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Comparison of different frame designs and materials.

Academic Skills ACHA4005

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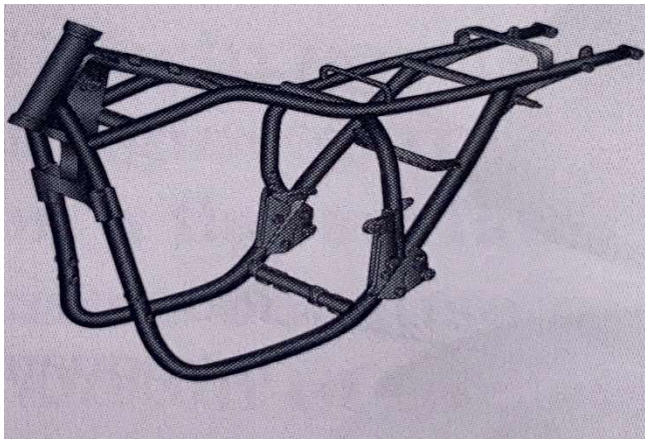
1 Introduction

This report will review some common frame designs such as a cradle, trellis and monocoque. Different materials that can be used in frame construction such as steel, aluminium and magnesium will also be discussed touching on key benefits but also disadvantages and compromises.

2 Frames

2.1 Cradle Frame

(Stoakes, 2012) describes a cradle frame as being a stiff structure commonly made from straight or curved steel tubing, this tubing is welded together at angles and passes below the engine providing support. Cross members can be utilised to add width to the frame and strengthening plates are added around structural mounting points to provide support. At the front of the engine the frame can be split into two sections, this configuration is commonly known as a Duplex type, if the configuration utilises a single downtube this is commonly known as a Spar type.



(Cocco, 2013) suggests this type of frame design is strong, practical and simple, many also have the additional benefit of being able to be disassembled in practical situations to aid the removal and installation of the engine.

Figure 1 Duplex Cradle frame (Cocco, 2013)

2.2 Trellis Frame

(Cocco, 2013) describes a trellis frame as a lattice structure that is light and rigid, its constructed from straight metal tubing which can be square or round, a trellis frame can be very delicate to fabricate due to the precision welding required around the inclined tubing. The engine can be used to close the trellis and would be considered an integral part of the frame since the stiffness of the frame is diminished without it.

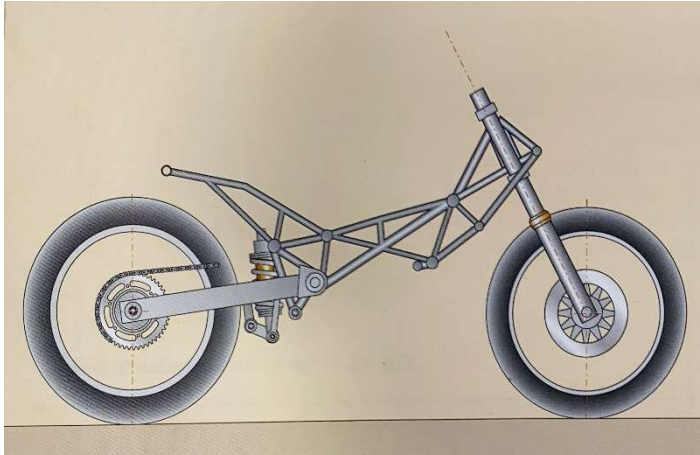


Figure 2 Trellis frame (Cocco, 2013)

(Foale, 2006) suggests that due to the wide size and shape of some engine configurations a trellis frame can become complicated and expensive due to the frame becoming wider to fit the engine. Engine configurations that are naturally narrow such as V-Twins and engines with horizontal cylinders like the 500cc Linto Twin's present no accommodation difficulties.

2.3 Monocoque

(Stoakes, 2012) explains that frame and bodywork are constructed as one piece with spot welds along the joints. Rubber mountings can be used when mounting the engine, transmission, steering and suspension but are not required.

(Foale, 2006) highlights that the racing Honda NR500 is an example of a motorcycle with a monocoque frame, the fairings were an integral part of the frame, a downside was extensive dismantling required when performing routine maintenance.

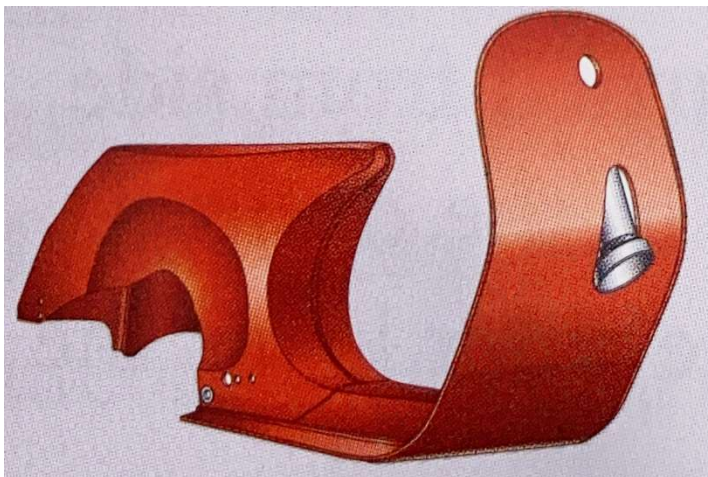


Figure 3 Monocoque frame (Stoakes, 2012)

(Cocco, 2013) describes poor adaptability in the frame design due to even a slight restyling or small modification would require a high investment machinery and equipment

3 Frame Materials

3.1 Steel

(Cocco, 2013) suggests that steel is the most used construction material, steel has a low cost with great strength, it's easy to bend and weld and it can be formed into square tubes which are great for mating surfaces together in preparation for welding. Round tubing is easier to bend and sheets can be pressed and joined to create box sections which have high stiffness and appearance benefits.

(Cocco, 2013) also states that there is a wide spectrum of steel with varying mechanical properties that can be used depending on what stresses will be subjected to the structure, these include the likes of superalloys with 1600N/mm² breaking strength value, alloyed steel with 1000N/mm² of breaking strength value and non-alloyed steel with 420N/mm² of breaking strength value.

3.2 Aluminium

(Cocco, 2013) details that aluminium's mechanical properties mean that in frame construction it is one of the most popular options of raw material, it is a lightweight alloy which weighs approximately one-third of iron and is a fantastic choice to keep the motorcycle's total weight down whilst maintaining a High Stiffness/Weight ratio. Aluminium has the possibility with various technological processes to be, forged, cast, pressure cast, extrudates and laminates. Forged aluminium provides good mechanical properties and appearance, cast and pressure cast provide thin wall thicknesses and complex shapes, extrudates provide the possibility of ribbed internals with thin wall thickness and complex forms and laminates are joined together by being pressed to produce box section structures.

(Cocco, 2013) also explains that when compared to steel there are some drawbacks. The raw material cost of aluminium is higher than steel and the welding process requires taking place in an inert gas-controlled environment to stop rapid oxidation of the welding bath. To achieve this a Mig (Co²) or a Tig (Heli-Arc) welder can be used.

3.3 Magnesium

(Foale, 2006) expresses that magnesium is extremely lightweight but has many drawbacks such as a high cost and poor welding properties, it is highly flammable and very prone to oxidation, however, this oxidation can be controlled with the coatings, but these are expensive and further add to the total cost. It is also worth noting that an increase in temperature causes decay in its mechanical properties.

(Cocco, 2013) reinforces that magnesium has a limited lifespan due to its poor ability to resist corrosion but also fatigue, welding difficulties and high material cost all contribute to the lack of use in motorcycle frames. Magnesium frames can be cast or fabricated but the material would be most suited to a triangular structure of tubing such as a trellis. A racing motorcycle would be an ideal use as they typically have a short lifespan and would make use of the weight saving.

4 Discussion

Taking into consideration the research that has been conducted, it is easy to understand that steel will be the material used for most of the production motorcycle market. It provides great strength whilst maintaining durability, it is easy to work with, easy to repair and its low-cost benefits both the manufacturer and the customer. Although steel frames can be quite heavy, this is a compromise that is accepted in most motorcycle design as it does not outweigh its benefits.

It is understood that aluminium does have a demand and need to be utilised in certain types of motorcycles, especially when you consider that it is roughly three times lighter than steel. Aluminium provides the motorcycle with an excellent stiffness/weight ratio and is the go-to material for keeping overall weight down. When searching for performance its benefits far outweigh the extra costs of the material and additional difficulty when welding.

Research suggests that magnesium frames would not suit the production motorcycle market, the high cost of the raw material and poor ability to resist oxidation would result in a short lifespan that would leave owners of the vehicle unsatisfied and have a negative impact on the manufacturer. The possible future development for this material would be the use in motorcycle racing where the lifespan is short and weight saving could be utilised fully.

5 Conclusion

It is understood that there isn't one frame design that suits all types of motorcycles and although each frame design could be made better to handle certain environments and situations, it must be taken into consideration by the manufacturer that the vehicle will be sold and used across the globe, compromises must be made so that the chassis is balanced and functions in all environments.

6 References

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