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Design and Development of Fuel Tank Caps according to Emission Standards Adopted by Regulating Authorities

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Abstract - *Automotive components are always designed in such a way that it do not harm the environment while fulfilling the basic functional requirement for what it is expected to do in actual service and for achieving this a reasonable margin of safety is to be taken according to engineering standards. Few decades ago, emissions of dangerous fumes in the environment was taken leniently and by the time as emissions engendered with increasing number of vehicles on road, regulating authorities took strict action. This article reiterates and discusses the impact of Emission Standards developed by international regulating authorities on Fuel Tank Caps for two-wheeler vehicles over the years. The Emission Regulations for the pollution control brought many changes in the design and implementations of the fuel tank caps. To emphasize the importance of these changes many detailed statistical data about evaporative systems that are acceptable have been discussed precisely. Few of the environmental standards and norms governed by the law holder of different countries have also been discussed in this study. The whole study has been articulated after the literature survey and is solely focused on Fuel Tank Filler Caps and confers about its future trends. It also elucidates some functional aspects of the working of the fuel tank cap. Finally, a design study of fuel tank cap has been discussed to illuminate working of the mechanism used to maintain pressure inside the fuel tank cap and monitor the evaporative losses from the fuel tank according to safety and environmental norms.*

Key Words: Fuel Tank Cap, Evaporative Emissions, Hydrocarbons, Emission control

1. INTRODUCTION

Right back from the Stone Age when the first wheel was discovered humans have been using many different types of modes of transport and in this new era two-wheelers are the most widespread mode used for transportation. According to the data from the reports of Ministry of Statistics & Programme Implementation, India in 2015, India alone has a staggering number of 154,297,746 two-wheeler vehicles registered which amounts to more than 73% of total vehicles registered in the country [4].

However, while these two-wheelers do provide the ease in maneuverability in difficult traffic situations but they also contribute to air pollution to a large extent. The major percentage of the vehicle on the road is two-wheeler more than any other type of vehicle on the road and contributes to a large chunk of pollution. There were many amends made to control pollution from bigger vehicles but certainly not on a two-wheeler which has made them accentuate the pollution much more than any other type of road vehicle collectively. There are many other alternative fuels used in bigger vehicles like CNG and LPG but two-wheeler mostly still run on petrol and diesel. There are some options as electric bikes but it has not received expected reception in south Asian market which is the major buyers of two-wheelers.

There are four different sources from which a gasoline-powered two-wheeler can escalate atmospheric pollution: the exhaust pipe, the carburetor, the fuel tank and the crankcase. The contribution of pollutants, according to sources are Evaporative loss (from the carburetor and the fuel tank) is 15 to 25% of hydrocarbons, Crankcase blowby gives rise to 20 to 35% of hydrocarbons and Exhaust pipe contributes with 50 to 60% of hydrocarbons and almost all of the carbon monoxide and nitrogen oxides [1].

The Evaporative Losses are the losses in which raw vapours of gasoline escapes into the atmosphere through an engine fuel system. Evaporative losses occur from two major sources carburetor and fuel tank. Fuel tank losses also are due to two reasons i.e. first during the refueling vapours that escape or by vaporisation of the gasoline in the fuel tank which pushes out hydrocarbon vapours through breather vents.

Fuel tanks are now incorporated with filler caps that have pressure valves these pressure valves release the vapours into the atmosphere in a controlled way. To do this work certain standards according to the country's pollution norms have been set up. In India, two-wheelers are still

running on BS IV which has to be changed to BS VI by 2020 that includes a lot of control measures on evaporative losses [9]. It induces the need of allowing only 1.5 gm/test of hydrocarbons escape which of earlier 2 gm/test [7].

2. EMISSION STANDARDS

There has been much work done for a sustainable future but much work is still needed to be done to ensure a greener and safer environment. For fortifying the future, some legal requirements have been set up by governments of different countries according to different implementation standards [10]. The United States has made its own legal laws under Environmental Protection Agency (EPA). However, some federal laws allow the state of California to implement its own firm standards. These standards are a set by the California Air Resource Board (CARB).

United Kingdom follows emission standards regulated by European Union termed as EURO. The first EU standard EURO 1 was implemented back in 1992 which rendered catalytic converter necessary. The latest implemented standard is EURO 6 in 2014.

Bharat Stage Emission Standards are the pollution control norms for automobile set by Government of India. First mass emission norms that were implemented dates back to the year 1991 and on 19 February 2016 the MoRTH (Ministry of Road Transport and Highways) jumped BS V and decided to implement BS VI for vehicles in major cities manufactured after April 2020. This implementation will align Indian standards with the European ones [11]. Many countries like China, Germany, Israel, Turkey and Hong Kong implements Euro or equivalent norms to govern the pollution controls standards.

3. EVAPORATIVE LOSSES IN FUEL TANK

Fuel tank losses also are due to two reasons, first while refueling vapours that escape directly and second by vaporisation of the gasoline in the fuel tank which pushes out hydrocarbon vapours through breather vents. When the atmospheric temperature is low, it also cools down the fuel tank and this induces air to be sucked in termed as breathing in of the air. While the vehicle operates, the temperature rises a lot or in the hot atmosphere also the temperature inside the fuel tank rise which forces it to breathe out while this process with air Hydrocarbon vapours are also pushed out of the tank. This happens due to an increase in vapour pressure and thermal expansion inside the fuel tank of the vapours [1].

In a partially filled open fuel tank, the equilibrium is maintained between partial pressure of liquid and partial pressure of the vapours. If due to any reason the temperature rises the vaporisation starts to restore the equilibrium. As more and more vapour accumulates the total pressure of the tank increases and the vapours are pushed out. The breathing out of vapours drastically increases if not only the liquid but vapours also are heated. These losses depend on many variables like:

1. Mode of vehicle operation
2. Tank capacity and amount of fuel in it
3. The volatility of the fuel in the tank
4. Design of the fuel tank
5. Position of the fuel tank with respect to the systems that produce heat.

4. FUEL TANK CAPS

Fuel tank cap is one of the most basic but essential part of the fuel system in any vehicle. It helps to retain the fuel inside the fuel tank. It acts as a valve which regulates the pressure inside the fuel tank. As the years have passed the simple fuel tank cap has turned into a complex part which needs special design consideration to work in accordance with the norms set up. It is the only part of the fuel system which is approachable directly unlike any other part of the system.

Fuel Tank Caps serves many functions which are hidden from layman's eye. It acts like a valve which regulates the pressure of the fuel tank it seals of vapours of hydrocarbons and saves much fuel from evaporating into the atmosphere. It is used for proper controlled emission of hydrocarbon vapours into the atmosphere according to the norms of a specific country. It regulates the pressure by releasing fuel vapours when the pressure gets high inside the tank and breathes in the air when pressure is low in the tank. It also discharges electrostatic charge on the human body.

Classification of the fuel tank caps are generally done on two bases first is on type of mounting and second on its breathing mechanism.

4.1 On the basis of the Mounting on the Fuel Tank:

a. ***Bayonet Type Caps*****:** These types of caps are connected directly on the opening of the filler neck which is attached to the fuel tank. It is easy to remove while preventing any massive fuel leakage.

b. ***Hinge Type Caps*****:** These types of caps are directly attached to the fuel tank and hinged upon it.

c. ***Push Types Caps*:** These are the most easily detachable caps available. It can be easily mounted or detached from the tank by applying axial force on the cap.

d. ***Screw Type Caps:*** These types of caps as the name suggest can be attached to the filler neck just by screwing it.

e. ***Cable Actuated Tank Cap*:** These types of caps have a connecting rod, lever, cable and spring assembly attached to it. The cable pulls the lever and actuates the cap.

4.2 On the basis of the Breathing Mechanism:

a. ***Vented Fuel Filler Caps*:** These caps are equipped with special breather valve so that it can be used on non-ventilated fuel tanks. This breather valve is a check valve which is used for venting air.

b. ***Non-vented Fuel Filler Caps*:** These caps have no breathing mechanism and are used with a fuel tank which already incorporates.

c. ***Regulated Fuel Filler Caps:*** These caps equipped with regulated breather valves for controlled release of high pressure due to vapours of hydrocarbons and also regulated suction of air to maintain the pressure in a specific range.

5. FUEL TANK CAPS OVER THE YEARS

5.1. Early System

Over the years fuel tank caps have gone through a very drastic change especially in the two-wheeler sector. Its purpose and functions have altogether added up over the years. For a very long-time fuel tank caps were just considered as a plug that separate outer atmosphere from the fuel, saves it from rain and dust etc. Most of the times these caps were just metallic covering with no other function. It was later when it was understood that the pressure outside the fuel tank and inside it needs to equalize so some of these caps started to come out with vented holes.

5.2. Introduction Valves

The most weighted factors that influenced the changes in the design of the fuel tank caps were the safety and environment issues. Safety concerns with keeping fuel away from situations like fire. The environment concerns with the pollution and contamination from the fuel vapours which are due to thermal expansion inside the tank.

From the early 1970s major concern over the two aforementioned issues started engendering changes in the design of the fuel tank cap [5]. Many problems like fuel loss due to impact and rollover were tackled during this period itself. Over many years continued changes and growth in the fuel tank cap design took place. Many countries started to implement laws and norms over many different kinds of emissions from the automobile. According to the California Regulations on Evaporative Emissions & Onboard Refuel Vapour Recovery from the mid-1970s to the mid-1990s, the norms of evaporative losses were more than 50% stricter [6]. This swayed many changes like:

- Easier attachment of caps with filler neck was a concern.
- An accurate sealing mechanism was introduced.
- The material was also taken into consideration so that any kind off deterioration can be avoided.
- Most importantly a better, accurate and safe venting system was introduced. Which led to the introduction of many valves in the design of the F.T. Caps, namely:

  i. Pressure release valve
  ii. Overpressure valve
  iii. Suction valve

5.3. Onboard Diagnostics System

It is a system developed to govern the various system integrated into the vehicle to establish that each system is working in good condition and under the allowed limits of expelling of the pollutants. It was first introduced in the 1980s and then improved by the Society of Automobile Engineers (SAE) & International Standardisation Organisation (ISO) and was named OBD II. This OBD II system tests the fuel tank and illuminates any problem in it. It is done by either pressurising the system or creating a vacuum and even if there is slight change it detects and warns about potential leakage. All new Fuel tank caps were to be designed in accordance with the OBD II system even a slight design error or leakage from sealing deems the fuel tank cap a failure.

6. DESIGN STUDY OF REGULATED FUEL FILLER CAPS

The operation mode, diurnal temperature changes and many other factors substantially affect the evaporation losses. When the tank temperature increases the loss increase. These regulated fuel filler caps are equipped with

a regulated breathing valve used generally on the non-ventilated fuel tanks. These caps have regulated check valve for the controlled release of the high-pressure fuel vapour from the tank and regulated check valve for controlled suction of the air from the outside atmosphere when the pressure level decreases in the tank. The vapours that are vented out from a partially filled tank during vehicle operation called soak, is a mixture of air and hydrocarbon. These vapours are harmful to the environment. The suction valve only lets the air in when the pressure in the tank is under a significant predefined value so that the tank does not draw a vacuum hence keeping the vapours inside. This not only prevents the escape of the vapours but also prevents further evaporation of the harmful fuel vapours by maintaining the equilibrium of the pressure and eventually stopping the thermal expansion. Some of the working condition and pressure of the fuel tanks are as follows [12]:

- Normal Condition 0.01~0.05bar
- Crash Condition 0.1~0.2bar (If the pressure is in this range the overpressure valve should not release the soak).
- Overpressure valve starts when the pressure reaches 0.3bar or greater [12]

When the pressure inside the tank increases in normal conditions the pressure release valve opens as the soak enters the fuel tank cap through the cover and is diverted to the canister which is used to contain the soak for these conditions.

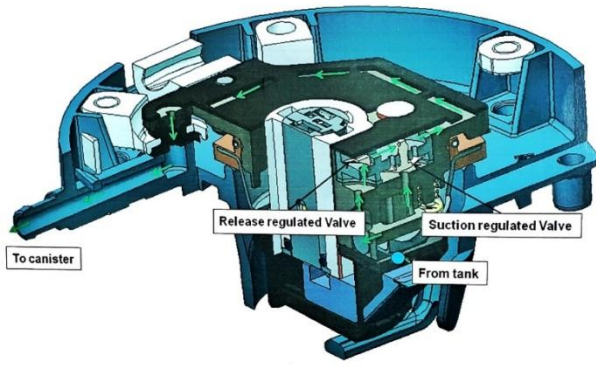

Fig 1. Fuel Tank Cap Breathing Out

When the pressure reduces and creates the condition of the vacuum, the soak/air is sucked from the canister. The suction valve opens and the soak/air is allowed to enter the tank hence creating pressure equilibrium.

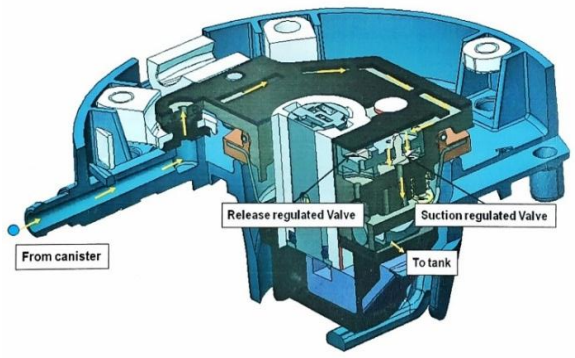

Fig 2. Fuel tank Cap Breathing In

In case of a crash, the release of the volatile vapours is generally avoided so that if the crash has created any fire it should not spread much. However, in some cases the pressure increases to a limit that it is dangerous to contain it in the fuel tank so it is released via overpressure valve in a controlled way.

7. FUTURE ASPECTS

Fuel tank cap has been changing exponentially in terms of design and uses from its inception. There is much work done now in term of safety and environmental issues. Even a cap-less fuel system is being discussed so that the evaporative losses can be fully removed, but its feasibility is in the far future. Some other thoughts are being poured into the inclusion of the cooling system in the filler cap assembly. Nowadays many high-end bikes have incorporated canisters which separate the carbon from the vapours and send that to the intake manifold occasionally. This reduces the contaminants expelled by the fuel tank to the atmosphere. But the new cooling system will condense any hydrocarbon vapours produced inside the tank and hence reducing the pollutants as well as maintaining the pressure inside the tank [2].

8. CONCLUSION

With ever-changing safety and environment norms and continuously advancing technology we will be seeing countless changes in the design and features of the Fuel Tank Caps that we see and use now. With each country leapfrogging many standards and jumping to the most strict and robust norms, we are sure to witness many changes in the near future itself. Inclusion of OBD has made it more important to follow these norms or the public will be directly aware if any compromises are being made in terms of safety and environmental issues. All these variables and transparencies has compelled the manufacturers to be complacent with these norms or even beyond them.

REFERENCES

[1] Internal Combustion Engine by M.L. Mathur, R.P. Sharma Chapter 20 Air Pollution.

[2] United States Patent, Patent No.: US 6,439,277 B1, Date of Patent: Aug. 27, 2002

[3] ICCT (2014) Bharat Stage IV Emission Standards for Two-Wheelers in India. http://www.theicct.org/policyupdate-bharat-stage-iv-emission-standards-two-wheelers-india.

[4] Ministry of Statistics & Programme Implementation, Government Of India http://mospi.nic.in/statistical-year-book-india/2017/189

[5] Evolution of Fuel Caps http://www.stant.com/index.php/english/products/consumer-products/caps/evolution-fuel-cap/

[6] California Regulation on Evaporative Emissions and Onboard Refueling Vapor Recovery: Title 13, California Code of Regulation 1976 & 1978

[7] Indian Emissions Regulations, ARAI the Automotive Research Association of India. https://www.araiindia.com/pdf/Indian_Emission_Regulation_Booklet.pdf

[8] Vehicular Emission Norms, Ministry of Road Transport & Highways, Government of India. http://www.indiaenvironmentportal.org.in/category/22804/publisher/ministry-of-road-transport-and-highways/

[9] Policy Update, India Bharat Stage VI Emission Standards, International Council On Clean Transportation. https://www.theicct.org/sites/default/files/publications/India%20BS%20VI%20Policy%20Update%20vF.pdf

[10] Emission Standards https://en.wikipedia.org/wiki/Emission_standard

[11] The Gazette of India, Ministry Of Road Transport & Highway, REGD. NO. D. L.-33004/99

[12] Leak Testing of Components (Fuel Tanks) https://products.inficon.com/getattachment.axd/?attaName=Leak-testing-fuel-DEF-tank