HIGH PERFORMANCE NONWOVEN AIR FILTERS FOR AUTOMOTIVE ENGINE INTAKE AIR FILTRATION

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ABSTRACT

A sophisticated air intake system of automotive vehicles requires high quality air filters for greater engine life, improved vehicular performance, and decreased operational cost. In this research work, a variety of innovative nonwoven filter media were developed, characterized, and tested for commercial engine intake application. Hybrid nonwoven media with multimodal distributions of fiber size & fiber shape and composite nonwoven media with hierarchical arrangements of fiber geometries & fiber orientation were produced by employing a laboratory-based needle-punching nonwoven production line. Chemically-treated needle-punched nonwoven media were prepared by utilizing an in-house fabricated apparatus for spraying of a wide variety of viscous liquids. The particle filtration behavior of the said filter media was determined at the cleaned state as well as at the clogging state by employing a gravimetric test equipment and a fractional efficiency tester. Analytical modifications were suggested for prediction of overall filtration efficiency and pressure drop evolution in case multimodal nonwoven filter media. The composite nonwoven filter media comprising hierarchically arranged fibers of different sizes or shapes or with different levels of anisotropic orientation displayed excellent filtration performance. The liquid-treated filter media registered higher gravimetric as well as fractional filtration efficiency, slower rise of pressure drop, and higher dust holding capacity as compared to the untreated one. The liquid treatment registered a higher magnitude increase of fractional efficiency for smaller particles as compared to larger ones. An expression for determination of single fiber efficiency due to adhesion was proposed. A few selected nonwoven filter media developed in this work were first pleated and thereafter assembled in a commercial air intake system. The performance of the nonwoven air intake filters was assessed and compared with that of a commercial paper filter in accordance with the globally accepted ISO 5011 standard. As compared to the commercial paper filter, the nonwoven air filters developed in this work exhibited much higher dust holding capacity, much lesser initial pressure drop, and much slower rise of pressure drop due to dust accumulation, besides much higher service life, more savings of energy, lower greenhouse gas emission, and less fuel consumption.