"A Comparative Study of Particulate Matter Characterisation for Biodiesel, Stright Vegetable Oil and Gasoline fuelled Engine Exhaust"

By
Abhishek Kothari

This study was conducted in the Engine Research Laboratory, IIT Kanpur, to compare the engine exhaust particulate chemical composition and exhaust particle size and number distribution for different fuels at different engine operating conditions. The study is divided into three main sections: (i) Comparison of heated 100% straight vegetable (Karanja) oil (K100), 20% blend of straight vegetable (Karanja) oil (K20) and mineral diesel exhaust particulate chemical composition i.e. their metal concentrations, benzene soluble organic fraction (BSOF), and structure & morphology by SEM imaging, performed on a Kirloskar DM10 single cylinder agricultural engine. (ii) Comparison of 100% biodiesel (B100), 20% blend of biodiesel (B20) and mineral diesel exhaust particulate's chemical composition, and particle size - number distribution performed on Mahindra DI (MDI 3000) 4-cylinder transportation engine, and (iii) Study of particle size - number distribution of gasoline fuel performed on Maruti Zen, 4-cylinder passenger car engine.

For the first part of the study, Kirloskar DM10 engine was operated at 5 different load conditions and engine speed was kept as constant at 1500 rpm. As engine load increases, metal concentration usually decreased for all the fuels because amount of unburned fuel decreased. Metals which are not present in the fuel usually increased with increase in load. Heated K100 showed lower metal concentration for almost all metals, as vegetable oil has very low metals in its own composition. K20 shows maximum metal concentration among the three fuels used in the study. Higher viscosity of K20 caused bigger fuel droplets, poor spray characteristics which in turns resulted into poor combustion efficiency, higher partially or unburned hydrocarbons, mixing with lubricating oil, oil layer thinning in combustion chamber, burning of lubricating oil and wear and tear of engine due to lubricating oil burning. BSOF, an indicator of carcinogenicity, decreases as load increases because combustion efficiency improves for higher load conditions. Heated K100 showed maximum content of BSOF in its exhaust particulate, K20 comes below K100 and lowest values are generated by mineral diesel.

For the second part of the study, Mahindra DI (MDI 3000) engine was operated at different load and speed conditions. Engine was operated at (a) Constant engine speed with varying load and (b) Constant load with varying engine speed. Metal concentration for varying load conditions follows the same trend as for DM10 engine. For speed varying conditions metal concentrations hits its minimum value at 1700 rpm and beyond it, they keep on increasing. BSOF decreases as load increases and increases with increase in engine speed but hits its minimum at 1700 rpm. Particle number decreased as load increases but curve shifts towards bigger size particles. Particle number increases as speed increases and curve remains in the smaller size of particles. Engine operating conditions have great influence on particle size and number distribution. Among all the fuels used during the study, B100 showed highest particle concentration. Several studies done on biodiesel have explained the effect of biodiesel on the total particulate mass coming out in engine exhaust. Total particulate mass i.e. mass of the particulate matter collected on the filter paper, reduces by using biodiesel as fuel, even blends of biodiesel showed significant improvements in total particulate mass. In this study, B100 exhaust showed very high number of particle concentrations for all engine operating conditions which also gives a hint that lower particulate mass is not an assurance of lower particle number emissions as well as lower hazardous potential.

In the third part of the study, a gasoline engine (Maruti Zen) has been used to study the particle number and size distribution for gasoline as fuel. For gasoline fuel, particles emitted were comparable to mineral diesel particles in concentration. Gasoline fuel showed different trend than mineral diesel for particle emissions. As load increased, particle distribution trend shifts towards the right direction which is similar to mineral diesel and peak particle concentrations also increased with increase of load. With speed variation, gasoline fuel exhaust showed same trend as mineral diesel exhaust i.e. as speed increased particle concentration increased and peak particle concentration shifts towards the right direction.