Improvement In Braking Performance of Vehicle By Creating Restriction At Exhaust

Mr. Sujit D. Kolhe[1], Mr. Utkarsh Mahajan[2]
[1]Lecturer, Dept of Mechanical Engineering
[2]Dept of Mechanical Engineering
[1]P. R. Patil Institute of Polytechnic and Technology Amravati, Maharashtra, India.
[2]Dr. Rajendra Gode Institute Of Technology & Research, Amravati

Abstract- *Now days in automobiles sector are getting more and more improved. In this system exhaust gases from engine is used to operate as a break. This project is to build a braking performance enhancing system for heavy vehicles as breaking in heavy vehicles itself is a crucial thing being these vehicles. The prepose of this model instead of break, exhaust gas is used to operate the break lever.*

Vehicles operating in the hills, mountains will use the brakes frequently and leads to reduction in the average fuel economy and performance. This modification is effective specifically for heavy vehicles in which inertia is huge on account of heavy weight. In this project work mainly consist of butterfly valve fitted on the exhaust pipe which regulates the flow of exhaust gases inside the exhaust pipe. The entire concept of braking system is based on back pressure which generated by butterfly valve. Whenever driver wants to applies brake of the vehicles the butterfly valve actuated that restricts the flow of exhaust gases and effectively lowering the rpm of engine and restricting it to that limit only on the other hand the active back pressure causes in direct assistance in the active braking of the vehicle. Thus by implementing this modification the entire vehicle performance improves. Exhaust braking systems supplement the service brakes, increasing the stopping power and reducing the likelihood that the service brakes will over heat. The results of analysis it can be seen that the exhaust braking system provides better braking of vehicles in emergency conditions.

Keywords- Exhaust, Braking, Butterfly Valve, Performance.

I. INTRODUCTION

Vehicles operating in the hills, mountains will use the brakes frequently and leads to reduction in the average fuel economy and performance. Road hazards are taking place due to the failure in the braking system. Diesel engines have high thermal efficiency due to their higher compression ratios. The high compression ratio produces the high temperatures which are used for auto-ignition, and this makes the engine discharge less thermal energy in the exhaust.

One of the examples is hand brake. Which is a essential system in the field of automobiles.The function of the hand brake is to stop the car in emergency situations and also in parking conditions. In case failure in the primary braking system then hand brake can be engaged to stop the vehicles. This proposed exhaust gas braking system has primary air brake function and also exhaust gas braking also. During emergency situations exhaust gas braking will be helpful to stop the vehicles [1].

With the development of highways, logistics and the pace of life weight and velocity of vehicles become more and larger, which has reduced the safety of driving an automobile. Braking load of vehicles increases quickly so that primary brake system is easy to be overloaded and damage for overheating, then traffic accident will take place. In addition, for vehicles in the hills, mountains and city, the driver have to use the main braking system frequently for security reasons, which leads to the average speed reduction and it would affect the operating cost. The transportation from production station to warehouses, warehouses to market, market to houses, malls, etc. involve road transportation by trucks or heavy duty vehicle. The road hazards related to such vehicles are due to the major cause of inefficient brake system or failure of brakes. The commonly used braking system in these heavy duty trucks is "Jake" brake used on diesel big rigs and dump trucks. A Jake brake works by using hydraulic pressure to momentarily open the exhaust valve at the end of the compression stroke, venting off the compressed air into the exhaust system. That’s where all the noise comes from. The braking of a Jake brake occurs because of the pumping loss compressing the air, and then eliminating the compressed air “rebound” on the power stroke. Additionally, there’s a pumping loss as the piston descends on the power stroke with both valves closed and no combustion [2].

An exhaust brake is a device that essentially creates a major restriction in the exhaust system, and creates substantial exhaust backpressure to retard engine speed and offer some supplemental braking. In most cases, an exhaust brake is so effective that it can slow a heavily-loaded vehicle on a downgrade without ever applying the vehicle's service brakes. An exhaust brake is basically a valve that can be closed in the exhaust system to restrict exhaust flow. This valve closes when the driver releases the fuel throttle. Under these conditions, the exhaust flow from the cylinders is bottlenecked and rapidly builds pressure in the exhaust system upstream from the exhaust brake. Depending on engine speed, this pressure can easily reach up to 60 PSI maximum working pressure. Maximum working pressure is limited as part of the design of an exhaust brake. In this example, that same 60 PSI also remains in the cylinder for the entire exhaust stroke (exhaust valve open) and exerts 60 PSI on the piston top to resist its upward movement. We can think of this as negative torque, slowing the engine for a braking effect. This might be even thought as just the opposite of the power stroke, and in effect, it is. Thus, simply restricting the exhaust flow can generate substantial braking. That's what makes an exhaust brake so effective

.

1.1 Exhaust braking system

An exhaust brake works by restricting the flow of exhaust gases through the engine. Heavy goods vehicles can often require increased braking, in situations where friction brakes could overheat and fail. This is achieved by using an exhaust brake.

It achieves this by closing a butterfly valve located in the exhaust manifold. This maintains high pressures in the exhaust manifold, and the engine cylinders, which in turn, acts as a brake against the engine rotating. This then slows the road wheels through the transmission, or power train. This invention relates to an exhaust braking system for an internal combustion engine and in particular, although not exclusively, to such a braking system for a diesel engine. It is well known that an exhaust braking system for an internal combustion engine effects secondary braking working in tandem with the normal friction brakes of a large commercial vehicle. A known exhaust brake comprises housing with a through passage which is arranged to be closed by a blade when braking is required. The exhaust brake generates a back pressure within the exhaust passage which lifts the exhaust valve from its seating and imparts a back pressure within the cylinder on the piston crown to cause retardation or braking of the rotational speed of the engine and subsequently the vehicle. The amount of back pressure is predominantly dependent upon the force exerted by the engine valve spring, since the back pressure must be sufficient to lift the valve from its seat. It will be appreciated that on the engine induction stroke the piston cylinder is vented to the atmosphere through the induction manifold by opening the induction valve so that the exhaust gas pressure within the cylinder is released.

Engine manufacturer's have become concerned that when exhaust brakes are used with internal combustion engines the back pressure created by the exhaust brake when lifting the exhaust valves from the valve seats will create a situation in which a piston upon its return to top dead centre will strike the head of the exhaust valve. To avoid this happening, it is common practice for a hole of a predetermined size to be provided through the blade of the exhaust brake so as to limit the back pressure in the exhaust system. It is desirable to increase the efficiency of the exhaust brake so as to produce greater retardation braking of the engine and one way of achieving such an improvement is to increase the back pressure created by the exhaust brake. However, an increase in the back pressure will only serve to hold the exhaust valve open increasing the likelihood of the piston striking the exhaust valve.

Several ways have been tried to overcome this problem, one of which is to increase the strength of the valve springs, but this is often undesirable since the valve operating mechanisms are then subjected to undue wear. Therefore, there is a need to provide a braking system for an internal combustion engine in which the above disadvantages are overcome.

According to one aspect of the present invention there is provided an exhaust braking system for an internal combustion engine having an inlet valve and an exhaust valve, the system comprising an induction valve arranged to be connected in an induction passage to the inlet valve, an exhaust brake arranged to be connected in an exhaust system connected with an exhaust valve, actuator means connected in a fluid circuit with the induction valve and exhaust brake for operating the induction valve and exhaust brake to close the induction passage and exhaust system when the rotational speed of the engine is to be retarded, timing means connected with the induction valve and exhaust brake for ensuring the exhaust brake is closed no later than the closing of the induction valve, a non-return valve arranged to be connected in the induction passage between the induction valve and the inlet valve for facilitating an increase in pressure within a piston cylinder of the engine to increase the engine retardation, and pressure relief means arranged to be connected in the induction passage or exhaust system for controlling maximum pressure of the braking system.

The timing means preferably comprises a pair of tubes of differing internal diameters, the tube of larger internal diameter having one end thereof connectible to the exhaust brake, and the tube of smaller internal diameter having one end thereof connectible to the induction valve, the opposing ends of the tubes being connected to the actuator means. The actuator means is preferably a manually operative foot valve which is conveniently connected with the brake pedal of a commercial road vehicle, for example. Alternatively, the valve can be operated independently or may be coupled to the accelerator pedal.

1.2 Butterfly valve:

The butterfly valve is actuated through hydraulic linkages in actual working model. This consists of a hydraulic pressure pump which is connected to the butterfly valve. This pump controls the operation of butterfly valve in following manner:

When brakes are applied by the driver, the cylinder reduces its pressure so that valve gets closed and restricts the path of exhaust gases. In this position butterfly valve remains perpendicular to the flow of exhaust gases and thus creates back pressure on the engine. This butterfly valve has some holes (may be one to three) into it so that there would not be complete blockage in the exhaust pipe. This assures the avoidance of abnormal damage due to high pressure.

Now when brakes are removed by the driver, cylinder generates pressure into it so that butterfly valve gets opened and allows the exhaust gases to flow into exhaust pipe. In this position butterfly valve remains parallel to the path of exhaust gases and thus releases the pressure on the engine and again speed increases.

II. LITERATURE REVIEW

Sandip Rajput *et al* [3] attempted to applicate constant pressure exhaust brake controlled mechanism though the control cylinder of exhaust brake system on the heavy duty diesel engine. The completely new concepts are generated based on requirement from customer & made complete system layout with considerations of optimization parameters with the help of Creo Modeling. The calculations for exhaust brake performance & for the complete system level are done for the design of complete system and for each individual component. So as to meet the requirement of constant back pressure to produce better exhaust brake performance at variable engine rpm. And some are validated through the CAE structural analysis. The critical parameter of threshold back pressure is maintained through the control mechanism. The calculations for exhaust brake performance & forces, torque acts due to threshold back pressure on the butterfly valve are done and some are validated through the flow analysis by CFD simulations. During the structural simulation some failures are observed and some are rectified based on result to achieve the requirement. Selection of materials for the different components of exhaust brake system at 600-800°Cel.& selection of manufacturing processes
Was the toughest challenge particularly for the plastic & rubber components.

Murari Mohan Roy *et al* [4] investigated the effect of engine backpressure on the performance and emissions of a CI engine under different speed and load conditions. A 4-stroke single cylinder naturally aspirated direct injection (DI) diesel engine was used for the investigation with the backpressure of 0, 40, 60 and 80 mm of Hg at engine speed of 600, 950 and 1200 rpm. Two parameters were measured during the engine operation: one is engine performance (brake thermal efficiency and brake specific fuel consumption), and the other is the exhaust emissions (NOx, CO and odor). NOx and CO emission were measured by flue gas analyzer (IMR 1400). The engine backpressure produced by the flow regulating valve in the exhaust line was measured by Hg (mercury) manometer. The result showed that, the brake thermal efficiency and brake specific fuel consumption (bsfc) are almost unchanged with increasing backpressure up to 40 mm of Hg pressure for all engine speed and load conditions. The NOx emission became constant or a little decreased with increasing backpressure. The formation of CO was slightly higher with increase of load and back pressure at low engine speed condition. However, under high speed conditions, CO reduced significantly with increasing backpressure for all load conditions. The odor level was similar or a little higher with increasing backpressure for all engine speed and load conditions. Hence, backpressure up to a certain level is not detrimental for a CI engine.

Venetia Sandu *et al* [5] provides an experimental method regarding the determination of a diesel engine power loss using the motoring method in order to simulate the brake system efficiency. For the heavy duty commercial diesel engine, 1035-L6-DTI, manufactured at Roman Truck Company there were performed specific power loss tests on the engine dynamometric test-bench, changing the braking systems (bleeder engine brake and exhaust brake, individually and combined).As main conclusions of the paper are the following :The introduction of exhaust brake is a very effective braking method as the power loss with closed valve is in average with 97% higher than power loss with open valve in the same condition of normal operation (normal exhaust valve clearances).The introducing of bleeding brake by increasing the normal exhaust valve clearance to a higher, permanent value of aperture increased the power loss with an average of 8% because of increased negative work on the indicated diagram as the system is not isolated and the pressure in combustion chamber is lower. The combination of bleeding brake and exhaust brake is not recommended as power loss decreases in comparison with power loss with exhaust brake. The authors consider that the research work has important technical contributions to vehicle safety concerning the efficiency of braking systems applied to engines, bringing experimental results in the literature regarding the study of bleeder and exhaust brake systems.

Karthikeyan B *et al* [6] focuses on Eddy current brakes, which are very essential for electro mechanical concepts. The frequency of accidents is now-a-days increasing due to inefficient braking system. The main aim of the present paper is to ensure efficient braking system in automobiles, a prototype model is fabricated. It is seen that the eddy current brake is an essential complement to the safe braking of heavy vehicles. It aims to minimize the brake failure to avoid the road accidents. Many of the ordinary brakes, which are being used now days stop the vehicle by means of mechanical blocking. This causes skidding and wear and tear of the vehicle. And if the speed of the vehicle is very high, the brake cannot provide that much high braking force and it will cause problems. 'The eddy current brake' is a frictionless method for braking of vehicles. This method eliminates the problem of wear of brake shoes and brake fluid leakage.

Akshyakumar S. Puttewar *et al* [7] focuses on electromagnetic brake, which is a new and revolutionary concept. Electromagnetic braking system is a modern technology braking system used in light motor & heavy motor vehicles like car, jeep, truck, busses etc. This system is a combination of electro-mechanical concepts. The frequency of accidents is now-a-days increasing due to inefficient braking system. In this research work, with a view to enhance to the braking system in automobile, a prototype model is fabricated and analyzed. It is apparent that the electromagnetic brake is an essential complement to the safe braking of heavy vehicles. It aims to minimize the brake failure to avoid the road accidents. It also reduces the maintenance of braking system. An advantage of this system is that it can be used on any vehicle with minor modifications to the transmission and electrical systems.

Prakash T *et al* [8] aims to design and develop an air brake system based on exhaust gas and which is called "fabrication of air brake system using engine exhaust gas". The main aim of this project is to reduce the workloads of the engine drive to operate the air compressor, because here the compressor is not operated by the engine drive. Here we are placing a turbine in the path of exhaust from the engine. The turbine is connected to a dynamo by means of coupling, which is used to generate power. Depending upon the airflow the turbine will start rotating, and then the dynamo will also starts to rotate. A dynamo is a device which is used to convert the kinetic energy into electrical energy. The generated power can be stored in the battery and then this electric power has loaded to the D.C compressor. The air compressor compresses the atmospheric air and it stored in the air tank and the air tank has pressure relief valve to control the pressure in the tank. The air tank supplies the compressed pneumatic power to the pneumatic actuator through solenoid valve to apply brake. The pneumatic actuator is a double acting cylinder which converts hydraulic energy into linear motion.

A.R. Sivaram *et al* [9] explains that automobiles play a key role in our day today life. Today, studying the parameters which affect the performance of diesel engines is important. In spite of the previous studies, still some aspects needs investigations. In previous researches, valve timing and fuel injection effects on engine performance was studied. In this work, the effect of changing the back pressure of the exhaust gases on the performance of the single cylinder four stroke diesel engine was studied experimentally. The study was experimentally made by varying the length of exhaust pipes with lengths of 0.250m, 0.500m, 0.750m, 1m and 2m. It was found that with increase in exhaust pipe length, the exhaust back pressure increases as this decreases the combustion efficiency. The fuel economy and the volumetric efficiency were found to be the best for a minimum exhaust pipe length.

Frederico Augusto Alem Barbieri *et al* [10] explains the role of the engine brake, which is to convert a power-producing engine into a power-absorbing retarding mechanism. Modern heavy-duty vehicles are usually equipped with a compression braking mechanism that augments their braking capability and reduces the wear of the conventional friction brakes. This work presents an engine brake mechanism modeling and design based on decompression effect, obtained by exhaust valve opening during the end of the intake cycle. Besides that, during the system operation the emissions are drastically reduced, even eliminated, since there is no fuelling, contributing to pollution level reductions. In this sense, this work describes a development of such engine brake system for a 4 and a 6 cylinder diesel engines. The engine brake performance was predicted by the development of 1D engine models. The 1D engine models are able to simulate the valve train, including the valves operation, brake flap actuation, hydraulic actuator behavior, and also the major engine breathing characteristics: gas flow rate, turbocharger efficiency, temperatures and pressures along the intake/exhaust system, etc. The gas distribution along the exhaust system can be predicted and its effects on the brake system performance evaluated. With these first assumptions, the first prototype is constructed and the simulation results are compared to the test bench acquired data.

Shoban Babu.M *et al* [11] focuses on the vacuum brake which was, for many years, used in place of the air brake as the standard, fail-safe, train brake used by railways. Pneumatic braking systems use compressed air as the force used to push blocks on two wheels. The vacuum brake system is controlled through a brake pipe connecting a brake valve in the driver's cab with braking equipment on every vehicle. A vacuum is created in the pipe by and ejector or exhauster. The ejector removes atmospheric pressure from the brake pipe to create the vacuum using steam on a steam locomotive, or an exhauster using electric power on other types of train. With no vacuum the brake is fully applied. The vacuum in the brake pipe is created and maintained by a motor-driven exhauster. The exhauster has two speeds, high speed and low speed. The high speed is switched in to create a vacuum and thus release the brakes. Slow speed is used to keep the vacuum at the required level to maintain brake release. Vacuum against small leaks in the brake pipe is maintained by it.

III. PROBLEM IDENTIFICATION

The problem of normal braking system used in heavy vehicles having diesel engines such as trucks, containers, etc is that while travelling at very high speed particularly in a slope, a huge force is exerted on a normal brake while braking and this huge force leads to brake failure causing accidents. And also the exhaust temperature is low while using the normal brakes in the same situation which results in increased emissions when burning the fuel again.

Objectives

1. To develop a concept of exhaust braking system
2. To analyze the performance of an exhaust brake
3. To analyze the effect of back pressure on engine performance
4. To develop a prototype of the exhaust braking mechanism
5. To improve the braking performance of vehicle
6. To develop a supplementary braking system for vehicles in emergency conditions

IV. EXPERIMENTAL SETUP

4.1 Design Methodology

The various terms involved in the design of exhaust brake mechanism are given below:

4.1.1. Back Pressure

The back pressure required to create the exhaust brake force generation is depends upon the threshold limit of the engine on which exhaust brake is operated. This back pressure is calculated based on no. Of engine parameters and for this project the limiting back pressure value is given as 4.5bar. Above which there can be abnormal effect on engine.

4.1.2. Housing

The second parameter as per the design methodology is the selection of Housing diameters in which exhaust brake butterfly valve get mounted. The housing diameters are depending on the turbocharger pipe diameter as which is connected to the turbocharger. In this project the housing diameter is given in input requirement document as 90mm.

4.1.3 Selection of cylinder stroke

The cylinder stroke is the distance required to travelled by the piston & push rod to close the butterfly valve. This is calculated based upon the kinematics done in Proe software modeling to decide this, first thing is the modeling of the required components like butterfly valve, housing, shaft, Rivets etc.

4.1.4 Butterfly valve

The butterfly valve made up of acrylic material made in the circular shape, having three peripheral circular cut on it. These circular cuts are given because it is not expected to block whole cross section of the exhaust pipe. If there were no holes, the engine would stop instead of slowing down. In the project, actual engine is not used but a blower; still this type of the valve is used to correlate it with actual arrangement.

Fig.4.1 Butterfly valve

Butterfly valve is designed based upon the housing dimensions & it should resist the stress generated by the back pressure generated during the actuation of exhaust brake. The important parameter is that shape of housing is circular one and butterfly valve should be mounted in such way that the there should be complete closing of the opening. So to achieve this requirement the shape of the butterfly valve is kept elliptical which gives the complete closing of valve by rotating with some angle. and also easy for assembly as well. The mounting is given at eccentric position which will helps in the closing of butterfly valve by extra couple developed due to the larger area of the butterfly valve. The detailed geometry is explained with the figures.

The shape of the butterfly valve is elliptical shape so that there should be complete contact with the hosing during butterfly valve closed position. The housing is designed based upon the connecting ends of the turbocharger pipe ends. The eccentricity is used to generate couple which will help during closing of the butterfly valve. Because of eccentricity the complete elliptical area of butterfly valve is divided into two halves which make two different areas. The pressure acting on the butterfly valve halves are same but the force action on the both e the areas are different due to different areas.

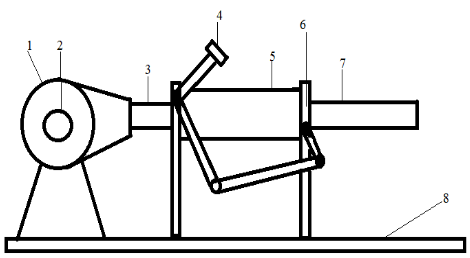

Fig.4.2 Block diagram of exhaust braking system.

Above block diagram is the schematic representation of the project model. The part names are as follows:

1- Blower casing, 2- PMDC motor, 3- PVC pipe of 75mm diameter (1st pressure measurement c/s), 4-Pedal brake, 5-PVC pipe of 90mm diameter (2nd pressure measurement c/s), 6- Location of butterfly valve, 7- Exhaust pipe (75mm dia.), 8-Stand

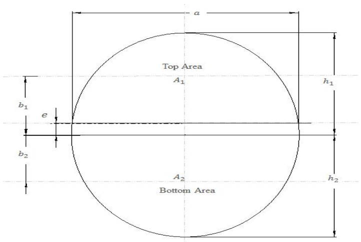

Fig.5.1 Butterfly valve geometry

4.1.5 Shaft with lever

The design of shaft and lever is depends on the transfer of the torque required to close the butterfly valve & it should sustain the stresses developed due to the back pressure development. The lever and shaft are single component made by forging operation. The selection of lever ratio is also dependant parameter on the amount of torque required to close the back pressure & resist the back pressure stress. The output force generated by actuating cylinder is get multiplied with the lever ratio and final output is generated. This lever ratio is controlled by the length of lever. The actuating cylinder is connected with the lever end with the help of push rod with connecting link. From the kinematics shown in fig. its shows that the required angle to complete close of butterfly valve and linear distance required rotating that angle. This linear distance termed as stroke of the cylinder.

V. EXPERIMENTATION PROCEDURE:

5.1 Experimental Methodology

Single cylinder four stroke diesel engine (Kirloskar engine) with test rig as shown in fig. 5.1 was chosen for the experimental study. The engine is connected with an exhaust pipe of 0.250 m. The butterfly valve is fitted in the exhaust pipe. The purpose of butterfly valve is to create the back pressure in the exhaust pipe. This exhaust back pressure is used to retard the speed of the engine without using the normal brake and here the concept of exhaust braking system came into existence. The performance of this exhaust braking system is analyzed on this engine by considering various positions of the butterfly valve i.e. at the various angles of the butterfly valve. After checking the fuel supply, water circulation and lubricating oil in the oil sump the engine is started. The engine is run on idle speed for a few minutes without any load. Gradually the engine is loaded and the speed is maintained constant. The value of load in terms is noted from the test rig. For the different values of loads and butterfly angle, the values of various parameters such as RPM, manometer height and back pressure are noted from the test rig.

Start engine without load and take 0° angle of butterfly valve i.e. normal condition reading. First check back pressure in exhaust pipe with help of U-tube manometer, then check rpm of engine by using tachometer, then check fuel consumption of engine 10 ml in how many sec., then check suction pressure in engine all reading is noted.

Now butterfly angle change to 10° then take pressure reading in exhaust pipe, rpm of engine, fuel consumption check, and suction pressure check. This thing is carried out up to the angle of 60° because we have time for one reading is 2 min. And it is not possible to hold exhaust gas in engine, so due to safety reason of engine only take reading up to 60°.

Then engine load increase up to 1.5 kg and set angle 10^o and check back pressure on engine then check RPM of engine, then also check fuel consumption rate of 10 ml in how many sec. Similarly changing angle of butterfly valve 20° , 30°, upto 60°.

Then increase load on engine 3 kg, 4.5 kg, 6.0 kg and similarly checking all above parameter.

Fig. 5.2 Single cylinder four stroke diesel engine with test rig.

The specifications of the engine is given below,

Table 3.1 Engine specifications

Engine make	Kirloskar
Number of cylinders	1
Power(BP)	5HP(3.7KW)
Speed(N)	1500 rpm
Bore(B)	80mm
Stroke(SL)	110mm
Fuel used	Diesel
Compression Ratio	16.5:1
Length of exhaust pipes	0.250m
Type of loading	Rope brake
Type of ignition	Compression ignition
Type of cooling	Air cooled
Diameter of rope brake drum(D)	0.320m
Diameter of Rope(d)	0.010m
Effective radius(r_e)	0.165m
Diameter of Orifice	20mm
Area of Orifice	0.000314m^2
Coefficient of discharge for orifice(C_d)	0.62
Specific gravity of fuel	0.838
Calorific value of fuel	46057 kJ/kg

The readings of various parameters taken on the above mentioned engine for various loads are given below in tables.

VI. RESULTS AND DISCUSSION

The performance of engine mentioned in the last chapter is analysed with exhaust braking system having butterfly valve and based on readings taken, the values of the various parameters showing effect of the back pressure on the engine are found which are discussed below in the tables.

When butterfly valve is closed at 0° to 10°, rpm is effectively reduced and after 10° gradually reduced up 50° and after 50° is reduced more effectively. At 1.5 kg loading condition same thing is happened. Generally when load of engine is increased, speed of engine decreased. In this case rpm is reduced as compare to no load condition but not effectively reduced due to present governor. Load is increased to 3 kg in this case rpm is reduced as compare to above condition due to loading condition and when angle set to same as above and rpm is reduced is in same manner 4.5 kg load in this loading at 10° rpm is reduced from 800 rpm to 790rpm. This slope is less as compare other loading condition and in this loading condition slop of graph is reduced gradually up to 50° and after 50° rpm is reduced more as compare to other Load is increased to 6.0 kg, in this case at an angle 10° rpm is reduced from 790rpm to 785 rpm is also less difference as compare to other load because due to loading effect, initial rpm is reduced and working of governor. From the results it can be seen that the RPM of engine gradually decreases with the increase in angle of the butterfly valve for any kind of loading condition. The main purpose of fitting the butterfly valve on the exhaust pipe is to restrict the flow of exhaust gases and due to this the back pressure is created in the exhaust pipe which is in return exerted on the engine. As the butterfly valve starts closing with the increase in angle, hence at maximum angle of butterfly valve the RPM of the engine will be minimum for any kind of loading condition. From analysis of all Fig. shows after butterfly valve angle of 50° rpm is reduced more as compare to other angles.

When butterfly valve closed gradually back pressure is create and this pressure measure with U-tube manometer. At an angle 0° the pressure is created 20.52 N/m^2 this inside pressure of exhaust pipe. When butterfly angle till up to 10° and getting manometric reading is 8 mm and hence pressure is created 80.24 N/m^2. In case of no load condition back pressure is increase gradually up to 30°. And at an angle 40° manometric height is 20 mm. and back pressure is created 198 N/m^2. After 40° manometric height is getting 30 mm due to increase of blockage of exhaust gases back pressure increased

296.4 N/m^2 and this pressure increases in same manner in after 50°.

Now increases load to 1.5 kg. In this case decreasing of slop is happened. But after 30° angle when load increases engine flow more exhaust gas as compare to no load condition, due to working of governor and when passage of exhaust gas was restricted, manometric reading was 19 mm. and hence back pressure is obtained 188.46 N/m^2. This pressure is also increase gradually up to angle of 40°. And after 40° back pressure created was more as compare to others. When increase load on engine governor supply the more fuel to the engine, that's reason create more exhaust gases, and when apply butterfly valve back pressure is created more, as compare to no load condition. For example at 60° no load condition back pressure is 381 N/m^2, at same angle 1.5kg back pressure is 401.4 N/m^2, 6 kg back pressure is created 472.39 N/m^2. When load on engine increase at same angle back pressure is also increased.

From the above discussion of Back pressure vs Angle of butterfly valve considering various loading conditions, it can be seen that the back pressure increases gradually with the increase in angle of the butterfly valve for any kind of loading condition. As the butterfly valve starts closing with the increase in angle, hence at the maximum angle the butterfly valve will be almost closed resulting in the creation of maximum back pressure in the exhaust pipe for any kind of loading condition.

From the above discussion, it can be seen that with the increase in angle of butterfly valve the back pressure in the exhaust pipe increases and which results in the reduction of RPM along with the increase in butterfly valve angle. Also, the brake power required is less with the increase in butterfly valve angle. The volumetric efficiency and the brake thermal efficiency also reduce with the increase in the butterfly valve.

VII. CONCLUSION

The project work thus carried out which exhibited expected results and satisfactory outcomes. The back pressure measured after the application of exhaust brake was quite acceptable because a type of blower is used than actual positive displacement engine to create exhaust. The testing was carried out on different speed of blower also still it is part of actual experiment that what kind of pressure rise get at different speeds of the actual engine, different powers of the engine, different force of application of the brake. The necessary modifications using turbocharger, staged valve pressure control are also suggested to overcome the limitations to this type of braking system. Thus, the future of this project work seems promising and optimistic. We look forward to the day when such type of braking system would become popular in India and also acceptable in the market of heavy duty trucks.

In conclusion the following considerations exist with Exhaust Brake use:

1. Exhaust Brakes should not be used as primary brakes. They shall always be used as complimentary or secondary brakes.
2. Diesel Engines do not create enough back-pressure to retard the motion of vehicle. Thus exhaust brakes are necessity for diesel engine.
3. Exhaust brake must not be shut down completely or it may have undesired ill-effects on the engine.

The obtained results can confirm the good design assumptions done at the early stages of the Engine Brake system development. Compared to the Exhaust Brake primary used, the Exhaust Valve Opening Brake System improved the engine brake power in 54%.

REFERENCES

[1] Air Brake System using the Application of Exhaust Gas in IC Engines Arunprasath S*, Veeranaath V. Journal of Chemical and Pharmaceutical Sciences ISSN (Print 0974-2115) (Online 2349-8552)

[2] Chengye Liu1 and Jianming Shen: Effect of Turbocharging on Exhaust Brake

[3] Design and Analysis exhaust brake system for heavy commercial vehicle applications. IERJ-1359-1358 published :2015, by Sandip Rajput.

[4] Effect of Engine Backpressure on the Performance and Emissions of a CI Engine. JIMEC'7, published: 2010, by Murari Mohan Roy.

[5] Test bench evaluation of heavy vehicle supplementary brake systems. CONAT20105001 published:2010, by Venetia Sandu.

[6] Emergency braking system in automobile using eddy current braking. IJARMATE-2454-9762, published :2017, by Karthikeyan B.

[7] Enhancement of Braking System in Automobile Using Electromagnetic Braking. IOSR-JMCE 2278-1684, published :2011, by Akshyakumar S. Puttewar.

[8] Fabrication of air brake system using engine exhaust gas. IJARIIE 2395-4396, published :2016, by Prakash T.

[9] Exhaust back pressure effect on the performance features of a diesel engine. ARPN 1819-6608, published :2017, by A. R. Sivaram.

[10] Decompression engine brake modeling and design for diesel engine application. Research Gate 2010-1-1531, published :2010, by Frederico Augusto Alem Barbieri.

[11] Vacuum braking system-Review paper. IJRET 2395-0056, published :2016, by Shoban Babu.M.