

Report Wheelbase

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Introduction:

In this small report we provide an analysis of the wheelbase and the effects/influences of the wheelbase on the dynamics of the motorcycle. The analysis is mainly based on information from the book Motorcycle Dynamics by Cossalter [1].

Influences:

An increase in the wheelbase will result in the following positive (+) and negative (-) effects:

(-) Increase in flexional and torsional deformability of the frame. Here note that more deformable frames result in less maneuverability. Difficult to find any concrete notes on the precise effect of the deformability on the maneuverability.

(--) Increase in minimum curvature radius

Minimum curvature for straight up bike increases at low speeds. However since this is straight up and at low speeds, it is therefore not important for race bikes.

Note that the actual turning radius is only defined by the (constant) lean angle and the speed and is not dependent on the wheelbase.

The longer wheelbase does however increase the time taken by the bike to reach that certain lean angle, thereby decreasing the maneuverability.

(-) Increase in the necessary steering torque

Since the wheelbase is longer, a larger steering torque is necessary from the driver to receive the same response by the motorcycle. Achieve concrete numbers on how much this is affected is difficult. However we note that in general the driver only has to race the bike for about 20 min, making it less important if he has to put slightly more power into steering, as long as it does not affect his driving style.

(-) More space in between to cover, increasing weight.

If done efficiently, the space can be covered without adding too much extra weight to the bike. The gain in acceleration/deceleration will be more than the loss due to extra weight.

(++) Decrease in load transfer, which results in more stability during acceleration/braking and decreases the pitch.

Due to the larger wheelbase, a wheelie and stoppie occur less fast, increasing the maximum acceleration and deceleration (assuming that the wheelie/stoppie are the main limiting factors and not engine/brake power or slipping).

(+) Reduction of pitching due to road unevenness

It should be considered that the racetrack has small unevenness and the pitching due to this factor is relatively small. Therefore the positive effect of the increased wheelbase is in reality small and can largely be ignored.

(+/-) Increase in directional stability

Directional stable is when a motorcycle tends towards its equilibrium in rectilinear motion.

The wheelbase influences the value of the trail and long trails lead to high directional stability at

high velocities. However directional stability is also influenced by other factors, such as steering geometry, forward speed, gyroscopic effects, inertial factors and tire properties.

However a high directional stability also implies more difficulty in handling in the corner, also named in the increased steering torque. The bike will roll slower into corners and takes more work for the driver.

(+) More room for the other components

A larger wheelbase will provide more room to place batteries and give more space to shift with the locations of different parts.

Also a longer wheelbase will allow the rider to have a more aerodynamic position.

Empirical values:

From literature it is found that the wheelbase of racing motorcycles are in the following range:

$$1300 \text{ mm} \leq p \leq 1500 \text{ mm} .$$

In table 1, the wheelbase values for current racing motorcycles can be found.

MOTORCYCLE	WHEELBASE(mm)
Yamaha YZF-R6	1380
Honda CBR600RR	1370
Kawasaki Ninja ZX-6R	1390
Suzuki GSX R600	1390
Ducati 749	1420
Kawasaki Ninja ZX-12R	1450
Energica Ego(Electric)	1465
Suzuki Hayabusa	1480

Table 1. Wheelbases for 8 different types of motorcycles

Considerations

In comparison to conventional bikes, electric motors can give maximal torque and acceleration continuously. It can be reasoned that the acceleration might be more limited by the wheelie. A small research into this topic and current electric bikes did not result in a conclusive answer on this topic.

Agility can be affected by many different parameters and can for example be improved by trail/caster angle (smaller= more agility) and height COG (lower is more instability/agility).

Also take into mind that the desired agility also depends on the preferences of the rider and should therefore be slightly flexible.

Conclusion and discussion:

In conclusion we can say that a larger wheelbase will improve the acceleration and braking since it will reduce the load shift and increase the conditions for the wheelie/stoppie. Further it increases the directional stability, decreasing its agility and responsiveness for cornering.

Looking at the advantages and disadvantages we would want to increase the wheelbase, such that we can make full use of acceleration, under the constraint that the bike is still agile enough for the track it needs to race.

Since it is hard (for now) to place any concrete numbers or constraints, we advise a starting wheelbase of 1450 mm with some room to increase or decrease it, e.g. with attachment point of the swingarm or the caster angle.

