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Transformation of Diesel Engine to Dual Fuel Engine Using Injector Nozzle of Multi Holes Geometries: A review

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Abstract

This paper is the delineation of the computational and test strategies for another injector nozzle for a consecutive dual fuel engine. The goal of this review was to audit the past take after a line of examination in the improvement of vaporous fuel injector for dual fuel changed over from diesel engine. At that point re-enactment of the fuel stream of the new injector nozzle was made utilizing FLUENT. The last goal was to investigate the execution qualities of the natural gas engine utilizing the new injector nozzle. The examination concentrated on engine execution in view of varieties in area of injector, number of gaps in injectors and heavy. The recreation of the fuel stream of the new injector nozzle expanded the shower conveyance, fuel-air blending and fuel stream speed. The modification done for fuel injection advancement was to deliver ideal fuel air blending and expanding the volumetric effectiveness of the engine that will advance a tantamount engine execution and productivity
.

Keywords: CNG, conversion of diesel CNG, CFD, FLUIENT, Port Injection.

1. INTRODUCTION:

In 1893, Rudolf Diesel manufactured heavy engine and ensured the relevant cycle in 1892 with Patent DRP N0, 67207, year 1892. In 1976, the total yield by the West European countries simply was 5,200,000 heavy begin engines. The reliable headway of ICE changes course in answer to advancing essential. In the 1970, the two most key issues choosing the change examples of engines advancement and particularly, their consuming structures. The compact connection of a varying characteristics of engine grasped in what takes after mainly concerns specific fuel usage, surges and diverse parameters (Andrzej, K., 1984, first release. In the immediate injection diesel engines or direct injection pressure start engines, in which fuel is infused by the fuel injection framework into the engine barrel toward the finish of the pressure stroke, just before the coveted begin of ignition.

The liquid sort of fuel is infused at higher speed as no less than one stream through little crevices on spouts in injector tip, which achieves atomization in little drops which invades into the consuming chamber. This fuel vaporizes and mixes with high temperature and high substantial chamber air. The air is given from confirmation port of engine because of the air temperature and substantial are over the fuel's begin point, rushed begin of fragments of the authoritatively mixed fuel and after air a put off time of a couple torque edge degrees. This result in altogether enlarges in barrel substantial and temperature. The noteworthy incident in weight begin engine start chamber arrangement is to achieve satisfactorily speedy mixing between the implanted fuel and the air from affirmation port in the barrel to get done with consuming in the reasonable torque edge interval close top core interest. Pull yield of a engine can be unmistakably improved through awesome confirmation port blueprint and create.

2. COMPRESSED NATURAL GAS:

Natural gas is acquired from gas wells or tied in with raw petroleum creation. Natural Gas is made up to a great extent of methane yet some follow measures of ethane, propane, nitrogen, helium, carbon dioxide, hydrogen sulphide and water vapour. Methane is the essential segment of natural gas. Naturally over 90% of normal gas is methane (Andrzej, K., 1984, Ganesan, V.,19993, Heywood, J.B., 1988, Richard, S., 1995, Shasby, B.M., 2004). The composition of natural gas is given in Table 1 by Shelby.

Table: 1 Chemical composition of compressed natural gas.

Sr.No.	Composition	Chemical Formulae	Volume Fraction(%)
1.	Methane	CH_4	91.82
2.	Ethane	C_2H_5	2.91
3.	Nitrogen	N	4.46
4.	Carbon Dioxide	CO_2	0.81
			Total : 100

This gas can be accessible in packed frame, so it can be put away effortlessly and utilized as Compressed Natural Gas. It requires a significantly bigger volume to store a similar mass of common gas and the utilization of high heavy on around 200 bar or 2,900(. Poulton, M.L., 1994). It is more secure than fuel and diesel numerous perspectives and furthermore it is having higher start temperature than gas and diesel. Notwithstanding that it is lighter than air so it will disseminate upward quickly if a burst happens. It is non-lethal gas and won't debase groundwater if spilled. It is a to a great extent accessible type of fossil vitality and consequently non-renewable.

3. ADVANTAGES:

Nonetheless, it has a few preferences contrasted with fuel and diesel from a natural point of view. It is consume with clean fumes so it is thought to be an ecologically clean contrasting option to those powers. As indicated by Ganesan (Ganesan, V., 1999) some favourable circumstances of packed characteristic gas as a fuel are octane number is very good for SI engine fuel, octane number is a quick fire speed, so engines can be work with a high pressure proportion, less engine emanations, less aldehydes than methanol and the fuel is decently abundant (Shashikantha et al,1999, Kato et al,1999) around the world.

4. CONSTRAINTS:

The primary imperative of packed characteristic gas as a engine fuel are low vitality thickness bringing about low engine execution, low engine volumetric proficiency since it is in vaporous frame, it requires expansive space for capacity, so there is some wellbeing worry with a pressurized fuel tank, conflicting fuel properties and refuelling of the compacted common gas is a moderate procedure. It can be utilized as a fuel basically in the shape in which it is separated. Some handling is done preceding the gas being circulated.

5. CNG CHARACTERISTIC:

The octane number of this fuel is about 130, as a result of that engines could operate at compression ratio of up to 16:1 without knock or detonation (Poulton, M.L., 1994,). Most importantly, it significantly reduces CO emissions by 20-25% compare to gasoline because simple chemical structures of natural gas (primarily methane-CH) contain one Carbon compare to diesel($C_{15}H_{324}$) and gasoline (C_8H_{18}) (Srinivasan, K.K., 2006,Poulton, M.L., 1994) the fuel characteristics are shown in Table 2.

Table 2. Characteristics of compressed natural gas

Sr No.	CNG Characteristics	Value
1.	Vapour Density	0.68
2.	Auto Ignition	7000C
3.	Octane Rating	130
4.	Boiling Point (Atm.Pressure)	-1620C

5.	Air Fuel Ratio (Heavy)	17.24
6.	Chemical Reaction with rubber	No
7.	Storage Pressure	20.6 MPa
8.	Fuel air mix quality	Good
9.	Pollution CO-HC-NOX	Very Low
10.	Flame speed m/sec	0.63
11.	Combust ability with air	4-14%

As methane and hydrogen is a lighter than air and can be mixed to decrease vehicle discharge by an additional half. Natural gas creation fluctuates extensively after some time and from area to area (Poulton, M.L., 1994). Methane substance is commonly 70-90% with the update basically ethane, propane and carbon dioxide (Shasby, B.M., 2004, Kato et al,1999). As per Poulton that characteristic gas has a high octane rating, for immaculate methane the RON = 130 and empowering a devoted engine to utilize a higher pressure proportion to enhance warm productivity by around 10% over that for a petrol engine, in spite of the fact that it has been proposed that advanced natural gas engine ought to be up to 20% more effective, in spite of the fact that this still can't seem to be illustrated. Packed common gas along these lines can be effectively utilized in start lighted interior burning engines.

It has additionally a more extensive combustibility go than fuel and diesel oil (Aslam, M.U., 2006). Ideal productivity from characteristic gas is gotten when consumed in a lean blend in the range A = 1.3-1.5, despite the fact that this prompts a misfortune in influence, which is boosted marginally rich of the stoichiometric blend. Also, the utilization of natural gas enhances engine warm-up proficiency and together with enhanced engine warm productivity more than adjust for the fuel punishment brought on by heavier stockpiling tanks. Non methane hydrocarbons are lessened by roughly half, NOx by 50-87, CO2 by 20-30, CO by 70-95% and the ignition of characteristic gas creates no Particulate matter (Fino, D et al,2006).

Natural gas controlled vehicles emanate no benzene and 1,3-butadiene which are poisons transmitted by diesel fuelled vehicles. The utilization of normal gas as a vehicle fuel is guaranteed to give a few advantages to engine parts and viably decrease upkeep prerequisites. In view of its low vitality thickness at barometrical heavy and room temperature, normal gas must be compacted and put away on the vehicle at high heavy naturally 20 MPa, 200 bar or 2,900 psi. The option stockpiling strategy is in fluid frame at a temperature of-162°C. Due to the constrained limit of most on-load up CNG stockpiling systems a natural gas-fuelled vehicle will require refuelling a few circumstances as frequently as a comparable petrol or diesel fuelled vehicle-a run of the mill dual fuel auto engine will give a scope of 150-200 km and a truck or transport some 300-400 km. It is conceivable that the space required and heavy of natural gas fuel stockpiling frameworks will fall later on accordingly of enhanced engine efficiencies as with committed plans and light heavy stockpiling tanks. At the point when a vehicle is working on natural gas around 10% of the incited wind current is supplanted by gas which causes a comparing fall in engine power yield. In execution terms the changed over bi-fuel engine will for the most part have a 15-20% greatest power diminishment than that for the petrol rendition. At the point when a diesel engine transformation is fuelled on gas more engine power can be gotten because of the abundance air accessible which, because of smoke impediments, is not completely expended. Since natural gas has a low cetane rating, a start change for diesel engines is required, adding to the transformation cost (Slope et al, 2000). Despite the fact that more power might be accessible, encounter has demonstrated that SI diesel engine changes are for the most part down-appraised to avoid intemperate ignition temperatures prompting segment strength issues. A diesel/gas double fuel change may encounter lost productivity, with respect to diesel-fuelling alone. A 15-20% misfortune in warm productivity was accounted for in a dual fuel substantial obligation truck exhibition in Canada, where common gas gave 60% of the aggregate fuel necessity amid dual fuel operation. A further burden of methane is that it is a nursery gas with a warming driving element commonly that of the important natural gas, CO , Gas spillage or vehicular discharge, thusly and the measure of discharge, will affect the green house effect flows execution in respect to the petrol or diesel fuel it substitutes (Sera et al,2003).

6. CONVERSION OF DIESEL ENGINE INTO DUAL FUEL ENGINE:

In the diesel engines changed over or intended to keep running on characteristic gas, there are two fundamental choices recommended. The first is double fuel engines. In this diesel engines working on a blend of natural gas and diesel fuel. Characteristic of this gas has a low cetane rating and is not along these lines suited to pressure start, but rather with the assistance of pilot injection of diesel happens inside the gas/air blend, ordinary start can be started. So 50% to 75% of diesel utilization can be supplanted by gas when working in this mode.

The engine can likewise backpedal to 100% diesel operation. The second is committed common gas engines. These engines are advanced for the natural gas fuel. Until maker Original Equipment (OE) engines are all the more promptly accessible, be that as it may, the act of changing over diesel engines to start will proceed with, which includes the substitution of diesel fuelling hardware by a gas carburettor and the expansion of a start framework and glow plugs (Sera et al, 2003).

Transports and trucks bigger and more prominent quantities of barrels are utilized than for light-obligation engines. For pressure start engines changes to spark the cylinders must be adjusted to lessen the first pressure proportion and a high-vitality spark system must be fitted. The framework is appropriate for compressed natural gas and is preferably suited to successive port injection framework yet it can likewise be utilized for single point and low heavy in-chamber injection. Gas generation gives more noteworthy accuracy to the planning and amount of fuel gave and to be further created and turned out to be progressively used to give better fuel discharges. The port-drafted or dual fuel produces unimportant levels of CO, CO2 and NO. Keeping in mind the end goal to incredibly diminish fumes gas outflows, a port injection framework was picked by Czerwinski and Kawabata(Kawabata et al,2004), in the meantime, exact Air-Fuel (A/F) proportion control and unique impetuses CNG fumes gas have been used. The subsequent natural gas engines yield control has been re-established to close to that of the fuel base engine.

With the port injection (successive) or trans-consumption valve-injection system, a fast gas spray is beat from the admission port through the open admission valve into the ignition chamber, where it causes impacts of turbulence and charge stratification especially at engine part stack operations. The system can decrease the cyclic varieties and to extend the point of confinement of lean operation of the engine.

The adaptability of gas injection timing offers the potential favourable position of lower discharges and fuel utilization. With three sorts of port injectors accessible available,

Czerwinski were looked at for stationary and transient engine operation. There are a few favourable circumstances of port injection, e.g., better plausibility to level the air-fuel proportion of the chambers, enhancement of the gas injection timing and of the gas vary for various working conditions. The port injection has an injector for every barrel, so the injectors can be put in nearness to the chamber's admission port (Abraham et al,1995). It likewise empowers fuel to be conveyed absolutely as required to every individual barrel (called consecutive) and empowers more refined advances, for example, skip-terminating to be utilized.

7. FUEL INJECTION ENHANCEMENT:

Change of gas injector nozzle openings geometries and fathom of the techniques in the engine consuming is a test because in the cold start process is shaky, heterogeneous, turbulent and three dimensional, extraordinarily capricious and since the spout fuel injector hole is can be assortment with any crevice geometry. In dual fuel engines, typical gas fuel is imbued by fuel spout injector by methods for affirmation port into consuming chamber and mixed with air must occur before begin of the gas fuel.

To improve blending of gaseous fuel and air in ignition chamber is nozzle openings geometry can be organized, nozzle shower heavy, altered of cylinder head, masterminding of cylinder top freedom, letting the air allow as turbulent and changing the CNG fuel edge of splash. The fuel nozzle injector multi openings geometries advancement is to create ideal fuel air blending and expanding the volumetric proficiency of the engine that will advance a similar engine execution. As per Czerwinski et al, in 2003 the CNG port injection framework has preferences to produce for the more productivity.

8. GASEOUS FUEL INJECTION SPRAY FORMATION:

Starting late vaporous fuel infusion recommendations and its direct on consuming chamber design have become huge core interest. In current circumstance facilitate infusion motors have been enhanced for use with liquid forces. The perfect courses of action may be remarkable in connection to what is required for vaporous stimulates. Tries by Abraham broke down the relative effects of start on liquid and vaporous fuel facilitate infusion planes. Occurs showed that fuel-air mixing and duplicating rates were at first slower for gas infusion planes than for liquid sprinkles. Since, replicating and mixing rates of the vaporous direct infusion in the subsequent periods of start extended in examination with liquid fuel sprinkles. Finally, regardless, the liquid sprinkle did not expend as absolutely as the gas stream. Past the hidden stage, the gas facilitate infusion stream demonstrated a higher consuming rate than that of the liquid fuel(Sera et al,2003), the basic duties to the appreciation of transient vaporous fly lead have been examined, made and investigated. The investigation a stream appear, in light of exploratory results, including four essential territories. Figure 1 shows a transient gas stream exhibiting the four crucial areas; the potential focus region, the rule fly territory, the mixing stream locale and the debilitating region (Abraham et al,1995, Fujimoto et al,1997). The vaporous stream trail is portrayed by a rapid, low temperature focal point of rich unmixed fuel confined to the fly pivot (Jennings et al,1994). This middle region is suggested as the crucial fly locale and contains most of the undiluted fuel. Turbulent vortices are made on the edge of the fly focus in like manner of shear qualities connected by the encompassing air in the heap (Fujimoto et al,2007). In the region close to the spout departure, in any case, no turbulence is made. This territory is known as the potential focus region, which is particularly consistent and depicted by low mixing rates. It extends from the spout exit to a division identifying with a z/d (entrance evacuate/spout opening separation over) extent of about 12.5 (Baik, S,2001).

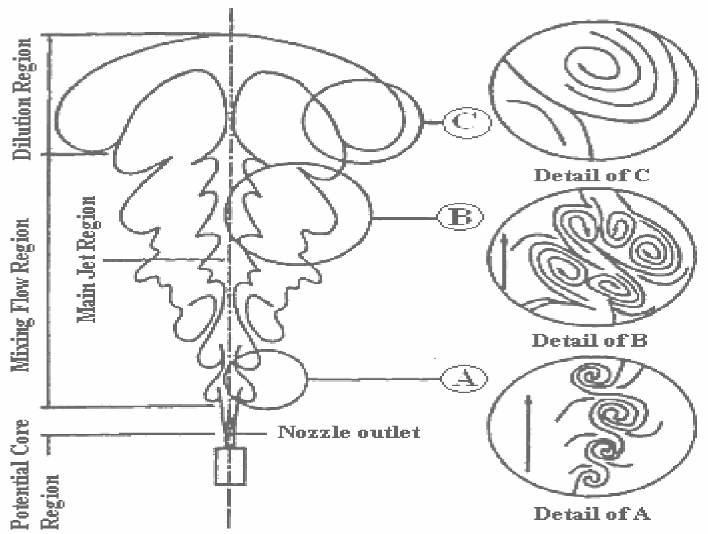

Figure 1. Transient gaseous jet structure (Hyun et al,1995)

Past this locale, broad scale vortices are made by shear obliges as air is entrained into the fly, realizing component mixing along the stream periphery. This region of enhanced mixing includes the guideline fly and is insinuated as the mixing stream area. As the fuel loses its essentialness, it is pushed aside by fuel spilling out of upstream. The tip of the fly broadens radially, moulding the debilitating area of the fly. This zone identifies with the fly tip and is depicted by low speeds and high fuel osmosis. The test consider by Tanabe et al in 1994 were shown that the ignitable district exists simply inside the thin layer around the edge of the fly. In the enveloping region of the spout, the temperature is low and the fly speed is high; as needs be it comes to fruition poor mixing conditions, these conditions don't give a perfect circumstance to creation reactions to happen. Downstream of the spout, in the mixing stream area, the temperature in the edge of the fly is reasonably high and the mix is for the most part stoichiometric. The stream has offset around there as result of imperativeness change between the fly and the entrained air, which gives satisfactory staying time to an engineered reaction to happen. In layout, the more then likely region for begin to happen and correspondingly the ideal place to acquaint a sparkle associate with the edge of the stream downstream of the potential central part region(Aesoy,V et al,1996).Additionally reinforce the finding. The focal point of the stream is fuel rich and uncommonly cold. The temperature of the inside is, to be sure, lower than the fuel temperature before infusion. This is a direct result of quick improvement of the stream at the spout exit and the rapid of the fly (Brombacher, E.J,1998).

The outside edge of the stream is higher in temperature because of warmth trade that occurs as the hot air is entrained into the jet[24] . It would be amazingly difficult to fulfill begin if a begin help device were to be set the focal point of the fly in light of the way that a great deal of warm imperativeness information would be required to lift the middle to the auto start temperature. Also, the high temperature slant between the radiance plug and the fly focus would achieve short connection advantage life. These conclusions give some illumination to the test revelations of Aesoy and Thring in 1997 and 1999 individually.

9. EFFECT OF NOZZLE GEOMETRY ON FUEL AIR MIXING:

Different audits have investigated that by reducing the injector spout opening estimation is a practical techniques for growing fuel air mixing in the midst of infusion (Brombacher, E.J,1998). The more diminutive spout holes were seen to be the most capable at fuel-air mixing for the most part in light of the way that the fuel well-to-do focus of the stream is tinier (Jennings et al,1994). Moreover, reducing the spout gap expansiveness dl would diminish the length of the potential focus area (Baik, S., 2001).Unfortunately, lessening spout openings measure causes an abatement in the turbulent imperativeness made by the fly. Since fuel-air mixing is controlled by turbulence delivered at as far as possible layer, this will offset the benefits of the diminished stream focus measure. In addition, planes ascending out of more diminutive spout gaps were exhibited not to enter like those ascending out of greater openings. This decrement in penetration suggests that the fuel won't be displayed to most of the available air in the chamber. For a lot of little spout assess, the upgrades in mixing related to reduced fire size may be revoked by a diminishing in extended passageway (Jennings et al,1994). Another basic segment of the infusion stream that requires thought is the penchant of the fuel trail to attach to the barrel head. The results are undesirable since it limits access to the chamber uttermost focuses where a critical piece of the air as lives (Brombacher, E.J., 1998).

This effect rises therefore of the speed and substantial fields incorporating the stream. Low overwhelming domains are surrounded above and underneath the stream, as a result of the entrainment of air mass into the fly from the area including volume. Underneath the fly, there is significant air mass in the volume between the chamber and the injector. Over the stream, space is limited and the air must be entrained from powerfully more remote downstream. As the fly develops, the air ought to over the long haul be entrained from the air into which the fly would enter. The entrainment stream is adequately strong to redirect the fuel fly upwards, achieving in the add to the barrel head. This ponder must be intentionally avoided in the layout of a trademark gas motor consuming chamber. The mixing was extended when the spout tip was put equidistant from the barrel and chamber head [34]. The spout containing various little openings would give best mixing over a spout including a singular endless crevice (Jennings et al,1994). This theory has been attempted by considering injectors with fluctuating amounts of spout holes. The breadths of the openings were adjusted with the true objective that each spout passed on a comparable general fuel mass stream. Computational examination assessing eight opening four crevice, two hole and one holes spouts, revealed that the mixing rate improved with the amount of spout gaps. Jennings did tantamount examination for 8, 12 and 16 openings spouts. Contrary to the example, the 16 openings injector performed ineffectually as a result of peak mixing. Tuft uniting unfavorable influences mixing in light of the fact that the total peak surface area available for mixing is decreased.

10. EFFECT OF COEFFICEINT OF DISCHARGE:

The Coefficient of discharge (Cd) for little scale spouts for compressible gas stream has measured by Snyder. The coefficient of discharge was described by geometry, where A was learned from the standard isentropic compressible mass stream association. There is a likelihood of further augmentation in Cd values with a further addition in the Reynold number. The little gap separate crosswise over and broad l/d extent had strong effect on Cd values for compressible gas stream. The following Eq. 1,2, 3 were proposed for Cd

$$2<l/d<10;\ 10<Re<20000 \quad (1)$$

$$Cdmax = 0.827-0.0085*1/d \quad (2)$$

$$l/Cd = l/Cdmax + 20/Re\ \{l+2.25*l/d\} \quad (3)$$

Where:

d = Orifice diameter

l = Orifice length

Cd = Coefficient of discharge
Cdmax= Maximum coefficient of discharge
Re = Reynold number

In a later research by Siebers, the Cd values were obtained again for different diameter orifices as shown in 3.

Table 3. Coefficient of discharge (Naber et al,1996)

Orifice Diameter (μm)	**Length to diameter ratio**	**Discharge Coefficient**
100	4.0	0.80
180	.2	0.77
251	2.2	0.79
246	4.2	0.78
267	8.0	0.77
363	4.1	0.81
498	4.3	0.84

11. EFFECT OF SPRAY CONE ANGLE:

An imperative inconvenience in the definition and estimation of the sprinkle cone edge is that the shower has twisted cutoff points as a result of the effect of air correspondence with the shower (Baik, S., 2001). An extensive part of the proposed relations are exploratory in nature and can't anticipate shower cone focuses correctly for different infusion structures. The associated dimensional examination to the data and induced the going with condition has used by Arai (M. M. Tabata et al,1984). The sprinkle cone edge increases as the opening separation crosswise over additions. In case θ is the cone point in measured shower, ρ is including air thickness, ΔP is substantial differentiation over the gap length, D is particle width and μ is encompassing air consistency. The Eq. 4 is utilized for ascertain the splash cone point of spout injector:

$$2\theta = 0.05\ (\rho a \Delta PD2\ /\ \mu a2)0.25 \qquad (4)$$

The other Eq. 5 by Siebers[41], the consistent c was streamlined to give the best fit the data. The effect of the spout geometry on sprinkle cone edges is not given particularly in the condition. The estimation of c is assorted for different spouts and its regard is on the demand of 0.26[35]:

$$\tan(\theta/2) = c[\ (\rho a/\rho f)0.19 - 0.0043\ (\rho a/\rho f)0.5] \qquad (5)$$

Where

θ = The cone angle in measured spray
ρa = Ambient air density
ρf = Fuel air density

12. ORIFICE SHAPES OF INJECTORS:

The effect of different opening shapes on the sprinkle characteristics over an extent of infusion heavys from 21-103 MPa has analyzed by Avoid, L.G.et al in 1992. The assumed that particular opening shapes have little effect on sprinkle quality and fuel air mixing rate The utilization of the model to the described geometrical condition of a gap provoked evasion of the liquid stream from the rotate of the immediate remembering the ultimate objective to restrict the surface domain of the volume segment. Certified redirection depended endless supply of triangle.

13. CONCLUSION:

Diesel fuel will wind up obviously confined and for the most part extravagant. CNG is a choice fuel winding up recognizably more objective. It has a couple purposes of intrigue appeared differently in relation to fuel and diesel from a characteristic perspective and the impediments is has cut down execution diverged from gas and diesel motors. Consequently, methodical audits have been done to improve techniques and change parts in making perfect CNG motors. To raise the power and specialist the exhaust gas outpourings. The changing over of diesel motor to dual fuel motor begin and upgrade the vaporous fuel injector spout holes geometries which worked in assortment infusion overwhelming and infusion timing will be give better execution and exhaust gas releases.

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