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Braking System of an All-Terrain Vehicle

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Abstract – *Brake system is vital for stopping or decreasing moving vehicle's speed. Hydraulic brake system is provided for All Terrain Vehicle that includes optimization of master cylinder and fixed caliper inputted in self customized outboard wheel. In the inboard brake system the brake discs are rigidly mounted on brake shaft or on drive shaft. The main advantage of using this braking technology is reduction of unsprung weight which improves handling and ride. The primary aim of this project is to show the utility and performance of the disc brakes with rear inboard braking system and to perform CAE analysis of brake discs used in braking system.*

Key Words: Brakes, Disc Brakes, Inboard Brake, Hydraulic Brakes, Brakes in ATV.

1. Introduction to ATV and It's Brakes

An ATV is the short-form of All Terrain Vehicle, which runs on as it name suggests all rough terrains. ATV consists of three or four nonlinear aligned wheels. The tires are kept in low air pressure to ensure optimum grip and shock absorbing capabilities of the vehicle even in off roads.

ATV comes in a single seater or a driver and a passenger seater variants. Some ATV also have a cage around the driver area which ensures driver safety in the case of a roll over.

Brake plays very crucial role in the performance of an ATV. Brake is a necessary mechanism used to decrease or to stop the speed of the vehicle by the means of friction. To generate this friction force various types of mechanisms are used although in every single one the heat energy is generated as the byproduct.

Working Principle: Most brakes commonly use friction between two surfaces pressed together to convert the kinetic energy of moving object into heat.

Friction brakes on automobiles store braking heat in drum brake or disc brake while braking then conduct it to the air gradually.

In modern vehicle the brake pedal is connected to the master cylinder rod with some leverage, when the brake pedal is pressed it pushes the master cylinder rod and the brake fluid carries the same pressure to the brake callipers through the brake lines. On the drum brake it is similar as the cylinder pushes the brake shoes against the drum which also slows down the vehicle.

1.1 Types of Brakes

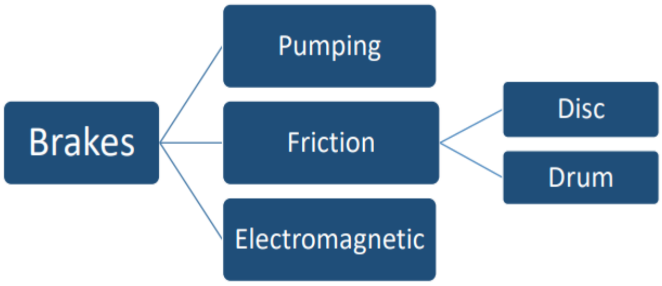


Fig -1: Types of Brakes

1.2 Friction Brakes

Friction brakes are most common and can be divided broadly into "shoe" or "pad" brakes, using an explicit wear surface, and hydrodynamic brakes, such as parachutes, which use friction in a working fluid and do not explicitly wear. Friction brakes means that pad/ shoe brakes and excludes hydrodynamic brakes, even though hydrodynamic brakes use friction.

Types of friction Brakes:

1. Drum brakes: This type of brake consists of a drum which houses the shoes connected with brake piston. When pushed the shoes expands and brakes the rotation of drum through friction force.

2. Disc brakes: A disc brake is a type of brake that uses calipers to squeeze pairs of pads against a disc or "rotor" to create friction. This action slows the rotation of a shaft, such as a vehicle axle, either to reduce its rotational speed or to hold it stationary. Heat energy is produced in this process which piles up as we brake frequently. Thus, disc should able to easily dissipate the heat energy.

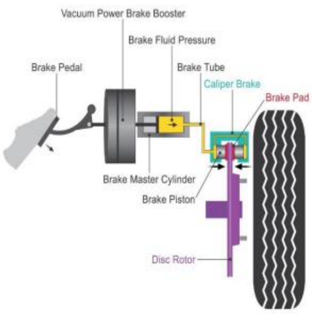


Fig 2. Disc Brake

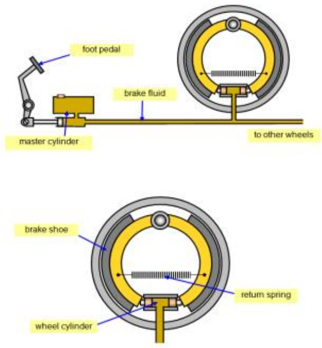


Fig 3. Drum Brake

2. Disc Brake

A Disc brake is a type of brake that uses calipers to squeeze pairs of pads against a brake disc to create friction. This action slows the rotation of wheel. Hydraulic disc brakes are widely used form of disc brake for motor vehicles.

Main components of Disc Brake:

Brake disc: It is the rotating part of a wheel's disc brake assembly, the brake pads apply friction force on this part.

Brake Caliper: It is the assembly which houses the brake pads and the pistons.

Aim of the project: The primary aim of the project is to show the utility and the performance of the brake system of an ATV with rear inboard braking system and to perform the CAE analysis of brake discs used in braking system.

Problem specification: Outboard configuration of braking is also a very efficient technique but the disadvantages of it are the brake lines, calipers, brake disc are exposed while mounting it in this configuration which lead to damage from obstacles such as rocks and often debris. It also required more space for the mounting of caliper's and ultimately it overall required more space for designing of wheel hub assemblies.

3. Design & Modeling of Brake Disc

3.1 Over view of Design:

The Braking system uses a front/rear split braking circuit. One master cylinder having bore diameter of 19.05 mm is used. Two fixed single piston calipers on front wheels and one dual piston floating caliper on the rear inboard disc is used. Bore diameter of front and rear brake caliper is 30 mm and 25.4 mm respectively. The brake calipers are connected to master cylinder through semi metallic brake lines which ensures no leakage of brake fluid.

3.2 Design Calculation:

3.2.1 Statics:

Weight of the vehicle (W) = m x g = 220 x 9.81 = 2158.2 N

Wheel base (L) = 25.4 x 54.14 = 1375.156 mm

Longitudinal distance of C.G. from front axle (L1) = 25.4 x 34.95 = 877.75 mm

Longitudinal distance of C.G. from rear axle (L2) = 25.4 x 19.19 =487.42 mm

The weight on front and rear axle in static condition can be calculated as,
Front axle static load (w1) = W x L2 / L
= 2158.2 x 487.42 / 1375.156
= 764.96 N

Rear axle static load (w2) = W x L1 / L
= 2158.2 x 877.75 / 1375.156
=1377.56 N

3.2.2 Dynamics:

Height of C.G. (h) = 25.4 x 22.46
= 570.49 mm

Co-efficient of friction between road and tires = 0.6

Radius of tire = (23/2) x 25.4
= 292.21 mm

Frictional force on vehicle (Ff) = µN =µmg = 0.6×2158.2
= 1294.92 N

Inertia Force due to deceleration (Fi) = m x d = 220×d
Ff = Fi
1294.92 = 220 x d
d = 5.887 m/s2
d/g = 0.6

Front axle dynamic load = wfd = {W(L2 + (d/g)h)}/L = {2158.2(0.487 + 0.6 x .570}/1.375 = 1302.17 N

Rear axle dynamic load = wrd = {W(L1 + (d/g)h)}/L = {2158.2(0.877 + 0.6 x .570)}/1.375 = 1914.76 N

Amount of frictional torque required on the wheels to stop the vehicle.

Frictional torque required at front wheels = Tf = µr x wfd x R = .6 x 1302.17 x .292 = 228.14 N-m
Frictional torque required at rear wheels = Tr = µr x wrd x R = .6 x 1914.76 x .292 = 335.36 N-m

3.2.3 Calculation for selecting Brake Disc:

Area of master cylinder bore (Amc) = ∏ 4 d 2 = ∏ 4 (19.05)2 = 285.02 mm2

Area of piston cylinder bore

For front caliper (Vespa) (Afc) = ∏ 4 df 2 = ∏ 4 (30)2 = 706.85 mm2
For rear caliper (Pulsar 150) (Arc) =2 x ∏ 4 dr 2 = 2 x ∏ 4 (25.4)2 = 1013.41 mm2

Pedal Ratio = 5:1
Pedal Force applied by driver = 350 N
Force at Balance bar = 350×5 = 1750 N
For Front Wheels:

Actuation force at master cylinder for front brakes = Force at balance bar x 0.5 = 1750 x 0.5 = 875 N

Pressure generated inside master cylinder = Force / Amc = 875 / 0.000285 = 3.07 Mpa

Force applied by caliper = pressure x Afc = 3.07 x 106 x 0.000706 = 2167.42 N

Clamping force = 2 x 2167.42 = 4334.84 N

Friction force applied by brake pad on rotor = Clamping force x μd = 4334.84 x 0.4 = 1733.93 N

Braking torque = Friction force x Effective radius of brake disc 114.07 = 1733.93 x Rdf
Rdf = 65.78 mm

Disc outer radius = (66+15) = 81 mm
Final disc diameter = 81 x 2 = 162 mm

For rear axle with inboard brakes:

Actuation force at master cylinder for rear brakes = 1750 x 0.5 = 875 N

Pressure generated inside master cylinder = Force / Area = 875 / 0.000285 = 3.07 Mpa

Force applied by caliper = Force x Arc = 3.07 x 106 x 1013.41 x 106 = 3111.16 N

Clamping force = 2 x 3111.16 = 6222.32 N
Friction force applied by brake pad on brake disc = Clamping force x μd = 6222.32 x 0.4 = 2488.92 N

Braking torque = Frictional force x effective radius of brake disc 167.68 = 2488.92 x Rdr
Rdr = 67.37 mm

Disc outer radius = (67.37+15) = 82.37 mm
Final disc diameter = 2 x 82.37 = 165 mm

Kinetic energy developed during braking:

KE = ½ mv^2
KE = ½ x 300 x $(11.11)^2$
KE = 13577.53 J

Total Braking energy / Heat required for the vehicle is equal to the total kinetic energy generated by the vehicle,
Thus (Qg) = 13577.53 J

Since assumption of 50-50 bias is made, this heat will be equally distributed in 4 wheels of the car, thus equally distributed in 4 brake discs.

So, heat generated in 1 brake disc, Qg = 3394.38

Now, the stopping time of the vehicle will be velocity/deceleration.
t = V/a
t = 11.11/5.887 = 1.88 s

Hence power generated in one brake disc,
P = Qg/t = 3394.38/1.88 = 1805.52 Watt

Hence we can calculate the heat flux

Heat flux for front brake disc = 4 x P/3.14 x (D_o^2-Di^2) = 4 x 1805.52/3.14 x (0.1632 -0.0552) = 97690.51 W/m^2

Heat flux for rear brake disc = 4 x P/3.14 x (D_o^2-Di^2) = 4 x 1805.52/3.14 x (0.1702 -0.0702) = 95834.39 W/m^2

3.3 Comparison of previous year's OEM brake disc & present year's brake discs:

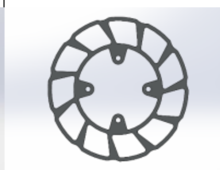
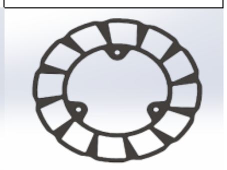
Previous year's OEM brake disc (Front & Rear)	Present year's brake disc	
	Front	Rear
		
Fig 6.	Fig 7.	Fig 8.
Inner dia. – 45 mm	Inner dia. – 55 mm	Inner dia. – 70 mm
Pitch circle dia. – 65 mm	Pitch circle dia. – 70 mm	Pitch circle dia. – 85mm
Outer dia. – 170 mm	Outer dia. – 163 mm	Outer dia. – 170 mm
Thickness – 3 mm	Thickness – 3.5 mm	Thickness – 3.5 mm
Weight – 425 gms.	Weight – 170 gms.	Weight – 179 gms.

Table 1: Difference between the OEM brake disc and our brake disc

4. Material selection of brake disc:

For cars, the most commonly used disc material is cast iron, because of its good friction properties, low cost, relative ease of manufacture and thermal stability.

Because of the significant reduction possible in the weight of the disc, Aluminium metal matrix composites (AMMC) with

SiC reinforcement is considered as a possible alternative to cast iron discs for cars. Although, Cast iron is cheaper then it, and is yet to be produced reliably in a large scale in mass production.

For motorcycles, stainless steel (SS 410 & 420) is the most commonly used material. They provide good resistance against corrosion, and can be induction hardened to increase the hardness for providing good wear resistance.

Racing motorcycles use carbon fibre discs. But, because this material requires high temperature to achieve the desired friction level, it cannot be used for normal motorcycles.

Property	SS 410	SS 420
Mechanical properties		
Density	7.7 gm./cm^3	7.7 gm./cm^3
Brinell hardness	190	190
Elongation at break	22%	8%
Fatigue strength	190 Mpa	220 Mpa
Shear strength	330 Mpa	420 Mpa
Ultimate tensile strength	520 Mpa	690 Mpa
Yield tensile strength	290 Mpa	380 Mpa
Thermal properties		
Thermal conductivity	30 W/mK	27 W/mK
Melting temp.	1530 ^{0}C	1510 ^{0}C
Thermal expansion	11 µm/mK	10 µm/mK

Table 2: Comparison between SS 410 and SS 420

5. Assembly of brake discs:

Front Assembly:

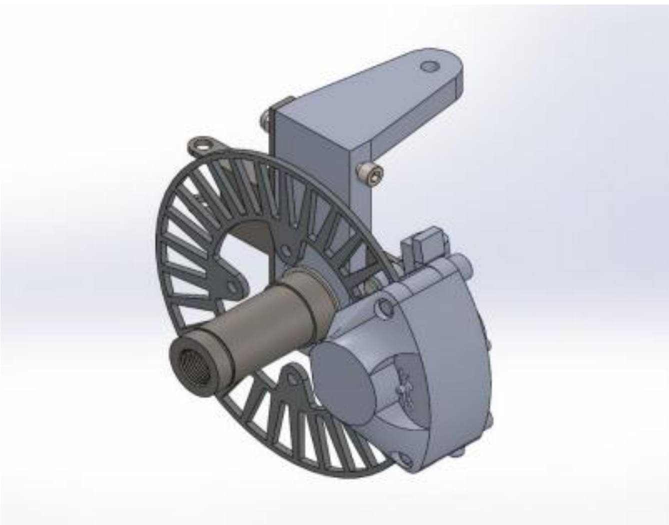


Fig- 4: Brake disc and Caliper mountion on Knuckel

Rear Assembly with inboard brakes:

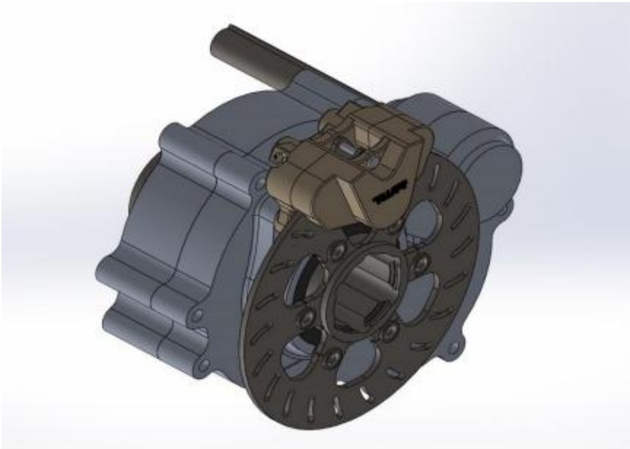


Fig- 5: Brake disc and caliper mounted on gearbox output shaft

3. CONCLUSION

Outboard configuration of braking is also a very efficient technique but the disadvantages of it are the brake lines, calipers, brake disc are exposed while mounting it in this configuration which lead to damage from obstacles such as rocks and often debris. It also required more space for the mounting of caliper's and ultimately it overall required more space for designing of wheel hub assemblies. While in inboard configuration the brake disc is mounted on the final drive. Brake discs are mounted directly on the output shaft or the brake shaft rather than the wheel hub, this configuration is called Inboard brake system. Hence by using inboard braking configuration with proper design calculation and modelling of brake disc we can avoid above problems of outboard configuration. As inboard configuration is very effective it reduces the weight of the braking system and reduces manufacturing cost & time. The main advantage of using this braking technology is reduction of unsprung weight which improves handling and ride

REFERENCES

[1] Aman sharma, Prakhar Amrute, Suryakant Singh Thakur, Jatin Shrivastav, Design, Analysis and fabrication of braking system with rear inboard brakes, IRJET, 2018.

[2] Richard Gardner, Disc brake caliper and mounting structure, US3910385A, 18/04/1974.

[3] Tatsuya Matsuura, Brake system layout for ATV, US6478103B1, 27/04/1999.

[4] Hitoshi Takeuchi, Brake disc, US7575107B2, 10/12/2007.

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