Analysis of E-Glass Fiber Wheel Rim by Using ANSYS

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1 Introduction

A wheel is circular made of the hard and durable material, and its center is a borehole circular in shape and connected directly with the axle of the vehicle about which wheel rotates. The wheel's moment is used to control the vehicle. When it is connected the crank, the wheel produces or transmits energy. Earlier wheel rims are made up of steel, but it has increased the weight and reduces the performance and speed of automobiles. After more improvising on materials, nowadays, aluminum is popularly used as wheel rim material. Aluminum is lightweight material, provides aesthetic look and supports the weight by giving appropriate strength. But in order to optimize the performance and strength to weight ratio, high-end automobiles are using carbon fiber.

Carbon fiber wheel rim: It is used by high-end automobile vehicles which require performance and more durability than other conventional such as sports cars, supercars, formula one racing cars use the carbon fiber wheel rim. Since the performance of carbon fiber-based wheel rim is best and more durable than convention wheel rims, but carbon fiber is costlier that is why for public comuters conventional wheel rims are used. The basic geometrical need of supercars is that they require high strength to weight ratio, toughness, resilience and great fatigue strength that is why the composite material is used in the manufacturing of wheel rim to full body manufacturing.

E-glass is a class of carbon fiber which has high strength and no corrosive nature, cheaper than the carbon fiber.

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1.1 Types of Wheel Rim

(a) **According to the dimensions, the wheel or rim is classified as follows**:

1. *Drop center wheel rim (DC)*
   It is the mounting which is shaped in slots or groove form in such a way that there is thin gap between the bead seat parts, which placed on both sides of the rim as shown in Fig. 1.
2. *Wide drop center wheel rim (WDC)*
   The design of wide drop center wheel rim is very similar with drop center wheel rim. In this, wheel's width is expanded little bit in comparison with DC wheel rim so that its lower flange is also elongated and made deeper. Such type of design for lower rim is applied to low aspect ratio tires.
3. *Wide drop center wheel rim with hump*
   This design has a hump and placed at the starting of the bead seat area of the tire (Fig. 2).

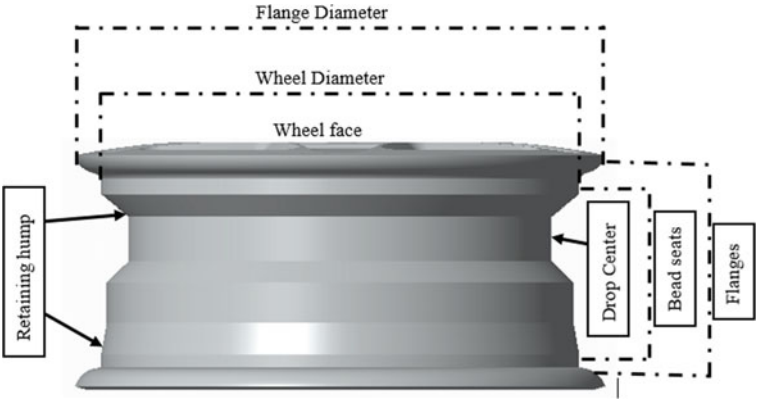

Fig. 1 Drop center (DC) rim

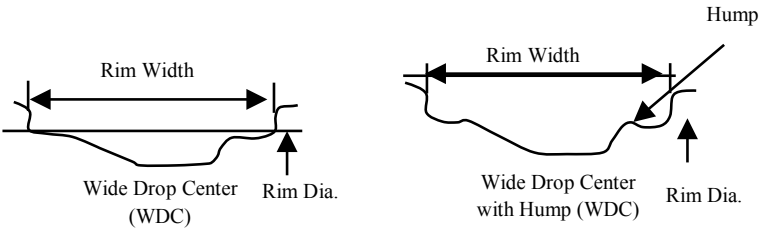

Fig. 2 Wide drop center (WDC) and wide drop center with hump wheel rim

2 Basic Nomenclature of Wheel Rim

1. **Wheel**: When disk and rim integrated with each other, then they form wheel.
2. **Rim**: It is the integral part of the wheel over which the tire is seated.
3. **Disk**: It is directly connected to wheel and mounted over the hub of vehicle axle.
4. **Bead Seat**: It is another integral part of the rim. The purpose of bead seat is to hold the tire in radial direction when radial forces applied toward the bead face.
5. **Hump**: The main purpose of hump is to prevent the tires for slipping from the rim when the vehicle is running and under the influence of high forces.
6. **Well**: The well is structured in order to facilitate the easy withdrawal and tire mounting over the rim (Fig. 3).

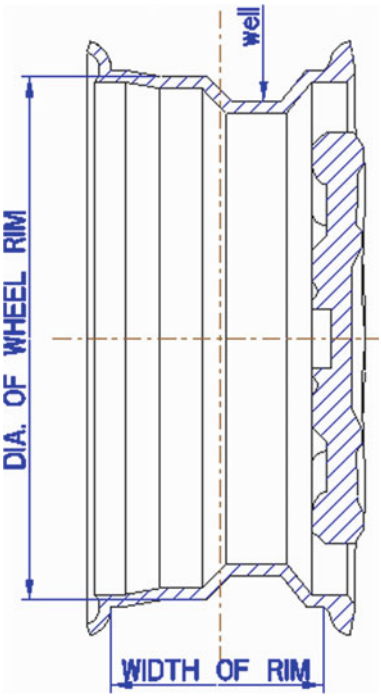

Fig. 3 Structure of wheel rim

3 Objective of Project

The main objectives of this study are as follows:

a. To show that multilayer wheel rim is suitable for high load and forces.
b. To show there is reduction in weight of wheel.
c. To show the stress in E-glass fiber in different orientation.
d. Wheel rim is designed as per JETMA.
e. The thickness of rim area of wheel is taken as 1 mm of seven layers.
f. The thickness of central part of wheel rim is taken as 1 mm of 14 Layers.

Problem Definition
To optimize the design of wheel rim, so that it will be more safe, lighter in weight with great strength than the conventional Al Alloy wheel rim used in present days. This paper has proposed the usage of E-glass fiber (Fig. 4; Table 1).

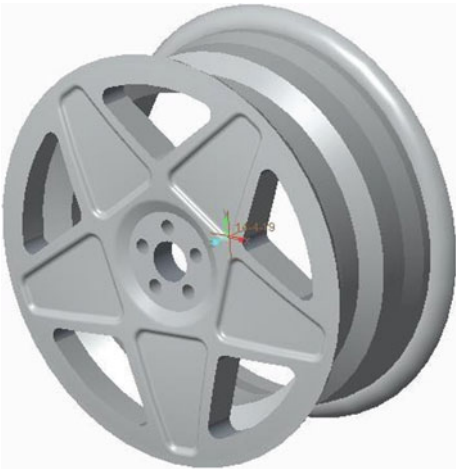

Fig. 4 Proposed 3D designed CAD

Table 1 Specification of proposed car wheel rim

S. No.	Specification	Value
1	Proposed width of rim (mm)	140 mm
2	Dia. of the rim (mm)	355 mm
3	Offset length (mm)	57 mm
4	Center hole dia. (mm)	40 mm
5	Thickness of the rim (mm)	7 mm
6	Dia. of stud hole (mm)	15 mm
7	Dia. of stud hole (mm)	68 mm
8	Number of stud holes	5 No's

4 Boundary Condition and Drawing

1. Fixed support is provided to set of five bolt-stud holes since wheel is seated over the vehicle axle with the help of bolts through stud holes.
2. The load is applied at the center of the hub in y-direction. As hub is fixed through the central hole of the rim so that maximum load is bore by this section. Total bearing load (P) = 7769.5 N.
3. On the tire allocation area, there is slight pressure of 0.241 Mpa which acts normally on the circumferential tread and flange portion of the wheel.
4. The diameter of tire as 550 mm, the proposed velocity of car rim taken 100 k mph, i.e., 965 rpm.
5. From annexure of AIS-073 (part-2), moment is taken as 5.0969e + 5 N mm.
6. Friction force is provided into the inner face of center hole which comes in action with axle (Fig. 5).

5 Static Analysis and Simulation of Composite Wheel Rim

The following load conditions will be shown in ANSYS Workbench 15.0 in analysis chapter (Fig. 6).

Variant-1

E-glass at [−25°, +25°] FW fiber orientation.

At ±25°, maximum deformation observed in flange area of the wheel rim shown in Fig. 7 is 0.2364 mm (Fig. 8).

At ±25° orientation of the lamina, there is maximum stress of 22.884 MPa at bolt area.

Layer stack up at ±25° of lamina is shown in Fig. 9

Variant-2

E-glass at [−35°, +35°] FW fiber orientation (Fig. 10).

At ±35° orientation of the lamina, there is maximum stress of 23.739 MPa at bolt area.

At ±35°, maximum deformation observed in flange area of the wheel rim shown in Fig. 11 is 0.2192 mm.

Layer stack up at ±35° of lamina is shown in Fig. 12.

Variant-3

E-glass at [−45°, +45°] FW fiber orientation.

At ±45°, maximum deformation observed in flange area of the wheel rim shown in Fig. 13 is 0.20061 mm (Fig. 14).

At ±45° orientation of the lamina, there is maximum stress of 21.736 MPa at bolt area.

Layer stack up at ±45° of lamina is shown in Fig. 15.

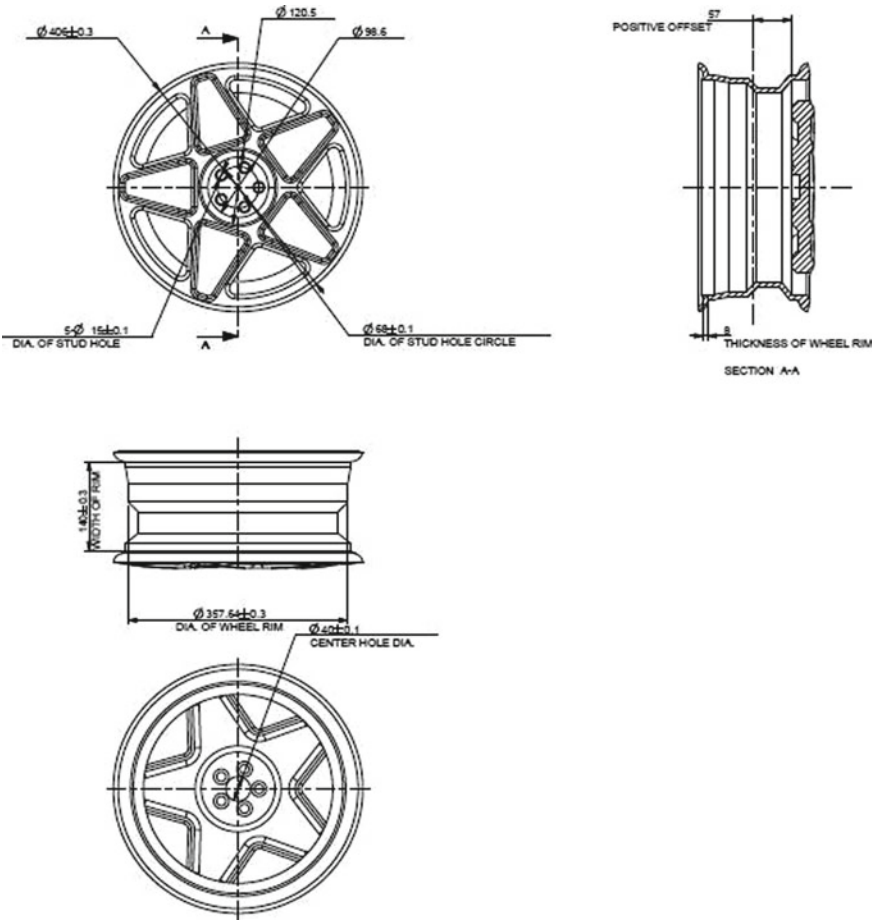

Fig. 5 Mechanical drawing

Variant-4

E-glass at [−55°, +55°] FW fiber orientation.

At ±55°, maximum deformation observed in flange area of the wheel rim shown in Fig. 16 is 0.19384 mm (Fig. 17).

At ±55° orientation of the lamina, there is maximum stress of 18.687 MPa at bolt area.

Layer stack up at ± 45° of lamina is shown in Fig. 18.

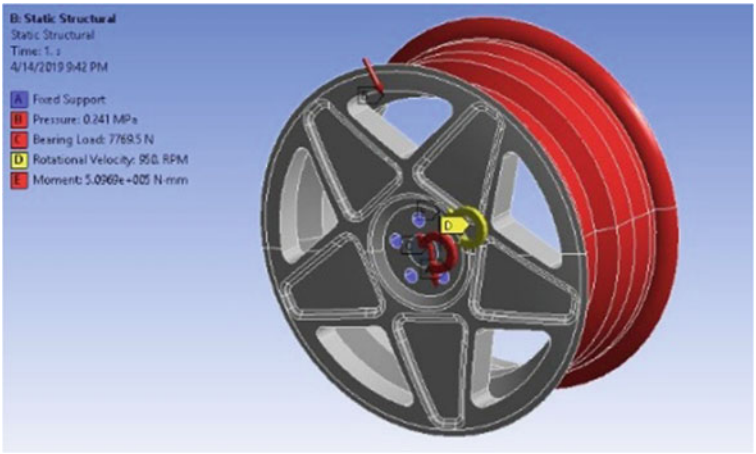

Fig. 6 Load condition for proposed wheel

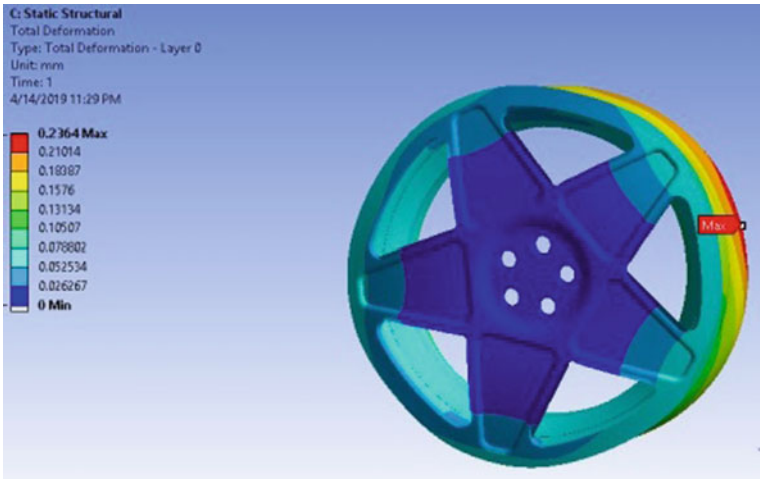

Fig. 7 Total deformation of E-glass at [−25°, + 25°] FW orientation of fiber

6 Conclusion

After analyzing all the four variants of composite wheel rim, we have created a table to show the stresses and deformation at different orientation angles of composite material wheel rim at a specified mentioned boundary condition.

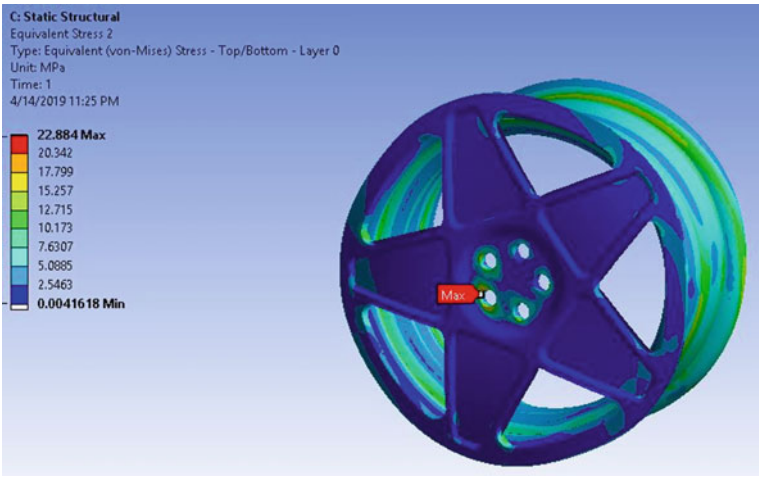

Fig. 8 Max stress is observed in bolt area

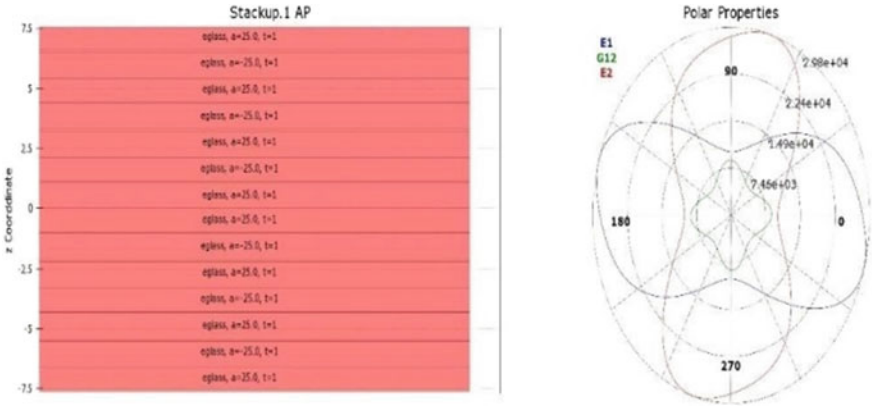

Fig. 9 Layer stack up at [±25°] FW

Variants	Orientation	Total deformation	Equivalent stress (MPa)
I	±25°	0.2364	22.884
II	±35°	0.2192	23.739
III	±45°	0.20061	21.736
IV	±55°	0.19384	18.687

- In current scenario, multilayered wheel rims are used in various automobile OEM's due to low weight and high strength along the wall thickness.
- Determined stress is less than allowable stress, so design is safe.

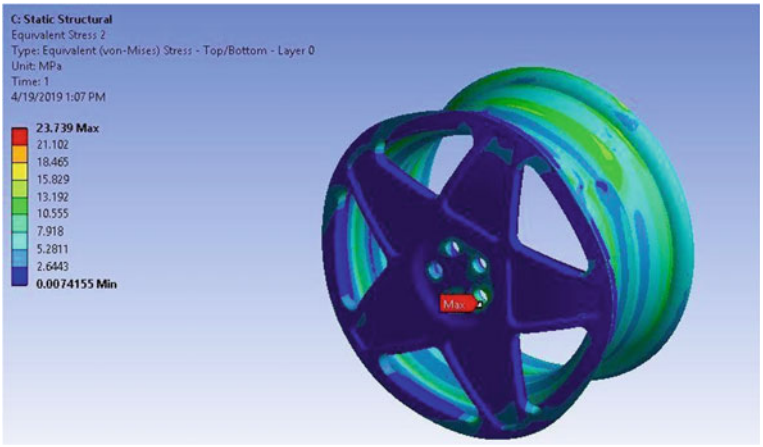

Fig. 10 Max stress is observed in bolt area

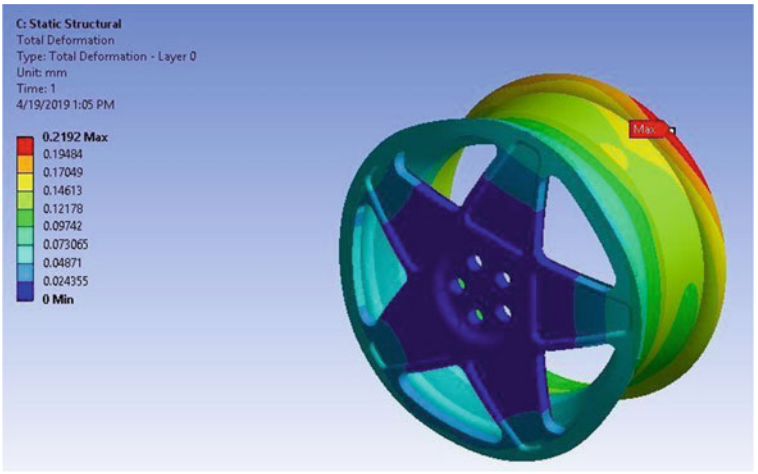

Fig. 11 Total deformation of E-glass at [−35°, +35°] FW orientation of fiber

- E-glass fiber having orientation [−55, +55] FW has less equivalent stress than currently using Al alloy wheel but greater deformation, which is allowed for safer design of particular geometry.
- It has good strength, and weight is around 7.8 kg.
- E-glass is 25% lesser in weight, and proposed design is safer.

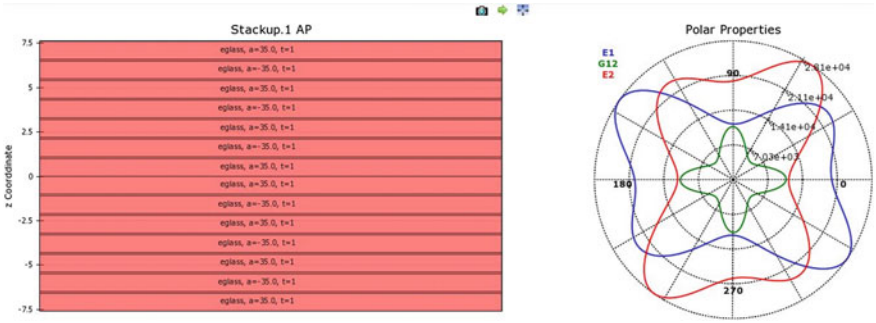

Fig. 12 Layer stack up at [±35°] FW

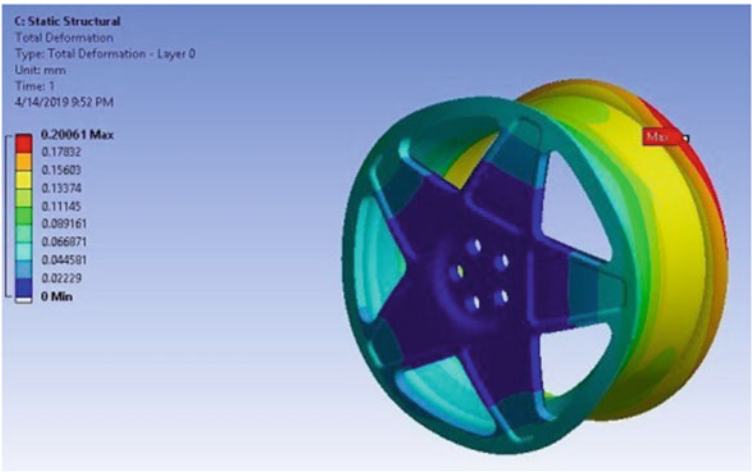

Fig. 13 Total deformation of E-glass at [−45°, +45°] FW orientation of fiber

7 Future Scope

The paper includes the static stress analysis, optimizes the design of composite wheel rim and reduces the weight of the wheel. In order to achieve greater strength to weight ratio, an E-glass is selected with different fiber orientation. But there is further scope in dynamic analysis of wheel rim, which includes the fatigue life of wheel rim.

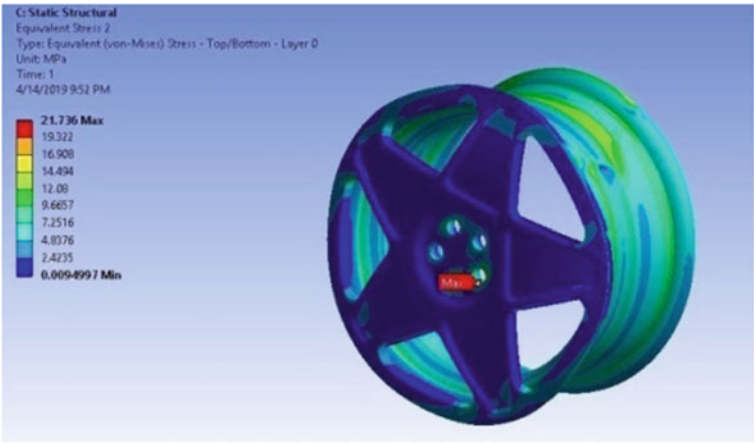

Fig. 14 Max stress is observed in bolt area

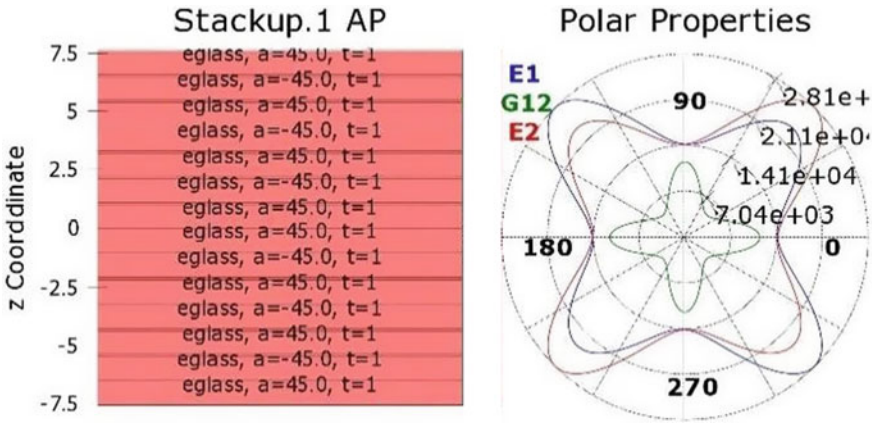

Fig. 15 Layer stack up at [±45°] FW

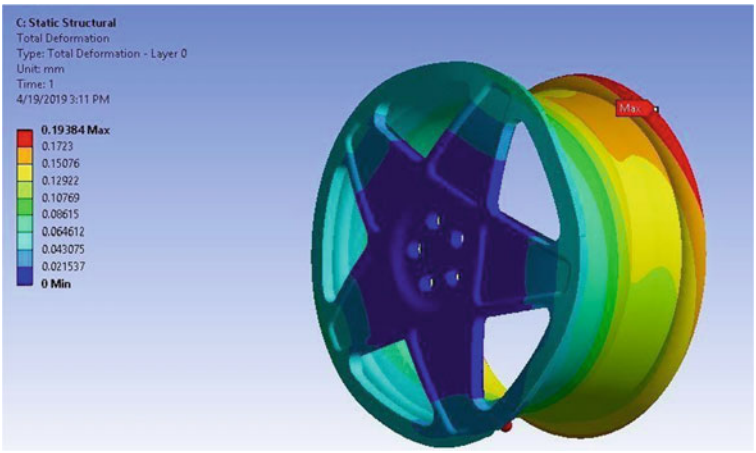

Fig. 16 Total deformation of E-glass at [−55°, +55°] FW orientation of fiber

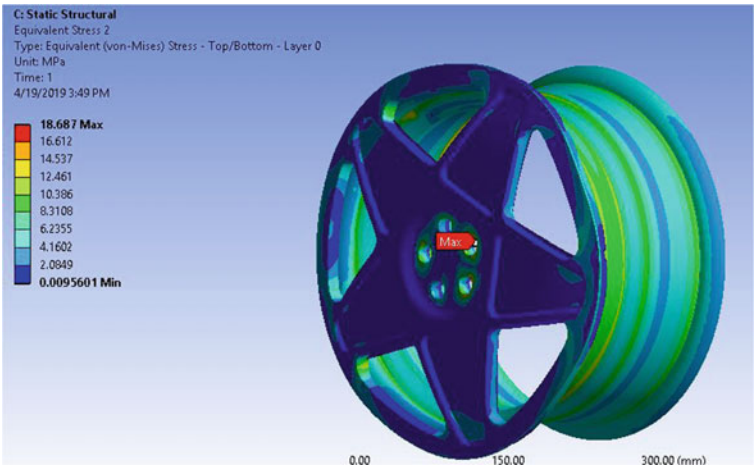

Fig. 17 Max stress is observed in bolt area

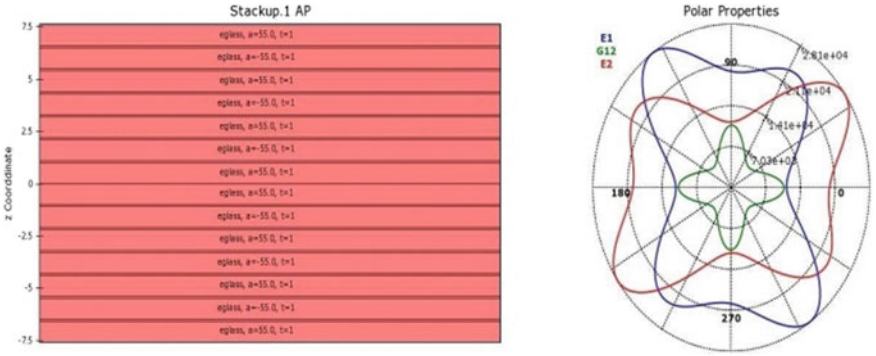

Fig. 18 Layer stack up at [±55°] FW

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