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134. Emissions from Diesel Engine and Exhaust After Treatment Technologies

Ali Azam[a,*], Shoukat Ali[a], Adnan Iqbal[a]

[a]*Department of Mechanical Engineering, Swedish College of Engineering & Technology, Rahim Yar Khan, 64200, Pakistan.*
**E-mail address: ali.azam3629d1@gmail.com*

Abstract

Diesel engines, with their low-operating cost, have high efficiency, reliability and durability. This is because diesel engines are especially used for heavy-duty vehicles. The diesel motors are considered as the principle donor to ecological contamination these days. They are the main cause of several health problems. They contribute to global warming through Particulate Matter, Hydrocarbons (HC), Nitrogen Oxides (NOx) and Carbon Oxides (COx) emissions. Their presence causes a number of respiratory diseases. Various effective techniques are currently available for reducing PM, HC, COx and NOx. This paper reviews various types of diesel engine emissions and their control technologies. Each type of diesel engine emissions and control technologies is broadly studied.

Keywords: *Diesel engine, Emissions, emission control technologies; DOC, EGR, SCR, DPF.*

1. Introduction

In a diesel motor, the chemical energy (fuel energy) is altered into heat energy through burning of fuel and heat leads to an expansion and rotate the crankshaft. The first stroke starts when air enters the combustion chamber due to the opening of intake valves. At the second stroke, air is compressed inside the cylinder by piston movement and intake valves are closed. The volume of the combustion chamber is smallest when the piston approaches the top dead centre. At this stage, fuel is injected into the highly compressed air and self-ignition take place for a short interval of time. Excessive supply of oxygen lead more burning of fuel and in this way, high combustion takes place in the combustion chamber. Thus, more power is produced to rotate the crankshaft [1].

The natural greenhouse is affected by burning fossil fuels. This lead to an expansion in the climatic pollutions called greenhouse gases [2-4]. Climate change occurs due to the presence of these gases in the atmosphere. CO2 is considered as the principal reason for global warming [5]. Emissions from transport are the main part of environmental pollution these emissions cause changing climate [6]. Global CO_2 emissions with the range of 22% are produced by the second largest sector Transport [7]. The rapid increase of transport disturbed climate in urban areas [8, 9].

This article reviews on the outflows from diesel motor and their control technologies. Four main discharges (CO, HC, NOx, and PM) from diesel motors are clarified individually. Different outflow control technologies are reviewed as DPF, DOC, SCR and EGR.

2. Emission from diesel combustion

The most astounding proportion of diesel outflows is because of NOx. NOx has emissions rate above than 50%. In diesel emissions, PM has the second highest percentage. CO and HC are produced due to incomplete combustion and are found in lowest concentration. Moreover, diesel emissions include a little amount of SO2 depending upon the details and quality of fuel. There is no after treatment technology to reduce SO2. These days, the vast majority of the oil wholesalers and clients like ultra-low sulphur diesel

(ULSD) for diesel motors to reduce the unwanted effect of SO2. Fig. 1 explains the composition of emissions from the diesel engine[10].

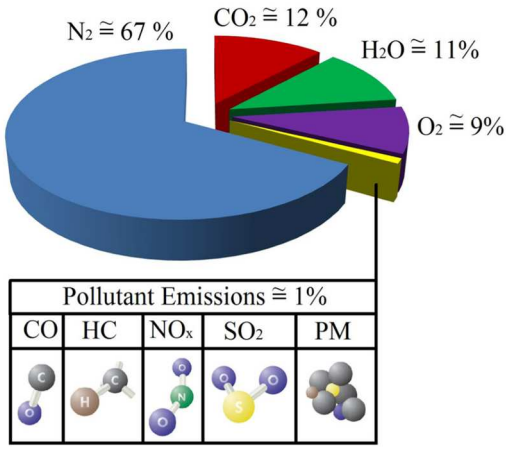

Fig. 1. Diesel emissions (%)

In this section, HC, CO, PM, and NOx outflows from the diesel motor are clarified. Each type of outflow is explored on an individual basis and accordingly the effects of each contamination on ecological and wellbeing issues are uncovered.

2.1. Nitrogen oxides (NOx)

The combination of nitrogen dioxide (NO_2) and nitrogen oxide (NO) is referred as NOx. There is 85-95% of NO contributions in NOx. NO_2 gas has a pungent smell with reddish brown colour while NO is an odourless and colourless gas [11, 12]. NOx for transport has 40-70% of contributing to worldwide pollution level. Now, diesel combustion is considered as the main contributors to NOx emissions. Diesel engine needs higher temperatures for combustion of diesel fuel. [13, 14]. Smog formation and acid rain are caused by NOx emissions [15]. Tropospheric ozone is basically originated in the atmosphere from NOx emissions reaction chemically with other pollutants. Both NO_2 and NO are toxic; but the level of toxicity of NO_2 is five times greater than the level of NO [16, 17].

2.2. Particulate matter (PM)

Insufficient supply of oxygen in combustion chamber produce incomplete combustion of the HCs which produce PM. An experimental study describe that PM consists of sulphates, moisture, unburnt lubricating oil, carbon element, unburnt fuel and metals and others substances[18]. In the diesel engine, PM emissions are six to ten times greater than petrol engines. There are main three types of Diesel particle emissions: soot, inorganic fraction (IF) and soluble organic fraction (SOF). SOF contains heavy hydrocarbons (HHC) which are adsorbed on the soot. At low exhaust temperatures with light engine loads, the values of SOF are too high. It is the combination of lubricating oil, unburned fuel and compounds which are produced during combustion [19-23].

2.3. Hydrocarbons (HC)

The formation of HC in diesel engines is caused by incomplete combustion and insufficient temperature which occur due to the lake supply of oxygen in the combustion chamber. HC formation is high near to cylinder wall is lower than the centre of the cylinder because the temperature of the air-fuel mixture is high in the centre of the cylinder [24]. Thousands of species contribute to making HCs most prominent of these are alkenes, alkanes and aromatics [25]. HC emissions occur normally at high load [26]. The environment is badly affected by HCs emissions. The formation of Ground-level ozone results [27, 28].

2.4. Carbon mono oxide (CO)

Carbon monoxide is an odourless and colourless gas. Incomplete combustion occurs due to incomplete oxidation which produces CO formation [29]. It occurs at the time of instantaneous acceleration and starting of the engine because of the rich mixture [26]. Human respiratory system inhales CO from the air and transmits it into the bloodstream. The presence of CO in the blood reduces the supply of oxygen in

the blood and the large concentration of CO in air leads to suffocation and death. The air having 0.3% volumetric concentration of CO can cause death within 30-minute of inhalation [30, 31].

3. Emission reduction in diesel engine

In today's world, ecological security has progressed. Several organizations and agencies in the world are trying to reduce greenhouse gases and toxic discharges for diesel engines. To lower the antagonistic impacts of diesel outflows on human health and environment, exhaust after-treatment technologies are considered as best. Here some after exhaust technologies are discussed in details.

3.1 Diesel oxidation catalyst (DOC)

DOC converts diesel exhaust emissions into harmless gases by means of catalytic oxidation. DOC is specifically designed for diesel powered engines. DOC reduces carbon monoxide and HCs and. Exhaust gases travel along the catalyst, they are oxidized thus DOC reduces exhaust emissions. The DOC oxidizes CO, HCs into CO2 and H2O. DOC replace mufflers on the engine and no extra modifications are required. DOC's are inexpensive, maintenance-free, and suitable for diesel engines [32].

3.2 Diesel particulate filter (DPF)

Thousands of tiny channels combine to make a ceramic filter (DPF). When exhaust passes through these channels, soot is trapped along the walls of the channel. The exhaust gases pass through the porous surface of the ceramic filter. The majority of the residue particles don't go through the ceramic filter and accumulate in it. This leads a develop heap of soot/ash in the channel builds the drop in pressure. To restore the original condition of DPF, filter has to be regenerated [32].

3.3 Selective catalytic reduction (SCR)

In SCR, urea a liquid-reluctant agent is injected through a catalyst into the exhaust fumes of a diesel engine. The urea starts the chemical reaction that produces NOx into N_2 and H_2O, which is then ejected through the engine exhaust pipe. The result of the SCR, NOx release in the form of Water and N_2 in the exhaust pipe. The chemical reactions of SCR technology are given below.

$$4NH_3 + 4NO + O_2 \rightarrow 4N_2 + 6H_2O \quad (1)$$

$$2NO + 2NO_2 + 4NH_3 \rightarrow 6H_2O + 4N_2 \quad (2)$$

$$8NH_3 + 6NO_2 \rightarrow 12H2O + 7N2 \quad (3)$$

3.4 Exhaust gas recirculation

NOx is also controlled by an effective technique known as EGR. The EGR system is utilized to diminish the NOx discharged. Approximately more than 15% of exhaust gases is recycled into the intake manifold of engine and combustion chamber. At low combustion temperature, low burning happens which indicates a decrease in NOx developments[33]. The mixing of intake air increase and exhaust gases increase specific heat of intake mixture which reduces the flame temperature. The reduction in the supply of oxygen at inlet manifold of engine generate low combustion that produces more CO and soot and reduces the formation of NOx and CO_2 [34].

4. Conclusions

This article surveys the qualities of primary toxin outflows (PM, HC, CO and NOx) and available after exhaust control techniques of these poison discharges in the diesel engine. Among these contamination outflows, CO and HC are discharged on account of poor burning and unburned fuel while NOx emanations are brought about due to high ignition temperatures above 1600°C. The PM emissions are due to the collection partially burned fuel, lube oil or sulphates, contents of ash and water. These toxin discharges adverse effect on the environment and human wellbeing. To control these poison discharges exhaust after-treatment technologies are considered best. Diesel fumes after treatment technologies include DPF, DOC, SCR and EGR. DOCs are utilized to lessen CO and HC outflows. DPFs are utilized with DOC to minimize outflows of PM from the exhaust of diesel engines. SCR systems are exceedingly powerful to decrease NOx outflows and NOx is also controlled by an effective technique known as EGR. With the after-treatment technologies, it is possible to lessen the harm of the poison outflows on air

contamination. These emission control technologies are most significance around the world.

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