Selection and Development of Crankcase Ventilation System for BS (CEV) IV off Highway Engine

NehaU.Karande[1], Sharad D. Patil[2], A. Choudhary[3]

[1,2]Department of Mechanical engineering, Rajarambapu Institute of Technology, Rajaramnagar, Affiliated to Shivaji University Kolhapur, Maharashtra, India,
[3]Product Design Specialist (EBU), Cummins India Ltd, Pune, Maharashtra, India

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Abstract -*The Crankcase ventilation system has got significance as the emission standards are getting tougher. To meet the prerequisites of the BS (CEV) IV off-highway emission standards, it is important to reduce emissions at each stage. The Significant goal of work revealed in this paper was to design and develop a Crankcase Ventilation (CV) system. The Variable impactor as a crankcase ventilation system based on the six sigma tools such as the Pugh matrix, technical profile, and FMEA is accepted. The result shows that Variable Impactor is more effective in crankcase pressure, oil separation, and also in PM emission than Baseline*

Key Words: Crankcase ventilation, Blow-by gas, aerosol, Particulate matter, six sigma tool.

1. INTRODUCTION

In an internal combustion engine the diesel engine is for the most part utilized in the wide scope of utilization in an off-highway vehicle, vessels, and equipment since; diesel engine has extraordinary effectiveness, high toughness, and unwavering quality with the low working expense. In the overall diesel engine necessity gets expanded, which brings about diesel engine emission is a significant supporter of air pollution. It is important to put more in innovative work to satisfy customer need and emission requirement that is high proficiency, better execution, and low emission according to emission standards. Diesel engines are likewise a significant wellspring of air pollution, especially emission of sulfur oxide gases (SOx), toxic air pollutants, nitrogen oxides (NOx) and particulate matter (PM) all of which add to genuine antagonistic wellbeing and ecological impact.

Diesel engine emission has to sources -1) Tailpipe emission 2) Crankcase emission. Since 2007 found that tailpipe emission contributes is 30% of total emission and the remaining 70% is crankcase emission [1]. Crankcase emission contains particulate matter (5% to 16% of total PM), carbon monoxide (1.3% of total CO), nitrogen oxide (0.1 % of total NOx), oxygen, oil aerosol, water vapors, and Hydrocarbon (3.7% of total HC). PM emission is more than other pollutants in the crankcase.

1.1 Crankcase Ventilation System

When the engine is running, during compression and expansion stroke pressure inside the combustion chamber reaches most extreme. Simultaneously burned and an unburned gas enters in crankcase through the crevice area. These gases are called blow-by gases. When blow-by gases consistently enter inside the crankcase the pressure of the crankcase increase. This pressure can affect the crankshaft, connecting rod, gasket, lubricating oil system, and overall engine emission. It is necessary to ventilate the crankcase and remove this blow by gases from the engine crankcase. The crankcase ventilation system tackles this issue.

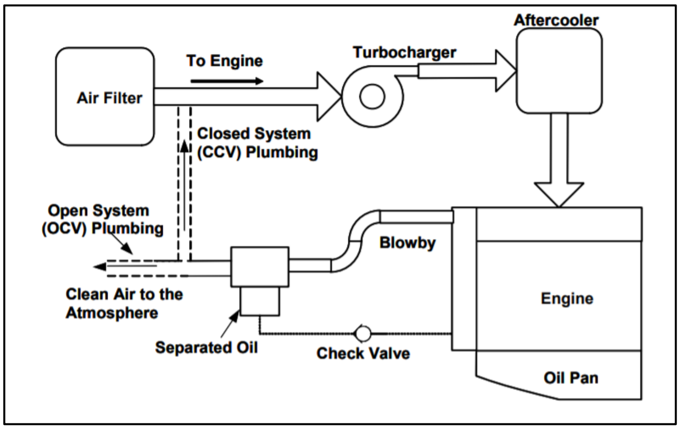

Fig-1: Schematic diagram of closed and open crankcase ventilation (CV) system [2]

The two significant sorts of crankcase ventilation system are appeared in Fig 1. In the OCV (open crankcase ventilation system), the blow-by gases is ejected from the engine crankcase to the environment. In the CCV (closed crankcase ventilation system), the blow-by gases is delivered to the engine's air intake system. In the two plans, the environmental parameters are comparable; notwithstanding, the impact is extraordinary. In the open crankcase ventilation system, the adulterators are delivered to the environment contributing to total engine emission [2]. To overcome these different types of technology is used in open crankcase ventilation system as follow [3]

1. Baffle-
2. Cyclone

3. Impactor
4. Variable Impactor
5. Coalescer
6. Centrifugal separator
7. Electrostatic separator

2. METHODOLOGY

2.1 Concept selection

Day by day emission norms become more stringent so it is important to design and develop a proficient crankcase ventilation system. Among the variety of technologies available in the market, there is a need to implement efficient technology in the crankcase ventilation to meet emission requirements. To achieve the expected goal of designing a crankcase ventilation system, a proven and effective methodology needs to be adopted. It is achieved with help of a six sigma tools such as technical profile, FMEA and Pugh matrix. The raw data of the voice of customers captured in the technical profile where the customer requirements converted to engineering specifications [4]. Then system functions are identified and analyses to understand failure modes, causes of failure, and its effects in FMEA tool. FMEA tool ranked the high-risk items and documented design control presentation and detection actions accordingly [5]. Then Pugh matrix used to rank these technologies and select one of them to satisfy stringent emission norms. Pugh matrix compare different types of CV systems based on selection parameters such as oil separation and aerosol efficiency to meet emission norms, pressure drop, Packaging, serviceability, cost, durability, and reliability which is identified in technical profile and FMEA tool.

Table 1 shows the Pugh matrix for concept selection, Where- better than the baseline a “+” is entered in the appropriate cell, worse than the baseline a "-" is entered in the appropriate cell, the same than the baseline an "S" is entered in the appropriate cell. In the wake of contrasting the different systems by utilizing a Pugh matrix clear the variable Impactor is the best system compare with baseline and cyclone. Variable Impactor has a variable geometry. Impactor nozzle open and close in the response of crankcase pressure. The higher the blow by rate, the more the nozzles are open. Blow-by gas comes inside the impactor and flows from the nozzle and impact on the wall. Because of gravity oil droplets gather at the base part and as aresult of low density filtered gas moves towards the top side.

Table -1: Pugh matrix for concept selection

Criteria/ concept	Existing ccv (baseline)	Coalescer	Variable impactor	cyclone	Centrifugal separator	Electrostatic separator	baffle
Global enterprise wide use	S	+	+	-	-	-	-
Pressure drop	S	-	S	S	S	S	S
Aerosol efficiency	S	+	+	-	+	+	-
Oil separation efficiency	S	+	+	-	+	+	-
Packaging	S	-	S	S	-	-	-
Serviceability	S	-	S	S	-	-	S
Cost	S	-	S	+	-	-	S
Reliability and durability	S	-	S	+	-	-	+
Aesthetics	S	-	S	+	-	-	S
Sociable	S	+	S	S	+	+	-
Total ∑+	0	4	3	3	3	3	1
Total ∑-	0	6	0	3	6	6	5
Total ∑S	10	0	7	4	1	1	4
Total	0	-2	3	0	-3	-3	-4
Rank	2	4	1	2	5	5	7

The selected system has the best system in light of following favorable circumstances-

1. Good experience from past program
2. Total carryover is exceptionally low when contrasted with other system, in this manner reduction in turbo/blower efficiency is less
3. Pressure drop is extremely low compare with baseline at both low and high blow by rate.
4. Maintenance expense is less.
5. Initial expense is

3. RESULTS AND DISCUSSION

3.1 Crankcase pressure and blow by assessment

Three types of engines were well-tried without CV systems and with CV system having existing CV system and variable impactor on various conditions to measure crankcase pressure and blow-by flow rate. It is observed that at 1) 50% load at peak power 2) 100% load at peak torque 3) 100% load at peak power, pressure and blow-by flow rate is most extreme. The remaining test is conducted on these three conditions because at maximum pressure and maximum flow rate, the crankcase emission is more.

3.2 Effect of total carryover and total efficiency on different test condition

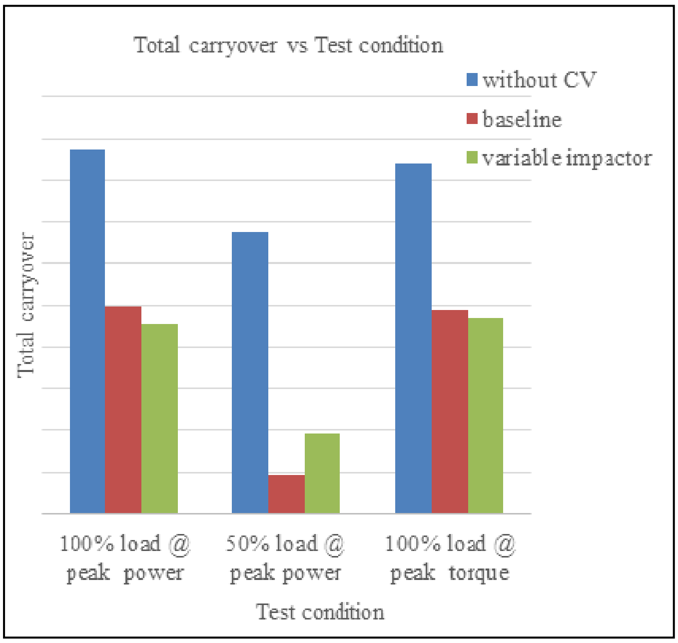

Chart -1: Total carryover on different test condition

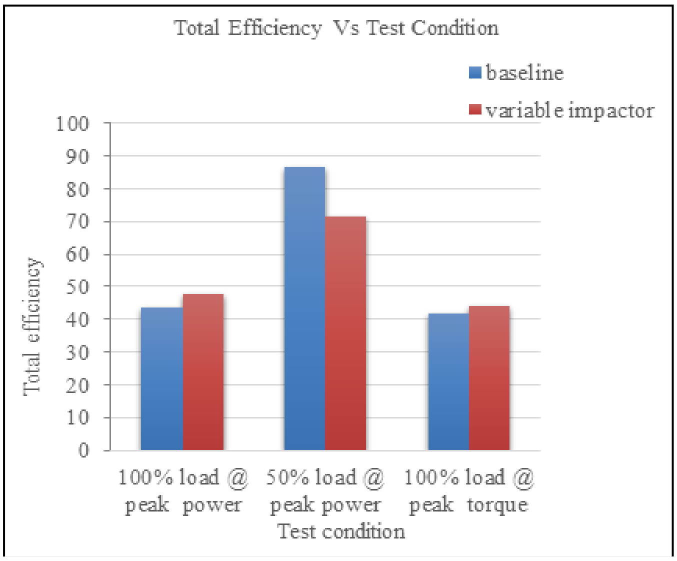

Chart -2: Total efficiency on different test condition

Chart 1 and chart 2 shows total carryover and total efficiency respectively on different test condition. Total carryover incorporates both aerosol and oil carryover test. In this, diverse paths for aerosol and oil and afterward combine both test outcomes and plot total carryover results. At 100% load peak power and peak condition total carryover measured using variable impactor is lower side compare with baseline. At 50% load peak power total carryover measured higher side in variable impactor compare with a baseline on account of crankcase pressure is high at this condition. Variable impactor has 4% high total efficiency than baseline.

3.3 Effect of PM emissions on different test condition

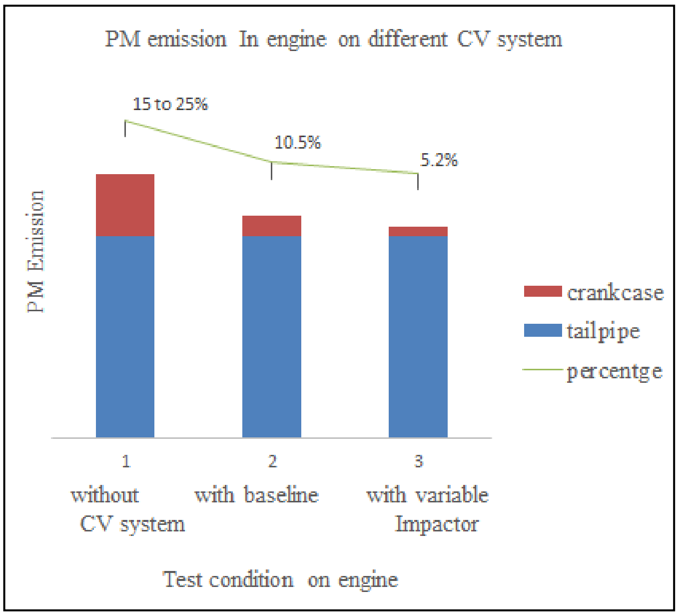

Chart -3: PM emission in engine on different CV system

In chart 3shows PM emission in engine on different CV system. Red shading shows the crankcase PM emission and blue shading shows the tailpipe PM emission. According to BS (CEV) IV off-highway norms Particulate matter (PM) emission prerequisite is 0.025 g/kWhr [6]. Engine lubricating oil added to around half of the PM emission from the engine crankcase, the other half was related to combustion emission and wear of component. Be that as it may, the contribution of crankcase Pm emission in total PM emission changes as per application and engine limit. For this situation consider crankcase emission contribution up to 15 to 20 % in total Pm emission. Using baseline CV system crankcase emission contributes 10.5% in total PM emission. Also, with using variable impactor crankcase emission contributes 5.2 % in total PM emission. The result shows that the variable impactor is better than the baseline CV system. The variable impactor is 50.47 % more productive compare with the baseline due to variable nozzle geometry.

4. CONCLUSIONS

In this paper, the selection and development of crankcase ventilation (CV) system for the off-highway engine are presented. It is observed that to meet the prerequisites of the BS (CEV) IV an off-highway emission standard, the emission is required to reduce at each stage. The crankcase ventilation system has got significance as the emission standards are getting more severe. To accomplish this, different sorts of the crankcase ventilation system and emission standards are experienced. The result shows that Variable Impactor is 20% effective in crankcase pressure when compared with Baseline. It is presumed that Variable Impactor has 4% higher in oil separation efficiency as compared with baseline. Furthermore, Variable Impactor is 50.47% more effective than the baseline in PM emission.

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