Performance Evaluation of Four-Stroke Twin Cylinder Diesel Engine with Optimum Cooling

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Abstract: Diesel as a fuel is now available with high rate and it causes more pollution as compared to other fuel which is the major problem in recent scenario. So attempt has been m=ade on energy conservation and management in diesel engine with different methods to reduced energy loss by optimum cooling, additives with lubrication. In this paper experiment on twin cylinder four stroke diesel engine has been done and engine performance is compared before engine overhauling and after engine overhauling. Found that there is increase in brake power by utilizing west heat energy reduction in emission. Heat balance sheet had been prepaid using servant readings and it was found that after changing lubricating oil found increase in mechanical efficiency of about 10-12%, decrement in specific fuel consumption of about 5-7%. By varying mass flow rate of cooling water at rated power we found optimum cooling rate (0.00014 m³/sec).

Keywords: **Diesel Engine, Optimum Cooling, Lubricating Oil, Maintenance, Overhauling, Repair**

I. INTRODUCTION

Engine means it is device which convert one form of energy to mechanical energy. And this mechanical energy is easily convert in electrical energy. Heat engine classified in two main class :-
(1)External Combustion Engine (EC Engine)
(2) Internal Combustion Engine (IC Engine). Combustion of the fuel with oxygen and air mixer in the engine so it called internal combustion engine. Example: petrol engine, diesel engine and gas engine. Diesel engine named after Rudolf Diesel. When the air is compressed then the temperature of the air is increased. Then after the fuel is inject with the help of the fuel injector. In diesel engine all the parts are same as used as in SI engine but spark plug replaces by the fuel injector. Diesel engine woks on the "Constant Pressure" cycle. Diesel engine has highest thermal efficiency due to very high expansion ratio. Diesel engine is two type stationery engine and moveable engine. Stationery engine is constant speed engine. Stationery engine is use in boat, ships etc. to take constant speed. The main purpose of any product or device is how efficiently it will satisfy need of consumer and provide optimum work. Any product which is in use that will require its MRO at regular time interval. MRO is a secret weapon to make product more efficient and useful in satisfying customer needs.

Increased sales or efficient products are certainly one of the goals of establishing or enhancing a value added service or MRO operation. MRO stands for (1) Maintenance (2) Repair (3) Overhauling. Maintenance can be defined as the checking of product at regular time interval on specified criteria. Maintenance can be classified as (1) Scheduled maintenance is used where equipment is inspected, maintained and protected before break down. (2) Corrective maintenance is used where equipment is repaired or replaced after malfunction. During maintenance if any component or part of the product is found to be in non-working condition that will be repaired. Overhauling can be defined as a process in which the part or component is repaired or replaced as per the requirement. 20w40 lubricating oil is used but there are some limitation so we used 15w30. Kinematic Viscosity at 100 C of 15w30 is more than 20w40. Viscosity Index is more than 20w40. Flash point is more and Pour point is less than 20w40. So 15w30 is used as par comparison.

From above definitions, focus is on optimum cooling. Waste heat of exhaust emissions and unaccounted utilized to increase brake power. From analysis we found that in diesel fuel driven automobiles having constant cooling water flow rate so at low load condition problem of *overcooling* will arise and that results in improper combustion. At high speed flow rate of cooling eater is constant so the problem of *under cooling* will arise and that results in over heating of engine and reduction in life cycle of engine. To solve the problem of over cooling and under cooling concept of optimum cooling used at rated power. When engine runs for certain period of time, the condition become steady for particular load. At this state energy enters to boundary is equal to energy out from the boundary. It is calculating by total heat supplied and where the heat is loss.

II. LITERATURE REVIEW

Ting Luo and et. al. [1] Nano-scale Al_2O_3 spherical particles, prepared via hydro thermal ethos and modified by saline coupling agent, can be well-dispersed in lubricating oil. Thetribology properties of Al_2O_3 nano particles as lubricating oil additives have been studied by four-ball and thrust-ring friction test, which illustrate that the modified Al_2O_3 nano particles can effectively improve the lubricating behave ours compared to the base oil. When the added concentration is 0.1wt%, the friction coefficient and the wears car diameter are both smallest. The lubrication mechanism is that a self-laminating protective film is formed on the friction surface and the wear behaviour changes forms lading friction trolling friction.

Ankit Kotia et. al.[2] In the present study, the performance of a 4-stroke diesel engine was experimentally evaluated upon adding Al_2O_3 or SiO_2 nanoparticles to the engine oil (SAE15W40). The viscosity and density of there salting nano-lubricants were determined while varying both the nano particle volume fraction and the temperature. Field emission scanning electron microscopy (FE–SEM) showed that the nano particles had a spherical morphology and dynamic light scattering analysis determined some aggregation of the nano particles in the engine oil.

Gosai D C et. al.[3] An attempt has been made to study the performance and exhaust emission studies of a diesel engine by insulating the combustion chamber using ceramic material attaining an adiabatic condition. The cycle average gas temperature and metal surface temperature are higher in adiabatic engine. Many researchers have carried out a large number of studies on LHRE (Low Heat Rejection Engine) concept. In the case of LHR engines almost all theoretical studies predict improved performance but many experimental studies show different picture.

Roop Lal et. al. [4] Piston rings are vital components in the internal combustion (IC) engines having reciprocating motion. The oil film thickness plays important roll and finally affects the performance of engine. Surface roughness of tribo pair material at the junction produce friction and it varies throughout the stroke length of piston. Loss of power in lubrication has the shear force due to boundary conditions. The tribological performance in IC engine can be understood when friction and wear are considered. It is also necessary to study the factors influencing reliability and performance along with wear.

Avinash A. Thakre et. al.[5] The purpose of this paper is to include investigation on extreme pressure lubrication behaviour of Al_2O_3 nanoparticles suspended in SAE20W40 lubricating oil. Effects of nanoparticles size (40-80 nm) and its concentration (0-1 per cent) on the coefficient of friction is studied using pin-on-disc tribo tester. Taguchi technique is used to optimize the process parameters for lower coefficient of friction. L18 orthogonal array involving six levels for one factor and three levels for remaining three factors is selected for the experimentation. The parameters selected for the study are sliding speed, normal load, nanoparticles size and its concentration in base oil.

Zhenyu J. Zhang et. al.[6] Lubricant additives, based on inorganic nanoparticles coated with organic outer layer, can reduce wear and increase load-carrying capacity of base oil remarkably, indicating the great potential of hybrid nanoparticles as anti-wear and extreme-pressure additives with excellent levels of performance. The organic part in the hybrid materials improves their flexibility and stability, while the inorganic part is responsible for hardness.

Filip Ilie et. at.[7] To improve the oil-solubility of nanoparticles, a new technology was used to prepare kind of lubricant containing titanium dioxide (TiO_2) nanoparticles. The microstructures of the prepared nanoparticles were characterized via transmission electron microscope (TEM) and infrared spectroscopy (IR). Tribological properties of TiO_2 nanoparticles used as an additive in base oil were evaluated using four-ball tribo meter and ball-on-disk tribo meter. In addition, the worn surface of the steel ball was investigated via polarized microscopy (PM) and X-ray photoelectron spectroscopy (XPS). The TiO_2 nanoparticles can be completely well-dispersed in the base oil under a new process (NP), which has no significantly negative effect on the anti-oxidation property.

V.A. Romanov et. al.[8] The cooling system of the designed diesel engine was investigated using specially prepared models. For selected initializations of a cooling fluid in the available cooling jacket, quantitative estimates of the levels of the heat flow to the coolant and of the temperature of the cooling surfaces of various cylinders were made.

Antonio J. Toreros et. al.[9] In this paper, a methodology for the design process of engine cooling systems is presented, which is based on the interaction among three programs: a code developed for radiator sizing and rating, a 3D commercial code used for the air circuit modelling, and a 1D commercial code used for the modelling and simulation of the complete engine cooling system.

Hussein S. Moghaieb et. al. Error! Reference source not found. As paper study, the researcher used c- Al_2O_3/water nano fluid for engine cooling. The tests were performed using c- Al_2O_3 nanoparticles with size range (21–37) nm and the aspect ratio was 0.8. The effect of nanoparticles volume concentration (0–2%), bulk temperature (60–80 _C), and flow velocity (1–2 m/s) are investigated for Variable heat flux (100–400 kW/m2).

Roonak Daghigh et. al. Error! Reference source not found. High temperature and mass flow rate of the exhaust gases of submarine diesel engines provide an appropriate potential for their thermal recovery. The cooling system is composed of a mixed effect absorption chiller with two high and low pressure generators. The obtained findings showed that the maximum heat recovery for the power cycle occurs in exhaust gas mass ratio of 0.23-0.29 and working fluid mass flow rate of 0.45-0.57 kg/s.

Arya K. Haghighat, et. al. Error! Reference source not found. A controlling model for the cooling system of an engine was developed in order to reduce fuel consumption and engine emission through the use of controllable engine cooling components including an electrical water pump, an electrical fan and a heated thermostat.

Nor Azwadi Che Sidik et. al. Error! Reference source not found. In this paper researcher used nano fluids for engine cooling. Nano fluids are suitable coolant due to its high thermal diffusivity and can be applied to any system that needs a quick response to thermal changes such as vehicle engine. For engine cooling system, nanoparticles can be dispersed in the engine oil to enhance the thermal conductivity of the liquid.

Ahmad Fayyazbakhsh et. al. Error! Reference source not found. The present review investigates modification of diesel fuel formulation and development of new model to enhance engine performance, improve fuel properties and reduce exhaust emission. This review paper studies the implication of different torque and various engine speeds. In some condition, it can even cause an increase in the content of carbon monoxides, carbon dioxide and nitrogen oxide.

Esmail Khalife et. al. Error! Reference source not found. Depletion of fossil fuel resources and stringent emission mandates has spurred the search for improved diesel engines performance and cleaner combustion. In this research paper the researcher used biodiesel and diesel additives. The effect of biodiesel/diesel additives on the performance and emissions of diesel engines. They used five types of additives oxygenated additives, metallic and non-metallic based additives, water, antioxidants and polymeric-based additives. The effects of each category on the engine performance were exclusively summarized and emission.

Arun Kumar Wamankar et. al. Error! Reference source not found. In this investigation carbon black was doped with diesel by following certain sequential processes and the mixture was commonly referred to as carbodiesel. The mixture containing 5% CB was denoted as carbodiesel5. Similarly 10%, 15%, 20% CB in carbodiesel were denoted by carbodiesel10, carbodiesel15, carbodiesel20. The results indicated that carbodiesel10 gave batter performance and lower emission compared to those of carbodiesell15 and carbodiesel20 at full load.

III. Experimental setup

Test rig: above schematic diagram shows the test-rig of our experimental set up. It contains different measurement instruments which are used in measuring performance of engine like; load rheostat, calorimeter, generator etc.

As shown in figure the experiment work was carried on twin cylinder four stroke vertical water cooled diesel engine with a bore of 80mm and stroke 110mm. The engine is rated for 7.35 (10 HP) and 1500 RPM with a centrifugal governor to control the speed. The engine was connected with load rheostat, which is used to measure the parameters like fuel consumption, load, speed of engine, cooling water temperature, inlet air and exhaust gas temperature etc. The engine test was carried out with constant speed of 1500 RMP and load was varied from no load to the maximum load conditions. For different load conditions engine parameters were checked on base engine. The following tests were carried out: Performance test and Heat balance test. During the experiment due care was taken to maintain optimum mass flow rate of cooling water for each load on engine for avoiding overheating and under cooling of diesel engine.

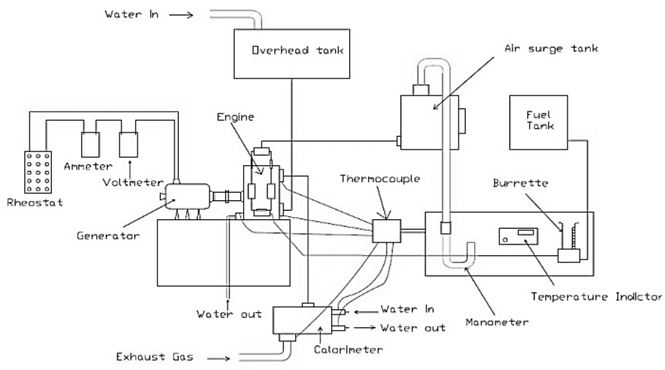

Fig. 1 Experimental Setup

IV. Result and Discussions

Graph 1 Brake Power vs Specific Fuel Consumption : Fig 2 shows the comparison of specific fuel consumption at particular brake power before changing lubricating oil and after changing lubricating oil. It is observed from the graph that in starting condition there is reduction in fuel consumption but as load increases it is almost constant. So it can conclude that by changing lubricating oil(15w40) about 2-3% fuel consumption is reduced.

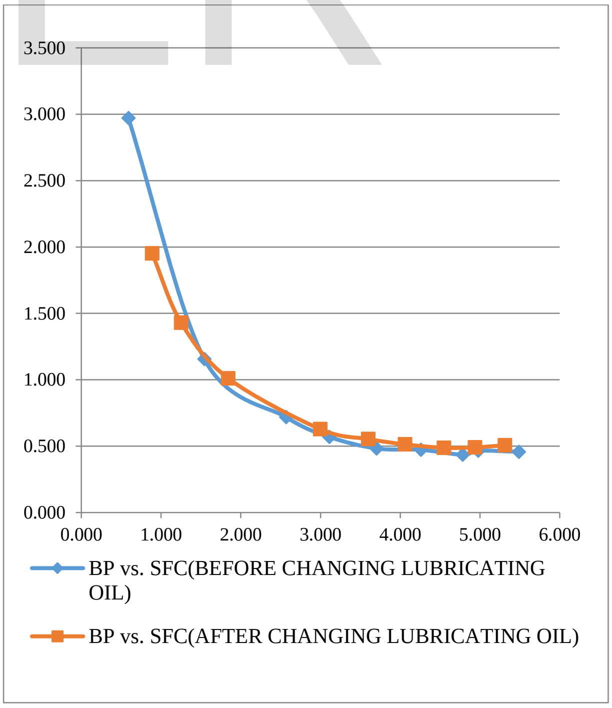

Fig. 2 BP vs SFC

Graph 2 Brake Power vs Mechanical Efficiency :

It can be seen from the graphs that mostly at all load conditions mechanical efficiency of engine after changing lubricating oil is 5 % higher compared to engine before changing lubricating oil. This may be due to reduction in heat loss because of components being subjected to lubricating oil having better properties. This may be due to minimize the friction in combustion chamber at higher operating temperature of lubricant oil.

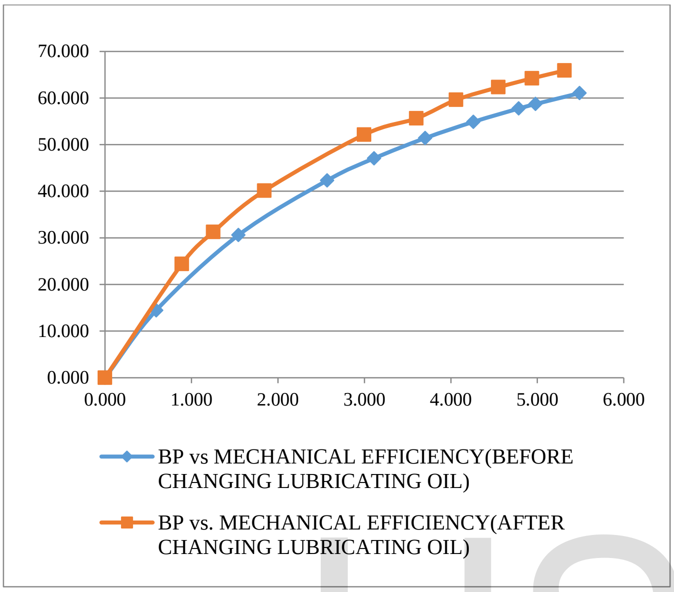

Fig. 3 Comparison BP vs SFC

Graph 3 Discharge vs Brake Power :
Optimum cooling rate is used in solving problem of overcooling and undercooling. By using concept of optimum cooling rate at rated power variation in mass flow rate of cooling water will give improvement in brake power at optimum cooling rate 0.0001083(m^3/sec).

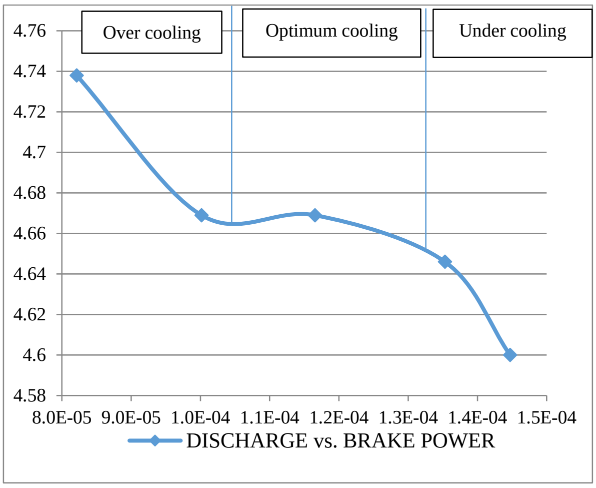

Fig. 4 Discharge vs B.P. (Optimum cooling)

Heat Balance Sheet (HBS):- It is found that heat used in producing brake power gets improved by about 6% due to optimum cooling rate. It can be seen that approx. 20% more heat goes with cooling as compared to engine without changing lubricating oil. This may be due to higher operating temperature of engine and reduced radiation losses. 4% more heat goes to the exhaust gas. Heat lost by radiation and unaccounted losses gets reduced by 16%. This may be due to optimum cooling rate.

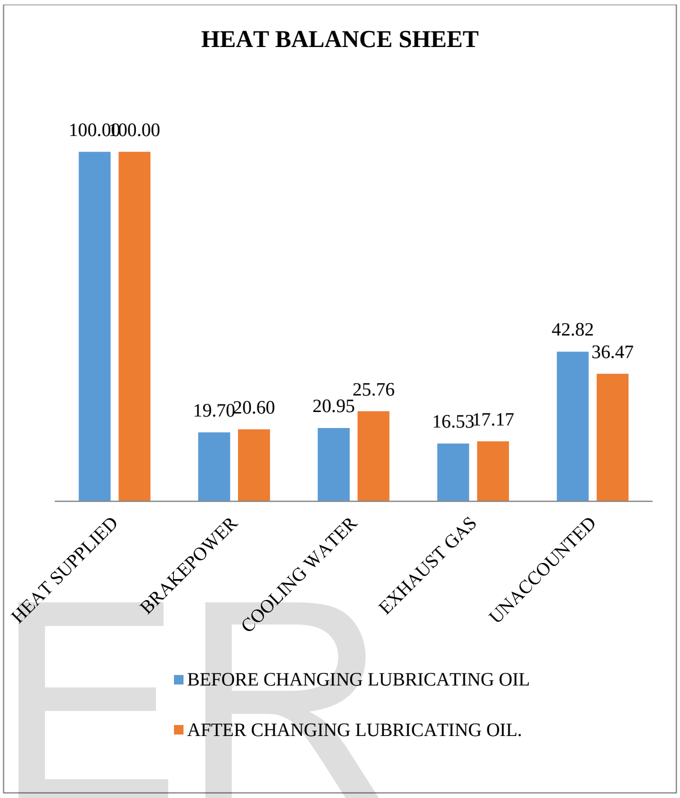

Fig. 5 Heat Balance Sheet at rated power

V. Conclusion

The following points were concluded on the bases of above discussed experimental results.

1. As the change in lubrication oil, the mechanical efficiency increased by 6% and 10% reduction in volumetric efficiency.
2. After optimum cooling at rated discharge, improvement in Brake Power at same Specific Fuel Consumption.
3. The Heat Balance Sheet indicates that some amount of heat wasted in unaccounted & exhaust energy is utilised to increase in Brake Power and Cooling water.

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