Mugla Journal of Science and Technology

EFFECTS OF USING PHASE CHANGE MATERIALS ON THE COLD START EXHAUST EMİSSİONS CHARACTERİSTİCS OF DIESEL ENGINES

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Received: 23.10.2015, Accepted: 31.03.2016
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Abstract

During the last two decades, the diesel engine performance and drivability have significantly improved with the latest technologic developments. Nevertheless, one of the disadvantageous of diesel engines is related to the difficulties for starting at cold conditions, particularly in the conditions where the ambient temperature is near or below 0ºC. Additionally, the harmful exhaust emissions are also at significantly important levels during the cold start conditions. Most of carbon monoxide (CO) emissions from diesel engines are produced during the engine warm-up period. In order to improve cold start characteristics of diesel engines, many measures have been proposed, such as glow plugs and air heaters in air intake lines.
In this study, in order to increase the cold start performance and improve the exhaust emission characteristics of a direct injection diesel engine, phase change materials (PCMs) have been used.
PCMs have high heats of fusion and they can absorb latent energy before melting. During the phase change, temperature of PCMs remains nearly constant. In this study, a PCMs was used with the 45-51ºC melting temperature band in a heat exchanger. Hot water from an external source was circulated in the exchanger to carry out the experiments in the same conditions and was used as heat source in order to melt the PCMs.
Engine intake air has been passed through the exchanger before engine intake manifold. During the engine cooling period, the PCM in the produced heat exchanger have increased the cooling time period of engine intake air.
An experimental setup has been established to observe the cold start characteristics of the two cylinder diesel engine with and without using the produced exchanger. Temperature measurements from different points, CO exhaust emissions, engine speed and in cylinder pressure measurements have been used to evaluate the contribution of exchanger and increasing the intake air temperature by using the PCMs. The experiments have been carried out at different PCMs and ambient temperatures. The increase in the temperature of intake air at low ambient temperatures assists the engine cold start performance, decreases the starting time of engine and improves the engine exhaust emissions characteristics.
Keywords: *Phase Changing Materials, Diesel Engines, Cold Start.*

DİZEL MOTORLARDA FAZ DEĞİŞTİREN MALZEMELERİN KULLANIMININ SOĞUKTA İLK HAREKETTE EGZOZ EMİSYON KAREKTERİSTİKLERİNE ETKİLERİ

Özet

Dizel motorların performansları ve sürüş konforları son teknolojik gelişmelerle son yirmi yıl boyunca önemli seviyede geliştirilmiştir. Bununla beraber, dizel motorların dezavantajlarından birisi soğuk şartlarda, özellikle de ortam sıcaklığının 0ºC'ye yakın veya altında olduğu şartlarda ilk hareket esnasındaki zorluklar ile ilgilidir. Buna ek olarak, zararlı egzoz emisyonları da soğukta ilk hareket koşullarında önemli seviyede artmaktadır. Dizel motorlardan çıkan karbon monoksit (CO) emisyonlarının çoğu motor ısınması esnasında üretilir. Dizel motorların soğukta ilk hareket karakteristiklerini iyileştirmek için hava giriş hattına kızdırma bujileri ve hava ısıtıcıları gibi pek çok öneriler öne sürülmüştür.
Bu çalışmada, doğrudan enjeksiyonlu dizel motorların soğukta ilk hareket performanslarını artırmak ve egzoz emisyon karakteristiklerini iyileştirmek için faz değiştiren malzemeler (FDM) kullanılmıştır. FDM'ler yüksek füzyon ısılarına sahiptirler ve erimeden önce gizli ısıyı absorbe edebilirler. FDM'lerin sıcaklıkları faz değişimi esnasında neredeyse sabit kalmaktadır. Bu çalışmada 45-51ºC erime sıcaklığı aralığındaki FDM üretilen bir ısı eşanjöründe kullanılmıştır. Deneylerde eşit şartların yakalanması için dış bir kaynaktan alınan sıcak su eşanjörde sirküle edilmiş ve FDM'yi eritmek için ısı kaynağı olarak kullanılmıştır. Motor emme havası, emme manifoldundan önce eşanjörün boruları arasından geçirilmiştir. İmal edilen ısı eşanjörünün içindeki FDM motor soğuma periyodu esnasında motor giriş havasının soğuma periyodunu artırmıştır. İki silindirli bir dizel motorun soğukta ilk hareket karakteristiklerini gözlemlemek için imal edilen eşanjörlü ve eşanjörsüz bir deney düzeneği kurulmuştur. FDM kullanılarak artırılan motor giriş hava sıcaklığının ve eşanjörün katkısını değerlendirmek üzere CO emisyonları kullanılmıştır. Farklı FDM ve ortam sıcaklıklarıyla deneyler gerçekleştirilmiştir. Düşük ortam sıcaklıklarında giriş havasının sıcaklığındaki artış motorun soğukta ilk harekette egzoz emisyon karakteristiklerinin iyileştirilmesine de yardımcı olmaktadır.
Anahtar kelimeler: *Faz Değiştiren Malzemeler, Dizel Motorlar, İlk Hareket*

1 Introduction

Nowadays, including transport in particular, electricity generation in machines in the industry, a significant amount of fossil-based energy needed in many areas such as lighting and heating are paid from the fuel due to the chemical composition of air use of fossil fuels we breathe as a result of being polluted every day.

People live their environmental awareness increases; it has raised this issue at the international level. As the result, this is still valid and has brought the expected entry into force of the future emission agreements. Therefore the emission limit is drawn down gradually and is forcing the manufacturers to produce cleaner and more efficient power systems. This requirement brings with it certain disciplines. (Yuksel et al, 2001). The Kyoto Protocol, signed in 1997, is one of these agreements. The aim of this protocol is the amount of carbon they release into the atmosphere to reduce the level of the country in 1990. (Kawano et al., 2006)

Also harmful emissions released into the atmosphere from vehicles have been prepared by the European Union standards to minimize and be implemented in 1992. These standards are drawn down periodically revised emission limits and entry into force of the Euro 6 standard in 2014.

It has led to several investigations and research for the researchers on the one hand new and environmentally friendly energy sources to seek forcibly other hand, more efficient use of existing energy sources to ensure the continuity of meet the increasing energy demand and energy supply. Especially made for this research has focused on the consumption of energy conversion systems commonly used in the area where transport sector. In the transport sector comes at the start of the internal combustion engine used in energy conversion systems.

Internal combustion engines convert chemical energy of fuel useful mechanical energy. Through the last two decades of work in performance and ride comfort, diesel engine technology has improved very significantly. In particular, the controls of combustion processes and exhaust gas through continuous development of new technology on diesel engines are constantly updated capture emissions standards. Diesel engines, compression and its temperature increases air spraying with high pressure fuel work with principle. However, low temperatures and cold engine, diesel or insufficient or no burn. Therefore, one of the most critical problems encountered in the use of diesel engines are problems in transition from the first move at low temperatures.

Liu et al (2003), the events during the transition from the first movement cold diesel engines is the most critical or important factors in the effect of ambient temperature, although affected by many parameters. Hene et al. (1992) rate of combustion instability during cold starting of diesel engines, exhaust gas temperature and composition were determined to be related to air temperature and accumulated fuel environment. Mohr and Urlaub (1994), an ignition plug of a diesel engine to adapt results showed that HC emissions are much reduced. Lindl and Schmitz (1999), the future emission standard regulations stated that focus of the first act in the cold process.

Two basic methods of diesel engines in order to facilitate the transition of the first movement of the diesel engine is used:

I. Using glow plugs in the combustion chamber to create hot spots.
II. Using air heater to increase the temperature of the air taken into the cylinder.

For this purpose also one of the studies, the phase change materials (PCMs) use of the thermal energy storage.

Gumus and Ugurlu (2011), in vehicles powered by LPG, starting problems in cold to minimize using PCMs is designed by our regulator system capable of storing thermal energy have concluded that improving the emitted pollutant emissions into the environment. Gumus (2009), for preheating of the the internal combustion engine by testing advanced experimental example of the thermal energy storage system, CO and HC with the effect of preheating the engine emissions at cold starting and combustion period observed that respectively 65% and around 15% decrease. Kim et al. (2010) using PCMs for new cooling strategies in automobile engine cooling system can reduce by 30% the size of the first movement and in cold showed that contributed to the reduction in harmful emissions. Korin et al. (1998) and Korin et al. (In 1999) the work carried out by using capsules of catalytic converter demonstrated efficient would be the reduction of gaseous pollutants emitted from vehicles. Birch et al. (1995) and Birch et al. (1996) using PCMs capsules in catalytic converters, during the first movement cold total NMHC (non-methane hydrocarbon), CO and HC have observed reductions in emissions.

2 MATERIAL AND METHODS

In the study we have this offer in order to reduce the disadvantages experienced during the transition to the first movement in a cold diesel engine, to deliver the same conditions in the experiment, the energy heat from an external source taken and stored placed in PCMs a heat exchanger manufacturer. Engine air intake during the first act was passed through the heat exchanger and providing increased compared to the ambient air temperature is delivered to the engine. Different PCMs plate surface temperature and the ambient air temperature in the different experiments were repeated. Changes in CO emissions with temperature measurements performed at different locations were examined.

2.1 General Information About PCMs

Substance from solid to liquid or liquid to pass event called phase change layer. This material, "Phase Change Materials" is called. PCMs stores heat by absorbing a certain amount of liquid passes from the solid, passing from solid to liquid can leave the same amount of heat released. PCMs while absorbing heat increase due seem sensible heat storage material in temperature. PCMs heat storage materials, unlike the sensible heat would absorb almost constant temperature and releases (Sharma et al. 2009).

2.2 Experimental setup

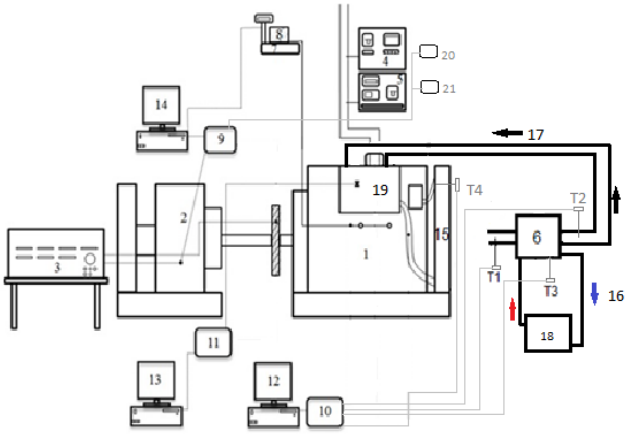

Figure 2.1. A schematic representation of the experimental setup

1- Engine
2- Hydraulic brake
3- The control unit
4- Exhaust Emissions Device III
5-Soot Meter
6- Heat Exchanger
7- Libra
8- Fuel Tank
9- NI PCI-6259 Converter
10- Advantech PCL 818 HG
11- NI PCI-6250
12- Personal Computers II
13 -Personal Computers II
14- Personal Computer-
15- Radiator Engine
16-Cooling Water Line
17- Engine Air Intake Line
18-Hot Water Tank
19- Piezo Pressure
20, 21-Cameras

2.3 Exhaust Emission Device

This study was conducted emission analysis of the exhaust gases. For this purpose, in order to measure the exhaust gas emission values can be used in both diesel and gasoline engine (Bosch BEA 270) exhaust emission device was used. (Figure 2.2)

Figure 2.2. Exhaust emission unit

In this study, the data obtained from the exhaust emission device with 5-second intervals and recorded with a camera that has been developed in MATLAB program shall transfer to the computer for processing. (Figure 2.3)

Figure 2.3. Camera display of test results at 5-second intervals

2.4 PCMs and Features That We Used In Our Experiments

Rubitherm (RT 50) in the process of phase change between solid and liquid (melting and freezing) in almost constant temperature, is a pure PCMs used as a heat storage material for storing large amounts of thermal energy and leave. RT50 PCMs provides higher yield for the storage of heat and cold, and can be applied even small differences in very small volumes of the operating temperature.
Properties:
- They have high thermal energy storage capacity.
- It is located at a relatively constant temperature during storage and release heat.
- There is no extreme cooling effect, they are chemically inert.
- A long-lasting products have stable performance during phase change.

2.5 Heat exchanger

Experiment 4.6 mm in diameter for use in heat exchanger is preferred. Heat exchangers between our 157mm * 94mm * 8.5mm gauge coils made of 9 pieces of copper material in which we have placed stuffed PCMs plates. Moreover, in order to increase the amount of PCMs 3 is used; 50cm^3 PCMs in filled plastic containers are placed at the edges of the heat exchanger. It made of sheet material in 1mm thickness of the enclosure shown in Figure 2.4 and the heat exchanger coated with insulating material is disposed. Experiments at different surface temperatures of the different temperature and PCMs plate was again.

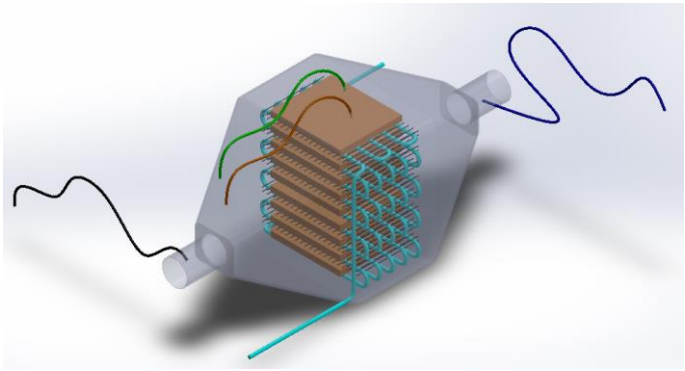

Figure 2.4. Heat exchanger

3 RESULTS

3.1. Observed exhaust emission levels in different PCMs Heat Exchanger Plate Surface Temperature
After the first move in different PCMs Figure 3.1 shows the change in surface temperatures observed CO emissions. Related four graphs respectively (a- 0°C, b- 2.5°C, c- 7.5°C, d- 12.5°C) The data are presented. When all the graphs examination PCMs plate surface temperature increases, decrease in the CO emissions.

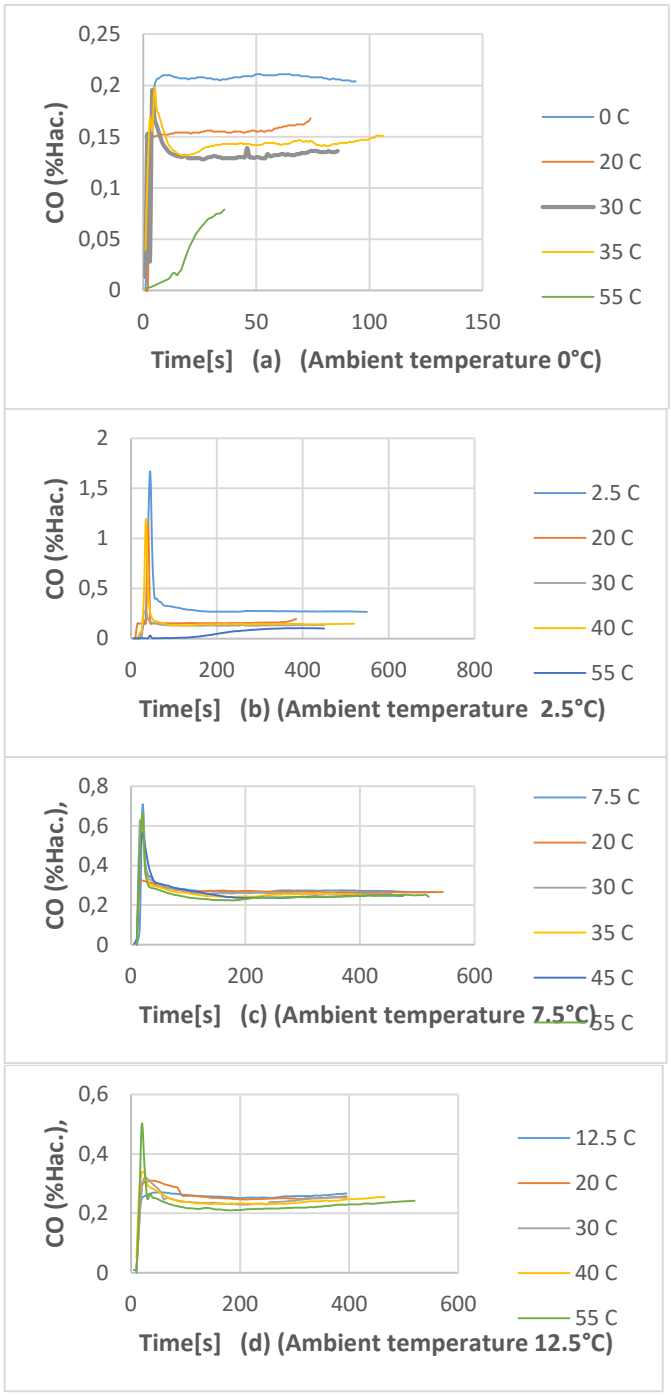

Figure 3.1 CO emission changes observed in all experiments

3.1 Start (ambient) temperature, respectively: a- 0°C, b- 2.5°C, c- 7.5°C, d- 12.5°C

Things emission tests PCM plate surface temperature increases, the increase of the CO emission level of the suction air temperature also showed a decrease. 12.5 ° C ambient in case of air passing after the first run in the experiments conducted under conditions of 200 seconds measured CO emission levels PCM plate surface temperature is 12.5 ° C, while the value of volume to 0.25% the same value PCM plate surface temperature of 55 ° C level to get the 0.21% volume decreased to value. In this case, CO exhaust emissions production level about 16% shows a decrease.

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