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HEAVY VEHICLES SAFETY IMPACT GUARD DESIGN ANALYSIS

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Abstract : Death is to Accidents are more than natural calamity in our country . One of the most dangerous cases is the crash between heavy vehicle andother small fourwheelers. Every year lacks of travelers are dead due to highway accidents in which 10% are due to truck and goods vehicles. Vehicles accident due to threatened of peoples and also goods. Accidents is unavoideable totally but the collision force is reduced by some applications and making such design of safety impact guard..

IndexTerms **- Collisions,Cylinder,Safetyimpact Guard,Under ride Spring.**

I. INTRODUCTION

In a highway accidents are more in between a fourwheelers and a goods vehicle occurs, all the safety features for the occupants built into the car,such as Air Bags ,Seat belts, have a reduced impacts. This is because of the very big differences in car and heavy duty vehicles. The very large height of the trailours, specially when the heavy vehicle is unequipped with a protection Guard, it can allow the underride or also called underrun of the other vehicles.Many people get injured during underride accidents. Because of high Collision impact between car and Heavy vehicle chassis, passenger present in car will cause death or seriously injured. To avoid such accidents safety guard has to be installed on the heavy good vehicle which would prevent the passenger of the small vehicle from getting fatal injuries. Without installation of the safety guard, entire energy will be on the frontal car structure which would not be able take such impact. The entire vehicle has gone underneath the truck and the car structure has got crushed due to the sudden impact load. Figure shows damage to small passenger vehicle during a rear underride accident

II LITERATURE SURVEY

Rear-Side Collisions

A vehicle usually an automobile or a truck crashes into the vehicle in front of it. Factors responsible for rear-end collisions includes loss of attention or distraction of driver, work fatigue or continuous hours of driving, Insufficient front lighting of passenger vehicle also in rainy season presence of water on road surface results into reduced friction between vehicle and road responsible for rear end collision.Condition of roadways on which vehicles travel is also important reasons behind the cause of accident, poorer condition of roadways leads to increased severity of accident. One of major roadways which carry most of road traffic in India is National Highways which is described as below:

As per NHAI, India's total road network is of 58 lakh Km, which is second largest road network in the world.Out of total 58 lacks km road network National Highways constitute only 5% but National Highway carries majority of road traffic which is about 50%.Number of vehicles has been growing almost at an average pace of 10% per annum over the last five years. Increase in number of total Registered vehicle in India from 2011- 2021 is as shown in figure:.

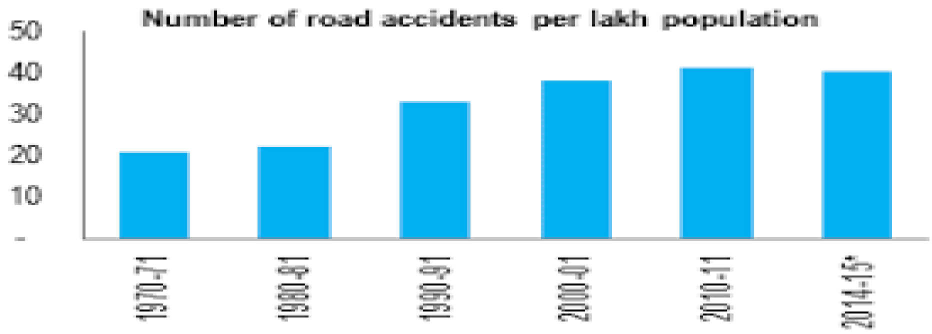


Fig 1.Road accident per lakh population in India

III Position of Rear Impact Guard

Recent Scenario of growth of population in India indicates that there is rapid increase in population over the last few decades. To fulfill the need of transportation of this increased population, number of vehicle goes on increasing. As explained earlier the reasons responsible for accidents and increased number of vehicles leads to increased in number of accidents. Therefore, to reduce number of accidents an underrun protecting device i.e. High Energy safety Impact guard is needed because of that we can save lives and prevent loss of property.Percentage of persons killed in total casualties in Road accidents during 2012-2017 is shown in Table

Table 1: Percentage of Persons dead in road accident

Year	2013	2014	2015	2016	2017
All India	30	30.5	40.0	44.5	39.8

IV Ground Clearance

One of major reason behind the underrun crash is ground clearance of Heavy duty vehicle. The ground clearance provided in Heavy Duty vehicles is larger compare to small passenger vehicle. Because of that when collision between car and heavy vehicle happens the rear side of heavy vehicle cuts the upper part of passenger vehicle. i.e. underride of car happens which results into death or severe injury to passengers which present in car.

VPosition of Rear Impact Guard

Consider the case in which, Passenger vehicle like car is travelling at a certain speed and ahead of car a loaded heavy duty vehicle is running. Obviously since heavy vehicle is loaded it will travel at lower speed than that of passenger vehicle. In case if any obtrusion comes in front of heavy duty vehicle it will apply sudden brakes, due to that speed of heavy vehicle reduces Immediately in fraction of seconds. Due to this driver of passenger vehicle could not get control over vehicle and car will undergo into beneath of heavy vehicle due to undercutting of upper part of passenger vehicle as shown in figure.3

Fig:2 Position of vehicle when collision happen

To overcome the problem of underride crash, hollow bar is attached at the rear end of heavy duty vehicle which will act like solid body i.e. it does not have shock absorbing capability. At the time of collision the impact force by car is such a large that this bar is not able to absorb the shock and get damaged and allows under running of vehicle.
Due to this problem High Energy safety Impact guard is attached to the rear end of Heavy duty Vehicle so that the underside crash should be avoided. Further new research and design modifications will be done and implemented.

VI .RESEARCH METHODOLOGY

The main objectives of this High energy safety impact guard is to avoid underride crashes and to reduce the impact force between passenger car and heavy duty vehicle so that life of passengers can be saved and also damages of vehicles can be prevented. With respect to our objective the proposed design of safety impact guard is as shown in figure.3

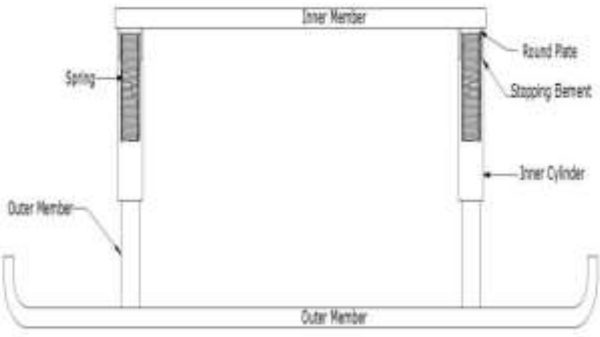


Fig:3 the proposed design of safety impact guard

VII Inner Member

This member is attached to the chassis of heavy duty vehicle at rear side using I section member, so that the clearance in between safety impact guard and ground is reduced therefore, underride crash is eliminated. As force is absorbed by the crushing element which is present in inner cylinder therefore effect of impact force on inner member as well as on chassis of heavy vehicle is reduced. Therefore, inner member act like a rigid body and net impact force experienced by heavy duty vehicle is negligible.

VIII Inner Cylinder

This cylinder is attached on the inner member. This device consist of round plate, stopping element, crushing element,. The diameter of inner cylinder should be greater than the outer cylinder, so the outer cylinder slide in inner cylinder when impact force applied on it.

IX Round Plate

Round plate is inserted in inner cylinder and act as back support for inner member. Strength of inner member is increases due to round plate also it not allows the motion of outer member to go beyond inner member

X.DESIGN OF SAFETY IMPACT GUARD

Design of Safety Impact Guard

In mechanics, an impact is a high force applied over a short time period when two or more bodies collide.

Impact Force = Kinetic Energy/ Impact Distance (1)

Consider the impact distance for maximum case, for this project impact distance is consider as 0.5m.

Kinetic Energy of a passenger vehicle is calculated as follows:

Kinetic Energy = $\frac{1}{2} mv^2$ (2)

Where m = mass of passenger vehicle i.e car; v = velocity of passenger vehicle

For sustaining all impact energy during collision we have to consider maximum impact force acting on heavy vehicle. For calculation of maximum impact force, consider maximum velocity of passenger vehicle allowed travelling on Indian highway is 80 km/hr. i.e. 22.23 m/sec.

We have the passenger vehicle mass i.e. of Hyundai *i10* 1040 kg. Therefore the eqn. (2) becomes:
K.E = $\frac{1}{2} * 1040*(22.23)^2 = 256.969*10^3$ J

Therefore equation (1) becomes:

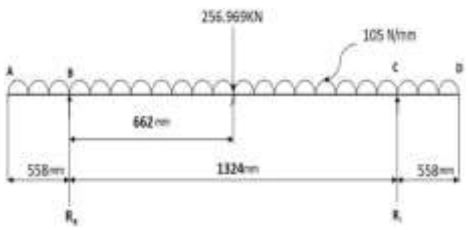
Impact Force $=256.969*10^3/0.5$

$=513.939$ KN

Total force acting on both the members is 513.939KN. Therefore, force acting on single member is half of it i.e. 256.969KN. Impact Force 256.969KN have to sustain by safety impact guard. By using impact force we have to design the safety impact guard to sustain this much of force in reverse manner.

We know the basic equation of stress which is: Stress = Force/Area

Compressive area = 2055.756 mm^2



. **Fig. 4: Loading Diagram of outer member**

XI Design of Plate Thickness

The Outer member will act like a overhang beam which is to be acted by uniformly distributed load.

To Find out Support Reactions R_B and R_C;

$\sum F_y = 0$

$R_B + R_C = 256.969$ (I)

To Find out R_B ; Take Take $\sum$Moment at point B= 0

$256.969 \times 662 - R_C \times 1324 = 0$

R_C = 128.484 KN, Put this value of R_B in Equation (I), we get; R_B + 128.484 = 256.969
R_B = 128.484 KN

2.3Shear Force Calculations.
Shear Force at A = 0
Shear Force at B_L = -105 x 558 = -58590 = -58.59 KN

Shear Force at B_R = 58590+128484= 69.894 x 10^3 = 69.894 KN
Shear Force at C_L = 69894 – (105 x 1324)= -69.126 x 10^3 = -69.126 KN
Shear Force at C_R = -69126 + 128484
= 59.358 x 10^3 = 59.358 KN
Shear Force at D = 0
Shear Force at D = 0

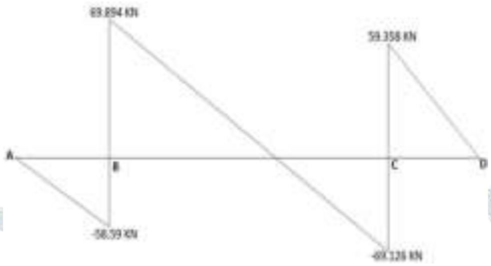


Fig. 5: Shear Force Diagram of outer member

XII Bending Moment Calculations.

$M_A = 0$

$M_B = -105 \times 558 \times \frac{558}{2} = -16.346 \times 103$ KNmm

$M_C = (-105 \times 1882 \times \frac{1882}{2}) + (128484 \times 1324) =$

-15.838 x10^3 KNmm2

$M_D = 0$

1) *Location of Maximum Bending Moment*

Let assume at a section x-x from point A; Bending Moment is Maximum

Mx-x = -[105* x*x] + 128484*(x-558)

Solving this equation; we get x = 1586mm from point A

2) *Maximum Bending Moment*

$= -105*1586 * \frac{1586}{2} + 12848*(1586-558)$

2

B.M. $_{max}$ = 23.262*10^3 KNmm

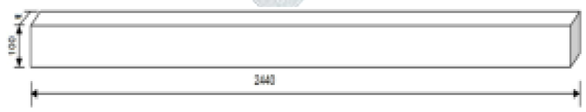


Fig. 6: Dimensions of outer member Plate

3) *Moment of Inertia of Plate*

Equation for Moment of Inertia of plate is

Equation for Moment of Inertia of plate is

$I = \frac{bd3}{12}$

$= \frac{2440\ t3}{12}$

I = 203.33 t3 mm4

Position of neutral axis from base

$y = \frac{100}{2}$

y = 50 mm

Therefore, using Maximum Bending Moment and allowable stress we can calculate the thickness of plate :

$\sigma = \frac{Mx * y}{I}$

$250 = \frac{23.262*106*50}{203.33t3}$

$t3 = \frac{23.622*106*50}{250*203.33}$

t3 = 28.33mm

t ≈ 30 mm

Therefore, thickness of outer member is selected as 30 mm and for inner member to increase its strength and rigidity thickness selected is 40mm.

XIII Modelling and Assembly of Safety Impact Guard

The Modelling and assembly of safety impact guard is done with help of in CATIA workbench. Design and parts for this model assembly was explained before. Assembly of High Energy safety impact guard consist of :

2 Inner Member, 4 Inner Cylinder, 4 Round Plate, Connecting Plate

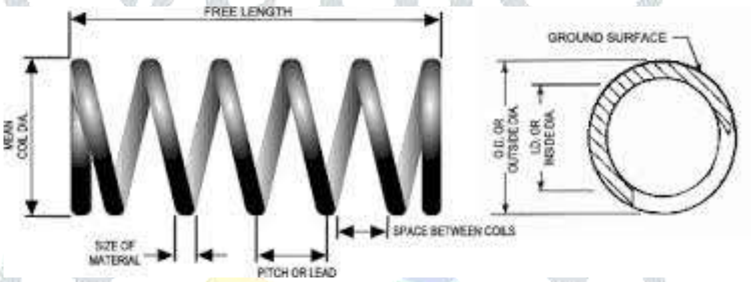


Figure 7: Helical Spring

IVX Calculation of Theoretical Stress: Stress In Coil (σ)

Plain spring given data

Type: Helical Compression Spring

End Condition: Both End Squared and Ground. Rod Diameter: 5 mm

Mean Coil Diameter: 21.8 mm

Inner Diameter =17 mm

Outer Diameter = 27 mm

Number of Turns =5 Free

Length =40 mm

G = 80 X 103 Mpa

Calculation of Theoretical Stress: Stress In Coil (σ)

$\sigma = \frac{K \times 8 \times P \times D}{\pi \times d3}$

Here,

K= Stress factor = 1.19 ----calculated used spring index.

$\sigma = \frac{1.19 \times 8 \times 246.3 \times 21}{\pi \times 533}$

σth = 15.6 N/mm2

As σ th < σ allowable

Thus spring is safe.

Result and Discussion.

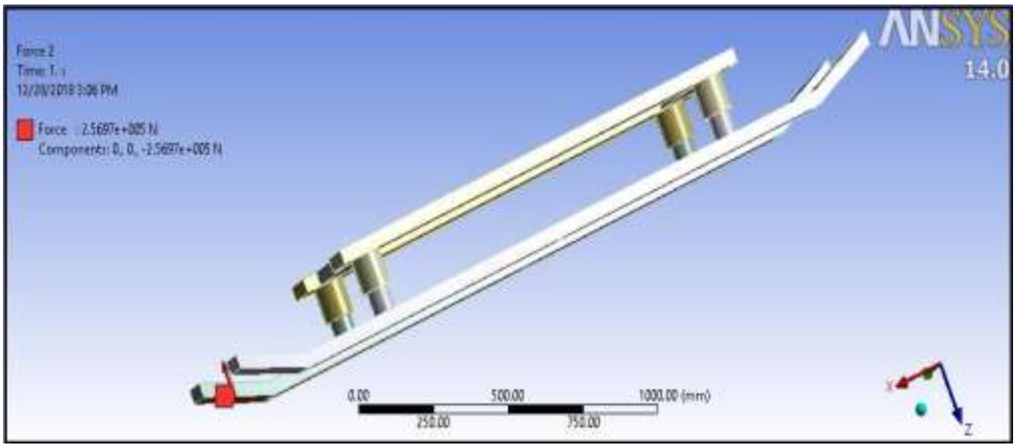


Fig8 .ANSYS Image: Application of Force on Outer Member

Analysis of Safety Impact Guard Step by step analysis of safety impact guard is explained ahead:Import CATIA Model in ANSYS WorkbenchImport external Catia file in ANSYS Workbench so that we can analyse the model in Here we apply 100 % load to the safety impact guard. Total force Applied is 256.969KN on each outer member, i.e.2.5697*10^5 N in magnitude. The result that safety impact guard can sustain this force or not is clear from the maximum stress acting on this

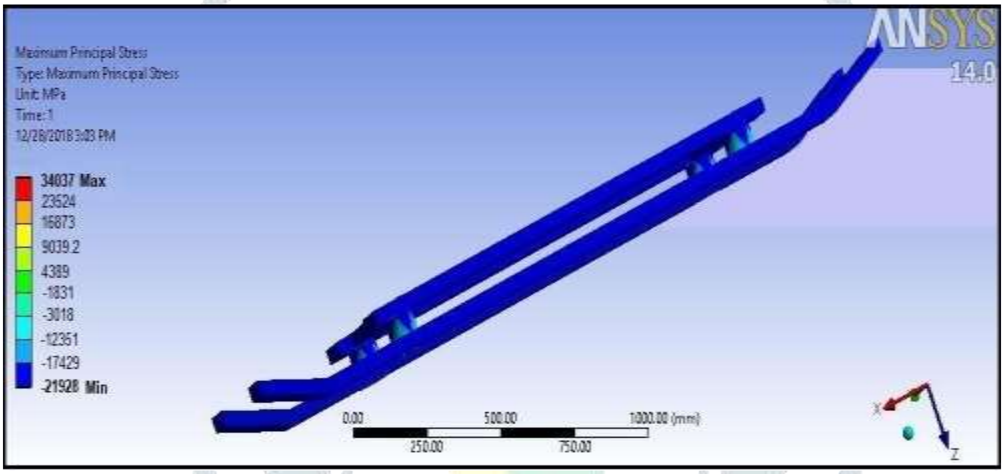


Figure 9: ANSYS Image: Image of Maximum Stress Induced Maximum stress induced on safety

Model.Maximum Stress induced Impact guard for 100% of loading is 34037 MPa which is very much higher. For this magnitude of stress impact guard goes in failure.

Maximum stress Induced:

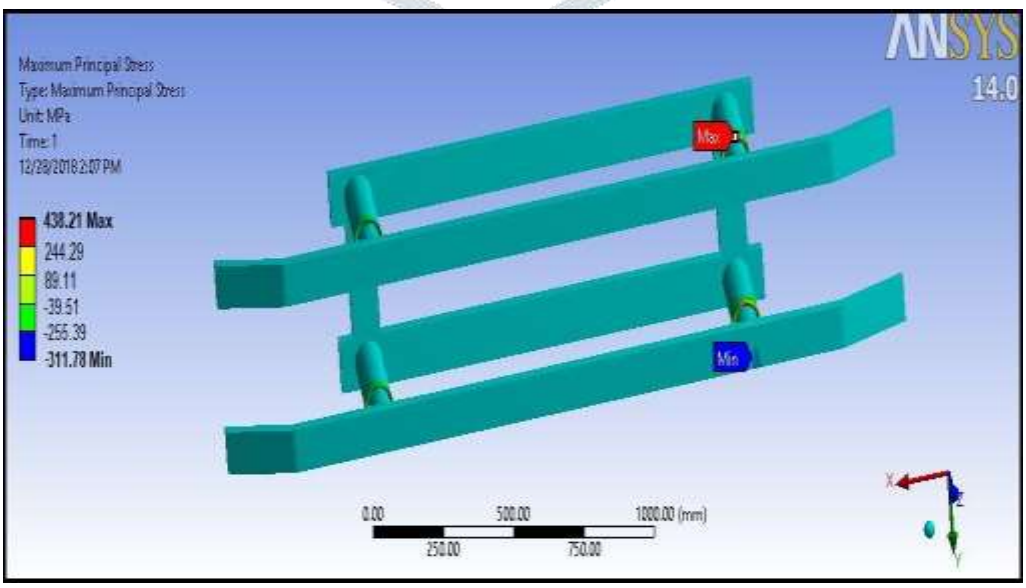


Fig.10 ANSYS Image: Maximum Stress Induced on Safety Impact Guard Designed for Sustaining 80% Loading

The result for maximum stress acting on the safety impact guard for 80% loading of total impact force is shown in above image. Result shows that maximum stress acting on the safety impact guard is 438.21 MPa, but it occurs in some region of inner member only. Where crushing member crushes and accumulated in inner member of safety guard. We can reduce this amount of stress induced by increasing diameter of inner member cylinder. This minor modification will be corrected in future. It is observed that stress in other part of safety guard is lies between 89-244 MPa. Therefore this trial for 80% loading is acceptable. Therefore, the aim of project is satisfied i.e. to sustain impact force and increase striking area and this design of safety impact guard is accepted conceptually.

CONCLUSIONS

High Energy Safety Impact Guard is one of the safety instruments which can reduce collision impact at rear end collision when accident occurs. Safety guard provides protection against under ride crashes by increasing striking area by using two outer members of safety guard. With respect to our objective design, modelling and analysis of High Energy safety impact guard is done. By implementing this safety impact guard life of passenger present in passenger cars can be saved and also passenger is saved from getting serious injuries, and vital parts of passenger vehicle i.e. engines etc. will be prevented from damage.

ACKNOWLEDGMENT.

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