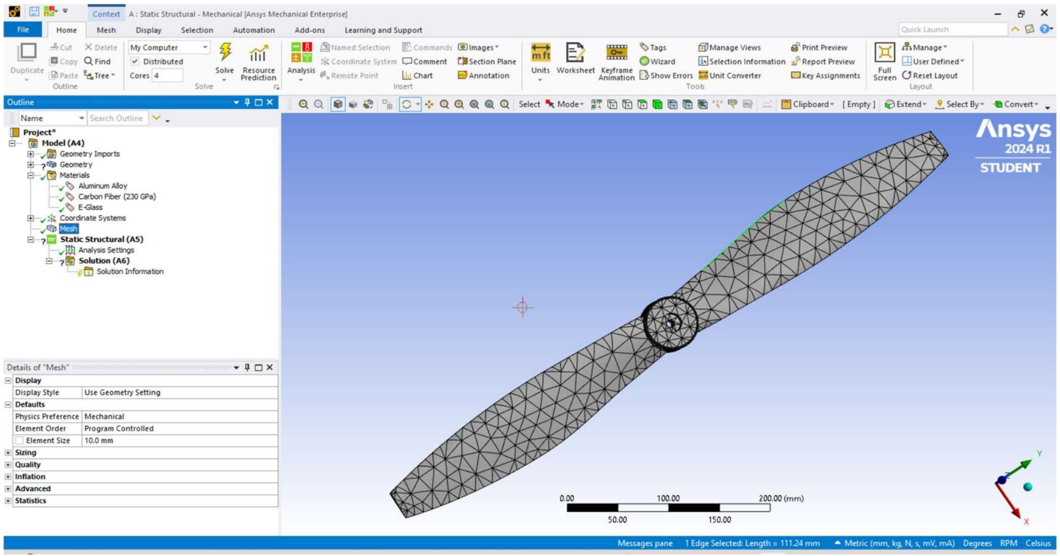


Figure No.3.3Designofcomponent



Details of "Mesh"

Display

Display Style: Use Geometry Setting

Defaults

Physics Preference: Mechanical

Element Order: Program Controlled

Element Size: 10.0 mm

Sizing

Quality

Inflation

Advanced

Statistics

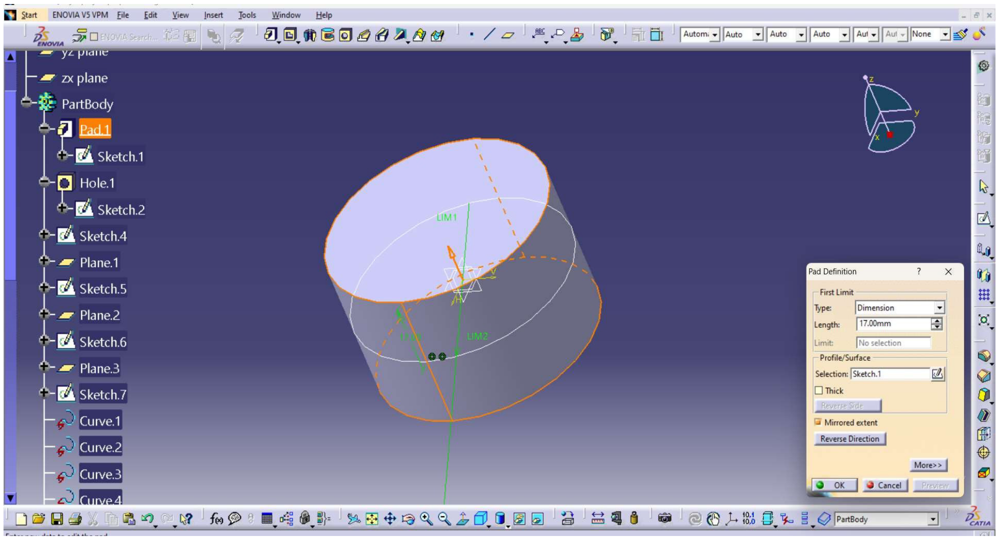
Messages pane | 1 Edge Selected: Length = 111.24 mm | Metric (mm, kg, N, s, mV, mA) | Degrees | RPM | Celsius

Figure No.3.4Meshofpropellerblade

## 4.1 DESIGNOFPROPELLERBLADES

### 1. GENERATIVESHAPEDESIGN:

The profile which is generated from the sketcher, is extruded along x-direction for forming a 3D surface for the hub.



Pad Definition

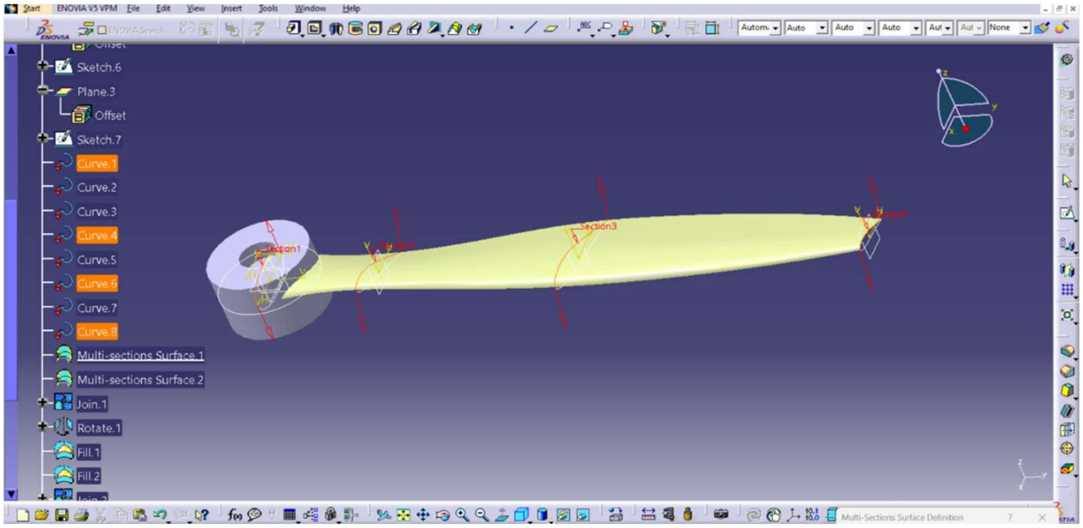
First Limit
Type: Dimension
Length: 17.00mm
Limit: No selection

Profile/Surface
Selection: Sketch.1
☐ Thick
☑ Mirrored extent

FigureNo.4.2Extrusionofhub

## 2. DESIGNOFAPROPELLERBLADE:

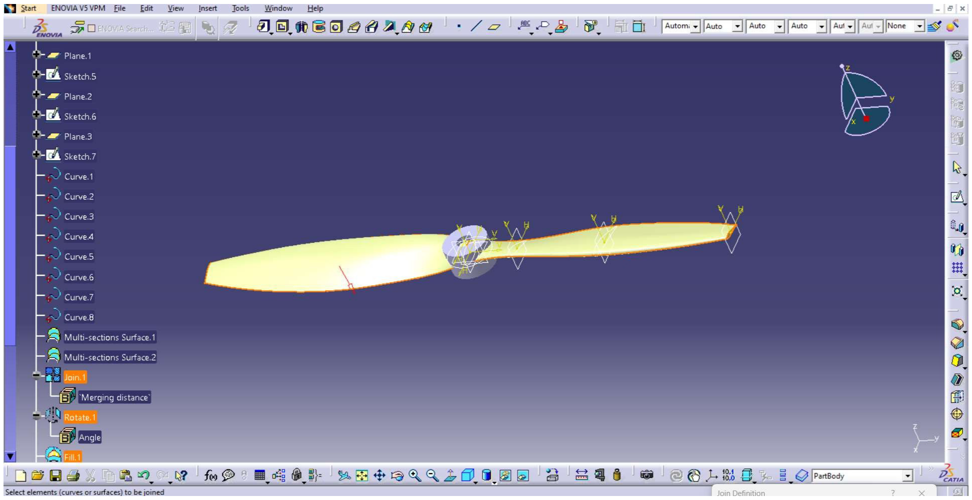
The profile of the propeller blade is generated from the Design data. The surface of the blade isgenerated by using “FILL” command.



FigureNo.4.3BladeDesign

## 3. REPLICATIONOFTHEBLADES:

The blade which is generated is replicated along the hub of the propeller by using “CIRCULAR PATTERN” command in Replication toolbar.

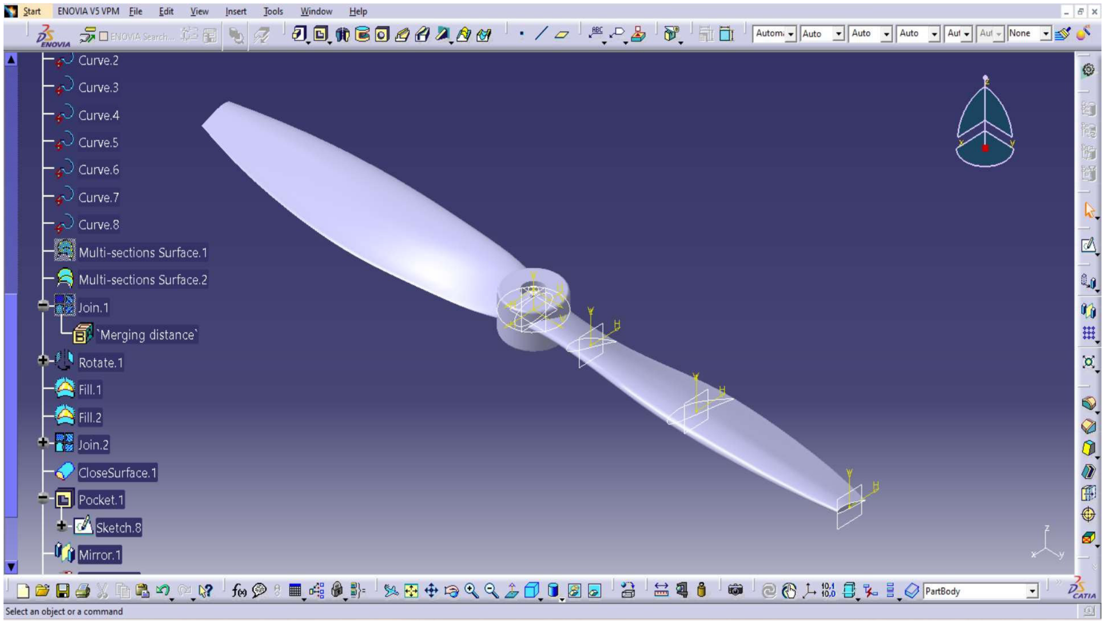


Select elements (curves or surfaces) to be joined

FigureNo.4.4Repetitionofblades

## 4. DRESS-UPFEATURES:

Aftergeneratingsolidsurface,filletisaddedattherootofthepropellerbladesandhub.



Select an object or a command

FigureNo.4.5Dressupfeatures

### 4.1.1 STEPSINVOLVEDINANALYSISOF PROPELLERBLADES

Before beginning the Analysis procedure let us consider the parameters we required for overall project.

| MATERIALS | SPEED(rpm) | MESH SIZE(MM) |
|---|---|---|
| ALUMINUM ALLOY 7075 | 7000-9000 | 10-100 |
| CARBON FIBER | 7000-9000 | 10-100 |
| E-GLASS FIBER | 7000-9000 | 10-100 |

TABLE4.2RequiredData

Letusconsiderspeedas7000rpmandmeshsizeas10mmparametertoperformthestepsof analysis.

#### 4.1.1.1 EVALUATIONOFSTATICANALYSISRESULTS

| Material | mesh size(mm) | speed(rpm) | Total deformation (mm) | stress (Mpa) |
|---|---|---|---|---|
| AluminiumAlloy | 10 | 7000 | 0.81508 | 147.83 |
| AluminiumAlloy | 15 | 7100 | 0.81675 | 144.94 |
| AluminiumAlloy | 20 | 7200 | 1.1924 | 154.02 |
| AluminiumAlloy | 25 | 7300 | 0.94588 | 152.54 |
| AluminiumAlloy | 30 | 7400 | 0.97402 | 162.47 |
| AluminiumAlloy | 35 | 7500 | 0.98473 | 166.27 |
| AluminiumAlloy | 40 | 7600 | 1.0152 | 181.08 |
| AluminiumAlloy | 45 | 7700 | 1.0311 | 185.11 |
| AluminiumAlloy | 50 | 7800 | 1.0575 | 177.83 |
| AluminiumAlloy | 55 | 7900 | 1.0371 | 183.6 |
| AluminiumAlloy | 60 | 8000 | 0.92688 | 182.42 |
| AluminiumAlloy | 65 | 8100 | 1.0878 | 203.46 |
| AluminiumAlloy | 70 | 8200 | 1.1149 | 208.51 |
| AluminiumAlloy | 75 | 8300 | 1.1422 | 213.63 |
| AluminiumAlloy | 80 | 8400 | 1.1684 | 221.41 |
| AluminiumAlloy | 85 | 8500 | 1.156 | 226.17 |
| AluminiumAlloy | 90 | 8600 | 1.1834 | 231.53 |
| AluminiumAlloy | 95 | 8700 | 1.211 | 236.94 |
| AluminiumAlloy | 100 | 8800 | 0.01239 | 242.42 |

| | | | | |
|---|---|---|---|---|
| AluminiumAlloy | 105 | 8900 | 1.2674 | 247.96 |
| AluminiumAlloy | 110 | 9000 | 1.1204 | 229.58 |

Table4.1AluminiumAlloyresults

| **MATERIAL** | **SPEED (rpm)** | **MESH SIZE (mm)** | **STRESS (Mpa)** | **TOTAL DEFORMATION (mm)** |
|---|---|---|---|---|
| CARBONFIBER | 7000 | 10 | 100.13 | 1.6507 |
| CARBONFIBER | 7100 | 15 | 97.92 | 1.69 |
| CARBONFIBER | 7200 | 20 | 102.23 | 2.5709 |
| CARBONFIBER | 7300 | 25 | 100.87 | 2.0215 |
| CARBONFIBER | 7400 | 30 | 109.34 | 2.0405 |
| CARBONFIBER | 7500 | 35 | 111.2 | 2.0675 |
| CARBONFIBER | 7600 | 40 | 121.82 | 2.1181 |
| CARBONFIBER | 7700 | 45 | 124.07 | 2.1498 |
| CARBONFIBER | 7800 | 50 | 119.54 | 2.1767 |
| CARBONFIBER | 7900 | 55 | 122.28 | 2.1307 |
| CARBONFIBER | 8000 | 60 | 121.27 | 1.9046 |
| CARBONFIBER | 8100 | 65 | 137.13 | 2.2843 |
| CARBONFIBER | 8200 | 70 | 140.54 | 2.3411 |
| CARBONFIBER | 8300 | 75 | 147.48 | 2.4567 |
| CARBONFIBER | 8400 | 80 | 147.42 | 2.426 |
| CARBONFIBER | 8500 | 85 | 150.64 | 2.3968 |
| CARBONFIBER | 8600 | 90 | 154.2 | 2.4535 |
| CARBONFIBER | 8700 | 95 | 157.81 | 2.5109 |
| CARBONFIBER | 8800 | 100 | 161.46 | 2.5689 |
| CARBONFIBER | 8900 | 105 | 165.15 | 2.6277 |
| CARBONFIBER | 9000 | 110 | 152.84 | 2.3141 |

Table4.2Carbonfiberresults

| **MATERIAL** | **SPEED (rpm)** | **MESH SIZE (mm)** | **STRESS(Mpa)** | **TOTAL DEFORMATION (mm)** |
|---|---|---|---|---|
| EGLASSFIBER | 7000 | 10 | 140.55 | 0.74801 |
| EGLASSFIBER | 7100 | 15 | 138.33 | 0.77087 |
| EGLASSFIBER | 7200 | 20 | 146.38 | 1.1783 |
| EGLASSFIBER | 7300 | 25 | 145.2 | 0.90668 |
| EGLASSFIBER | 7400 | 30 | 154.39 | 0.90617 |
| EGLASSFIBER | 7500 | 35 | 157.85 | 0.918 |
| EGLASSFIBER | 7600 | 40 | 171.66 | 0.94749 |
| EGLASSFIBER | 7700 | 45 | 175.59 | 0.95959 |
| EGLASSFIBER | 7800 | 50 | 169.02 | 0.96636 |

| | | | | |
|---|---|---|---|---|
| EGLASSFIBER | 7900 | 55 | 174.23 | 0.93466 |
| EGLASSFIBER | 8000 | 60 | 165.42 | 0.80908 |
| EGLASSFIBER | 8100 | 65 | 193.07 | 0.9990 |
| EGLASSFIBER | 8200 | 70 | 197.86 | 1.0239 |
| EGLASSFIBER | 8300 | 75 | 202.72 | 1.049 |
| EGLASSFIBER | 8400 | 80 | 209.34 | 1.0763 |
| EGLASSFIBER | 8500 | 85 | 213.87 | 1.066 |
| EGLASSFIBER | 8600 | 90 | 218.93 | 1.0913 |
| EGLASSFIBER | 8700 | 95 | 224.05 | 1.1168 |
| EGLASSFIBER | 8800 | 100 | 229.23 | 1.1426 |
| EGLASSFIBER | 8900 | 105 | 234.47 | 1.1687 |
| EGLASSFIBER | 9000 | 110 | 219.03 | 1.0381 |

Table4.3E-glassfiberresults

### 4.1.1.2 EVALUATIONOFMODALANALYSISRESULTS

| FREQUENCIES AND MODE | Aluminium alloy 7075 | Carbon Fiber | E-glass Fiber |
|---|---|---|---|
| Freq(HZ) | 0 | 0 | 0 |
| Mode1 | 2330 | 91.403 | 89.99 |
| Freq(HZ) | 89.761 | 61.986 | 65.517 |
| Mode2 | 2845.6 | 333.34 | 109.66 |
| Freq(HZ) | 95.75 | 69.89 | 69.89 |
| Mode3 | 2865.8 | 112.14 | 110.44 |
| Freq(HZ) | 373.77 | 264.6 | 278.47 |
| Mode4 | 2755.6 | 264.6 | 278.47 |
| Freq(HZ) | 626.27 | 433.5 | 106.54 |
| Mode5 | 4037.6 | 433.5 | 457.59 |
| Freq(HZ) | 641.32 | 443.88 | 468.38 |
| Mode6 | 4102 | 161.29 | 158.43 |

Table4.4Frequenciesresults

## MACHINELEARNING

### 5.1.1 TheprocesswhichwefollowinML:

FigureNo.5.1Processofmachinelearning

### 5.1.2 ImplementationofMachineLearning

#### 5.1.2.1 DataCollection

The below given parameters we have considered and collected data fromANSYS Software Parameters Present in Data Set

1. **Speed:**Itisgiventothehubtomakepropellerbladerotate.
2. **MeshSize:**Meshingistheprocessoftransformingamorphousshapesinto"elements".
3. **Stress:**stressistheforceactingontheunitareaofamaterial.

| SPEED(rpm) | MESHSIZE(mm) | STRESS(Mpa) |
|---|---|---|
| 7000 | 10 | 140.55 |
| 7100 | 15 | 138.33 |
| 7200 | 20 | 146.38 |
| 7300 | 25 | 145.2 |
| 7400 | 30 | 154.39 |
| 7500 | 35 | 157.85 |
| 7600 | 40 | 171.66 |
| 7700 | 45 | 175.59 |
| 7800 | 50 | 169.02 |
| 7900 | 55 | 174.23 |
| 8000 | 60 | 165.42 |
| 8100 | 65 | 193.07 |
| 8200 | 70 | 197.86 |
| 8300 | 75 | 202.72 |
| 8400 | 80 | 209.34 |
| 8500 | 85 | 213.87 |
| 8600 | 90 | 218.93 |
| 8700 | 95 | 224.05 |
| 8800 | 100 | 229.23 |
| 8900 | 105 | 234.47 |
| 9000 | 110 | 219.03 |

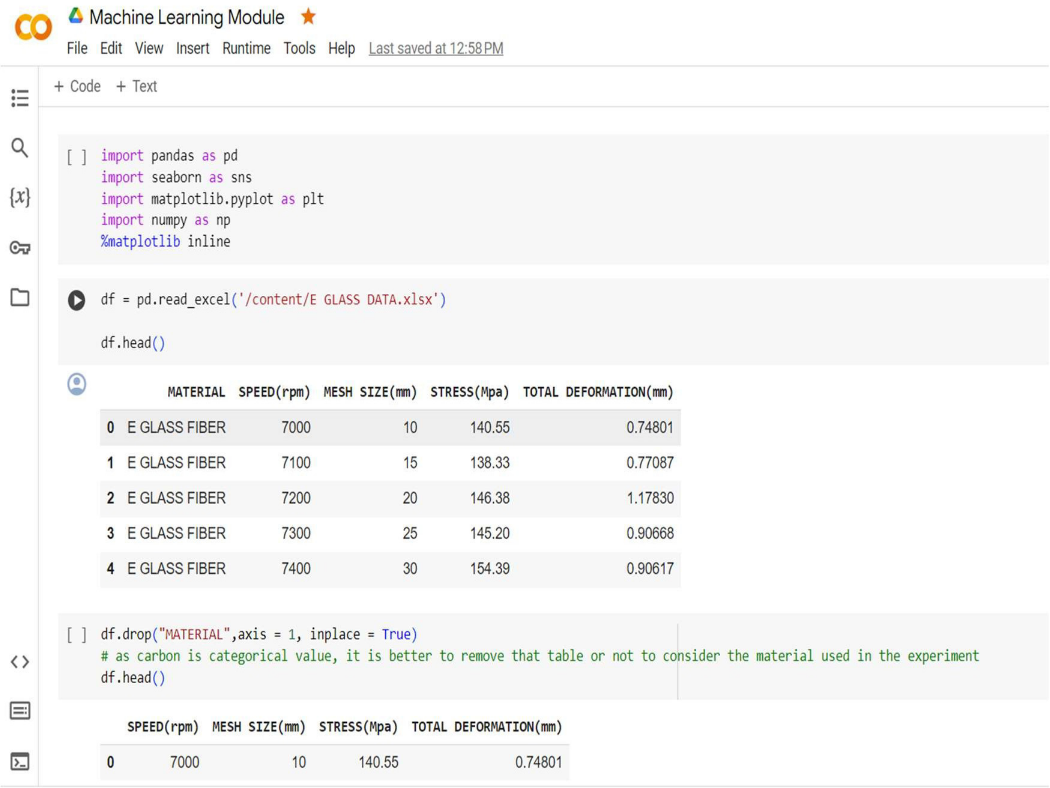
TABLE5.1Collectionofdata

Inthis,wehavetocallthefunctionbeforegoingtothePrediction

1. **NumPy-**NumPyisaPythonLibraryusedforworkingwitharrays.

2. **Pandas-**Pythonlibraryfordatamanipulationandanalysis.

3. **Seaborn-**PythonLibraryforVisualization.
4. **Matplotlib**-ForadvancedVisualization.



```
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import numpy as np
%matplotlib inline
```

```
df = pd.read_excel('/content/E GLASS DATA.xlsx')

df.head()
```

| | MATERIAL | SPEED(rpm) | MESH SIZE(mm) | STRESS(Mpa) | TOTAL DEFORMATION(mm) |
|---|---|---|---|---|---|
| 0 | E GLASS FIBER | 7000 | 10 | 140.55 | 0.74801 |
| 1 | E GLASS FIBER | 7100 | 15 | 138.33 | 0.77087 |
| 2 | E GLASS FIBER | 7200 | 20 | 146.38 | 1.17830 |
| 3 | E GLASS FIBER | 7300 | 25 | 145.20 | 0.90668 |
| 4 | E GLASS FIBER | 7400 | 30 | 154.39 | 0.90617 |

```
df.drop("MATERIAL",axis = 1, inplace = True)
# as carbon is categorical value, it is better to remove that table or not to consider the material used in the experiment
df.head()
```

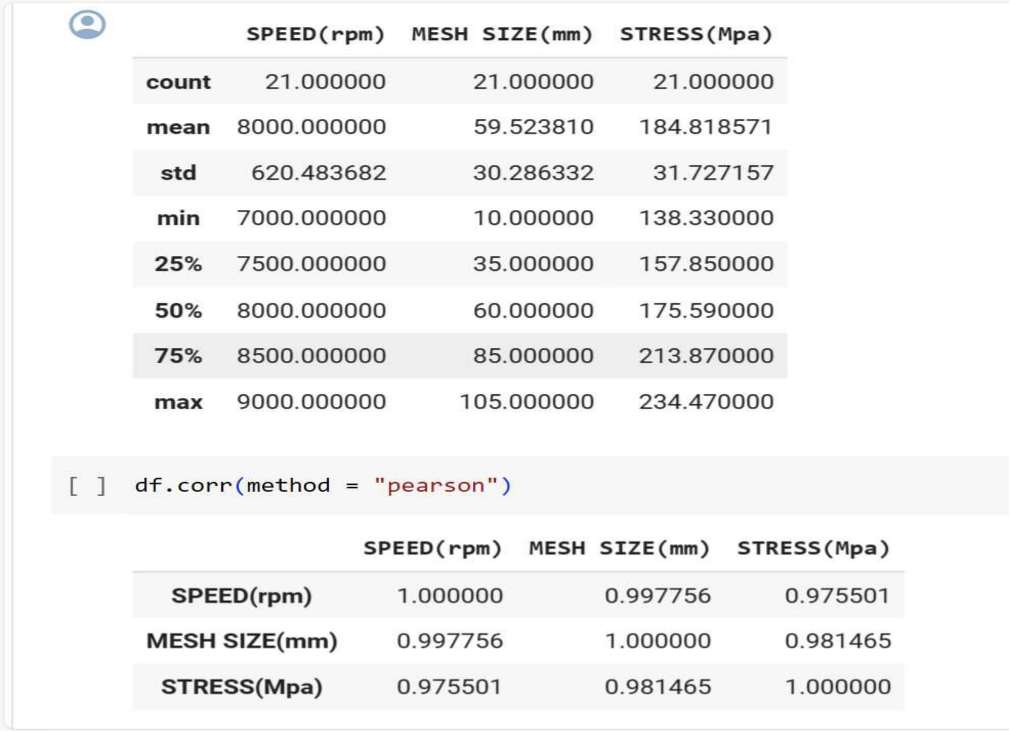
| | SPEED(rpm) | MESH SIZE(mm) | STRESS(Mpa) | TOTAL DEFORMATION(mm) |
|---|---|---|---|---|
| 0 | 7000 | 10 | 140.55 | 0.74801 |

FigureNo.5.2Importingoflibraries.

### 5.1.2.2 DataPreprocessing

Data preprocessing in machine learning refers to the technique of preparing raw data and making it suitable for building and training machine learning models. It is a crucial step that ensures the data is clean, transformed, and organized ina format suitable for building ML models.

**DataExploration:**



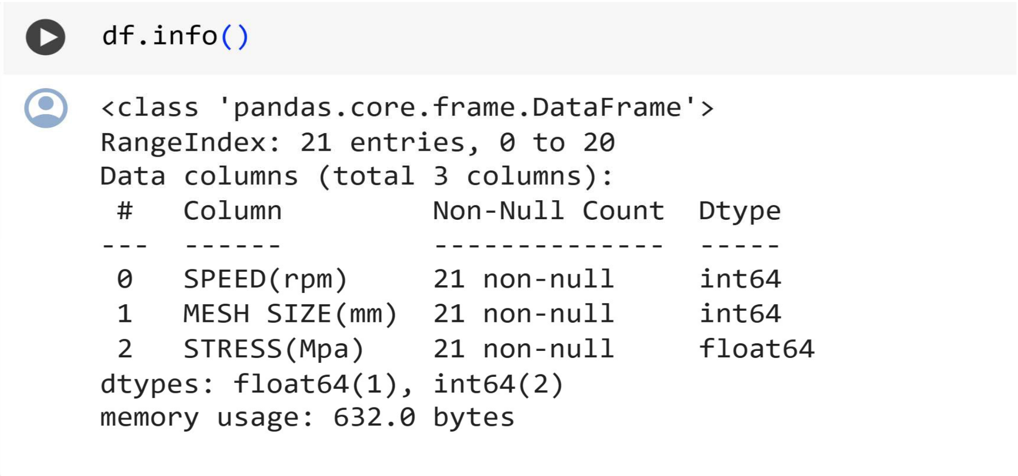
| | SPEED(rpm) | MESH SIZE(mm) | STRESS(Mpa) |
|---|---|---|---|
| **count** | 21.000000 | 21.000000 | 21.000000 |
| **mean** | 8000.000000 | 59.523810 | 184.818571 |
| **std** | 620.483682 | 30.286332 | 31.727157 |
| **min** | 7000.000000 | 10.000000 | 138.330000 |
| **25%** | 7500.000000 | 35.000000 | 157.850000 |
| **50%** | 8000.000000 | 60.000000 | 175.590000 |
| **75%** | 8500.000000 | 85.000000 | 213.870000 |
| **max** | 9000.000000 | 105.000000 | 234.470000 |

```
[ ] df.corr(method = "pearson")
```

| | SPEED(rpm) | MESH SIZE(mm) | STRESS(Mpa) |
|---|---|---|---|
| **SPEED(rpm)** | 1.000000 | 0.997756 | 0.975501 |
| **MESH SIZE(mm)** | 0.997756 | 1.000000 | 0.981465 |
| **STRESS(Mpa)** | 0.975501 | 0.981465 | 1.000000 |

FigureNo.5.3Describingofdata

**Insight:**Inthiscode,describesaboutthecount,mean,standarddeviation,minimum,25 percentile, 50 percentile,75 percentile, maximum value in the variables.



```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 21 entries, 0 to 20
Data columns (total 3 columns):
 #   Column         Non-Null Count  Dtype
---  ------         --------------  -----
 0   SPEED(rpm)     21 non-null     int64
 1   MESH SIZE(mm)  21 non-null     int64
 2   STRESS(Mpa)    21 non-null     float64
dtypes: float64(1), int64(2)
memory usage: 632.0 bytes
```

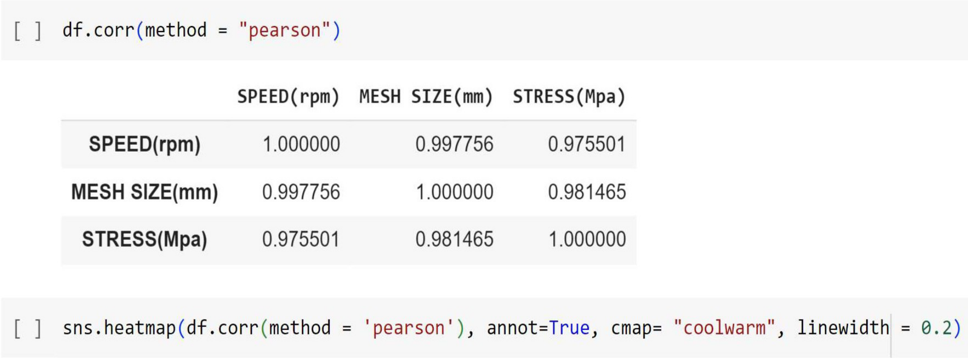
FigureNo.5.4CheckingforNullvalues

**Insight:**Hence,therearenonullvaluesinthedataset,datacleaningisnotrequired.

**CorrelationMatrix:**

Correlation is a statistical measure that describes the relationship between two variables. It indicates how closely the variables are related to each other and the direction of their relationship. Correlation is often expressed as a correlation coefficient, which ranges from -1 to +1.Acorrelation coefficient of +1 indicates a perfect positive correlation, meaning that as one variable increases, the other variable also increases in a linear fashion. Conversely, a correlation coefficient of -1 represents a perfect negative correlation, where as one variable increases, the other variable decreases in a linear fashion. A correlation coefficient of 0 indicates no correlation between the variables, suggesting that there is no linear relationship between them. It's important to note that correlation does not imply causation. Just because two variables are correlated, it does not necessarily mean that one variable causes the otherto change. Correlation only measures the strength and direction of the relationship between the variables.

Correlation can be calculated using various methods, such as the Pearson correlation coefficient, Spearman's rank correlation coefficient, or Kendall's tau coefficient, depending on the nature of the data and the assumptions made. These coefficients provide a numerical value that represents the degree of correlation between the variables.



```
[ ]  df.corr(method = "pearson")
```

| | SPEED(rpm) | MESH SIZE(mm) | STRESS(Mpa) |
|---|---|---|---|
| **SPEED(rpm)** | 1.000000 | 0.997756 | 0.975501 |
| **MESH SIZE(mm)** | 0.997756 | 1.000000 | 0.981465 |
| **STRESS(Mpa)** | 0.975501 | 0.981465 | 1.000000 |

```
[ ]  sns.heatmap(df.corr(method = 'pearson'), annot=True, cmap= "coolwarm", linewidth = 0.2)
```

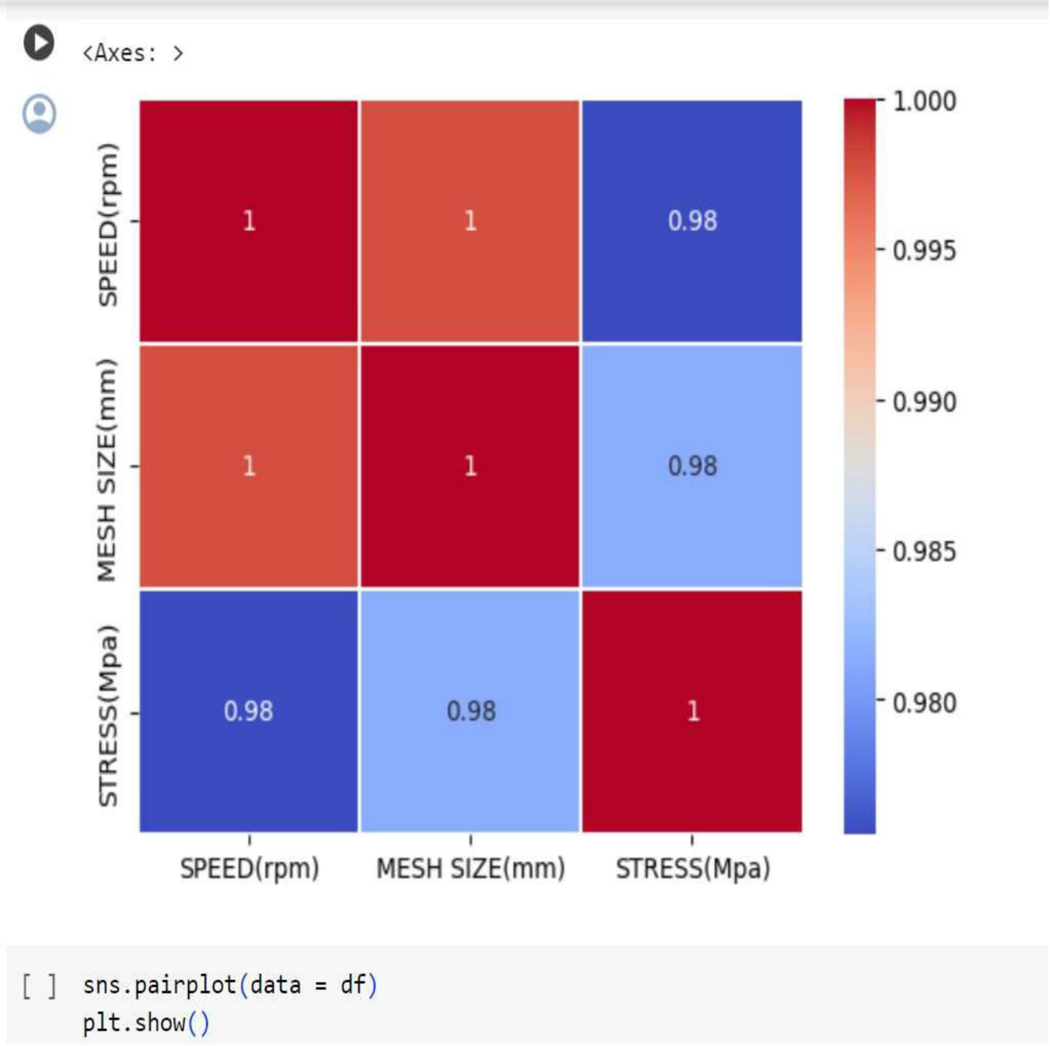
FigureNo.5.5CorelationMatrix

**Insight:** There is strong negative correlation between the Total Deformation and Diameter i.e., -0.86

## HEATMAP

A heatmap is a graphical representation of data where the values of a matrix are represented as colours. It is a useful visualization tool for understanding patterns and relationships within a dataset, especially when dealing with large amounts of data.

In a heatmap, each cell of the matrix is assigned a colour based on its value. Typically, a colour gradient is used to indicate the magnitude of the values, with lighter colours representing higher values and darker colours representing lower values. This colour mapping allows patterns and trends to be easily identified.



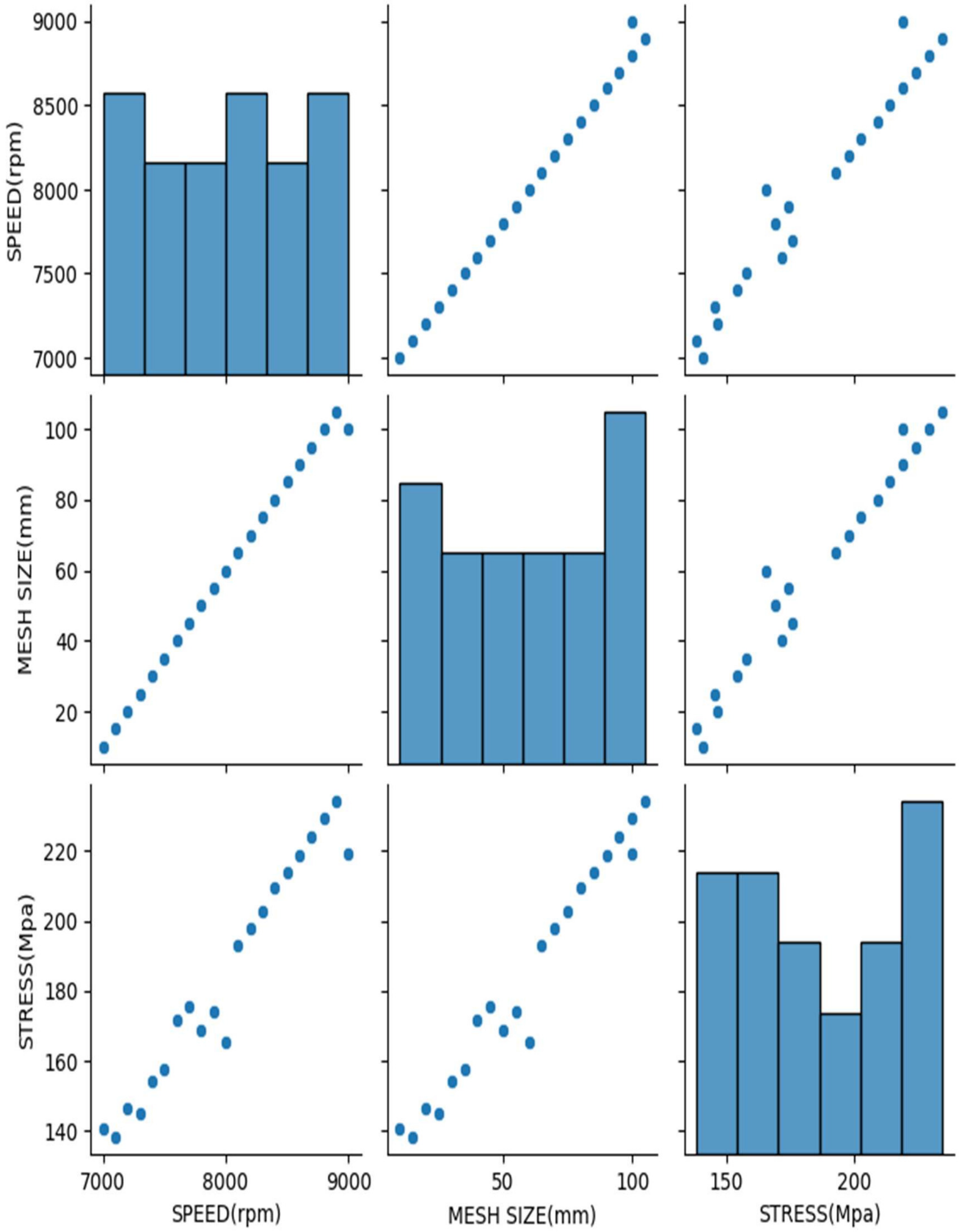
```
<Axes: >
```

```
[ ] sns.pairplot(data = df)
    plt.show()
```

FigureNo.5.6CorrelationHeatMap

**Insight:** There is strong negative correlation between the Total Deformation and Diameter i.e., - 0.86

## Pairplot:



FigureNo.5.7PairPlot

**RESULTS:**

- Thedecisiontreeexhibitsthelowestmeanabsoluteerrorat0.0098.

- Thedecisiontreehasthesmallestmeansquarederrorat0.0001.

## CONCLUSION

The proposed study aims to explore the mechanical properties and structural behaviour of a Propeller blade design using three distinct materials: carbon fiber, E-glass and aluminium alloy 7075. Through the use of CATIA V5 for design and Ansys R21 for analysis, the research will provide a comprehensive evaluation of static structural analysis and modal analysis, focusing on the impact of fixed loads and natural frequencies across the various materials.

In conducting this analysis, we expect to uncover key insights intothe mechanical characteristics of each material when applied to the aircraft propeller blade. Specifically, we will assess their capacity to withstand different loads and their natural frequency response, which will help us determine which materials offer optimal performance for specific applications.

This study has broader implications for the use of in real-world engineering contexts. By comparing, we aim to establish a comprehensive understanding of each material's effectivenessin creating robust and adaptable Design propeller blade, paving the way for future developments in aerospace engineering and design.

It was concluded that Decision Tree algorithm is the best machine learning algorithm which is predicting the total Stress with minimum error.

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