Propulsion and Power Research 2013;2(2):162–175

http://ppr.buaa.edu.cn/

Propulsion and Power Research

www.sciencedirect.com

ORIGINAL ARTICLE

Multidimensional modeling of the effect of fuel injection pressure on temperature distribution in cylinder of a turbocharged DI diesel engine

Sajjad Emami[a,*], **Samad Jafarmadar**[b]

[a]*Young Researchers and Elite Club, Khoy Branch, Islamic Azad University, Khoy, West Azerbaijan 58159 -15149, Iran*
[b]*Mechanical Engineering Department, Technical Education Faculty, Urmia University, Urmia, West Azerbaijan 57561-15311, Iran*

Received 3 August 2012; accepted 16 January 2013
Available online 6 June 2013

KEYWORDS

Injection pressure;
Indicated power;
Temperature contour;
Equivalence contour;
Soot;
NO_x;
Combustion modeling

Abstract In this study, maintaining a constant fuel rate, injection pressure of 275 bar to 1000 bar (275×10^2 kPa to 1000×10^2 kPa), has been changed. Effect of injection pressure, the pressure inside the cylinder on the free energy, power, engine indicators, particularly indicators of fuel consumption, pollutants and their effects on parameters affecting the output of the engine combustion chamber have been studied in droplet diameter. Finally, the effects of fuel mixture equivalence, Cantor temperature, soot and NO_x due to the increase of injection pressure, engine efficiency and emissions have been examined.

© 2013 National Laboratory for Aeronautics and Astronautics. Production and hosting by Elsevier B.V. All rights reserved.

1. Introduction

Diesel direct injection (DI) is widely used in automotive and industrial applications. In the past decades, the main approach is the design of combustion engines and power generation, but because of today's tougher engine emission regulations and standards, a new viewpoint has opened in the motor engineering.

Sugiyama and colleagues had studied numerical high-pressure fuel spraying only in two cases, 150 MPa and 50 MPa [1]. The results show that when the spray pressure is increased, the maximum pressure inside the combustion chamber increases too and the time to reach maximum pressure is also shorter. Abu Bakar and his colleagues studied the effects of high pressure diesel fuel spraying in a direct spray diesel engine in 2008 [2]. In their study, the range of spraying pressure changes from 100 MPa to

---

*Corresponding author: Tel.: +98 441 2972000.

E-mail address: emami_eng@yahoo.com (Sajjad Emami)..

Peer review under responsibility of National Laboratory for Aeronautics and Astronautics, China.

Production and hosting by Elsevier

2212-540X © 2013 National Laboratory for Aeronautics and Astronautics. Production and hosting by Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.jppr.2013.04.003

200 MPa. Based on their results, the best performance of 220 bar (220×10^2 kPa) of spray pressure engine was obtained and the minimum conditions on fuel consumption and fixed spraying pressure of 200 bar (200×10^2 kPa) was obtained. Patterson and colleagues used the code KIVA-II for reforms after studying spraying schedule, spraying pressure and multi-level spraying some stages so that the carbon black was reduced to about 30% and the maximum of carbon black was 75% of one level injection [3]. In terms of emission behavior, NO_x is produced to a great extent, due to the high local temperatures found in diesel engines which are highly dependent on the initial rise of heat release. In addition, soot production and oxidation are both dependent on the mixing rate and local flame temperatures [4]. The injection velocity is one of the most influencing parameters on the previous factors, because it controls both the mixing process and the rate of heat release. This is why injection system parameters and nozzle geometry have been extensively studied due to their direct relationship with the fuel injection rate and fuel velocity. To support this, it has been recognized that the characteristics of the injection system are some of the most important factors in influencing emissions and performance of diesel engines [5–7].

In recent years, computer codes for simulating three-dimensional (3D) combustion in internal combustion engines have been used. This paper studies the theoretical effects of fuel injection pressure and the temperature contours of the emission function equivalence on four-cylinder direct injection diesel engine equipped with a turbocharger in the form of a numerical simulation by CFD code.

2. Governing equations

Governing equations including continuity, momentum and energy are modified based on Reynolds average and according to Reynolds-averaged Navier-Stokes (RANS) equations based on semi-implicit method for pressure-linked equations (SIMPLE) algorithm, and k-ε standard turbulence model for numerical simulation of flow inside the combustion chamber is used.

$$k=\frac{1}{2}\overline{u_i'u_i'} \tag{1}$$

Where turbulent kinetic energy (TKE)

$$\varepsilon=\left(\frac{\mu}{\rho}\right)\overline{u_{ij}'u_{ij}'} \tag{2}$$

where viscous dissipation rate of turbulent kinetic energy

$$\begin{cases} \rho\dfrac{\partial k}{\partial t}+\rho u_j k_{,j}=\left(\mu+\dfrac{\mu_t}{\sigma_k}k_{,j}\right)+G+B-\rho\varepsilon \\ \rho\dfrac{\partial \varepsilon}{\partial t}+\rho u_j \varepsilon_{,j}=\left(\mu+\dfrac{\mu_t}{\sigma_\varepsilon}\varepsilon_{,j}\right)+C_1\dfrac{\varepsilon}{k}G+C_1(1-C_3)\dfrac{\varepsilon}{k}B-C_2\rho\dfrac{\varepsilon^2}{k} \end{cases} \tag{3}$$

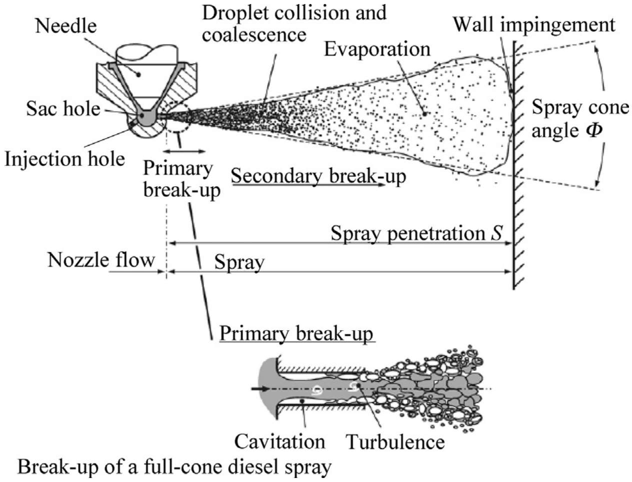

Figure 1 Injection of the jet fuel from the nozzle [8].

where

$$G=-\rho\overline{u_i'u_j'}u_{i,j} \tag{4}$$

$$B=\overline{\rho' u_i'}g_i \tag{5}$$

$$\mu_t=C_\mu\rho\frac{k^2}{\varepsilon} \tag{6}$$

and the coefficients have the following standard values:

C_μ	$C_{\varepsilon 1}$	$C_{\varepsilon 2}$	$C_{\varepsilon 3}$	$C_{\varepsilon 4}$	σ_k	σ_ε	σ_ρ
0.09	1.44	1.92	0.80	0.33	1.00	1.30	0.90

2.1. *The fuel spray*

The discrete droplet method is used to spray the fuel through separate droplets. The schematic view of the injection of the jet fuel from the nozzle is shown in Figure 1.

2.2. *Model of heat transfer and evaporation of fuel droplets*

Heat transfer and mass transfer processes by the model obtained by Dukowicz are modeled [9,10]. Assuming a uniform temperature drop, track changes in energy balance equation to determine the temperature drops that heat energy transferred to the drop caused by the drop heating and evaporation will result in the model are as follows:

$$m_d c_{pd}\frac{\mathrm{d}T_d}{\mathrm{d}t}=L\frac{\mathrm{d}m_d}{\mathrm{d}t}+\dot{Q} \tag{7}$$

Heat flux transferred from the gas surrounding the droplet surface is obtained from the following relationship:

$$\dot{Q}=\alpha A_S(T_\infty-T_S) \tag{8}$$

Download English Version:

https://daneshyari.com/en/article/1719678

Download Persian Version:

https://daneshyari.com/article/1719678

Daneshyari.com