Design And Analysis Of Ship Propeller By Using Braided Composite Material

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Abstract— Braided composites are becoming popular especially for structural applications because of their natural tendency to conform to intricate shapes and more balanced properties than unidirectional laminates. In the present work three dimensional finite element analysis (FEA) of Biaxial braided composite have been performed by developing meso-scale model to evaluate the effective material properties of carbon/epoxy material system. A unit-cell based methodology has been adopted to account for the braiding style, matrix and the fiber-matrix interface. The simulations were performed using commercial FEA code ANSYS and periodic boundary conditions (PBC) has been applied on the unit cells. By varying the braiding angle from 15° to 75°, the effective material properties were predicted and the variation of the engineering constants with the braiding angle was studied. The results obtained were in close agreement with the available reviewed articles. The technique of developing the meso-mechanical model for analyzing the mechanics of textile composite is very effective. It truly reflects the braided structure and corresponds with the actual pattern of the braided composites. In addition to that the static and dynamic response of the ship propeller by Appling braided composite material properties is investigated.

Keywords— Braided composites; Biaxial braided composite; PBC; meso-scale model; ship propeller

I. INTRODUCTION

The commonly used composites are tape laminates and textile composites. Tape laminates have good in-plane properties. Textile composites, which include woven, braided, and knitted fabrics, are also important when considering out-of-plane properties. Textile composites generally have better dimensional stability, out-of-plane properties, and impact and delamination resistance. Figure 1 shows the different orthogonal weave patterns of textile fabric. Braiding is an ancient textile process that is simple and highly productive. Braided fabric is used for many secondary structures such as stiffeners, wing spars, floor beams, fuselage frames, ducting, and housings in aerospace applications. There is a growing interest in using this technique to manufacture composite performs for primary structures like wing flaps, horizontal stabilizers, and fuselage especially for small business jet applications

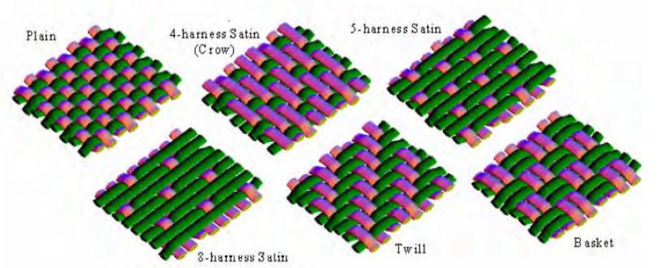

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Figure 1. Different Weave Patterns of Textile Fabric (Plain, Twill, Satin, and Basket)

Braid architecture resembles a combination of filament winding and weaving. Fibers in braided tubes have continuity between the ends of the part and are mechanically interlocked.

II.LITERATURE REVIEW

Many researchers have developed models for textile composites. A lot of literature has been written on the analysis of textiles. Most of the research has been focused on weaves because of their relative geometric simplicity. It can be noted that away from boundaries, there exist some similarities in geometry of weaves and braids. For example, a 1x1 braid with braid angle of ±45° is similar to a plain weave and a 2x2 braid with braid angle ±45° is similar to a twill weave. Ishikawa and Chou were two of the pioneers in the analysis of textile composites [14-15]. They did a good deal of work on the Thermo-mechanical modeling of plain weaves. They used the classic laminate theory as a basic tool for developing their models. Naik,Shembekar and Ganesh [16-17] have extended the 1-D models of Ishikawa and Chou into 2-D elastic models that take into account the undulation in both the warp and weft directions and the cross-section shape of the yarn. Hahn and Pandey [18] extended the above 2-D models to a 3-D thermo-elastic model that models the undulation of fibers in both directions along with a sinusoidal cross-section shape of the yarns. R Naik developed an analysis tool called TexCad that calculates the 3-D effective properties by a yarn discretization scheme that again assumes iso-strain condition. Paumelle et al. have used the finite element method to get all the 3-D effective properties by applying the different loading conditions and the periodic boundary conditions on the model.

In summary, considerable progress has been made in the area of quasi-static analysis of woven composites. Relatively little has been done for quasi-static analysis of braids. Given this state of the art, in the next section, we propose the following research for the 2x2 biaxial braided composites.

III.OBJECTIVES AND SCOPE OF THE PRESENT WORK

Braided composites have a wide range of applications in many areas like aerospace, industry, medicine and recreation. The advantages of the braids are a result of their fiber continuity and the mechanical interlacing. To exploit the advantages that these materials offer, their mechanical behavior needs to be characterized. Not many attempts have been made to analyze the 2x2 braids. Mainly the research has been focused in the area of quasi-static analysis of woven composites and relatively little has been done for the braids because of their complex microstructure. A full three dimensional stress state exists in braids and their stress analysis tends to be even more complicated than that of weaves. The present work will be focused on the following topics:

1) Define the idealized tow architecture to analyze the microstructure of the 2x2 braids.
2) Study the effect of various parameters like braid angle, waviness ratio, and tow cross-section, stacking sequence and material properties on the effective engineering properties of the 2x2 braids.
3) Compare the difference in predictions of the 3D finite element analysis and the simple 3D laminate analysis.
4) Predict the three-dimensional stress state. Determine the effect of the braid angle on location and magnitude of the peak stresses, which will be helpful in locating the potential damage spots for different braids.
5) High strength of layup angle has to find out and which have to implement in ship propeller.
6) Different analysis has to perform like fluent analysis to find out dynamic pressure acting on face of propeller. As well as static, buckling and vibration analysis have to perform r application.

IV.MODELING OF BIAXIAL BRAIDED COMPOSITES

The present work, texgen software is used to develop the CAD model of the braid structure. The modeling process starts by developing the tow cross-section, here a lenticular section is considered. The cross-section is then swept along the undulation path. The cross-section plane and the plane locating the undulation path are not perpendicular but are at an angle with each other. The measure of this angle is equal to twice the braid angle e. For biaxial braid modeling the bias tows are arranged at a specified angle with each other. There is some gap between the two adjacent tows after which the matrix is merged with the tows. Fig. 4 shows modeling approach for biaxial (2/2) braided structure.

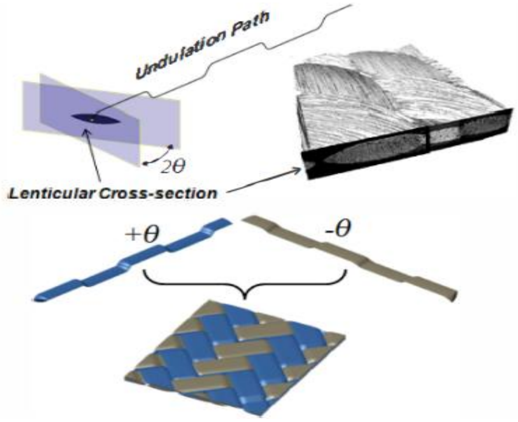


Fig:2. Modeling Procedure for Biaxial (2/2) Braid Structure.

Meso-scale analysis technique for textile composites is an efficient way for homogenization of mechanical properties. The complete modeling procedure is a multi level modeling process incorporating micro-meso-macro level modeling (Fig. 6). The micro level model provides material properties of homogenized impregnated tows and plies. The results of micro level are used by meso level model to provide material properties for macro analysis (structure analysis).

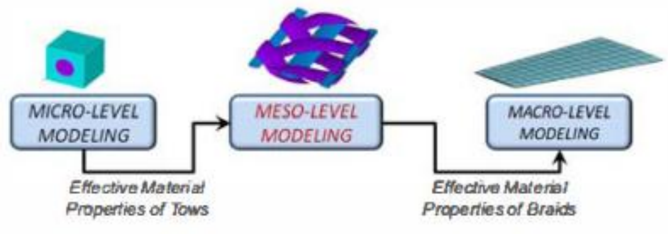


Figure:3.. Multi-level modeling process

TexGen generates realistic models of textiles, including their properties. Its primary application is in the design and manufacture of fiber-reinforced composites. A composite material is one that is made by combining two existing materials; in a fiber-reinforced composite, stiff, strong fibers form one part of the composite, reinforcing the other. In manufacturing, it is common for this reinforcing material to be supplied in textile form, woven from ‘yarns’ made from the fibres.TexGen creates computer models of such textiles, incorporating the structure of the weave, so as to simulate the behavior of the material carbon/epoxy. By using TEXZEN software we can make braided composites from 15 to -75 degrees angles.

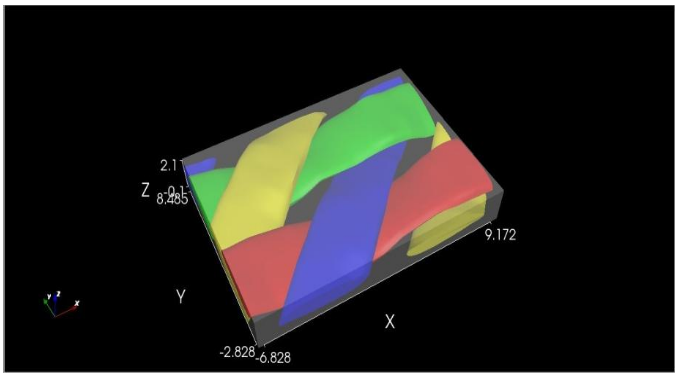


Fig:4. Biaxial braided composite at 45^0 tow angle.

V.MATERIAL PROPERTIES EVALUATION

It is an important technique in Finite element methods. Generally mesh 200 element is available in the ANSYS workbench. These elements are used to solve in the shell and solid element. When there is number of element present we can get the exact results. At the same time, hexagonal meshing gives best results. In the present work, the entire assembly components are divided into 203276 tetrahedron elements and 50261 nodes. Bounded connections are provided between matrix and carbon fibers. Load applied on exterior face of the epoxy. Here 400 N loading is applied at both opposite faces.

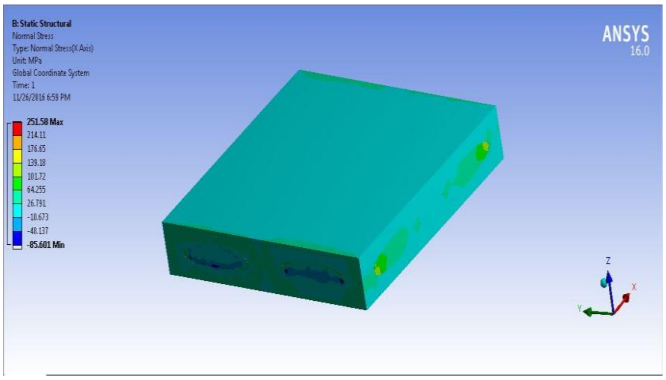


Fig:5 .X-direction normal stress.

The above image shows the X-directional normal stresses. Here results have taken after the 400N load applied on both sides of resin box. And maximum stresses are available at nearly fiber and resin contact area and value is 251 MPa. The below image shows the Y-directional normal strain. Here results have taken after the 400N load applied on both sides of resin box. And maximum strains are available at nearly fiber and resin contact area and value is 0.0019 MPa. Likewise, we found stresses and strains in x, y and z-directions.

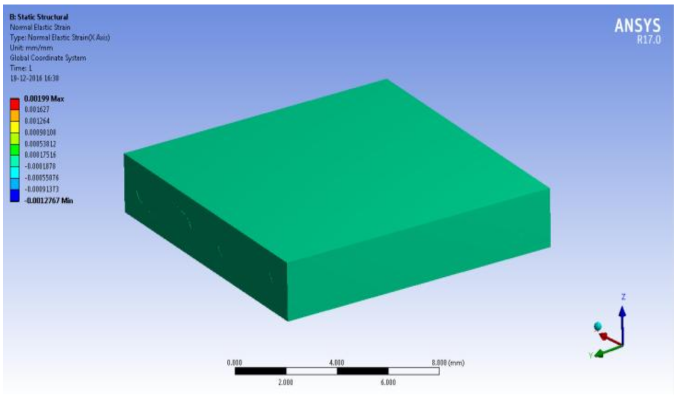


Fig:6. X-direction normal strain

The young's modulus and poisons ratio is calculated from analysis results of ANSYS. Here after perform the analysis final normal stresses of all direction and normal strains of all direction have noted to find out the combined material using following equation.

A rod-like specimen subjected to uniaxial tension will exhibit some shrinkage in the lateral direction for most materials. The ratio of lateral strain and axial strain is defined as **Poisson's ratio**

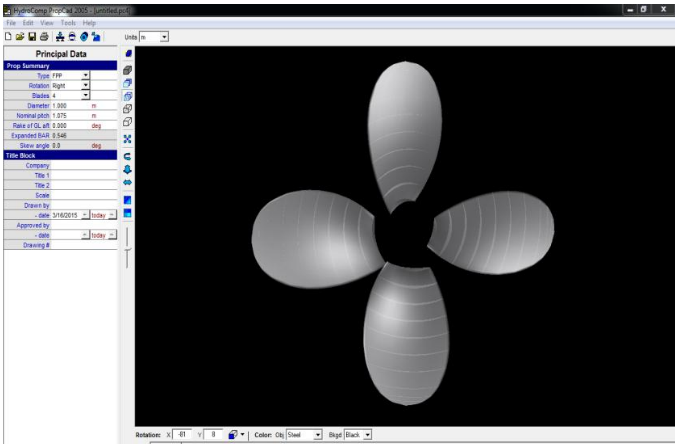
Angle	Ex (GPa)	Ey (GPa)	Ez (GPa)	Poissons ratio
15	115	16	16	1.2
30	38	17	17	1.3
45	18	18	18	0.8
60	17	38	38	0.4
75	16	120	120	0.1

Table:1.Material properies of biaxal braiding composites with different angles.

VI.IMPLEMENTED MODEL ANALYSIS

From the above material properties,take the best value of the young's modulus at an angle.That is at 15 degrees angle,take the material properties values and apply to the implemented model SHIP PROPELLER.

A. MODELING OF PROPELLER: Hydro Comp Prop Cad is the industry-standard software for geometric modeling of marine propellers for design and manufacture.



Fig;7.Dimensions considered in hydro comp propcad

After we got shape and all dimensions of the propeller that is imported to

catia

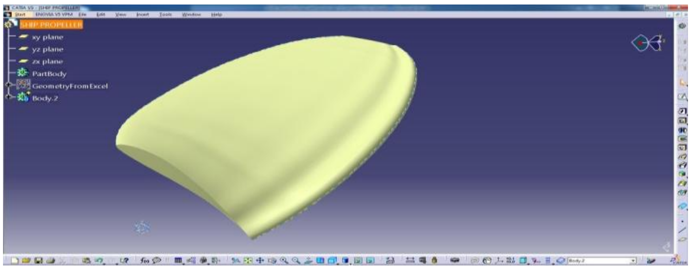


fig:8..suface model created in

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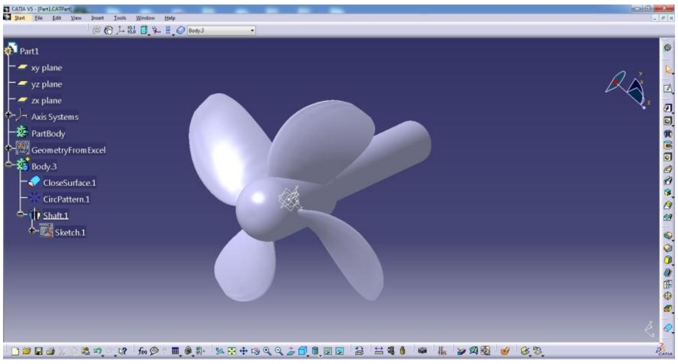

fig:9. Final model of propeller

B.ANALYSIS OF SHIP PROPELLER:

i.Fluent Analysis: CFD is useful in a wide variety of applications and here we note a few to give you an idea of its use in industry.

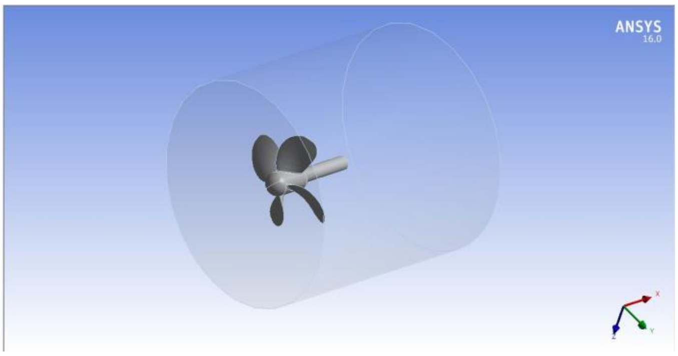

Fig:10. Fluid domain created in ANSYS

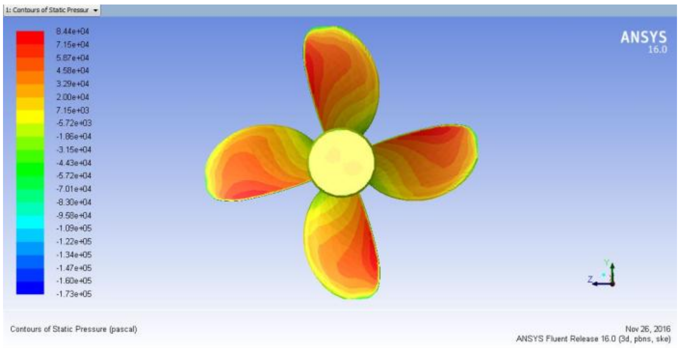

Fig:11Pressure distribution on face of propeller

After completed the fluent analysis, dynamic pressure is directly transfer to static structural analysis on same faces of ship propeller using ANSYS transfer module. Here one end of ship propeller shaft is rigidly fixed. And static structural analysis is performed and results have taken as shown below.

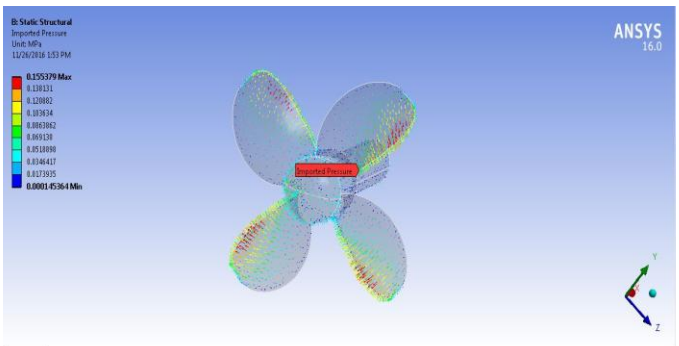

Fig:12.Dynamic pressure imported into structural analysis.

ii.Modal Analysis: Modal analysis is the procedure of determining a structure's dynamic characteristics; namely, resonant frequencies, damping values, and the associated pattern of structural deformation called mode shapes.

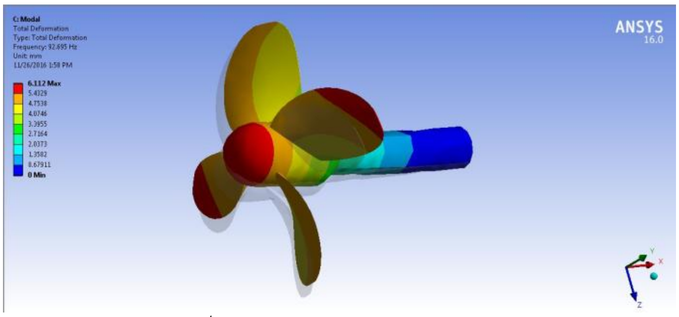

fig:13.1stmode of ship propeller.

The above image shows the different mode shape of ship propeller at 92 Hz natural frequencies. Like that do for same analysis at 215Hz and 239Hz. Here natural frequencies are very important to avoid the resonance. When propeller is in running condition defiantly vibrations will occur. Due to which the member can failure due to resonance. so before go to design we have to check the natural frequencies of propeller and which cannot be same as artificial frequencies and natural frequencies of braided ship propeller are 92 Hz, 215Hz and 239Hz.

iii.Harmonic Analysis: Harmonic analysis results are used to determine the steady-state response of a linear structure to loads that vary sinusoid ally with time, thus enabling you to verify whether or not your designs will successfully overcome resonance, fatigue, and other harmful effects of forced vibrations.

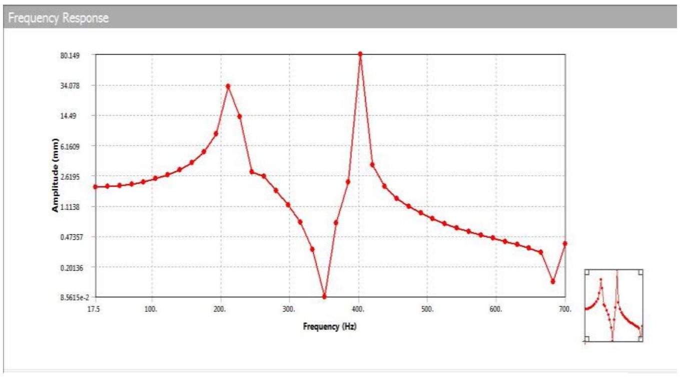

Fig:14. X-direction displacement with frequency.

The above image show the behavior of deformation of different directions for different applied frequencies. Here at 215 Hz we can see the maximum deformation and which same natural frequency we got in modal analysis is 215Hz. And at 400Hz the deformation is increases. Resonance frequencies are noted as 215Hz and 400Hz.

VII.CONCLUSION

In the present study the effective material properties for biaxial braided composite have been calculated by developing unit cell model of the complete structure. Different models were developed by changing the braiding angle. For braided composite the technique of developing the meso-scale model (fiber and matrix detail geometry) and using finite analysis is very effective in predicting the mechanical properties. Also periodic boundary conditions, works perfectly for such cases and the unit cell acts as a representative for the whole structure. The calculated material properties were compared with the available reviewed articles and close agreement was found. Also the effect of changing the braiding angle on the dynamic behavior of the structure was studied. It was found that for fixed fiber volume fraction the braiding angle is the key parameter for braided structure dynamic response. The braided composite is implemented in ship propeller. Final 15^0 braiding angle material properties is selected and applied on ship propeller. Initially fluent analysis is performed to find out dynamic pressure acting on propeller face. And using same pressure static structural and buckling analysis is performed to find out maximum deformation and stresses. Deformation and stresses are in considerable limit. And critical load is above 140 times of applied. Frequency analysis also performed to avoid the resonance. And working frequencies are below the resonance frequencies. So if we use the braid composite we can improve the life and with reducing the weight , power demand to run the propeller can be reduced.

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