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Belleville Spring Based Impact Damper

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Abstract – *Many laws have been made by the governments all around the world regarding vehicles to protect the drivers and passengers.. Passenger vehicle bodies have shock absorbing zones developed through rigid flat barrier testing and improved passenger cell stability has resulted from consideration of offset deformable frontal impacts. The problem of accident of speeding vehicles in highway transportation is common but very crucial. Traffic accident leads to loss of life and property. We cannot stop accidents completely but ultimate result of accident we can reduce by applying safety measures, safety instrument in the form of re-usable sacrificial vehicle crash energy absorber –damper. In the design of an automobile, the most important task is to minimize the occurrence and consequences of automobile accidents. Too many passengers die or injure every year because of accidents. Most of the vehicle manufacturing companies are unable to control these accidents. We are coming across the many accidents which were the result of poor designing and maintenance. 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. The spring damper system is a passive safety system which 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.*

Key Words: **Belleville Spring, Impact Damper, Safety, Pressure relief valve, Shock Absorbtion,**

1.0 INTRODUCTION

From the beginning of human life in order to move from one place to another we are using different Transportation systems, But today there is no guarantee that we will reach the destination safely It is very important to know various factors that will influence the impact of an accident. In present most of the vehicles are manufactured with the bumper which will break under the load. An experiment was conducted on a cushioning model that was made to test the impact force was explored using a metal ball and varying thicknesses of polyster, it is found that the collision time is increasing with thickness of sponge up to some thickness and which makes less force on the metal ball. Spring damper system works on the same principle which will dissipate the energy without causing damage for a specified range of speeds.

A damping element was introduced into the bumper to improve on the impact and kinetic energy absorption capacity. The energy absorption capacity of the bumper was improved with the addition of a damping element. To validate these results experiments were conducted. To mitigate the degree of damage to passengers caused by automobile collisions, a friction damper was built and used in experimental tests to test its effectiveness in impact energy attenuation. One can contribute a major step in the safety of the vulnerable road users without compromising on the safety of the occupants. In this work, the issue of vehicle-front design for safety of pedestrians is addressed. A damper having an elastically deformable part with a spring located behind an impact plate on the front bumper, with energy absorbed in a vehicle collision as a result of the deformation of this spring. Depending on the vehicle speed, the impact damper is adjusted for the impact to be softer or harder by a change in spring force. An impact damper for a motor vehicle has deformation elements with different degrees of stiffness that are plastically deformable in various impact speed ranges to absorb impact energy. A bumper is a structure attached to or integrated with the front and rear ends of a motor vehicle, to absorb impact in a minor collision, ideally minimizing repair costs. A goal of the project consists in designing an impact damper, which can be made economically and so that it can adapt its deformation resistance to the load in a vehicle collision. This goal is achieved by providing such an impact damper, wherein at least one part can be connected to the elastically deformable part, said plastically deformable being capable of being impacted by the impact plate and absorbing energy plastically in a vehicle collision.

1.1 Problem Statement:

There are many safety provisions and government regulations in recent days which are aiming at reduction in accidents such as ABS, EBD, Airbags, Sensors, etc. Even so, accidents do happen.

Also there aren't any safety components installed on the exterior of the vehicle, except a bumper, which is easily collapsible during a larger impact force, which can protect vehicle as well as passenger during a collision.

In this project we are designing a Damping device which will reduce the fatality of accident, absorb impact and prevent it from reaching to the drivers end, thus save live and reduce the number of injuries.

This device will also reduce the damage caused to the vehicle, thus reduce cost of reparations, just by installing this device in between the chassis and vehicle body.

1.2 Objectives

1. Determination of impact force and system design of impact energy absorber through theoretical calculation of momentum and kinetic energy of moving vehicle and development of scaled model of the pressure relief valve as per IS standards
2. Design Analysis of sacrificial energy impact damper, to validate the theoretical stresses and preparation of manufacturing drawings for the impact damper and pressure relief valve.
3. Manufacturing of the pressure relief valve along with the critical components of the system and the test rig to test the impact damper.
4. Test and trial of the impact damper for different simulated conditions of vehicle speed .

2. Concept

2.1 Construction

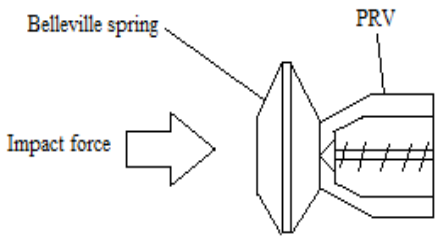

Fig-1: Concept diagram

Above is conceptual diagram of Belleville spring based hydraulic impact damper. Two Belleville spring are joined together on their large ends and seal together. One end is sealed and on the other end, a pressure relief valve is attached and made leak proof. Oil is completely filled inside the spring component.

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Now, when there is collision of vehicle, an impact is occurred on bumper as well as the chassis. As there is no impact absorbing element present, the passenger as well as vehicle has to suffer from the shock.

Our component would be placed between the bumper and chassis. This component will absorb impact and reduce the rate of deceleration, thereby reducing the fatality of accident and damage to the chassis.

The spring will compress because of the impact. The oil inside the spring will come out as the volume inside the spring component will be reduce as the result of compression. The function of pressure relief valve is to keep the oil inside the spring upto a safe impact force. Once the impact force is unsafe (i.e. at higher speed), the PRV will let the oil come out.

2.1.1) Components:

A) Belleville spring:

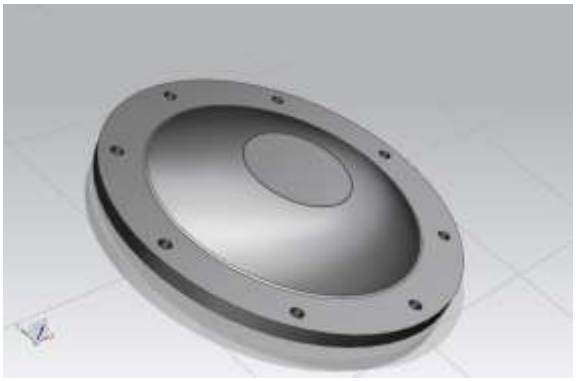

Fig -2: Belleville spring

These springs are circular in shape in Top View, Trapezoidal in side view. This type of spring is used instead of other springs, as is compact and can store oil inside it when 2 springs are joined together. Disc springs have a number of advantageous properties compared to other types of springs.

- Very large loads can be supported with a small installation space,
- High service life under dynamic load if the spring is properly dimensioned,
- Provided the permissible stress is not exceeded, no impermissible relaxation occurs,
- With suitable arrangement, a large damping effect may be achieved,
- Because the springs are of an annular shape, force transmission is absolutely concentric.

B). Pressure relief valve:

PRV mainly used to relief the exceed pressure from the system its mainly in closed position when the system pressure the exceed the safety line its relief the exceed pressure through bypass it to the reservoir to the oil tank.
Component of pressure relief valve .

- valve body
- adjustable screw
- spring
- poppet

- inlet, outlet port to valve body

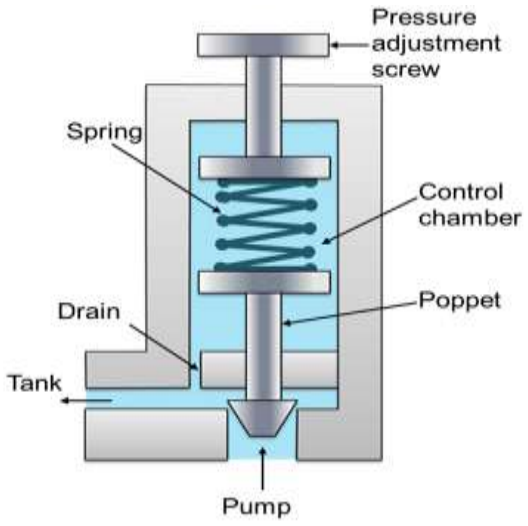

Fig -3: PRV

2.2 Working

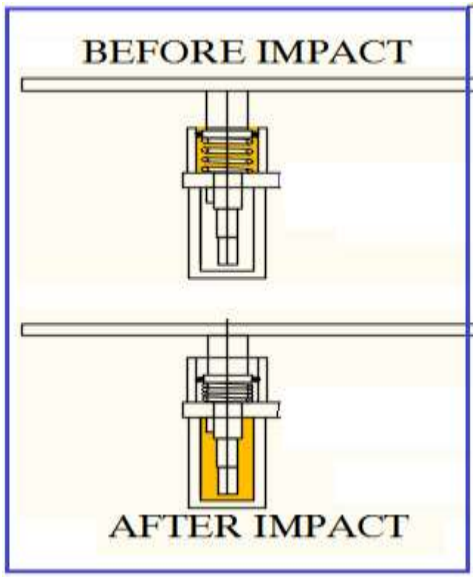

Fig-4: Valve before and after impact

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 action like a 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.

3. Impact Rig

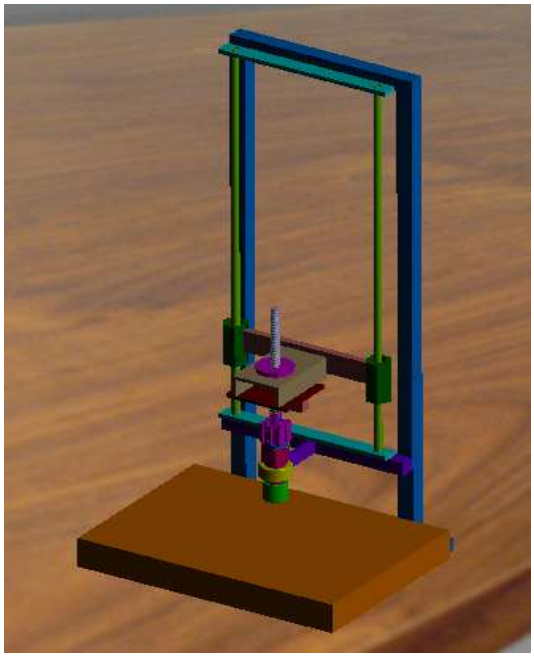

Fig-5: Impact test rig.

The impact test rig will be used to simulate the impact of a collision on the spring. The impact will be done at various speeds, heights, and orientation. Various test results will be achieved and further improvement, modifications, failure reduction, inaccuracies would be discussed.

4. Results

4.1 Test and trial on Composite Belivelli Spring :

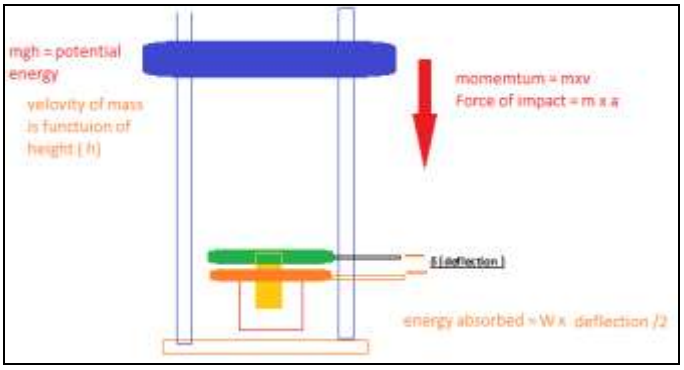

Fig-6: Principle of impact testing rig

Load (kg)	Drop height (m)	Theoretical displacement	Actual displacement	Actual energy absorbed (j)	% Safety
3	0.3	0.6	0.53	7.79895	88.33333

3	0.4	0.8	0.74	10.8891	92.5
3	0.5	1	0.91	13.39065	91
3	0.6	1.2	1.06	15.5979	88.3333
3	0.7	1.4	1.24	18.2466	88.57143

Table -1: Results of testing

4.2 Graphical Representation Of Results.

a. Graph of theoretical deflection Vs Drop ht:

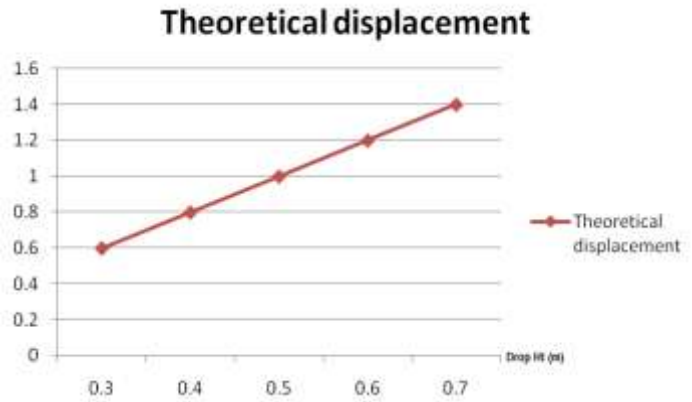

Chart -1: Graph of theoretical deflection Vs Drop ht

The above graph shows that, the deflection of the spring increases with the amount of load on it. Hence it is absorbing more energy with more impact. Thus the spring is utilized on both low and high speeds.

b. Graph of Actual deflection Vs Drop ht:

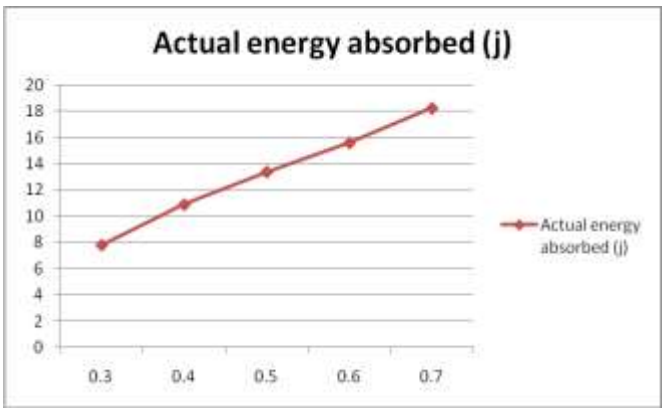

Chart -2: Graph of Actual deflection Vs Drop ht

The graph shows that with increase in load on the spring the energy absorbtion increases hence the spring absorbs energy at various speeds.

c. Comparison of Theoretical and Actual Deflections:

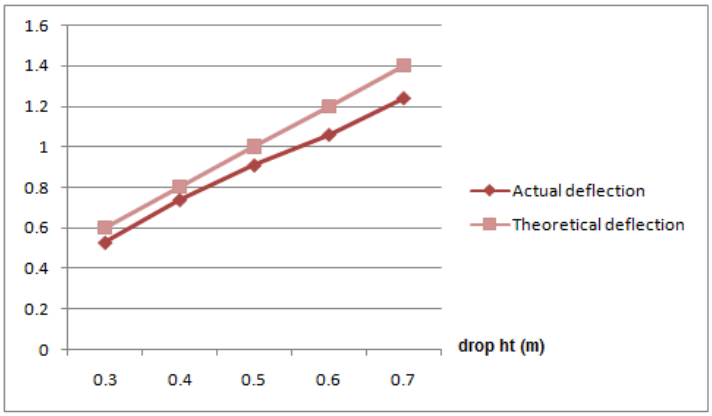

Chart -3: Comparison of Theoretical and Actual Deflections

From the graph above it is clear that the actual damper shows lesser deflection than the theoretical values indicating slight inefficiency of device however this is limited below 10 percent of the theoretical value thereby validating the design of the damper.

d. Graph of energy absorbed Vs drop Ht:

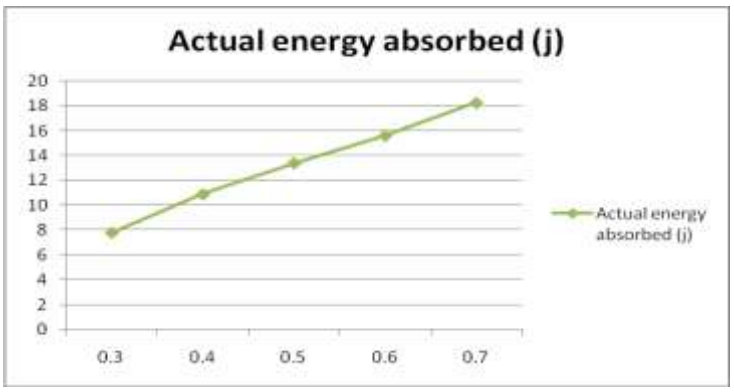

Chart -4: Graph of energy absorbed Vs drop Ht

The graph indicates that the damper absorbs maximum impact energy before cracking pressure is attained. The actual graph shows similar trend as therotical energy absorbed.

e. Graph of Percentage Safety Vs Drop Height:

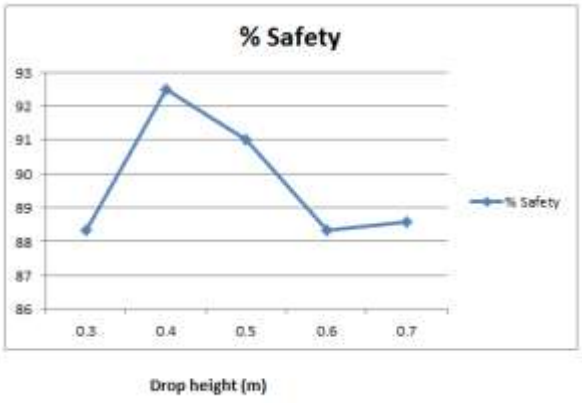

Chart -4: Graph of Percentage Safety Vs Drop Height

The graph of the percentage safety vs the drop height indicates that the maximum safety is of the order of 92 percent when the drop height of 0.4 ...hence the corresponding speed of the vehicle will result into maximum safety when used with the composite damper.

5. CONCLUSION

In this project we provided a solution to a problem regarding vehicular and traffic accidents. We cannot avoid accidents completely but ultimate result of accident we can reduce by applying safety measures, safety instrument. We developed a component which would absorb impact force occurring on the vehicle during the event of an accident. We manufactured a Belleville spring based impact damper along with a pressure relief valve. For testing purposes we also manufactured an impact test rig. After testing and analysis of component, we found out the magnitude of absorbed impact at various heights, safety of the component at various loads, amount of deflection of the component, etc. thus ultimately indicating that this component would reduce fatality of accidents, reduce cost of damage and save lives.

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