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Crash Simulation of a Car Body

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ABSTRACT: This paper presents the simulation of frontal crash of a car for various speeds. Study parameters includes-variation in total deformation, velocity, acceleration and stresses induced. Structural steel and Aluminum alloy have been used as the car body material.

KEYWORDS: Crash Simulation, Directional Deformation, Total Deformation, Equivalent Stress.

I. INTRODUCTION

Crash Simulation is a way to test the crashworthiness of the car body virtually by using various simulation software. The advantage of crash simulation over real crash is that you can use the same model again and again to check the different parameters involved in crash analysis with different materials.

Information about the capabilities of the car body to protect the vehicle and its occupants is obtained from the data collected during a crash simulation. Important parameters are steering wheel intrusions, occupant space and the occupants subjected to deceleration levels. These are governed by legal crash simulation regulations. Crash simulation to create real life situation also include use of crash test dummies and passive safety devices such as seat belts, air bags, shock absorbers and dash board.

II. LITERATURE OVERVIEW

Mnyazikwiye et al [1] and Pawlus et al [2] have used mathematical models and physical parameters (stiffness and dampers) estimated. Models were validated with experimental results from real crash tests.

Jain et al [3,4] have done the crash simulation on Ansys v14. Car model was developed in Solid Works 2015. The analysis included using of different materials, simulation was done at a speed of 33.33mps. the parameters predicted were total deformation, elastic strain and equivalent stress. They concluded that the Steel V-250 has the maximum stress and polycarbonate give least value.

Ambati et al [5] has simulate a frontal impact of a Chevrolet C1500 pick-up truck model moving with a velocity of 15.65m/s or 35m/h ($\approx 56.3\text{km/h}$) in to a rigid immovable barrier is carried out. The software used by them for simulation is LS-DYNA. They concluded that the bumper, engine and the rails absorb most of the energy before the wheel impacts the wall and half the energy of the crash is absorbed by these components after about 0.04sec of the crash initiation.

In the present work Suzuki swift car has been modelled in Solidworks 2016 and then it is imported in Ansys v19 (Academic student) which has been used to simulate the car crash for speeds (85km/h, 95km/h, 110 km/h) with different material (structural steel and aluminum alloy).

III. SIMULATION OF CAR CRASH

The Suzuki swift car has been modelled in Solidworks 2016. First the side view was drawn and then extruded the surface to its width to obtain the main shape of the body. Then a wall is drawn in front of the car at a distance of “0.10m” and then it is imported in Ansys v19 (Academic student) using Ansys design modeler. In the mechanical workbench the thickness of the wall and the car body is defined and then the meshing is done.

Elements Formation

The model is made in 2 parts, 2 bodies, number of elements are 3844 and number of nodes are 3989.

Analysis setting and Boundary conditions

Velocity is then defined for the car body as the initial condition. And the velocity is defined by the components and is given to the ‘x’ component with a negative sign so that the car body moves only in ‘-x’ direction and ‘y’ and ‘z’ components are set to zero value. Fixed support is given to the three sides (left, right and bottom) of the wall. Parameters of study i.e., total deformation, directional deformation, total velocity, total acceleration and equivalent stress are obtained using the Ansys software when the front crash simulation of the car body is done at speeds (85km/h, 95km/h, 110 km/h) with different material (structural steel and aluminium alloy).

IV. RESULTS AND DISSCUSSION

Variation in the total Deformation(mm), directional deformation(mm), total velocity, total acceleration, and equivalent (von-Mises) stress at varying speeds(mm/s) using structural steel as a material.

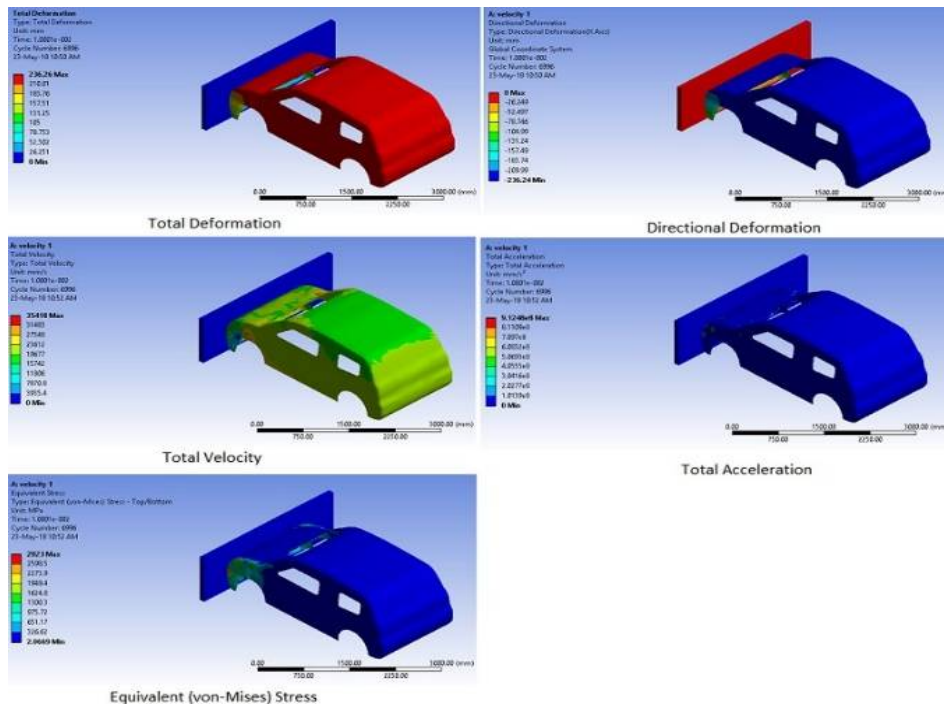


Fig.1 Variation in the total Deformation (mm), directional deformation (mm), total velocity, total acceleration, and equivalent (von-Mises) stress at speed of 85 km/h

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Variation in the total Deformation(mm), directional deformation(mm), total velocity, total acceleration, and equivalent (von-Mises) stress at varying speeds(mm/s) using aluminum alloy as a material.

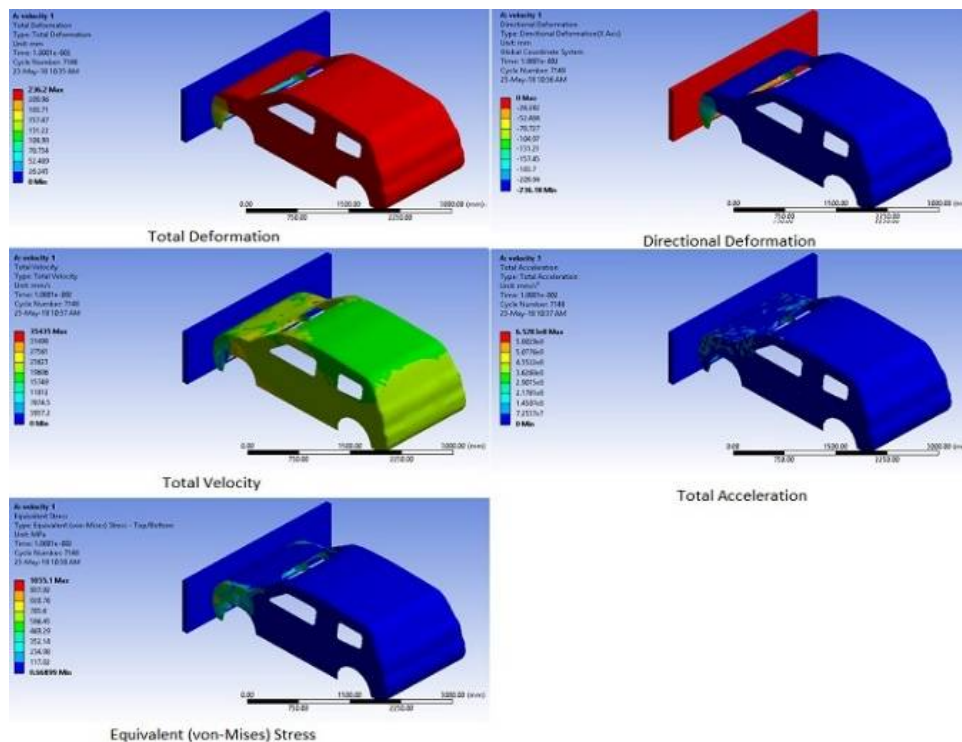


Fig.2 Variation in the total Deformation (mm), directional deformation(mm), total velocity, total acceleration, and equivalent (von-Mises) stress at speed of 85 km/h

Table.1 Various parameter for structural steel at different speeds

| Speed (mm/s) | Total Deformation (mm) | | Directional Deformation (mm) | | Total Velocity (mm/s) | | Total Acceleration (mm/s ²) | | Equivalent Stress (MPa) | |
|-----------------|---------------------------|--------|---------------------------------|--------|--------------------------|-------|--|----------|----------------------------|--------|
| | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| 23611.1 | 0 | 236.26 | -236.24 | 0 | 0 | 35418 | 0 | 9.124e8 | 2.0069 | 2923 |
| 26388.9 | 0 | 262.98 | -262.97 | 8.8516 | 0 | 42246 | 0 | 3.25e8 | 1.9035 | 3393.8 |
| 30555.6 | 0 | 304.24 | -303.73 | 28.364 | 0 | 46445 | 0 | 2.3995e8 | 0.56523 | 4902.3 |

Table 1 gives the minimum and maximum values of deformation, velocity, acceleration and equivalent stress during a simulation of car crash for a car body of structural steel for speeds of 23611.1mm/s (85km/h),26388.9mm/s (95km/h) and 30555.6mm/s (110km/h). The maximum value of retardation is -9.12 for an initial speed of 23611.1mm/s (85km/h), maximum equivalent stress of 4902.3MPa and deformation of 304.24mm for an initial speed of 30555.6mm/s (110km/h).

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Table.2 Various parameter for aluminum alloy at different speeds

| Speed (mm/s) | Total Deformation (mm) | | Directional Deformation (mm) | | Total Velocity (mm/s) | | Total Acceleration (mm/s ²) | | Equivalent Stress (MPa) | |
|-----------------|---------------------------|--------|---------------------------------|--------|--------------------------|-------|--|----------|----------------------------|--------|
| | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| 23611.1 | 0 | 236.2 | -236.18 | 0 | 0 | 35435 | 0 | 6.5283e8 | 0.66899 | 1055.1 |
| 26388.9 | 0 | 262.94 | -262.94 | 1.5033 | 0 | 45933 | 0 | 3.6649e8 | 0.67748 | 1207.5 |
| 30555.6 | 0 | 304.21 | -303.71 | 27.816 | 0 | 47783 | 0 | 3.565e8 | 0.22897 | 1726.2 |

Table 2 gives the minimum and maximum values of deformation, velocity, acceleration and equivalent stress during a simulation of car crash for a car body of aluminium alloy for speeds of 23611.1mm/s (85km/h), 26388.9mm/s (95km/h) and 30555.6mm/s (110km/h). The maximum value of retardation is -6.5 for an initial speed of 23611.1mm/s (85km/h), maximum equivalent stress of 1726.2MPa and deformation of 304.21mm for an initial speed of 30555.6mm/s (110km/h).

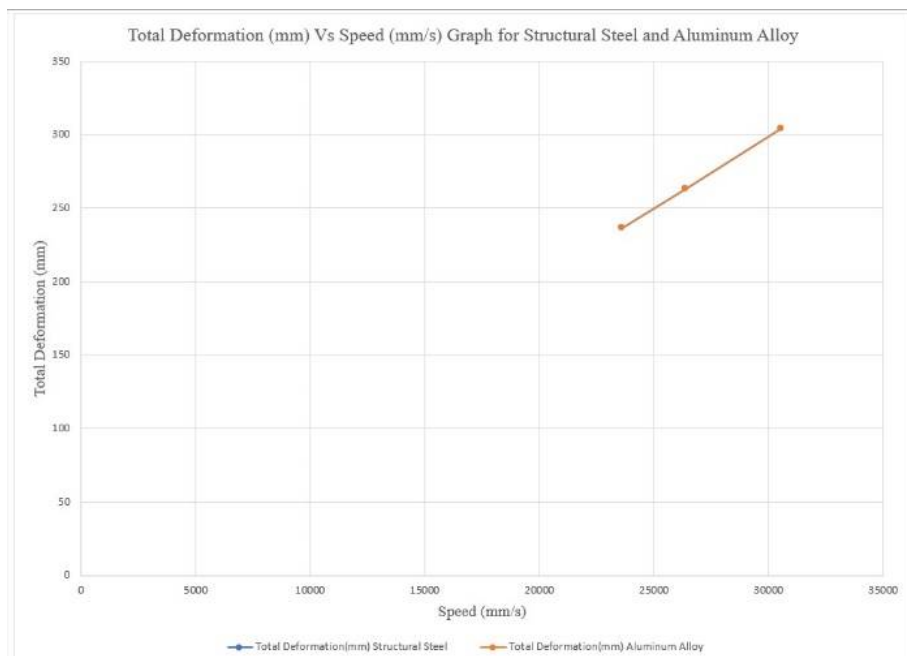


Fig.3 Variation of total deformation with speed for structural steel and aluminum alloy

Fig.3 show variation of total deformation with speed for structural steel and aluminum alloy. The total deformation for both the material increases as the speed increases and as it can be seen that the values in both the cases for deformation is almost similar that's why the line coincide each other for both the material.

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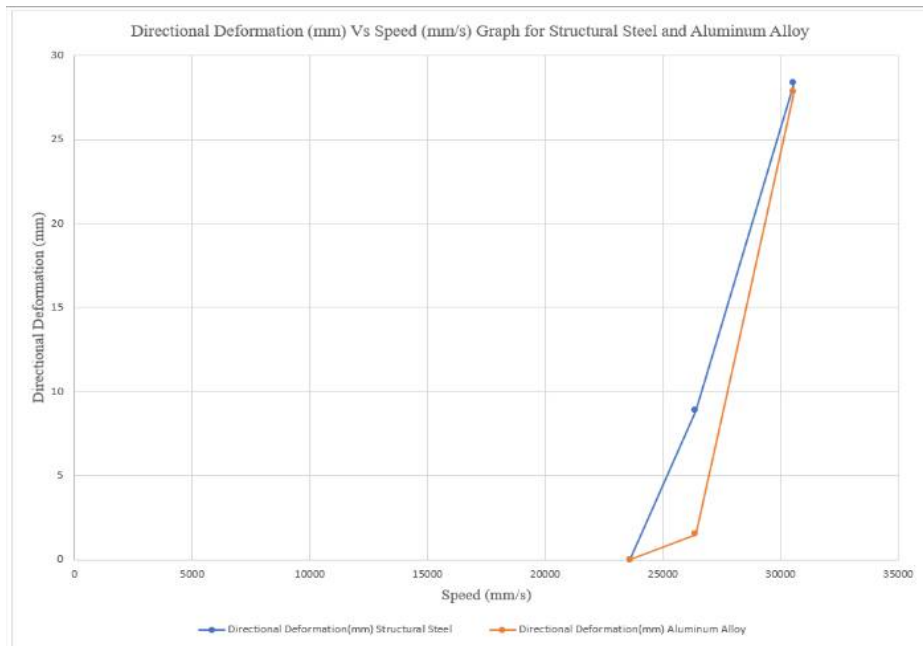


Fig.4 Variation of directional deformation with speed for structural steel and aluminum alloy

Fig.4 show variation of directional deformation with speed for structural steel and aluminum alloy. The directional deformation initially is zero for both the material at the speed of 23611.1mm/s (85km/h) and then increase with increase in speed.

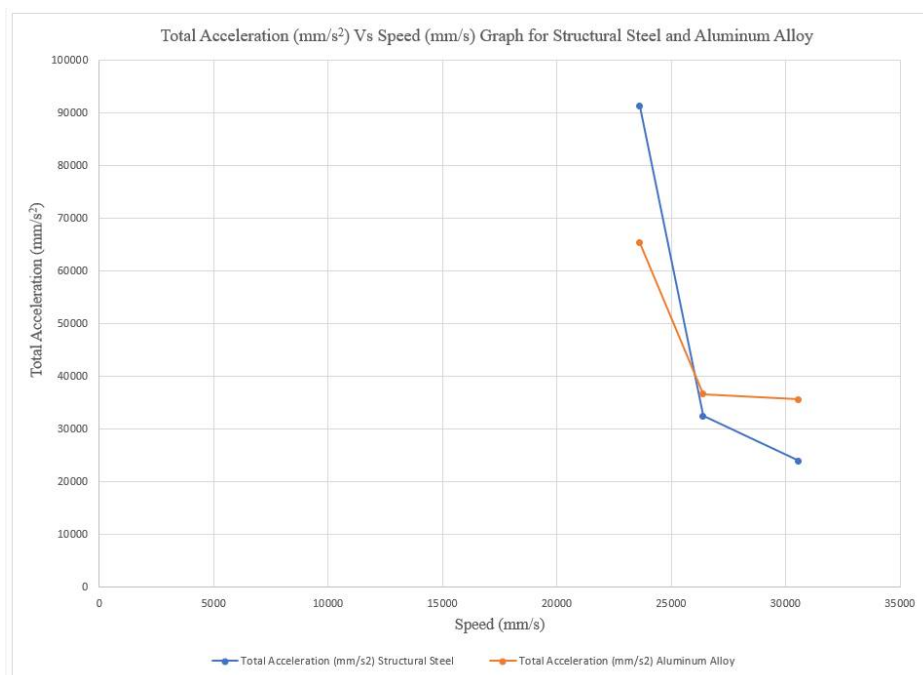


Fig.5 Variation of retardation with speed for structural steel and aluminum alloy

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Fig.5 show variation of retardation with speed for structural steel and aluminum alloy. The graph shows that there is continuous retardation in both structural steel and aluminum alloy.

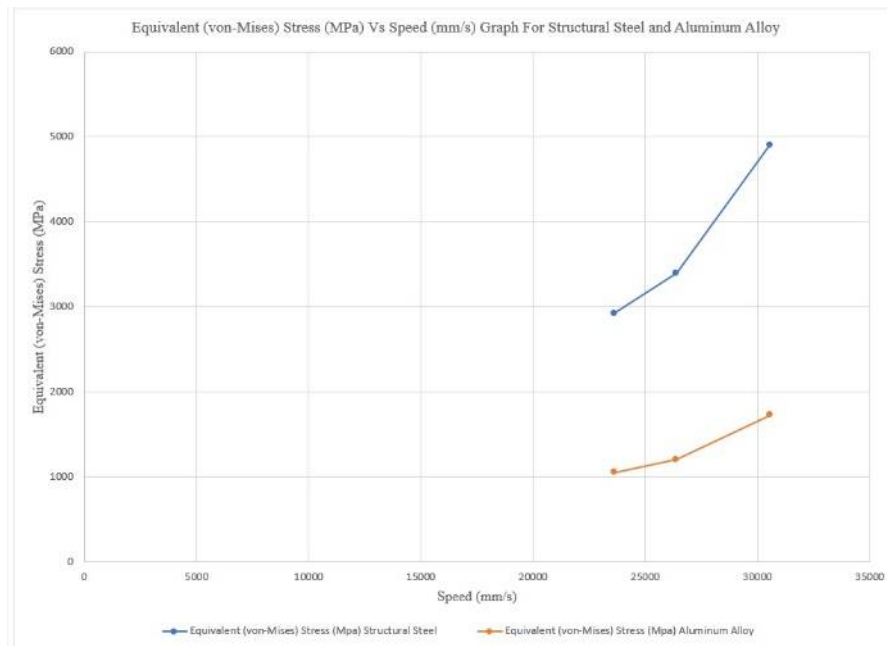


Fig.6 Variation of equivalent stress with speed for structural steel and aluminum alloy

Fig.6 show variation of equivalent stress with speed for structural steel and aluminum alloy. The stresses in both the material increases with the increase in speed and structural steel have high value of stress as compared to that of aluminum alloy.

It is evident from these analysis that the equivalent stresses in aluminum alloy body is only 35% of that of structural steel body and deformation is almost same.

V. CONCLUSION

Frontal car crash simulation was done of Suzuki swift car body by using structural steel and aluminum alloy as a material for obtaining different parameter at different speed by using ANSYS v19 (Academic student) and the following points were concluded.

1. The total deformation for both the material increases as the speed increases and deformation is almost same.
2. In both structural steel and aluminum alloy there is continuous retardation.
3. The Equivalent (von-Mises) stress in both the material increases with the increase in speed and structural steel have high value of stress as compared to that of aluminum alloy.
4. The Equivalent (von-Mises) stress in aluminum alloy body is only 35% of that of structural steel body and deformation is almost same.

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