HEAT TRANSFER STUDY ON A DI DIESEL ENGINE USING DIESEL AND BIODIESEL FUELS

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ABSTRACT

An experimental investigation has been undertaken to study operating temperatures and heat fluxes in the cylinder walls of a water-cooled diesel engine. Temperatures were measured under a wide range of load at various locations in the block and cylinder head of the engine employing infrared thermocouple arranged to obtain thermal gradients and subsequently deduce the corresponding heat fluxes and wall surface temperatures. First diesel is used as a fuel and the temperature readings are found using an optical thermometer, then bio diesel (B20 blends and B100) is used as a fuel and temperature readings and noted. From the data collected the heat transfer coefficient is found for the fuels. A comparative study is made between diesel and bio diesel (B20 blends and B100) and heat transfer rate is estimated.

KEYWORDS: Heat Transfer Coefficient, Heat Transfer, Reynolds Number & Biodiesel

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1. INTRODUCTION

Diesel engines have provided power units for road transportation systems, ships, railway locomotives, equipment used for farming, construction, and in almost every type of industry due to its fuel efficiency and durability. However, Diesel engines are the major sources of and particulate matter emissions, which are environmental concerns. The use of alternative fuels for internal combustion engines has attracted a great deal of attention due to fossil fuel crisis and also Greenhouse Gas impact. Alternative fuels should be easily available, environment friendly, and techno economically competitive.

One of the promising alternative fuel considerations for diesel engine is biodiesel, because the main advantage of being able to readily use in existing diesel engines without engine modification. Even though biodiesel has many advantages, because of engine problems its use is restricted to maximum 20% only. Also, when biodiesel is used as fuel in existing engines, there is decrease in power, drop in thermal efficiency, increase in specific fuel consumption, and higher emissions. In order to overcome these problems various modifications in engine operating parameters are suggested.

Present research work has been focused to investigate the effect of combustion parameters of cotton seed oil blended fueled engine. All experiments are carried out on a single-cylinder diesel engine at a constant idle speed of 1500 rpm. The experimental results of heat transfer coefficient and heat transfer coefficient were analyzed at various loads points of 0%, 25%, 50%, 75%, and 100%.

The work presents the principles of thermo-fluid dynamic behind heat transfer phenomena relevant to internal combustion engines. The emphasis is on the relations between heat transfer and fluid flows. The work provides an overview of the flow-fields characteristics of internal combustion engines. The different approaches to accurate three-dimensional transient modelling of heat transfer and fluid flow are introduced and compared. This information is the backbone to select an appropriate simulation strategy for heat transfer related problems in internal combustion engines. Mirko Bovo [1]. The advances in engine modelling and simulation by providing more accurate boundary conditions necessary for the application and validation of current design and simulation tools, such as computational fluid dynamics (CFD) and finite element analysis (FEA). Another possible outcome is to decrease thermal bore distortion in engines, which is the main cause of deformation in the engine block. This would be partly a result associated with the advances in FEA and CFD applications as well as in cooling systems. Reducing bore distortion improves engine block to cylinder head conformability, and more importantly is a major factor in optimizing the piston-ring-cylinder assembly. Carlos Adolfo Finol Parra [2]. In this paper, they propose a thermodynamic single-zone computational model based on the step-by-step filling and emptying method proposed and valid for turbocharged diesel engine.

The study focuses on the investigation and analysis of the effect of several engine parameters (thermodynamic and geometric) on the convective heat flux and max heat flux from fluid to the cylinder wall of the combustion chamber to provide a better understanding on the convective heat transfer of a turbocharged compression ignition engine. For this purpose, a computer simulation program is developed in Fortran language, and use of a commercial GT-Power software for comparison and validation of the results. Brahim Menacer [3].

2. EXPERIMENTAL SETUP

An experimental investigation has been undertaken to study operating temperatures and heat fluxes in the cylinder walls of a water-cooled diesel engine. A complete thermal survey was obtained by measuring steady-state metal temperatures in the engine block and cylinder head using infrared thermometer. These quantities were inlet and exhaust manifold, intake air mass flow rate.

The thermal survey consisted of steady-state measurements designed to reveal the spatial variation of temperature and heat flux over a wide range of operating conditions. The optical thermometer was used to measure the temperature at three different locations in the cylinder walls and cylinder head. Consequently, it is feasible to determine the subsequent heat transfer rate and heat transfer coefficient in the cylinder surface, which is the main intention of this work. The experimental setup is shown in figure 2.1

Experiments have been conducted using diesel, and biodiesel blends have been performed on a 5.2 kW, single cylinder DI diesel engine at 0%, 25%, 50%, 75% and 100% loads.

Figure 2 1: Experimental Setup

(1) Diesel engine, (2) Electrical dynamometer, (3) Dynamometer control panel, (3) Air box, (4) U-tube manometer, (5) Fuel tank, (6) Fuel measurement, (7) Pressure transducer, (8) TDC position sensor, (9) Charge amplifier, (10) TDC amplifier circuit, (11) Analog to digital card, (12) Personal computer, (13) Exhaust gas analyzer, (14) AVL smoke meter.

3. RESULTS AND DISCUSSIONS

3.1 Effect on Engine Speed

Figure 3.1.1 shows the variation of heat transfer coefficient with speed. When the engine speed is high, the gas velocity into and out of the engine will increase and this leads to a rise in convection heat transfer coefficients. This effect increases the heat transfer occurring during intake and exhaust strokes and even during the early part of the compression stage, whereas, during the combustion and power stroke. Heat transfer co-efficient decreases for Diesel and B20, whereas subsequent increase for B100 with increase in speed. Figure 3.1.2 shows the variation of heat flux vs speed. The same is determined from the heat flux, diesel and B20 decreases and for B100 it increases.

Figure 3.1.1: Heat Transfer Co-Efficient Vs Speed

Figure 3.1.2: Heat Flux Vs Speed

3.2 Effect on Load

Figure 3.2.1 shows the variation of heat transfer co-efficient vs load. The heat transfer co-efficient is initially high for B100 when compared to Diesel and B20, but as the load increases the value drops drastically for B100. Whereas for Diesel and B20 has a very low value initially, increases until 50% load and then slightly decreases when reaching 100% load. Diesel and B20 has an increased value from 0% - 100% load.

Figure 3.2.1: Heat Transfer Co-Efficient Vs Load

Figure 3.2.2: Heat Flux Vs Load

Figure 3.2.2 shows the variation of heat flux vs load. B100 has a higher value in 0% load than diesel and B20. The value increases when the engine is operated at 50% load, but drastically decreases while operating at 75% load and decreases further while operating at 100% load. But for diesel and B20 has a subsequent low value in 0% load, the value increases with increase in load.

3.3 Effect of Crank Angle

Figure 3.3.1: Pressure Vs Crank Angle (Diesel)

Figure 3.3.2: Pressure Vs Crank Angle (B100)

Figure 3.3.3: Pressure Vs Crank Angle (B20)

Figure 3.3.1, 3.3.2 and 3.3.3 show the variation of pressure vs crank angle for diesel, B100 and B20 respectively. The variation is observed for 0%, 25%, 50%, 75% and 100% load. The peak pressure is high for B100 when compared to diesel and B20.

3.4 Effect of Heat Release Rate

Figure 3.4.1: Heat Release Rate Vs Crank Angle (Diesel)

Figure 3.4.2: Heat Release Rate Vs Crank Angle (B100)

Figure 3.4.3: Heat Release Rate Vs Crank Angle (B20)

Figure 3.4.1, 3.4.2 and 3.4.3 shows the variation of heat release rate vs crank angle. The variation is observed for 0%, 25%, 50%, 75% and 100% load. The heat release rate is high for B100 when compared to diesel and B20.

4. CONCLUSIONS

In the course of work, an experimental investigation to study operating temperatures, heat transfer and heat transfer coefficient in the cylinder walls of a single cylinder diesel engine was carried out for diesel, biodiesel (B100) and biodiesel blend (B20). The study relied on a significant amount of data, which included measurements of metal thermal gradients at different locations in the cylinder walls of the test engine under a wide range of operating loads. Heat transfer rate and heat transfer coefficient is more for B100 than diesel and B20 when evaluated with speed of the engine. But diesel has higher heat transfer coefficient when evaluated with different operating load of the engine.

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