ISSN 2395-1621

Radiator Pressure Cap

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ABSTRACT

Internal combustion engines, produce high-temperature gases at high pressures to drive certain components of the engine. Because internal combustion engines are high heat atmospheres, cooling systems must be employed to ensure they don't start a fire or explode. In vehicles, the radiator is used to keep the engine cool enough to continue to function. Coolant that has absorbed some of the heat from the engine passes through the radiator where it is cooled using a fan. A radiator is essential to ensuring that a vehicle doesn't overheat and coolant levels need to be checked and adjusted periodically so that the radiator has something to cool. Because radiators require coolant to be added when the level gets too low, they feature a cap on top that is easily accessible. This cap allows vehicle owners to quickly add coolant when needed and allows pressure to escape the radiator. Radiator caps contain a spring-loaded plunger that diverts the excess coolant into the overflow tanks when the cap's maximum pressure is reached. In addition to diverting the coolant, the spring inside the cap allows pressure to be released from the radiator when the cap reaches its maximum pressure.

ARTICLE INFO

Article History

Received :29th February 2016

Received in revised form :

1st March 2016

Accepted : 4th March 2016

Published online :

6th March 2016

Keywords- Radiator, Pressure Cap, Cooling of IC Engine

I. INTRODUCTION

The car's radiator acts as a heat exchanger, transferring excess heat from the engine's coolant fluid into the air. The radiator is composed of tubes that carry the coolant fluid, a protective cap that's actually a pressure valve and a tank on each side to catch the coolant fluid overflow. In addition, the tubes carrying the coolant fluid usually contain a turbuletor, which agitates the fluid inside. This way, the coolant fluid is mixed together, cooling all the fluid evenly, and not just cooling the fluid that touches the sides of the tubes. By creating turbulence inside the tubes, the fluid can be used more effectively. One way to help prevent a coolant boiling is to use a radiator pressure cap that uses pressure to change the temperature at which water boils. The pressure cap is similar to the safety valve found on a kitchen pressure cooker. The pressure cap seals the operating cooling system forcing the hot pressurized coolant to carry approximately 50 more degrees of heat than the normal boiling point of water. Pressure cap is a relief and recovery valve used in engine cooling system. It is normally fitted on radiator, pressure cap assembly primarily consists of two parts:

a) Pressure valve – this has a set predetermined pressure rating. it opens up in case of system pressure exceeds the set value and allows passage for pressure relief.
b) Vacuum valve – this valve ensures that coolant from no loss tank is sucked back in cooling system
in case the pressure inside the cooling system goes below atmospheric pressure (Partial vacuum).Caps are designed to ensure that the prescribed pressure on the cooling system is maintained at all times during operation by allowing air to escape in case of overpressure. They should therefore be considered "the safety valve" of the cooling system.

PROBLEM STATEMENT

A radiator cap is used to keep water or coolant inside of the radiator but it is also in place to relieve pressure if the temperature of the coolant is too high. When the pressure inside the radiator is too high it can become a very dangerous situation. The radiator cap, which is spring loaded, will rise to release the excess pressure. If the radiator cap begins to fail the car can overheat frequently.

The following article will explain how to troubleshoot the most common issues associated with a failing radiator cap.

2.1 Worn or Damaged Seals

A radiator cap is typically fitted with a seal on the underside of the cap. The seal is often made out of rubber which can stand up to the heat generated by the radiator. The seal works as a sort of stopper which prevents water or coolant from overflowing out of the radiator. If the coolant or water is being heated to a boil and flowing out of the radiator then chances are the seals on the radiator cap are damaged.

2.2 Stuck or Jammed Plunger

As the water or coolant boils it becomes compartmentalized within the radiator. This helps to prevent the radiator from overflowing or having the radiator cap exploding off of the radiator. Once the coolant or water reaches the radiator cap it rises from the radiator which allows the coolant to flow to another chamber. If this is not happening then chances are that the spring on the cap may be stuck or jammed.

2.3 Rust and Corrosion

Since the radiator is either filled with water or a chemical coolant the radiator cap will become rusty over time. It can also corrode over time due to other chemicals. When the radiator cap comes rusted a lot of things can go wrong. The coolant or water can boil over, the plunger can stick due to a bad spring or it will no longer create a tight fit.

II. SCOPE

The radiator cap is an integral part in the working of automobile often referred as heart of engine is designed to seal the cooling system to prevent coolant loss, maintain pressure within the cooling system and raise the boiling point of the coolant. The function of radiator cap is to vent the pressure that builds up in a radiator due to overheated coolant fluid. Radiator caps contain diverts the excess coolant into the overflow tanks when the cap's maximum pressure is reached. It also allows pressure to be released from the radiator when the cap reaches its maximum pressure.

III.LITERATURE REVIEW

Polish-born Russian, businessman, Franz San Galli invented the heating radiator in St. Petersburg during 1855-1857. His invention was taken up by the wealthy Victorians although the Radiator sensation in Great Britain really took off during the early 20th century. Although there are earlier beginnings of radiator development in the 1830's the concept we see today is mostly based on designs by the inventive Americans, Joseph Nason and Robert Briggs in around 1863 with later design additions of the cast iron 'Bundy Loop' by another American, Nelson H Bundy in 1872. All the radiators of the day were run by steam, rather than hot water today. Steam works at great pressures hence all early radiators were fitted with steam valves which might suddenly release their steam should the pressure rise too much.

Later Karl Benz patented the first radiator in 1885. Benz used his invention on the horseless carriage, which boiled away gallons of water every hour to cool the engine. The honeycomb radiator was invented by Wilhelm Maybach and was used in the Mercedes 35 hp. Early radiators, even those manufactured as late as the 1970s were constructed from copper and brass because they were deemed the best metals for the job.

Aluminium, which is much lighter than copper or brass, was chosen because it distributes heat well and is less expensive than copper and brass.

Although aluminium was the preferred radiator material from the 1970s through the 1990s, the copper industry began making a comeback in the radiator market in the 1990s. They developed a lighter, more durable, and stronger radiator design to compete with the aluminium radiators then in favour. In addition to being more durable and comparable in weight to their aluminium counterparts, copper radiators are more resistant to corrosion and are less expensive to repair.

IV.RADIATORS

Radiators are heat exchangers used for cooling internal combustion engines, mainly in automobiles but also in piston-engine aircraft, railway locomotives, motorcycles, stationary generating plant or any similar use of such an engine.

Internal combustion engines are often cooled by circulating a liquid called engine coolant through the engine block, where it is heated, then through a radiator where it loses heat to the atmosphere, and then returned to the engine. Engine coolant is usually water-based, but may also be oil. It is common to employ a water pump to force the engine coolant to circulate, and also for an axial fan to force air through the radiator.

In vehicles, the radiator is used to keep the engine cool enough to continue to function. Coolant that has absorbed some of the heat from the engine passes through the radiator where it is cooled using a fan. A radiator is essential to ensuring that a vehicle doesn't overheat and coolant levels need to be checked and adjusted periodically so that the radiator has something to cool.

A radiator helps excess heat, contained in the vehicle's coolant fluid, escape into the environment, cooling down the engine so that it can work properly. The fluid, which is contained in tubes that run throughout the engine, passes through the radiator, where it is cooled using a fan. The liquid inside the tubes is agitated using a turbulator in most engines so that the fluid is cooled evenly. If the turbulator was not used, the coolant closest to the outside of the tubes would cool while the liquid in the center of the tubes would remain hot.

Coolant that is overheated expands. As it enters the confined space of the radiator, it expands even further, creating even more pressure. Excess pressure is released via the radiator cap, which acts as a pressure valve. When the pressure builds up above a specific point, the radiator cap vents the pressure and the excess coolant spills into the radiator's coolant reservoirs. Once the coolant in these tanks has a chance to cool down, it is recycled into the cooling system.

In automobiles and motorcycles with a liquid-cooled internal combustion engine, a radiator is connected to channels running through the engine and cylinder head, through which a liquid (coolant) is pumped. This liquid may be water (in climates where water is unlikely to freeze), but is more commonly a mixture of water and antifreeze in proportions appropriate to the climate. Antifreeze itself is usually ethylene glycol or propylene glycol (with a small amount of corrosion inhibitor).

A typical automotive cooling system comprises:

A series of channels cast into the engine block and cylinder head, surrounding the combustion chambers with circulating liquid to carry away heat;

A radiator, consisting of many small tubes equipped with a honeycomb of fins to convect heat rapidly, that receives and cools hot liquid from the engine;

A water pump, usually of the centrifugal type, to circulate the liquid through the system;

A thermostat to control temperature by varying the amount of liquid going to the radiator;

A fan to draw fresh air through the radiator.

The radiator transfers the heat from the fluid inside to the air outside, thereby cooling the fluid, which in turn cools the engine. Radiators are also often used to cool automatic transmission fluids, air conditioner refrigerant, intake air, and sometimes to cool motor oil or power steering fluid. Radiators are typically mounted in a position where they receive airflow from the forward movement of the vehicle, such as behind a front grill. Where engines are mid- or rear-mounted, it is common to mount the radiator behind a front grill to achieve sufficient airflow, even though this requires long coolant pipes. Alternatively, the radiator may draw air from the flow over the top of the vehicle or from a side-mounted grill. For long vehicles, such as buses, side airflow is most common for engine and transmission cooling and top airflow most common for air conditioner cooling.

V. RADIATOR CONSTRUCTION

Automobile radiators are constructed of a pair of header tanks, linked by a core with many narrow passageways, giving a high surface area relative to volume. This core is usually made of stacked layers of metal sheet, pressed to form channels and soldered or brazed together. For many years radiators were made from brass or copper cores soldered to brass headers. Modern radiators have aluminium cores, and often save money and weight by using plastic headers. This construction is more prone to failure and less easily repaired than traditional materials.

6.1 Honeycomb radiator tubes

An earlier construction method was the honeycomb radiator. Round tubes were swaged into hexagons at their ends, then stacked together and soldered. As they only touched at their ends, this formed what became in effect a solid water tank with many air tubes through it. Some vintage cars use radiator cores made from coiled tube, a less efficient but simpler construction.

6.2 Coolant pump

Radiators first used downward vertical flow, driven solely by a thermo-syphon effect. Coolant is heated in the engine, becomes less dense, and so rises. As the radiator cools the fluid, the coolant becomes denser and falls. This effect is sufficient for low-power stationary engines, but inadequate for all but the earliest automobiles. All automobiles for many years have used centrifugal pumps to circulate the engine coolant because natural circulation has very low flow rates.

6.3 Heater

A system of valves or baffles, or both, is usually incorporated to simultaneously operate a small radiator inside the vehicle. This small radiator, and the associated blower fan, is called the heater core, and serves to warm the cabin interior. Like the radiator, the heater core acts by removing heat from the engine. For this reason, automotive technicians often advise operators to turn on the heater and set it to high if the engine is overheating, to assist the main radiator.

6.4 Car engine thermostat

The engine temperature on modern cars is primarily controlled by a wax-pellet type of thermostat, a valve which opens once the engine has reached its optimum operating temperature.

When the engine is cold, the thermostat is closed except for a small bypass flow so that the thermostat experiences changes to the coolant temperature as the engine warms up. Engine coolant is directed by the thermostat to the inlet of the circulating pump and is returned directly to the engine, bypassing the radiator. Directing water to circulate only through the engine allows the temperature to reach optimum operating temperature as quickly as possible whilst avoiding localised "hot spots." Once the coolant reaches the thermostat's activation temperature, it opens, allowing water to flow through the radiator to prevent the temperature rising higher.

Once at optimum temperature, the thermostat controls the flow of engine coolant to the radiator so that the engine continues to operate at optimum temperature. Under peak load conditions, such as driving slowly up a steep hill whilst heavily laden on a hot day, the thermostat will be approaching fully open because the engine will be producing near to maximum power while the velocity of air flow across the radiator is low. (The velocity of air flow across the radiator has a major effect on its ability to dissipate heat.) Conversely, when cruising fast downhill on a motorway on a cold night on a light throttle, the thermostat will be nearly closed because the engine is producing little power, and the radiator is able to dissipate much more heat than the engine is producing. Allowing too much flow of coolant to the radiator would result in the engine being over cooled and operating at lower than optimum temperature, resulting in decreased fuel efficiency and increased exhaust emissions. Furthermore, engine durability, reliability, and longevity are sometimes compromised, if any components (such as the crankshaft bearings) are engineered to take thermal expansion into account to fit together with the correct clearances. Another side effect of over-cooling is reduced performance of the cabin heater, though in typical cases it still blows air at a considerably higher temperature than ambient.

The thermostat is therefore constantly moving throughout its range, responding to changes in vehicle operating load, speed and external temperature, to keep the engine at its optimum operating temperature.

On vintage cars you may find a bellows type thermostat, which has a corrugated bellows containing a volatile liquid such as alcohol or acetone. These types of thermostats do not work well at cooling system pressures above about 7 psi. Modern motor vehicles typically run at around 15 psi, which precludes the use of the bellows type thermostat. On direct air-cooled engines this is not a concern for the bellows thermostat that controls a flap valve in the air passages.

6.5 Airflow control

Other factors influence the temperature of the engine, including radiator size and the type of radiator fan. The size of the radiator (and thus its cooling capacity) is chosen such that it can keep the engine at the design temperature under the most extreme conditions a vehicle is likely to encounter (such as climbing a mountain whilst fully loaded on a hot day).

Airflow speed through a radiator is a major influence on the heat it loses. Vehicle speed affects this, in rough proportion to the engine effort, thus giving crude self-regulatory feedback. Where an additional cooling fan is driven by the engine, this also tracks engine speed similarly.

Engine-driven fans are often regulated by a viscous-drive clutch from the drivebelt, which slips and reduces the fan speed at low temperatures. This improves fuel efficiency by not wasting power on driving the fan unnecessarily. On modern vehicles, further regulation of cooling rate is provided by either variable speed or cycling radiator fans. Electric fans are controlled by a thermostatic switch or the engine control unit. Electric fans also have the advantage of giving good airflow and cooling at low engine revs or when stationary, such as in slow-moving traffic.

Before the development of viscous-drive and electric fans, engines were fitted with simple fixed fans that drew air through the radiator at all times. Vehicles whose design required the installation of a large radiator to cope with heavy work at high temperatures, such as commercial vehicles and tractors would often run cool in cold weather under light loads, even with the presence of a thermostat, as the large radiator and fixed fan caused a rapid and significant drop in coolant temperature as soon as the thermostat opened. This problem can be solved by fitting a radiator blind to the radiator which can be adjusted to partially or fully block the airflow through the radiator. At its simplest the blind is a roll of material such as canvas or rubber that is unfurled along the length of the radiator to cover the desired portion. Some older vehicles have a series of shutters that can be adjusted from the driver's or pilot's seat to provide a degree of control. Some modern cars have a series of shutters that are automatically opened and closed by the engine control unit to provide a balance of cooling and aerodynamics as needed.

6.6 Coolant pressure

Because the thermal efficiency of internal combustion engines increases with internal temperature, the coolant is kept at higher-than-atmospheric pressure to increase its boiling point. A calibrated pressure-relief valve is usually incorporated in the radiator's fill cap. This pressure varies between models, but typically ranges from 9 to 15 psi (0.621 to 1.03 bar; 62.1 to 103 kPa).

As the coolant expands with increasing temperature, its pressure in the closed system must increase. Ultimately, the pressure relief valve opens, and excess fluid is dumped into an overflow container. Fluid overflow ceases when the thermostat modulates the rate of cooling to keep the temperature of the coolant at optimum. When the engine coolant cools and contracts (as conditions change or when the engine is switched off), the fluid is returned to the radiator through additional valving in the cap.

6.7 Engine coolant

Before World War II, engine coolant was usually plain water. Antifreeze was used solely to control freezing, and this was often only done in cold weather.

Development in high-performance aircraft engines required improved coolants with higher boiling points, leading to the adoption of glycol or water-glycol mixtures. These led to the adoption of glycols for their antifreeze properties.

Since the development of aluminium or mixed-metal engines, corrosion inhibition has become even more important than antifreeze, and in all regions and seasons.

VI. RADIATOR CAP

The radiator cap is designed to seal the cooling system to prevent coolant loss, maintain pressure within the cooling system and raise the boiling point of the coolant. Radiator caps are manufactured to a predetermined pressure rating, utilizing either metal or plastic design, and are suitable for use on sealed recovery or open non recovery vehicle cooling systems.

7.1 The Purpose of a Radiator Cap

The main purpose of a radiator cap is to vent the pressure that builds up in a radiator due to overheated coolant fluid. Radiator caps contain a spring-loaded plunger that diverts the excess coolant into the overflow tanks when the cap’s maximum pressure is reached. In addition to diverting the coolant, the spring inside the cap allows pressure to be released from the radiator when the cap reaches its maximum pressure.

7.2 Recovery Caps (double seal)

In a sealed or recovery cooling system the recovery radiator cap (double seal) allows coolant to flow to and from the recovery or expansion tank, maintaining the integrity of the cooling system. In a correctly operational recovery cooling system, coolant checks are only required at recommended service intervals as the coolant is maintained within the system.

7.3 Non Recovery Caps (single seal)

The open or non recovery cooling system does not have a recovery or expansion tank; the non recovery radiator cap (single seal) allows the release of coolant and the return of air to the cooling system. The non recovery cooling system requires regular coolant checks and replacement to ensure the system does not run dry.

NOTE: A recovery radiator cap (double seal) may be used on a non recovery system, however a non recovery radiator cap cannot be used on a recovery cooling system.

7.4 Safety Lever Radiator Caps

Safety Lever Caps are suitable for both performance and mining applications preventing scalding and burns during cap removal.
This cap has an inbuilt lock where the lever must be lifted prior to turning to enable the cap to be removed. Safety lever caps feature a stainless body and brass pin to conform to mining requirements. The cap contains no aluminium components.

VII. FUNCTION

In the normal position both the pressure and vacuum valves of the cap remain closed. The pressure in the cooling system rises as the temperature rises. When the pressure begins to exceed the caps rated pressure, the pressure valve opens releasing pressurized coolant from the radiator into the recovery or expansion tank. The pressure valve closes as the excess cooling system pressure reduces. The cycle of opening and closing the pressure valve continues, maintaining the appropriate system pressure and protecting cooling system components from over pressurization. As the system cools down cooling system pressure reduces, creating negative cooling system pressure. Negative pressure can cause radiator tanks and hoses to collapse leading to damage to the cooling system. To prevent damage, radiator caps have an additional vacuum valve to allow coolant or air to return to the radiator as the pressure reduces. This serves a dual purpose of allowing the cooling system pressure to equalize as well as allowing coolant to return to the radiator.

VIII. CONCLUSION

The pressure cap is a relief and recovery valve used in engine cooling system normally fitted on radiator. It is designed to ensure that the prescribed pressure on the cooling system is maintained during the operation of engine. Thus it acts as a heart of the engine which controls the high pressure and temperature generated. It maintains the proper flow of control of heat avoiding overheating of engine. Also, when negative pressure is created it allows the coolant to flow from the vacuum valve to return to the radiator. But since the radiator is either filled with a chemical coolant the radiator cap gets corroded with time. The seals on the radiator cap get damaged when the coolant is being heated at boiling temperature for longer duration. At times, the pressure cap explodes off the radiator if it can't sustain the rising pressure. This is overcome by materials that have high withstanding capacity at higher temperatures. Hence, the pressure caps prove to be an essential valve in the safety of IC engine which prevents overheating and thus increasing its life.

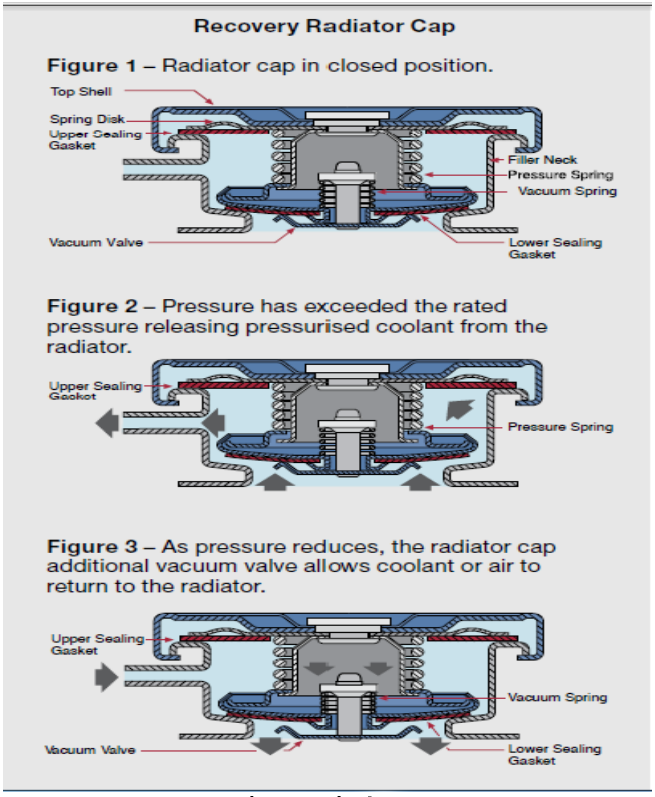

Fig. function of radiator cap

ACKNOWLEDGEMENT

It is my privilege to express deep gratitude to everyone who has rendered valuable help in presenting this dissertation work. I would like to express my sincere gratitude to my guide Prof. M. Deshmukh for whom I have greatest amount of respect and admiration. He has not only afforded me the opportunity to work on this topic but also provided valuable guidance and support throughout my time as a student in Mechanical Engineering Department, ISB&M School of Technology, Pune. His enthusiasm, interest and inspiration, was a constant source of motivation for my encouragement.

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