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Comparison between the Backbone and Double Cradle motorcycle frame approaches

L0- Academic Skills – ENGINEERING
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1 Introduction

In this assignment It will be show what a Backbone and Double Cradle frame is and what the properties of both frames entail, meaning that both frames will be compared, showing the advantages and disadvantages between them. Furthermore, this assignment will include the history behind each of the frames and the approach taken towards them, in both design and production. With the designs of the frames, they derive originally from the design of a bicycle as the first motorcycle was a bicycle with an engine strapped to the frame that was made in the late 1800s, but when the engines started getting bigger, that's when the different branches of motorcycle frames arose, hence the development of both frames.

1.1 Justification

The intent of this project is to compare the Backbone and Double Cradle frame overall, researching the advantages and disadvantages of both frames and to show which frame gives a better overall performance and how safe the frames structure is, thus' showing which approach was better overall. This will also cover the sales through certain years to show which frame and company produce the best results.

1.2 Aims

The first aim of this report is to research the history of both the motorcycle frames and what they originated from and what the idea behind the design was.

The second aim of this assignment is to research the sales between different brands that us both the Backbone and Double Cradle frame to understand which motorcycle frame has been purchased more and why it has.

The third aim is to research the advantages and disadvantages of both frames and what makes each frame different from the rest, where torsional stiffness or rigidity will be covered.

1.3 Objectives

The first objective of this report is to compare the advantages and disadvantages between the backbone and double cradle frame and research how this effects the performance of the motorcycle in both areas of driveability and durability.

The second objective is to show what torsional rigidity is and compare the level of torsional rigidity there is between the two models of frames and how this can affect the performance of the motorcycle itself, Showing the formula for torsional rigidity and statistical data.

The third objective of this assignment is to compare the sales between motorcycle corporations that use both frames and convey that by using graphical and statistical data.

2 Background

Backbone Frame

The Backbone frame is a frame that follows the bodywork shape that forms a “spine” like shape, hence the name Backbone. The Backbone frame was first used in the early 1900s, the design uses substantially less steel than most frames, therefore making it a much more cost effective in production. However, the design of the Backbone has a relatively large top tube that runs along underneath the top of the bike, this tube holds most of the loads, but the frame also uses the engine as a part of itself this is called a “stress member”, a stress member is when the engine is bolted onto the frame rather than there being pipes underneath the engine to hold it in place. This is where the “stress” part plays a role because the engine is bolted on, when pressure is put on the frame it is then transferred to the engine as well to share the load, this makes for a ‘stiffer frame and improves the sharpness of the handling (Skwarczek, 2021)’.



Figure 2-1 This image shows the spine like shape of a backbone.

Advantages

The Backbone frame has substantially less steel in its framework meaning that it is cheaper to produce this means that it can be mass produced at a more cost-effective rate than other motorcycle frames. This means that they are used in beginner motorcycles, which means that they can promote it to different audiences.

Due to the Backbone frame having the engine bolted to the frame and using it as a stress member means that the motorcycle will have better overall handling, thus’ giving better control during leaning.

Disadvantages

The Frame has insufficient strength and torsional stiffness, 'torsional stiffness is how much torque a material or object can withstand before deforming (Young, P.E, 2023)'. This means that when the motorcycle frame is subjected to high amounts of torque on the frame it could deform quicker.

Due to the frame having a low strength this means that it can only handle lower powered engines as heavier and powerful engines will cause too much stress on the frame and due to its low rigidity, the frame could deform.

Double Cradle Frame

A Double Cradle frame is derived from the older single cradle frame design, the frame was first brought upon through Norton motorbikes in the early 1900s and the approach taken for this frame was for it to have 'two steel down tubes that run along the side and underneath the engine (CarBikeTech Team, 2020)' thus giving more support to the engine, which in turn compared to the Backbone frame it only has support from the areas it's bolted onto. The double down tubes also cause the frame to have more rigidity and durability meaning that the frame can withstand more pressure, Due to this it means that the Double Cradle frame can handle powerful engines, where



compared to the Backbone frame being able to handle only lower-

Figure 2-2 This shows the double down pipes and frame itself.

Powered engines.

Advantages

The Double Cradle frame has two down pipes that follow alongside and underneath the engine giving it improved support, this also gives the frame more overall rigidity and torsional stiffness meaning that the frame is less likely to deform when subjected to high levels of torque.

‘(CarBikeTech Team, 2020) suggests that Double Cradle frames have better control over forces during a higher lean angles making turning easier for the rider and the braking system supplies heavier breaking than a single cradle frame’ or backbone frame.

The frame itself is cost effective due to the price being only slightly more than the single cradle, as Honda double cradle frame prices range from £800-£1250, where Honda backbone frame prices range from £200-£900 which shows that backbone frames are more cost effective.

Disadvantages

The Double Cradle frame has a disadvantage due to the size of the chassis, meaning that it is much heavier compared to other frame models. With the frame being heavier it was designed more for a “comfort” ride and is not used in ‘modern day competitive racing as lighter builds are the way to go (WeBikeJapan, 2020)’

Although the Double Cradle frame is relatively cheap to produce, the instalment of the engine and the removal of the engine is extremely difficult to do compared to the Backbone frame where these processes are much easier. This means that the maintenance of the motorcycle becomes difficult for the customers or companies.

3 Discussion

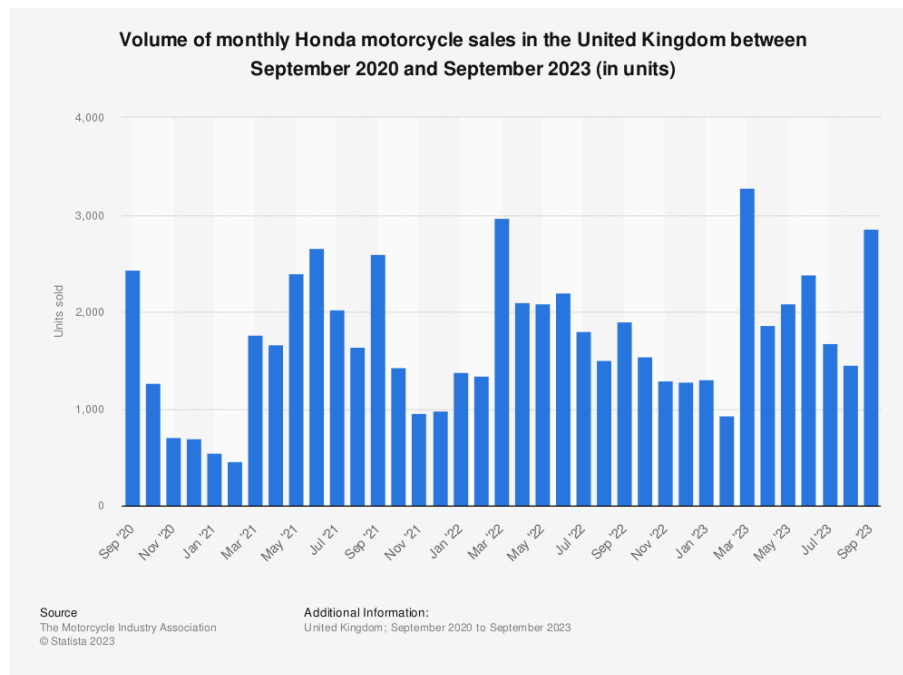


Figure 3-1 A Graph that shows the monthly sales of Honda motorcycles in the UK between 20/09/20 and 23/09/23 (Statista Research Team, 2023).

Through research I have found a graph that shows the monthly sales in the United Kingdom of Honda motorcycles as shown in figure 3-1. As figure 3-1 shows the peak is 3,279 sales in the month of March 2023 this shows that the backbone sales are much higher than that of double cradle frames as backbone frames are mostly used in Honda motorcycles and double cradle frames are mostly used in Harley Davidson motorcycles. This means that Backbone frames are more readily available than double cradle frames, as shown in Figure 3-2 the most sold in a month was 821 which is substantially less sales than that of the Honda motorcycles.

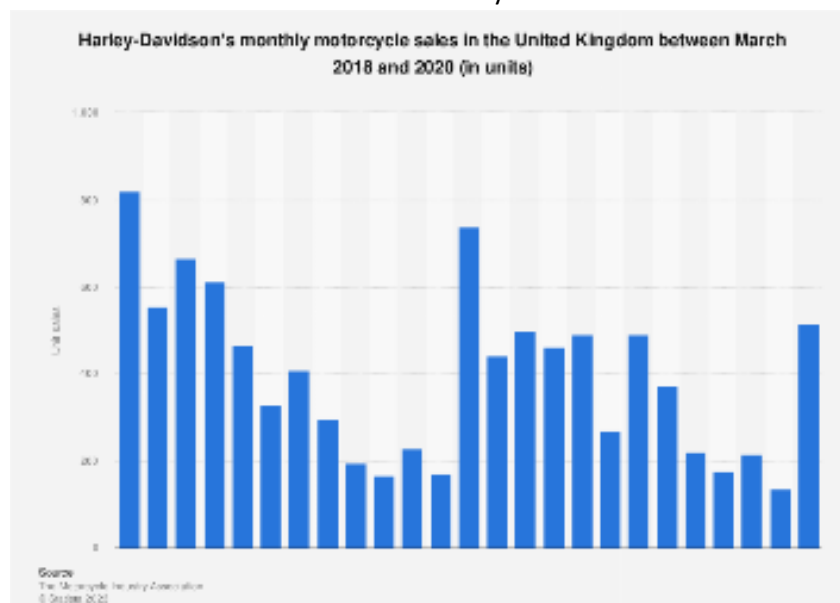


Figure 3-2 This graph that shows the monthly sales of Harley Davidsons in the UK between 18/03/18 to 20/03/20 (Statista Research Team, 2023).

Torsional Rigidity

Torsional rigidity can be measured using the formula,

Modulus of rigidity x Polar moment of inertia = applied torque x Length of object/ angle of twist

So, with this equation the torsional Rigidity of both frames can be measured when a torque is applied to the tubing which will give us the value of the torsional rigidity based on how stiff the framing is, because 'the structural stiffness of the frame has significant impact on the damping of the structural vibrations that are caused to the frame when excited in motion (Mateusz, Arkadiusz and Piotr, 2020)'. Therefore, with the Backbone due to the lack of framing this means that its torsional stiffness is low as when the frame is subjected to torque and vibrations during motion this will deform the frame at a quicker rate, As shown in Table 1 the smaller diameter of the tubing has a lower torsional stiffness this shows that with less of a frame and that is thinner than double cradle framing, thus' double cradle has a higher torsional stiffness level.

Table 1 shows that an increase in diameter and an increased force will increase the stiffness of a tube (Tanmay Mathur, 2019)

Tube Number	Diameter of tube (mm)	Force applied J (mm ⁴)	Stiffness (N/m)
1	40	2.51x10 ⁵	1.09x10 ⁵
2	60	12.7x10 ⁵	15.1x10 ⁵

4 Conclusion

To Conclude the results, show that the Double cradle frame is the overall more advantageous frame type as it has higher torsional rigidity than the Backbone frame meaning that it is safer and handles better at higher speeds and with heavier loads as it can support more weight than that of the backbone. Although they are less cost effective than Backbone frames, they offer more support to the engine and the structure of the motorcycle, thus' giving support to the rider as it has a better handle against forces when taking corners that require leaning and the braking system offers better handling during heavy braking compared to that of the system on the Backbone frame.

5 References

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