

Solutions to Reduce Environmental Pollution with Active Crank case ventilation System

Son Do Khac¹, Truong Nguyen Quang²

*University of Transport and Communications, Hanoi, Vietnam¹
Central Transport College N^o.3, Ho Chi Minh City, Vietnam²*

Submitted: 10-08-2022

Revised: 20-08-2022

Accepted: 22-08-2022

ABSTRACT: Emission standards are one of the driving forces behind many technological changes in the automotive industry. 20% of all hydrocarbons emitted in passenger cars are caused by gaseous crankcases. The active crankshaft box ventilation system (active crankcase ventilation system) removes unwanted gases from the crankcase of the internal combustion engine. The system usually consists of a hose, a check valve and a vacuum source (such as an intake manifold). Unwanted gases are gases from the combustion chamber that leak through the bamboo shoots. The original engines released these gases into the atmosphere as they simply leaked through the crankcase seals. The first crankshaft box ventilation system was a tube that used a partial vacuum to draw gases and release them into the atmosphere. The active positive crankcase ventilation (PCV) system – first used during the Second World War and present on most modern engines – returns the crankcase gas to the combustion chamber, to reduce air pollution.

Keywords: Crankshaft box ventilation system, PCV, PCV valve, air pollution

I. INTRODUCTION

Until the beginning of the 20th century, gas escaped from the crankcase by leaking through seals and washers. Oil leaking from the engine and dripping into the ground is considered normal, as this has also happened to steam engines in previous decades. The gaskets and shaft seals are intended to limit the leakage of oil, but they are not usually expected to be able to completely prevent that. The incoming gases diffuse through the oil and then leak through seals and gaskets into the atmosphere, causing air pollution and odors.

This system works very effectively in removing crankcase vapors that are harmful to the engine. Just like previous engines, the pipeline system also produces pollution and unpleasant odors. [1] The

pipe may become clogged due to snow or ice, in which case the crankcase pressure will rise and cause oil leakage and gasket failure. [2]

On slow-moving delivery vehicles and boats, there is often no suitable gas flow for draft pipes. In these situations, the engine uses positive pressure at the exhaust pipe to push the gas out of the crankcase. Therefore, the air intake is usually located in the airflow behind the cooling fan of the motor. [1] The gas crankcase escapes into the atmosphere through an air duct. Active crankcase ventilation system.

II. HISTORY

Although the current purpose of an active positive crankcase ventilation system is to reduce air pollution, the original purpose was to allow the engine to operate underwater without water leakage. The first PCV systems were built during the Second World War, to allow tanks to operate in underwater enclosures, where conventional suction ventilators would allow water to enter the crankcase and destroy the engine. [3]

In the early 1950s, Professor Arie Jan Haagen-Smit suggested that pollution from automobile engines was the main cause of the smog crisis in Los Angeles, California. [4] The California Motor Vehicle Pollution Control Board (the predecessor of the California Air Resources Board) was established in 1960 and began studying how to prevent direct emissions into the atmosphere. [5] The PCV system is designed to recirculate gases into the intake air so that they can be combined with fresh air/fuel and burned more completely. In 1961, California regulations required all new cars to be sold with PCV systems, thus, representing the first deployment of vehicle emission control equipment. [6]

By 1964, most of the new cars sold in the U.S. were equipped by the industry's voluntary operation so as

not to have to create multiple state-specific versions. Pcv is quickly becoming standard equipment on all vehicles worldwide because of its benefits not only in reducing emissions but also in terms of engine internal cleanliness and oil life. [1] [7]

In 1967, a few years after it went into production, all U.S. auto companies agreed not to cooperate in smog control activities for a period of ten years. [number 8] In the decades since, laws and regulations on vehicle emissions have been fundamentally tightened. Most gasoline engines today continue to use PCV systems.

III. ACTIVE CRANKCASE VENTILATION SYSTEM

1.1. PCV VALVE

There have been many studies on the flow of PCV valves prominent among them by author Choi Yoon-Hwan [11]. Currently, the material of PCV valves for cars is made up of carbon steel, and several types of vehicles are being developed and commercialized using materials using plastic materials. PCV valves made of plastic are known to have superior noise and service life during fabrication or operation compared to carbon steel materials, and it is believed that in the future, Pcv made of plastic materials will be the number one choice. Research on PCV valves conducted so far has been mainly on carbon steel materials, and the flow rate of the valves according to the flow field and the difference in crankcase pressure inside PCV valves made of carbon steel have obtained results. However, this study did not interpret all valve operations according to pressure differences, and the characteristics of the valves were analyzed assuming a near-normal state.

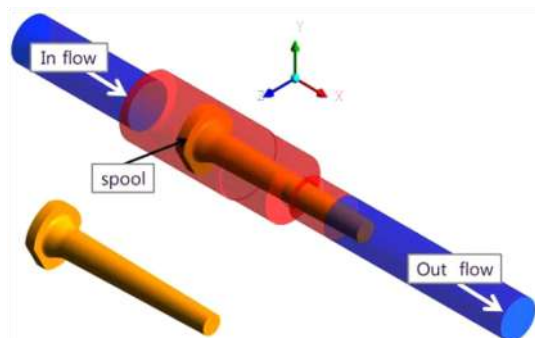


Fig. 1. Flow direction and shape of the PCV valve

The drive structure of the PCV valve is as shown in Figure 1 of the valve mouth. The flow force is applied to the spool by the pressure difference at both ends of the PCV valve, causing

the spool to move in the direction of the outlet, and the outlet flow rate to change as the cross-sectional area of the inner hole changes with the displacement of the spool. In numerical analysis, the valve core tube is moved by the difference between the total pressure and viscous force of the flow and the elastic force generated by the deformation of the flow control spring.

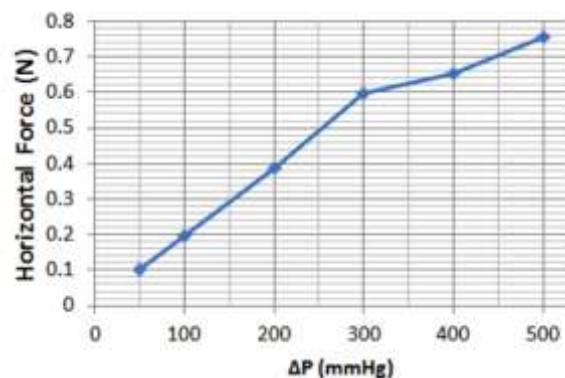


Fig. 2. The relationship between pressure and horizontal force acting on the tube

In this study, the following conclusions were obtained by performing differential pressure simulations on plastic PCV valves.

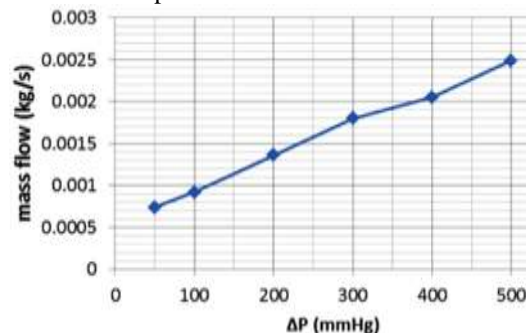


Fig. 3. Velocity distribution for different pressure differences.

- 1) At intervals of a pressure difference of 50-300 [mmHg], the displacement of the spool increases linearly, but somewhat rapidly, and in the next period, 400-500 [mmHg], it increases modestly.
- 2) As the pressure difference increases, the flow rate through the hole increases in proportion up to 300 [mmHg] of the pressure difference, but above 300 [mmHg], the increase is reduced with viscosity.
- 3) At differential pressures above 300 [mmHg], the fluid is compressed to increase the fluid density, and the quality flow rate through the hole increases accordingly.

1.2. PRINCIPLE OF OPERATION OF THE CRANKSHAFT BOX VENTILATION SYSTEM

During the work of the engine, combustible gas is often leaked down to the crankshaft box, so in the crankshaft box the amount of gas entering usually 70 to 80% is non-combustible gas (e.g. steam and other exhaust gases) accounting for 20% to 30% of the rest, which causes some harm such as:

- Staining the lubricating oil and causing the lubricating oil to deteriorate due to impurities contained in the combustible gas;
- The translational movement of the Piston is more difficult because the combustible gas leaking downwards causes the pressure below the Piston to rise;
- The pressure in the crankshaft box also pushes the viscous through the sealing seals outwards, making the performance of the lubricating oil no longer guaranteed;
- Previous vehicles had 1 air tube attached to the crankshaft box to allow these gases to escape into the atmosphere, so they polluted the environment and also failed to take advantage of the fuel vapors contained in them. On the other hand, when the car is slow, the exhaust gas is leaked into the crankshaft box, but it is not completely discharged because at this time the vehicle speed is small, the pressure drop at the end of the pipe is small.

Because of the above bad causes, it is necessary to have a system to guide this incoming gas to the combustion chamber and re-ignite. [9]

In this type, all the gas in the crankshaft box will be returned to the common intake line by the system with a new intake gas to the engine for combustion.

When using this system, the ventilation efficiency is very high, but due to the introduction of fuel vapor and combustible gas to the intake line, it is easy to stain xupap and cylinders.

If the amount of gas from the viscous crankcase is allowed to blow into the intake manifold at all times with any amount of gas, then the working mixture will not be stable and will not be suitable for the working requirements of the engine. At the same time to prevent backburn from the intake manifold to the crankshaft box, it is additionally installed in the PCV valve system. This valve is responsible for regulating the amount of steam from the crankcase entering the intake system of the engine.

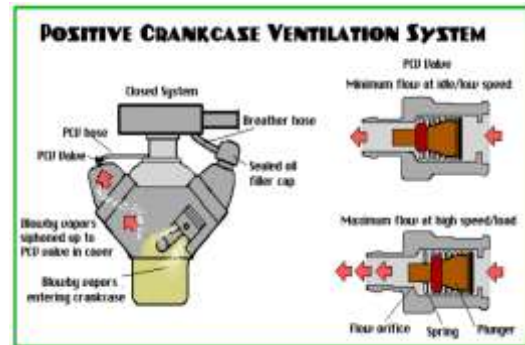


Fig. 4. PCV valve [10]

The operation of the PCV valve is as follows: When the engine is idle, there is no presence of vacuum in the intake manifold. At this time, the spring pushes the valve to seal the intake line

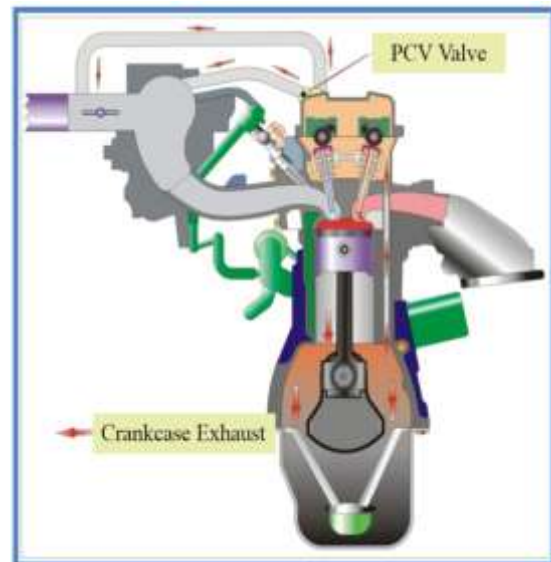


Fig. 5. Crankshaft box ventilation system crankcase exhaust

In case of reverse combustion from carburetor to the crankcase (crankshaft box). At this point, the valve will close to avoid causing a fire.

When the engine operates in stall or slow mode, the vacuum on the large intake manifold sucks the PCV valve piston up to the valve platform. At this time, because the vacuum gap is still narrow, only a small amount of air from the crankshaft box enters the intake manifold to avoid diluting the air in the engine.

When the engine is operating normally, the vacuum in the intake manifold is medium, so the PCV valve piston is up to the middle, so the vacuum gap is large for more air to enter.

In other modes, depending on the vacuum in the intake manifold, the tension of the spring will

correspond and will specify an appropriate position of the PCV valve

IV. ACTIVE CRANKCASE VENTILATION SYSTEM (PCV)

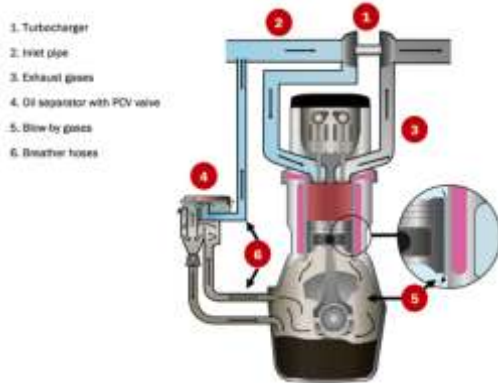


Fig. 6. Active crankcase ventilation system on turbocharged vehicles



Fig. 7. Old generation PCV valve



Fig. 8. New PCV valve

The PCV system consists of five main parts, which are presented according to the diagram below:

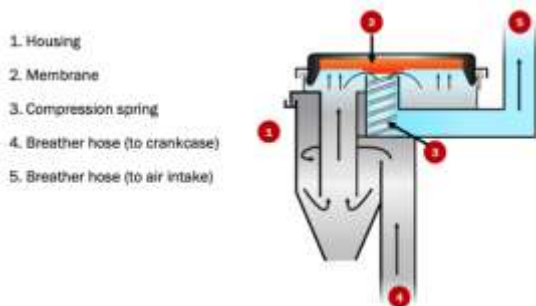


Fig.9. Main parts of the PCV system

1.3. VALVE DIAPHRAGM

Under low vacuum conditions in the intake system pipe, or when the pressure of the crankcase gas increases, the valve diaphragm opens, allowing the crankcase gas to enter the intake.

When a vacuum is formed in the intake system, the diaphragm closes and interrupts the air flow from the crankcase to the intake system, thus avoiding the problem of having too much vacuum in the oil pan.

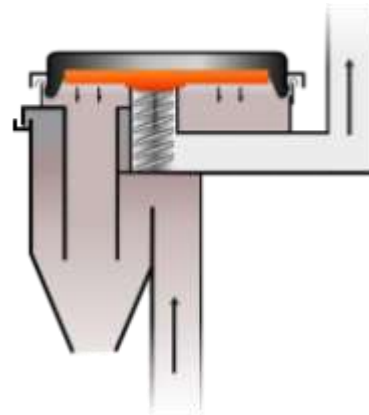


Fig.10. Valve diaphragm (closed)

1.4. OIL SEPARATOR

In the case of high oil temperatures and a high number of engine revolutions per minute (RPM), the oil in the air intake tends to be generated then circulating through the engine's air ducts and PCV, creating carbon in the intake system and combustion chamber. This unit is located in front of the PCV and is responsible for condensing the oil mist and returning the oil droplets to the crankcase, preventing them from entering the intake tract, thus creating less carbon deposition.

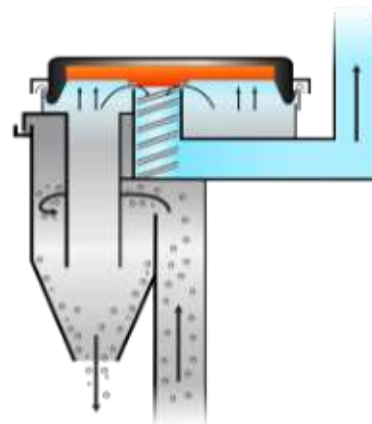


Fig.11. Oil separator

V. DISCUSSION

By introducing the Active Crankcase Ventilation System, which essentially seals the crankcase and allows the gas passing through the engine to be burned, the crankcase hydrocarbon emissions will be completely eliminated. Active crankcase ventilation (PCV) systems use variable flow PCV valves used in most automotive gasoline engine applications. By correctly combining ventilation flow with characteristics, crankcase ventilation performance is optimized, while engine performance and drivability remain unaffected. The valve closes during backburning to prevent flame from entering the crankcase, where it can ignite the attached fuel vapor.

REFERENCES

- [1]. Rosen, Erwin M. "The Peterson Automotive Troubleshooting & Repair Manual". New York: Grosset & Dunlap. ISBN 978-0-448-11946-51975.
- [2]. "Gus Saves a Friend from a Snow Job". Popular Science (February 1966). Retrieved 3 October 2019.
- [3]. TM 9-1756A, Ordnance Maintenance-Ordnance. Department of Defense. 1943. pp. RA PD 311003.
- [4]. "LA Smog: the battle against air pollution". www.marketplace.org. 14 July 2014. Retrieved 11 October 2019.
- [5]. "Fifty Years of Clearing the Skies". www.caltech.edu. Retrieved 11 October 2019.
- [6]. "Environmentally Correct Cars: The Air You Breathe". www.thecarguy.com. Retrieved 11 October 2019.
- [7]. "Crankcase and Exhaust Emission Control". NAPA Echlin Service Bulletin (February 1968).
- [8]. "United States v. Automobile Manufacturers Association" 307 F.Supp. 617 (1969) - supp6171809". www.leagle.com. Retrieved 3 October 2019.
- [9]. <https://www.otosaigon.com/threads/he-thong-thong-khi-hop-truc-khuyu.1307439/>
- [10]. <https://mectips.com/positive-crankcase-ventilation-pcv-system-components-working-principle-testing-removal-and-installation/>
- [11]. Yoon-Hwan Choi, Yeon won Lee "Flow Visualization of Plastic type PCV Valve with Horizontal Force". <https://www.researchgate.net/publication/263647188>