Analysis of front side car door for Indian regulations by using NITINOL

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Abstract— The present market is safety oriented and survival of any products/manufacturer is largely depends on cost, quality and performance of the product. The design work is continuously focused on increasing the safety of overall vehicle without compromising in quality and performance. Under this light, the present work is focused on automotive car door assembly to increase the safety and quality by using NITINOL. The door assembly is an important closure in the automotive system. The door assembly is mainly includes inner panel, outer panel, glass railing supporting bracket, speak mount bracket etc. The strength and stiffness of the door panels are important and it should meet the design requirements. The strength and stiffness of the door panel depends on many factors like design, material, gauge thickness etc. In this work, automotive door is considered for the analysis. The topology optimization will be carried out to improve the performance and to increase the quality of the overall door assembly. For this, the finite element model will be built and analyzed using ANSYS.

Indexed Terms- Car door panel; smart material; hyper mesh; finite element method.

I. INTRODUCTION

The vehicle door is a type of door, typically hinged but sometimes attached by other mechanisms such as tracks, in front of opening which is used for entering and exiting a vehicle. A vehicle door can be opened to provide access to the opening or closed to secure it. These doors can be opened manually, or powered electronically. Powered doors are usually found on minivans, high-end cars, or modified car. The exterior side of the vehicle door contrasts sharply from its interior side (the interior side is also known as the car door panel). The exterior side of the door is designed of steel like the rest of vehicle's exterior. In addition, its decorative appearance, typically colored with a design, is intended to match with the rest of vehicle's exterior, the central purpose being to add the overall appeal of the vehicle exterior. Doors are one of the major components in a car which provide easy access for passengers into the car. With the growing demand on car styling, comfort, safety and other systems integration (window regulator, latch, speaker, motor and electronics) in the door, designing this system is a great challenge to engineers. Door system mainly consists of window glass, window regulator assembly, door latch, sealing and structural components of the door assembly. Traditionally these parts were designed, manufactured and procured separately. A door module is an assembly of functional elements mounted on a carrier plate. Unlike conventional door systems, where the window regulator assembly was directly attached to the door inner panel, the door module comprises of a carrier plate with window regulator assembly, glass motor and speaker. The window regulator consists of a motor assembly, one or two rails to guide the glass up and down. The window regulator, speaker and other wire harnesses are mounted on the carrier plate using bolts, rivets and clips. The carrier plate is bolted to the inner panel. This module approach helps the car makers in reducing assembly time and hence the cost. Thus, design and manufacture of door modules is very important.

Fig 1: car door panel

II. PROBLEM DEFINITION AND SOLUTION

To design and to carry out analysis for car door module to reach a weight reduction compared to steel door

panel. Materials for light weight construction in automotive engineering must meet complex requirements. It is essential to combine good formability with high strength in service, excellent corrosion resistance. The main concept is to reduce the weight, increase the life of door, safety and assembly time.

By considering NITINOL as the material for outer door panel the analysis is done. The main reason to consider smart material is that it has unique property which is, even after the plastic deformation it can regain its original shape and size by treating the deformed model under suitable temperature.

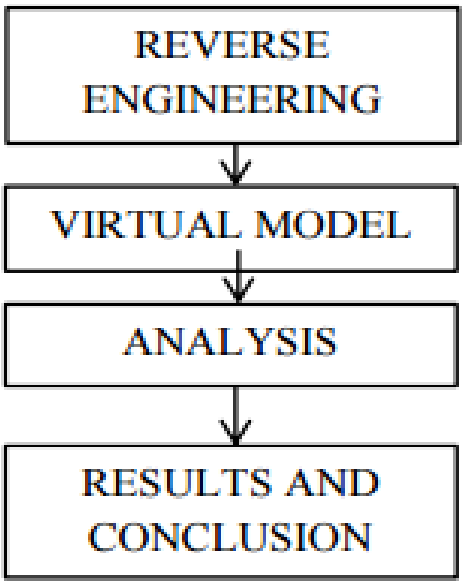
Material properties Material selection is very important stage for designing a model. The concept of material selection is to reduce the cost to reach the production stage The well-known properties of NITINOL alloys are their thermal shape memory and super elasticity. The word 'shape memory' derives the process of restoring to original shape by means of heating which has plastically deformed.

Material properties	**NITINOL**
Density	6.45g/cm^3
Elastic modulus	75 to 83 Gpa
Yield strength	195-690 Mpa
Possion's ratio	0.33
Ultimate tensile strength	895 Mpa
Electric resistivity	82x10^{-6} Ω.cm

Specifications of door

Terms	**Values**
Door weight	35.89kg
Upper hinge	0.97kg
Lower hinge	0.86kg
Material grade	Sp781bq

III. METHODOLOGY



Reverse engineering

It is a methodology that improves in the generation of technical concepts and geometrical values of any mechanical model by the process of analysis by which terms such as structure, functions and operations are known. It is a process which consists of developing the complete 3D models of the existing model

There are two ways to generate the 3D models

1. Manual method
2. Scanning method

Manual method

It is a methodology under which the parameters are measured manually by using mechanical measuring instruments such as vernier caliper, screw gauge etc. The model is dis assembled and each part is considered for manual measurements. As the measurements are carried out the values generated have to listed separately in an drawing sheets or using any software. All the parameters are important to generate virtual 3D model. The main drawback under manual method is critical parts cannot be measured accurately.

Scanning method

This method is very useful in generation of model in automotive industries and even in many other fields. The results obtained from this method is very accurate than the manual method. Under this method geometric

features of the part such as steps, slots, pockets, and holes etc. can easily be scanned.

Mainly part geometry is scanned by the using three dimensional scanning instruments which can generate the cloud points easily. In this method sensor are used in wide range for the generation on of the model required. The generated points will be the main reference to 3D model to build up.

In this method two types of sensor are used:
1. Contact sensors
2. Non-contact sensors

Contact sensors In this the probe will be used in which it will be contact with the model. By that probe that mode; will be generated. In the existing market range the probe tolerance is in the range of +0.01 to 0.02 mm. Under this method the result generation will be slow because of the moment of probe will be in low range. Since the probe has to get in contact with all the parts the result generation will be consume time. While scanning process the degree of probe is maintained constant. This contact force limits the use of contact devices, the materials such as rubber cannot be easily scanned the results will not be accurate.

Non-contact sensors
Noncontact devices use lasers, optics, and chargecoupled device (CCD) sensors to capture point data. Although these devices capture large amounts of data in a relatively short space of time, there are a number of issues related to this scanning technology. The typical tolerance of noncontact scanning is within ±0.025 to 0.2 mm.

Some noncontact systems have problems generating data describing surfaces, which are parallel to the axis of the laser.

Noncontact devices employ light within the data capture process. This creates problems when the light impinges on shiny surfaces, and hence some surfaces must be prepared with a temporary coating of fine powder before scanning.

Virtual model
The 3-d model is generated by reverse engineering. By using photo scanning method the model is created.

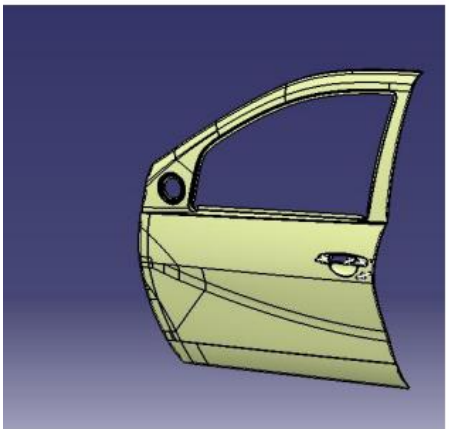


Fig 2: Outer Door Panel

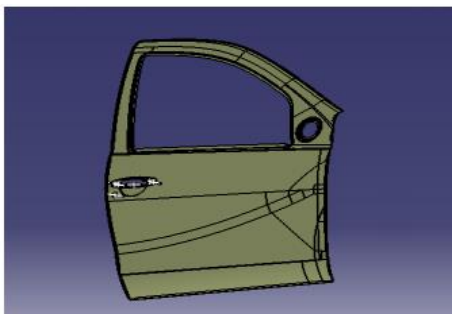


Fig 3: Inner Door Panel

IV. ANALYSIS

The analysis is carried out by using ANSYS for static structural analysis by using gravitational force.

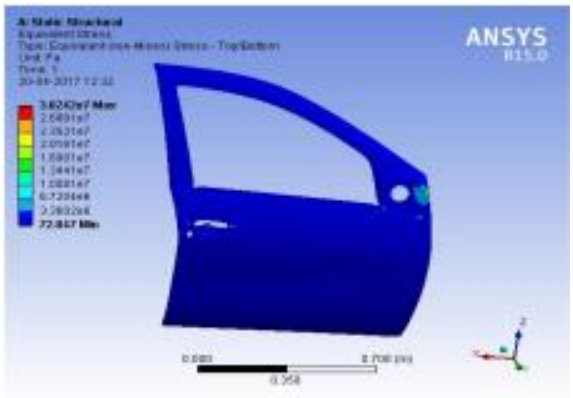


Fig 4: equivalent stress

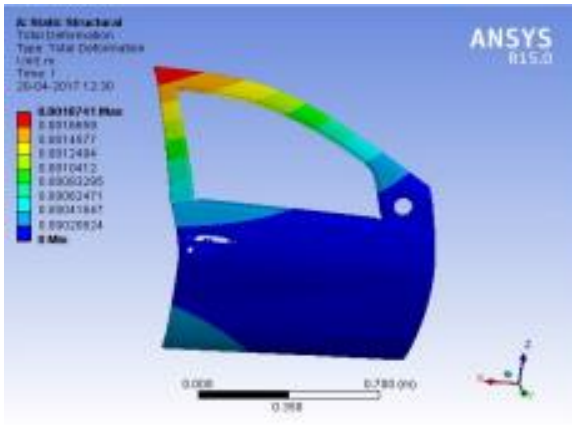


Fig 5: Total Deformation

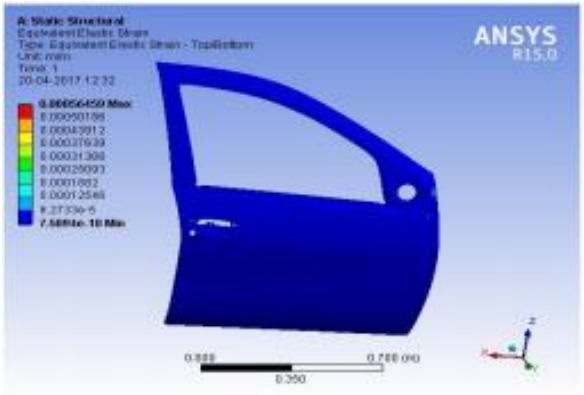


Fig 6: Equivalent elastic strain

Now by applying pressure on the front part of the door panel, the results generated are pictured

Pressure of 75KN

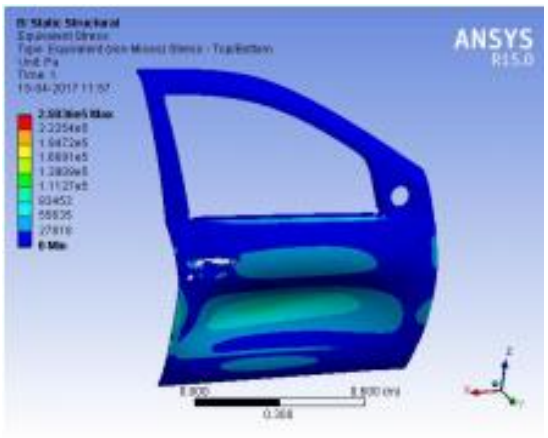


Fig 7: Equivalent stress

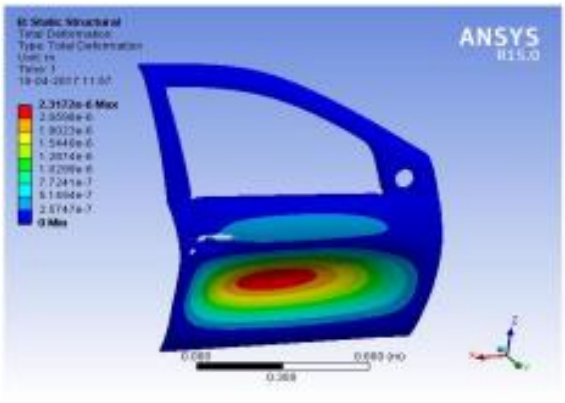


Fig 8:Total deformation

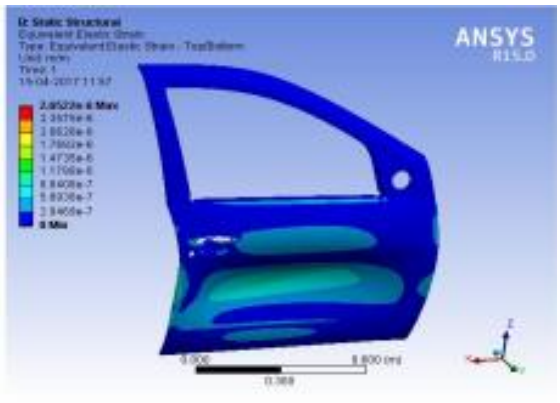


Fig 9: Equivalent elastic strain

Pressure of 100 KN

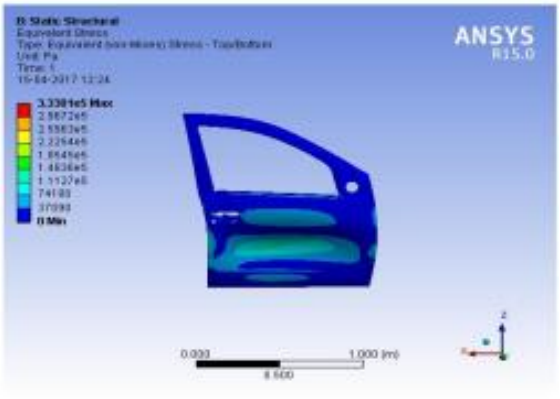


Fig 10: Equivalent stress

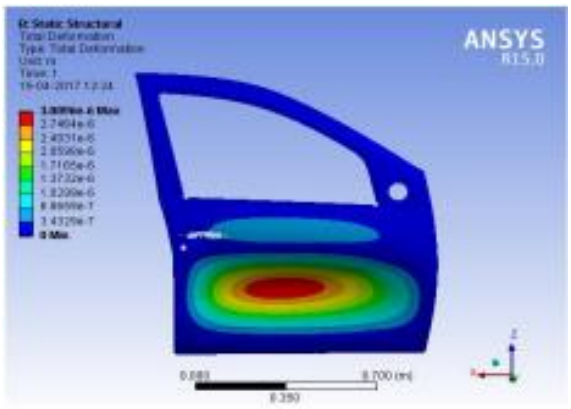


Fig 11: Total deformation

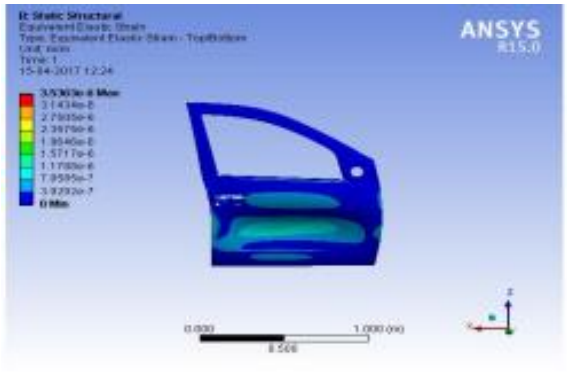


Fig 12: Equivalent elastic strain

CONCLUSION

By FE tool ANSYS the finite element analysis is done under different pressure conditions. The analysis is done for obtaining stress, total deformation and elastic strain. Instead of creating a physical model of door panel the model is generated by the using modeling software. By using finite element process the design related can be easily solved and product can reach the recommended targets. The results show the development in the strength and stiffness of the door as the limits of stresses will be maximum. As the material used is NITINOL the weight of the door panel reduces and strength of the door will be more. So the life of the car door will be high compared to existing door. By this analysis the stress distribution is differential with respect to the pressure applied and it can be considered for optimization purposes by reducing material distribution where the stresses are low. As the analysis is done by various loading conditions, the stress distribution will be maximum at hinges under gravitational force. The pressure of 75KN and 100KN is applied on the outer panel of door by fixing both ends.

The cost of the car door panel is high by using shape memory alloy, but as the usage of this kind of door increases the production rate will be high in the market so but this the cost of SMA reduces in which overall price of door weight reduces.

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