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Optimization of Two-Wheeler Chassis for Weight Reduction

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ABSTRACT

A two wheeler frame consists of various components which provide stiffness to vehicle. The strength of vehicle depends on components used, considering road conditions. Now a days two types of frames namely square and tubular are mostly used. Objective of this paper is to focus on vehicle frame model to analyse destructive testing methodologies. This paper is useful to study analysis of motorcycle frame. Different motorcycles need different types of frames. The motorcycle frames are categorized depending upon their construction and application. Various performance parameters of a motorcycle need different frame designs. The frame is an important part in a Two Wheeler and it carries the load acting on the vehicle. So it must be strong enough to resist the shock, twist, vibration and other stresses. In vehicle frame different types of failure occur due to static and dynamic loading conditions. Natural frequency, damping and mode shapes are the inherent structural properties and can be found out by experimental modal analysis. The engine is mounted with a high degree of rigidity, and results in a well-balanced chassis that delivers a ride with responsive handling and great stability.

Keywords: Chassis, Motorcycle, Modelling, Better Handling.

1. INTRODUCTION

In this paper whole problem related with motor cycle frame with their constraints. Due to increased competition in market the manufacturers are facing more problems for their survival mostly in automotive sector they have to face problems like manufacturing light weight bodies and more stiffness etc. To increase vehicle capacities like speed, loading capacity, mileage, grade ability of vehicle. It is necessary to concentrate on weight and size of systems and components of which vehicle is made. Therefore it is considered as the most valuable element of a vehicle as it holds all the components and part together. The strength of vehicle frame varies according to material used. It is necessary that the frame should be not buckle due to varying road conditions such as uneven road surfaces and that any distortions which may be produced should not be transmitted to the body. As commonly used frame materials steel and carbon epoxy shows different strength results. As optimization process involves preparation of cad model of the existing component which can be done with the help of 3D modelling software's like CATIA VS, Pro-E, and Solidworks. And the analysis of this model can be done with the help of software like ANSYS which help in calculating maximum stress and displacement values of the model. In this paper, more focus on vehicle frame is discussed as the framework of vehicle is main structure on which various subassemblies are bolted which further protects main parts of vehicle. Due to complexity, cost, weight distribution, speed, stiffness, Power output may be different for different vehicles there is no perfectly ideal frame design. This paper deals with design of two-wheeler chassis frame and its weight optimization. Various loading conditions like static and dynamic loadings will be carry out on the chassis and the structural stability of the chassis will be analyse by using alternate material while maintaining the strength. The various materials will be study and the best material will be selected as the solution.

1.1 Automobile chassis :

The frame consists mostly of hollow tubes and serves as a skeleton on which components like the gear box and engine are mounted .Suspension The frame also serves as a support for the suspension system, a collection of

springs and shock absorbers that helps keep the wheels in contact with the road and cushions the rider from bumps and jolts. Wheels Motorcycle wheels are generally aluminium or steel rims with spokes, although some models introduced since the 1970s offer cast wheels. Cast wheels allow the bikes to use tubeless tires, which, unlike traditional pneumatic tires, don't have an inner tube to hold the compressed air .Brakes The front and rear wheels on a motorcycle each have a brake. The rider activates the front brake with a hand lever on the right grip, the rear brake with the right foot pedal.

1.2 Chassis for two wheeler

What forms a very important aspect of a motorcycle frame's cost and its capability is the material that it's made of. Traditionally, and even today , for budget oriented motorcycles , frames are made of steel tubes, and are bent or welded together to suit a specific chassis requirement. While steel is cost- effective, reasonably strong and very suitable for motorcycles with low to moderate performance requirements , modem motorcycles require their chassis to be stiffer, more lightweight and look better than what traditional steel tubes could offer modem motorcycles , thus, make use of materials such as aluminium and alloys to achieve the target.

2. Design consideration

While designing a frame for two-wheeler type of frame structure for required should be specified first. Available type of motorcycle frames in practice is as follows:

2.1 Frame Design

1. Spline Or Backbone:

This frame allows flexibility to system as single wide beam used to mount engine on it. It acts as a core structure.

Fig.1 *Spline Or Backbone*

2. Single cradle frame:

It have smaller diameter steel tube, these tube surrounds engine with main tube on top and base. At exhaust double cradle frame is used mostly used in off-road motor vehicles. A single cradle frame, also known as single downtube or diamond frame, is most commonly used on budget-friendly motorcycles. It mimics the look of a bicycle chassis. Here, the frame acts as a bed for the engine with two tubes connecting the steering head or yoke.

- Advantages- It is a cost-effective and good choice for low power vehicles.
- Disadvantages- Cannot be used in performance-based products, for reasons similar to the backbone frame.

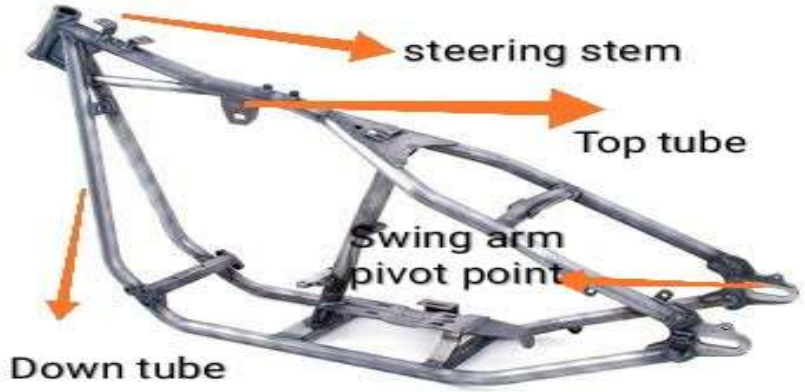

Fig.2 *single cradle frame*

3. Double cradle frame:

It uses two cradles on each side of engine, these are used in simple and custom motorcycles similar to perimeter frames. This is very similar to the single cradle frame and the only difference lies in the engine support. In the single cradle frame, one steel tube goes underneath the engine and supports it whereas in a double-cradle frame the engine is supported by two tubes, Thus providing better strength and structural rigidity.

- Advantages- This frame is better than the other basic frames and is the strikes the best balance between quality and cost in a price-conscious market.
- Disadvantages- The design is kind of old and outdated and cannot be relied on for a performance-specific product and other higher-cost offerings.

Fig.3 *Double Cradle Frame*

4. Perimeter frame

The perimeter frame or the twin-spar frame is the popular choice when it comes to performance-based motorcycles. Research, based on motorcycle racing found out that there is a noticeable increase in rigidity when the steering hand is connected to swing arm in the shortest possible distance. The rods connecting these should be adequately stiff and results improve with a decrease in weight. Two beams (twin spars) reaching out to the pivot arm surround the engine and that's where the name twin-spar frame comes from. Earlier these spars were made of steel but lightweight aluminium took its place in the modern world.

- Advantages- This is the most popular choice for performance-based motorcycles.
- Disadvantages- There have been complaints of reduced power in some motorcycles using the perimeter frame when compared to the trellis frame.

Fig.4 *Perimeter Frame*

5. Trellis Frame:

Frame is made up of large number of short steel and aluminium tubes welded together to form series of triangle these frame are very stiff. The trellis frameworks on the same principle as the perimeter frame. The primary objective is to connect the steering bar to the swingarm. The difference lies in the way the connectors are constructed. In the trellis frame, steel or aluminium tubes are welded together to form a trellis-like structure.

- Advantages- The trellis frame is lighter and easier to construct and it aces the lightweight construction.
- Disadvantages- It is the best among a huge class of motorcycles, but for most extreme cases, monocoque frame takes the lead.

Fig.5 *Trellis Frame*

6. Monocoque frame

Similar to perimeter frame, monocoque frame has a structure where load are supported by external mountings. The manufacturing of the monocoque frame is the most capital intensive and it needs top-notch robotisation for production. It is not just a viable option for a lot of bike makers out there. This process is employed for the rarest products which come with extremely high power figures. The entire structure, in this case, is a super stiff, single piece with the stiffest and lightest manufacturing materials like carbon fibre and magnesium.

- Advantages- This is made by using the most sophisticated technology out there to bring out the best according to needs.
- Disadvantages- These are too expensive to be viable for a large market proportion.

Fig.6 *Monocoque frame*

2.2 Materials used

1. Materials plays vital role in frame design, the chemical composition of various elements in existing conventional suspension frame steel (AISI 1086 I SAE 1086) is as below.
2. Four material composites e.g. Steel, Aluminium, compound (A360), Magnesium and Carbon fibre, Strengthen polymer can be used.
3. Programming can utilize work piece in NX-CAD for displaying which can be analysed by ANSYS.

3. Problems and Methodology

Material selection among suitable materials is necessary also as per convenient use of vehicle proper selection of frame design is necessary. Following methodology can be used to do so.

1. Reverse engineering can be done to select dimensions. NX-CAD or Pro-E can be used for design modifications. Static or modal analysis can be done to extract results as for maximum stress and maximum deflection.
2. Predetermining 3D model frame by previous design in NX-CAD software. 3D model of frame is then converted into Para solid file. This Para solid file can be imported to ANSYS to carry out test analysis. Static analysis on framework can give deflection and stresses for different materials. Finite elemental method for two wheeler frame chassis.
3. ANSYS software is used for FEA in which division of complex system in elements are to be done. These elements are further useful for behavioural analysis.
4. While designing frame chassis it is necessary to understand forces and point of application of forces on frame.
5. Calculated forces can be converted to G-force by dividing with weight of vehicle.

3.1 Various forces acting on a frame

1. Downward Weight: This weight includes weight of power train, accessories as well as rider's weight.
2. Bump force: due to ground disturbance bump
3. Force is exerted on frame.
4. Side force: Also known as lateral force which is produced vehicle turning at comers.
5. That force is to be considered equivalent to centrifugal force produced by turning.
6. Brake force: It is the product of pressure at
7. Fluid line with total calliper piston area & coeff. Of friction in between brake pad & brake disc. Usually generated by front of steering.
8. Longitudinal forces: These forces are
9. Produced due to moment of inertia of vehicle.
10 Impact forces: when the vehicle is subjected to collision with obstacle then force should be distributed along frame structure to avoid deformation.

3.2 Limitations

1. Assumptions regarding hypothetical forces.

2. If modifications are to be done in frame structure then cost of manufacture may get higher. It can be seen that the future scope for weight reduction by reducing frame weight can be implemented.

4. Conclusion

It is concluded that, the analysis done on two wheeler chassis frame for different materials shows significant force differences; while modifying the chassis considering weight reduction will lead to increase fuel efficiency. It is more suitable to use carbon epoxy material for two wheeler chassis frame as it seen to be safe for static and shocks load. Geometrical parameters tends to change dynamics on vehicle, Tubular frame structure shows more deformation and stresses as compare to beam frame during acceleration but shows contradiction during braking operation. To reduce vehicles weight it is more suitable to use carbon epoxy with rectangular cross section in suspension frame.

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