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CFD Analysis of Injection Mixer for CNG Engines for Optimized Performance

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ABSTRACT

Use of vaporous fuels for energizing the Engines lessens receptive hydrocarbons and do not pose the issue of vaporization as with the fluid powers. One of the issues of vaporous blenders is the capacity to set up a homogeneous blending of air and fuel at a particular air-fuel proportion preceding entering the motor coming about high fumes discharges. The Objective of this undertaking is to complete three dimensional CFD examination of CNG infusion blender to comprehend the stream conduct of air fuel blend and to enhance the configuration of infusion blender. The Analysis would be completed by shifting the infusion position and infusion slant. The aftereffects of the CFD recreation could be utilized to comprehend the impact of position of fuel tube, infusion slant in the blending of air and fuel. Further the consequences of the study would likewise be considered for the configuration change.

INTRODUCTION

One of the issues of vaporous blenders is the capacity to set up a homogeneous blending of air and fuel at a particular air-fuel proportion before entering the motor. This issue, if not being dealing with, might bring about high BSFC and high fumes outflows. Consequently, examination was led to upgrade the blending in Throttle Body Injection Mixer (TBIM), which is the new era of blender for a CNG bike, through CFD reenactment. The reason for this study is to set up a homogeneous blending of air and fuel at a particular air-fuel proportion before entering the motor. air-fuel blending in an immediate infusion sparkle ignition (DISI) motor (Rosli Abu Bakar, 2008) estimation of in-chamber blending rate (Chang SiuHua,), recreation of the association of admission stream and stream shower in a DISI motor (Yusaf, T.,), reenactment and control of CNG motors (HowHeoyGeok, TaibIskandarohamad,2009), streamlining of air-fuel blending homogeneity and execution changes of a stratified-charge direct infusion burning framework (Semin and AwangIdris, 2009) et cetera. In this examination, CFD recreation was directed to decide and upgrade the infusion recurrence in TBIM for the best air-fuel blending preceding entering the motor. Up 'til now, the exploration works accessible in enhancing the blending nature of infusion sort blenders incorporate the investigation of geometry configuration, infusion to cross stream speed proportion, cross stream whirl quality, infusion timing, divider impinging infusion with a knock set in the infusion impingement district, infusion position and infusion slant points (Semin and Abdul Rahim Ismail, 2009). Study on the impact of different infusion frequencies on blending is still once in a while seen. Henceforth, to guarantee the recreation condition was perfect with the genuine motor working condition, test work was led at the beginning of the exploration to get the motor suction weight in the admission complex for every contextual investigation. The information was then confirmed completely through past work before applying it in the CFD recreation (Semin and Abdul Rahim Ismail, 2009). The same exploration technique had

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been completed to research the impact of different infusion slant edges on the blending in TBIM and its outcomes were observed to be steady with past work (Semin and Abdul Rahim Ismail, 2009). Worry over the consistency of CFD recreation results with the comparing hypothetical and trial discoveries has been an issue following the most recent couple of years. By the by, the execution of CFD recreation has demonstrated a emotional change after sequential refinements throughout the years. Ref [3] asserted that CFD reenactment was an equivalent accomplice with unadulterated hypothesis and immaculate examination in the investigation and arrangement of liquid element issues. Different inquires about, for example, and (Syed Kaleemuddin and G. Amba Prasad Rao, 2009) have likewise demonstrated the legitimacy of the outcomes got through CFD reproduction. What's more, CFD recreation of the single-stage blending issues has been entrenched.Thus, the outcomes acquired in this reenactment work can be used with an abnormal state of certainty.

CFD Simulation Ofthrottle:
Body injection mixer:

Air-fuel blender is a gadget where fuel is metered and blended with the approaching air as per motor necessities. Attributable to the disappointment in the blending homogeneity and air-fuel proportion control of the current air-fuel blender, another air-fuel blender called Throttle Body Injection Mixer (TBIM), which is of electronic fuel controlled, was created. A schematic graph of TBIM is appeared in Fig. 1. It comprises of a throttle valve, fuel injector, reducer and admission complex. The measure of air entering TBIM is controlled by the opening of throttle valve though the measure of fuel required is controlled by the fuel injector. The air and fuel are blended in TBIM before entering the motor. In this work, the fuel is infused by setting the injector at different positions along the length of the blender furthermore the injector is situated with vertical, 15˚ and 30˚ slants. CFD recreation of TBIM initiated with model cross section, trailed by and determination of turbulent model before beginning the calculation

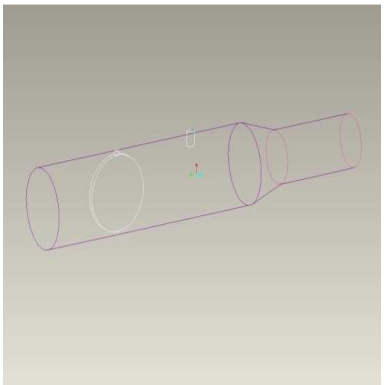

Fig. 1: Wire Fame Model of Injection Mixer.

2.1 Meshing:

Network era is the procedure by which spatial discretisation of CFD model is expert. Lattice depends on tetrahedron component discretisation. There are two sorts of networks to look over for model coinciding, i.e. organized and unstructured networks. The first is made out of hexahedral components while the last one comprises of tetrahedral components. A general dependable guideline is to apply the organized lattices on basic geometries and the unstructured networks on complex geometries. For an intricate geometry, for example, the fundamental assortment of TBIM, which comprises of a throttle valve and an injector, the unstructured lattices were connected (Fig. 2). Then again, the organized networks were decided for straightforward geometries such as the admission complex (a curved chamber) and the reducer (an apex less cone) that join the fundamental collection of TBIM with the admission complex(Fig. 2).

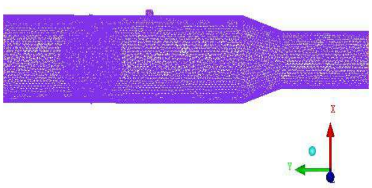

Fig. 2: Meshed Model.

A general rule of model cross section is to dependably work the more basic spaces (i.e. high speed, high weight or weight drop stream fields) ahead of time of the less basic ones. For TBIM, the more basic spaces incorporate the districts around the openings of throttle valve and the injector (Fig. 2). The fineness of network connected increments with the criticalness of a space. After TBIM was suitably coincided, the limit states of TBIM were distinguished for the air delta, fuel outlet, blend outlet and the symmetry plane .Boundary states of 'weight gulf' and 'mass stream channel' were chosen for the air bay and fuel outlet, while the blend outlet and the symmetry plane were given the limit state of 'divider'. These decisions of limit condition were relying upon the accessible information furthermore the information required from the reproduction.

2.2 Turbulence Model:

Among all the turbulent models, the kεmodel wasselected in this work because it is the most widely used andvalidated one in terms of consistency and reliability (Akinori Miura and FumitakeHonjou, 2000; Barroso, G. and A. Escher, 2005).There are three types of k-εmodel, namely the Standard k-εmodel, Renormalization Group (RNG) k-εmodel andRealizable k-εmodel. The major differences between thesemodels are the methods in calculating the turbulent viscosity, turbulent Prandtl numbers and the generation and destructionterms in the εequation.The Standard k-εmodel is the most extensively usedand validated turbulent model among all the k-εmodels. It hasachieved notable successes in calculating a wide variety of thinshear layer flows. The transport equations of k-ε used in this analysis are

$\partial (\rho k)/\partial t + \mathrm{div}(\rho\, k\, U) = \mathrm{div}[\mu_t/\sigma_k \text{ grad } k] + 2\, \mu_t E_{ij}.E_{ij} - \rho\varepsilon$

$\partial (\rho\varepsilon)/\partial t + \mathrm{div}(\rho\varepsilon\, U) = \mathrm{div}[\mu_t/\sigma_\varepsilon \text{ grad } \varepsilon] + C_{l\varepsilon}\varepsilon/k\, 2\, \mu_t E_{ij}.E_{ij} - C_{2\varepsilon}\rho\varepsilon^2/k$

where$\rho$is the fluid density, kis the kinetic energy, ε is thedissipation rate and $\sigma_k, \sigma_\varepsilon, C_{l\varepsilon}, C_{2\varepsilon}$ are constants.

Stoichiometric Air Fuel:
Ratio

The term stoichiometric ratio describes the chemically correct air-fuel ratio necessary to achieve complete combustion of the fuel. In this analysis, air and fuel were delivered into TBIM at stoichiometric air-fuel ratio, i.e. 17.3:1. Nevertheless, the air-fuel ratio of the mixing before entering the engine could be differed from this value owing to poor mixing. A good mixing would give a stoichiometric mass fraction of methane ($M_{CH4.S}$) locally throughout the mixing region.

The $M_{CH4.S}$ was calculated as follows:

$M_{CH4.S} = 1/18.3 = 0.0546$

RESULTS AND DISCUSSION

4.1 Mass Fraction of CH_4:

Mass fraction of CH_4 refers to concentration of CH_4 in the mixture of air and CH4.

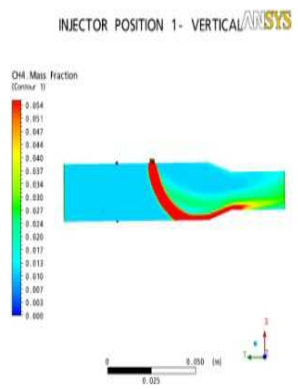

Fig. 3: (a) Vertical Position.

Fig. 3 Distribution of CH_4 Mass Fraction stoichiometric mass division of methane has been ascertained as 0.055. Figure demonstrates appropriation of mass division of CH4 in the blending area and outlet of infusion blender for the different infusion slants. It has been seen from the outcomes that for vertical infusion position mass part of methane declines in the close divider towards outlet. 15˚ degree infusion position indicates expanded dispersion of mass division close divider district and in addition at outlet. The aftereffects of 30˚ infusion position demonstrates that relatively expanded mass division of methane in the divider locales and additionally towards outlet than other infusion positions.

4.2 Inter phase Mass Transfer Rate:

Inter phase mass transfer rate refers to rate of mass transfer between the air and CH_4 after which is expressed as kg/s.m^3. Better the mass transfer rate would result in good mixing along the flow. Figure shows the distribution of mass transfer rate after the injection occurs. For the vertical injection position mass transfer rate decreases along the flow from the mixing region towards

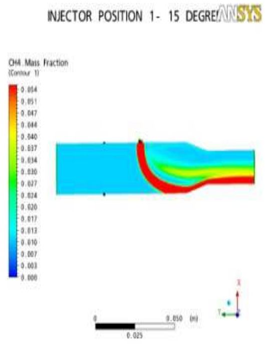

Fig. 3: (b) 15° inclination.

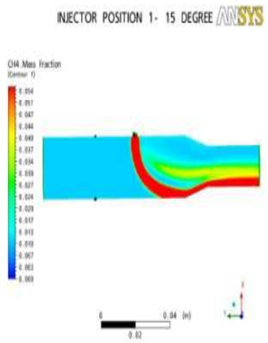

Fig. 3: (c) 30° inclination.

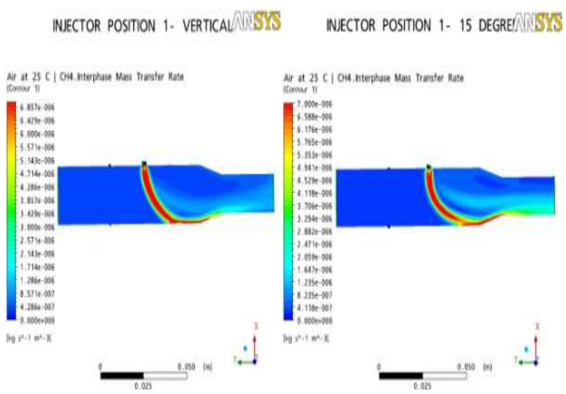

Fig. 4: (a) Vertical Position (b) 15° inclination.

Fig. 4 Interphase Mass Transfer Rate outlet. The decreased rate is observed in the near wall region after nozzle. A slight increase in the mass transfer rate observed in 15˚ degree injection position. 30˚ degree injection position shows comparatively increased rate in the near wall region as well as at outlet.

4.3 Turbulence Eddy Frequency:

Turbulence eddy frequency refers to frequency of eddies formed in the flow region which is expressed in terms of unit time period. Increased eddy frequency is desirable in the mixing region. Figure shows the distribution of turbulence eddy frequency for various injection inclinations.

Fig. 5Turbulence Eddy Frequency

Increased turbulence eddy frequency is observed in the mixing region of vertical injection position. For 15˚ degree injection inclination eddy frequency rate is high in the mixing region as well as in the near wall region which is undesirable. The eddy frequency rate is comparatively low in the case of 30˚ degree injection position.

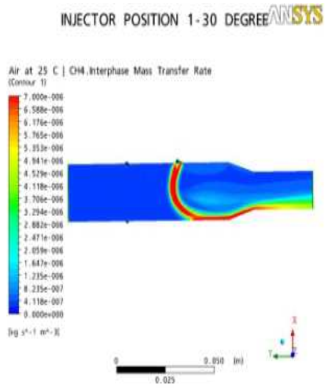

Fig. 4: (c) 30° inclination.

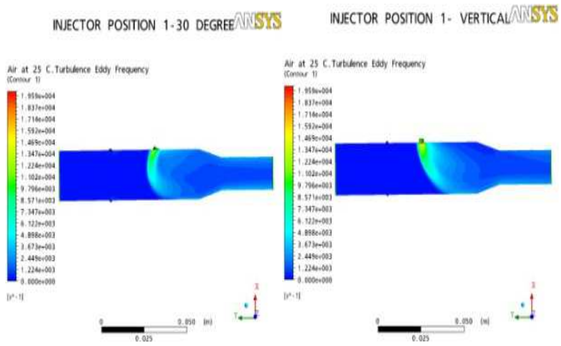

Fig. 5: (a) Vertical Position. (b) 15° inclination.

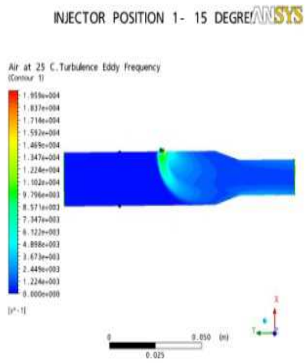

Fig. 5: (c) 30° inclination.

4.4 Turbulence Kinetic Energy:

In fluid dynamics, turbulence kinetic energy (TKE) is the mean kinetic energy per unit mass associated with eddies in turbulent flow. Physically, the turbulence kinetic energy is characterised by measured root mean squared (RMS) velocity fluctuations. The velocity fluctuation is directly proportional to intensity of turbulence in the flow field.

Fig. 6Turbulent Kinetic Energy Variation

Figureshows the kinetic energy distribution for the various injection inclinations. Increased turbulence kinetic energy is observed in the mixing regions for all injection inclination positions. This is quietly high in the case of 30˚ degree inclination which is highly desirable. But increased level in the downstream is observed for 30˚ degree position causes fluctuations in the flow which results in energy dissipation.

Conclusion:

Based on the present analysis following conclusion has been drawn.

- Increased stoichiometric CH_4 mass fraction is observed in the mixing and outlet regions when the injection angle increases.
- Increased mass transfer rate is observed in the mixing region of injection angle 30˚.
- The intensity of turbulence is comparatively high in the mixing region of injection angle 30˚ which is highly desirable for better mixing.

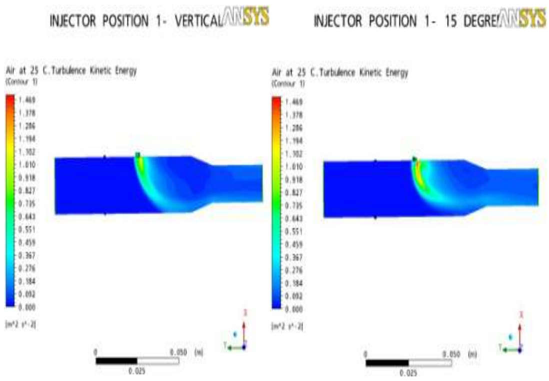

Fig. 6: (a) Vertical Position. (b) 15° inclination.

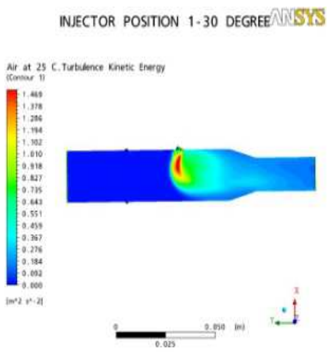

Fig. 6: (c) 30° inclination.

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