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Review paper on Design, Modelling and Analysis of Safety Impact guard with PRV Based Damper

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Abstract— Road traffic crashes and their effects are quite complicated and expensive. Too many passengers die or injure every year because of highway accidents. Most of the vehicle manufacturing companies are unable to control this matter successfully. Several studies have been conducted to improve road safety and reduce the number of accidents on the roads. As we cannot avoid accidents completely but impact of accident can be reduce by applying safety measures and safety instrument. Because of the lack of effective rear underride guards attached to trucks, trailers and semi-trailers, rear underride crashes are responsible for thousands of deaths every year throughout the world. Safety impact guard is one of the safety instruments which can reduce collision impact at rear end collision when accident occurs. Also provide safety against under ride crashes which is cause due to passenger vehicle collides with the truck or trailer. Proposed design of safety impact guard includes pressure relief valve as force absorbing element. When rear end collision is occurs the force or energy or impact is absorbed due to action of PRV.

Index Terms— Impact, Safety Guard, Pressure Relief Valve, Underride.

1 Introduction

From the beginning of human life in order to move from one place to another we are using different Transportation systems, at the early stage people used horses, Carts but after inventing the engines people are ready to use vehicles like bikes, cars and buses. But today there is no guarantee that we will reach the destination safely. It is important to know the risk factors associated with vehicular transportation.

Road safety is certainly one topic of great interest that concerns the whole community at national and global level. Several studies have been conducted to improve road safety and reduce the number of accidents on the roads. The total number of accidents can be reduced through the safety systems installed in vehicles.

However, it was found that many traditional safety measures such as seat belts, airbags, etc. are reducing their effectiveness. It is therefore unlikely that they will bring further improvements in safety at reasonable cost.

Road accidents are the leading cause of death by injury and tenth-leading cause of all deaths globally. The occurrence of an accident must take into account the key variables that constitute the whole road system: the road, the driver, the vehicle and the environment.

1.1 Rear-End-Collision:

Rear-end-collision is taken into consideration for this project. A rear-end accident caused by a commercial truck is more common, collision of a passenger car into a truck is more likely to result in fatalities. Commercial trucks are very large and are often more than 40 times the size of other vehicles on the nation's roadways. Because of this weight discrepancy, they are less maneuverable, slower to start and take longer to stop than passenger vehicles. This combination can lead to catastrophic damage if a collision occurs. Commercial trucks generally are more limited than passenger vehicles when it comes to controlling acceleration, braking and visibility — an important factor that contributes to commercial truck accidents.

There are two types of rear-end collisions involving these massive trucks. The first, and more common, occurs when a commercial truck strikes a passenger vehicle. The second, and often more deadly, happen when a passenger vehicle strikes a commercial truck.

Rear-end collisions caused by commercial trucks are often the direct or indirect result of faulty brakes. Fatigue or a lack of attention was is also often a contributing factor to accidents in these situations. This danger occurs most often on interstates, when drivers traverse long stretches of road without many turns, stops or intersections. As a result, the drivers+ are more likely to relax their vigilance, thus reducing the

Fig. 1 Underride Crash

drivers' ability to promptly respond to slowed or stopped vehicles.

The second type of rear-end collision, a passenger car striking a commercial truck as shown in the fig. 1 can be

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caused by poor lighting conditions and is almost twice as likely to occur at night. Commercial trucks struck by passenger vehicles are often in violation of lighting regulations. This may make trucks more difficult to see and respond to safely.

This type of accident has a higher fatality rate because of a phenomenon known as truck underride. A truck underride crash occurs when a passenger vehicles goes partially or wholly under the truck or trailer. Since the passenger vehicle's point of impact is not at the car's bumper, those inside the vehicle are less likely to receive the protections offered by both the bumper and the car's frame. This vulnerability greatly increases the likelihood of death or serious injury to occupants of the vehicle.

Most semitrailers are required to have underride guards. These are steel bars that hang from the backs of trailers to prevent the front of a passenger vehicle from moving underneath during a crash. Earlier research showed that the minimum strength and dimensions required for underride guards are inadequate.so these cannot prevent the passenger cars and its occupants effectively.

However, not all trucks have underride guards, not all underride guards perform as they should in keeping passenger vehicles from sliding under the back end of a truck and getting crushed. Rear impact guards must be able to prevent passenger cars from sliding under the rear end of the truck to the point where the passenger compartment is struck.

The current stiff rear underride guard standards are a safety compromise that does not protect all sizes and weights of current vehicles. They ultimately are too stiff for small vehicles or are too weak for large vehicles. Only energy-absorbing guards provide protection for most sizes and weights of current vehicles and modern designs are cheap and simple to implement.

2 Literature Review

A safety impact guard were designed which could reduce collision impact at rear end collision when accident occurs. The safety impact guard included a crushing element as force destroying material. Because of that when rear end collision was occurs the force or energy or impact was destroyed due to crushing action. Another aim of this project is to reduce the height of safety impact guard from ground so that the truck under ride crashes should be avoided. And also we can save the life and prevent the loss of property. The objective of this entire project would be of possible design of rear impact guard which provides safety against rear end collision. [1]

A spring damper system was designed which was the passive safety system. The vehicles should have active safety system which will avoid the accidents as much as possible and passive safety system which will reduce the damage and loss of lives. Passive system will decrease the impact of accident. In this systems spring will store the energy and damper will dissipate the energy. This spring damper system reduces the impact of accident by increasing the time of collision as the spring needs some time to compress it totally. In this to check the amount of reduction in impact force when two bodies collide is analyzed with the spring damper system and without the spring damper system. The Impact force is significantly reduced with the spring damper system. [2]

3 Methodology

For this project, to design a safety impact guard two vehicle models are chosen as follows:
Heavy Duty Vehicle: TATA LPS 3516 EX
Passenger Vehicle: Hyundai i10

From the above specification and dimension we can design some member of safety impact guard.

3.1 Calculation of Impact Force:

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

$$\text{Impact Force} = \frac{\text{Kinetic Energy}}{\text{Impact Distance}}$$

Impact distance in maximum case consider as 0.5m.

For this project also, impact distance is consider as 0.5m.

Kinetic Energy of a passenger vehicle is calculated as:

$$\text{Kinetic Energy} = \frac{1}{2} \times m \times v^2$$

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 80km/hr. i.e. 22.23 m/sec.

We consider the passenger vehicle mass i.e. Hyundai i10 as 1040 kg.

Therefore the Kinetic Energy becomes:

$$\text{Kinetic Energy} = \frac{1}{2} \times 1040 \times 22.23^2$$

$$\text{Kinetic Energy} = 256.969 \times 10^3 \text{ J}$$

Therefore impact force can be calculated as:

$$\text{Impact Force} = \frac{256.969 \times 10^3}{0.5}$$

$$\text{Impact Force} = 513.939 \text{ KN}$$

3.2 Force Distribution:

$$\text{Total Force} = 513000 \text{ N}$$

$$\text{Force per impact damper} = \frac{513000}{2} = 256500 \text{ N}$$

The impact force is distributed as follows:
10% by outer member = 25650N
30% by spring =76950 N
30% hydraulic damper = 76950 N (Maximum Pressure of 18 kg/cm2 is developed)
10% by inner member: 25650N

4 Experimentation

4.1 Proposed design of Safety Impact Guard:
The safety impact guard includes the following component:

1. Inner Member
2. Inner Cylinder
3. Pressure Relief Valve
4. Round Plate
5. Stopping Element
6. Outer Member
7. Outer Cylinder

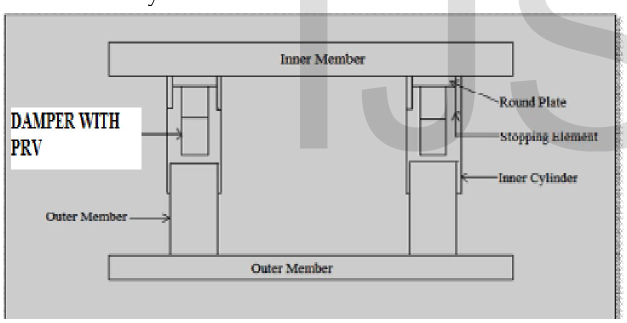

Fig. 2 Block Diagram of Safety Impact guard with PRV based damper

4.1.1 Inner Member:

This member should attach to the chassis of heavy duty vehicle through the projections made by I section member. So that the height of this safety impact guard from ground level should reduce. So our first aim should be completed i.e. 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.

4.1.2 Inner Cylinder:

This attached to the inner member. These consist of crushing damper element, round plate, pressure relief valve. 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

4.1.3 Pressure Relief Valve:

Damper is the element which displaces after impact comes from the outer element. Damper element is collapsible, it employs heavy duty spring that absorbs the primary impact energy which is accounted to be 30 % of the total impact energy, and then the rest amount of energy is dissipated with help of pressure relief valve. Due to displacement effect the impact force will destroyed as well as the effect of this damper will temporarily collapse as it plays important role in destruction of impact energy. According to impact force to sustain this force specifications of the damper and inner element can be vary.

4.1.4 Round Plate:

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

4.1.5 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 is very large therefore to stop this motion stopping element is added.

4.1.6 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.

4.1.7 Outer Cylinder:

This is attached to the outer member. The impact force is transmitted through the outer cylinder to the damper element. The diameter of this outer cylinder is less than the inner cylinder.

4.2 Experimental Setup of Safety Impact Guard:

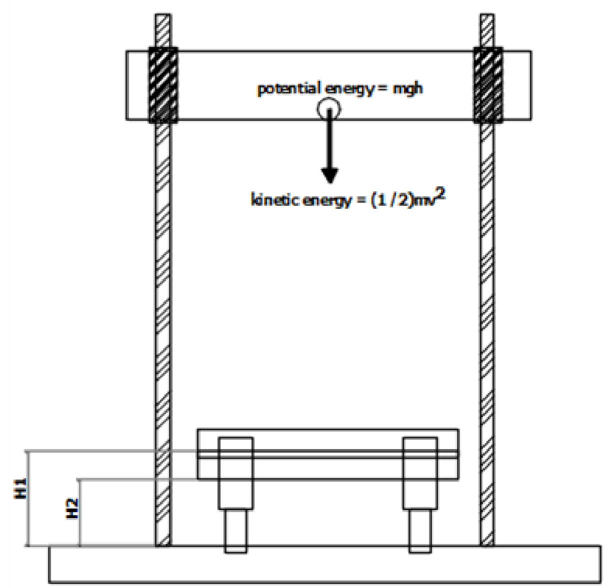

Fig. 3 Experimental Set-Up

The experimental setup of safety impact guard with pressure relief valve is as shown in the fig 3. In the setup, the impact force of collision is applied by the weight attached at the top of the setup. The weight consider in this project is 5 kg. The damper is arranged at the bottom. Damper consists of the outer and inner cylinder, spring and the pressure relief valve. The damper is located between the outer and the inner member. The weight is release from the height on the outer member as the impact force of collision. So the potential energy of the weight is converted into the kinetic energy when the weight is release from the height. The outer member is displaced by the weight. Then this motion is transmitted through the outer cylinder to the damper. Damper consists of the spring which is then deflected and pressure relief valve is actuated. The pressure relief valve is operated at the set pressure and absorbs the impact force by releasing the oil.

The energy absorbed by the damper is then calculated by finding the deflection of the outer member. The deflection is calculated by taking the difference between H1 and H2. Then the input energy is the kinetic energy and output is the energy absorbed by the damper. From this the efficiency of the damper is calculated.

4.3 Working of Damper:

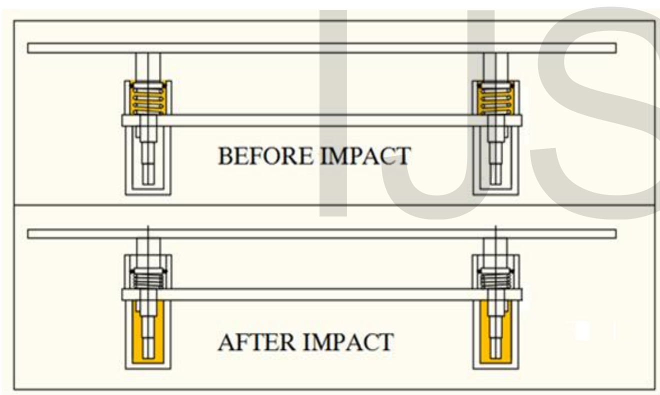

Fig. 4 Operation of Damper

Once impact takes place the system displaces the outer member towards the inner member such that the spring inside damper is deflected to 90% of free length when the PRV is actuated to release the oil which is at pressure above the cracking pressure of PRV and thus this action will like an action of shock absorber in automobile suspension thus the impact force is properly damped without damaging the inner member or outer member. The system resembles the safety feature of air bag so that it can be reset for next use.

4 Conclusion

Safety impact guard with pressure relief valve is used as a safety instruments in heavy duty vehicle to avoid the rear collision.It also provides safety against underride crashes which is cause due to passenger vehicle collides with the truck. By implementing this safety impact guard passenger life present in passenger cars can be safe. Also vital parts of passenger vehicle i.e. engines etc. will be safe. For resistance of impact force there is no need to add any safety instrument on passenger vehicle as this safety impact guard attached to the heavy duty vehicle.

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