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Review Paper on Design, Modelling and Analysis of High Energy Safety Impact Guard for Heavy Duty Vehicle

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Abstract - *Accidents are killing more people in India than terrorism or natural disasters. Every year thousands of passengers are killed, out of which 8% are due to large truck accidents. Traffic accident leads to loss of life and property. We cannot avoid accidents completely but impact of accident is reduced by applying safety measures or safety instrument. High Energy Safety impact guard is one of the safety instruments which can reduce collision impact at rear end collision when accident occur, it also provide safety against underride. Another aim of this project is to increase the striking area of collision by using two pairs of outer members, so that the underride crashes of car should be avoided. Proposed design of safety impact guard includes crushing element as force destroying material. Because of that when rear end collision occur the impact force or energy is destroyed due to crushing action. This paper proposes analysis of new design of High Energy Safety guard mounted on the rear end of a heavy vehicle to protect under running of smaller vehicles like car.*

Key Words: **Impact, Crushing Element, Safety Guard, Crushing, Underride.**

1. INTRODUCTION

When a road accident between a car and a heavy vehicle happens, all the protection features for the occupants built into the car, such as seatbelts and airbags, have a reduced effectiveness. This because of the very big differences in geometry and stiffness between the two vehicles. The very large height of the truck, especially when the heavy vehicle is not equipped with a Safety Guard, it can allow the underride of the car.

Many people get injured during underride accidents. During such accidents the passenger compartment of the small vehicle strikes the chassis of the heavy vehicle causing severe injuries to passenger in the smaller vehicle. 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.

Figure 1: Underride Crash of Car

According to ministry of road transport and highways transport research the increase in rate of accident from year 2013-2017 is shown in the table.

Table 1: Number of Accident and Number of Persons Affected from 2013 to 2017

Year	Total no. of Accidents	Killed	Injured	No. of Persons killed per100 accidents
2013	4,86,476	1,37,572	4,94,893	28.3
2014	4,89,400	1,39,671	4,93,474	28.5
2015	5,01,423	1,46,133	5,00,279	29.1
2016	4,80,652	1,50,785	4,94,624	31.4
2017	4,64,910	1,47,913	4,70,975	31.8

In 2017, 53 accidents and 17 deaths occurred per hour. According to the publication, the most productive age group 18-45 accounted for a share of 68.6% of all road traffic accident deaths in India which will reflect on economy of the nation. Problem of under ride crashes can solve by attaching safety impact guard at rear end of Heavy Vehicle. Also, force or impact of collision can reduce by action of crushing of crushing element used in rear impact guard.

2. LITERATURE REVIEW

Before going to direct design consideration about rear impact guard we will see some other chapters which are related directly or indirectly to working of rear impact guard

2.1 Causes of Accidents:

The various causes of road accidents are:
1. Road Users: Excessive speed and rash driving, violation of traffic rules, failure to perceive traffic situation or sign or signal in adequate time, carelessness, fatigue, alcohol, sleep etc.
2. Vehicle: Defects such as failure of brakes, steering system, tyre burst, lighting system.
3. Environmental factors: unfavorable weather conditions like mist, snow, smoke and heavy rainfall which restrict normal visibility and makes driving unsafe.

2.2. Road Traffic Collisions:

Road traffic collisions generally fall into one of four common types:
1. Lane departure crashes, which occur when a driver leaves the lane they are in and collide with another vehicle or a roadside object. These include head on collisions and run-off-road collisions.
2. Collisions at junctions include rear-end collision and angle or side impacts.
3. Collisions involving pedestrians and cyclists

Although other types of collision do occur. Rollovers are not very common, but lead to greater rates of severe injury and death. Vehicle rollovers are divided into two categories: tripped and untripped. Tripped rollovers are caused by forces from an external object, such as a curb or a collision with another vehicle. Untripped crashes are the result of steering input, speed, and friction with the ground. Due to this the vehicle starts to turn over. Some of these are secondary events that occur after a collision with a run-off-road crash or a collision with another vehicle.

2.3 Rear-End Collisions:

A vehicle usually an automobile or a truck crashes into the vehicle in front of it. Common factors that contribute to rear-end collisions include by driver inattention or distraction, tailgating, panic stops, and reduced traction due to weather or worn pavement. It may also be a rail accident wherein a train runs into the rear of a preceding train. Typical scenarios for rear-ends are a sudden deceleration by the first car for example, to avoid someone crossing the street so that the following car does not have the time to brake and collides with the first. Alternatively the following car may accelerate more rapidly than the leading for example, leaving an intersection resulting in a collision.

Figure 2: Rear end Collision

According to NHAI, Indian road network of 56 lakh Km. Is second largest in the world.
1. About 65% of freight and 80% passenger traffic is carried by the roads.
2. National Highways constitute only about 2% of the road network but carry about 40% of the total road traffic.

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 1951- 2016 is as shown in figure:

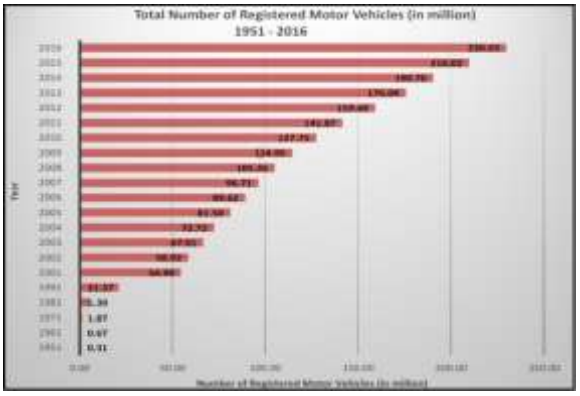

Chart1: Total Vehicle Population (In Millions)

By statistical study of accident occurrence at a particular road or location or zone of study for a long period of time it is possible to predict with reasonable accuracy the probability of accident occurrence per day or relative safety of different classes of road user in that location.

Table2: Percentage of Persons Killed to Total Casualties in Road Accidents during 2012-2017

Year	2013	2014	2015	2016	2017
All India	28.3	28.5	29.1	31.4	31.8

In short as we see Indian scenario population goes on increasing, transportation also goes on increasing, number accidents are increases because of several reasons as mentioned before. Therefore to reduce the effect of accidents i.e. to save the life we have to implement strong and efficient

safety instrument. Rear impact guard is safety device or instrument because of that we can save lives and prevent loss of property.

2.4 About Rear Impact Guard

We consider the case that truck, trailer or heavy loaded vehicle travelling on road and behind that passenger vehicle is travelling. In case sudden brake is applied by heavy loaded vehicle or passenger vehicle could not stop the vehicle then the passenger vehicle crashes to front vehicle i.e. heavy loaded vehicle. But passenger vehicle speed is greater as that of trailer or truck because of that the passenger car goes under the trailer or truck position. As shown in following figure this situation can also cut the wind screen which also cut upper part of body of the passenger. Also the impact of the collision is much greater.

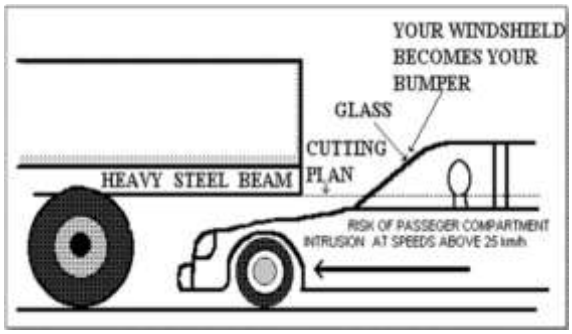

Figure 3: Position of Vehicle when crash going to happen

Initially to overcome both these problem, at the rear end of the truck bar is attached. If collision happens then the bar acts like bumper to stop the car. But only this bar is not sufficient to stop the car because small vehicle speed and impact is greater. Due to sudden force exerts on bar then the bar may be fail.

Further more research and design is modified and implemented. This arrangement is as shown in following picture: But only this bar is not sufficient to stop the car because small vehicle speed and impact is greater. Bar may fail or break due to large force. Therefore to absorb or destroy this energy we need some more arrangement like rear end safety impact guard.

3. METHODOLOGY

As explained before when we consider the rear end collision, then two main problems are underride crashes and loss of life and property. To overcome these problems, rear impact guard is a solution. The possible designs for rear impact guard as explained follows:

3.1 Experimental Setup:

Setup of safety impact guard should include:

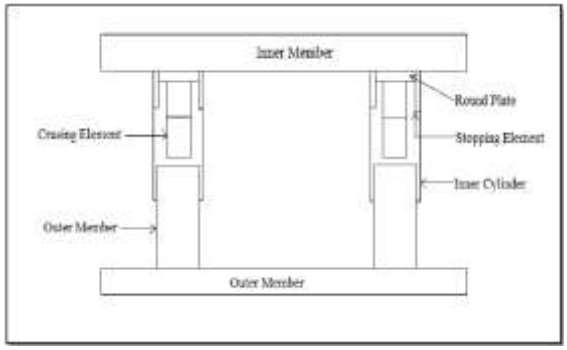

Figure 4: Setup High Energy of safety impact guard

1. Inner Member: This member should attach to the chassis of heavy duty vehicle trough the projections made by I section member. So that the height of this safety impact guard from ground level should reduce. So that we can reduce the ground clearance of safety impact guard to avoid under ride crashes. As this member is attached to chassis of heavy duty vehicle so the effect of impact is negligible on chassis. Therefore the Inner member and chassis act as rigid member. The overall effect of impact on heavy duty vehicle is negligible.

2. Inner Cylinder*:* This attached to the inner member. These consist of crushing element, round plate, stopping element. The diameter of inner cylinder should be more than the outer cylinder. So the outer cylinder can play sliding motion in inner cylinder when impact comes.

3. Crushing Element: Crushing element is the element which crushes after impact comes from the outer element. Crushing element is hollow in geometry. Due to crushing effect the impact force will destroyed as well as the effect of this crushing element also destroyed. We accept the destruction of crushing element as they play important role in destruction of impact energy. According to impact force to sustain this force number of crushing element and inner element can be vary.

4. Round Plate: Round plate is place inside the inner cylinder as back support. Due to round plate strength of inner member & cylinder increases also restricts the motion of outer cylinder going besides the inner member.

5. Connecting plate: Connecting plate is used to connect the two inner members of safety guard in parallely.

6. Stopping Element: Stopping element is added in inner cylinder to stop the motion of outer cylinder. When impact force acts on the outer member then it pushes outer cylinder which causes sliding motion between inner and outer

cylinder. This impact force very large therefore to stop motion this stopping element is added.

7. Outer Member: The outer member is the element on which the impact force acts or the passenger vehicle back to the heavy vehicle crashes on this outer member.

8. Outer Cylinder**:** This is attached to the outer member. The impact force is transmitted through the outer cylinder to the crushing element. The diameter of this outer cylinder is less than the inner cylinder.

For this project to design such type of safety impact guard two vehicle models are chosen as follows:

Heavy Duty Vehicle: TATA LPS 3516 EX
Passenger Vehicle: Huyndai *i10*

3.2 Impact Force:

In mechanics, an impact is a high force or shock applied over a short time period when two or more bodies collide.
Impact Force = Kinetic Energy/ Impact Distance
Impact distance in maximum case consider as 0.5m. For this project impact distance is consider as 0.5m.

Kinetic Energy of a passenger vehicle is calculated as:

$$\text{Kinetic Energy} = \tfrac{1}{2} mv^2$$

Where; m = mass of passenger vehicle,
v = velocity of passenger vehicle

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

We have the passenger vehicle mass i.e. Hyundai *i10* 1040 kg. Therefore the eqn. (2) becomes:

$$K.E = \tfrac{1}{2} * 1040*(22.23)^2 = 256.969*10^3 \text{ J}$$

Therefore above equation becomes:

$$\text{Impact Force} = 256.969*10^3/0.5$$
$$= 513.939 \text{ KN}$$

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.

4. PROPOSED DESIGN OF SAFETY IMPACT GUARD:

Safety Impact guard will consist of two outer and inner members respectively which will make contact through inner and outer cylinders. The two inner members of safety impact guard will be connected trough connecting plate.

The impact force is applied on outer members equally and that impact force is destroyed in crushing element which is present in between inner and outer cylinder.

According to proposed design the modeling of safety impact guard is done in CATIA and analysis is to be done in ANSYS workbench. The proposed design of high energy safety impact guard is as shown in figure

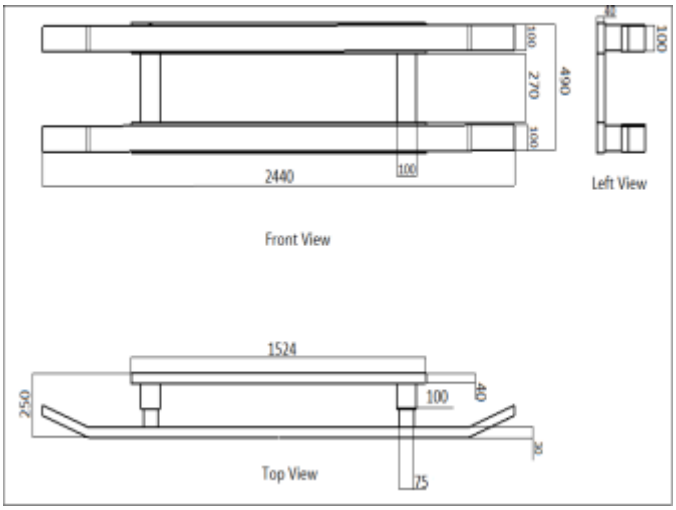

Figure 5: Proposed Design of High Energy Safety Impact Guard

5. CONCLUSION

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. According to that design, modelling & analysis will be 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.

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