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Optimizations of outer door handle in automobiles using composite material

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Abstract - *This work presents the creation of Automotive outside door handle for fiber reinforced PA plastic. A comparison between different material cards such as Elastic, Elastic Plastic, Elastic Plastic with Fiber orientation, Elastic-plastic with Fiber orientation and damage and Elastic Plastic with Fiber orientation and damage for Door handle were prepared and compared by using software such as Hyperworks, Converse and Abaqus.*
An overview of composite material, their classification, the role of constituents, different factors affecting its performance with advantages and disadvantages are explained. We have used Short Glass fibers in reinforced PA plastic. The Mechanical behavior of short Glass fibers composite is explained. The Effect of fiber orientation on the properties of composite and the factors for deciding fiber orientation are studied. To understand damage criteria, Fracture mechanics theory is explained.
FE Analysis has done using different material models and Experimental tests are done to validate the FEA results.

Key Words: **Door handle, FEA, Fiber orientation, Damage.**

1. INTRODUCTION

As its name suggests, a door handle is used to open and close car doors. It is found on both the exterior and interior sides of automobile doors, although they are used differently on each panel. The one on the outside is pulled to open the car door, while the inside door handle is used to release the door latch before you can push the door to let yourself out. In this project outside door handle is taken into consideration.

A comparison between different material models such as Elastic, Elastic-Plastic isotropic, Elastic-Plastic anisotropic with the consideration of Fiber orientation and Elastic-plastic anisotropic with Fiber orientation and Damage has to be considered and compared.

The very basic intention is to simulate the static overload of outer door handle virtually in vehicle Y-direction and to compare the experimental and FEA results of stresses and displacement of Car door outer handle assembly.

Composite material, Polyamide as matrix and Glass fibers as reinforcement is used. We used composite material because they are light in weight, cost optimized, compared to most woods and metals they have high strength to weight ratio, they have dimensional stability, they are corrosion resistance etc.

2. MECHANICAL BEHAVIOUR OF SHORT FIBERS

Materials can be isotropic, anisotropic, and homogenous or heterogenous. Most general engineering materials such as metals, plastics or ceramics are typically considered to be isotropic. Whereas most composite materials are neither homogeneous nor isotropic. Composites are inhomogeneous (or heterogeneous) as well as non isotropic in nature. When defining isotropic material, we need to define 2 independent elastic constants (young modulus of elasticity and poisson's ratio). Similarly for orthotropic material 9 independent constants and for transversely isotropic material 5 independent constants need to be defined.

3. FIBER ORIENTATION AND FRACTURE MECHANICS

It has been observed that fiber orientation has a substantial effect on the properties of composite material. The short fibers which are randomly oriented behave as isotropic in nature. But as the orientation becomes more aligned the properties become more anisotropic. It has been observed that the properties are much stronger in direction of fiber orientation than to the transverse direction. The graph in Figure 1 demonstrates this and it can be seen that the elastic modulus is much higher in the direction of fibre orientation than in the transverse direction.
Ductile materials usually fail as the result of nucleation, growth, and the coalescence of microscopic voids. The most widely used continuum model for void nucleation is due to Argon et al. According to the Argon et al. model void nucleation occurs more readily in a triaxial tensile stress field, a result that is consistent with experimental observations. Once voids form, further plastic strain and hydrostatic stress cause the voids to grow and eventually coalesce.

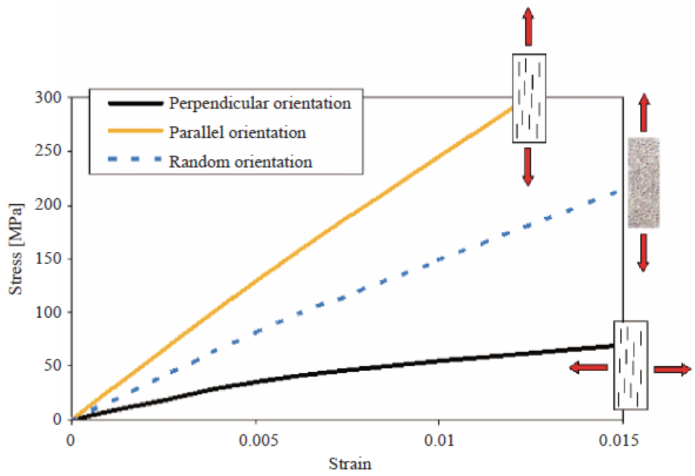

Fig. 1 Stress-strain graph

4. FINITE ELEMENT ANALYSIS

Structural Analysis and optimization using finite element method are key parts of the Design & Development of the Door Handle system. Here we use Hyperworks, Converse and Abaqus for finite element analysis.
Hyperworks offers Hypermesh for pre-processing, Converse is used for mapping fiber orientations and Abaqus is used as a solver.

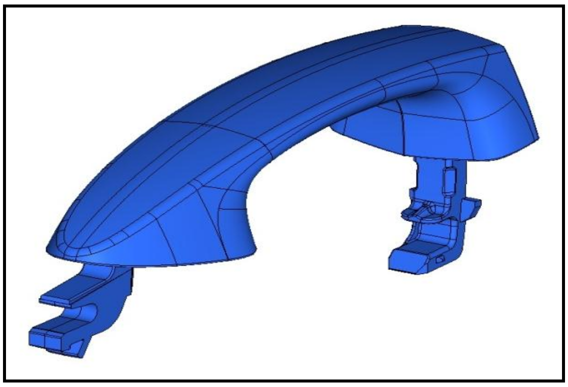

Fig. 2 Cad Geometry of Handle

Here CAD geometry of Handle Body as shown in fig 2 is imported as an input in <.igs> form into Hypermesh. After importing the geometry, one has to mesh or discretized the model. Any continuous body has infinite number of points and hence infinite number of degree of freedom. Solving in this form would not be possible. Finite element method performs meshing or Discretization and reduces the infinite number of freedoms to finite.

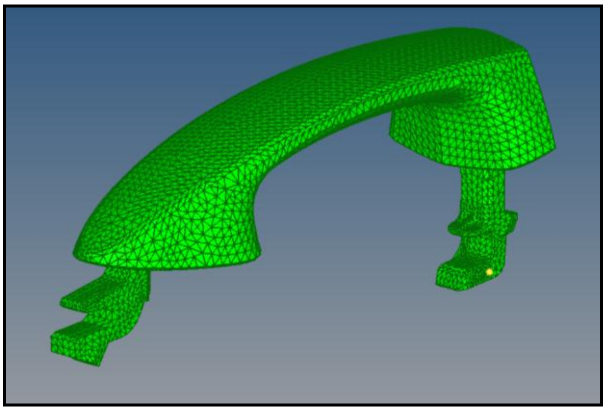

Fig. 3 Finite Element Model of Handle

Fiber orientation mapping is done using converse software

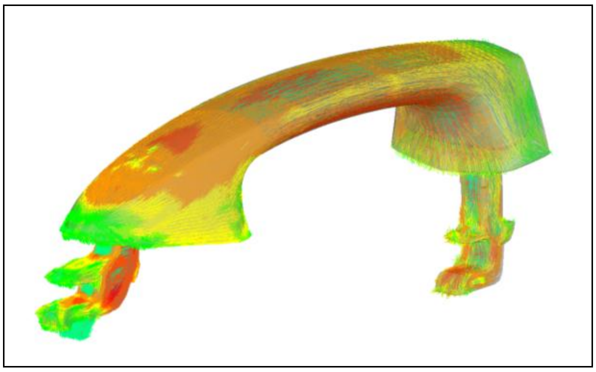

Fig. 4 Handle Body with Fiber Orientation

This file is used in mechanical finite element analysis with consideration of Fiber orientation. So as the effect of fiber orientation and its anisotropic behaviour should be taken into account.

Next step is to run the F E Analysis; following are the loading and boundary conditions.

a) Loading Condition:

- To check the strength of Hand in principal Y direction.

- Handle Body is in the closed position and a pulling force of 1200N is applied.

-Handle body has to sustain a force of 1000N Plus 20% is taken as factor of safety.

b) Boundary Condition:

-Door sheet is fixed at all direction

-General contact is used to define contact between all components.

-Tie contact is used between Handle body and slider, and in Reinforcement.

-Material card of composite material PAGF30 is to be used.

5. MATERIAL MODELS USED IN FEA

Following material models are used for FE analysis

5.1 Linear Elastic Material Model

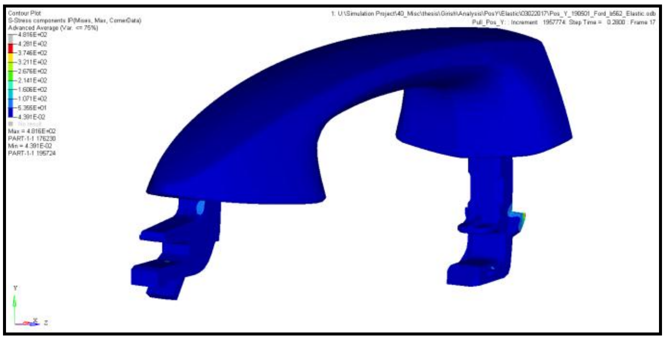

Fig. 6 Contour plot of von-mises stress for an "elastic material card"

As shown in Fig. 6, when we have defined *"Elastic material card"* only, we can see that there is no any high stress region.

5.2 Elastic Plastic Material Model

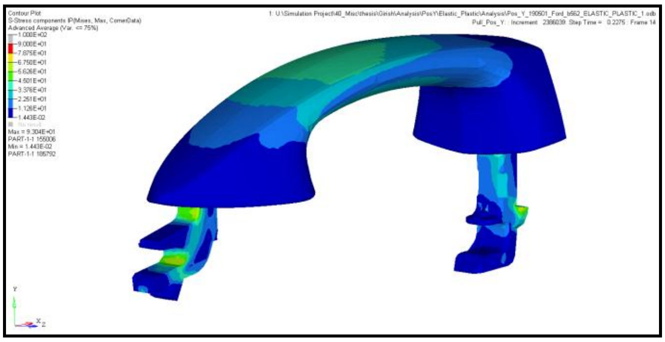

Fig. 7 Contour plot of von-mises stress for an "elastic plastic material card"

As shown in Fig 7, when we defined with *"Elastic plastic material card",* the stress values are much lower than the yield strength of the material.

5.3 Elastic Plastic Material Model with the consideration of fiber orientation

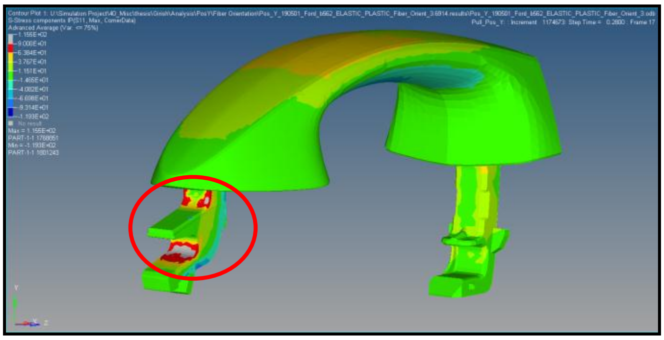

Fig. 8 Contour plot of Stress in X-direction for an "elastic plastic material card with the consideration of fiber orientation"

Here in this material model and upcoming material model we are not going to check Von-mises stress as checked in previous material models instead of that we have considered normal stress because we have considered effect of fiber orientation and its anisotropic behavior. Normal stress is checked for each direction and maximum value of stresses in particular direction is considered.

Then after plotting stress contour, I observed higher values of stresses in X- direction (S11), which is shown in above [fig 8]. We can see high stress values at encircled region, which are higher than the yield strength of the material at some region. But depth of stresses for that region is very less so it is acceptable.

5.4 Elastic Plastic Material Model with the consideration of fiber orientation and damage

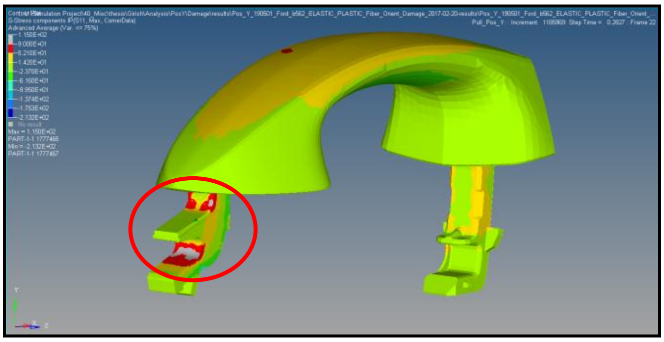

Fig. 9 Contour plot of Stress in X-direction for an "elastic plastic material card with the consideration of fiber orientation and Damage"

From Fig. 9 the encircled region shows the high stress region. Here the maximum stress at 1217.03N of force is 115 N/mm^2 which is more than the yield strength of the material which is 93.042 N/mm^2. But depth of stresses for that region is very less so it is acceptable.

6. EXPERIMENTATION AND VALIDATION

Requirement: Handle needs to withstand a static load of 1200N. Failure will be defined as any permanent deformation, fracture, breakage, loosening or other inability to mechanical function.
Experimental setup:

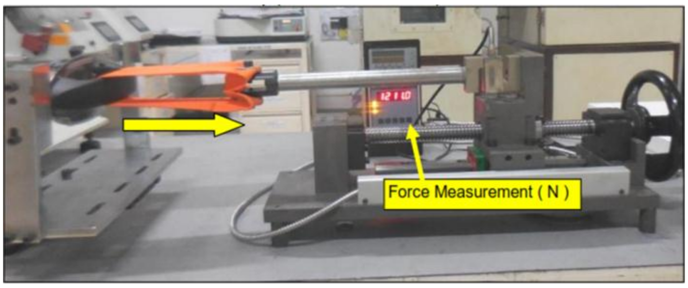

Fig.13 Experimental Setup

As shown in above Fig. 13 Door handle body assembly is fixed in a fixture. A pull force is applied in the direction shown by yellow arrow with the help of a belt and a rod. Handwheel and ball screw are used to increase the pull force gradually. The handwheel is rotated in anticlockwise direction to apply a pull force.

Results: Applied a pull force of 1210N at Door handle and no any permanent deformation, fracture, breakage, loosening or other inability to mechanical function observed.

Further retest was done on the specimen up to the failure and results were noted as shown in Fig.14 below.

Fig: 14 Handle hinge side breakage.

After increasing the load gradually after 1210N the component broke at a load of 1310N at the hinge side as shown in the Fig.14

We observed hardly different values between the FEA results and the Test results.

7. CONCLUSIONS

From the analytical and experimental investigation on Automotive outside door handle. The manufacturing of Handle using composite material with Glass fiber as reinforcement and Polyamide as a matrix was successful.

The relative density of PA GF30 is less than steel. However it is strong enough to fulfill the loading conditions. This makes it suitable for structural applications like door handle. The investigation has shown that 80% of weight reduction is achieved by using PAGF than that of steel.

It is concluded that simple modeling rather than total modeling with adequate boundary condition equivalent to real situation gives reasonable computational results with saving modeling effort and computation time.

If we compare the experimental test value which is 1310N and our requirement is 1200N there is hardly any difference in load carrying capacity. Hence we can conclude that optimum amount of material is used to manufacture the Handle no any excess material is used.

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