Fully synthetic filter materials for engine air filtration

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Leadership in Filtration

MANN+HUMMEL

Authors
›› Thilo Müller is a materials and product developer in Air Filter Elements Development
›› Dr. Till Batt is a materials and product developer in Air Filter Elements Development
›› Dr. Michael Heim is Head of Air Filter Elements Development

Air filter elements with fleece media impress through their excellent volume-specific service life. Using them therefore offers great advantages over paper elements – particularly in relation to the further reduction in installation space. New options for material design and in manufacturing technology also hold out the prospect of a further positive development in filter performance.

The challenge of ever-decreasing installation space

Air intake systems are responsible for supplying combustion engines with clean air. The primary task of the air filter element is to clean the air taken in of dust and biological material. Decisive factors for the lifetime of filter elements include, on the one hand, the filter media used and, on the other, the available installation space. The more volume there is available, the greater the filter area that can be accommodated. The introduction of new safety- and function-relevant components in the engine compartment has lead however to intense competition for the available installation space. Given current technological trends such as hybridization and thermal engine encapsulation, we can assume that the situation in terms of installation space for engine air filtration will continue to become more challenging in the near future.

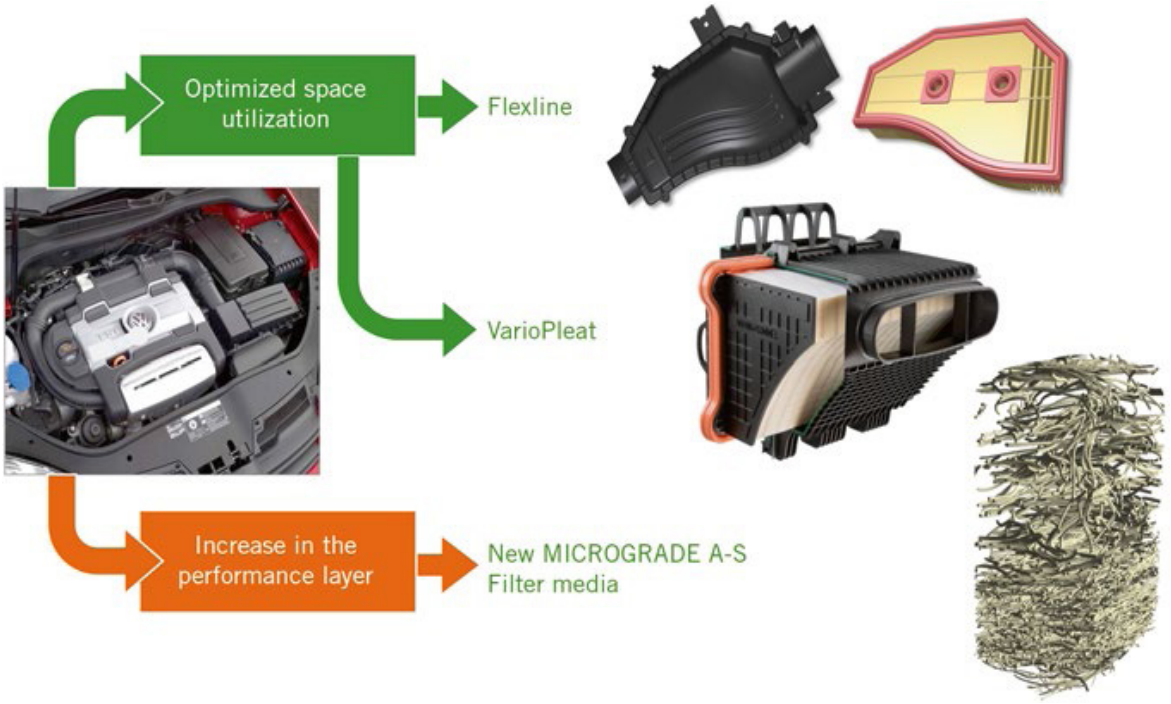

FIGURE 1: Strategic approaches to installation space optimization (© MANN+HUMMEL)

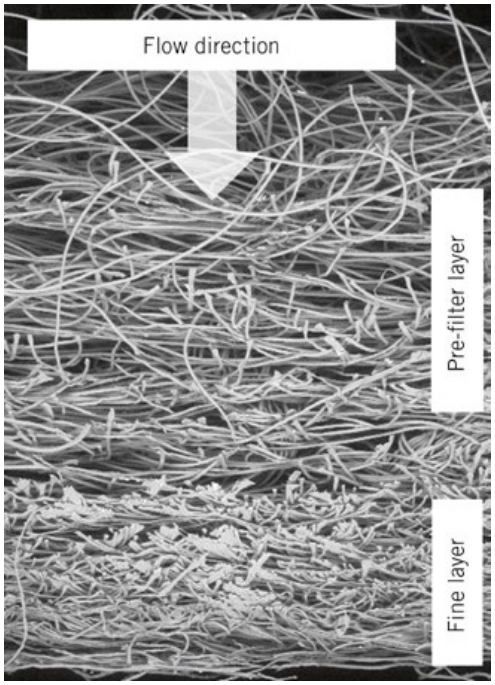

FIGURE 2: Structure of a fleece filter medium for air filtration (© MANN+HUMMEL)

To improve the utilization of installation space, two optimization concepts are being pursued at MANN+HUMMEL; these are shown in FIGURE 1. On the one hand, these include innovative component designs that make difficult to access areas of the engine compartment usable. To this end, filter housings and appropriate filter inserts with unconventional external shapes are being used. Parallel to these design concepts, new filter materials are being developed in a very targeted way, in order to increase the volume-specific component lifetime. The latest generation of synthetic filter media stands out thanks to its extremely high dust capacity and therefore represents a promising alternative to the cellulose-based filter media customary on the market.

Operating principle of fleece media

Fleece filter media for engine air filtration comprise synthetic fibers that are arranged in several layers, FIGURE 2. Normally, a compacted fine filter layer is combined with at least one openpore pre-filter layer. This is the reason for the high dust collection capacity of these media. While in conventional filter media, the removed dust is primarily collected on the surface and builds up there to form a difficult-to-permeate dust layer, in the fleece medium, it is distributed evenly on the fibers of the pre-filter layer [1]. Even when very heavily laden with dust, this is never completely clogged with dust particles. The air permeability of such depth filters therefore drops only very slowly, so large dust quantities can be accommodated in the medium [2].

In terms of the material design, fleece media have the advantage that all of their individual layers can be optimized individually. This relates, on the one hand, to the fiber composition. Fine, effectively filtrating fibers can be combined with coarse fibers that improve the mechanical properties of the material. On the other hand, using compaction technology, the layer thickness and the course of the packing density of the fibers can be very accurately set. This creates a great degree of freedom in terms of the development technology, which can be used to optimize the dust capacity in a targeted fashion.

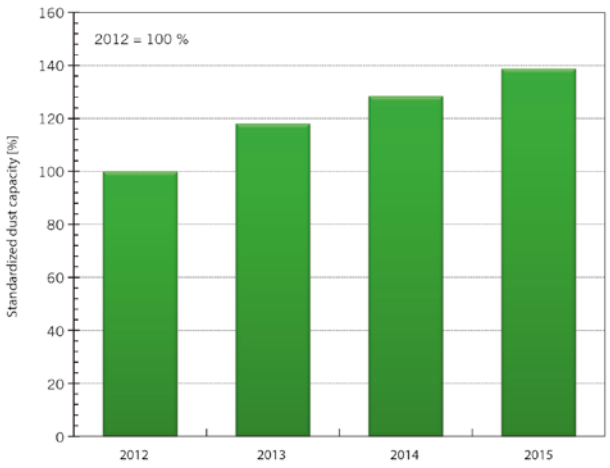

FIGURE 3: Development of volume-specific dust capacity of fleece media (© MANN+HUMMEL)

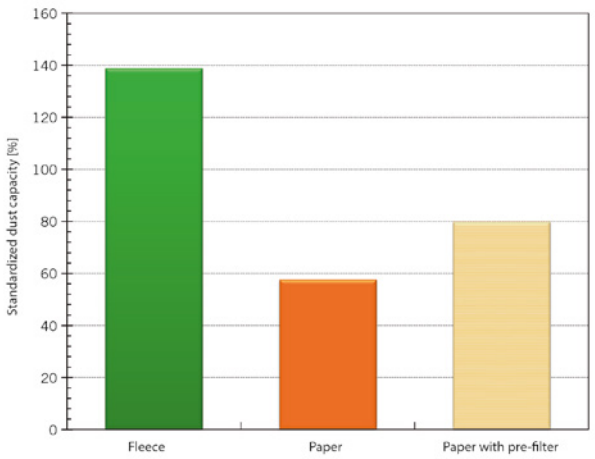

FIGURE 4: Comparison of dust capacity of fleece and paper air filters (© MANN+HUMMEL)

Fully synthetic engine air filter fleeces

The most appropriate fiber material for engine air filtration is polyester, because of its advantageous material properties. Through the high rigidity of the polyester fleece, folded filter bellows are particularly stable and barely warp in full-load operation. This rigidity is impaired neither by heavy water exposure of the filter element nor by high operating temperatures. In addition, the fleece materials are flame resistant. Another advantage: their suitability for plastic injection molding. As a result, variable element shapes can also be implemented in large-scale production. In individual cases, the use of fleece elements also improves the acoustic damping of undesired noise.

Development of performance of fleece media

At MANN+HUMMEL air filter elements have been fitted with fleece media since 1998. In this time, the performance of the materials has improved continuously. FIGURE 3 shows the development of volume-specific dust capacity over the last number of years. The visible trends can be transferred directly to the service life of the filter elements. The rapid increase in dust capacity in recent years is particularly striking; it is attributable to the introduction of a completely new generation of fleece media. The data is based on standard market dust tests in accordance with ISO 5011[3] using filter elements with identical designs under comparable flow conditions.

The same tests are also performed with conventional paper elements. FIGURE 4 illustrates a comparison between fleece and paper elements. In the same installation space, the fleece elements always offer clear service life advantages. However, a similar advantage in terms of the installation space cannot be automatically derived. A volume reduction always implies a reduction in the filter surface area. This increases the speed of the air flow through the filter medium. From a filtration technology perspective, an increase in speed is always accompanied by a decline in the efficiency of separation. Accordingly, the target specifications for the level of separation efficiency stipulate how much the volume of a filter element can be reduced by using a corresponding fleece material. Realistic values here are between 5 and 25 %.

Technical perspectives

The positive developments in the performance data of fleece elements in the recent past pose the question as to whether we can expect further significant increases in performance in the near future. These are predicated on further improvements in material design and their realization in production technology.

In recent years, MANN+HUMMEL has developed new simulation techniques [4], with which the material structure can be examined and improved in a targeted way. The starting point for the virtual optimization is to have imaging techniques with a very high resolution, which can be used to measure filter media three-dimensionally and to reconstruct them virtually. This permits the creation and fine tuning of the individual filter layers with respect to dust deposits, efficiency of particulate separation and flow resistance, FIGURE 5. Positive trends are also evident in relation to the ability to manufacture increasingly more complex material structures.

Improvements in plant engineering for manufacturing the fleece and laminating individual layers are responsible for this. In addition, increasingly finer fibers can be produced and processed, which fundamentally benefits the separation performance of filter media [5].

A thoroughly positive overall picture emerges then in terms of the future prospects of synthetic filter materials. It is therefore expected that the filter performance of such filter media will improve significantly again in the coming years.

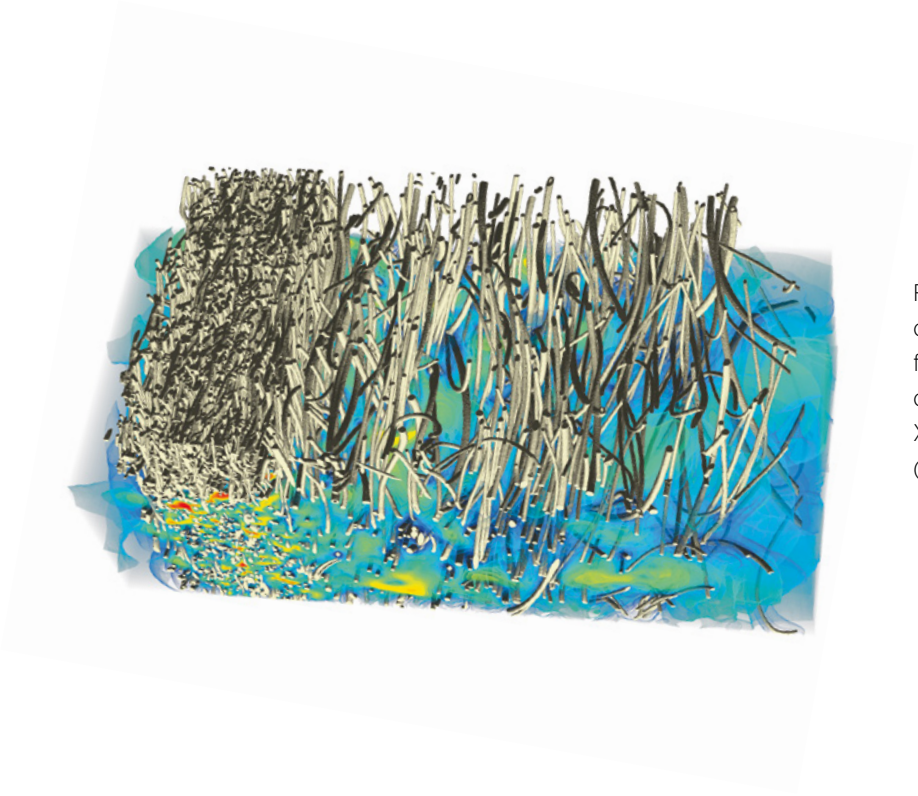

FIGURE 5: CFD simulation of the flow field through a fleece medium for material optimization, based on X-ray tomographs (© MANN+HUMMEL)

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