Sandhya et al. 2016. *Int. J. Vehicle Structures & Systems*, 8(3), 183-186
ISSN: 0975-3060 (Print), 0975-3540 (Online)
doi: 10.4273/ijvss.8.3.12

International Journal of Vehicle Structures & Systems
Available online at www.maftree.org/eja

Performance Analysis of Diesel Particulate Matter Filter using Glass Fibers

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ABSTRACT:

To limit the adverse health effects to human beings due to the sub-micrometer particles emitted from the diesel engine exhaust, various after treatment devices have been developed. Number of researches have been done to improve the efficiency and to reduce the cost of the filters used to trap these diesel particulate matters. In this paper glass fiber filters have been used to trap the particulate matters. This attempt to use glass fiber as a filter is mainly to reduce the cost of the filter and to find a better alternative for trapping diesel particulates.

KEYWORDS:

Particulate matter; Wide open throttle; Smoke opacity; Total particle mass concentration; Light extinction coefficient

CITATION:

K.R. Sandhya, D. Rekha and P. Shanmughasundaram. 2016. Performance Analysis of Diesel Particulate Matter Filter using Glass Fibers, *Int. J. Vehicle Structures & Systems*, 8(3), 183-186. doi:10.4273/ijvss.8.3.12.

1. Introduction

The automobile density in the world is increasing day-by-day, so the emission standards have become more stringent than the past. The importance and usage of diesel engine also in turn made the emission limits more stringent. Emissions formed during burning of the heterogeneous diesel air/fuel mixture depend on the conditions during combustion, during the expansion stroke, and especially prior to the exhaust valve opening. The major emissions in diesel engine are unburnt hydrocarbons (HC), oxides of carbon, (CO and CO_2), oxides of nitrogen, (NO and NO_2), oxides of sulphur, (SO_2 and SO_3), particulates, soot and smoke. The particulate matter emission doesn't have any relation with oxides of Nitrogen and HC, but it has influence on these emissions during their control. Diesel particulate emission poses a great impact on human health. So control of diesel particulate emission is very important. Diesel particulates are the individual particles present in diesel exhaust gas.

Particulate matter (PM) represents compounds with high carbon content (e.g. aromatics) that have not completely burnt when the combustion chamber is exhausted. These combine with sulphur and water to form particulate matter (soot). PM is generated in diesels primarily during the diffusion flame. Maximum density of particulate emissions occurs when the engine is under load at wide open throttle (WOT). At this condition maximum fuel is injected to supply maximum power, resulting in a rich mixture and poor fuel economy. Soot particles are clusters of solid carbon spheres of diameter from 9nm to 90 nm. But most of them are within the range of 15-30nm. The spheres are solid carbon with HC and traces of other components absorbed on the surface. A single soot particle may contain up to 5000 carbon spheres. Diesel soot or Diesel Particulate Matter (DPM) is not entirely comprised of combustible carbon but also contains non-combustible ash resulting primarily from the additives used in crankcase lubrication oils, fuel or intake air additives, and from the fuel itself. The composition of DPM [6] is given by,

$$DPM = soot + SOF + IF \quad (1)$$

The term SOF (Soluble Organic Fraction) refers to the organic material that can be extracted using a Soxhlet apparatus. IF (Inorganic Fraction) contains volatile and semi-volatile compounds like sulphates and nitrates, ash and water. By convention, SOF is combined with sulphates and nitrates to a single component termed as Volatile Fraction (VF) which can be determined by heating particles in an inert atmosphere. The size of particles is directly linked to their potential for causing health problems. Small particles less than 10 μm in diameter pose the greatest problems, because they can get deep into human lungs, and some may even get into your bloodstream. Exposure to such particles can affect both human lungs and heart. Larger particles are of less concern, although they can irritate human eyes, nose and throat. Small particles of concern include "fine particles" (such as those found in smoke and haze), which are 2.5 micrometers in diameter or less, and "coarse particles" (such as those found in wind-blown dust), which have diameters between 2.5 and 10 μm.

The air that was breathed by human being contains numerous particles. The human body has protective measures against larger particles, but it cannot protect itself against particles roughly smaller than 10 μm, also known as PM-10. To reduce the health problems to humans due to particulate matter emission, the control of these particles becomes essential. Filters have been used to physically capture the particulate matter in the diesel exhaust and prevent their discharge from the exhaust pipe, while allowing exhaust gases to escape. These