Design and Development of Variable overhang chassis mechanism

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Abstract

This mechanism is designed in such some way that the vehicle can have safe, simple and stable mobility even at the higher speeds. To confirm that the overhang is safe and secure while expansion and retraction positions. This mechanism will be powered by hydraulics and electronics by functionality. As this mechanism only be used for electric vehicles, it brings a modern approach for utilizing the massive existing space in the electric vehicle and proving additional safety to the vehicle. This concept of the variable overhang mechanism also provides a new approach in designing the vehicle of future as the frontal crumple zone will be expanded and retracted in accordance to the speed variation. This system will be acting as an active safety system providing different configurations in adjustment to the road conditions and speed variations. Among the major road crashes which occurs in our day to day lives, most of those crashes are notes as head on collision. The current safety systems such as seatbelts and airbags perform a good job in safeguarding a person from upcoming injuries but despite of them we still require an additional system which will further improve the current safety conditions. This design will function by variable overhang mechanism which will further be helpful in crash reduction and will support vehicle as an added safety. In addition to this, it will support vehicle as a safety component by the introduction of honeycomb bumper, which will further sustain the impact and would be a great tool of utility. The honeycomb bumper will help sustaining the initial impact of the vehicle over crashes. This will result in drastic impact reduction at cabin area and improvising the safety conditions for the vehicle and certainly limit the impact transfer to the passenger cabin area. This safety feature will work on the principle of crumple zone, where the front mechanism of the vehicle will act as the frontal crumple zone to the vehicle by its self-breakdown tendency.

Keywords: Variable Overhang, Bumper, Extension mechanism, Chassis, Simulink
1. Introduction

In this work, we have aimed to design an active safety system, which will help reduce damage in the cabin area. As most of the collision that occurs are noted head-on collision which are roughly 70% and those incidents cause serious injuries to the passengers by transmitting the impact to the cabin area due to lack of active safety mechanisms. The current safety systems such as seatbelt and airbags are good at protecting the passenger from unintended incidents but still constitutes in severe fatalities therefore we still require a system which acts as an added advantage to the overall safety components and provides further stability and safety. Hence, this mechanism is designed in such a way to help reducing damage in chassis and cabin area by extending the frontal crumple zone in accordance to the speed variation and the honeycomb bumper sustains the initial impact of the collision. [6] This Study describes the design and evaluation of crumple zone using for front-end module of an automobile that can absorb the impact of collision with any pedestrian. A 1D-spring element model was used to design a plastic crumple zone. Analysis and Performance of the design was tested with upper leg form to bonnet leading edge test conducted under European New Car Assessment Program test condition.[2] This study proposes a new bumper model, which has more crashworthiness than previous exiting bumper. Due to lack of proper safety system each year rate of automobile accidents are increasing. A Toyota Camry 2012 model was chosen as the test subject. Two new bumper model designs were proposed, one of them contains aluminium foam material inside the bumper and the other one has steel honeycomb structure inside the existing bumper. The exiting bumper model has is made of steel. Design and analysis in this work are done by using software’s like PTC Creo, Hypermesh and LS-Dyna.7 All the crash tests were executed in software environment. According to results, in the honeycomb model 11.26% energy absorption capacity increases compared to the existing steel bumper and in the aluminium foam bumper the increased energy absorption capacity is 6% compared to existing steel bumper. [8] The purpose of this investigation is to use an integrate vehicle dynamics control system to increase accidents in the event of a full frontal collision of the vehicle with an obstacle using an expandable bumper. This paper includes the development and analysis of new vehicle dynamic mathematical models and multibody occupant mathematical models. The first model combines the vehicle dynamics model with the front end structure of the vehicle to define the vehicle body collision dynamics parameters of the vehicle. The second model captures the dynamics of survival during a complete collision. [5] From this review it is observed that the chassis is the internal framework of the car that supports complete vehicle, it serves as the basic foundation of vehicle which gives strength and all part of the machine rest on it. Chassis is a prominent structure for a body, which absorbs the loads during serious accidents, costly recalls; this also has a great impact on product image. If the chassis fails, the entire vehicle system will crash and cannot be easily replaced. The chassis structure safely supports the weight of the vehicle components and transmits the load due to the longitudinal, lateral and vertical accelerations, which is experienced in the racing environment without failure. Meshing and analysis is done on HYPERMESH and ANSYS respectively. As part of the conclusion, after careful analysis of the various studies conducted so far, it was found that the research on the variable segment concept and the trailer chassis was
insufficient also, there is need to research for the base material for the load variation. Various alternate materials like carbon fibre, aluminium alloy and titanium have been studied and compared with mild steel. [9]Modelling and simulation of hydraulic control systems is necessary in order to acknowledge the advantages and drawbacks before starting a design of a system. By acknowledging, the inconsistency between the model of a physical system and a system in a virtual environment, engineers will be able to handle the optimization and it will help save time and money. FluidSim is comprehensive software used for simulation of fluid control systems; it is mostly fitted for use in educational purposes. Hydraulic systems are used where there is a demand for high power and fast response. Such demands include hydraulic industrial mobile machinery, aerospace hydraulics, wind turbines, etc. Here, the mathematical model of a system is compared with model designed by block diagrams in FESTO FluidSim, this is used to simulate fluid power system’s behaviour such as hydraulic or pneumatic system. Results obtained from modelling in FluidSim show differences compared to the general mathematical representation of a hydraulic system.

2. Method of investigation

It is a mechanism which will extends its length from front overhang of chassis according to speed using hydraulic cylinders, the extended part is designed in such a way that there is minimal transition of forced impact to the cabin or passenger area. The extended part acts as a subsidiary system fitted to the frontal part of the chassis. Keeping in mind the future trend of electric vehicles, this work is only appropriate for the modern electric vehicles by optimizing the space it provides for the fitment of the mechanism and thus could not be carried in the conventional gasoline vehicles. The platform is designed in such a way that it can exclusively be used in electric vehicles having the rear end electrically power drive train system. The hydraulic cylinders will be placed inside the front part of chassis. This design of bumper includes a honeycomb structure material inside the bumper to provide extra strength and rigidity to design in order absorb collision force, using these bumpers amount of force transferring further towards chassis will reduce. Honeycomb structure is mainly supported by hydraulic cylinder that will be responsible for movement of the bumper. This system will be using two hydraulic cylinders on each side fixed to move arm of the bumper. A 4/3 solenoid operated double acting DCV, it is used to operate hydraulic cylinders. These cylinders have capacity to withstand high amount of load and pressure. Cylinders being used have Bore diameter – 105mm, Rod diameter – 40mm, Stroke length – 200mm, which makes them to withstand large amount of pressure. Hydraulic cylinder is also attached with a flow control valve at the backend of the cylinder to stop back pressure occurred due to high impact force. The DCV has a closed center for speed variations and withstanding high pressure. Since, this mechanism is aimed to be developed for an electric car, this mechanism will be fully automatic and is operated by ECU.
3. Proof of concept

Every year in India, about 3,47,000 road crashes take place, 7 out of 10 of those road crashes occur to be head on collision. As major percentage of the incidents are head on collision, the inspiration for this work becomes the reduction of head on collision crashes in the maximum form possible by influencing certain factors which could therefore satisfy the needs required to save the vehicle from unintended incidents. The major impacts are sustained by three phases as mentioned below.

3.1. Honeycomb bumper

The Bumper we designed for the generic electric chassis is the initial component which experiences impact during the collision thus it constitutes in the provision of added safety by proving structural rigidity and sustaining greater impact than a normal bumper which is attached to the chassis.

3.2. Extension Mechanism

The extended part acts as a subsidiary system fitted to the frontal part of the chassis where the hydraulic cylinders will be placed. This mechanism will be electronically controlled by the micro controller and circuit.

3.3. Crumple Zone

The entire mechanism will act as an crumple zone to the vehicle and the structure material inside the bumper to provide extra strength and rigidity to design in order absorb collision force, using these bumpers amount of force transferring further towards chassis will reduce.

4. Design

The approach and the need to make CAD drawing and design is to make an idea representation on software to understand the impact and further process of analysis to make sure that it withstands the design intellect and parameter. The process was to completely design and develop the chassis with different extensions so that finite element analysis can tell the details about them failure point and structures well as velocity impact on different sections. Initially the planning has to be clear and the major discussion must be on dimensional geometry and section design with the material selection to be next. The proper process must be followed to execute the required CAD design and simulation with precision and similar as expected.

The Finite component Analysis (FEA) is that the simulation of any given natural phenomenon victimization the numerical technique known as Finite component methodology (FEM). Engineers use it to cut back the amount of physical prototypes and experiments and optimize
parts in their style section to develop higher product, faster. It is necessary to use arithmetic to comprehensively perceive and quantify any physical phenomena like structural or fluid behavior thermal transport, wave propagation, the expansion of biological cells, etc. Most of those processes delineated victimization Partial Differential Equations (PDEs). However, for a pc to resolve these PDEs, numerical techniques are developed over the previous few decades and one amongst the distinguished ones, today, is that the Finite component Analysis.

![Image of finite element analysis of honeycomb bumper](image)

**Figure 1. Finite element analysis of honeycomb bumper**

4.1 *Hydraulic system*

Hydraulic systems are used where there is a demand for high power and fast response. This system is used in various machineries, aerospace hydraulics, wind turbines, etc. In this system, hydraulic system is modelled and simulated, which can be used in applications such as hydraulic press, excavator actuation for bucket, elevator system, etc. The hydraulic circuit uses a solenoid valve, actuator, pump, PRV and tank. This system is designed in FESTO FluidSim, which is used to simulate fluid power system behavior of hydraulic and pneumatic systems.
Figure 2. Hydraulic Circuit

Figure 3. Working of extension mechanism Top View
Figure 4. Bumper arm

Figure 5. Hydraulic cylinder setup
5. Simulation

The Simulink model of hydraulic circuit shown in figure 7 consists of a variable displacement pump attached to 4/3 solenoid valve, hydraulic fluid flows from tank connected below pump, pressure relief valve is connected to maintain pressure and to avoid excess flow of fluid. Movement of spool is controlled by Simulink PS converter. The valve is connected to hydraulic cylinder. One end of cylinder attached to mechanical reference to restrict its motion, other end is connected to Translational Spring and Translational Damper. These spring and damper are attached to simulate the mechanism in realistic conditions, since our mechanism has dampers attached in the extended part. This model was then run to check the results using the simulation parameters listed in table 1.

| Quantity          | Symbol | Value | Unit   |
|-------------------|--------|-------|--------|
| Pump Displacement | DP     | 0.0016| Cm<sup>3</sup>/rev |
| Angular Velocity  | ωP     | 3000  | rev/min |
| Pump Pressure     | P      | 30    | MPa    |
| Piston Diameter   | dP     | 60    | mm     |
| Piston Rod Diameter | dPR    | 35    | mm     |
| Stroke Length     | L      | 200   | Mm     |

Table 1 Simulation Parameter
6. Results and Discussion

The FEA were executed in the ANSYS of a honeycomb structure embedded on the front overhang in comparison with the honeycomb and without honeycomb overhang to understand the strength capabilities of honeycomb and how it can play a vital role during the time of collision. This given the direction of brief behaviour of crush and the force propagation during time in the sections. This validated our theories and the system behaved in the particular manner as planned it to be which made it strong about the aspects of approach. The reports were obtained regarding the FEA of different modal and dynamic analysis with the frequency of stress and strains induction as well as the safest and most dangerous part of the chassis. Then also got the data of the propagation of crack in the mechanism and cross section of chassis with the dynamic load feature, this reports also includes the factor of safety and its variation with the increase in strain and property behaviour of the particular section and material. The same data were obtained for the honeycomb overhang in comparison with the non-honeycomb structure and easily we can identify the safety increment in the honeycomb structure. The inside material in the cover or shell of the bumper cover is generally industrial foam, which can be replaced by the other strong materials like honeycomb flakes or micro dampeners etc. The ANSYS test result for the total deformation of the chassis is shown in Figure 8.

Figure 7. Simulink Model
A MATLAB model is created using the Simulink technology which states the function and equation variation of the work mechanism ideally. This states that the timing between the circuits and sensors to be uniform and case dependent as it was presented above. The code was programmed as such that it responds to the situation hazard or scenario as soon as possible and contributes towards the safety of the passenger cabin area. The response of the Double acting cylinder, translation damper and translational spring are shown in the following Figures.
Figure 10. Response of the Translational Damper

Figure 11. Response of the Translational Spring
6. Conclusions

The design of overhang mechanism and its extension is quite of a complex work and the approach we used to execute this by making a cad model of chassis with the overhang part and analyzing it with FEA with different speed and different extensions. The first and foremost step we took to design a chassis on a paper which made us look into the lot of considerations of IS standard of chassis metal and the sections which we selected was also to complement the dimensions of other sections. We settled on the steel alloy IS 4923 YST 310 and also with the I-section of IS 2049 BR250 and it was the most suitable structure available for the task. We used the software solidworks 2017 and started making the different sections on the particular plane. Usually started with the single line of outline chassis and then planted the section on it. Executed the extrusion on the particular section according to the main line. Divided the chassis into 6 parts of construction to avoid any type of dimensional errors and equidistant from the points of reference. I section was made separately for the chassis and then it was assembled on the main frame. This made our chassis have a metallic structure completed by far with the required dimension. We then started with the overhang mechanism. The approach was to insert the overhang mechanism into front member of the chassis to make it easy for to and fro motion of direction. What we had to make the overhang mechanism to execute according to the decide direction. We completed our main frame part with this insertion of overhang and it was made separately and then got assembled with the main frame to avoid any difficulty of fixation.

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