A Review Paper on behavior of Disc Type Fuel Injector Nozzle

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Abstract

To design a disc type cam operated injector nozzle to improve the ignition characteristic of fuel. This project include the injector nozzle disc with holes for spray and cam mechanism for needle operation. Nozzle needle will be operated by camshaft instead of fuel pressure as operated in conventional fuel injection system. Disc will be placed at the tip instead of multi hole. Disc consist number of holes in specific pattern. Disc will be rotated to obtain the swirl flow & fuel will be injected in such a way that it will be completely mixed with the air to form a uniform mixture. By this swirl flow and wide spray injection the fuel will be properly mixes with air and desired output can be obtained. By this project it is assumed that ignition characteristics will be improved increase in efficiency increase in power and reduction in pollution.

Keywords: Diesel-Engine, Injector, Nozzle, Spray

I. Introduction

As we All know that world is suffering from air pollution. The air pollution is created major by industries & automobiles vehicles especially by Diesel engine. Several research are done to control air pollution and going on till today various system have been developed, designed & employed to control the automobile air pollution in this project one of the new & innovative design of injector is developed to improve in this project new design of injector is developed in this type the injector nozzle is of disc type operated by direct cam mechanism holes are made on disc to spray & inject in wide area disc will rotate at the time of injection to produce the swirl mixture fuel will be injected in such a way that it spreds in whole combustion chamber it is assumed that it spray far better than single hole & multi hole nozzle.

II. Literature review

In 2016, Fuying Xue , Fuqiang Luo, Huifeng Cui, Adams Moro, Liying Zhou[1] Here in this paper, mathematical theory and model associated with the cavitation and turbulence is presented. The turbulence flow pattern and cavitation evolution for nozzle holes of an asymmetric multi-hole diesel injector were replicated using the multi-phase two fluid flow approach where the effect of injection conditions on bubble number density was considered. The fuel flow characteristics in each nozzle hole were simulated and the effect of cavitation and turbulence were analyzed. The cavitation holes evolution varied significantly. It was observed that the nozzle angles and needle lifting process influenced the cavitation, mass flow rate and flow velocity.

In 2016, F.J. Salvador, D. Jaramillo, J.-V. Romero, M.-D. Rosello[2] In this paper, the behaviour of the internal nozzle flow and cavitation phenomenon are numerically studied for non-conventional Diesel convergent-divergent nozzles in order to assess their potential in terms of flow characteristics. The used nozzles differs each other in the convergence-divergence level of the orifices but all of them keep the same diameter at the middle of the nozzle orifice. The calculations have been performed using a code previously validated and able to simulate cavitation phenomenon using a homogeneous equilibrium model for the biphasic fluid and using a RANS method. For the simulations, one injection pressure and different discharge pressures were used in order to assess the characteristics of nozzles for different Reynolds conditions involving cavitating and non-cavitating conditions.

In 2016, F.J. Salvador, J. De la Morena. Martínez-López. Jaramillo [3] in this paper, an investigation of the compressibility effects in nozzle flow simulations has been carried out for injection pressures up to 250 MPa. To do so, the fluid properties (including density, viscosity and speed of sound) have been measured in a wide range of boundary conditions. These measurements have allowed to obtain correlations for the fluid properties as a function of pressure and temperature. Then, these equations have been incorporated to a CFD solver to take into account the variation of the fluid properties with the pressure changes along the computational domain. The results from these simulations have been compared to experimental mass flow rate and momentum flux results, showing a significant increase in accuracy with respect to an incompressible flow solution.

In 2016, V. Lazarev, G. Lomakin, E. Lazarev [4] Perfection of output parameters of diesel engines is considered as a result of the rail-pressure increase and modernization of nozzle tribosystems represented at high (up to 300 MPa) values of the fuel pressure. The nozzle with the modified design and additional (bottom) precision guiding interface is used and hydrodynamic parameters of injection are analyzed. The computational fluid-dynamic (CFD) modeling for estimation of hydrodynamic parameters of the fuel flow and force distribution in the "needle – nozzle body" system is used. The results of the injection modeling and contact parameters for the modified design of nozzle precision interfaces are established and discussed. The ways of increasing the stability of needle position in the nozzle body with perfection of parameters of fuel injection are presented.

In 2016, Tao Qiu , Xin Song, Yan Lei, Hefei Dai , Chunlei Cao , Hui Xu , Xiang Feng [5] This work investigates the impacts of the injection back pressure on the nozzle inner cavitation developing, especially the flow characteristic during choking process. The following are the main observations: As the back pressure drops, the cavitation process is divided into 3 periods.

- During choking period, the back pressure has little effect on the mass flow.
- During choking period, the discharge coefficient declines as the back pressure drops.
- During choking period, the interface between the liquid and mixing section is constant.
- During choking period, the outlet velocity increases as the back pressure drops.

In 2015, Hengzhou Wo , Karl D. Dearn , Ruhong Song , Enzhu Hu , Yufu Xu , Xianguo Hu [6] biomass oil/diesel blend was prepared using an emulsion method and combusted in a diesel engine. An injector was then removed and the morphology, composition, and structure of the carbonaceous deposits on the pintle type nozzle were characterized using a combination of HRTEM, SEM/EDAX, Raman and XRD. Results showed that the carbon deposition of the emulsified fuel with high crystallinity was greater than that of diesel. The agglomerated particulate diameters of the deposited carbon from diesel and emulsified fuel were approximately 10–30 μm and 50 μm, respectively. The carbon deposition mechanism from the emulsified fuel was attributed to the high oxygen content of the groups leading to increased polymerization and subsequent condensation on the nozzle surfaces that was then carbonised.

In 2013, Zhixia He, Wenjun Zhong, Qian Wang, Zhaochen Jiang, Zhuang Shao [7] A flow visualization experiment system with a transparent scaled-up multihole injector nozzle tip was setup for getting the experimental data to make a comparison to validate the calculated results from the three dimensional numerical simulation of cavitating flow in the nozzle with mixture multi-phase cavitating flow model and finally a good agreement was seen between the two sets of data. The critical conditions for cavitation inception were derived as well as the relationship between the discharge coefficient and non-dimensional cavitation parameter in numerical simulations. Afterward, the testified numerical models were used to analyze the effects of the nozzle sac volume, orifice inlet curvature, orifice inclination angle, injector needle lift and needle eccentricity on the cavitating flow inside the nozzle. Numerical simulation results can clearly reveal the three-dimensional nature of the nozzle flow and the location and shape of the cavitation induced vapor distribution, which can help understand the nozzle flow better and eventually put forward the optimization ideas of diesel injectors.

In 2012, Tong Haoa, Li Yonga, Zhang Longa, Li Baoquanb [8] In this study, a micro EDM equipment was developed for drilling the spray holes. Key technologies were discussed including an electrode feed head, a workpiece positioning mechanism and process control methods. In order to machine micro-taper holes and improve processing efficiency, the electrode feed head was designed with the special multifunction modules of a novel taper-swinging mechanism (TSM), a piezoelectric (PZT) actuator for assisting high-frequency vibration, and a dual-clamps inchworm mechanism for wear compensation of wire tool electrode. The equipment can achieve the spatial positions of pitch angle, roll angle, focal distance, and reference points of nozzles. The particular attention was also given to the proposed process control methods to ensure high consistency accuracy in machining multi-nozzles. In addition, performance tests and applied experiments were carried out. The study results show that the equipment can meet the machining requirements of the spray holes with diameters ˚140–300 _m, taper-angles 0–1.3◦ (K-factor 0–2.3) with adjustment error <0.037◦, space accuracy <0.2◦, dimensional accuracy ±2 _m and machining-feed efficiency of 1.5 mm/min.

In 2016, Zhixia He , Zhengyang Zhang , Genmiao Guo , Qian Wang , Xianying Leng , Shenxin Sun [9] this paper, particular attention was focused on the transient flow characteristics in the real-size diesel nozzle. An experimental study under different pressures was conducted to analyze the evolution of cavitation inside diesel nozzle, and it was found that higher injection pressure leads to earlier cavitation inception. The bubble "suction" from orifice exit at the end of injection and the bubble "discharge" at the initial stage of the next injection were observed as well. Moreover two types of "string cavitation" were observed and the "string cavitation" as a special cavitation phenomenon which considerably boost the spray angle was investigated in details. It was found that the occurrence of "string cavitation" has a strong relationship with the location of needle, the injection pressure, and the shape of sac. Furthermore the effects of these three factors on the occurrence regularity of the "string cavitation" were also investigated.

In 2016, Simin Anvari , Hadi Taghavifar, Shahram Khalilarya , Samad Jafarmadar , Mohammad Taghi Shervani-Tabar [10] A numerical investigation is conducted to survey the flow in a diesel injector and the cylinder. Different CFD models are applied for two-phase flow of the injector and cylinder, i.e. a RANS homogeneous-mixture model is used for the injector analysis, and a LES-based Eulerian-Lagrangian approach for the in-cylinder simulations. The unsteady nature of the SMD (sauter mean diameter) is due to the LES (large eddy simulation) method employment, which is capable of capturing the detailed turbulence mechanism. The contours of volume fraction and viscosity have been displayed across the injector for various injection pressures and included angles. The nozzle flow characteristics are transferred through coupling the boundary information of the exit of the injector to the cylinder flow. This helps to simulate the spray structure in terms of sgs (subgrid-scale) averaged turbulence and fluid mass fraction.

The results are significant in terms of spray-wall impingement time and SMD trends with simultaneous variation of the injection angle and pressure. The injector turbulence is calculated based on k- ζ-f method while spray evolution is based on LES approach.

In 2014, Sanghoon Lee , Sungwook Park [11] This paper analyzes the spray characteristics of a group-hole nozzle in terms of spray behavior and atomization process in comparison to the characteristics of a single-hole nozzle as reference. Spray visualization and PDPA (phase Doppler particle analyzer) experiments were performed using a GDI adjustable injector, which can adopt a different type of nozzle at free spray conditions. By analyzing the spray development behavior and distribution of droplet velocity and diameter based on a time series, and comparing these results with that of a single-hole nozzle, the effects of the group-hole nozzle on the spray characteristics in a GDI injection were elucidated. Experimental results showed that the development processes of spray behavior from a group-hole nozzle were similar to that of the single-hole nozzle. Both the sprays had similar spray tip penetration and dispersion at the same stages of development. However, owing to the constant spray momentum from a spray interaction, the spray behavior from the group-hole nozzle seemed to be more stable than that of the single-hole nozzle. In terms of the averaged droplet size, the group-hole nozzle held an advantage over the single-hole nozzle in decreasing Sauter mean diameter (SMD) by approximately 2 lm. In addition, in comparison to the spatial distribution of droplet diameter and velocity between them, it can be confirmed that the group-hole nozzle has strong effects on reduction in diameter as well as rapid disperse of droplet due to active air entrainment. These atomization characteristics are considered as an important advantages for improving mixture formation in GDI engine.

In 2016, Bo Wang, Tawfik Badawy , Yizhou Jiang , Hongming Xu, Akbar Ghafourian , Xinyu Zhang [12] An optical-based experimental study of the injector deposit effect on a multi-hole GDI injector was performed first. After carefully calibrating the spray model with the experiment data, a three-dimensional computational fluid dynamics (CFD) simulation was then carried out to study the deposit effect on the air/fuel mixture preparation process in an optical research GDI engine. Six different injection timings were used for full-cycle simulations. The numerical engine condition was at stoichiometric ratio, 1200 rpm and 150 bar injection pressure. The experimental results showed that injector deposit would lead to lower fuel mass flow rate, with 5.4%, 5.7% and 6.1% loss at 50, 100 and 150 bar respectively. Injector deposit resulted in longer penetration length and the effect displayed hole to hole difference. The maximum increment was observed for the ignition jets with 11.6% at 150 bar. Injector deposit led to higher droplet velocity and larger droplet size and the difference increased with injection pressure. For the air/fuel mixing simulation, the injector deposit led to more fuel impingement on the piston and cylinder walls, as well as a lower mean equivalence ratio during late injection events. The distorted spray pattern led to higher fuel stratification level. In very late injection cases, the injector deposit led to a very lean mixture near the spark plug which could result in unstable engine performance; while the rich regions at the cylinder sides could result in higher emissions.

In 2016, Yangbo Deng, Hongwei Wu , Fengmin Su [13] The present experimental study aims to investigate the combustion and emission characteristics of the flow through a low swirl injector (LSI). An experimental study was carried out on the flame structure, the temperature distribution and the exhaust emission of low swirl pre-mixed combustion under the condition of different swirl number and different fuel composition. In order to qualitatively analyze the flame structure, the velocity distribution of the non-reacting flow through the LSI was measured using the particle image velocimetry (PIV) technique. Experimental results indicated that: (i) the LSI can generate a blue lift-off ‘‘W” type flame which consists of four clusters of flames connected together and holds up a long yellow pulsating flame, (ii) the blue flame structure converts the ‘‘W” type flame into the ‘‘broom” type flame and the distance between the front of the flame and the nozzle shortens with increasing swirl number, (iii) there exist high temperature region flanked by two peaks on the temperature profiles in the blue flame while uniform higher temperature in yellow pulsating flame, (iv) the NOx and CO emission level of the LSI mainly depends on the gas composition and thermal load.

In 2012, F.J. Salvador , J. Martínez-López , M. Caballer, C. De Alfonso [14] In this paper, an extended computational study has been performed in a multi-hole nozzle modeling 10 different fixed needle lifts. The internal flow has been modeled with a continuum nozzle flow model that considers the cavitating flow as a homogeneous mixture of liquid and vapour. Due to high Reynolds numbers, turbulence effects have been taken into account by RANS methods using a RNG k–e model. Firstly, the code has been validated against experimental data at full needle lift conditions in terms of mass flow, momentum flux and effective velocity, showing a fairly good agreement with experimental results. Once the code has been validated, it has been possible to study in depth the internal nozzle flow and its characteristics at the outlet at different partial needle lifts. Nevertheless, not only the main flow features have been explained, but also the cavitation appearance and the turbulence development, which present huge differences between the different needle lifts simulated.

In 2005, E. Delacourta, B. Desmeta , B. Besson [15] Injection pressure is one of the most influential factors on the performance of diesel engines and particulate emissions. Car manufacturers have gradually increased this pressure over recent years. The objective of this study is therefore to investigate the effect of injection pressure on the macroscopic spray characteristics for a wide pressure range (up to 250 MPa). For this, we developed a measurement technique able to extract these characteristics both quickly and reliably. The results obtained make it possible to widen the application fields of the temporal evolution law already suggested by some authors and establish new laws for other spray characteristics (angle, area, volume).

In 1984, LYNN A. MELTON, JAMES F. VERDIECK [16] In a series of demonstration experiments, we have shown that exciplex visualization systems can be used to photograph either the liquid or the vapor pattern in a hollow cone fuel spray. Thus, vapor density information can be obtained without the analysis of droplets. Furthermore, through image analysis of digitized negatives, we have obtained a quantitative presentations as false color maps and contour density plots. The exciplex visualization systems exploit the reversible equilibrium which may exist when an excited organic molecule (M*) reacts with a suitable ground state organic molecule to form an emitting exciplex (E*). The emission from M* can be made characteristic of the vapor and the emission from E* can be made characteristic of the liquid. Because the emission from E* is shifted with respect to that from M*, filters can suppress either the M* or E* emissions, and hence with laser sheet excitation, two dimensional vapor or liquid sections of the fuel spray can be photographed.

In 2002, Jeekuen Lee, Shinjae Kang, Byungjoon Rho [17] The intermittent spray characteristics of a multi-hole and a single-hole diesel nozzle were experimentally investigated. The hole number of the multi-hole nozzle was 5, and the hole diameter of the 5-hole and the single-hole nozzle was the same as dn=0.32 mm with the constant hole length to diameter ratio (In/dn=2.81). The droplet diameters of the spray, including the time-resolved droplet diameter, SMD (Sauter mean diameter) and AMD (arithmetic mean diameter), injected intermittently from the two nozzles into the still ambient were measured by using a 2-D PDPA (phase Doppler particle analyzer). Through the time-resolved evolutions of the droplet diameter, it was found that the structure of the multi-hole and the single-hole nozzle spray consisted of the three main parts : (a) the leading edge affected by surrounding air and composed of small droplets; (b) the central part surrounded by the leading edge and mixing flow region and scarcely affected by the resistance of air; (c) the trailing edge formed by the passage of the central part. The SMD decreases gradually with the increase in the radial distance, and the constant value is obtained at the outer region of the radial distance (normalized by hole diameter) of 7-8 and 6 for the 5-hole and single-hole nozzle, respectively. The SMD along the centerline of the spray decrease shapely with the increase in the axial distance after showing the maximum value near the nozzle tip. The SMD remains the constant value near the axial distance (normalized by hole diameter) of 150 and 180 for the 5-hole and the single-hole nozzle, respectively.

In 2005, Prashanth Ravi, Jake Blanchard , Mike Corradini [18] The current paper discusses the efforts to fabricate 3-D micro-nozzles using a novel, modified MEMS-LIGA process. These nozzles may provide a spray pattern to minimize inter-spray drop collisions and optimize the entrainment of air among the array of liquid spray streams. The paper also discusses the efforts made to form a bond between the micro-nozzle tips and the production nozzle, providing an improved attachment scheme. Finally, experimental spray data test results are presented for various micro-nozzles using this technique. These data indicate an improvement in the SMD using these 3D micro-nozzles, but a design methodology for nozzle use is still under development for diesel sprays.

III. CONCLUSION

For study above literature review it is studied and observed that to increase spray width the disc type nozzle is more suitable as the spray width is twice in multihole nozzle than in single hole. The cylindrical nozzle with 8.6% larger diameter, in spite of higher mass flow rate and momentum flux, shows slower spray tip penetration when compared to the conical nozzle. The spreading angle is found to be inversely proportional to the spray tip penetration. The spreading angle is largely influenced by the nozzle geometry and the ambient density. By proper spreading angle & swirl flow there will be improve in spray tip penetration. It is observed that in test of injectors, the increased injection pressure leads to the decrease of the droplet size distribution in the initial spray. But, there is little difference of the droplet size at low and high injection pressure in middle and latter period after the injection. As studied and observed in other research paper that the results show that the Sauter Mean Diameter (SMD) reduces with the increase of the distance from injector tip and the SMD of the central axis is bigger than that of the periphery. With the increase of the injection pressure (40–120 MPa), the spray SMD decreases significantly. In addition, as the orifice diameter goes smaller, the SMD decreases and the effect of the orifice diameter on the spray SMD becomes weak.

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