ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Emission &Performance characteristics of single cylinder CI engine using cold EGR (Exhaust Gas Recirculation).

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Abstract

Abstract—In this paper we studied the effect of exhaust gas recirculation for reduction of harmful gases like NOx,CO2 etc. at a same time effects of cold EGR on performance of engine such as brake thermal efficiency, cylinder pressure, cylinder temperature exhaust temperature.etc Above parameter studied for stationary water cooled DI Diesel single cylinder engine by looking towards running(2014) and upcoming emission Norms. Also to incorporate technology to study effects of EGR on combustion temperature and so to reduce NOx by surveying emissions papers to have outlook of EGR Route system and important equipment that need to be furnished in further study in same project to have smooth and positive effects from performance side under study. Professor Avinash M.Wankhade et al found that while re-circulating exhaust gas it reduced about 65.26% of NOx which is improved results of Avinash Wankhade et al and Pratik Sapre et al under guidance of Dr.S.B.Thakare et al[ ].Use of EGR significantly reduced NO emissions at normal condition when passing 20% of EGR. The Particulate emissions increased as EGR rate is increased but we don't deserve it so to vanish this effets further experiments can be done with blending diesel with fish methyl oil ester, sun flower oil methyl ester[14]. This reduces NOx as well HC.So Exhaust gas was recalculated in intake stroke and cooled by intercooler of partially cooled type via venturi meter.
Keywords: Diesel Engine, NOx, EGR, Heat Exchanger

Introduction

As compared to gasoline engine diesel engine operate more efficiently as due to high compression ratio and due to lower throttling losses. This results in increment in thermal efficiency by 15% in brake specific fuel consumption(BSFC) in earlier study [12] Avinash M.Wankhade,Pratik G.Sapre found that due to EGR performance of diesel engine is get lowered but they had achieved significant decrement in NOx emission. Now in this study they looked towards cold EGR conditioned when exhaust gases was being cooled with help of heat exchanger or exhaust calorimeter. Some amount of heat is gained by water and gets further used to calculate heat balance sheet.

They looked diesel engine under study due to higher popularity due to its higher efficiency lower value of diesel fuel. It widely used in irrigation sector, small electric power generation, transportation sector in form to lift water from lake sea etc. widely used diesel engine must have lower emission with higher performance so EGR is effective way to reduced the emissions like NO,CO2,PM soot particles as well further modification in route system can be well suited for this achievement. The U.S.EPA has established a new set of emissions under national ambient air quality standards for natural air pollutants like ozone(O3) and (PM) further past decades to reduced ozone more struggle has efforts to reduce the HC, Volatile organic compound(VOC) and also NO from above organic enlisted parameters NO is harmful to reduced ozone layer depletion and resulted in reduction in ozone layer so to increased global warming and side by side it have effects on human skin adversely, so our main aim was to reduce this unwanted NO from diesel engine and this unwanted NO from diesel engine and this can be achieved by exhaust gas recirculation. Past year EPA standers for heavy duty medium duty engine or diesel fuel have enlisted cut off values in table 1 as shown. Up to year 1999 EPA standards to manage emissions from engine according to this; engineers design combustion system and fuel injection rate and timing control however to meet 2006 standards for NO use of Exhaust Gas Recirculation is used. In this technique portioned of exhaust gas is re circulated in combustion chamber from start of intake charge via orifice meter. In this paper we have plotted results and value got from DA system and manually plotted to show performance and emissions.[1]

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Year → gm/bhp-hr ↓	HC	CO	NOx	PM
1990	1.3	15.5	6.0	0.6
1991	1.3	15.5	5.0	0.25
1994	1.3	15.5	5.0	0.10
1998	1.3	15.5	4.0	0.10
2004	-	15.5	2.4-2.5	0.10

Table no 1:-Emissions norms for Medium duty engine

1.1 BASICS BEHIND REDUCTION OF NOX WITH EGR

NO production in cylinder is to due to higher temperature of cylinder and most chances when at peak cylinder pressure. Experiments by sihling and woschni[ ]have shown much of NO emitted from engine due to high cylinder temp. The level of premixed burning in the combustion chamber has a direct influence on NO formation. The most effective ways of controlling of premixed burning are timing retardation and the introduction of exhaust gas in combustion chamber[1].

N2,CO,NO,H2O vapors are main constituents in exhaust gases are being re circulated in combustion chamber. In start of intake stroke.

Three main process thoroughly which combustion process can be identified by sir ladomantos et al [1].

1] Thermal Effects
2] Dilution Effects
3] Chemical Effects

In thermal effects; by introducing H2O vapors and CO2 in combustion chamber acts as a bulk of ideal gases and due to which specific heat of charge is increased due to which lowered in peak cylinder temperature resulting in decrement in NO emissions.

In dilution effects reduces the oxygen conc.in charge by replacing oxygen with Nitrogen,CO2,and water vapor. Above sentence can be validated by carring actual experimental engine and results plotted by Pratik G.Sapre during academic project study and reach up to the conclusion in which NO emission reduces and stringent increment HC level.Shiozaki et al[16] observed as significant increment in ignition delay with reduced oxygen conc. Ropke et al[17] also found oxygen factor which could resist to increased NO emission.

In chemical effect results with dissociation of CO2 and water vapors.This highly endothermic reaction occurs at high temperature absorbs the thermal energy of combustion, hence reducing peak pressure and temperature of cylinder From above this three effects dilution effects is most effective.

2 EXPERIMENTAL SETUP & METHODOLOGY

A single cylinder,naturally aspirated four strokes,vertical air cooled engineis taken.Various parameters are measure by electric alternator type dynamometer used to measure brake power,techometer to find rpm of engine of,thermocouple to measure temperature,AVL five gas analyser to measure varoius emissions like NOx,CO,HC etc.

2.1 .SPECIFICATION OF THE DIESEL ENGINE

Diesel engine used for this test is naturally aspirated water cooled single cylinder four stroke CI engine.

Engine Specification:-

4 Stroke single Cylinder air cooled self start CI engine.	Make:-Kirloskar
Rated Power:-7.5kw (10 HP)	Bore Dia.:-80mm
Stoke Length:-110mm	Connecting Rod Length:-234mm
Swept Volume:-562cc	Compression Ratio:-17.5:1
Rated Speed:-rpm	Rated Torque:-4.6kg-m
Arm Length:-150mm	

2.2.EGR TECHNIQUE

It is a well known to reduce NOx emission in which a part of exhaust gas is recirculation. The cooled EGR systems shown used in this research was provided by kirloskar engine company. Modification

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in default engine that allowed the installation of the EGR system are changed exhaust gas manifold two way outlet and heat exchanger. The exhaust gas cooled by use of heat exchanger of type partially cooled and inlet and outlet water temp. Measured by PT 100 sensors.

Intake charge temperature of exhaust gas depends upon intercooled outlet temperature. The exhaust gas is partially cooled in system by regulating flow of water temperature of intake charge of exhaust gas can be varied cold water regulating valve after intercooler and before intake exhaust gas passed via orifice meter called as EGR valve and amount of EGR calculated as;

EGR %=Megr/Mi*100

Fig 1.Schematic of orifice meter

Fig 2.Indirect type partially cold Heat Exchanger

The objective of developing this experiment test set up is to investigate and demonstrate the effect of various EGR rates on engine performance and emission. The water inlet for Stainless Steel pipe is given outlet source. In order to get the heat transferred from the exhaust gas to the water. It must be continuously supplied for maintaining the temperature of exhaust gas nearly equal to atmospheric temperature.

3 Results and Discussion

As shown in fig 1. By applying mode of venturi with diesel engine a series of engine tests were carried out on medium capacity diesel at 1500 rpm and different EGR rates in order to show the effect of EGR on NOx, HC, CO,CO2,& engine performance parameters.

3.1 NOx Emission

It is observed that with increased in EGR rates NOx emission also decreased due to lower flame temperature and oxygen concentration in combustion chamber. from fig 3 it is clear that on without EGR it s taken as 850(ppm) & then after 20% of EGR NOx emission is at its peak value that is at 310(ppm) but as we increases EGR (%) on after 20% EGR , NOx emission also increased as cylinder temperature increased and mostly because of re-entry of exhaust gases with particulate matter, various emission like HC,CO,CO2 ,NO & soot particles & due to this amount of NOx is again increased up to 364(ppm).So about 63% of NOx is get reduced by using partially cold heat exchanger as shown fig 2 so as to maintained peak temperature of cylinder.

Sr. No.	EGR Rate (%)	NOx (ppm)	Reduction in NOx (ppm)
1	0	850	0
2	5	838	12
3	10	688	162
4	15	498	352
5	20	310	540
6	25	364	486

Table 2. NOx reduction values at varying EGR rates

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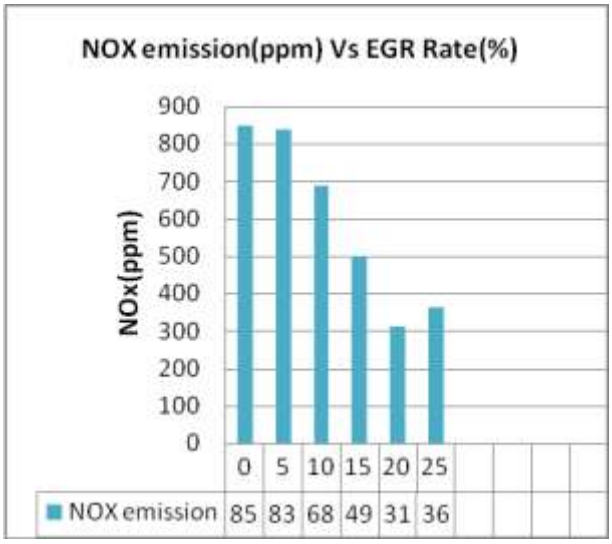

Fig 3 Amount of NOx reduction (ppm)Vs. EGR Rate(%)

Fig 4 shows relation between NOx Reduction Vs. engine torque at different EGR rates. As all (%) of EGR causes reduction in NOx emission but considerable difference can be observed by comparing 5(%) of EGR case and 20(%) of EGR case & both cases with NO EGR case.

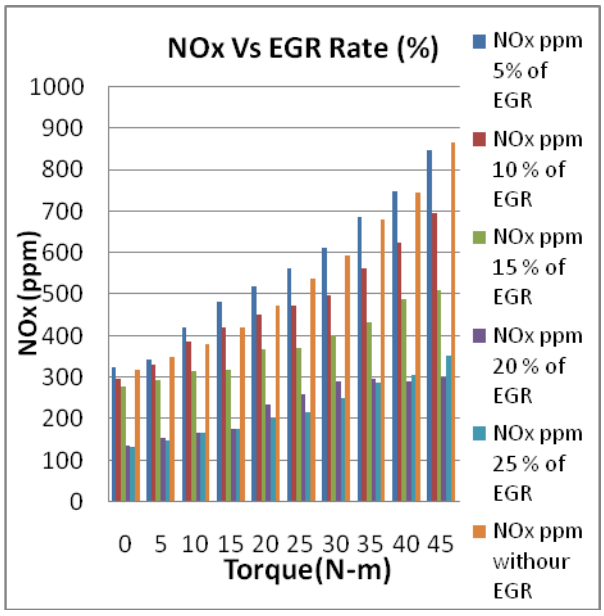

Fig 4 NOx(ppm) reduction Vs. Torque (N-m)

3.2 HC,CO2,NOx emissions with varying EGR Rates

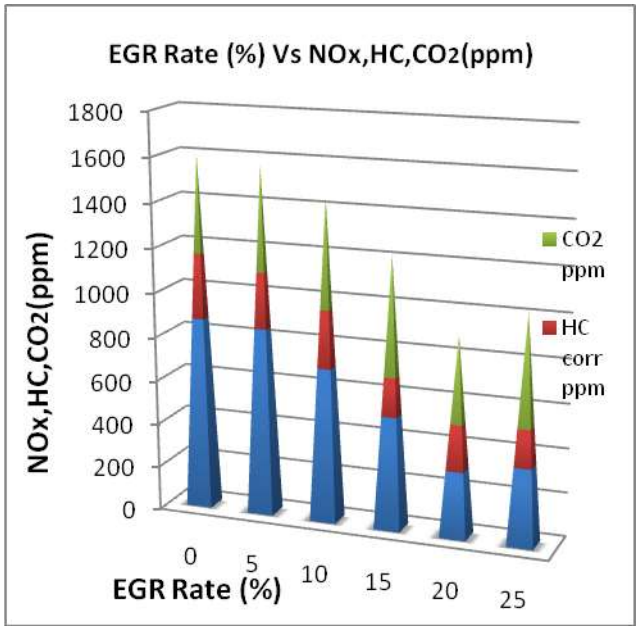

Fig 5. HC,CO2,NOx (ppm) Vs.EGR rates(%)

Above fig 5 shows combine relation between engine emission parameters with varying EGR rates (%) on 45 N-m Torque. When torque is increased it requires more fuel rate as compare to lower loading condition so in combustion chamber more amount of free air from atmosphere took part in chemical reaction.

A significant effect on NOx emission is obtained. Also combustion is affecting up to certain extent as a result of which HC emission is also getting increased as shown at same time amount of carbon dioxide is increased at higher EGR rate[12].

"Above test conducted on single cylinder four stroke water cooled CI engine, Babasaheb Naik College of Engineering Pusad 445215, SGBA University, Dist. Yavatmal, MH, India

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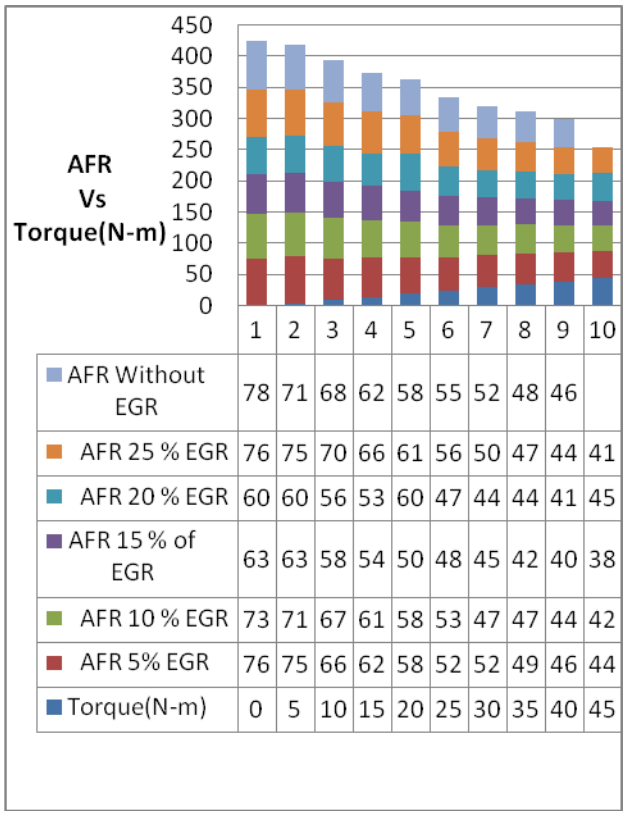

Fig 6 Infuence of Torque on Air Fuel Ratio

Above graph shows variation between Air Fuel Ratio and Torque. It can be noted that conventional diesel operation exhibits lower Air Fuel Ratio. This is because diesel combustion process involves utilization of large amount of excess air due to heterogeneous mixture. That is leaner mixture at high load condition. The effect become more visible on above graph as the EGR (%) increased at high load. As a result Air Fuel Ratio higher than that associated with diesel and effects are more apparent with high EGR (%).[7].

3.5 Brake Specific Fuel Consumption vs Torque(N-m)

In given fig BSFC Vs. Torque plotted. It indicates the variations of brake specific fuel consumption with increasing EGR rate. There is remarkable improvement in fuel consumption with increasing EGR. One of the main reason for that effects is due to the reduction of pumping work as the amount of EGR rate is increased(with fuel and air flow rate remains constant),the pump work get reduced and hence the entire inlet charge needing to come passed the throttle. Again due to the reduction in heat loss to the wall of cylinder the significant reduction in burnt gas reduction, improve the fuel consumption trends. The reductions in degree of dissociation in high temperature burn gases also improve brake specific fuel consumption.[8].

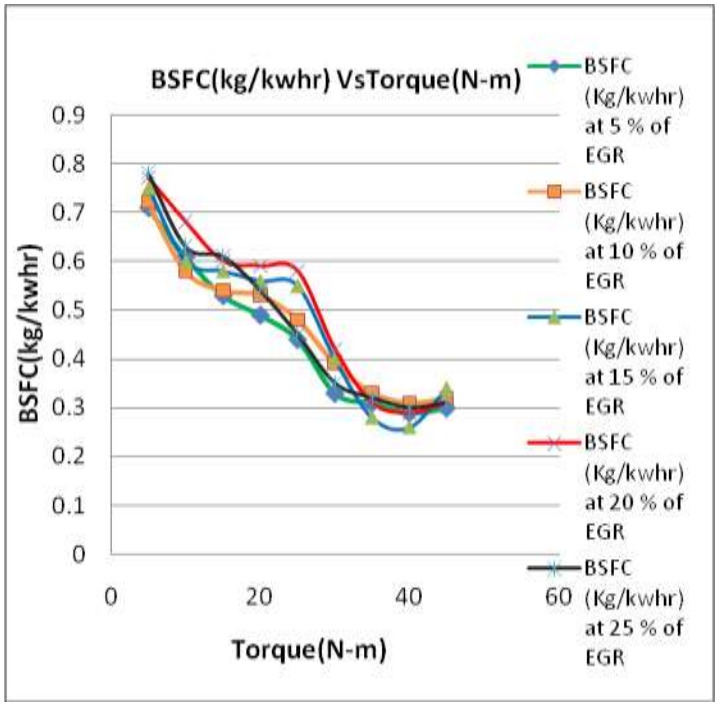

Fig 8 BSFC(kg/kWh)Vs. Torque(N-m)

In above fig BSFC Vs. Torque plotted. It indicates the variations of brake specific fuel consumption with increasing EGR rate. There is remarkable improvement in fuel consumption with increasing EGR. One of the main reason for that effects is due to the reduction of pumping work as the amount of EGR rate is increased(with fuel and air flow rate remains constant),the pump work get reduced and hence the entire inlet charge needing to come passed the throttle. Again due to the reduction in heat loss to the wall of cylinder the significant reduction in burnt gas reduction, improve the fuel consumption trends. The reductions in degree of dissociation in high temperature burn gases also improve brake specific fuel consumption.[7,8].

Conclusion

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● An experimental investigation was done on a single cylinder four stroke, water cooled diesel engine. The effect of EGR on Performance & Exhaust emission of the diesel engine was observed & the result of this study may be concluded as follows:

● The NOx emission was decreased with increasing EGR flow rate from fig NOx decreases from 850 ppm to 310 ppm on 20 % of EGR supplement.

● From the experiment it can be suggested that 20% of EGR is optimum for NOx reduction without significant penalty on brake specific fuel consuption and HC emissions

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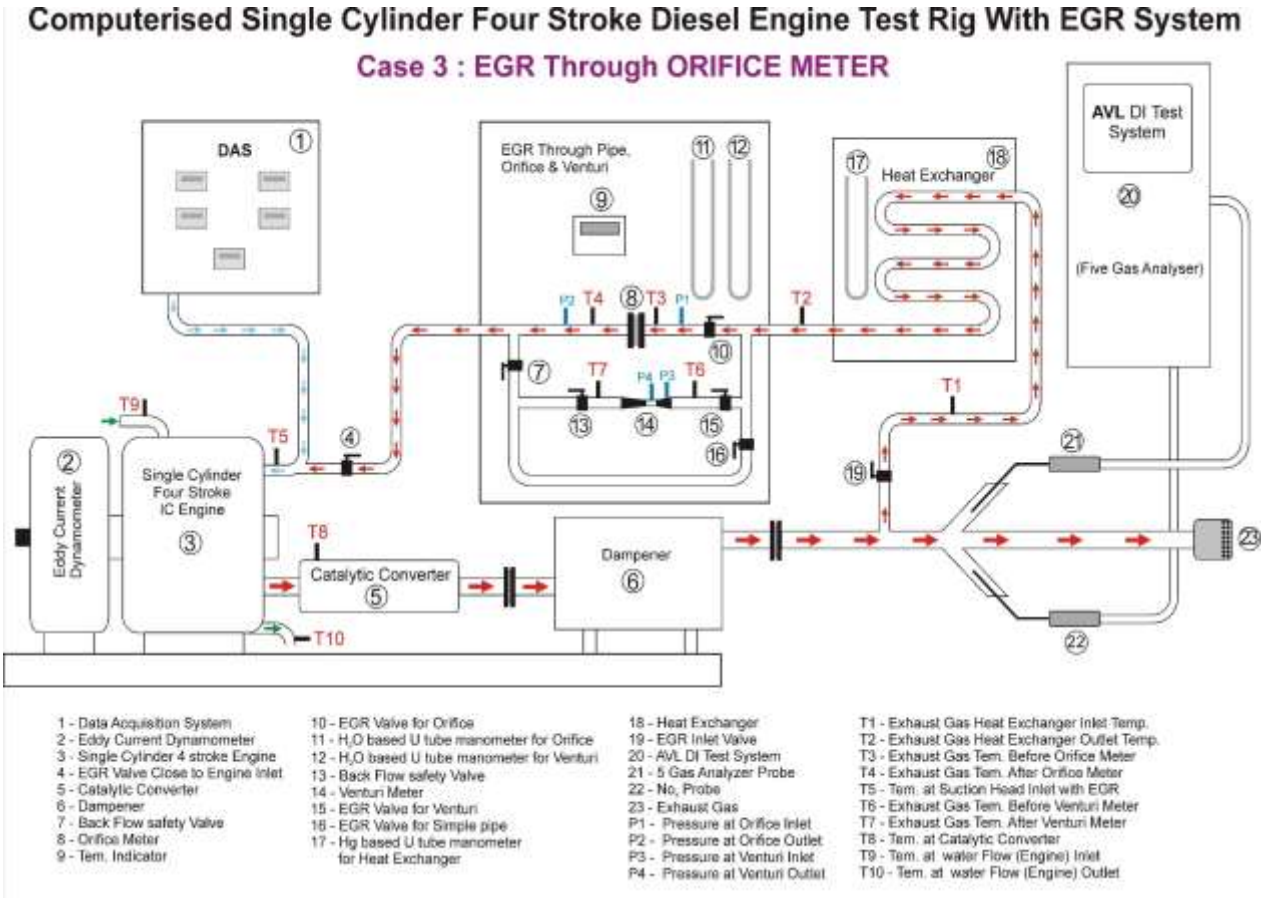

Fig 9 Line diagram of proposed Exhaust Gas Recirculation test rig & flow though orifice meter