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A Comparative Analysis of the crankcase ventilation system with integrated valve cover

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ABSTRACT: Combustion in the cylinder of an internal combustion (IC) engine releases energy and generates combustion products and by-products, most of which are exhausted from the cylinder into the exhaust system of the engine during exhaust stroke. However, some of the combustion products enter into the crankcase by blowing past seal rings around the pistons and are thus termed as 'blow-by'. Blow-by gases contain pollutants normally found in exhaust gases, such as hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_x), soot and unburned or partially burned fuel. In addition, because the crankcase is partially filled with lubricating oil being agitated at high temperatures, the blow-by gases also contain oil droplets or oil vapor. As blow-by gases build up in the crankcase, they must be vented to relieve pressure in the crankcase. However, the pollutants in blow-by gases are harmful to the environment. A crankcase ventilation (CV) system is implemented in engines to filter out oil aerosol from blow-by gases.

KEYWORDS: Crankcase ventilation, ANSYS Workbench, Velocity drop, Pressure drop.

I. INTRODUCTION

Internal combustion engines are devices that generate work using the products of combustion as the working fluid. Combustion, also known as burning, is the basic chemical process of releasing energy from a fuel and air mixture. In an internal combustion (IC) engine, the ignition and combustion of the fuel occurs within the engine itself. To produce work, the combustion is carried out in a manner that produces high-pressure combustion products that can be expanded through a turbine or piston. The engineering of these high-pressure systems introduces several features that profoundly influence the formation of pollutants.

There are three major types of internal combustion engines in use today: (i) the spark ignition (SI) engine, which is used primarily in automobiles; (ii) the diesel engine, which is used in large vehicles and industrial systems where the improvements in cycle efficiency make it advantageous over the more compact and lighter-weight spark ignition engine; and (iii) the gas turbine, which is used in aircraft due to its high power/weight ratio and also is used for stationary power generation.

Each of these engines is an important source of atmospheric pollutants. Automobiles are major sources of carbon monoxide (CO), unburned hydrocarbons (HC), and nitrogen oxides (NO_x). Probably more than any other combustion system, the design of automobile engines has been guided by the requirements to reduce emissions of these pollutants. While substantial progress has been made in emission reduction, automobiles remain important sources of air pollutants. Diesel engines are notorious for the black smoke they emit. These systems also release unburned hydrocarbons, carbon monoxide, and nitrogen oxides in large quantities.

During the operation of an IC engine, products of combustion are formed. These gases contain unburnt hydrocarbon, NO_x, particulate matter, soot, and other products. At high pressures, some portion of these gases escape from the combustion chamber, flow past piston rings, and enter the crankcase. Blow-by also contains oil droplets and oil aerosol. These gases increase pressure inside the crankcase, which is required to be relieved.

II. RELATED WORK

Earlier study describes the solution to reduce environmental pollution with an active crankcase ventilation system. In the paper, producing the active crankcase ventilation system, which essentially seals the crankcase and allows the gas passing through the engine to be burned, drug crankcase hydrocarbon emissions will be eliminated. Active crankcase ventilation 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 driveability remain unaffected. The valve closed during back burning to prevent the flame from entering the crankcase, where it can ignite the attached fuel paper.

III. METHODOLOGY

The project begins with a thorough literature review encompassing technical papers and material data books to establish a foundational understanding. Following this, an input study delves into the problem statement and conducts root cause analysis regarding crankcase ventilation. Based on these findings, a design proposal emerges, outlining the integration of a valve cover integrated CV system with the valve cover assembly. Utilizing Creo 4, a 3D geometry of the proposed system is crafted in the model creation phase. Subsequently, the design undergoes rigorous analysis, including structural assessment and CFD analysis, employing FEA software to ensure both robustness and optimal performance. Transitioning to the lab/performance testing phase, the CV assembly undergoes comprehensive testing to evaluate its functionality, with experimental validation conducted to ascertain its alignment with target values. Additionally, an examination of the gap between testing capabilities and organizational infrastructure is undertaken. Finally, the project culminates in result comparison, where data from design calculations, FEA simulations, and lab testing are juxtaposed to gauge the efficacy of the valve cover integrated CV system.

IV. EXPERIMENTAL RESULTS

CFD analysis of the CV assembly design is done to determine the Total pressure drop and Velocity profile and oil carry-over. Figure 1 illustrates the selection of plane locations for pressure drop determination. These planes are created for reference in the model, considering them as critical sections from a flow perspective. These are the locations at which sudden bends or flow restrictions are created in the flow path. Thus, any major changes in pressure drop or velocity are expected at these planes. The total pressure drop (pressure loss) is equal to the sum of static pressure difference and dynamic pressure difference.

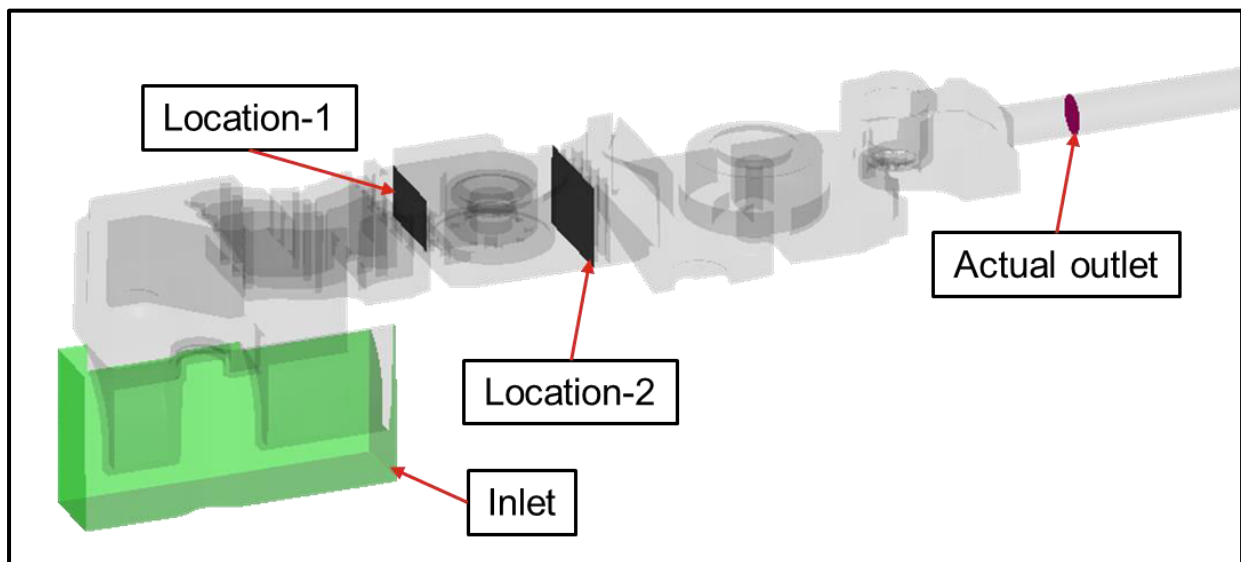
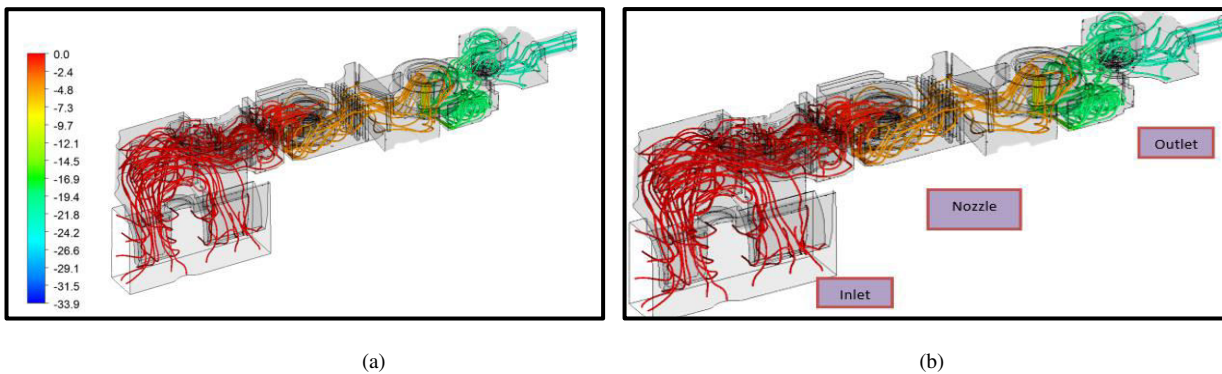


Fig. 1. Model for CFD analysis.

Figure 2 illustrates the CFD analysis results for total pressure drop in CV assembly. It shows that a major pressure drop takes place at the nozzle assembly and CDR valve. However, the actual pressure drop across the CV assembly is difficult to predict as the opening of the CDR valve depends on engine and intake conditions, which are not in the scope.



Velocity profile and oil carry-over: The velocity profile, as determined from CFD analysis, is illustrated in Figure 3. Analysis indicates that velocity increases after passing through the nozzle and CDR valve. Higher velocity in the outlet indicates increased chances of oil carryover in the CV. Velocity is reduced after impaction at nozzles to reduce oil carryover. However, it increases again after passing through the CDR valve.

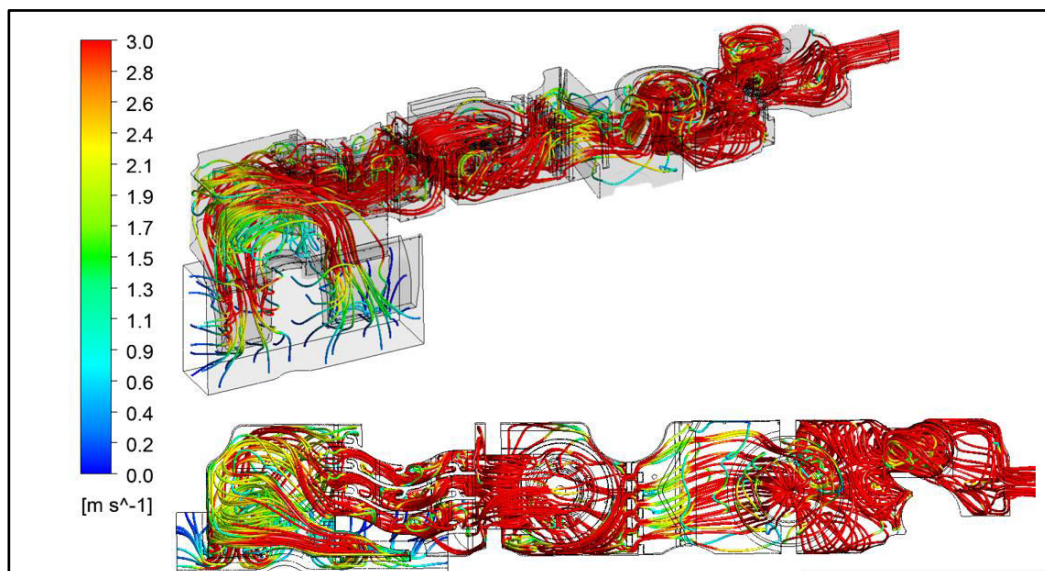


Fig. 3 Velocity Profile result in CFD analysis

Validation of CV assembly: The results of experimental validation are as mentioned in Table 2:

Task	Test / Analysis	Task Name	Task Description	Acceptance Criteria	Results
1	CFD	Pressure Drop Measurement	To determine total pressure, drop across CV assembly	Pressure Drop across CV assembly in the tolerance range of ± 3 kPa	Pressure drop is lower than ± 3 kPa across CV assembly.
2	CFD	Oil Carryover Analysis	To determine whether oil carries over from CV assembly to outlet	No oil carryover from CV assembly to outlet	NO oil carryover detected



V. CONCLUSION

The final CFD analysis of CV assembly resulted in estimating total pressure drop across the CV assembly and nozzle assembly. The pressure drop across the nozzle assembly is within the target value. The CFD analysis for the velocity profile yielded that there are chances of some oil carryover through this CV.

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