

Book Review: “Handbook of Nonwoven Filter Media”

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SUMMARY OF REVIEW

The *Handbook of Nonwoven Filter Media* is a new textbook and is one of the few books dealing with the subject of nonwoven filter media through the entire text. It is highly recommended as a prime reference for people in the nonwovens industry. This book culminates a productive career in the field and impressively lives up to the author's aim, as stated in the "Preface," "to provide the reader with a fundamental understanding of nonwoven filter media." Gas, liquid, and engine filtration are discussed in a way as to identify the types of filter media used in these applications. The theoretical presentation based on flow through porous media, which is rather useful as applied to liquid filtration, is developed around a nonwovens or engineered fabrics orientation. In addition, for aerosol filtration, the author has presented in detail "single fiber theory" developed for the filtration of particles from an air stream. Those properties that identify filter and separation media are reviewed. This includes electrostatic media (electrets), coalescing media, adsorptive media, and antimicrobial media. The author describes several mechanisms for imparting an electrostatic charge to a medium; such as electrostatically spun fibers, fibrillated electret film, triboelectric effects, and corona discharge. Four categories of raw materials are identified: polymers, fibers, binders, and additives. The discussion of raw materials is the most extensive chapter in the book. This work will prove to be an essential book for universities offering courses in filtration theory and practice and nonwovens technology, for industry and

academic researchers and for supervisors of technical and quality control personnel.

REVIEW

The *Handbook of Nonwoven Filter Media* is unique because it deals exclusively with the subject of nonwoven filter media. It provides basic information on how filter media is made, how it is tested and used. It should be highly useful as a prime reference for professionals in the global nonwovens industry. This includes raw material suppliers, nonwoven media manufacturers, filter manufacturers, and end users who use filters containing nonwoven filter media. Thus the text should prove to be a valuable resource for the filter technologists and research scientists, and in this professor's opinion can serve well as either a primary textbook or on the required reading list for undergraduate seniors and graduate study. "The book is technical in nature. It does not provide marketing or economic information on nonwoven filter media." The latter is left to the able consultants on filtration markets.

Although enough information is provided to make this book a primer on nonwovens in general, the scope and the focus are strictly on filter media. Membranes, which are outside of the major focus, are only minimally covered. The book is extensively illustrated with photographs, diagrams and tabulated data. The processes are described in detail and the raw materials are well documented. The properties and test methods discussed are those that relate to the filter application. Gas, liquid, and engine filtration are discussed in a way as to identify the types of filter media used in these applications. The author develops a theoretical presentation based on flow through porous media, which is rather useful as applied to liquid filtration. A classic Monte Carlo technique is presented to help understand the structure of nonwoven filter media and the pore size characteristics. In addition, for aerosol filtration, he has presented

in detail “single fiber theory” developed for the filtration of particles from an air stream, mostly based on that offered by Davies (*Air Filtration*, Academic Press, 1973). The last chapter (10) is a serious attempt to identify and list global standard organizations and standards that relate to nonwoven filter media.

The author sets the scope at the beginning of Chapter 1 by defining Filtration (and separation), nonwovens, and filter media. He acknowledges the desire to differentiate nonwovens from paper, and yet includes in his definition of nonwovens “any wet laid structure, including paper, whose specific purpose is to be a medium in a filtration and/or separation application.” The inclusion of paper filter media is justified by the intermingling of paper and nonwovens in filter media markets and the difficulty of presenting an adequate discussion of nonwoven filter media without including the paper forms.

The definition of filter media includes other separation functions in addition to the removal of solid particulate matter from a fluid stream. Included are adsorption, coalescence, electro-filtration, antimicrobial activity and others.

The author classifies nonwoven filter media by forming process. He identifies two major forming processes: both dry laid and wet laid. The dry laid processes are subcategorized into air laid, dry laid (carding processes), spunbond, melt-blown, and electrospun, all of which are described in detail in Chapter 5. Composite structures are treated as a separate category. Converting operations which include fiber bonding are treated as subcategories of the forming processes. For example, needle punch is treated as one of several bonding mechanisms for carded webs, which also include spunlace, thermobonding, stitch bonding, and chemical bonding.

The properties of nonwoven filter media are developed in accordance with their forming process and subsequent converting and/or finishing operations. Product data sheets of several media suppliers are used to illustrate the properties of the various fabrics. Those properties that identify the media used for separation are reviewed. These media include electrostatic media (electrets), coalescing media, adsorptive media, and antimicrobial media. The author describes several mechanisms for imparting an electrostatic charge to media; such

as electrostatically spun fibers, fibrillated electret film, corona discharge, and triboelectric effects.

Four categories of raw materials are identified: polymers, fibers, binders, and additives. Organic and inorganic fibers are described. The description of glass microfibers, the most prominent of the inorganic fibers, includes diagrams of its manufacturing processes, and property tabulations. The discussion of raw materials is the most extensive chapter in the book.

A number of photographs are used to illustrate the nature of bicomponent fibers. In addition to numerous displays of the properties of polymer and inorganic fibers, there is a data-packed review of natural fiber sources that includes wood pulp, cotton, and rayon. Vegetable fibers such as sisal, abaca, hemp, esparto, coir, and kenaf, and animal fibers such as wool and hog’s hair are also included. The author anticipates that because of the ongoing crises with petrochemical based fibers, there may be a return to more traditional, plant and animal fiber forms of nonwovens.

To provide a more in-depth understanding of the chemistry of fibers and binders, chemical formula structures are shown for most of the polymers in the reader may encounter in the filtration area. These include fibers such as polyester and nylon and binders such as phenolics and acrylates. The author is careful in his definitions: for example, polyacrylonitrile (PAN) fibers are defined as containing in excess of 85% by weight of acrylonitrile monomers. Thus the text is most useful as a reference for filter technologists and product developers, as well as a textbook for college students.

Binders are divided into solvent based and water based. Phenolics lead the discussion for solvent based resins while latex and emulsion resins are the features of the water based categories. Again there is considerable tabulated and illustrated data for the various binder systems.

Additives include flame retardants, adsorbents, water repellents, and antimicrobial agents. Functions of these additives are related to their application to filter media. The description of flame retardants includes summaries of flame retardant mechanisms.

The discussions of the various processes for producing nonwoven filter media generally follow the classification by forming process. The processes are abundantly diagrammed and illustrated. For example, the REICOFIL spunbond process is described with a series of photographs illustrating each phase of the process. The melt blown process is described in a similar fashion.

The major converting processes are well described. Processes included are the needlepunch process for converting carded and garneted webs, the pleating process for wet laid materials, and the various chemical bonding processes for dry laid and wet laid webs.

Through the first five chapters, the author gives the reader a concept of what nonwoven filter media is all about. He defines and then classifies them, provides a theoretical background to explain their functionality, reviews their properties, and then explains how they are made from their raw materials and by their processes. He recognizes that people working in one area of nonwovens may not be familiar with other disciplines of nonwovens. Although the material is technical and detailed, a layman's approach has been used in the explanations so that a technician familiar with nonwovens can understand how the "other guy" may do it. This reviewer has found the text particularly useful in recent technical discussions with industry visitors to The University of Tennessee Textiles and Nonwovens Development Center (TANDEC) who are interested in developing better diesel fuel filters and has utilized the book for strengthening his background on the theory and practice of filtration. The book should be excellent for self-tutoring for professionals already trained in nonwovens and could also be similarly helpful to beginning scientists and engineers.

The second half of the book deals with the testing, standards, and applications of nonwoven filter media. Chapter 6 on testing maintains its focus on the filter media relationship. Many of the test methods are well summarized with pictures and diagrams. The concept of porosity is well developed and several methods to measure this property are described. The author makes good use of the stress-strain curve to describe the various strength properties such as tensile strength, elongation, and tensile energy absorption (TEA). Several test methods to

measure filtration efficiency are described. The book squarely addresses water resistance and water repellency and explains the difference.

The applications of nonwoven filter media are divided into three major application areas: liquid, air, and engine. The author argues that the market for engine filtration is sufficient to justify a separate chapter (Chapter 9). This justification is supported by an illustration of an automobile showing 25 different filters within the automobile.

The structure and types of various liquid filters and how nonwoven media is used within these filters is a major topic in Chapter 7 on liquid filtration. Photographs and diagrams are used to illustrate how the various filters are constructed. Cartridge, bag, and roll filters are all described and detailed with numerous graphics. The testing of liquid filters is featured with a description of the multi-pass test stand. Included is a description of the standardized contaminants for this type of operation.

The book contains some historical discussions that provide for interesting reading. For example, Chapter 8 on air filtration includes a brief history of the development of high efficiency particulate air (HEPA) media. The topic of air filtration includes bag houses, American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) filters, and high efficiency air filtration. American and European standards are compared. Various types of clean rooms are diagrammed. Respirators are described by a detailed summary of 42CFR, Part 84. Also discussed are surgical face masks, vacuum cleaners, air purifiers, and air demisters.

Turbines are considered as engines and turbine air intake filters are included in the chapter on engine filtration. Other topics in this chapter include: cabin air, engine intake, fuel and lube oil filtration. The subject of fuel filtration includes fuel/filter separation techniques for pipeline fuels in fuel transportation systems.

Chapter 10 is a valiant effort to list and tabulate organizations and standards that relate to nonwoven filter media. By the author's own admission the listing is not complete, nevertheless, organizations and standards from North America, Great Britain, Europe, Australia, and Japan are listed and tabulated. In 2005, INDA Association of the Nonwoven Fabrics

Industry and the European Nonwovens and Disposables Association (EDANA) collaborated to issue a set of “Standard Test Methods for the Nonwovens Industry.” The table of contents for this manuscript is included in Chapter 10.

In addition to the ten chapters covering the broad and versatile range of nonwoven filter media, there is an extensive glossary, a listing of over 200 references, and nomenclature identifying the terms used in the numerous equations used throughout the book, which contains 473 pages, including the index.

It is evident that the author has a great deal of experience in the area of nonwoven filter media. It is also evident that he has conducted a great deal of literature research and consulted with a large number of people. If you were in any way involved in the development of the book, you might wish to check the Preface – your name may be listed. This will not be just another book on nonwovens technologies (although the number of books for such an important field is surprisingly small), but will prove to be an essential book for universities offering courses in filtration theory and practice and nonwovens technology, for industry and academic researchers and for supervisors of technical and quality control personnel.

The author, Erwin Marshall Hutten has been actively involved with fibers, paper and nonwovens for over 40 years, having worked for Monsanto, DuPont, Dexter, James River, and Institute of Paper and Technology before joining Hollingsworth and Vose in 1996 as Manager of Filtration Media Technology and was retained by H&V as a consultant after his retirement in 2001.

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