CFD Studies of Split Injection in DI Diesel Engine Combustion and Emissions.

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ABSTRACT

CFD software is used to study the combustion and emissions of a DI diesel engine. The trade-off between soot and NOx is a fundamental obstacle to lowering diesel engine emissions. To reduce both soot and NOx emissions, split injection might be a smart strategy to use. If one injection is broken up into a series of injections with a predetermined time interval, it is known as a "split injection." Diesel engines with a single cylinder and four strokes were researched for their ability to maintain constant speeds. A model of a DI diesel engine was built to provide accurate estimates and evaluations. The finite volume method was utilised to study combustion chamber design and emission characteristics. The findings showed that split injections were more beneficial than a single injection in terms of efficacy.

Keywords–Split Injection,CFD tool,DI diesel engine,Emission,Optimum split injection.

INTRODUCTION

The trade-off between soot and NOx is a fundamental obstacle to lowering diesel engine emissions. To reduce both soot and NOx emissions, split injection might be a smart strategy to use. Soot and NOx levels must be reduced at the same time if significant reductions in exhaust pollution are to be achieved. A reduction in NOx emissions seems to be impossible without an increase in soot emissions. A CFD tool will be used to model and analyse an internal combustion engine (Fluent, ANSYS 14.5 package). The CFD Fluent programme is used to investigate the combustion and emissions of a DI engine with split injection. The emission parameters of the combustion chamber are generated and analysed using finite volume analysis for each of the six conceivable split-injection situations.

THE COMPUTER PROCESS

Fluent software (ANSYS 14.5 package) was used to build the multidimensional model, and the different equations were automatically solved. Engine speed, single injection injection parameters, bore, stroke, connecting rod length, starting pressure, and temperature are the most essential inputs[1]. [2]. For each of the six separate split injections, the process is performed six times. The simulation model is used to forecast the results of the programme.

Pressures, temperatures, and emissions from the exhaust system and its cylinders etc. Graphs and outlines for the findings created by software that are easy to read and understand (NOx, Soot, etc.).

THE MODEL'S DEFINITION

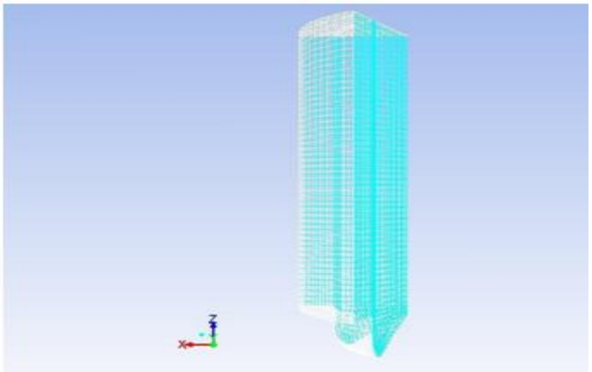
3D geometry was used to examine the impact of centrally located injectors.

ANSYS Workbench was used to produce the mesh.

The diagrams and specifications of the engine are provided below. The hexadominent mesh was produced in all study locations using the ANSYS 14.5 FLUENT programme. Faces and nodes make up the mesh's total count of 19722.

Figure 1 shows a cylinder's geometry.

Connecting rod length	:140 mm
Bore	:80 mm
Crank radius	:55 mm
Crank shaft speed	:1500 rpm



The cylinder mesh geometry is shown in Figure 1.

Modeling turbulence is possible.

Turbulent flows are described by their volatile velocity fields. Among the quantities impacted are momentum, energy, and species concentration. It is difficult to adequately describe these changes in engineering calculations because of their small size and high frequency. A more efficient set of equations may be constructed by the use of time-averaged or other instantaneous (precise) rule change. It is necessary to use turbulence models to estimate new unknown variables introduced by the modifications. This research makes use of the K-model[1].

ASSESSMENTS IN CONNECTION WITH THE TABLE.

The next step is to provide the criteria for defining the border.'

Viscosity-Energy (V-E) modelling is used in this study to account for species mobility. Needs and parameters for an injection are summarised as follows:

X-position :0.50038 mm
Y- velocity :468 m/s
Diameter :0.287 mm
Temperature :341 K
Flow rate :0.001044 kg/S
Start crank angle :355 deg
Stop crank angle :377deg

Mainly 6 types of split injection cases are considered. They are 85%,5-15%,90%-5-10%,95%-5-5%,85%-10-15%,90%-10-105,95%-10-5%.In the 85%-5-15% split injection case ,85% of the total fuel is injected at first and remaining 15% of the fuel injected at a crank angle difference of 5 deg. All the other properties will be the same as in the single injection case.

RESULTS AND DISCUSSIONS

1. Combustion Characteristics.

Single injection and all six split-injection combustion characteristics were analysed.

And the peak pressure and temperature readings were close to the predicted values, as was the pressure.

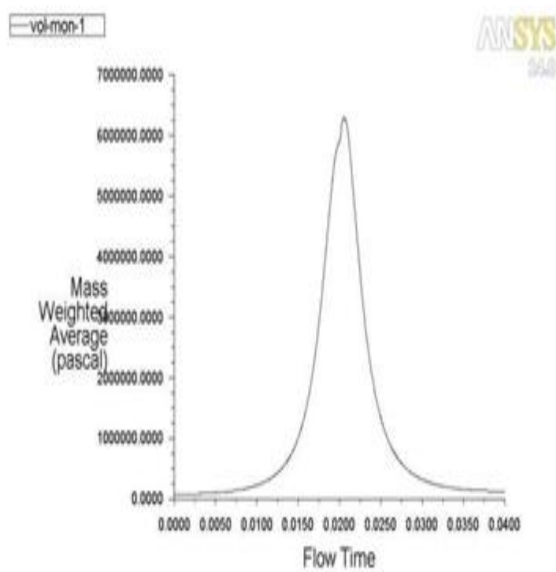


Fig. 2. Pressure v/s Flow time

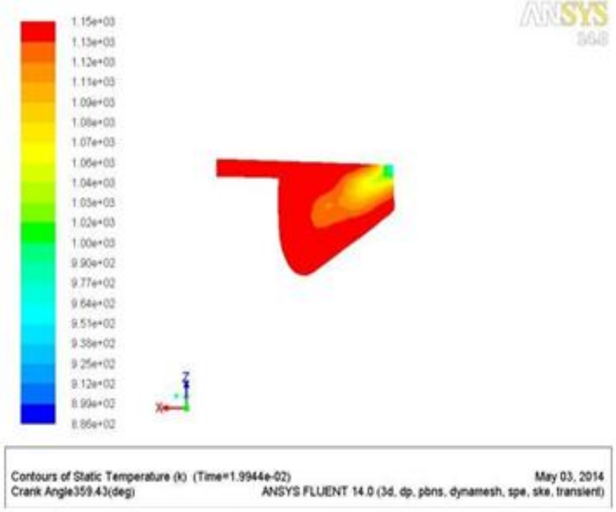


Fig. 3. Temperature contour

Characteristics of Emission

It was determined that the split injection instances had a lower NOx and soot emission rate.

The single injection example was compared to the outcomes obtained.

Single injection contour emissions of NOx and soot are illustrated in Fig.4.

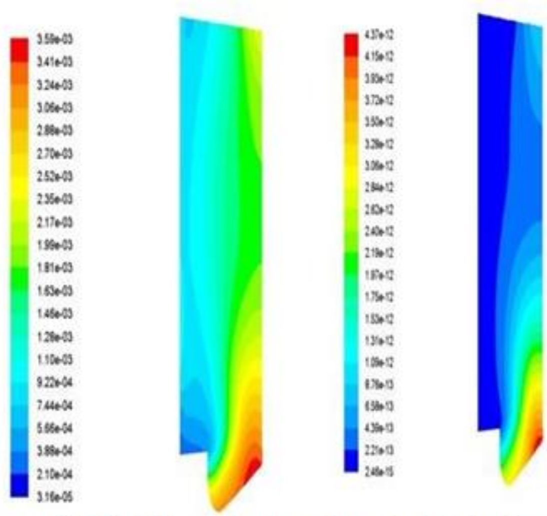


Fig. 4. NOx and soot contour-single injection

Soot and NOx emissions were reduced less in the 85 percent -5-15 percent and the 90 percent -10-10 percentage points, respectively. Figure 5 illustrates the differences between the two scenarios. Crank angle was plotted against NOx and soot emission to see how it compared to the single injection illustrated in Figure 6. Once the best split injection case has been determined, it is compared to the other split injection instances in Fig.6.

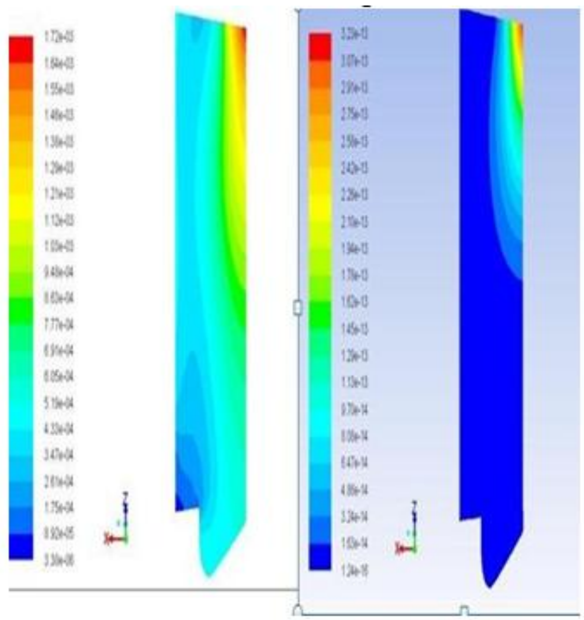
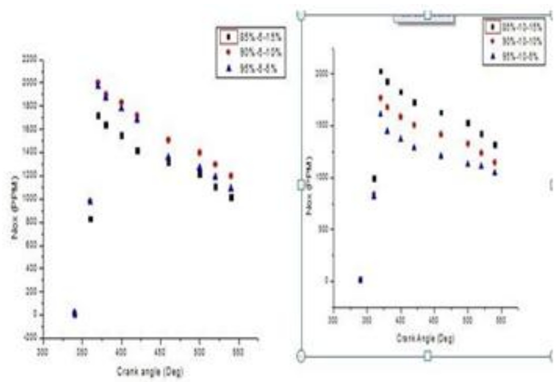
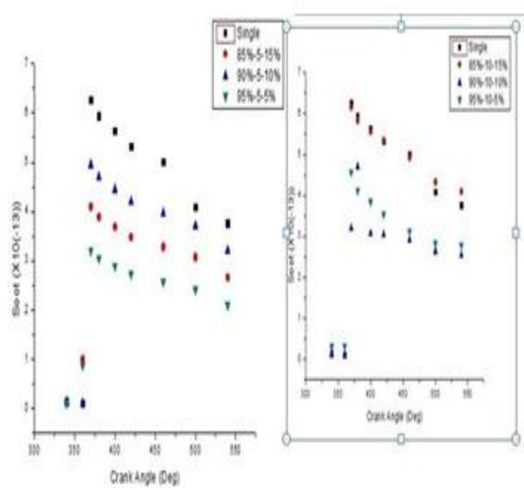


Fig. 5. NOx (85%-5-15%) Soot(90%-10-10%)contour





Details	Nox(PPM)	SOOT(e-13)	Nox reduction	Soot Reduction	Average Reduction(%)
Single Injection	2170	6.27	0	0	0
85%-5-15%	1720	4.1	0.207	0.346	27.67
90%-5-10%	2000	4.95	0.078	0.210	14.45
95%-5-5%	1970	3.21	0.092	0.488	29.01
85%-10-15%	2030	6.16	0.064	0.017	4.1
90%-10-10%	1770	3.2	0.184	0.489	33.69
95%-10-5%	1610	4.56	0.258	0.273	26.53

FIG. 6. COMPARISSION OF EMISSION CHARACTERISTICS

CONCLUSION

To investigate the impact of split injection on combustion and emissions in DI diesel engines, this research used a CFD software. The exhaust NOx and soot concentrations for these engines were optimised to the lowest possible levels. Split injection strategies were explored with 5%, 10%, and 15% of the total fuel. Depending on the model, the dwell time in between injection pulses might range from 5°CA to 10°Crank angle. The use of CFD has resulted in savings in terms of money, time, and resources.

The following is an overview of the findings.

All the combustion and performance parameters, exhaust NOx and soot emissions were computed and theoretically predicted to be consistent. • At 85 percent-5-15 percent and 90 percent-10-10 percent, NOx and Soot emissions are the lowest. In the best-case scenario, NOx and soot emissions might be cut by as much as 90%.

REFERENCES

Lakshminarayanan, P. A. et. al, Modellingdiesel combustion (Springer, 2009)

Abdullah N, Tsolakis A, Rounce P, Wyszinsky M, Xu H, Mamat R et al.,. "Effect of injection pressure with split injection in a V6 diesel engine," SAE Paper NO. 2009-24-0049; 2009.

Bianchi GM, Peloni P, Corcione FE, Lupino F et al., "analysis of passenger car HSDI diesel engines with the 2nd generation of common rail injection systems: The effect of multiple injections on emissions",SAE Paper NO. 2001-01-1068; 2001

Chryssakis CA, Assanis DN, Kook S, Bae C et al.,. " Effect of multiple injections on fuel- air mixing and soot formation in diesel combustion using direct flame visualization and CFD techniques", Spring Technical Conference, ASME NO. ICES2005-1016; 2005

Ehleskog R et al.,. " Experimental and numerical investigation of split injections at low load in an HDDI diesel engine equippedwith a piezo injector", SAE Paper NO. 2006-01-3433; 2006.

F. Payri , J. Benajes, X. Margot , A. Gil et al., "CFD modeling of the in-cylinder flowin direct-injection Diesel engines" ,

Computers & Fluids 33 (2004) 995–1021

Franz X. Tanner et al "CFD-based optimization of fuel injection strategies in a diesel engine using an adaptive gradient method". Applied Mathematical Modelling 33 (2009) 1366–1385 .

Gomaa M, Alimin AJ, Kamarudin KA etal.,"Trade-off between NOx, soot and EGR rates for an IDI diesel engine fuelled with JB5",World Academy of Science, Engineering and Technology 2010; 62:449-450 .

J. Blazek,"Computational Fluid Dynamics:Principles and Applications", Elsevier Science Ltd,2001,1-39.

Jafarmadar S, Zehni A. et al., " Multi- dimensional modeling of the effects of split injection scheme on combustion and emissions of direct-injection diesel engines at full load state" IJE, 2009; Vol. 22, No. 4