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# Design Evaluation and Optimization of a Two Wheeler Front Frame Technology

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**ABSTRACT:** The two-wheeler chassis consists of the frame, suspension, wheels and brakes. The chassis is what truly sets the overall style of the two-wheeler. Automotive chassis is the main carriage systems of a vehicle. The frame serves as a skeleton upon which parts like gearbox and engine are mounted. It can be made of steel, aluminum or an alloy. It keeps the wheels in line to maintain the handling of the two-wheeler.

The frame of a motor vehicle supports all the drive assemblies, i.e. the engine, gearbox and axles (front and rear). In addition the suspension and steering systems and the shock absorbers are attached to it. The appropriate body is fixed to the chassis. It is essential that the frame should not buckle on uneven road surfaces and that any distortions which may occur should not be transmitted to the body. The frame must therefore be torsion-resistant. The frame of a motor vehicle is the load bearing part of the chassis which supports all forces (wheel forces) and weights. It should be as rigid as possible.

## I INTRODUCTION

### 1.1 Motorcycle Chassis

The motorcycle chassis mainly consists of the following components. They are Frame, Suspension, Wheels & Brakes etc.

#### **Frame**

Motorcycles frame generally made of steel, Aluminum or its alloy and consists of hollow tubes. The main components of motor cycle like engine, gear box are mounted on the frame and also it keeps the wheels inline to maintain the handling of motor cycle.

#### **Suspension**

The frame also serves as a support for suspension system, a collection of shock absorbers & springs that helps keep the wheel in contact with road & cushion the rider from bumps & jolts. For rear suspension system swing arm design is the most common solution. One end of the swing arm holds the axle of rear wheel & other end attached to the frame via swing arm pivot bolt & attaches the top of the frame, just beneath the seat. With internal or external springs / shock absorbers, the front wheel & axle are mounted on the telescoping fork.

#### **Wheels**

Motorcycle wheels rims are generally made of aluminium or steel, and some models are introduced cast wheels also. Cast Wheels allow the bikes to use tubeless tyres, which unlike traditional pneumatic tyres; don't have an inner tube to hold the compressed air. Instead, the air is held between the rim and the tyre, relying on a seal that form between rim and tyre to maintain internal air pressure.

#### ➤ **Brakes**

For two wheeler motor cycle, front & rear wheels have each separate brake. The front brake is operated with right hand lever and rear brake is operated with right foot lever. In previous days upto 1970's drum brakes were used, now a days used superior performance of disc brakes. Disc brake consists of steel braking disc and it is sandwiched between brake pads. This entire system connected to wheels, when rider operator one of the brake, the hydraulic pressure action



through the brake line, due to frictional resistance brake pads to squeeze the disc on both sides, then the wheels are slow down or stop. Due to repeated use of the brake pads are wear out, so brake pads are replaced periodically.

## 1.2 Introduction To Suspension Frames

Whenever to build a motor cycle, the frame gives a basic overall look of the bike. Of the frames affects not only appearance of bike but also handling and safety of the finished machine. The main components of bike like engine, gearbox & tanks etc are hold by frame and also support for the whole bike.

Motorcycle frames are generally made of steel, aluminium or alloy, recently used carbon-fiber in some expensive or custom frames. The various components of bike are bolted to the frame, so it acts as a base of the motor cycle. The engine sits inside the frame, front forks are attached to front of the frame and the rear swing arm is attached by pivot bolt.

## 1.3 Types of Suspension Frames:

**Motorcycle frames generally fall into one of several categories:**

- > **Single cradle frame** – It is simplest type of frame and looks similar to the first ever motor cycle frames. It consists of smaller diameter tubes made of steel that surround the engine with a main tube above and other. It becomes double cradle frame at the exhaust; it is referred to as a split single cradle frame. These are usually found in off-road motor cycles.
- > **Double cradle frame** – These are descended from single cradle frames. In this, the engine can support with two cradles on either side. Double cradle frames are commonly used in simpler road bikes and custom motor cycles. They are offer good compromise between strength, rigidity & lightness, now; they have been technically surpassed by perimeter frames.
- > **Backbone frame** – It is most desirable frame, the engine is suspended by single, wide main beam. This frame allows great flexibility in design, because it concealed inside the finished motor cycle. The engine simply seems to hang in mid air. It is simple & cheap to make, and usually found on naked and off-road motor cycle.
- > **Perimeter frame** - Motorcycle racing research shows that to major advantages are to be gained in terms of rigidity by joining steering head to swing arm in a shortest distance as possible. Flexure and torsion are abnormally reduced; this is the main concept behind the perimeter frame. In previous days perimeter frame is made of steel, but need to improve rigidity to weight ratios adopt aluminum. For modern super sports motor cycles are made of aluminum perimeter frame is most popular frame.



Fig 1.2 : Perimeter Frame





□ **Monocoque frame** – These are mainly used exclusively on competition bikes and is very rarely found on road-going bikes. It acts as a single piece unit that functions as seat mounting, tank and tail section. Though monocoque frames offer good rigidity, they are heavy and generally not worth the effort.

□ **Trellis frame** - The trellis frame rivals the aluminium perimeter frame for weight & rigidity. An European & Italian manufacturers are proved that a great success in racing and competition. The principle behind the Trellis frame & perimeter frame is the same, the main difference in Trellis frame is connects steering head and swing arm as directly as possible, but in case of perimeter frame connects a shortest distance as possible. This frame is made up of large no. of short steel or aluminium tubes welded together to form a trellis. The manufacturing of Trellis frame not only easy but extremely strong as well. The pictures of frame is from the Suzuki SV65OS

#### 1.4 Frame Materials

##### > **Steel**



Fig 1.4: Norton Featherbed frame in a Triton.

Examples: a) Norton Featherbed frame

b) Early Honda CBR600

##### > **Aluminium**

Example: Honda VFR750

##### > **Aluminium and carbon-fibre**

Example: Bimota SB8K (composed of two aluminium alloy beams and carbon fibre

Plates)

##### > **Carbon fibre**

Examples: Ducati Desmosedici, MotoCzysz C1

##### > **Titanium**

Example: 1971 Titanium Husqvarna Inter-AMA Motocross

Example: 1988 Elf ROC-Honda Elf5-NSR500 500 cc Grand Prix

##### > **Magnesium and aluminium**

Example: MV Agusta F4 750 Serie Oro

#### 1.5 Carbon fiber motorcycle frames vs. Steel motorcycle frames:

Motorcycle frames are built from a range of materials such as steel, aluminum, titanium and carbon fiber. Carbon fiber is a thread-like material with a diameter of approximately 0.0002 to 0.0004 inches. A carbon fiber composite is created by mixing thousands of these threads with epoxy.

##### > **Strength**

○ Steel tube motorcycle frames are built by welding tubes together. Welding points, or "joints", are required to resist repeated amounts of force. The strained joints potentially represent structural points of weakness. Steel does not possess carcass flexing properties, like those of carbon fiber. Zoltek, a company which produces high-performance carbon fiber, notes that at its highest tensile strength, carbon fiber is 10 times stronger than steel.



➤ **Weight**

○ A poorly engineered, heavy steel frame can cause unnecessary drag, robbing a motorcycle of horsepower and nimbleness. Conversely, a lightweight, carbon fiber motorcycle frame could theoretically free up horsepower, increase agility and allow for more efficient braking. According to Zoltek, carbon fiber is five times lighter than steel.

➤ **Corrosion**

○ Steel framed motorcycles are highly susceptible to rust and corrosion in damp climates or when water is otherwise not dried from the frame. Carbon fiber is a non-metallic material and is, therefore, not at risk of rust or corrosion.

**1.6 Material Properties Of Steel:**

The material properties plays a vital role the design of the product. The suspension frame steels have different nomenclatures based on different systems and it has been shown in table. The chemical composition of various elements in the existing conventional suspension frame steel (AISI 1086 / SAE 1086 / UNSG 10860) has been shown in table. The mechanical properties of the existing conventional suspension frame material are shown in table.

**1.7. Material Properties of Carbon Epoxy Resin:**

There are two suspension frames on which the analysis is carried out, one is conventional steel frame and the other is carbon epoxy resin frame. The Mechanical Properties of Composite (Carbon Epoxy Resin) material can be taken as per Ansys Standard material library.

**2.5.2 DIFFERENT MODULES IN PRO/ENGINEER:**

- PART DESIGN
- ASSEMBLY
- DRAWING
- SHEETMETAL
- MANUFACTURING

**2.6 Introduction to FEA: -**

Present day Super computers are now able to give accurate results for all types of parameters. FEA design the computer model that analyzed and stressed for the specific results. It is used to design the new product and refinement of existing product. Based upon the client's specifications and requirement, the modify the existing design or produce the new design. In case of structural failure, FEA may be used to meet the new conditions with the help of determine the design modifications.

Generally two types of analysis are used in industries. They are 2-D modeling, and 3-D modeling. 2-D modeling uses simplicity and analysis done in normal computers. But it gives less accurate results. 3-D modeling produces more accurate results and able to run on fastest computers effectively. FEA uses a complex system of points called Nodes which make a grid called a Mesh. This mesh is programmed to contain the structural material properties which define how the structure will react the certain loading conditions. Depending upon the anticipated stress levels of a particular area, the nodes are assigned at a certain density. The regions where the larger amount of stress levels are received have higher density of nodes available. Similarly the lower amount of stresses are anticipated, have lower density of nodes available. The mesh acts like a spider web in that from each node, a mesh element is extended of the adjacent nodes.



**2.7 Types of Engineering Analysis: -**

Structural analysis consists of linear and non-linear models. Linear models use for simple parameters and assume that the material is not plastically deformed. Non-Linear models consist of stresses in material past its elastic capabilities, the stresses are vary with deformation. The vibrations, shocks and impacts of material are tested by vibration analysis. To find the fatigue life of material due to effect of cyclic loading is determined by fatigue analysis. Models of the conductivity or thermal fluid dynamics of material by Heat transfer analysis, and this may consists of a steady state or transient state.

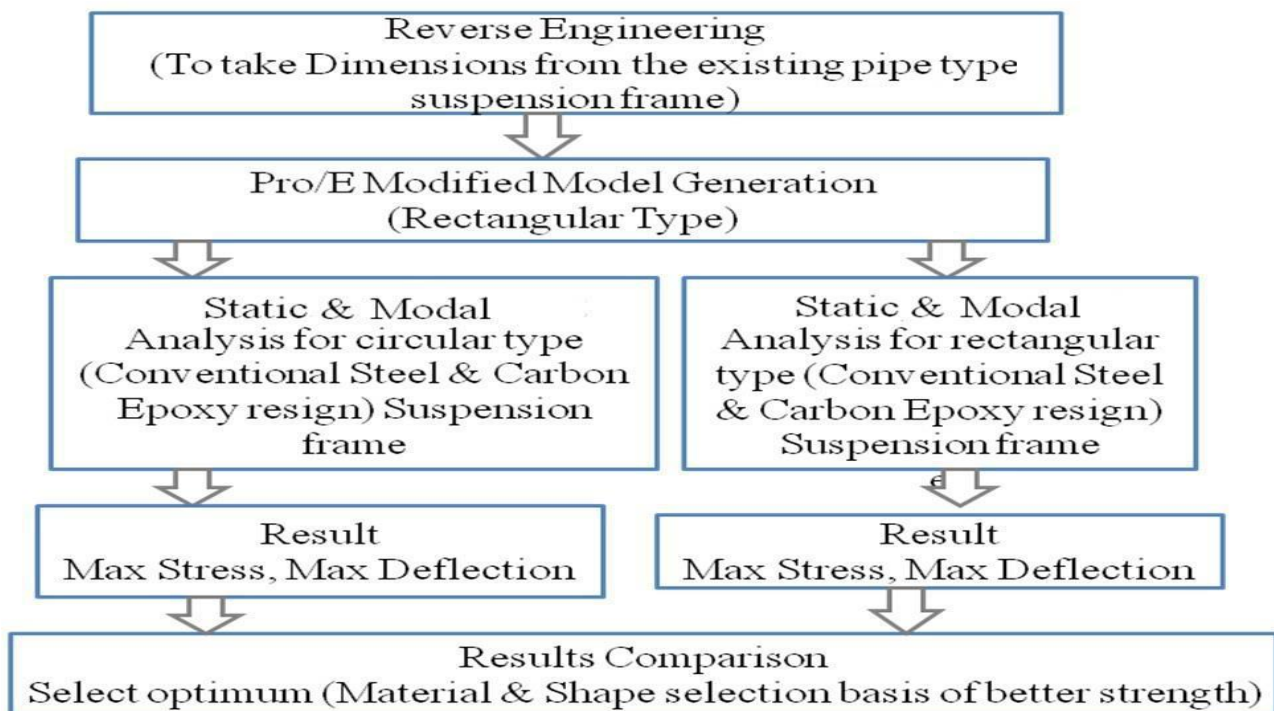
**2.8 Results of Finite Element Analysis: -**

FEA becomes a solution to the task of finding the failure due to unknown stresses by showing the areas of problem in a material and allowing designer to see all of the theoretical stresses within. This method is very useful and economical for product design because the sample was actually built and tested before manufacturing. In practice, FEA usually consist of 3 principal steps.

- > Pre Processing
- > Analysis
- > Post Processing

**II. A METHODOLOGY & MODEL OF SUSPENSION FRAME**

In order to achieve objective of the present project, a flow chart is prepared which shows various steps involved in the analysis. The flow chart is shown in fig 3.1



**Figure 3.1:** Flow Chart to achieve the object



**3.1.1 2D Procedure Of Circular Cross Section Suspension Frame:**

Open>pro/engineer>file>set working directory.  
File>new file>sketch>toggle off>ok set units>mmns>ok>sketch>ok

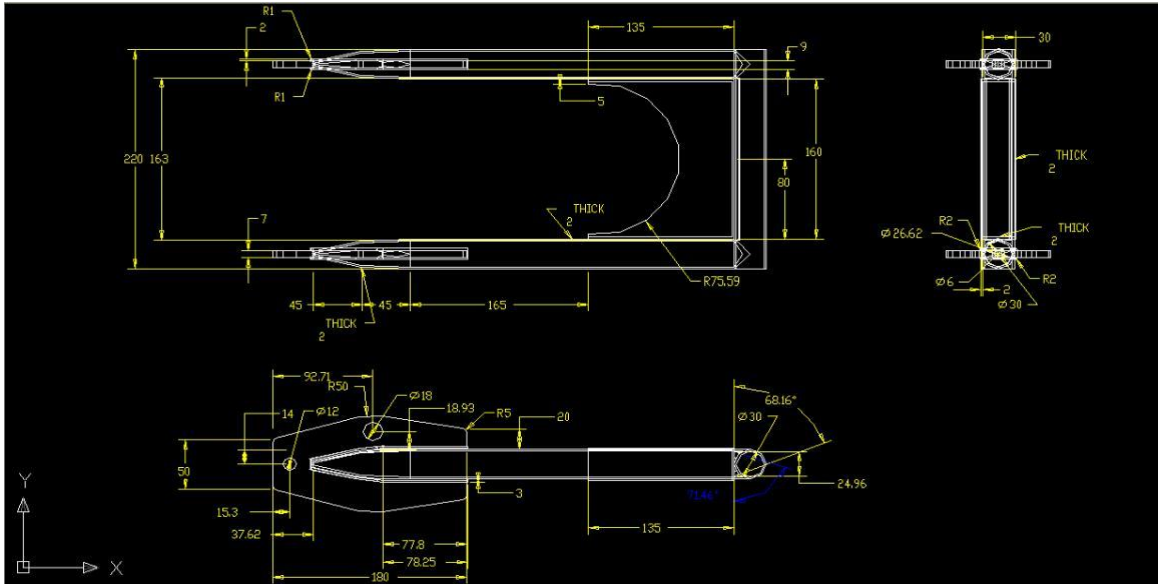


Figure 3.2: 2D Diagram of Circular Suspension Frame

**3.1.2 3D Procedure Of Circular Cross Section Suspension Frame:**

Open>pro/engineer>file>set working directory.  
 File>new file>sketch>toggle off> units>mmns>ok  
 **5.1 CIRCULAR MODEL:**

Table 5.1.1: Structural & modal analysis results of Circular Suspension Frame using Steel.

	RESULTS	
DISPLACEMENT (mm)	0.297e <sup>-3</sup>	
VONMISES STRESS (N/mm <sup>2</sup> )	2.383	
	Frequency (Hz)	Displacement (mm)
MODE 01	0.024473	0.922 e <sup>-3</sup>
MODE 02	0.025756	0.001876
MODE 03	0.026079	0.001991
MODE 04	0.02613	0.925 e <sup>-3</sup>
MODE 05	0.032796	0.004175



### III. CONCLUSION

From the above investigation the following conclusion are made:

In my project I have modeled a suspension frame used in two wheeler. The original cross section is circular and later changing the model to rectangular cross section. Modeling is done in Pro/Engineer.

I have done Structural & Model analysis on both models of suspension frame using materials Steel and Carbon Epoxy.

After static analysis I have conducted model analysis. Model analysis is mainly used to determine the frequency of suspension frame model.

Present used material for suspension frame is steel. It is replaced by Carbon Epoxy. The density of Carbon Epoxy is less than that of Steel, so the weight of the frame reduces when Carbon Epoxy is used.

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