International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 13 Issue: 07 | Jul 2026 www.irjet.net p-ISSN: 2395-0072

Finite Element Modelling and Analysis of Composite Material Spoiler for Aerodynamic Drag and Roll over Forces analysis

Shaikh Muzammil Shaikh Nisar[1], Prof. Prashant Bajaj[2]

[1]Research Scholar, [2]Professor, Department of Mechanical Engineering, Hindi Seva mandal's Shri Sant Gadge Baba College of Engineering & technology, Bhusawal, Jalgaon (Maharashtra, India)

Abstract - *A spoiler is an automotive aerodynamic device whose intended design function is to 'spoil' unfavourable air movement across a body of a vehicle in motion, usually described as turbulence or drag. Spoilers on the front of a vehicle are often called air dams. Spoilers are often fitted to race and high-performance sports cars, although they have become common on passenger vehicles as well. Some spoilers are added to cars primarily for styling purposes and have either little aerodynamic benefit or even make the aerodynamics worse. In the current research work the aesthetics and loading conditions of spoiler of car has been studied. The material of spoiler is ABS and PP. In the current research work the material of spoiler has been studied for bio materials of Banana and sisal fiber. The materials are prepared using hand layup technique of manufacturing. The experimental testings of tensile, impact, flexural and density are done. The finite element analysis is carried out for Aerodynamic drag and roll over forces of the material.*

Key Words: Spoiler, Aerodynamic Drag, Roll over Forces, Wind Pressure.

1. INTRODUCTION:

1.1 Spoiler in Automobile

Figure 1 Spoiler in Automobile

Spoilers started to come into vogue in the 1960s as automakers sought to improve the aerodynamics (the management of air flowing around a vehicle) of racecars and performance vehicles. Later, federal fuel economy regulations motivated automakers to improve the aerodynamics of all vehicles to generate higher mileage ratings. A car with less wind resistance uses less fuel at highway speeds.

As a vehicle travels faster, aerodynamic drag increases, making the engine work harder to maintain speed. More air gets underneath it, as well, creating "lift," which reduces grip and makes the vehicle less stable. Front spoilers reduce the amount of air going under the vehicle. At the rear, where airflow tends to be more turbulent and generate more lift, spoilers create more downforce to keep the vehicle firmly planted on the road. But spoilers are only one part of the aerodynamic picture, and they may be only a small part. The styling and height of a vehicle, the size of the grille, shape of the front bumper and headlights, the design of the roof, rear window and trunk, and other factors all play significant parts in managing airflow.

1.2 Functions of Spoiler:

The spoiler serves the below mentioned purposes.

- After your vehicle reaches a certain speed, your engine power is mostly battling wind resistance. Within that equation, more wind resistance and drag mean more power and fuel usage.
- The function of a spoiler varies depending upon the location where the carmakers install it i.e. which effect it is going to spoil.
- The most common function of the spoiler is to reduce the effect of the turbulence created by the airflow. It does so by "spoiling" the streamlined flow of air and providing a cushion like a boundary layer. However, different types of airflow may need spoilers to work differently.
- Hence, the manufacturers may need to install the spoilers at different locations to control a variety of air resistance.

1.3 General Materials of Spoiler:

- **ABS:** It is with various admixtures, typically granular fillers, which introduce stiffness to this inexpensive material.

- **Fiberglass:** Fiberglass is sufficiently durable and workable, but has become unprofitable for large-scale production because of the labor involved.
- **Silicone:** More recently, many auto accessory manufacturers are using silicon-organic polymers. The main benefit of this material is its phenomenal plasticity. Silicone possesses extra high thermal characteristics and provides a longer product lifetime.
- **Carbon Fiber:** Carbon fiber is lightweight and durable but also expensive. Due to a large amount of manual labor, large-scale production cannot widely use carbon fiber in automobile parts currently.

2. MATERIALS:

2.1 Sisal Fiber:

Sisal Fiber is one of the most widely used natural fiber and is very easily cultivated. It is obtain from sisal plant. The plant, known formally as Agave sisalana. These plants produce rosettes of sword-shaped leaves which start out toothed, and gradually lose their teeth with maturity. Each leaf contains a number of long, straight fibers which can be removed in a process known as decortication. During decortication, the leaves are beaten to remove the pulp and plant material, leaving the tough fibers behind. The fibers can be spun into thread for twine and textile production, or pulped to make paper products. Sisal is a leaf fiber and it is obtained from the leaves of agaves and also serves as strengthening component. Generally it is used for the production of cordage and ropes. Rarely used for fabric, other than packing materials and carpets.

Figure 2. Sisal Fibre

Sisal fiber is derived from the leaves of the sisal plant. It is usually obtained by machine decortications in which the leaf is crushed between rollers and then mechanically scraped. The fiber is then washed and dried by mechanical or natural means. The dried fiber represents only 4 % of the total weight of the leaf. Once it is dried the fiber is mechanically double brushed. The lustrous strands, usually creamy white, average from 80 to 120 cm in length and 0.2 to 0.4 mm in diameter

2.2 Banana Fibre:

Banana fiber, a ligno-cellulosic fiber, obtained from the pseudo-stem of banana plant (Musa sepientum), is a bast fiber with relatively good mechanical properties. Banana plant is a large perennial herb with leaf sheaths that form pseudo stem. Its height can be 10-40 feet (3.0-12.2 meters) surrounding with 8-12 large leaves. The leaves are up to 9 feet long and 2 feet wide (2.7 meters and 0.61 meter). Banana plant is available throughout Thailand and Southeast Asian, India, Bangladesh, Indonesia, Malaysia, Philippines, Hawaii, and some Pacific islands.

Figure 3. Banana Fibre

Banana fiber is very less cost available fiber in India. It is light in weight and easily achievable. Banana fiber is eco-friendly, non-toxic, biodegradable and odourless fiber. Banana fiber which is used for manufacturing of composite. Banana fiber is very light in weight and is used in fabrication of composites.

3. FINITE ELEMENT ANALYSYS

3.1 Methodology of Finite Element Analysis:

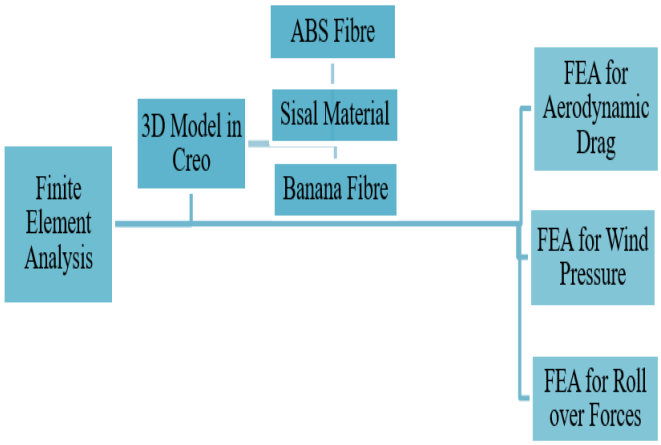

Figure 4. Process of FEA.

3.2 3D Modelling of Spoiler Element:

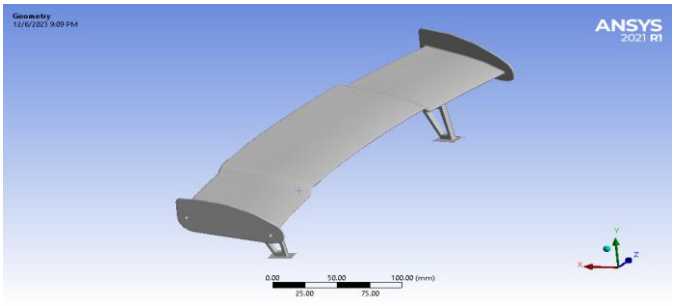

Figure 5. 3D Model exported in Ansys

The spoiler model is prepared in creo software using the dimensions and aesthetics of the component. The Spoiler component in one single part. The file extension of this component is (dot) part, and hence in order to use this model in Ansys it is to be converted to IGES format.

3.3 Aerodynamic Forces :

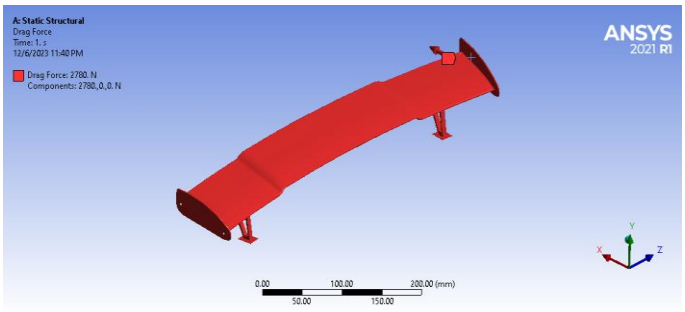

Figure 6. Application of Aerodynamic Drag Force

When the vehicle moves across the stream of the wind, the self-weight of vehicle with the speed of vehicle and resistive wind produces the drag on the vehicle. Hence forth, forces is directly acting on the component rather than any of the surface of the component.

3.4 Wind Pressure Analysis:

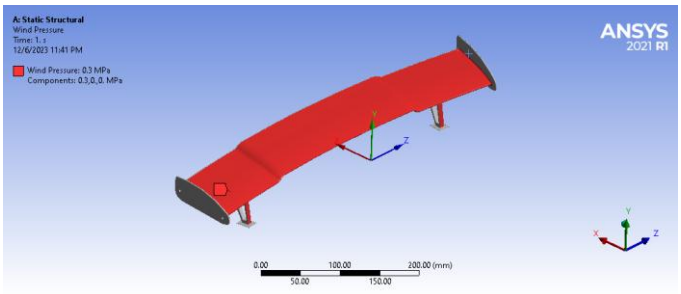

Figure 7. Application of wind pressure Analysis

The vehicle is moving with respective speed and the density of air creates the resistance on the vehicle due to which it affects the speed of the vehicle. Such resistance is called as wind pressure. Hence in this case, the wind pressure is acting on the upper surface of the spoiler.

3.5 Roll over Forces:

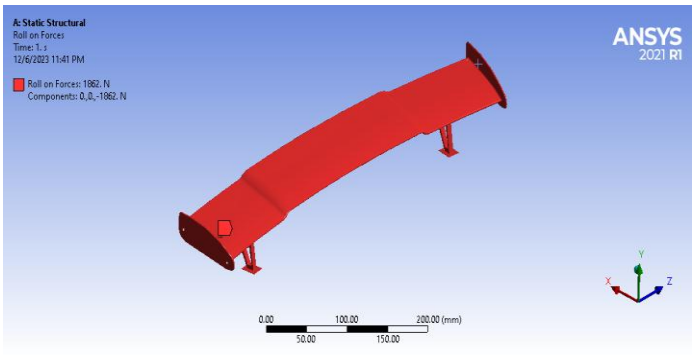

Figure 8. Application of Roll on Forces

When the vehicle with respective speed, and during the turning point, the aerodynamic drag changes its nature. This is called as roll on forces. This forces are acting during the turning radius of the vehicle.

4. RESULT AND DISCUSSIONS:

4.1 Analysis of Aerodynamic Drag:

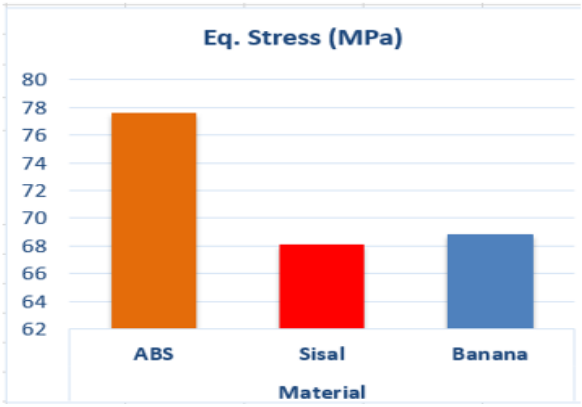

Figure 9. Eq. Stress in Aerodynamic Drag

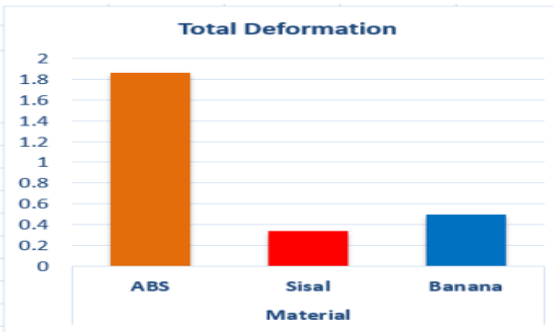

Figure10. Total Deformation Aerodynamic Drag

The Sisal material appeared to be the most stress and strain effective material with gaining 0.33 mm of deformation followed by banana fiber with 0.49mm amongst the all. The Sisal fiber composite gained the lowest amount of stress 68.08 Banana acquires 68.80 MPa. If we observe the stress criteria, the maximum stress is produced for ABS followed by Banana and least was absorbed by Sisal Composite.

4.2 Analysis of Wind Pressure:

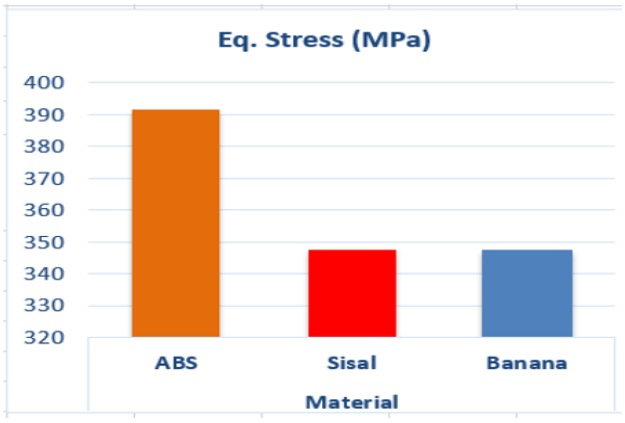

Figure 11. Equivalent Stress Produced in Wind Pressure Analysis

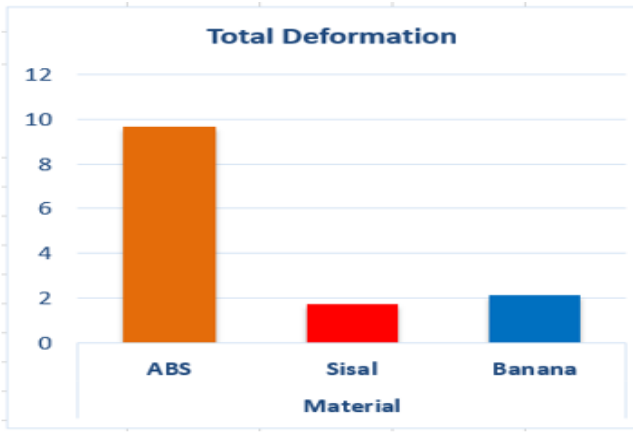

Figure 12. Deformations Produced in Wind Pressure Analysis

The Sisal material appeared to be the most stress and strain effective material with gaining 1.73mm of deformation amongst the all in wind pressure too. The Sisal composite gained the lowest amount of deformation in whereas Banana material gains 2.14 mm. If we observe the stress criteria, the maximum stress is produced for ABS followed by Banana and least was absorbed by Sisal Composite.

4.3 Analysis of Roll over Forces:

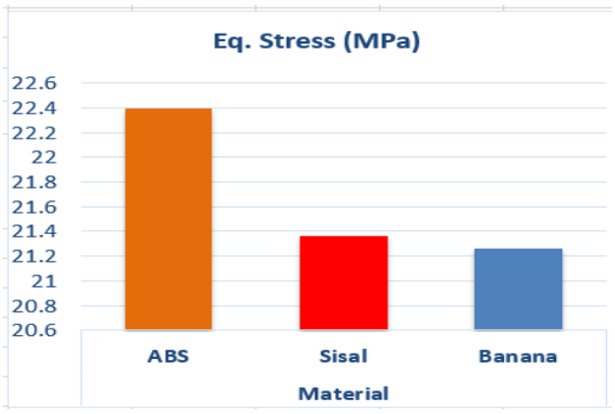

Figure 13. Equivalent Stress Produced in Roll over Forces Analysis

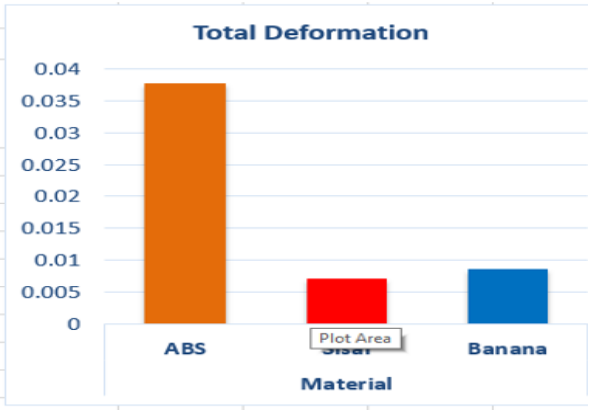

Figure 14. Deformation Produced in Roll over Forces Analysis

The maximum Deformation and stress is achieved by ABS, whereas the maximum energy is absorbed by ABS. In this case, the maximum deformation and stress is the major criteria for sustainable material. If we observe the stress criteria, the maximum stress is produced for ABS followed by Banana and least was absorbed by Sisal Composite.

4. CONCLUSIONS

- The JFEA model and Double BFEA model is been selected as energy absorber component due its ease in manufacturing, its capacity and cost factor availably.
- The car spoilers are generally made of Polypropylene and ABS composites. The cost of these materials are generally more. Hence in this study an attempt is made to study the strength of ABS material considering the spoiler material.
- The different loading constraints acting on the spoiler is been studied and the real time implementation of car spoiler is done using finite element simulation. under Aerodynamic drag, wind pressure and Roll over forces.

- Considering the stress and deformation criteria, sisal fiber material acquires least or similar amount of results as that of ABS for all the three analysis of drag, wind pressure and roll over forces. Hence considering the same criteria, Sisal fiber can be proven to be better sustainable material as that of other two.
- The bio Composite material also satisfy the weight criteria as the sisal observes less weight than ABS where banana gained similar weight.

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