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A Review Paper on Diesel Engine Characteristics for Varying Nozzle Depth at Different Spray Angles

Rahul Kumar Singh[1], Dr. Dinesh Kumar Soni[2] Rupesh Kumar Malviya[3]
[1]*PhD Scholar, Mechanical Engineering Department, Rabindranath Tagore University Bhopal-464993, M.P., India.*
[2]*Associate Professor,, Mechanical Engineering Department, Rabindranath Tagore University Bhopal-464993, M.P., India.*
[3]*Research Scholar, Mechanical Engineering Department, Rabindranath Tagore University Bhopal-464993, M.P., India.*

Abstract: *The need of petroleum fuels is increasing everyday despite of their speculation regarding the depletion of petroleum fuels. The petroleum fuels are categorized as suspicious element for human being due to its well known major harmful effects on the environment. The concern is that the need of petroleum fuel is increasing simultaneously with its price in the market. The researchers around the world are focusing either on the reduction of harmful effects which produced from the petroleum fuel or finding another a batter substitute of the petroleum fuel. The present research is about the reduction of harmful gases from the exhaust of a diesel fuel operated diesel engine. This research also includes the details analysis of combustion and performance parameters. A kirloskar single cylinder diesel engine (model –TV-1) is selected for the numerical simulation using commercially available software AVL FIRE. The operating and boundary condition of single cylinder diesel engine is referenced in the published articles. The hemispherical bowl piston geometry is generated and meshed in the software the research is further processed with the selection of three different spray angles like 120^o, 140^o, and 160^o. Whereas 120 spray angle is the standard spray angle. Additionally to analyzed the effect of nozzle depth on the emission, combustion and performance parameters four nozzle depth values are also included in the research. The four nozzle depths are 0.5mm, 1mm, 1.5mm and 2mm. whereas 1mm nozzle depth is standard nozzle depth. All four nozzle depths are examined under 120^o, 140^o, and 160^o spray angle. The results reverted that the emission parameter and depends on the spray angle and nozzle depth. To get suitable emission result from the above case some compromise has to be considered for performance and combustion parameters.*

Keywords: *spray angle, nozzle depth, numerical simulation, emission parameters, combustion parameters, and performance parameters.*

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I. Introduction

The modern diesel engine development is governed by maximum efficiency and low emission requirements the variation in spray angle at different nozzle depth has enhanced engine efficiency and decreased emissions by improving the atomization characteristics of the fuel spray. The variation in spray angle at different nozzle depth has been studied by several researchers with different angle and different nozzle depth. The experimental investigation of diesel sprays angle and different nozzle depth is very challenging due to no any modification is possible in engine from its standard condition and position of nozzle depth inside the combustion chamber and spray angle of nozzle. Hence here we use suitable software for getting result data from this variation in engine operating condition.

Emissions from diesel engine are not only harmful for the present, but it also unfavorable for the future of the world. It must be control today by considering its hazardous effect on tomorrow. The severity of the emission problem has judged by a life cycle assessment of new diesel engine, and the results clearly show that, the global warming and photochemical ozone formation have major impact of 19.47% and 17.54% respectively, of total impacts of the diesel engine. On this stage, numerous researches are proceeding to control emissions from diesel engines by means of different facets of applied science. The technology has been used with the new dimension of nozzle depth (in mm) inside the combustion chamber at varying spray angle.

HISTORICAL BACKGROUND: EMISSION CONTROL

The very first indication of exhaust problem was observed during early 1950s in Los-Angeles region of USA, where transport vehicles were responsible for the formation of photochemical smog due to the emission of

Unburned Hydrocarbons and Nitrogen Oxides. The initiative against emissions from vehicles and achieved milestones are listed in following:-

Table 1 Historical background of emission control (N-69)

Year	Achievements and Events
1952	The photochemical reactions between Unburned Hydrocarbon and Nitrogen Oxides were explained by Prof. A.J Hagen from University of California. He demonstrated that, these reactions are responsible for the formation of photochemical smog observed in Los-Angeles.
1965	The first vehicle emission regulation and laws made in California, USA.
1968	The emission regulation was set for the all states of USA.
1970	European countries prepared vehicle emission standards.
1974	The catalytic converter was discovered for the oxidation of Unburned Hydrocarbon and Carbon monoxides in USA to achieve emission targets.
1981	The three way catalytic converter was invented for simultaneous reduction of CO, HC and NO_x emission from vehicles.
1992	The catalytic converter was implemented on gasoline vehicles to achieve EURO-1 norms in European countries.
1994	The catalytic converter was improved for the vehicles, working under lean mixture operating condition.
1994	The emission norms in USA were redefined to achieve reduction CO, HC and NO_x emission by 96%, 97.5% and 90% respectively in US Tier-1 standard.
2000- 2005	Numerous researches were carried out to achieve target of US Tier-2 by reducing CO, HC and NO_x emission up to the level of 98%, 99% and 95% respectively.

Significant progress has been made during the last decade in the area of emission control.

Many researchers claim that the most of the part of entire pollutions is in the form of emissions from compression ignition engines. They justified their claims due to the use of major propulsion power source for land and marine transport applications. The high rate of pollutions affects human life and the environment adversely. As per their research the control of emissions seems to be the possible way to reduce pollutions from environment. Based on history of emission control, some methods have potential to reduce emissions from diesel engine, are discussed as follows:-

a) The enhanced air fuel mixing due to change in design of piston geometry leads to improved combustion process and reduce emission parameters.
b) The air fuel mixing is also affected by swirl method to reduce emissions from diesel engine.
c) The emissions can also be reduced by using exhaust gas recirculation method in compression ignition engines.
d) The most popular method in the present scenario is the use of bio fuel with diesel to reduce emission from CI engines. Simultaneously, alcohols and water emulsified diesel have received attention in this regard too.
e) The optimization in spray parameter is helpful for better combustion process because of enhanced air fuel mixing.

II. Problem Statement

Combustion of diesel fuel is used to produce high power in transportation sector. High emission from diesel engine is a major concern in terms of health and environmental aspects. The present work is aimed to conduct an investigation on combustion, emission and performance characteristics by varying nozzle depth at different spray angles through numerical simulation approach on a diesel engine.

The motivation of present research is gained by keeping the mentioned aim in mind. The present paper illustrates the effect of varying spray angle at different nozzle depth of a single cylinder diesel engine. This method is applied in present research to reduced emission from diesel engine and for improves performance of diesel engine.

It will be an interesting discussion to analyze the influence of varying spray angle at different nozzle depth on all emission parameters, combustion parameters and performance parameter.

The present investigation will involve the optimization of spray angle and nozzle depth. The results from the optimization process will be analyzed to justify the object of the present research.

III. Research Methodology

Commercially available numerical simulation software knows as AVLFIRE is used for this research. Present research work consist a numerical simulations approach for the optimization of spray angle. The spray angles are categorized in three cases to achieve an optimum case, furthermore, four nozzle depth parameters are also categorizes under each case of spray angle. At the end of analysis the combinations of spray angle and nozzle depth are examined for satisfactory (compromised) outcomes of research.

The research methodology can be presented as following flow diagram:

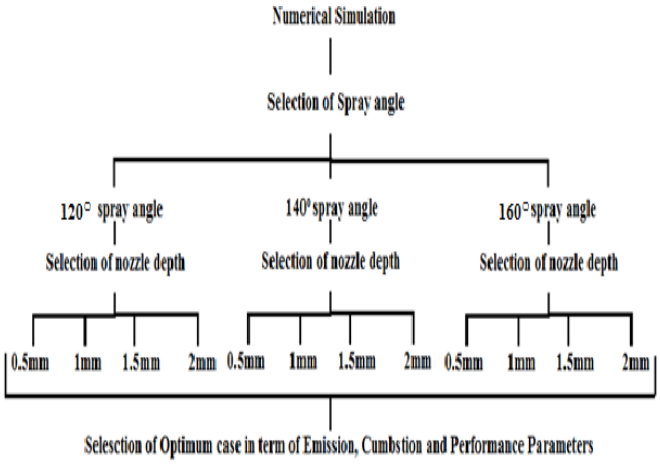

Fig. 1.1 Schematic flow diagram of research methodology

IV. Review Of Literature

The varying nozzle depth at different spray angle engine is used extensively in the field of IC engine research. Many researchers are focused on that engine due to its easiness of operation. Some promising researches are present in the literature review.

Numerical simulation is a very important tool to examine the effects of combustion in a diesel engine. Some important simulation software are AVL FIRE, KIVA 3D, STAR CD. This simulation software are used to simulate combustion process by change in fuel, geometries, speed, spray, models, swirl, injection parameters etc. The accuracy (validation) of this software is presented by many researchers. Now a day, simulation software has great impact over research in science. Some articles related to effect of geometry and fuel variation on different parameters is discussed in this section.

Soni, et al. [1] analysed performance combustion and emission parameters by comparing hemi-spherical bowl piston geometry and re-entrant piston bowl geometry. It was concluded that, re- entrant piston geometry is better than hemi- spherical bowl piston geometry for the decrease of NO emissions. Other parameters were also compared, but the re- entrant piston geometry was again batter then hemispherical piston geometry. Furthermore it can be used for soot mass fractions with 160° spray angle, but minimal conciliation has to be well-thought-out for performance strictures.

Soni, et al. [2] investigated the effects of three emission reduction methods numerically on a single cylinder diesel engine. The three methods were namely, change in swirl ratio, amount of recirculation of exhaust gases in Exhaust Gas Recirculation (EGR) procedure and addition of methanol in several quantities to prepare diesel- methanol blends. Detailed simulation analysis proves that methanol blended diesel fuel is much promising to reduce emissions from the engine.

Soni, et al. [3] analysed emission parameters by using water nano emulsion method in methanol-blended diesel fuel. The diesel-methanol blend was categorized in three different blends to find an optimum blend. The optimum blend of diesel methanol blend was treated with water nano emulsion blend. It was concluded that, the water nano emulsion method has ability to decrease NO_x emission further from the optimum blend of diesel-methanol.

J. Li, et al. [4] investigation done on three dissimilar bowl geometries specifically: Hemispherical Combustion Chamber (HCC), Shallow depth Combustion Chamber (SCC), and the baseline Omega Combustion Chamber (OCC) were shaped with the same compression ratio of 18.5. To simulate the combustion method, computational fluid dynamics (CFD) modeling based on KIVA-4 code was accomplished. The assessments amongst three bowl geometries were accompanied in terms of velocity vector field, cylinder pressure, HRR, AHRR, temperature delivery in the combustion chamber and the mass fraction of emissions (CO and NO) at engine speeds of 1200, 2400 and 3600 rpm.

Prasad, et al. [5] thorough three-dimensional CFD simulations connecting flow and combustion chemistry are used to learning the consequence of swirl tempted by re-entrant piston bowl geometries on contaminant emissions from a single-cylinder diesel engine. The standard engine outline contains of a hemispherical piston bowl and an injector with finite sac volume. The combustion chamber geometries were created for in cylinder air motion and an optimum geometry selected in terms of swirl motion and turbulence kinetic energy (TKE) for in compression top dead centre (TDC). The optimal nature of this re-entrant piston bowl geometry is established by thorough combustion simulations and emission expectations.

Rakopoulos, et al.[6] In the current work, a firstly effort is made to associate two recent engine simulation models established by the authors. The firstly one is a CFD model advanced from scratch and the second one is a thorough quasi-dimensional model. These two models have been apply to simulate the closed part of the cycle of a HSDI diesel engine functioning under motoring situations, expending three piston bowl geometries for three engine rotational speeds of 1500, 2000 and 2500 rpm. These substitute geometries are created by changing the ratio of piston bowl diameter to cylinder diameter (d/D) from 64% (which is the standard case) to 54% and 44%, accumulative respectively the piston bowl height so as to retain the compression ratio constant.

Ke Li, et al. [7] In this paper, a model of the free piston engine successively similar charge compression ignition combustion below numerous piston trajectories is accessible. The idea of trajectory-based combustion control is projected. Simulation outcomes signpost undoubtedly that with the capability of accurate piston trajectory tracking, the FPE is capable to adjust the complete combustion procedure by varying the volume outline of the combustion chamber and consequently changing the in-cylinder gas temperature and pressure traces, the indicated output work and the heat loss.

Yao, et al. [8] The initially thing paid consideration to is that a great deal of essential hypothetical investigation has been carried out. Firstly, numerical simulation has turn out to be a moral remark and a powerful tool to examine HCCI and to progress control approaches for HCCI since of its better flexibility and lower cost associated with engine investigates. Five types of models functional to HCCI engine modeling are deliberated in the current paper. Second, HCCI can be applied to a variation of fuel varieties. Combustion phasing and procedure range can be controlled by the alteration of fuel features. Third, it has been comprehended that progressive control approaches of fuel/air mixture are more significant than simple similar charge in the procedure of the monitoring of HCCI combustion procedures.

Bari, et al. [9] This investigation began with enhancing the design of the guide vanes over the simulation technique. Nevertheless, the optimization was inadequate only to the quantity of guide vanes while vane height, angle, and length were retained endless. Afterward investigating the simulation consequences of in-cylinder airflow features of TKE (turbulence kinetic energy), velocity, vortices, and swirling strength of 10 guide vanes models of dissimilar vane quantities that varied in between 3 and 12, the model with 4 vanes was initiate to be the finest one. Afterward that, five guide vanes models with the quantity of vanes ranging amongst 3 and 7 were invented and verified one by one on a CI engine run with biodiesel along with a normal CI engine run with biodiesel and petro-diesel having no vanes.

S. Scott, et al [10] A unrestricted piston, internal combustion (IC) engine, functioning at high compression ratio (~30:1) and low equivalence ratio (f~0.35), and applying similar charge compression ignition combustion, has been projected by Sandia National Laboratories as a means of suggestively Refining the IC engine's cycle thermal efficiency and dissipate emissions. The engine was examined through a zero dimensional thermodynamic model approach, where friction elements heat transfer and experimental scavenging models has been used for the functioning of engine. The cycle simulations expending hydrogen as the fuel, have designated the precarious factors upsetting the engine's enactment, and recommend the limits of enhancement promising comparative to conventional IC engine technologies.

After a detailed discussion, it can summarize that performance and emission analysis has not carried out by any researcher in varying nozzle depth at different spray angle in view of emission parameters, combustion parameter and performance parameters. Now, it is very much essential to investigate the effects of variation in nozzle depth and spray angle due to its importance in terms of performance and emission characteristic.

V. Research Objectives

The performance and emission characteristics will be analyzed numerically for a single cylinder kirloskar diesel engine by varying nozzle depth at different spray angle the objectives of this work are as follows.

1. The nozzle depth will be changed from 0.5mm to 2mm and spray angle will be change from 120^{o} to $160^{o.}$
2. The optimum nozzle depth and spray angle will be founded by analyzing performance and emission characteristics of diesel engine. Commercially available simulation software will be used for numerical simulation.
3. The present research illustrates the effect of variation in nozzle depth at different spray angle on a kirloskar single cylinder diesel engine.

The researchers all around the world are trying to reduce heat loss from the CI engine, thus it requires more attention to analyze the heat balance at varying nozzle depth at different spray angle engines and to check there effects on thermal efficiency and power at various nozzle depth at different spray angle of nozzle. There is need to explore the optimum nozzle depth and optimum spray angle on which engine gives best result.

VI. Conclusion

The conclusion of present research is gained by keeping the mentioned aim in mind. The performance and emission characteristics will be analyzed numerically for a single cylinder kirloskar diesel engine in a varying nozzle depth at different spray angle engine is an interesting area for research. The emission is the governing factor which affected whole engine and produce power. Every fuel in the world is used to produce certain amount of emission by either mechanical or chemical process.

The emission is produced by fuel, which is used to reciprocate piston inside combustion chamber after combustion and this reciprocating motion is converted to rotational power of flywheel. Therefore, it is necessary to investigate the performance and emission characteristics of a easily available single cylinder diesel engine by varying nozzle depth at different spray angle. The commercial simulation software will be used for the analysis by using different models of internal combustion engines.

VII. Future Scope

Researchers and engineers around the world are focusing more on emissions from diesel engines owing to serious environmental issue and understandably ready to compromise with power and efficiency. The present research showing an simulation work to achieve low emissions. The present research can be further enhanced by using combination of other spray parameters with spray angle and nozzle depth. The presented work is numerical simulation approach which can be further treated in an experimental work by considering it's cost analysis.

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