ISSN 2395-1621

Development of Oil Mist Separator System for Two Cylinder Diesel Engine

[#1]Sachin S. Wetal, [#2]Sachin V. Mutalikdesai

[1]sachin_wetal@yahoo.com
[2]sachin.3182@gmail.com

[#12]Mechanical Department, Savitribai Phule Pune University
Trinity College of Engineering and Research, Pisoli, Pune Maharashtra India

ABSTRACT

In crankcase ventilation system, the blow-by gases from the crankcase are routed to the intake manifold through oil separator system. Both current exhaust emissions and continuously growing customer demand of less oil consumption drive diesel engine manufacturer to develop more efficient crankcase ventilation and oil separation system. The oil carry over will ultimately affects the oil change interval and emission contents. The range of oil carry over nowadays followed is between 0.2 to 0.4 g/hr. While designing oil separating systems, various factors like cost, space, effect on the engine parameters, feasibility and reliability of system are taken into consideration. At the same time, the crankcase pressures are considered as it will decide the life of various seals in engine. In the present work an attempt is made for modification in head cover by using five different configuration of baffles so as to obtained maximum oil separation from blow by gases. The best baffle configuration was obtained to achieve minimum oil carry over with the suitable crankcase pressure values desirable for better functioning of the engine. The value for oil carry with the optimized baffles was found to be54 g/hr. The optimized baffles option in head cover was used for investigation of oil separators for the separation efficiency. Three types of OMS were developed with different size and shape to get maximum and optimized oil separator efficiency. The oil carry over with final configuration was found 0.4 g/hr.

Keywords— Blow by gases, Diesel Engines, OMS (oil mist separator), Positive Crankcase ventilation (PCV), separator Index.

ARTICLE INFO

Article History

Received :18th November 2015

Received in revised form :

19th November 2015

Accepted : 21st November , 2015

Published online :

22nd November 2015

I. INTRODUCTION

Crankcases in reciprocating engines have to be ventilated, because gases from the combustion chamber flow past the piston rings into the crankcase (blow-by). In addition, periodic volume changes in the crankcase caused by the kinematics of the crank mechanism must also be compensated. The piston movement produces high gas velocities inside the crankcase. The oil droplets carried along with gas are penetrating into the crankcase ventilation system. [1]

The major role in positive crankcase ventilation is played by the Blow by gases. The mechanism of generation of the blow by gases is due to crevice volumes. Gas flows through these volumes during the engine operating cycle due to change in cylinder pressure.As the cylinder pressure rises during compression, unburned mixture or air is forced into each crevice region. During combustion while the pressure continues to rise, unburned mixture or air, depending on engine type, continues to flow into these crevice volumes. After flame arrival at the crevice entrance, burned gases will flow into each crevice until the cylinder pressure starts to decrease. Once the crevice gas pressure is higher than the cylinder pressure, gas flows back from each crevice into the cylinder. The volumes between the piston, piston rings, and cylinder wall are shown schematically in Fig. 1. These crevices consist of a series of volumes (numbered 1 to 5) connected by flow restrictions such as the ring side clearance and ring gap.

A. Need

In reciprocating internal combustion engines, the gas that leaks at the piston, rings and liner system is usually called blow by. The blow by is a complex mixture of air, burned and unburned gases and oil mist. In order to avoid the external pollution, the blow by is recycled into the intake system. This is called as closed crankcase ventilation. Both current exhaust emissions and continuously growing customer demand of less oil consumption drive the diesel engine manufacturer to develop more efficient crankcase ventilation and oil separation system.

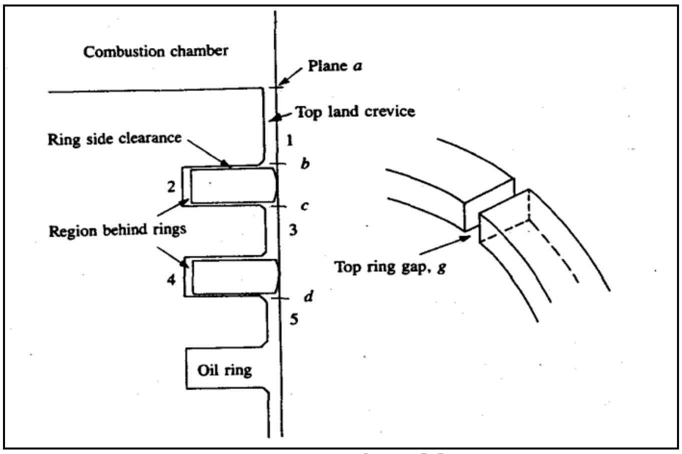

Fig. 1 Crevice Volumes [1]

The oil carry over will ultimately gives the oil change interval and emission contents. Lesser the oil carry over, better the system implemented and it should be optimized for the factors taken into consideration during experimentation. The range of oil carry over nowadays followed is in between 0.2 to 0.4 g/hr. while designing oil separation system, the various factors like cost, space, effect on the engine parameters, feasibility and reliability of the system is to be taken into consideration.

B. PCV system

PCV system consist of the area from which the blow by enters i.e. crankcase to the intake system where it is again fed to the combustion chamber. The blow-by gases will carry oil mist from chain cover through baffle plate and then to the oil separator. The oil separator will separate the oil mist with condensation into the droplets and return it to the oil sump through oil drain pipe. The blow-by with filtrated oil will passed to suction and then in the intake manifold. Due to pressure difference between the crankcase and the suction pressure after air filter, the crankcase gases will be sucked into the intake system

II. Methodology

Catch Can Method

Catch Can is a simple bottle with predefined dimensions connected between breather outlet and intake manifold before compressor. The bottle is designed with the help of the blow by flow rate and its velocity of flow. Generally it is designed for velocity of flow in the range of 1 to 1.5 m/s. Lower the velocity, higher the chance of the oil droplets to be collected. The construction of the bottle is as shown in Fig 2. The diameter and the length of the bottle should be kept as more as possible for better separation.

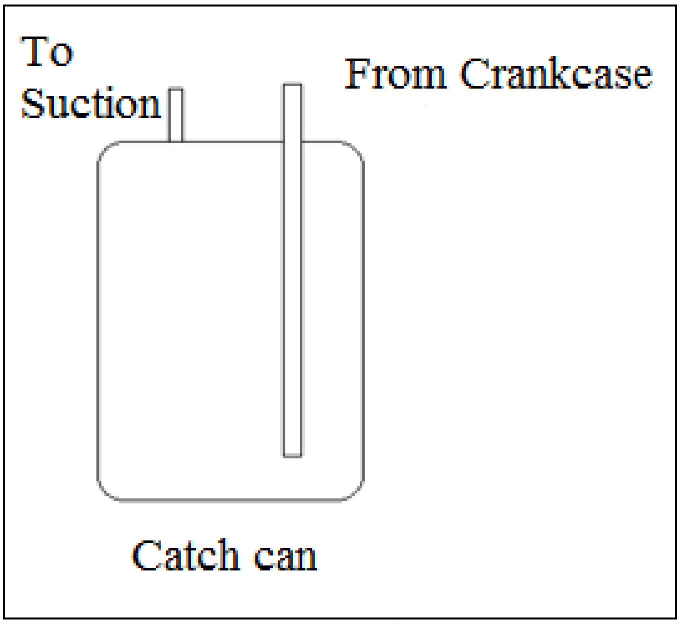

Fig. 2.Construction of catch can

The pipes are welded to the bottle cap. The longer pipe length is for the gases coming from the tappet cover. The bottle lid has inlet such that the gas flows down to the bottom of the bottle, some remaining oil decant and the gas moves up to the outlet towards the intake manifold. The schematic of the test setup is shown below in Fig 3. The blow-by gases are fed to the oil separators inlet. The oil separate out and remaining gases will flow to the bottle. The bottle collects the oil which is carried over by the separator.

The weight of the bottle before and after test will give the total oil carry over throughout the test. The weight divided by the total hours for test will give the oil carry over by separator in gm/hr. In Fig. 3 the dotted line indicates the direct connection with the engine without the test setup

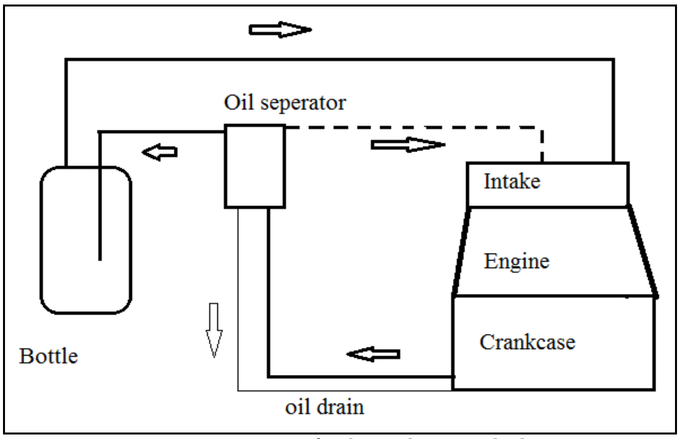

Fig. 3 Test Setup for the catch-can method.

The Endurance Test for the oil carry over is according to the IS 10003-1988. The engine running in is carried out in the 5 cycles with 2 hours each i.e. 10 hrs. The 2 hours test cycle is shown below in Table I

TABLE I
STANDARD ENDURANCE CYCLE

Time (minutes)	**50**	**45**	**5**	**20**
Rpm	Rated Power rpm	Rated Torque rpm	Idle	Rated Power rpm
load	75%	100%	0	100%

THE TEST CYCLE FOR THE 1.1 L CRDI ENGINE IS AS BELOW,

Time (minutes)	**50**	**45**	**5**	**20**
Rpm	3600	2400	900	3600
Load	75%	100%	0	100%

III. EXPERIMENTAL DATA

The experiment for the oil carry over test is carried in two phases

C. Phase I

In the initial phase i.e. Phase I five different types of baffles are tried without oil separator so as to obtain maximum oil separation.

During experimentation initially the engine out (without restrictor plate) for the base oil carry over value evaluation was done then baffle type 1as shown in Fig 4, baffle type 2 shown in Fig 5, baffle type 3 with different deflector angles of 60 deg, 45 deg and 30 deg as shown in Fig 6 was carried out.

Fig. 4Baffle Type 1 restrictor plate

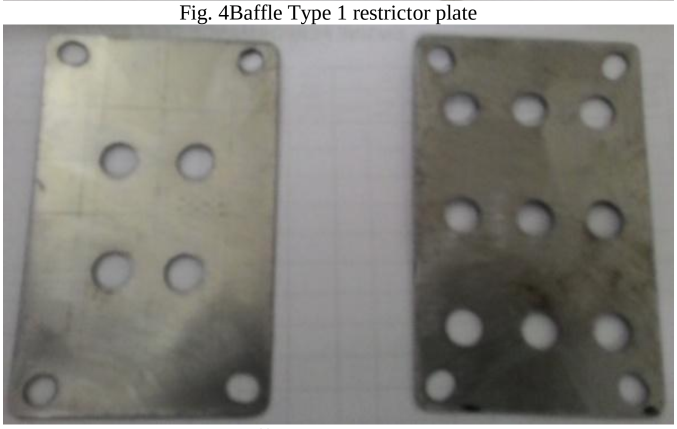

Fig. 5 Baffle Type 2 restrictor plate

Fig. 6 Baffle Type 3 restrictor plate

D. Phase 2

In Phase 2 of experimentation in combination with finalised configuration of restrictor plate is taken and then various types of oil breather are used for oil carry over measurement.

The experiment was conducted initially with engine out oil carry over test (without oil separator), further three oil separators were tested in the following sequence i.e. cylindrical type separator, conical type and conical with simple restrictor plate.

1. Cylindrical type breather

Fig. 7 shows the cylindrical type breather. The idea behind the configuration is encouraged with the catch can method itself. The catch can could be used as buffer element in the method.

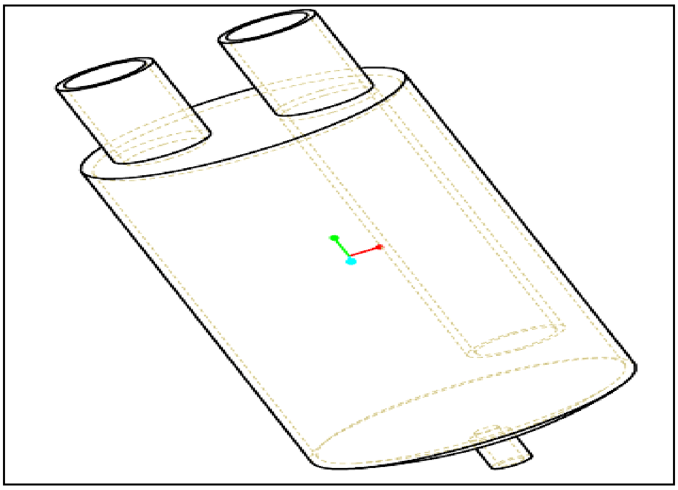

Fig.7 Cylindrical breather

Only difference is the drain is to be kept for oil to transfer towards the oil sump. The configuration is made with 60% reduction in size of the catch can.

2. Conical breather

Conical breather is as shown in Fig 8. It is same as the cylindrical breather, only difference is the converging conical section at the bottom which leads to vortex formation and 180 degrees turning of the flow. The reduction in velocity at the bottom will give better separation of the oil.

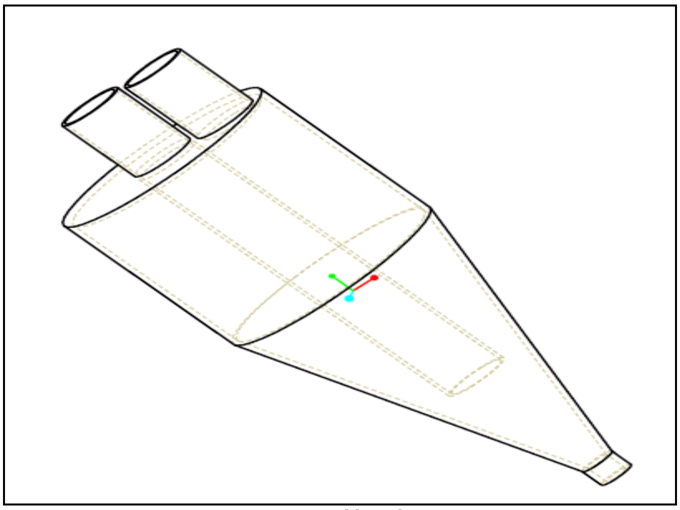

Fig. 8 Conical breather

The angle of the convergence is selected in such a way that the flow separation will be smooth. The sudden change in the direction of the flow is giving better impact on the separation efficiency.

3. Conical breather with restrictor plate:

Conical breather with restrictor plates is shown in Fig 9. To account for the better separation efficiency, the labyrinth plate with 2mm thickness is provided. As the major separation is already done with the conical part, it is not affecting much and results in the same oil carry over as that of the cylindrical type.

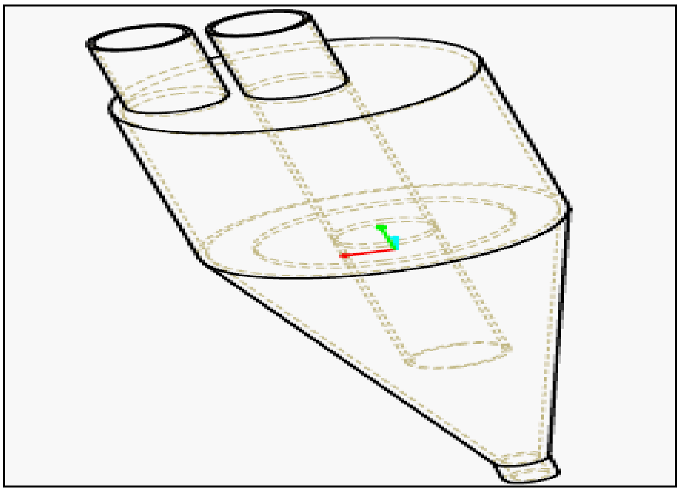

Fig. 9 Conical breather with restrictor plate.

IV. RESULT

The results obtained in Phase I are discussed. During phase I the major concentration was given to find out best configuration of baffle plate with the maximum oil separation in tappet cover without effecting on the crankcase pressure.

TABLE II
OIL CARRY OVER FOR DIFFERENT BAFFLE TYPES

Configuration	**Initial Weight**	**Final Weight**	**Oil Carry over after 10 hrs**	**Test period**	**Oil Carry over**
	g	**g**	**g**	**hr**	**g/hr**
Without Baffle	1238	1800	562	0.08	7025
Baffle Type 1	1238	1940	702	4	175.5
Baffle Type 2	1238	1840	602	4	150.5
Baffle type 3 – 60 deg	1238	1610	372	4	93
Baffle Type 3 –45 deg	**1238**	**1454**	**216**	**4**	**54**
Baffle Type 3 – 30 deg	1238	1390	152	4	38

From the results as shown in table II for Baffle Type 3 – 30 deg it was observed that it has very low oil carry over. But baffle type 3 – 45 deg is taken forward for further experimentation. As the oil carry over results for baffle type 3 – 45 deg is slightly higher than baffle type 3 – 30 deg but it has crankcase pressure of the engine less as compared to baffle type 3 – 30 deg. Also during testing of all baffle, performance of engine found comparable in terms of Power, torque, blow by, boost pressure, crankcase pressure etc. Fig. 10 shows the oil carry spread for the different types of baffles except the engine out value as it is very large.

Further with the optimised baffles type 3 – 45 deg various type of oil separator was tested.

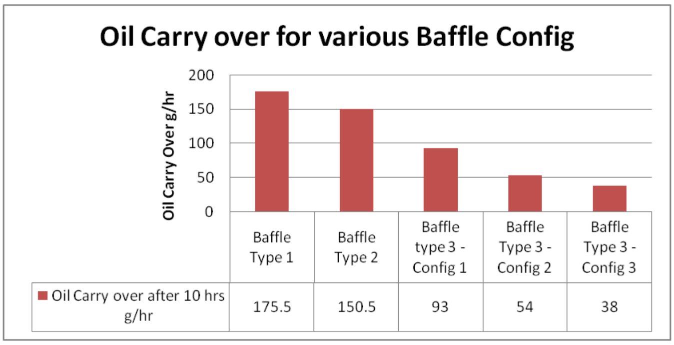

Fig. 10Oil carry over for Baffle Configuration

The performance of the engine is comparable. Further the crankcase pressure for cylindrical types of breather is comparable and within the acceptable value of the engine while it is higher in case of conical breather. Further the blow by values is comparable for all types of breather tested during experimentation.

The best configuration of baffle is selected which gives us the optimum oil carry over without affecting engine performance. The various types of separators are used with selected baffles. The oil carry over value for entire setup is determined as shown in table III.

TABLE III
OIL CARRY OVER FOR DIFFERENT BREATHER TYPES

Configuration	Initial Weight	Final Weight	Oil Carry over	Test period	Oil Carry over after 10 hrs
	g	g	g	hr	g/hr
Cylindrical Breather	1604	1608	4	10	0.4
Conical Breather	1238	1242	4	10	0.4
Conical Breather with Restrictor	1238	1242	4	10	0.4

From the results it can be seen that the oil carry is about 0.4 g/hr for cylindrical as well as both conical type of breather. Fig. 11 show the oil carry over spread for different separator in combination with selected baffle plate.

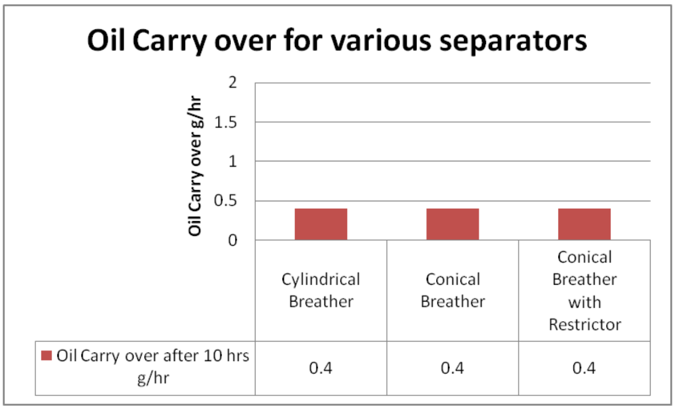

Fig. 11Oil carry over for Oil separators

Fig. 11 indicated that oil carry over is same for all the types of separators but the cylindrical type of separator is finalised as it maintains the crankcase pressure of the engine as per the desired value. In case of conical separator it was observed that though the oil carry over is 0.4 g/hr but the crankcase pressure exceeds beyond the desired value. In long run of engine it will lead to the leakages of seals hence the use of conical breather is avoided.

V. CONCLUSION

From the experimentation following are the findings -

1. If any of the leakage path is present, then the blow by rate is substantially increased which again lead to the higher oil carry over. The increase in blow by from 24lpm to around 70 lpm is observed during the leakage.
2. The baffle plate modifications inside the tappet cover will reduce the amount of oil entering into the breather inlet. The modifications are preferably done if the direct engine out oil carry over is beyond the limit and which cannot controlled only with the help of the oil breather. In the present cases Baffle Type 3 – 45 deg is taken forward as it lead to less crankcase pressurization and has considerably low engine out oil carry over.
3. The final oil carry over with the Baffle type 3 – Config 2 and cylindrical type of breather was 0.4 g/hr. The cylindrical breather is cost effective solution with the simple cylinder assembled having inlet and outlet pipe.
4. The particulate matters are substantially reduced with the breather assembly. As per the literature, the 20 % reduction in PM is done with the reduction in the oil carry over.

ACKNOWLEDGEMENT

a Thanks to Mr. Sachin V Mutalikdesai, for his valuable contribution in the development of the oil separator system for the 1.1 liter two cylinder diesel engine. Also special thanks to Mr. S S More for his valuable guidance during the course of the project.

REFRENCES

[1] S Suresh Bagavathy, N Balasubramanian, D Premnath and S Krishnan, "Establishing The Method Of Evaluation And Layout Optimization Of Crank Case Blow-By Circuit For 3 Cylinder Diesel Engine", SAE International Paper (2011) 26 – 0034 pp 1-6.

[2] Heinz W. Ebner and Dr. Alfred O.Jaschek, "The Importance of Blow-by Measurements, Measuring Equipment and Implementation", SAE Technical paper.(1998) 1081.

[3] Wolfgang Krauss, Karl H. Spies, Laurence E. Bell and Fritz Ebert, "Oil Separation in Crankcase Ventilation – New Concepts Through System Analysis and Measurements", SAE Technical Paper (1995) 0939 pp 257 - 268

[4] Alexander Zink, Manfred Piesche, Pius Trautmann and Micheal Durst, "Numerical and Experimental Investigations of a Disc Stack Centrifuge Used as an Oil Mist Separator for Automotive Application", SAE Technical Paper (2004) 01 – 0638pp 1-9

[5] Sydney Tekam, Marc Demoulin and Virgenie Daru, "Prediction of the Efficiency of an Automotive Oil Separator: Comparison of Numerical Simulations with Experiments" SAE Technical paper (2004) 01–3019 pp 1–7.

[6] Christophe Guillon and Laurent Guerbe, "Blow By gases Coalescing Separation – Performances of the Rotating Solution" SAE International Paper (2011) 01 – 0049

[7] Pedro Bastias, Dieter Grafl, Jurgen Wagner, DimtriusCalghero, Michael Puckett and David Nash, "Air / Oil Separation in Cylinder Head Covers" SAE Technical paper (2004) 01 – 2933