Bicycle braking systems

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The Kinetic potential energy that is present in a moving bicycle is converted in to 3 different forms of energy; heat, sound and light. This is done through the resistance of a wheel to move when a brake applies a frictional force against the spinning movement of a wheel. Three different types of brakes are generally used on bicycles today; the Caliper, Drum and Disk systems. These three popular braking systems have their own unique set of advantages and disadvantages that persuade the population to purchase them.

It is necessary for these brakes not to only perform well once, but over many instances, including moments of hard excessive braking. In today's modern bicycle, many things will affect the braking systems ability to be effective. The weather, wear and tear over many uses, as well as the type of braking taking place can all have adverse effects on brakes. Drum brakes are not the most popular style of brake for a bicycle. This could be accredited to their effectiveness over time compared to both caliper brakes and disc brakes. Drum Brakes are typically very heavy, complicated to perform maintenance on and are often subject to brake fading.

Break fading can be defined as the loss of braking force able to be exerted by the braking system at any point, and this often happens due to overheating as a result of consistent hard braking. Drum brakes are unable to dissipate heat anywhere near as efficiently as disc brakes as the frictional forces that turn kinetic energy into heat are all enclosed within the drum itself, which is often housed at the hub of the wheel. In fact, many companies have been forced to put warning labels on their hubs to make

sure children aren’t unaware of the heat generated, and subsequently burn themselves.

This makes them particularly susceptible to brake fading, something that both disk and caliper brakes don’t have a great problem with. In adverse weather conditions, the drum brake can show of its unique asset both the disc and caliper brake does not have. The Drum brake is fully enclosed, and therefore is not affected by rain, mud and other substances that may impede the frictional force exerted on the wheel. 12: Disc brake to be fitted to a Mountain Bike 12: Disc brake to be fitted to a Mountain Bike Disc Brakes are very popular on Mountain Bikes, which require thick wheels and are often subject to muddy terrain.

Because the disc brake is mounted to the hub, a certain clearance from the ground is maintained at all times, generally keeping mud from obstructing the pads and disc. If water is to get stuck under a disc brake’s pad, there are generally holes through which it can quickly escape so to not compromise the friction produced in the system. Touring bikes have been known to prefer disc brakes to types of caliper brakes, as the long journeys and significant use of brakes would not wear out the rim as they do using a caliper brakes system.

The typical Disc Brake system is a very adaptable structure as it can perform better than Caliper Brakes in the mud, rain andsnowas the coefficient of friction isn’t as at risk of contaminants disturbing the system. Disc brakes are also less prone to brake fading when subject to long periods of braking pressure, as they are very good at cooling down compared to drum and caliper brakes. A disk brake is also less likely to cause a popped tyre, with

the heat not being dissipated directly into the tyre as in caliper brakes. 14: Shimano Bicycle Caliper Brake 14: Shimano Bicycle Caliper Brake

Caliper Brakes are generally the most common of the braking system for the everyday bicycle. Excluding the original design quality of the equipment and materials, caliper brakes are often affected mostly by the moisture that is on the rim, as that will significantly hinder the ability to stop. Tyre thickness can also pose a problem to the caliper braking system, as the arms will be under greater flexion, thus lessening brake effectiveness. However, the Caliper brake system is effective on the average road bike and is the simplest and easiest to perform maintenance on of all three designs.

This system also has a very big ‘ mechanical advantage’, meaning very little effort has to be put in by the rider in order to properly apply the brakes. Caliper brakes are also by far the lightest and least expensive, making them popular among non-competitive riders, with most road bikes still come fitted with this system. Performance: The performance of a braking system is based on the raw stopping power and ability for one single use. This comparison will be based purely on stopping power and performance, disregarding things such as;

- Weight of system
- Weather/Terrain Brake Fading
- Heat Dissipation

The Disc Brake is said to have the greatest stopping power, and therefore provides least stopping distance, of all three systems. This means they are often fitted to competitive riders bikes, because they are often going a higher speed and therefore need the greater stopping power that the disc

brake provides compared to that of the drum and caliper braking system. In a report By Guy Kesteven for UK organization ‘ What Mountain Bike’, a variety of disc brakes were tested from many different manufacturers to test the power of each system.

The test was performed as follows: “ All the brakes were tested with a 180mm rotor and a 50Nm force on the lever (1N is the amount of force required to accelerate 1kg at 1m/s2), with the stock pads. To fully bed in the rotors and pads, the brakes were given 60 one-second pulls at 15km/h, followed by 30 two-second pulls at 20km/h. After a 30-second cooling-down period, the testing began. With the wheel spinning at 30km/h, each brake was applied for three seconds and then left to recover for 10 seconds. This cycle was repeated 15 times. The results were then averaged out to provide a single power rating. - Guy Kesteven; What Mountain Bike. After the test had been completed, the Formula R0 disc braking system had the greatest power of all 33 parts tested. It was found to have a power of 124 Nm when stopping, which is equal to 12. 645 kilogram-force meters. Caliper Brakes have one of the best designs in terms of their Mechanical Advantage. Very little effort has to be put in by the user to have the brakes perform as well as possible. Disc Brakes have an overall stopping power advantage over the general caliper brake, however some versions of the caliper brake have a greater stopping power than the drum brake design.

With the huge variety of designs in the field of Caliper Brakes, stopping power can range from quite poor to very high. An example of this stopping power is the test carried out by Matt Pacocha in the June 2009 edition of Velonews. A group of Bicycle Caliper brakes were to be tested to measure

their stopping power: “ This test was performed on a flat, windless road. For each brake, the rider accelerated to 40km/hr then grabbed the brakes — hard — on a pre-determined mark and recorded stopping distance.

This test was performed 10 times for each brake, and the stopping distances were averaged. ” – Matt Pacocha; Velonews. At the end of the test, the Shimano 7900 dual pivot caliper brake was found to have the greatest braking force, with the shortest stopping distance of 7. 18 meters. It was also found that the average deceleration of the bicycle was 8. 59 m/s2, whilst the greatest deceleration was recorded at 10. 35 m/s2 (Over 1 G-force). Drum Brakes are less powerful than the disc brake, and therefore have a greater stopping distance in normal, controlled conditions.

Compared to Caliper brakes it is not clear-cut which has a better stopping distance, as there are many different versions of each type of brake to choose from. However, it is said that the modern drum brake is able to provide a much smoother, more reliable deceleration than the majority of caliper brake systems. Features: Each of these braking systems have their own features which help to enhance the ability to stop the movement of a bicycle. Whilst some of these advantages are purely performance based, others may have features that are cost-effective or maintenance friendly.

One of the most important features in the success of the disc brake is its ability to dissipate the heat generated from the frictional forces. Disc brakes are out in the open air with a large surface area, meaning the cooling process happens more quickly and efficiently. Another important, yet perhaps underestimated feature of the disc brake is it’s positioning. Disc brakes are well away from the tyres and ground, thus creating distance

between the braking system and mud, dirt and other potential environmental interferences.

Drum brakes however, are certainly the best in resisting those environmental factors. As the braking mechanism itself is housed within a shell of sorts, no amount of weather can have an adverse effect on the ability of the drum brake to perform its task. Once installed, drum brake system is also very low maintenance, and often doesn’t have to be managed again until a new wheel is needed. Despite this, Drum Brakes can be a hassle if maintenance must occur, as they can be difficult to access because of the shell it is housed in. Caliper Brakes are generally the cheapest of the three designs available.

As they are often mounted to the bicycle at one single point, accessing the brake pads and cables is made much easier than the other systems. Another feature that is useful on the majority of road bikes with caliper brake systems is the quick release mechanism. This feature is designed as to loosen the brake system enough so the wheel can be removed without having to mess around with loosening brake cables as well. Materials used for construction and frictional components Brake Pads are perhaps the most important part of both the Disc and Caliper braking systems.

The brake pad is generally made from a product that possesses a moderately high coefficient of friction, but also depends on the materials ability to absorb and dissipate the heat produced in the process of braking. If these criteria can be met without having a negative impact on overall braking performance, an appropriate material has been found. In years gone by, an asbestos based compound was the most common material from which

brake pads would be made, however because of the toxic nature of asbestos that practice no longer allowed. The modern bicycle Brake Pad is enterally made from rubber compound. The rims on bicycles directly affect the performance of the Caliper braking Systems. Some bike rims today are made from an aluminum alloy, which provide a coefficient of friction when in contact with the rubber composite of the brake pads of approximately 0. 4. Other materials, such as various Carbon steels, have recently become more popular as they are light and aerodynamic. However, they do not provide a very good frictional force between the everyday brake pad, and so other materials are often preferred by the everyday cyclist.

Caliper brake systems also have brake cables that transfer the motion actuated by the rider from the brake lever to the braking system itself. These brake cables are made from thin wire steel that has been braided together to improve its tensile strength and ability to perform. The Disc in the Disk brake system is an integral part of the bicycles stopping power. The Brake pad (rubber composite) must have a high enough coefficient of friction when applied to the disc to halt movement with damaging the surface.

To provide this, the disc is made from metal, with stainless steel being popular among mountain bikes. A brake drum has an outer shell in which the braking system itself is contained. This outer shell is subject to weathering from the outside and heat from within. With this in mid, cast-iron is generally the material chosen as it can cope with these two burdens other materials could falter under. The shoes of the Drum brake are the parts that push outwards to produce the frictional forces needed in the brake design.

These brake shoes are generally made when two pieces of sheet steel are welded together. After they are welded together, the frictional material known as brake lining is connected on to the sheet steel with either adhesive resin or other means such as a rivet. It is also important to remember that the rubber composite of bicycle tyres also has frictional forces acting from the material it is rolling on. For instance, if a cyclist was riding along a concrete surface, the coefficient of friction would be 0. 8, much higher than that of rubber or brake lining to metal (0.). Thankfully, the relatively light weight of the human body - compared to the force exerted by our mechanical braking systems – allows us to still move along these surfaces. (FF = ? RN) How they differ from comparable car systems On most bicycles, the braking systems installed will often be very simplistic and just there to do the job. Most will have the same type of brake on both front and back wheel, with the braking of the bike mostly relying on human action with levers and cables, as well as the mechanical advantage some of these designs provide.

However, when upgrading these systems to work on a much heavier vehicle such as a car, many things can change. It is not uncommon to have different types of brakes on the front and back set of wheels, and hydraulics become a very important part of stopping your car. In today’s modern designs, at least one set Disk Brakes are fitted to almost every car on the road. Disk Brakes are the most effective type of braking system that we could fit to our cars, however, it is still common for the front brakes to be disk, but the rear to be drum brakes.

Drum brakes can be used as the parking brake, and by fitting them to the rear of the car, companies can savemoneyby not having to install another braking system. The Disc Brake in a car is obviously in a much larger scale than that of a bicycle. Despite this, the two systems are very similar in the basic design concept. Strength of this part however, must be much greater when installed in an Automobile. Winnard & Sons Ltd, a company based in the UK that deals with commercial vehicle braking components, has a guideline to the tensile strength on the brake contact surfaces of their products. Guideline tensile strength on test pieces machined from brake drum/disc contact faces: - 241 N/mm2 European Requirement minimum - 35, 000 psi Amercian Requirement minimum" - Winnard & Sons Ltd: Brake Disc and Brake Drum Material Specification The materials used in the brake pads of both the disk and caliper brakes are different when they are made for cars. When halting the momentum of a car, the brake pad is put under a much greater force than when stopping a bicycle. This is due to a number of things, including the speed at which the car is travelling and the mass of the vehicle, both of which are generally higher in cars.

The metals used are usually steel, copper or brass fibers, as well as a mixture of many different composites including – graphite, iron oxide, glass fibers, phosphate and rubber – that are bonded together with a resin of phenol formaldehyde. The metals that are added help to increase life p by improving the ability of the compound to dissipate heat at high speeds. The complexity of all three designs is greatly heightened when moving from bicycle to motor vehicle. One aspect of Motor Vehicle braking that creates extra pressure is the hydraulic action of the brakes.

Hydraulics rely on brake fluid, typically containing ethylene glycol, to transfer pressure from the controlling unit to the brake mechanism. In a motor vehicle, drum brakes often serve a specific purpose that they would be useless for when installed on a bicycle – the park brake. As I stated earlier, these Drum brakes are fitted to the rear wheels and can save companies significant amounts of money by not having to install a completely separate parking brake. As this asset of an emergency brake is vital to a larger system, not only are they more common in cars, but they must also be bigger and exert a greater force.

These three types of braking systems hold the same principles when applied to a greater size vehicle in amotor car, however many things must change to accommodate these increased forces. Conclusion: Each of these three braking systems are often used by a specific type of bicycle with a specific need. An example of this is Disc brakes being preferred by those who ride either Mountain or Touring bikes. As shown by the two field tests referenced in this report, completed by Velonews and What Mountain Bike, both Caliper brakes and disc brakes both have a very big potential to have immense stopping power.

But to have that stopping power, the proper materials with appropriate frictional forces would have had to been in place. At the absolute top of the line models, every little detail is considered, i. e:

- Weight
- Frictional Forces
- Materials
- Angle

- Type of System

It was also discovered that as we transition from bicycle to car braking systems, many things must be altered. Although the basic engineering principles are often the same, there are many variables that are altered to improve to braking systems to cope with the extra forces exerted by a motor vehicle.

For example, the change in materials of brake pads to accommodate the much more intense levels of heat being produced when heavy braking is taking place. I believethis report reveals that the braking system you own can make a big difference on effectiveness and performance. The features, materials used and frictional forces in play can all be positive or negative depending on the type of riding taking place. Recommendations: I recommend selecting one of these three types of braking systems based on what their use in the long run will be.

If you plan to use the bike for competitive purposes when increased stopping power is necessary, I would suggest purchasing a Disc brake system. However, if the bike is simply for leisure, perhaps the more cost effective Caliper Brake system would better suit. If you are planning to ride in muddy areas where the possibility of substances interfering with the frictional forces throughout the braking system, the fully enclosed drum brake system could be the appropriate option. However, if you wish to simply have the greatest overall stopping power, I would recommend a Disk Brake system be installed. The most important thing to remember is that every situation is unique, and to do research in order to attain the correct brake for your needs.