Design and development of hybrid chassis for two wheeler motorcycle

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Abstract
The primary objective of this work is to design and develop a hybrid chassis for a two-wheeler motorcycle. Perimeter and Trellis are the most commonly used chassis types in motorcycles. Designing a new hybrid chassis of a two-wheeler for better high-speed stability and agility. Trellis frame is meant for good stiffness and rigidity, which is required for track scenarios, trellis frame consists of metal tubes arranged in triangulated reinforcements, these triangulated trusses eliminate additional resonance frequencies. While a Perimeter frame has a bit of flex and are compact in nature which is used for road-going scenarios. However, chassis stiffness is the most fascinating area of chassis design, as it reduces the overall vibrations induced in a frame which helps in having multiple ways to mount the engine depending on the resonance factors. Engineers want the frame and ancillaries to offer excellent longitudinal stiffness, so the bike stays straight and stable while pulling 1.5g during braking, and they also want enough stiffness so the bike reacts to rider steering inputs. By combining both the parameters and characteristics of perimeter and trellis frame, vibrations can be reduced and both stability and agility are achieved.

Keywords: Analysis, Frame, Triangulated trusses, Hybrid chassis,

1. Introduction

Etman et al. explained it is a core structure that supports all other sub-assemblies such as steering unit, front forks, engine, and rear swing arm unit and suspension pivot point. The engine sits inside chassis so that it provides protection to the engine and prevents major damage to the chassis.[1] The front forks are attached to the steering head of the frame. Mihailidis et al described the swing arm is attached to the pivot point and bolted with shock absorber, to which wheels are attached. Various functions of chassis are: It should provide good structural support to the chassis, and hold components firmly, nothing should ever break under normal conditions. Suspension mounting points need to be proper, so that the handling is safe and at higher speeds and bump loads it is consistent to provide support for the rider and pillion components and has long reliability. [2] To provide good alignment to the wheels in single straight-line Chassis design is mainly based on three aspects, they are rider, engine, and suspension. A rider is the largest lump mass on the chassis, proper ergonomics need to be provided. Suhane et al stated engine occupies more space in chassis since it is fixed in its position, the engine should be placed properly so that the weight distribution is accurate. Suspension mounting points are always fixed, proper suspension geometry needs to be provided. A good design of chassis considers these aspects in a more efficient way. Aluminum and mild steel are the most commonly used materials for the fabrication of chassis, even...
though aluminum chassis is lighter when compared to mild steel chassis, the stiffness to weight ratio is almost the same.\[3\] The frame of a two-wheeler chassis is a structure, or in other words a skeleton upon which parts like gear box and engine are mounted.

Yu et al explained the frame is an automotive which carries the load on the vehicle. For a frame to resist shock, vibration, twist and other stresses, it has to be strong so that it does not fracture easily. It manifests that frame should have high ultimate tensile strength. A frame is basically a support for the suspension system, springs and shock absorbers which as a result helps in keeping the wheels in contact with the road and buffers the rider from bumps and jerks.\[4\] Therefore, chassis is considered as the most important part of a vehicle which holds all the parts and components together. Chassis is a core structure that supports all other sub-assemblies such as steering unit, front forks, engine, and rear swing arm unit and suspension pivot point in any automobile. The engine sits inside chassis so that it provides protection to the engine and prevents major damage to the chassis. The front forks are attached to the steering head of the frame.\[5\] The swing arm is attached to the pivot point and bolted with shock absorber, to which wheels are attached. Various functions of chassis are: It should provide good structural support to the chassis, and hold components firmly, nothing should ever break under normal conditions. Suspension mounting points need to be proper, so that the handling is safe and at higher speeds and bump loads it is consistent to provide support for the rider and pillion components and has long reliability. To provide good alignment to the wheels in single straight-line Chassis design is mainly based on three aspects, they are rider, engine, and suspension.\[6\] A rider is the largest lump mass on the chassis, proper ergonomics need to be provided. Engine occupies more space in chassis since it is fixed in its position, the engine should be placed properly so that the weight distribution is accurate. Suspension mounting points are always fixed, proper suspension geometry needs to be provided. A good design of chassis considers these aspects in a more efficient way. Aluminum and mild steel are the most commonly used materials for the fabrication of chassis, even though aluminum chassis is lighter when compared to mild steel chassis, the stiffness to weight ratio is almost the same explained by Krishnan et al. \[7\]

2. Design of a chassis model

The main geometric considerations are to achieve a high-performance chassis that is comprised of both advantageous factors of a typical trellis frame and a perimeter frame type chassis. Features such as light weight nature and high stiffness factor of the trellis frame gives the bike more straight-line speed while the perimeter frame is more compact making the wheel base shorter and also has a slight flex which helps in high speed cornering. By combining both the parameters and characteristics of these chassis, both stability and agility are achieved. The center of gravity is a point in a body or system around which the systems mass or weight is acted upon by the gravitational force.\[8\] The lower the center of gravity the more stability is achieved. Wheelbase is the distance between the centers of the axes of rotation the front and rear wheels. The longer the wheel base the straight-line speed increases. But the shorter wheelbase helps with cornering stability. The main purpose of a trail is to increase the amount of steering stability and also reduce the turning radius if the vehicle this also helps in better lean-in position of the rider during cornering. Rake angle is the angle of the front forks with
with respect to the vertical axis from drawn perpendicular from the ground. The rake angle is indirectly proportional to the steering angle and turning radius.

3. Static structural analysis

Structural Analysis is a type of Finite Element Analysis. A static analysis calculates the effects of steady loads and forces a structure. Static analysis includes steady inertia loads and time-varying loads that can be approximated to equivalent loads in a static condition. Static analysis comprises the strains, stresses, forces and displacements in structures or components caused by load. \[9\]

The types of loads that are be applied in a static analysis comprise of Externally applied forces and pressures Steady-state inertial forces which include forces such as gravity or rotational velocity. Imposed nonzero displacements, Temperatures for thermal strain. Given chassis is imported to the Ansys software for structural analysis. The step format solid model is opened in Ansys and material is specified as AISI 1030. Few calculations need to be made for further analysis, such as rider and engine weight. Rider weight = 100 kg.

Force acting on the saddle pipes = 100*9.81 = 981 N Engine weight is action on six mounting points. Engine weight = 40 kg Force acting on the mounts = 40*6*9.81 = 2354.5 N. The force acting on the saddle pipes is of 1000 N approximately. The force acting on the mounts are 2400 N, at each mount the force applied is approximately 400 N.

![Figure 1: Equivalent stress plot](image)

4. Design of perimeter frame

Given chassis is imported to the Ansys software for structural analysis. The step format solid model is opened in Ansys and material is specified as AISI 1030. Few calculations need to be made for further analysis, such as rider and engine weight. Rider weight = 100 kg, Force acting on the saddle pipes = 100*9.81 = 981 N Engine weight is action on six mounting points. Engine weight = 40 kg. Force acting on the mounts = 40*6*9.81 = 2354.5 N. The force acting on the saddle pipes is of 1000 N approximately. The force acting on the mounts are 2400 N, at each mount the force applied is approximately 400 N. By selecting the saddle pipes of the chassis.
load of 1000N will be applied and by selecting the mounting points load of 2400 N is applied on the mounts.

![Figure 2: Equivalent stress plot](image)

### 4. Design and analysis of hybrid chassis

Given chassis is imported to the Ansys software for structural analysis. The step format solid model is opened in Ansys and material is specified as AISI 1030. Few calculations need to be made for further analysis, such as rider and engine weight. Rider weight = 100 kg. Force acting on the saddle pipes = 100*9.81 = 981 N Engine weight is action on six mounting points. Engine weight = 40 kg. Force acting on the mounts = 40*6*9.81= 2354.5 N. The force acting on the saddle pipes is of 1000 N approximately. The force acting on the mounts are 2400 N, at each mount the force applied is approximately 400 N. By selecting the saddle pipes of the chassis load of 100N will be applied and by selecting the mounting points load of 2400N is applied on the mounts.

### 5. Results and Discussion

As basic standards of safety have to be met keeping this is in mind, we estimated the restricting force potentially offered by the seat-belt and in our case the length of the seat belt was approximately 1.5 feet and offered decent protection. Using simple Newton mechanics, the force was roughly around fourteen thousand kilo newtons. Another challenge in his calculation is that there is no clearly established method to estimated lateral impact and how it might affect the design and safety of the passenger during roll over or topple. Thus, we had to make a choice between the entire shaft column being elastic or incorporating a separate elastic member to absorb force there by making the shaft lighter and cheaper in terms of choice of materials.
thereby circling back to the main aim of our work which is affordability and safety at a reasonable cost.

The first alpha product or design was developed only keeping this in mind with a rigid shaft in place and not much to offer. The design was further improvised to be a 2-piece setup with an outer and an inner shaft both concatenated to each other and interconnected by means of a cuboid shaped spline. The design was supported by means of an elastic member which primarily represents a DNA strand, the whole logic was to offer support in both directions of the principle axis with respect to force. This did not prove to be an effective design as the shaft simply slides into the secondary shaft even when the slightest amount of force acted on it. Adding further problems was the fact that the turns of pattern could not simply make the cut to take on the load.

![Figure 3: Equivalent stress plot](image)

Realizing all the problems at hand we reworked on the design of the shaft now we too inspiration from an actual collapsible rod, we did obtain the overall length and with the help of trial and error method we did a lot of changes to the outer and inner diameter and length. After finalizing on a base prototype, we moved on to add a balance component to the shaft portion. Then we spline the shafts by taking inspiration from tensile ring concept, this led us to develop a steering shaft which had a torque transmission capability of around 69 newtons whereas we had to at best transmit only 56 newtons. Following this our next key goal was to develop an elastic member preferably a member which had close connections to a spring type structure as a spring back effect in the event of offloading or extremely minor bumps is convenient. So, based on these conditions we moved on to choose a helix pattern as the primary load bearing member. Now the development of the helix pattern had only one goal been to with
14KN, for this we had to use simple mathematical formulas and manipulate the number of turns until we achieve a configuration which can support more than 14KN.

5. Conclusion

The Designing and analysis of the different types of bike chassis were done using the solid works 2018 software with an objective to prove that a hybrid chassis (a combination of both perimeter and trellis frame) has combined effects of the two frames in order to have a good balance in both straight line stability and cornering agility and sharpness. As these frames are analyzed for their structural integrity in the ansys 19.2 software Stress, strain and displacement values as result for given load condition for each chassis are noted and tabulated for comparison. In the above comparison of results, we can see that the von mises stresses of the hybrid chassis as a result if applied load conditions proved to be higher than that of a trellis and lower than the perimeter frame giving us a positive result regarding the straight-line stability of the chassis. The strain being higher than trellis frame compared to the other two gives a small hit of less flex factor which helps in cornering agility, sharpness and flick ability of the chassis at high speeds. From the results of the table we conclude that the HYBRID chassis are more efficient and effective than conventional trellis and perimeter frames for both motor-sports as well as conventional production designs.

This breakthrough for us was attained at approximately 6 turns and we finalized the configuration by varying it through assimilated load simulation and analysis. Now the last key part of the work is getting the assembled view of the setup this was achieved using solid-works. The assembled view was subjected to a load analysis using a simulation software in our case ANSYS. The entire assembly experienced a deformation of 110mm and breakage points were obtained. Thus overall, I would like to conclude by saying that collapsible steering system should be incorporated as compulsory passive safety system in all cars as with the growing population of cars on road a greater number of accidents are prone to happen and by incorporating a simple design such as our many lives can be saved.

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