

Study of Various Motorcycle Transmission Drives

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Abstract: Motorcycles, generally seen around the world has chain drive transmission system to transmit the power generated from the engine to the rear wheel. But there are few other types of transmission drive like Belt Drive and Shaft Drive to do the same work. All three of them (Chain, Belt and Shaft Drive) have their own advantages and disadvantages over different parameters like mechanical efficiency, power transmission, durability, maintenance, usage, and cost. The proper study of all the three drives has been discussed in this paper. It also enlightens the difference between them and which one is better over other in which kind of circumstances.

1. Introduction:

Motorcycles are one of the best creations of the mechanical engineering. From top to the bottom, every motorcycle is created for its best performance in power delivery, efficiency as well as for adventure, entertainment, and safety. It has various components designed with precision like frame or chassis, engine, safety systems and transmission systems.

Generally for power transmission from the engine to the rear wheel various mechanical components and systems are required like clutch, gearbox, and finally transmitting drive. All these three combined together make a transmission system in a motorcycle.

The transmitting drives are the mechanical connection from the output shaft of the gearbox to the rear wheel. In scooters, the engine is placed at the rear or back end so there is a direct connection between out shaft of the gearbox to the wheel but in motorcycles, the engine is placed in front, in between both wheels and so there is enough gap between the output shaft of gearbox and wheel. To connect these two, transmitting drive is used. Over the years there has been a lot of development in this drives. In earlier days, Chain Drive were the only drives that were used but now Belt Drive is also becoming one of the

choices for many automotive companies. Let it be Chain, Belt or Shaft drive, but it is supposed to transmit the power and torque to the rear wheel with the highest efficiency. (Mechanical efficiency can simply be defined as the ratio of the work input to the work output, of a system.)

If we want to attain maximum efficiency, all components must have minimum losses and final drive is one the component which has a direct influence on efficiency and losses due to friction, as it is almost present in the open space and its maintenance and lubrication depends completely on the owner and mechanic completely.

Loss of power or lower efficiency in these drives depends on various other factors like friction, air resistance, inertia, lubrication, wear, tear, and slag or tightness of the drives.

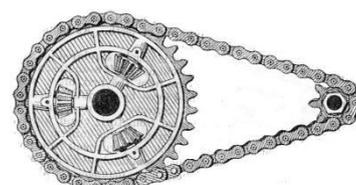
So, in regard to transfer power with higher efficiency there is generally three kinds of transmission drive:

1. Chain Drive
2. Belt Drive
3. Shaft Drive

2. Chain Drives:

Chain drives (See Figure 1) are one of the most common types of the drive which are used for the transmission of power and torque from the engine to the rear wheel of the motorcycle or bike.

Figure 1. Chain Drive



Chain Drive has a series of a link connected with one another which makes a long, circular, rigid, and continuous component that can be used to transmit power. This chain is placed between two

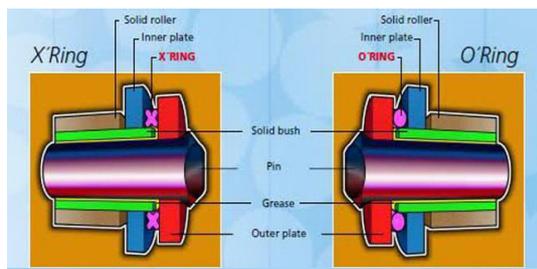
sprockets or cogs, one attached to the output shaft of gearbox whereas another attached with the rear wheel of the motorcycle. Chain rolls over the sprockets or the cogs when either of the sprockets rotates. Generally, in a motorcycle or bike, one cog or sprocket that is attached to the engine or output shaft of the gearbox is the main driving sprocket and one attached to the wheel is the driven one. So power generated in the engine is transmitted from gearbox to the sprocket or cog attached to it, to chain and from chain to the sprocket or cog attached to the rear wheel of the bike.

According to the requirement or according to the power generated from the engine or according to the amount t of the torque to be transmitted the thickness of chain link and sprockets/cogs can vary. For very high power transmission, sometimes double chain system is used, ie. Two chains are joined together but this system was not practically used and was rejected at prototype level but after many trials, research and experiments on chains, its strength and performance has increased and now chains have some classification and types for different requirements of strength and power transmission like

1. Standard roller chains or Non-O-ring chain
2. O-Ring chains (See Figure 2)
3. X- Ring Chains (See Figure 2)

Figure 2. X-Ring and O-Ring

All three of them are the very primitive type of



final chain drive system. A chain drive system theoretically may have up to 99% efficiency and 1% loss occur due to the friction and air resistance.

But in real life practice in motorcycle, a chain drive may up to 3% losses that are extra 2% loss due to the performance of lubrication, friction, air resistance, wear and tear with usage and passage of time. Even after this much of loss, a chain drive may have up to 97% efficiency which the highest in all drives. Moreover, chain drive also enables designers and engineers to maintain exact same gear ratio, required during operation.

2.1 Advantages of Chain Drives:

1. Chain drives are comparable cheaper to other drives.
2. Chain drives are also light in weight as compared to other drives and so have low inertia, which reduces power consumption and increases acceleration by maintaining weight to the power ratio.
3. Chain drives are easy to operate and these can bear very high stresses.
4. Chain drives have compact assembly unit and have high transmission efficiency, which is up to 97%.
5. Chain drives can be operation in extreme conditions and even though it has less, cheap and easy maintenance.

2.2 Disadvantages of Chain Drives:

1. Chain drives require constant lubrication and maintenance that is after every 500-800 km of the ride.
2. If chain drives are not lubricated properly then it gets corrode very easy that is it not corrosion resistance.
3. Chain drives are very noisy that is it produces mechanical rolling and sliding noise while in operation.

3. Belt Drives:

Belt drives (See Figure 3) are another most common type of final transmission drives in motorcycles but this is generally used in cruiser bikes and very limited number of superbikes. This drive system consists of a driving pulley, belt, and a driven pulley. Driving pulley is attached to the output shaft of the gearbox whereas driven pulley is attached to the rear wheel of the motorcycle. The belt is placed in between both of the pulleys and power transmission takes through the combination of all three working together. Both the pulleys have grooves, which matches the outer structure of the belt and provide enough frictional force to transfer torque and power.



Figure 3. Belt Drive

Belt of the belt drive is made up of polychloroprene rubber reinforced with the metallic torsional chords. This reinforcement provides extra tensile

strength to the belt. Another reinforcement of the nylon coating over the surface of belt prevents it from the cracking due to stretching and contracting at tension and slack side respectively. Any belt with crack or broken teeth is needed to be replaced immediately for smooth running.

In some regards, belt drives are better than chain drives because of the flexibility and corrosion resistance properties but it also has slipping problem. It also does not require any lubrication and maintenance in its whole lifespan so it is used in cruiser bikes to hit miles but a belt drive has comparably smaller life span than chain drives. In spite of this, belt drives have managed to make a significant place in automatic or gearless two vehicles transmission system. Belt drives are widely used in CVT that is Continuous Variable Transmission, in which different gear ratios are provided with the change in diameter of the operating pulleys.

A Belt drive can have efficiency up to 89% that is there is about 11% of power loss due to slipping, stretching, air resistance, wear and tear.

3.1 Advantages of Belt Drives:

1. The major advantage of the belt drive is that it has zero maintenance requirement over its lifespan. It doesn't even need to be lubricated periodically like as chain drive.
2. Another major advantage of the belt drive is that it has a very silent operation. It does not produce any kind of frictional noise while in operation.
3. Belt drive can absorb shocks but cannot bear instant or sudden power transmission due to the stretching property of belt material.
4. It is also very efficient that is it has mechanical efficiency up to 89%.

3.2 Disadvantages of Chain Drives:

1. Belt drives a major issue of slippage at high power transmission which results in loss of power and torque at the rear wheel while in operation
2. Belt drive can be used to deliver a limited amount of power that is for higher power transfer, it is necessary to switch from belt to chain or shaft drives.

4. Shaft Drives:

Shaft based transmission system in a motorcycle contains a shaft, as suggested by the name. This shaft is placed parallel to the longitudinal axis of

the wheel. The output shaft of the gearbox is attached to a bevel gear arrangement (See Figure 4) which is used to change the power transmission orientation by some angle, in this case by 90 degrees. A universal joint is also used at the shaft to provide the flexibility to the shaft to perform up and down or the cross motion with the suspension during jerks. If this universal is provided then the shaft will get damaged or will break because of its hardness and property to not adjust with the up and down motion of the rear wheel. Another bevel gear arrangement of 90 degrees is also present at the rear wheel hub end so that shaft can transmit the power the rear wheel from the engine. Both the bevel gear may be present in an oil bath to provide continuous lubrication to the gear system.



Figure 4. Bevel Gear

The shaft which is used, is generally hollow, because of mechanical engineering aspect. A hollow shaft which same cross-sectional as of solid and of the same material, transmits more power or torque as compared to the solid shaft. Moreover, the hollow shaft does not have a whirling problem at high speed.

The efficiency of the shaft is about 75% which means there is a power loss of about 25% which is very high. This power occurs due to the extra gear arrangements and the presence of the shaft. The net weight of the system is also higher as compared to the other two drives that are chain and belt. This increase in weight also results in the increase of fuel consumption, reducing the efficiency of the motorcycle. The operational feature is much better of shaft drive as compared to the chain and belt drives, as it is very quiet and needs almost no maintenance, only the lubrication oil of the bevel gears present in the sump is needed to be changed at fixed interval of time.

4.1 Advantages of Shaft Drives:

1. These are very silent that means it does not produce much noise which makes the ride very comfortable and luxurious.
2. Shaft drive does not require any maintenance and can be used for over a

1,00,000 km of the ride. Most of the bikes do not have this much of lifespan, which means it could last forever. Only lubrication oil is needed to be changed at the prescribed time interval.

3. Shaft drive also increases the ground clearance of the bike that means more space for bumps and the obstacles in the path.

4.2 Disadvantages of Shaft Drives:

1. The shaft drives have a lower efficiency that is up to 75% or 80% and higher power loss of about 25%, this lower efficiency increases the fuel consumption of the bike.
2. The weight of the complete drive is higher as compared to another transmission system which also increases fuel consumption.
3. The shaft drive is not a compact drive and the manufacturing cost of the shaft drive is also higher, that is if broken or damaged then repairing cost is also very higher.

5. Tabled Comparison of Chain, Belt and Shaft Drives:

Parameters	Chain Drive	Belt Drive	Shaft Drive
Power Loss	3%	11%	25%
Weight	Medium	Low	High
Durability	Low	Medium	High
Cost	Medium	Low	High
Noise	High	Medium	Low
Power Transmission	Medium	Low	High
Maintenance	Medium	Low	Nil
Rebuilding (Approximate KM)	25,000 (With care 40,000 km max.)	60,000 to 90,000 km	1,50,000 km
Maintenance Interval (Approximate KM)	700-800 km	No Maintenance (Only Replacement if spoiled)	2000-2500 km (Only change of Lubrication Oil)

6. References:

1. Sclater, Neil. (2011). "Chain and belt devices and mechanisms." Mechanisms and Mechanical Devices Sourcebook. 5th Ed. New York: McGraw-Hill. pp. 262–277.
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