

An Investigation on Failure of Automotive Components in Cars

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Abstract – Failures do occur in every industrial component. It is about the nature of the component, the failure occurs often or periodically or rarely. Replace of automotive components do occur often and the cause for such replacements tends to be none other the failure of the component. Replacements can be preventive or breakdown. This research work focuses in identifying the modes of failure in various automobile components and tends to identify suitable methods to avert such replacements. Though methods cannot be devised to avert completely the replacement, there are methods that when implemented could prolong the period of use of the component in the system. Modes of failures have been classified and a cause analysis has been performed.

1. INTRODUCTION

Each and every component has a unique role to play in the automotive system. In cars, the scenario is even more crucial as the components in cars not just owe for the transmission and transport but also do play a role in luxury. Even the SUVs (Suburban Utility Vehicle) that look like station wagons, now preferred by families, are now considered cars. Suzuki has recently introduced the concept of LUVs (Life Utility Vehicles) and it is also on the run. Though it may be a conventional ‘to be called car’ or a SUV or a LUV, failures occur in components. Major components that have listed substantially replaced often are as follows [1]

1. Clutches
2. Brake Calipers.
3. Wheel Cylinder
4. Master Cylinder
5. Tires
6. Shocks and struts
7. Brake Pads
8. Spark Plugs.
9. Belts
10. Water Pumps

Preventable maintenance will cause no harm as the component will just be replaced with a new one or will be worked on with. In other categories, breakdown failure of components may sometimes lead to severe disastrous happenings. Accidents happen often due to sudden failure of components, especially components that are involved in

transmission systems. Hence it is an engineer’s duty to prevent such failures that cause a loss of soul.



Fig -1: Car met with an accident due to brake failure in Canada, 2014 [2]

2. FAILURE ANALYSIS IN CLUTCHES

Major component of a clutch system include (a) Clutch flywheel (b) Pressure Plate, (c) Clutch Disc, (d) Throw out clutch bearings and release system

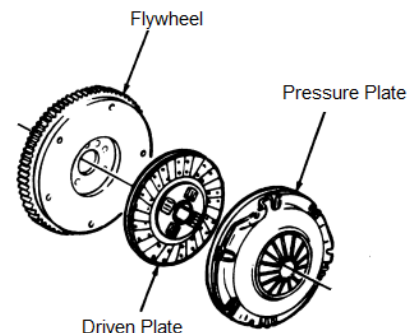


Fig -2: A Typical Clutch system [3]

An analysis in the clutch system in a TATA vehicle [4] shows that the driven plate faces failure due to heavy cyclical loading. Analysis results have shown that the failure in the side plate of the driven plate is possible only when the maximum value of stress is near to the endurance limit. To avoid such failures, the thickness of the side plate can be increased and also the fillet thickness can be increased. Irrespective of the type of clutch the factor of safety must also be well above the limits [5] to put the stresses under the safer limits. Clutches have to be properly adjusted and must be properly lubricated to avoid failure [6]. Another research work [7] has identified crack

formation areas in clutches and has observed that the side plate is more vulnerable. As the side plate has a number of slots for the damping springs to engage, a crack is formed in the engagement. Hence to avoid such failures, the design should be modified so as to increase the factor of safety taking into consideration the operating stresses.

A research work [8] has analyzed the failure mechanism in clutches. It has been observed that the brittle intragranular failure mechanism is the most dominant mode of failure in this case. Also the propagation of the crack originated from the middle of the plate and towards the front and back of the plate. It can be observed that in various failure analyses conducted [6-9], the factor of safety of a safer operation is well above 1.5 and upto nearly 3 in certain cases. Hence it can be considered that the factor of safety in design also plays a major role in the failure of the clutch

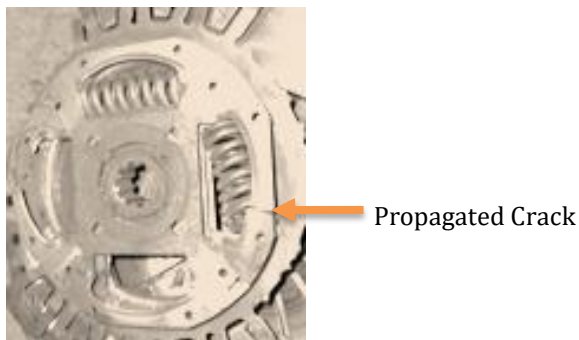


Fig -3: A Typical Clutch Failure

Jovan et al [10] devised a fault tree analysis for the failure analysis in clutches. From the fault tree analysis it can be inferred that due to the clutch pull, pressure disk failure can be due to the following:

1. Buckling
2. Surface Damage
3. Tilting

A lot of issues have been discussed in the research work, and from the research work the modes of failures can be classified as:

1. Failures due to improper maintenance
2. Non Preventable Failure
3. Failures due to improper operation
4. Progressive Failures

The failures reported from the fault tree [10] have been visualised in Fig.4. Also several research works are reporting that the failure of the clutch directly throws light on the reliability of the system. Hence it is of high importance that a regular preventive maintenance to be done. Some measures to prevent clutches from early failure can be taken from the driver itself.

1. Avoiding unnecessary shifts in gear.
2. Change in gear must be smooth and quick.

3. Avoiding parking with gears. Use Hand Brake for parking
4. Always shift to neutral while in standby.

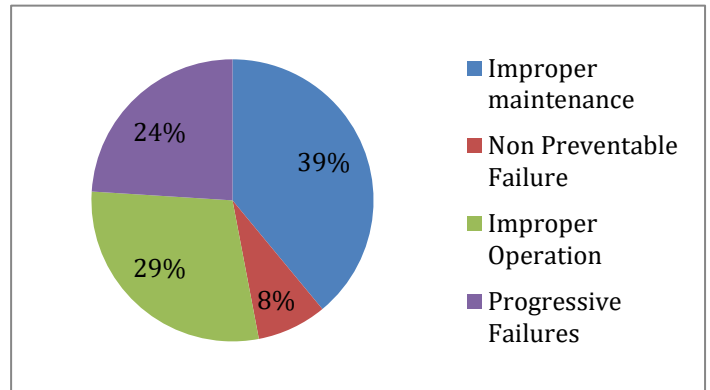


Fig -4: Distribution of Clutch Failures

3. FAILURE IN BRAKE CALIPERS

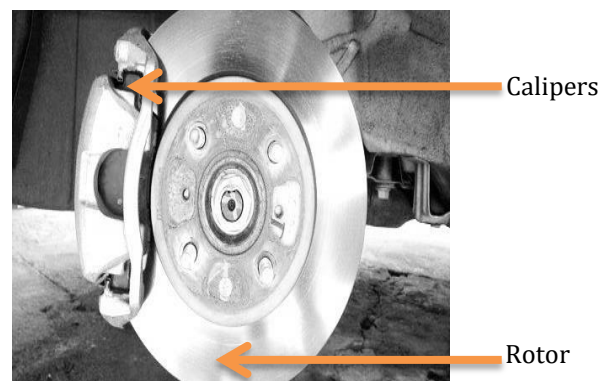


Fig -5: A typical brake caliper [11]

Brake calipers are the vital components in any disc brake assembly. In a disc brake the rotor speeds in controlled by created by a caliper that creates a source of friction between itself and the rotor. Brake pads engage itself in the process creating friction.[12]

One of the most important causes of failure is the fluid leak in the braking system. The fluid leak is prevented by the soots and seal. Due course of operation, heating of braking systems will cause wearing of the seals, causing fluid to leak and the brake caliper to fail. Calipers have to be operated at an optimum fluid pressure. Hence the fluid system plays an important role.

Another important failure in the disc brake caliper is that the seizure of the piston of caliper. The main causes of seizure are:

1. Piston corrosion.
2. Caliper boot damage.
3. Moisture between bore and piston

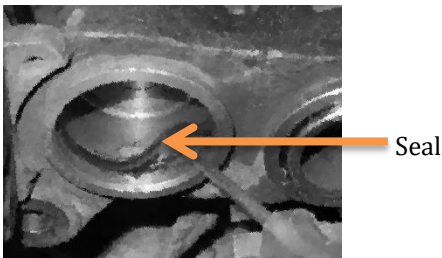


Fig -6: Inspection of Seal in Brake Caliper

4. FAILURE IN WHEEL CYLINDER

The wheel cylinder proves its worth in association with a drum. The rear wheel cylinder is to be properly checked for erroneous operation for as to prevent any sudden failures. The fluid pressure is equally distributed to front wheel caliper systems and the rear wheel cylinder drum cylinder

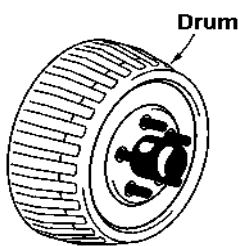


Fig -7: A Typical Brake Drum

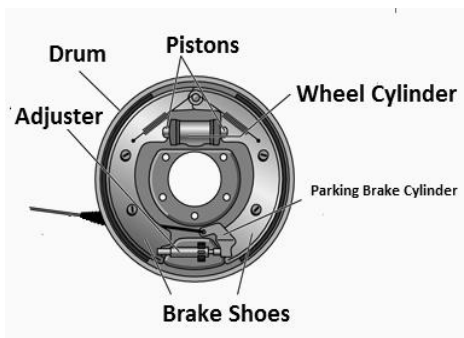


Fig -8: Illustration of rear wheel cylinder and brake shoes

The main reason for replacement of wheel cylinders is the fluid leak. Fluid leaks have to be properly checked on. Contaminants on the brake shoes will also aid the faster deterioration of the performance of the rear wheel cylinder. Wheel cylinder cups also cause failure to a certain extent. The cylinder bore may in due course of time be worn out, pitting, scorching discolored and this required immediate honing. If the wearing out is high, then the entire system has to be replaced. Push on boots will also have to be checked for failures and must be accordingly acted with. Though boots, contaminants account for minor failures, the major failure and

replacement is due to the fluid leak and hence it has to be taken care of. Preventive maintenance will be better in this case than having a sudden failure of the component.

5. FAILURE IN MASTER CYLINDER

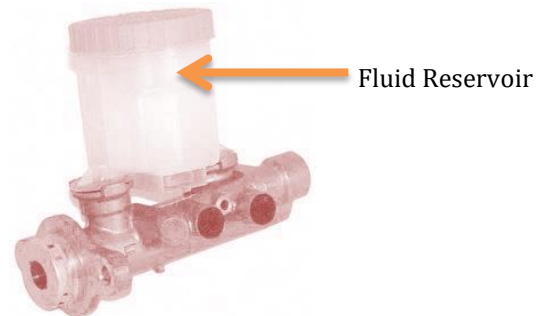


Fig -9: A typical brake master cylinder

A brake master cylinder is framed to be the most vital component in a fluid braking system as the pressure applied by the brake pedal is transmitted to the brake fluid lines through the master cylinder. Some of the symptoms of a master cylinder failure are as [13]:

1. Improper behavior of brake pedal
2. Master Cylinder Sensor indication in cabin
3. Brake fluid contamination

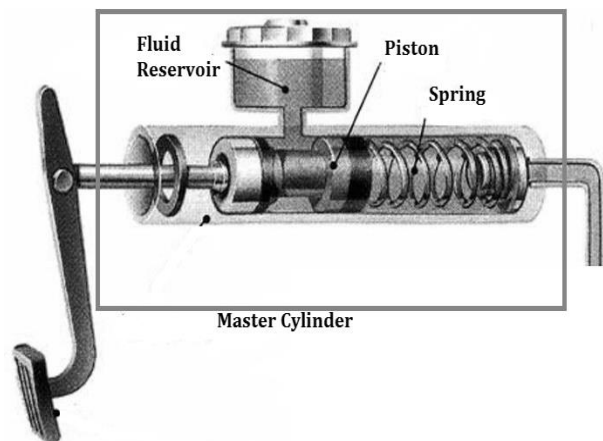


Fig -10: Working of a Brake Master Cylinder

In a typical brake master cylinder, the reservoir is generally of plastic and the plastic reservoir is coupled with the metal part using grommets made of rubber. Deterioration or weakening of such grommets will also be a source of failure in brake master cylinder. Some of the sources of failure in master cylinder are:

1. O-rings in cylinder may get damage and leak fluid.
2. Metal Fluid lines to the master cylinder may rot and cause fluid leak.
3. Brake fluid pressure has to be set in the right optimum level

4. Cylinder wear.
5. Low pedal level due to worn linings.
6. Caused misalignments.

6. FAILURE IN TIRES

Tires are the most crucial components in any automobile as it directly meets the road and responsible for the traction. Any damage in the tire will directly affect the stability of the vehicle and also the allied system. Sudden failure of tires will definitely cause accidents especially in highways.

One of the most important causes of failure of tires is under inflation of tires. When tires are under inflated, it will definitely increase the rolling resistance of the tires and hence the fuel economy of the vehicle will also get affected. On the contrary, overloading will also reduce tire life. Tires should be properly checked for their load rating and should be properly matched with the load. If they do not comply, tires must be upgraded to a higher rating. Over and under inflated tires are shown in Fig.12

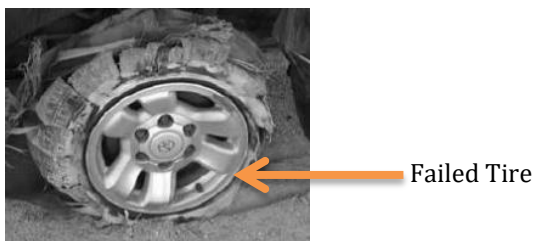


Fig -11: A typical tire failure

Penetration of any foreign object with the tires will cause a leak in the tires and hence any constant leakage must be immediately rectified and the tire must be replaced. Tires are made of rubber and when the rubber treads break or dislocate the rubber will begin to crack. This will happen in due course of operation when the tire is used for a prolonged period that it should be.

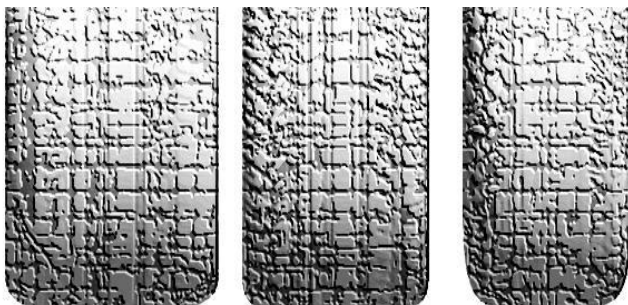


Fig.12 (a) Under inflated tire (b) Right Inflation (c) Over Inflation

Other factor that will account for tire failure is as follows;

1. Misaligned tires
2. Unnoticed wears
3. Damage due to impacts
4. Tears and prominent cuts.

7. FAILURE IN SHOCKS AND STRUTS

In order to maintain a state of contact between the tire and the road, it is of necessity that a system is present to put on road the tires despite the ups and down on the road surface. General types of shock absorbers for the purpose include:

1. Telescopic Type
2. Spring seated Type
3. Strut Type

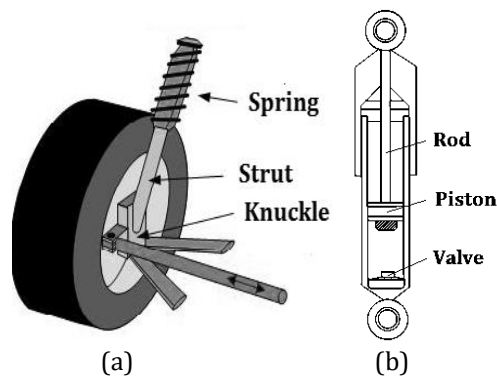


Fig.13 (a) Strut Suspension (b) Conventional Suspension

In a failure analysis research work[14], it has been proposed that some of the causes of premature failure is as:

1. Misalignment of ring and piston-rod
2. Welded nugget not positioned correctly
3. Contamination of welded surfaces.

A research work [15] has proposed that plastic deformation mode of failures take place in the central area of tube bottoms. In McPherson suspension system, an impulsive load will cause a brittle rupture that will propagate itself [16]. A researcher [17] has developed a fuzzy logic for the sprung mass and this mathematical modeling is found to be efficient for the case.

The shock absorber valves too undergo failures. A research work has modeled the fretting failure in the shock absorber valves [18]. Fretting failures occur due to an oscillatory motion happening due to two mating surfaces when applied with cyclical loading or impact. This research work has identified that contact between the washer and disc is the main reason behind this type of failure. Some of the other failure modes include:

1. Wearing of piston seals
2. Busing damage
3. Oil leakage
4. Breakage of rod seal of shock absorber
5. Dent in a body.

8. FAILURE IN SPARK PLUGS

Spark plugs are the most important component in any SI Engine system. The combustion phenomenon depends on this spark plug and also the time of ignition. The time of combustion and quality of combustion depends also on the performance of the spark plug.

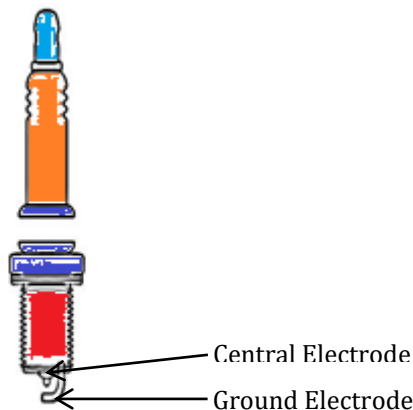


Fig -13: A Typical Spark Plug

Failure does occur in sparkplugs. Advancing of ignition timing will cause overheating of the spark plug which will make the tip deteriorated. If the heating exceeds the acceptable limits, then melting will also occur. If gasoline used in the engine has exceeding quantity of lead in it, then definitely erosion, corrosion and sometimes oxidation of the electrodes will occur leading to premature failures.

Researchers [19] have devised a Spark Plug and Magnetic Field (SPMF) technique which will diagnose the failure modes of spark plug and will have a preventive maintenance impact. Some of the important parameters related with the failure detection of spark plugs are Risk Priority Number (RPN) and Detection rating [19, 20]. It is also proven that iridium electrodes will improve spark plug life [21].

If spark plugs are deteriorated the fuel economy is well decreased and will cause incomplete combustion and also will have a rough idling. Oil contamination and carbon deposits due to the fuel can also cause premature failure of spark plugs too. Certain mechanical parameters will also cause failure of spark plugs. Spark plugs must be rightly torqued. Under torqued spark plugs will not make the right contact with the clearance zone of the combustion chamber and moreover it will also be a reason for improper combustion, causing rise of temperatures in the cylinder which will be further source of knocking, detonation and other harmful events. Hence proper positioning of the

spark plug is necessary. Other damages that occur in spark plugs generally are:

1. Damage in the threads
2. Depositions
3. Ceramic Punctures
4. Electrode wears
5. Widening of electrode gap

9. FAILURE IN DRIVE BELTS

A drive belt is responsible for the transmission of power from the engine to auxiliary systems such as air conditioner, power steering and other system that will require input power. It is an important component that the belt failure will completely stop the transmission of power to such systems.

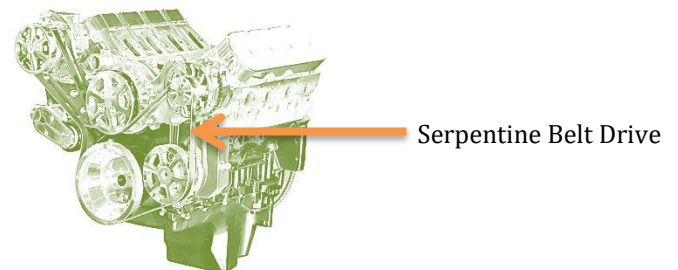


Fig -14: Drive Belt

Some of the failures that can occur in the drive belt system are:

1. Misalignment of belt pulleys
2. Belt slipping
3. Improper handling
4. Foreign object accumulation between belt and sprocket.
5. Improper belt tensioning
6. Rotation of belt teeth causing tearing

10. FAILURE IN WATER PUMPS

Water pump plays an inevitable role in the automobile engine's cooling system as the sole purpose of this is to circulate the coolant through the engine's cooling system. Any failure in the water pump will affect the performance of the engine.

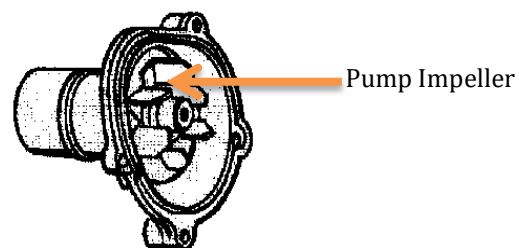


Fig -15: Automobile Water Pump

Water pumps do fail prematurely. Some of the failures that occur in the automobile water pump are:

1. Cavitation in Pumps
2. Bearing Failure
3. Fluid Leakages
4. O-ring failures
5. Corrosion due to oxidation
6. Improper alignment
7. Breaking of shafts
8. Failure of seals

Many researches are being undertaken to improve the efficiency of the pump.

11. FAILURE IN BRAKE PAD

Brake pads are the components that come in contact with the rotating body creating friction and lower the speed of the vehicle. Of course, brake pads do fail. The major reason for the failure of brake pads is the overheating of brakes and creation of hotspot that will thin the brake pads. Failure of brake pad reflects the failure of the braking performance.

Bad brake boosters also cause failure of brake pads to an extent. Brake pad failures can be easily diagnosed by lower pedal, squeaking noise.

12. CONCLUSION

This article has discussed various failure modes occurring in various automobile components. Failures will do occur, and they are unavoidable. But proper maintenance can make the component perform better for its stated period of time. It is due to improper preventive maintenance that we lose souls in accidents that occur due to sudden failure of any component. Though, an engineer's view may be on the physical performance of the component, it is definitely for human life. Failure of components can be compromised but not the human life. The article also stresses on the importance of preventive maintenance of automotive components.

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The authors dedicate this article to every soul that has been lost in accidents due to ignorance in vehicle maintenance. The authors also dedicate this article to all engineers who work hard in the betterment of human life safety in vehicles.

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