INTERNATIONAL NONWOVENS Journal

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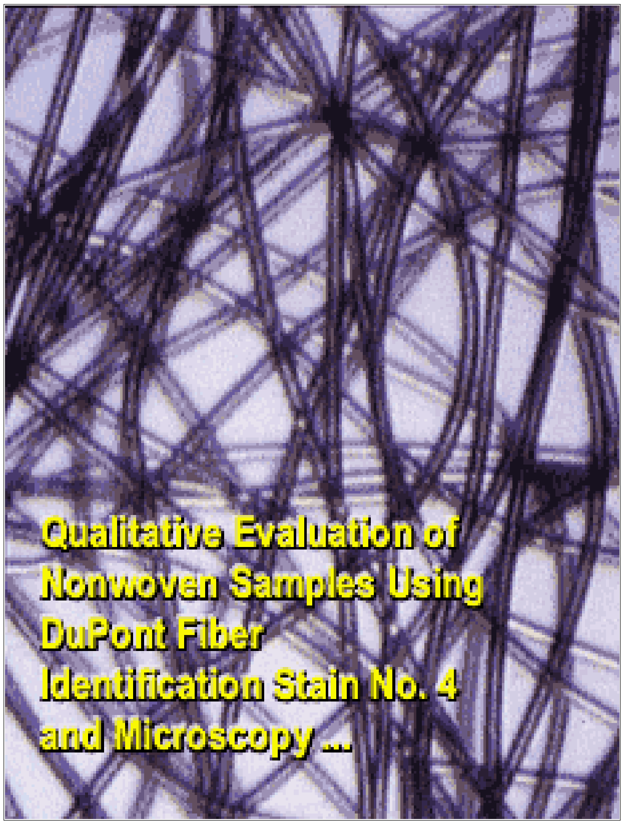

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INTERNATIONAL NONWOVENS Journal

GUEST EDITORIAL

An Invitation To An Historic Nonwovens Event

By Peter Wallace, Business Manager, Nonwoven Resins, Borden Chemical; INTC 2000 Conference Chairman

"Coming together is a beginning; Keeping together is progress; Working together is success." — Henry Ford

What better time than the dawn of a New Millennium for us in the nonwoven industry to work together for success? I'm referring to the International Nonwovens Technical Conference 2000 (INTC 2000), which will take place in Dallas, TX from September 26-28.

This marks a milestone for our industry — the first time that INDA and TAPPI are holding a joint nonwoven technical conference. These two organizations have long played valuable roles in the nonwovens industry, both in North America and globally - but independently. Each sponsored technical conferences, each taking advantage of its own unique approach to the world of nonwovens. INDA has accomplished this with INDA-TEC, while TAPPI has held an annual Nonwovens Conference.

These two quality technical symposiums have grown to overlap as technology has evolved. It makes sense, at the threshold of a new era for our industry, to combine both conferences into one major event - the INTC 2000.

INDA, Association of the Nonwoven Fabrics

Robert Shambaugh	Univ. of Oklahoma
Ed Thomas	BBA Nonwovens
Albin Turbak	Retired
Larry Wadsworth	Univ. of Tennessee
J. Robert Wagner	Consultant

Industry, is a trade association with corporate membership and a marketing approach with goals that support the nonwovens industry in global markets. It has a strong professional staff and a very deep and loyal base of corporate members and professionals who staff its committees and work to develop standards and foster the cause of the industry.

TAPPI (Technical Association of the Pulp & Paper Industry) is a professional association of individuals that has its roots in the pulp and paper industry, but long ago expanded to form its Nonwovens Division, which now has over 250 individual members from all fields of the nonwovens industry.

For more than a year, a joint task force has been working behind the scenes to find the strengths of each organization in order to capitalize on them and create the best comprehensive conference. The result is what we think is the best of each organization's approaches, contacts and abilities, combined to meet the needs of our industry.

You can't see the blood, sweat and tears that went into the planning of this event, but it was impressive and exciting to see how willingly people put aside individual or association interests for the common good. TAPPI and INDA staffs pulled together to handle the administration details and support the many volunteers. People from both camps reveled in the discovery of what can be achieved when we work together. It is truly a case of the sum being greater than its parts.

Attendees at this pioneering event will include mid- to upper-level management from R&D, sales and marketing, quality control, plant production, corporate division heads, academia, machinery and equipment manufacturers, suppliers of fibers, chemicals and finishes, roll good manufacturers, private, government, and academic research facilities, and end-users.

We would like to invite you to take part in this milestone event. With over 17 separate technical sessions, more than 60 speakers and with the added strength of networking between the two associations, we are sure this conference will set a pace for the Next Millennium.

—INJ

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THE DIRECTOR’S CORNER

Building Team Savvy
A popular concept of a scientist or engineer is that of a "loner" who works in isolation, with minimal contact with the rest of society. In reality, today's major contributor to science and technology is a member of a team, working in an environment where the contributions from several individuals make for real success and progress. Learning the skills of working within a group focused on a common goal is not a talent that comes at birth. It is a skill and ability that can be learned, however, and must be learned by a good team member.

One group in academia has recognized the importance of learning such skills and has taken some major steps to incorporate such know-how into an academic curriculum. As reported by Professor J. A. Kampmeier, of the University of Rochester, "The Workshop Project" for teaching such skills is one of the five national science foundation's Systemic Initiatives to educate students in the skills required for success in industry. Dr. Kampmeier has provided the following explanation:

Since 1995, the project, headquartered at City College of New York, has explored and developed a model of Peer-Led Team Learning (PLTL) to guide students to new understanding and accomplishment in chemistry courses. Recently, the project was awarded a National Dissemination Grant to extend the model to other science disciplines. The PLTL model is built on theoretical ideas about the way students learn and on practical experience that has shown that teams do work.

* Learning theory shows that the process of constructing individual understanding is facilitated by social interaction. Experience demonstrates that teams achieve remarkable levels of insight and accomplishment by sharing different ideas and perspectives in pursuit of a common goal.

* In the PLTL model, teams of students meet weekly to solve challenging problems that are directly related to mastering the subject matter. Each team has a leader, a peer who was successful in the course and is trained to build a team of students who work effectively to learn. In 1998-99, more than 50 faculty and 300 leaders at more than 30 colleges and universities guided weekly PLTL workshops for 2,500 students each semester.

The accumulated results from five years of experience are clear: Workshop students are more successful than traditional students in their chemistry courses. This increased success comes from the PLTL structure that requires them to "get team savvy." To learn more, check out The Workshop Project Team website at www.sci.ccny.cuny.edu/~chemwksp)

New Products Development
The paradigm of growing popularity within many companies is the necessity to shorten the product development path. This may mean the elimination of conventional test markets, as well as shortening the cycle of various stages.

For the research director, it generally means abbreviating the product development cycle and especially adopting strategies that facilitate new products development (NPD).

The Industrial Research Institute, a major professional association of research directors, recently formed a small study team to explore the role of research and development in the NPD process. The team set out to vilify the best NPD practices used by successful companies. They surveyed 383 U.S.-based companies to measure the effectiveness and efficiency of innovation processes. The survey used a graded scale to assess the degree to which best practices have been adopted.

While the most successful companies differed somewhat in their approach to putting NPD principles into practice, there appeared to five, guiding features:

- Clarity - Management went to great length to insure that there was sufficient clarity and understanding throughout the organization to achieve the goals. This clarity was present at project initiation, but continued throughout the life of the project. The entire NPD group knew what needed to be done, by whom, when and how.
- Ownership - Successful NPD activities were viewed as an enterprise-wide process rather than one that was owned by the research group, marketing group or any other group. Top management took pains to engage and integrate all people and resources within the organization that could contribute to successful commercialization of a new product.
- Leadership - NPD activities must be strongly promoted and championed by top management. Opportunities for frequent reporting to the top must be created and involve various levels of the NPD task force. The satisfaction of successful completion of NPD must be shared, and awards and recognition for NPD innovators were employed.
- Integration - The NPD effort was integrated into all functions of the organization that could make a contribution. In addition, integration of key processes such as market assessment, portfolio management, capital project management, product branding, ISO compliance or safety and hazard reviews were thoughtfully assured.
- Flexibility - The organization and operation of the NPD process must be flexible enough to adjust to needs and desires. As feedback was obtained from lead customers, appropriate adjustments and adaptations were made quickly and with full communication.

The authors of this study pointed out that NPD must be viewed as an corporate-wide process rather than being owned by any one function; they also pointed out that senior management must go beyond advocacy to full engagement as sponsors of active participants of NPD. Additional information can be obtained from the website of Research-Technology Management at http://www.iriinc.org.v0000007.htm.

Recycling's Dilemma
Recycling is a very old friend of the textile industry. As has been previously reported in this department, textiles have been recycled for decades. Some of this recycling was done within individual households, but a major portion involved collecting old rags in use in producing cotton-based paper products.

Within the past couple of decades, the concept of recycling has become very fashionable. It is a major element of environmental concern. Within the textile industry, the Council for Textile Recycling has taken on a major responsibility for this effort. The council is a non-profit (501-C-3 tax classification) educational foundation whose mission is to promote the importance of recycling textile materials and encourage the use of materials made from recycled textile materials. The council has carried out their work in two major areas:

- The council municipalities and recycling organizations to promote the recycling of both pre-and post-consumer waste materials. This includes household items as well as post-producer waste that would otherwise be landfilled.
- For recycling to be successful there has to a market for these materials. The council promotes the use of materials made from recycled textile products. Protecting and preserving our natural resources is an important message of the council.

The nonwovens industry must applaud and support these efforts and is actually playing a significant role in several areas and in a variety of market segments. Some of these market segments have been very successful and profitable. Several successful companies within the industry have built their organizations around the use of secondary fiber and recycled products.

Despite these successes, several segments of the recycling system are in trouble. Some of this results from unrealistic goals that were established or forced upon segments of industry. The paper and plastics industries are particularly noteworthy in this respect. Anticipating the growth and expansion in the use of recycled paper products, many smaller de-inking mills were established close to metropolitan areas.

The waste paper flow from these areas was frequently referred to as "urban forests" and characterized as a cheap and reliable source of raw material. Unfortunately, the market for such fiber furnish quickly outstripped the supply. Despite efforts by industry and the Federal Government to encourage, and in some cases, enforce the use of the recycled paper, the market imbalance has resulted in the closure of many of these operations.

In too many instances, components of the household waste stream that were dutifully sorted by the householder found their way into the landfill instead of a recycled application. The imbalance of supply and demand, coupled with the realities of economic values, has resulted in many problems in an otherwise laudable effort.

There is a growing recognition that there are natural and market limits in the recycling of many materials. The Scientific and Research Institute TNO (Zeist, The Netherlands) has studied the recycling of plastics packaging waste and has found that recycling more than 15% of this type of waste would be costly and have limited economic benefit for European countries. The European Commission is pressuring the Plastics Institute to increase the portion of plastics waste that is recycled to more than 15%. However, the study indicates that increasing plastic recycling wastes from 15 to 50% would increase costs by a factor of 3, while the environmental impact would remain broadly similar.

Although the study focused solely on plastics packaging waste, it has been indicated that the study's results could be indicative of the situation for other plastic waste streams as well.

As a result, the sponsoring organization for this study says most plastic waste should be burned to generate energy, instead of attempting to raise recycling to more than 15%. Also, the point is made that plastics recycling should focus on post-industrial waste rather than post-consumer waste in this case.

About 70% of European plastics wastes is landfilled, 15% is burned for energy recovery, 12% is recycled and 3% is recovered to produce chemical products. This study suggests that it would be more cost-effective and environmentally efficient to recycle 15% of plastics waste and recover 85% as energy.

While each waste material stream has its own situation, it is increasing apparent that recycling will work only as it makes sense.

For more information, contact the Council for Textile Recycling, 7910 Woodmont Avenue, Suite 1130, Bethesda, MD 20814; 301-718-0671; Fax 301-756-1079; or www.textilerecycle.org

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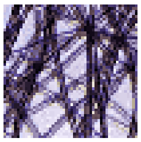

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EMERGING TECHNOLOGY WATCH

Protective Garments Under The Sun
Protective garments take many forms, as there are a great number of conditions from which protection is needed. In actual fact, a baby's diaper is a protective garment; it protects mother, dad and the environment.

The total U.S. industrial protective garment market for all types is very substantial, amounting to about $595 billion in 1999. The growth rate (slightly over 4% per year), which has been driven by government regulations the past several years, has slowed somewhat in the past three years, as regulations have not changed significantly.

A new type of protection is flirting with this market; this is the protection afforded by wearing apparel against the influence of sunlight. While the tremendous number of sunbathers doesn't seem to reflect it, there is a growing concern with excessive sunlight exposure, leading to the initiation and proliferation of human skin cancer as well as some other problems. The expanding use of protective lotions with their specific sunlight protection factor (SPF) is a reflection of this concern.

Contrary to this concept, there is a school of thought that says the peeling of skin from a sunburn is beneficial, as it gives a renewed layer of skin and disposes of the older layer. There is a considerable use of 9-fluorouracil to accomplish this condition chemically.

Despite the contradictory views, there is considerable activity with textiles to provide increased sunlight protection.

Common sense would seem to indicate that textiles in general will give some shielding from damaging sunlight, and the more dense the fabric the better protection. Increasing fabric weight and thickness is counter to the prevailing desire in clothing, however, especially in athletic clothing. Thus, the growing technology in the sunlight protective action of apparel.

Research indicates there is a difference in the various dyestuffs used to color fabrics. Simple black is not necessarily the best protection. In fact, some of dyestuff concerns are conducting extensive research into the value of various materials; some companies are beginning to offer products specifically selected for their protection potential.

One company, Ciba Specialty Chemicals, is seeking recognition from the Skin Cancer Foundation (New York) for its ultraviolet protection products in such protective clothing. Athletic uniforms containing such UV protection are expected to receive considerable attention at the forthcoming 2000 Summer Olympics in Sydney, Australia, as the Australian ozone depletion problem has made sunlight protective garments of interest there. Also, apparel manufacturers in Israel are focusing on this feature to promote some garments specifically designed with this property.

Because of the twisted and condensed nature of fibers within a yarn element in woven and knitted garments, the covering power of nonwovens may be of interest in this niche market. With the use of individualized fibers in a nonwoven structure, the same number or weight of equal fibers in a nonwoven can provide much greater covering power or shielding compared to twisted, highly condensed yarn structures. This may be an application of considerable potential for nonwovens with the right innovation and exploitation.

Digital Printing Use Expanding

The use of computers, laser printers and desktop publishing is widespread, well understood and fully developed. The application of this technology to the printing of fibrous substrates, however, is not advanced; recent developments indicate that textile digital printing is now coming into its own, with some substantial advancements that might have utility within the nonwovens industry.

One of the best known, early commercial applications of digital printing to textile substrates was the use on full-width carpet fabrics. With flexible computer control, this provided a means of going full width with wide flexibility on print patterns. The European printing industry has been particularly aggressive in applying the technology in the past few years. A survey of two years ago indicated that one-third of Europe's textile screen printers viewed digital printing as a threat, rather than as an opportunity. At the present time, however, 97% of these firms reportedly see the technology as a possible route to improve sales and profits.

A great deal of further development work is required to fully exploit the technology on textiles. This is a result of the fact that textile webs are quite wide and digital print heads are comparatively slow. Also, most of the print head developments are targeted at paper printing.

As a result, digital printing of textiles is still quite limited. Mark Hanley, of I.T. Strategies, Hannover, MA, recently listed the main textile end uses of digital printing:

- Proofing and sampling.
- Personalization
- Customization
- Short-run and rapid-response manufacturing

Some of the machinery manufacturers that are normally associated with textile printing are included among the companies that are pursuing these developments; other companies in this list include those that are recognized because of their previous involvement with computer inkjet printing. These companies include the following:

- Hewlett Packard
- Canon
- Lexmark
- Epson
- Xaar
- MIT
- Brother
- Data Products
- TriDent
- Spectra
- UT
- Seiren
- Stork
- Zimmer
- Encad
- Mimaki
- Konika
- Lectra Systèmes

The ability to use the computer and thereby produce a very quick and inexpensive sample of a new print pattern is one of the strengths of this methodology. Also, the ability to customize and personalize print

Substitution of existing production printing methods

According to Hanley, digital printing can be accomplished by several available technologies, as follows:

Thermal Drop on Demand (DoD inkjet)
Piezoelectric DoD inkjet
Airbrush/valve jet
Continuous inkjet
Electrostatic; sublimation and resin
Electrophotography; laser and LED
Thermal transfer
Photographic development

patterns by preparation via the computer is a powerful factor. Reduced environmental problems is another plus for the technology. However, further development is required for a full palette of suitable inks and finishing techniques.

Current usage of digital printing, as indicated, is much more extensive at the present time on paper substrates. Growth markets in this segment include banners, promotional building wraps, murals, flags and exhibition graphics. Wide bed printers are increasing in use to serve these markets. It is interesting to note in this regard that Kimberly-Clark recently established a subsidiary to do this type of work (Kimberly-Clark Printing Technology, Inc.; Roswell, GA). This organization is apparently using its Kimdura durable paper substrate extensively; they apparently have also used some of their nonwoven fabric substrates for this technology.

Additional insight into this development can be obtained from the Computer Integrated Textile Design Association (CITDA; www.citda.org).

Combination Spunbond/Spunlace Process

Suggestions for innovative nonwoven processes come and go. However, when a major producer adopts a new system and promotes it as a novel and flexible process, it is pretty certain that the technology at least is sound. Thus, the introduction of the EVOLON nonwoven process by Freudenberg deserves attention as a major blip on the technology horizon.

Freudenberg, the world's largest nonwovens producer, has been working on this system for over five years under the project name, "OMEGA." The first significant technical description of the process was released at the recent EDANA Nonwovens Symposium in Prague in June.

This presentation contrasted the dryform staple process with the continuous filament spunbond process, highlighting those properties of spunbond fabrics that are normally deficient compared to staple processes. The description then proceeded to indicate how the new EVOLON process enables the spunbond system to essentially match or exceed the properties of the staple fiber process.

Fiber fineness and fiber crimp of the staple process were indicated to be strong points for this system, along with the accompanying fabric softness, drape, loftiness and resilience. With respect to these fabric properties, as well as other textile qualities, the new process was stated to give an equivalence, while maintaining the strength, integrity and isotropy characteristics of the spunbond process.

The filaments of the new process are continuous and micro-fine, with a denier range of about 0.09 to 0.13 dtex. These filaments have an elongated triangular cross-section, because they are formed from conjugate fibers of "orange" or "pie" cross-section prior to splitting. In the Freudenberg process, the original continuous filament is hollow, so that all of the individual micro-filaments are of the same configuration and no large central "spoke" filament remains. The original hollow filament also is superior for the hydraulic splitting which follows. The filament configuration employed by Freudenberg generates 16 micro-filaments from the original composite filament.

The adjacent pie-shaped micro-filaments are composed of different, incompatible polymeric materials, giving an intimate mixture of filaments of the two polymer types in the final fabric. Polymer combinations that Freudenberg found suitable for their process include polyester/polyamide (6 or 66), different polyesters (PET and PBT), polyesters with polyolefins and polyamides with polyolefins.

The weight ratios of the polymers can vary from 20/80 to 80/20. According to Freudenberg personnel, the most commonly used combination is 65%PET/35% PA-66. The lower raw material costs for PET compared to polyamide might be the driving force for this combination.

The process sequence is to extrude the two polymers through two different extruder systems into the composite spin-pack and die combination. Filament quenching and stretching follow. These filaments are then laid down on a continuous forming belt to form the isotropic nonwoven web.

In order to provide a high degree of splitting (97%) many parameters were studied as to their impact, and adapted to each other. These parameters included spinnerette hole size, quenching conditions, rate of stretching and others. Also, the water pressure for the waterjet stage had to be increased to 400 bar. Following splitting and entangling, the web is dried by a through-air drying system and then batched.

The initial applications of this fabric family has been directed to exploit the outstanding fabric drape, wearing comfort and mechanical strength. The prime focus has been in hygiene and medical applications. Initial applications include: backing substrate (80 gsm) for medical plasters and wound dressings; extensible backing (35 gsm) for medical plasters and wound dressings (necked-stretch); and extremely lightweight, apertured hygiene topsheet. The lightweight topsheet (15-17 gsm) is split, entangled and apertured, all in the final waterjet stage.

Other potential applications are being investigated by means of pilot plant production; this includes OR surgical gowns and drapes. A full-scale production line will be put on-stream during September 2000.

Freudenberg personnel expressed confidence that this combination process will be an important element in future nonwoven technology and business.

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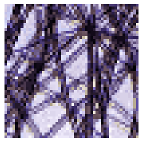
EDANA Technical Symposium Held in Prague

The European nonwovens industry, along with representatives from other continents, assembled at the Diplomat Hotel in historic, picturesque Prague for the EDANA Technical Symposium June 6-7. The approximately 400 executive-level delegates were treated to high-quality presentations in Nonwoven Markets, Nonwovens Developments, Hygiene and Raw Materials. Networking and opportunities for informal discussions also served to bring all attendees together.

The Czech nonwovens industry was highlighted via a display located in the Hotel Diplomat. Significant participation of Eastern European delegates was supported by reduced symposium registration fees. Presentations included:

- **Nonwoven Markets - Moderator: Luc Maes, Libeltex NV (Belgium)**
  - E-Business: successful strategies, Jean-Claude Stessels, J.C.S. Associates S.A. (Belgium)
  - A survey of the nonwovens industry worldwide, Nicolas Meeus, Arthur D. Little AG (Switzerland)
  - From stabilization to growth: post socialist-type economies in transition, Dipl.-Ing. Sabine Martini-Werner, S. Martini Consulting (Germany)
  - An assessment of the conformity of regulations valid in the Czech Republic and the EU, Dr. Pavel Malcik, The Textile Testing Institute, Brno (Czech Republic)
- **Nonwovens Developments - Moderator: Robert Dunn, Don & Low Ltd Nonwovens (Scotland)**
  - Nonwoven sorbents for collection and removal of oil spillages from the environment, Natalie Ecenkova, Nonwovens Research Institute (Russia)
  - Innovative products from stitchbonded hydroentangled nonwoven composites for technical applications, Dipl.-Ing. Elke Schmalz, Sachsisches Textilforschungsinstitut e. V. (Germany)
  - Nonwovens - the carrier of "added value," Jan Marek, inoTEX s.r.o. (Czech Republic)
  - Smart textiles: state-of-the-art and future developments, Dr. Bruno Chevet, Institut Textile de France (France)
- **Hygiene - Moderator: Ingemar Bengtson, Trioplanex AB (Sweden)**
  - New hydrophilic spunmelt composite with tailor-made liquid flow and controlled pore size, Jorgen Bech Madsen, Fibertex A/S (Denmark)
  - The baby diaper of Y2K - the challenge for the nonwovens industry continues, Frantisek Klaska, Pegas a.s. (Czech Republic)
  - Ultrafine microfiber spunlaid nonwoven for hygiene and medical applications, Dr. Dieter Groitzsch, The Freudenberg Nonwovens Group (Germany)
  - Finally, a pragmatic way to approve batches of absorbent products through performance, Franck Courtray, Courtray Consulting - Labservice (France)
- **Raw Materials - Moderator: Jean-Michel Anspach, Anspach Nonwovens Development (Belgium)**
  - New developments in biodegradable nonwovens, Calvin Woodings, Calvin Woodings Consulting Ltd. (UK)

- Antibacterial protection of nonwovens, John Payne, Avecia Biocides (UK)
- Stretch the imagination, Isabella Ford, National Starch & Chemical (UK)
- Multifunctional fibres for air laid and dry laid applications, Niels K. Christensen, Fibervisions a/s, Denmark



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RESEARCHER'S TOOLBOX

Easy Polymer Identification

Previously in this Department, equipment for the fast and easy identification of polymers has been described. This has generally been associated with the quick ID of recycled plastics, as an aid to the recovery and sorting of mixed plastics and similar situations.

It is well established that "mixed plastics are suitable for landfill and little else." Many attempts have been made to develop processing conditions and potential markets for mixed plastics, but the rheological and other properties of the complex and varying mixtures encountered in unsorted plastic wastes are such that realistic use or sale are completely thwarted.

Even by carefully controlling the nature of a waste plastic stream to one chemical type, it can still be a difficult task to select proper processing conditions and potential applications to make such a venture successful. Thus, a polyethylene waste stream can involve materials of different densities, melt indexes, additives, and other properties to make the recycling task difficult. A similar need for identification of nonwoven wastes can also be a problem.

Thus, a simple and fast technique to correctly identify waste polymers can be an important element of a successful recycling system.

The "Rapid Identification System for Plastics Recycling" is a technique that has been developed in Japan by researchers at Toyota Central R&D Labs Inc (Aichi-gun, Japan). Their special interest, of course, is in identifying the various plastic wastes arising from efforts to recycle automotive materials. This is an especially pressing needs for recycling interests. Their system uses pyrolysis infrared spectroscopy to identify all kinds of plastics, even samples with dark colors, surface degradation and stains.

In this system, an operator uses a hand-held probe weighing about one pound. A small area of the sample is pyrolyzed, the vapors are passed through a flexible and heatable gas guide to a Fourier transform infrared (FTIR) detector and a computer. The pyrolysis products in the gas cell allow for quite extensive analysis and identification of the plastic.

A device developed by a group of Purdue University researchers and manufactured by SpectraCode Inc. (Purdue Industrial Research Park, West Lafayette, IN) provides a similar capability. This unit, called the "RP-1 Polymer Identification System," uses a hand-held photo-element which is focused on the surface of the polymer. The reflected spectra is then analyzed by an adjacent desktop unit.

This system won the Purdue scientists an award as one of the 25 Technologies of the Year selected by *Industry Week* magazine (www.industryweek.com).

Another unit designed for the identification of waste plastics has more recently been adopted by several Japanese companies as a resin quality control tool. This is the "PlaScan-SH" system, which was developed by Infrared Fiber Systems Inc. (Silver Springs, MD), Opto-Research Inc. and the American Plastics Council of Washington, D.C. and MBA Polymers (Richmond, CA).

This unit scans the near-infrared spectrum of the waste sample using an acousto-optic tunable filter (AOTF) patented by IFS. This AOTF unit is claimed to distinguish in real time between the chemical signatures of over 30 types of plastics with a reported 100% success rate. Also, using add-on software, the system can also reportedly characterize the major additive types present in the plastic material (off-line analysis). Polymers that can be handled by this system include styrenics, polyolefins, polyesters, polyamides, acrylics, polycarbonate, polyurethanes and blends.

Interlaboratory Test Variability

While interlaboratory tests, intralaboratory testing and the variability associated with such procedures have been of interest for a considerable time, the major role played by government agencies and international authorities, such as ISO, have made this entire subject of increasing importance.

For instance, the new ISO Guide 17025, "General Requirements for the Competence of Testing and Calibration Laboratories," will request that uncertainty data be given with any analytical result. In this context, high-quality test data are a real need.

Although not always acknowledged, interlaboratory test variability is well recognized. It is often hoped that standardized testing methods will completely eliminate such variability, and this is a driving force for much standardization work of many associations and societies.

It has been pointed out that the individual constant biases of laboratories operating in their own environment are transformed into random error in the interlaboratory arena (Chapter by Lloyd Currie of the National Institute of Standards & Technology, in Kolthoff and Elving "Treatise on Analytical Chemistry," 2nd Edition, Volume 1, John Wiley & Sons, NY; 1978).

Studies have been made of large volumes of laboratory test data (over 10,000 sets); this has allowed the condensation into a very simple expression relating to the interlaboratory standard deviation of a set of analytical chemical results. It is likely that a similar situation exists for physical measurements. In some areas, the precision of many analytical results have not improved much over the years despite the introduction of modern instrumentation.

All of this suggests that a careful and competent watch must be maintained over the testing activity as to precision and accuracy, and especially as to the interpretation of such results

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WORLDWIDE ABSTRACTS AND REVIEWS

A sampling of Nonwovens Abstracts from Pira International —
A unique intelligence service for the nonwovens industry

Role of nonwovens in household goods; development of floor wiper
Wooden flooring is very popular in Japanese houses due to easy cleaning and low mite infestation. However, vacuum cleaners raise dust and oil mops cannot collect flocking dust, so a new wiper has been designed. According to research, tangled fibres catch house dust very effectively and spunlace nonwovens are ideal because of their loose structural fibres. By controlling process conditions, optimum entanglement was obtained, and a net composite spunlace nonwoven sheet was developed to gain required strength for use. Since Kao Corporation launched the "Quickle Wiper" using the sheet in 1994, the Japanese floor wiper market has grown enormously. To promote nonwovens applications in household goods, emphasis must be put on critical quality control as with fibre entanglement for floor wipers. (6 fig, 1 tab, 2 ref)

> *Author: Shizuno S*
> *Source: Jpn Nonwovens Rep.*
> *Issue: no. 309, 10 Oct. 1999, pp 1-5 (In Japanese)*

Fascination and difficulties in the household goods market
Ozu Corporation is a Japanese trading company and converter of industrial goods in paper and nonwovens. They have already gained a consistent share in industrial wipe and medical gauze markets by utilizing Asahi Chemical Industry's wet spunbond cotton nonwoven, Benlize. The excellent performance of these products reflects Ozu's product development in the household goods field, such as make-up cleansing sheets, thin wet tissues and face masks. Household goods have low profit margin due to high logistics costs. They are also vulnerable to changes in fashion and distribution systems. Despite such difficulties and hard competition, more and

These pages feature an extract from *Nonwovens Abstracts*, compiled by Pira International from international business journals, newspapers, market research reports and conference proceedings, keeping you up-to-date on the latest business and technical developments in the nonwovens industry.

Nonwovens Abstracts provides international coverage on all aspects of nonwovens production: fibers, raw materials, web formation, bonding and converting. Information is also provided on all of the different nonwovens products from composites to cleaning materials, medical disposables and more new suppliers enter the market and consider the field very fascinating because products can obtain public recognition and act as company advertising. (1 fig)

Author: Anon
Source: Jpn Nonwovens Rep.
Issue: no. 309, 10 Oct. 1999, p. 6 (In Japanese)

Product development caring for the global environment and humans
Nisshinbo Industries Inc, Japan, has developed Cotton Sheet from 100% cotton nonwovens. The sheet eliminates discomfort or soreness to the skin, which occurs when paper tissues are used frequently to remove make-up, blow the nose or clean a baby's bottom. Cotton Sheet is very strong, even when impregnated with cosmetic lotions or when used to wipe off excess grease, and having lint-free surface, the sheet is also suitable for use in cosmetic application. Nisshinbo is expanding their cotton product range and two types of Cotton Sponge, for body washing and kitchen use, have been made. Cotton Sponge feels soft, and its high heat resistance allows boiling sterilization, thus sponge hygiene can be maintained. (2 fig)

Author: Anon
Source: Jpn Nonwovens Rep.
Issue: no. 309, 10 Oct. 1999, p. 13 (In Japanese)

Activated carbon fibre explores air filters of next generation
Activated carbon is essential to improve the air and water environment. Besides powder and granular types, activated carbon fibre has been highlighted due to high absorption speed and processability. Osaka Gas Chemical KK (OGC), Japan, started full-scale production of carbon fibre and activated carbon fibre in 1991 by using coal pitch from coal tar. Actual manufacturing is done by associated companies (DONAC and AD'ALL) and OGC carries out surface treatment and transforms finished products, such as purifier filters, masks, air filters, diatomaceous earth walling material, moulded insulation material and electromagnetic shielding material. Activated carbon filter is known to be effective in dioxin removal. In 1999 OGC announced their newly-developed catalyst technology would decompose and eliminate 99% of dioxins. (5 fig, 3 tab)

Author: Anon
Source: Jpn Nonwovens Rep.
Issue: no. 310, 10 Nov. 1999, pp 14-16 (In Japanese)

industrial materials and the companies and markets involved.

A monthly journal is available and readers can also access the information from the Paper, Printing and Packaging Database on CD-ROM, updated quarterly. The information is available online at www.pira.co.uk. The web and other online databases are updated weekly. Pira can provide full text copies of documents cited in the Pira Database and the associated abstract's journals. The full text will normally be in the language of publication.

For a sample journal, a free trial of the web database or more information, please contact the Information Centre, Pira International, Randalls Road, Leatherhead, Surrey, KT22 7RU, U.K. Fax 00 44 (0)1372 802239 or e-mail to infocentre@pira.co.uk.

For this particular selection, non-English language publications were reviewed in an effort to provide coverage of relatively less accessible sources to a large portion of the *INJ* audience.

Semia V (VOC-absorbent sheet)
Due to modern building methods and constant use of air conditioners, recent Japanese houses have become air-tight and insulated. The use of new building materials, paints and adhesives is also increasing. Volatile organic compounds (VOC) generated from them in a closed indoor atmosphere can cause Sick Building Syndrome. Semia V from Asahi Chemical Industry Co. Ltd is excellent for eliminating VOC, in particular formaldehyde, but also toluene, xylene, hydrogen sulphide, acetic acid, ammonium or amine compounds. It also absorbs unwanted smells from rotten foods, tobacco smoke and pets. The sheet is made of activated carbon and spunbond nonwovens treated with a VOC absorption agent. Sheet form allows versatile applications including wallpaper, building materials, furniture and air purifier filters. (6 fig, 4 tab)

Author: Kato K
Source: Jpn Nonwovens Rep.
Issue: no. 310, 10 Nov. 1999, pp 10-13 (In Japanese)

Dioxin elimination system under tight control
New guidelines for prevention of dioxin generation were established in Japan in 1997, including the use of high-efficiency dust-collecting equipment and specifications of temperatures and dust concentration for exhaust gas treatment. The spraying of activated carbon will be introduced to improve efficiency. New treatment of heating flying ashes with air and nitrogen gas is thought promising. The catalyst-added bag filter is used to reduce concentrations of dioxin and nitrogen oxides simultaneously. Recently use of super-critical water is highlighted due to short decomposition time, low equipment costs and no secondary contamination by excreta. For bag filters, selection of fibres and filter structure are keys to determine heat resistance and electrical properties required for removal of dioxin and other hazardous substances. (3 fig, 4 ref)

Author: Takaoka Y
Source: Jpn Nonwovens Rep.
Issue: no. 309, 10 Oct. 1999, pp 27-33 (In Japanese)

Current situation and prospects of air filters (Part 1)
Use of nonwovens in the filtration field reached 50,000t in Japan in 1997, which is 18% of the total nonwovens demand. In air conditioner filters the need for added functions is rising, and various types of functional filters such as anti-virus catching filters have appeared. However, highly functional and efficient filters will not perform correctly without adequate maintenance, so maintenance costs and easy handling must be highlighted in product development. Modernization of hospitals and food factories stimulates filter use to prevent in-house infection, and comply to HACCP (Hazard Analysis and Critical Control Point system). Clean Rooms create an enormous market for various grades, from coarse-dust type to HEPA and ULPA filters. Halogen-free filtration materials must be developed to avoid dioxin during incineration. (8 fig, 1 tab)

Author: Ikkanzaka I
Source: Jpn Nonwovens Rep.
Issue: no. 310, 10 Nov. 1999, pp 20-28 (In Japanese)

Advanced technology of plasma and its applications to fibre fields

Neon signs and fluorescent lamps are examples of plasma in everyday life. Two physical conditions, quasi-neutrality and multiple systems, define the plasma state. Plasma processing is a highly advanced applied technology, and the following three areas are highlighted: surface treatment, processing in equilibrium conditions and creation of new substances. Typical surface treatment is found in chemical vapor deposition and sputtering in semi-conductor chip manufacturing or ion-plating with titanium. Use of plasma for fibres or nonwovens can make value-added products. Adhesiveness of plastic film in nonwoven composite products, or dye-affinity, coloring and hydrophilic property of synthetic fibres can be improved. Thin metal-coating gives a unique texture as well as anti-static finish. (5 fig, 3 ref)

Author: Takaoka Y
Source: Jpn Nonwovens Rep.
Issue: no. 310, 10 Nov. 1999, pp 39-45 (In Japanese)

Strong and impact-resistant: the impact modification of natural fibre mat-reinforced thermoplastics

An overview is presented of the impact strength of natural fibre mat reinforced thermoplastics and the way in which it can be improved. The current status of the impact strength of flax fibre mat reinforced polypropylene and biodegradable matrices is illustrated and data for glass mat reinforced polypropylene are given for comparison. The potential for increasing impact strength, which is largely influenced by the mechanical properties of the three components in the composite (fibre, matrix, interface), is explored. Geometry and orientation parameters also influence the fibre. Impact modification through the addition of fibres is investigated. Results indicate that the addition of cellulosic fibres with high strength and elongation can significantly increase the impact strength of natural fibre mat reinforced thermoplastics. Tensile and flexural properties are maintained, as is the natural basis of the reinforcing components. (5 fig, 1 tab)

Author: Mieck K P; Reubmann T
Source: Kunstst. Plast Eur.
Issue: vol. 89, no. 12, Dec. 1999, pp 37-39

Polyamide combines with polyester to produce fibre

Development by Kuraray of a fibre made from PA9T, a new heat resistant polyamide resin, is documented. The fibre, designed for industrial applications, is made by spinning polyester and PA9T to create a heat resistant strong fibre with low moisture absorption. It can be used as a direct replacement for high tenacity polyester. A 1000tpy plant has gone in to operation at the company's Saijo factory with the aim of marketing the product by 2005. (Short article)

Author: Anon
Source: New Mater. Jpn
Issue: Feb. 2000, p. 4

Antibacterial viscose rayon

Daiwabo Rayon Co of Japan has developed a viscose rayon staple fibre containing milk. It is available with the addition of milk as a whole or with added milk protein only. Both varieties have antibacterial properties and it is expected they will be used in nursing, baby products and domestic materials. (Short article)

Author: Anon
Source: New Mater. Jpn
Issue: Mar. 2000, p. 6

Recyclable polyester nonwovens for the automobile industry
Holger Erth of the Saxon Textile Research Institute reported that around 75% of materials are recovered from Germany's 1.3-1.5m scrapped vehicles annually with the remaining 25% classed as hazardous waste. A 95% recovery rate is the target. Textiles recovery is discussed, particularly relating to car upholstery, which presently comprises textile cover, foam plastic interior and some knitted fabric. Research is under way to improve these structures. KUNIT and MULTIKNIT stitchbonding processes are employed to manufacture the textile upholstery material and the reuse of torn fibres in nonwovens production is being investigated.

Author: Anon
Source: Allg. Vliesstoff-Rep.
Issue: no. 1, 2000, pp 24, 26

Using gaseous media for fiber web entanglement in the production of nonwovens - opportunities and limits
Fibre web entanglement technology is used to produce nonwovens. This process involves high water supply, treatment and circulation, which are expensive. In an attempt to reduce energy consumption, gaseous media are investigated. Comparable physical principles in these methods are explained and pulse forces and air pressures are compared. Steam use is also studied and results of tests comparing air and steam-based web entanglement are listed. Steam and hydraulic entanglement results to achieve specific fibre web strengths are broadly comparable, but further studies on compressed-air entanglement with higher pressures are advocated. (5 fig)

Author: Fuchs H
Source: Tech. Text
Issue: vol. 43, no. 1, Mar. 2000, pp E4-E5, 17-18d

R.STAT: antistatic and antibacterial fibers
Nylon 66 (N fibres) and high tenacity polyester (P fibres) are produced by R.STAT, Vaulx en Velin, France. P fibres are used in filter media and their properties and applications are described. Good permanent electrical conductivity and antibacterial characteristics are evident in both PA and PET fibres and, with only 2-3% of the R.STAT fibres introduced into a textile, bi-functional antistatic and antibacterial properties are present. A conductive stainless-steel fibre is also available. (Short article)

Author: Anon
Source: Tech. Text.
Issue: vol. 43, no. 1, Mar. 2000

Trends in natural, manmade and synthetic leathers at the turn of the century
Shoes will be assumed to remain the biggest consumer of real and artificial leather, and shoe demand will continue to grow due to both an increasing and aging world population. Production of leather, however,

cannot keep up with demand, so the proportion of non-leather shoes is gradually increasing. Composite technology for leather, such as coating or filling with synthetic resin, has been developing to improve leather's weak properties and add commercial value. Use of leather powder for coating manmade leather is also underway to give synthetic leather the features of natural leather.

Author: Sugano E
Source: Jpn Nonwovens Rep.
Issue: no. 1, Jan. 2000, pp 187-194 (In Japanese)

Geosynthetics
Geosynthetics have wide-ranging uses and properties. In civil engineering works they can perform hydraulic functions of drainage and filtration, and mechanical functions of separation, protection and reinforcement, simultaneously or separately. The properties necessary for each of these functions are explained, and details of how geosynthetics are used in each application, with the benefits they offer, are listed. Examples of areas using these materials are earthworks, roads and railways, river, coastal and water works, parks and gardens. Geosynthetics are easy to lay and can be joined by superposition, stitching or stapling. (19 fig)

Author: Mandal J N
Source: Indian Text. J.
Issue: vol. 110, no. 2, Nov. 1999

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THE NONWOVENS NET

Metasearchers and Metacrawlers

A typical search engine is designed to go out and search a portion of the Internet directly. As has been pointed out previously, search engines usually only cover a small portion of the Internet and are often focused on certain categories.

Another type of search capability is the metasearch site, or metacrawlers. Metasearch engines do not search directly themselves, but they send a specific search to several search engines at one time. As a result, metasearch engines do not allow for input of many search variables. Also, their best use is to find hits on obscure items or to see if something is on the web, or to get a "quick and dirty" overview of what is available.

Some of the best known metasearchers are as follows:

- About (www.about.com)
- All in one search Page (www.allonesearch.com).
- Ask Jeeves (www.askjeeves.com).
- DeBriefing (www.debriefing.com).
- Dogpile (www.dogpile.com).
- Fast Search (www.alltheweb.com)
- Find-It (www.itools.com/find-it)
- Highway 61 (www.highway61.com).
- metaFind (www.metafind.com).
- Mamma (www.mamma.com).
- Metacrawler (www.metacrawler.com).
- ProFusion (www.profusion.com).
- SavvySearch (www.savvysearch.com).

A Search of Search Engines

As the Internet increases in size, the quest for an ideal search engine continues unabated. The number of indexable web pages hit over one billion during the later part of last year. As a consequence, the leading search engines are pushing hard to expand the number of indexed pages and thus catch the title of BIGGEST search engine. The race for this position has shifted over the past several months, as indicated by the following numbers:

MILLIONS OF WEB PAGES INDEXED

Search Engine	**6/97**	**12/97**	**6/98**	**12/98**	**6/99**	**12/99**
AltaVista	35	100	140	140	150	200
Northern Light		50	65	95	150	200
FAST	-	-	-	-	90	200
Excite	55	55	55	55	55	150
Google	-	-	25	60	85	125

Source: SearchEngine.com

While the number of indexed pages is a useful guide, it does not address the matter of subject material. A useful measure of this factor can be gained by the use of a search engine for a particular type of material. The following list comprises the "Best Search Engine" as compiled by a source which focuses on the usage for scientific and technical searches:

- Hotbot
- www.dogpile.com
- www.csa.com (Cambridge Scientific Abstracts)
- Google.com
- About.com
- Uncover.com
- www.sci.com (Scientific Citation Index)

These ratings will undoubtedly change with time. In our next issue of INJ, an attempt will be made to develop the "Best Search Engine for Nonwovens Studies," based on INJ readers' responses.

AATCC Technical List Server

A list server on the Internet is a web site that is available to a variable number of users or subscribers. The most frequent use of the List Server is to allow participants to insert a message, which is then sent to all members of the list group.

The American Association of Textile Chemists and Colorists (AATCC) has recently established a Technical List Server for those concerned with textiles, textile chemistry, dyeing, printing, finishing, and related interests. The objective of this site is to provide a forum where a subscriber can submit questions on textiles and textile processing, and receive answers from any of the other subscribers.

As a question is submitted by e-mail to the List Server, the message goes out to all of the subscribers via e-mail. If an individual subscriber has a response or answer to the query, an e-mail reply can quickly be prepared and sent. If the subscriber has no response or interest to that particular inquiry, the e-mail is ignored.

The AATCC Technical List Server currently has over 200 subscribers from over 28 countries. A subscriber can leave the List at any time, and can rejoin as often as desired. For more information log on to http://www.aatcc.org .

Internet Source for Environmental, Health and Safety Information

A very helpful site providing information on environmental, health and safety (EHS) topics has been established by ThermoRetec Corporation of Tucson, Arizona. This is a Gateway Site, which bypasses much of the tangled web of the Internet to sites specifically related to the EHS topic.

The site is organized by 11 key industries (chemical and pharmaceutical; financial; real estate and transaction support; forest products; government nuclear facilities; industrial fuel users; manufacturing and consumer goods; medical facilities; mining; petroleum industry; transportation; utilities) and government sectors (emergency response; environmental news sources; EPA; Federal Environmental Legislation; other federal agencies; non-profit environmental groups; state and environmental agencies and organizations; technical and engineering resources).

In addition, direct links to specific areas within the site are provided; most of the links are annotated to help in the choice of sites which best meet the specific need (www.ehsgateway.com).

e-Business Growth

Just as the number of Internet pages increase, there is much evidence that e-business - business conducted on the Internet - is increasing also. B2B (business-to-business) as well as B2C (business-to-consumer) has shown explosive growth over the past months. A striking manifestation of this growth was provided by the situation at the recent Annual Conference and Exhibition of AORN (Association of Operating Room Nurses, now renamed as the Association of Perioperative Nurses). Just one year ago, there were three companies doing business in the segment, with Internet marketing to hospitals, clinics, nursing homes, physician offices, out-patient clinics and the like. In the recent Annual Conference there were 23 companies seeking this business on a national and international basis. It hardly seems possible that the market can support this number; a shake-out of these participants seems more likely.

There could easily be a new category of Internet business: B2R&D, as the number of businesses directed toward the R&D activity and using the Internet increases.

SciQuest.com is a good example of this type of business, with e-marketing to the global scientific products industry. Their new website enables users to easily search through almost one million products as well as consolidate purchases through an e-marketplace into single orders and to confirm and track orders online. Additional features of this site include an enhanced resources section with easier access to online journals. Scientific reference guides, conference calendars and other useful R&D sites are available at this location. The site also features live, online auctions, as well as the opportunity to lease, purchase or sell laboratory equipment. (SciQuest.com, P.O. Box 12156, Research Triangle Park, NC 27709).

Another striking example of business-to-business auctions with special emphasis on scientific and laboratory equipment is DoveBid (www.dovebid.com). With 62 years of experience in conventional auctions, Dove Brothers has made a strong pitch for this extension of their business.

Another interesting Internet business activity to scientists and technicians is the Internet exchange for scientific measurement services. This site (www.labseek.com) is for users and suppliers of scientific measurements services. Companies that need scientific testing/expertise are given access to labs and scientists via the site's secure system. Any type of scientific measurement is matched with resources of labs capable of constructing these tests, based on information in a proprietary member database. This database has an inventory of each participant's available instrumentation, scientific expertise and methods capabilities. The needs addressed by this service range from research and problem-solving to highly defined analyses, to consulting on necessary test development and required resources. Primary industries served include chemical polymer, petroleum, food, pharmaceutical, agriculture, environmental, scientific products, clinical research and conformance testing. (LabSeek.com, 9608 Loiret Boulevard, Lenexa, KS 66219).

Further evidence of this trend is supplied by the various Internet companies exhibiting at the recent Pittcon Conference on chemical and analytical technology. These included the following:

- www.daigger.com : The site of A. Daigger & Co., lab suppliers.
- www.biosupplies.com : Supplier of biosupplies and chemicals for analysis.
- www.chemdex.com : Major chemical supplier on internet.
- www.ni.com : National Instruments, suppliers of laboratory instruments.
- www.comdisco.com : Laboratory equipment management specialists.
- www.atlims.com : Online laboratory information management systems supplier.
- www.auction.fishersci.com Surplus equipment site of Fisher Scientific.

—INJ

Book Review

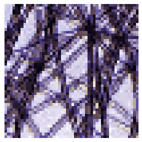
Spunbond/Meltblown Handbook

"The Spunbond and Meltblown Technology Handbook," Prepared for INDA by Ian Butler, International Nonwovens Consulting, Inc.; edited by Edward Vaughn, Ph.D., Clemson University and Larry Wadsworth, Ph.D., University of Tennessee; 50 pages.

Full of pictures, graphs and diagrams, this handbook does a great job of covering the basics of these important and growing technologies. Also included are spunbond/meltblown composite fabrics as well as an introduction to the major market applications and physical properties of each technology segment. Available from INDA at www.inda.org, major topics include:

- Historical developments, including the major milestones and drivers for each technology.
- Worldwide and regional market growth.
- Physical properties of the important resin types.
- Principal end markets and specific market "success stories."

Considerable market size information and a glossary complete the handbook, making it a handy reference for a wide range of people involved in the field of nonwovens.

 Return to International Nonwovens Journal Home Page & Table of Contents

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ASSOCIATION NEWS

ANSI Change of Address
ANSI (The American National Standards Institute) is the official U.S. representative to the world's major standards bodies, which includes such organizations as ISO (International Organization for Standardization) and the IEC (International Electrotechnical Commission), plus several others. It is a private, non-profit organization that administers and coordinates the U.S. voluntary standardization system.

ANSI recently announced the opening of its new headquarters in Washington, D.C. It had been headquartered in New York City since its founding in 1918.

In announcing the new office, it was indicated that "the decision to relocate ANSI Headquarters to the nation's capital will enable us to work even more closely with U.S. public policy leaders. This strengthened link between the private and public sectors will greatly enhance the Institute's ability to focus on domestic, regional and global issues in line with the Institute's mission."

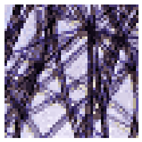
The Institute's domestic and international standards facilitation programs, and its administrative operations, will remain in the New York City offices. The address for the new headquarters is The American National Standards Institute, 1819 L Street, NW, Sixth Floor, Washington, DC 20036; 202-293-8020; Fax 202-293-9287

AAMI Membership
Because of interest shown by numerous members, INDA has obtained official membership in AAMI, the Association for the Advancement of Medical Instrumentation. The driving force for INDA membership in this association is the fact that AAMI has been a prime driver for advancement of materials and methods for cutting-edge medical technology.

In addition, AAMI has a committee (PB 70) devoted to work on a standard for "Barrier Performance and Classification for Protective Apparel and Drapes in Healthcare Facilities." This committee is slated to assign class values for such products as well as descriptive terms relating the the performance of such products. It is also planned that the committee will complement the eventual standards with test methods and test results to be applied to each product class. The label requirements for such products will also be developed. The FDA has indicated that it will likely adopt these standards as its own once the work is completed.

In addition to INDA, several individual INDA members are active in AAMI. Other participating organizations include AORN, FDA and the American College of Surgeons, as well as other groups and independent healthcare experts. Active INDA participation will help insure that single-use gowns and drapes remain competitive in this market.

—INJ



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A recent TAPPI Nonwovens Division meeting was enlivened by a lunch celebration of Norm Lifshutz's birthday. Pictured are (l-r) Charles Bohanan, Chuck Diller, Pete Wallace, Marsh Hutten, birthday boy Norm Lifshutz, Jim Tanger, Keh Dema, and T.M. Singh. Photo by Rob Bender.

The TAPPI Nonwovens Page

TAPPI Nonwovens Division Looks Forward To First Joint INTC Meeting in Dallas

As has been the focus of much of this issue of the International Nonwovens Journal, TAPPI and INDA will be joining forces for the first time to sponsor the 2000 International Nonwovens Technical Conference (INTC), to be held September 26-28, 2000, at the Hotel Inter-Continental in Dallas, TX.

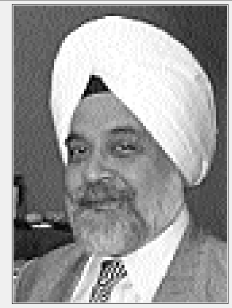
At the request of the industry, TAPPI and INDA are combining their technical conferences to produce the largest nonwovens technical conference in the world, which will feature information on fibers, properties and performance, process technologies, filtration, building and industrial mats, absorbents, binders and additives, barriers, melt extrusion and hydroentangling.

Executives from around the world will attend INTC 2000. The conference will be the place to network with nonwoven fabric producers, converters of nonwoven fabrics, and suppliers to nonwoven fabric producers. Managers with responsibility for new product development, research and development, technical marketing and sales, and testing and quality control will also benefit from attending.

The keynote speaker will be Michael Schuman of Procter & Gamble, who will discuss current and future products in the nonwovens industry. TAPPI technical committees will meet at the conference. At the end of the conference there will also be a "TAPPI Town Hall" meeting for TAPPI members to discuss the findings and recommendations of the TAPPI 2010 committee, which has worked diligently over the last year to help set the future direction for the organization.

Registrations for the INTC 2000 Conference are being handled by INDA; call 919-233-1210, ext. 126, or Fax 919-233-1282 to sign up. To get the early-bird discount registration fee, be sure to register before August 18, 2000. Visit the INDA web site at www.inda.org or the TAPPI web site at www.tappi.org for more details

Chairman's Corner



A Path Forward

By T.M. Singh

We all know TAPPI has the privilege of a glorious past of approximately 85 years of service to the Pulp and Paper and Allied Industries. The Nonwovens Division, though relatively newer, has its own special place in the organization.

Over the past decade and a half, your Nonwovens Division has provided its members with impressive technical programs and conferences, well-attended trade shows, relevant professional tutorials, and short courses on different aspects of nonwovens. Globalization of the industry, large-scale mergers and acquisitions, a revolution in communication technology, fierce economic competition, and fast-moving application technology, along with shorter life cycles of products, have had profound effect on how we have done business lately.

It seems imperative that we look at our current TAPPI structure and simplify it to make it more effective for future generations of technology leaders. TAPPI President Dick Barker has created the 2010 Committee to examine current TAPPI structure and recommend how to respond to new business realities of today and tomorrow. You will learn more about TAPPI's action on 2010 Committee recommendations and how TAPPI members can get the value they expect, and benefit by way of participation in various activities in the near future.

As active Nonwovens Division members, some beneficial results include your participation in the joint annual technical conference with INDA in September 2000 at Dallas (INTC 2000) and co-sponsoring this joint publication - *the International Nonwovens Journal*. The *INJ* has been well received and I look forward to your participation in excellent technical programs at the International Nonwovens Technical Conference in September.

TAPPI administration and membership will continue to communicate using the full palette of electronic multi-media to ensure flow of information, highlighting how we plan to provide our core values and objectives, which have made us strong in the past, while we march on the path forward in the New Millennium.

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Where The Nonwovens Industry Comes To Learn

Clemson University's School of Textiles offers industry newcomers a chance to bone up on the basics

Dr. Edward Vaughn, of Clemson University's School of Textiles, teaches one of his very popular Nonwovens Fabric Forum courses

The nonwovens industry is one of the areas of the textile market. Not only is it fascinating and economically viable, it is an area experiencing a tremendous amount of growth. And it is this growth that is causing a good amount of textile industry members to venture out of the traditional areas of wovens, fibers and paper to the wonderful world of nonwovens.

Although this is well and good, these nonwovens newcomers are entering upon a highly competitive market with an established set of places and faces, which they now have to learn about in order to succeed. This is where Clemson University's expertise in nonwovens comes in handy.

Established in 1898, Clemson University's School of Textiles,. Fiber and Polymer Science was the first of its kind in the South. The School was founded to become file academic center for the textile. fiber and polymer-based industries. both in the South and world-wide. It strives to meet this mission through technical guidance, knowledge through research and undergraduate, graduate and continuing education, The school covers all aspects of the textile industry. from fibers to evaluating textile performance. What makes Clemson's textile school such an authority within the nonwovens industry is the amount of' work, research and dedication the school has put into it, as well as the knowledge it gives to those within the industry.

Focusing On Nonwovens

Clemson began its interest in the nonwovens sector in the 1970's with the efforts of Professor of Textiles Edward Vaughn, who had joined the School in 1966. "1 felt that nonwovens were a part of the textile industry that showed the potential for future long-term growth," Dr. Vaughn explained when discussing how he had decided the university should become involved in the nonwoven industry 31 years ago.

Dr. Vaughn began his excursions into nonwovens with the first Nonwoven Fabrics Forum -- a 'short course for both industry newcomers and veterans. Since then, the conference has become an annual event that draws, large attendance. "I did the first Forum in 1970 and since then it has become what I hoped it would be - an anticipated annual event within the nonwovens industry," Dr. Vaughn stated. "This is an area where all the young, aggressive, intelligent and creative people are launching their careers. It has been a joy for me, as I have made more new friendships than I can count."

According to Dr. Vaughn, over 2500 industry members have come through the four-day forum over the past 30 years, with some even coming back two or three times throughout the years. Each year since the early 70's the majority of speakers have been from the nonwovens industry itself and have included many current chief executives, R&D directors, marketing and sales vice presidents, developers of numerous nonwoven products and inventors of new technologies. The forum also acts as an interactive experience by allowing ample time for attendees to informally meet speakers, faculty and other members of' the nonwovens industry *(for more information on the Forum. see sidebar).*

In addition to the Nonwoven Fabrics Forum, Clemson is also involved in nonwovens research through its on-site R&D facilities. "We have been involved in a lot of nonwovens research, which has been ongoing for many years," Dr. Vaughn explained. "We have had quite a number of studies with students going for their degrees, governmental and proprietary research." The school has hosted work of a variety of nonwoven processes. such as hydroentangling, needlepunching, meltblowing, spunbonding, resin bonding, thermal bonding and foam bonding. Some of' the equipment available at its nonwoven laboratory includes web formation, processing and finishing equipment.

Meeting The Nonwovens Future

As for the future direction of the school's involvement in nonwovens, Dr. Vaughn asserts that plans are being made to expand its commitment through program and faculty additions.

"For the past 30 years we have been really involved within all phases of the nonwovens business and we will be expanding our efforts," he added. This expansion will reflect the growth of the nonwovens industry as a whole, as more traditional textile members migrate into the nonwovens area and continue to need a neutral place — such as the Nonwovens Fabrics Forum — to learn about the people, places and basic ideas that define the nonwovens market.

"I hope the Forum will always be around because it creates the room to provided perspective on what has been done with the industry before, which is something some people forget to look at that is important," Dr Vaughn stated We bring in people from the industry to reach those interested in the industry on a neutral ground where they can learn objectively."

www.clemson.edu/success

Nonwovens 101

Approximately 140 nonwovens industry members were expected to venture to Clemson, South Carolina late this June for the 31st Annual Nonwovens Fabrics Forum at Clemson University. In addition to four days packed with basic nonwovens information, the Forum provides informal networking opportunities and the chance to ask questions and exchange ideas with other attendees.

Each year the Forum's program includes fundamental information on many areas of the nonwovens industry, including manufacturers, raw materials, processes and technology presented from experienced colleagues from all areas of the industry.

On the first day, the Forum offers a basics course of the principles of woven, knitted and nonwoven fabrics, as well as a tour of Clemson's School of Textiles' nonwovens laboratory, where fiber processing and manufacturing, woven and nonwoven fabric manufacturing and product evaluation are examined.

On the following days, the program includes presentations on such topics as a history of nonwovens, fabric manufacturing basics, market and company profiles, fiber fundamentals, the future of the industry, bonding, finishing and converting.

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If you have comments regarding our website, please contact Cindy Garcia (cgarcia@inda.org),
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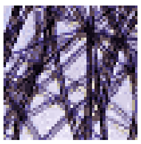

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INJ DEPARTMENTS

NONWOVENS CALENDAR 2000-01

August 2000

Aug. 20-24, 2000 **220th American Chemical Society National Meeting**. Washington DC, USA. ACS Meetings, 1155 16th St. N.W. Washington, DC 20036-4899; 202-872-4396; Fax: 202-872-6128; natlmtgs@acs.org

Aug. 27-31, 2000. **TAPPI Polymers, Laminations & Coatings Conference**. Westin Hotel, Chicago, IL, USA. TAPPI, Charles Bohanan; 770-209-7276; cbohanan@tappi.org

September 2000

Sep. 13-15, 2000. **Bobbin Americas.** Georgia World Congress Center, Atlanta, GA, USA. Blair Keever; 972-906-6659; bkeever@mfi.com or visit Bobbin Americas website at www.BobbinAmericas.com.

Sep. 19-21, 2000. **INDA-Mexico 2000**. World Trade Center, Mexico City, Mexico. Marilyn Bellinger, INDA, Association of the Nonwoven Fabrics Industry, P.O. Box 1288, Cary, NC 27512-1288; 919-233-1210 ext. 118; mbellinger@inda.org; www.inda.org.

Sep. 25-28, 2000. **International Technical Nonwovens Conference - Co-sponsored by INDA and TAPPI**. Hotel Inter-Continental, Dallas, TX, USA. Deanna Lovell, Education Coordinator, INDA, Association of the Nonwoven Fabrics Industry, P.O. Box 1288, Cary, NC 27512-1288; 919-233-1210 ext. 119; Fax: 919-233-1282; dlovell@inda.org www.inda.org; or TAPPI, Charles Bohanan; 770-209-7276; cbohanan@tappi.org

October 2000

Oct. 4-6, 2000. **EDANA Absorbent Hygiene Products Training Course**. Brussels, Belgium. Valérie Skupiewski, EDANA, 157 avenue Eugène Plasky, B-1030 Brussels, Belgium; Tel: +32-2-734-93-10; Fax: +32-2-733-35-18; edana@euronet.be

Oct. 15-18, 2000. **EuroGeo 2000**. Bologna, Italy. Susanna Antonielli, Italian Geotechnical Society (AGI); Tel: +39-6-4424-9272; Fax: +39-06-4424-9274; agi@mercurio.it

Oct. 15-28, 2000. **American Association of Textile Chemists and Colorists, International Conference and Exhibition**. Benton Convention Center, Winston-Salem, NC, USA. AATCC, Research

Triangle Park, NC, USA; 919-549-8141; Fax: 919-549-8933; www.aatcc.org

Oct. 18-20, 2000. **Tech Textil Asia**. INTEX Osaka, Japan. Michael Jänecke/Silke Sakouchy, Messe Frankfurt, TechtextilTeam, Ludwig-Erhard-Anlage 1, D-60327 Frankfurt am Main; +49-69-7575-6415-6578-6406; Fax: +49-69-7575-6541; techtextil@messefrankfurt.com

Oct. 23-27, 2000. **ATME-I 2000 American Textile Machinery Exhibition-International 2000**. Palmetto Expo Center, Greenville, SC, USA. J. Robert Ellis, ATME, P.O. Box 5823, Greenville, SC 29606. 864-233-2562; Fax: 864-233-0619; atmei@textilehall.com

Oct. 29-Nov. 3, 2000. **American Chemical Society-Eastern Analytical Symposium**. Atlantic City, NJ, USA. Eastern Analytical Symposium, P.O. Box 633, Montchanin, DE 19710-0633; 302-738-6218; Fax: 302-738-5275; www.eas.org

November 2000

Nov. 8-10, 2000. **The Tenth Annual International TANDEC Nonwovens Conference**. The University of Tennessee Conference Center, Knoxville, TN, USA. Dr. Dong Zhang, Conference Chairman, Textiles & Nonwovens Development Center, 1321 White Avenue, University of Tennessee, Knoxville, TN 37996; 865-974-3573; tancon@utkux.utk.edu; www.utk.edu/~tancon

Nov. 8-10, 2000. **The Fiber Society, Fall 2000 Meeting**. Callaway Gardens, Pine Mountain, GA, USA. Dr. Steve Michielsen and Dr. Mary Lynn Realf, Georgia Tech; 404-894-2430; Fax: 404-894-8780.

Nov. 12-14, 2000.. **Annual Private Label Trade Show and Conference**. Rosemont Convention Center, Chicago, IL, USA. PLMA, 369 Lexington Ave., New York, NY 10017; 212-972-3131; Fax: 212-983-1382.

Nov.. 26-Dec. 1, 2000. **The 10th International Wool Textile Research Conference**. Aachen, Germany. Deutsches Wollforschungsinstitut, Veltmanplatz 8, D-52062 Aachen, Germany; ++49 (0) 241/44-69-129; Fax: ++49(0)241/44-69-100; contract@dwi.rwth-aachen.de.

Nov. 28-30, 2000. **Filtration 2000**. Pennsylvania Convention Center, Philadelphia, PA, USA. INDA, Association of the Nonwoven Fabrics Industry, P.O. Box 1288, Cary, NC 27512-1288; 919-233-1210; Fax: 919-233-1282; www.inda.org

Nov. 29-30, 2000 . **Aachen Textile Conference**. Aachen, Germany. Deutsches Wollforschungsinstitut, Veltmanplatz 8, D-52062 Aachen, Germany; Tel: ++49 (0) 241/44-69-129; Fax: ++49 (0)241/44-69-100; E-mail: contract@dwi.rwth-aachen.de. .

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INTERNATIONAL NONWOVENS Journal

NONWOVENS PERSPECTIVE

Qualitative Evaluation of Nonwoven Samples Using DuPont Fiber Identification Stain No. 4 and Microscopy

By Michèle Mlynar, Group Leader, Specialty Polymers,
Rohm and Haas Company, Spring House, PA

Abstract
In this paper, we describe how the DuPont Identification Stain No. 4 provides a simple means to quickly identify individual fibers using a microscope. We looked at different nonwoven samples, including polyester, rayon, wood pulp and polypropylene fibers as well as several finished webs with different fiber blends, thermobonding points and binder distributions.

Introduction
This paper is intended to be a "fun" paper with no chemistry or equations. It should be labeled more as an "arts and crafts" applied to nonwoven evaluation.

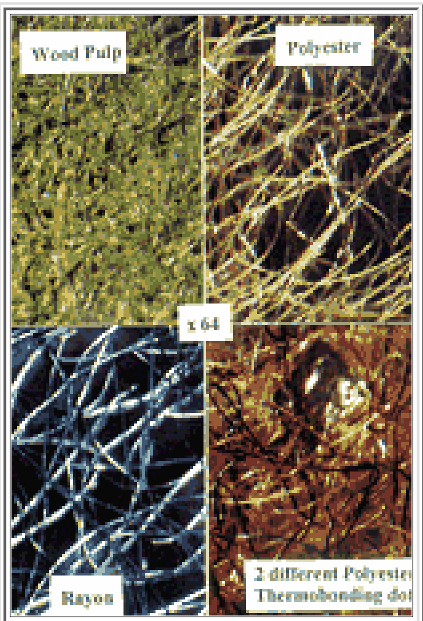


Figure 1
NONWOVEN FIBERS

The technique presented involves staining a nonwoven sample *(Figure 1)* with a dye, DuPont Identification No. 4, and the evaluation of the fibers or the structure of a nonwoven under a microscope.

The DuPont Identification No. 4 (proprietary composition) was developed for the textile industry to provide a simple means for quickly identifying individual fibers, whether alone or used in a blended fabric. The stained fabrics show different colors depending on their contents. Here are some examples:

Fiber	Color
cotton	blue-gray
Dacron	orange
nylon	reddish brown
silk	dark purple&
viscose	blue-green
wool	brown

A picture of an old textile swatch of known composition is shown in *Figure 2*. This was given by DuPont years ago when we could purchase the dye from them. The DuPont

Identification No. 4 can now be purchased through Pylam Products Company, 2175 East Cedar Street, Tempe, AZ 85281. A similar technique can be applied to nonwovens. A personal "library of the different fibers" colors can be built and used to evaluate new nonwoven samples.

Experiment

Procedure

To dye the nonwoven sample, the following procedure should to be followed:

1. Place the sample into a boiling 1.0% solution of DuPont Fiber Identification No. 4, using a 20:1 bath to fiber ratio,
2. Hold the sample in the boiling bath for 1 minute,
3. Remove the sample,
4. Rinse,
5. Dry.

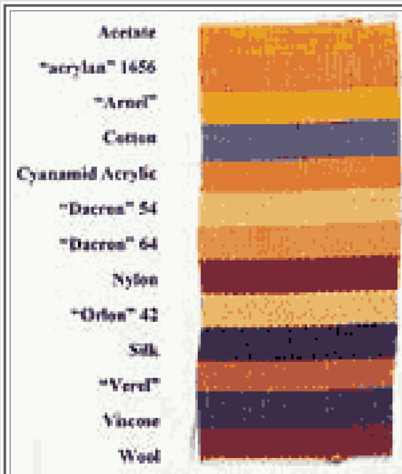


Figure 2
AN OLD TEXTILE SWATCH

Staining will vary with the quality, preparation, and processing of the fibers.

Figures 3a and 3b show some of the materials needed to perform this test.

It is important to rinse the sample very well until no color bleeds. Place paper towels under and over the sample to test/see if the sample is rinsed properly. If no color bleeds through the paper towel, the sample is rinsed properly. However if bleeding is observed, the sample should be rinsed again.

If fibers or weak nonwovens have to be tested, we recommend that the sample be placed in a net before entering the boiling dye solution.

The dye solution can be reused, and should be filtered to eliminate any loose nonwoven fibers.

The dyed fibers and nonwoven samples were evaluated using an Olympus microscope SZH with a color video camera. The pictures were printed with a Sony color video Printer Mavigraph. The magnification used for this study varies between of 7.5 to 128. *Figure 4* shows the setting used for this particular study.

Examples

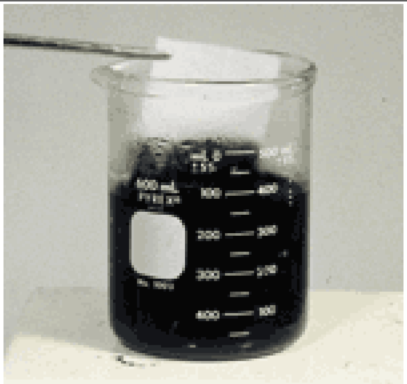
Reference samples

To be able to evaluate different nonwovens, it is important to build knowledge of different fibers. For this, we dyed different fibers as well as different nonwoven samples of known composition. The pictures of some of these reference samples are included and can be described as follows:

Figure 4
EQUIPMENT SETTING

Polyester Fibers -- Gold color (can vary from almost white to red); Round uniform fibers

Figure 5a (x 30): Very light orange fibers with a lot of light reflection
Figure 5b (x 128): Very light color uniform round diameter fibers
Figure 6 (x 30): Slightly thermobonded polyester, two different colors, the low melt polyester usually appears as dark orange fibers



Figures 3a and 3b
EQUIPMENT FOR THE EXPERIMENT

Figure 7 (x 30): Polyester spunbond, very dark orange

Rayon Fibers -- Greenish-blue; round uniform fibers
Figure 8 (x 128)

Wood Pulp -- Bluish-green; flat, non-uniform fibers
Figure 9 (x 64)

Polypropylene -- Pale pink; round, uniform fibers

Acrylic binder-- orange

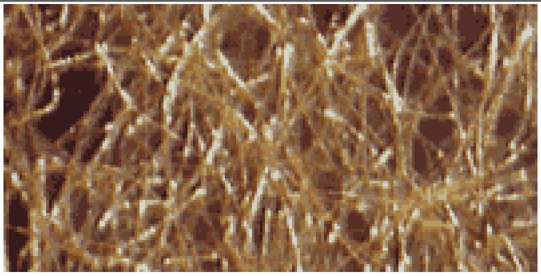


Figure 5a
POLYESTER (X 30)

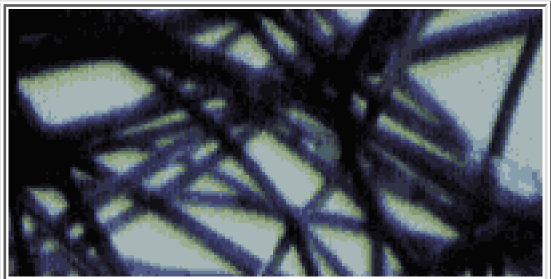


Figure 8
RAYON (X 128)

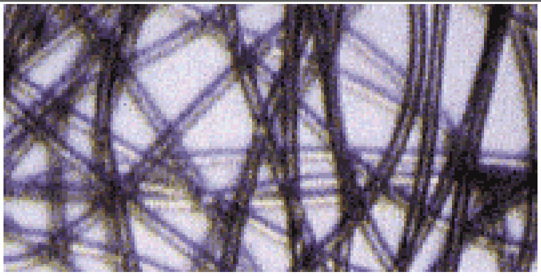


Figure 5b
POLYESTER (X 128)

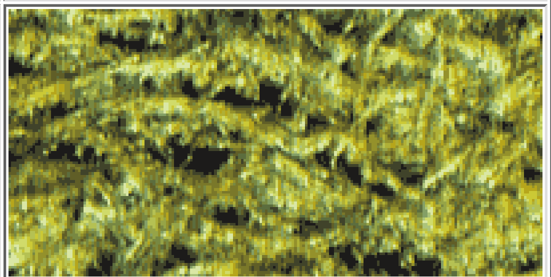


Figure 9
Wood PULP (X 64)

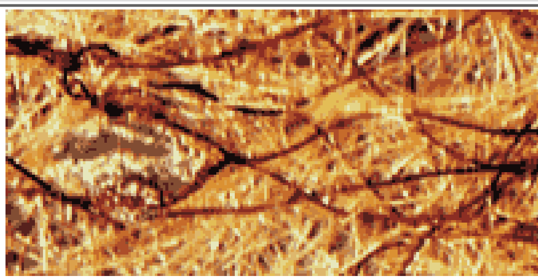


Figure 6
POLYESTER LIGHTLY THERMOBONDED(X 30)

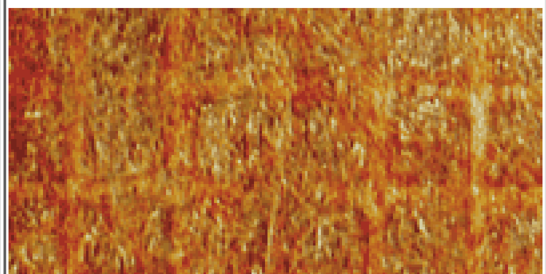


Figure 10
NONWOVEN SAMPLE (X 7.5)

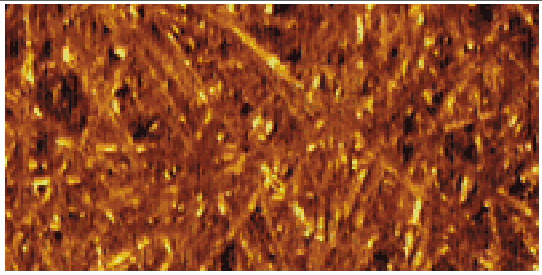


Figure 7
POLYESTER SPUNBONDED (X 30)

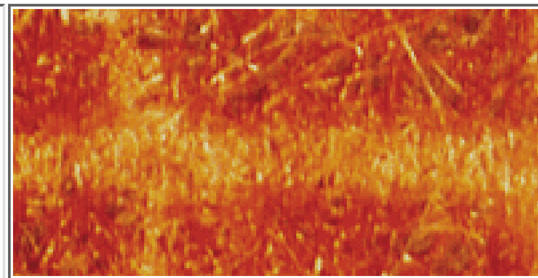


Figure 11
NONWOVEN SAMPLE (X 30)

Nonwoven samples
We are going to present different nonwoven samples, study their composition, and evaluate their possible problems. The nonwovens are taken from the industry, either commercial products or problems studied to improve production.

* Example 1: A lightweight nonwoven thermo and chemically bonded

Figure 10 (x 7.5): A blend of rayon (greenish-blue round, uniform fibers) and polyester (almost white and orange/gold round fibers) binder with dark orange spots and thermobonded lines

Figure 11 (x 30): Mainly polyester fibers with thermobonded lines (squares) and orange binder

Figure 12 (x 30): Mixed rayon and polyester fibers, some binder, poor thermobonding

Figure 13 (x 30): No thermobonding, almost no binder, polyester and rayon fibers

From these pictures, we can conclude that the fiber blend is not uniform, the fibers are poorly dispersed, some spots with only rayon (greenish-blue), and some spots with only polyester (gold/orange). We also see part of the nonwoven with no thermobonding, especially on the heavier rayon containing areas.

* Example 2: Another lightweight nonwoven thermo and chemically bonded

Figure 14 (x 30): Rayon fibers (very dark blue), two types of polyester (very light and dark orange), some binder (dark orange spots)

Figure 15 (x 64): Same observation as above at higher magnification

Figure 16 (x 7.5): Different samples were taken throughout the width of the nonwoven web and dyed at the same time. We can observe different shades of orange, which indicates more binder for the darker shades. These pictures show an uneven distribution of the binder

Figure 17 (x 64): Here we see the thermobonding dots. The fibers are melted through creating a hole in the nonwoven structure

These pictures show that the binder distribution is uneven throughout the width of the web, and that the thermobonding is probably done at a too high temperature therefore melting through the fibers and creating weak spots instead of reinforcing the web structure.

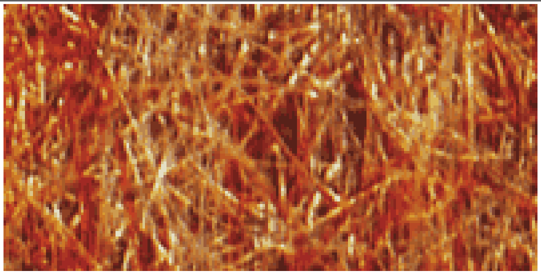


Figure 12
NONWOVEN SAMPLE 1 (X 30)

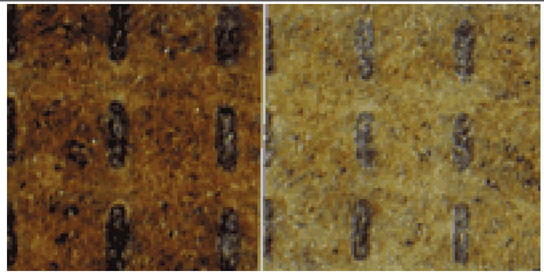


Figure 16
NONWOVEN SAMPLE 2 (X 7.5)

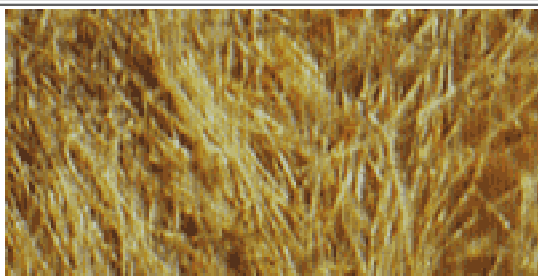


Figure 13
NONWOVEN SAMPLE 1 (X 30)

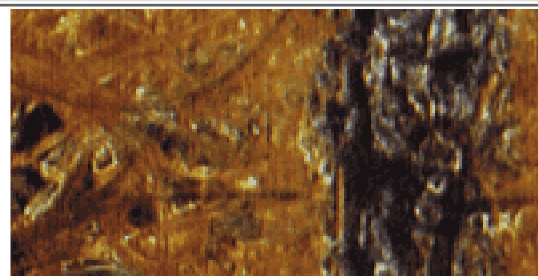


Figure 17
NONWOVEN SAMPLE 2 (X 64)

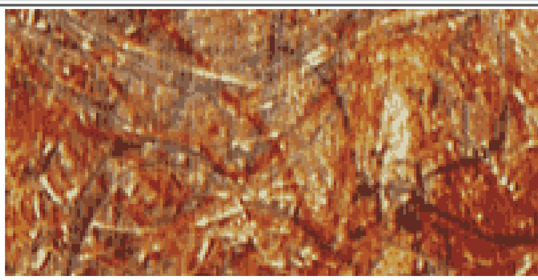


Figure 14
NONWOVEN SAMPLE 2 (X 30)

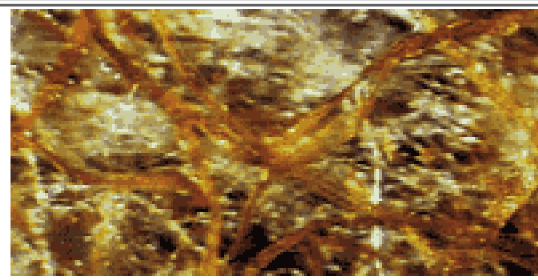


Figure 18
COMMERCIAL BABY WIPE (X 64)

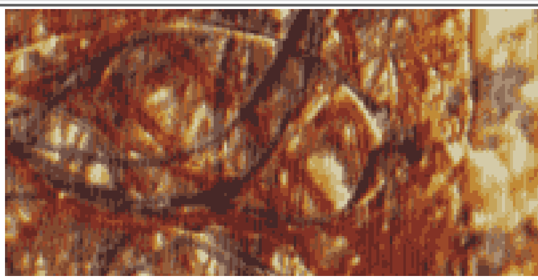


Figure 15
NONWOVEN SAMPLE 2 (X 64)

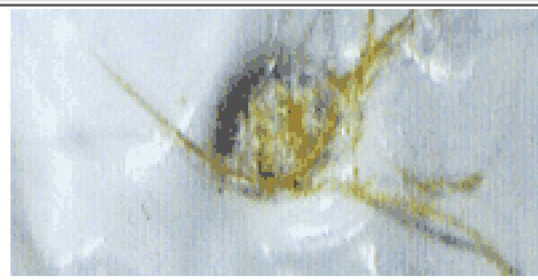


Figure 19
COMMERCIAL BABY WIPE (X 40)

* Example 3: This example is from a newly commercialized baby wipe (at the time of the study).

Figure 18 (x 64): From this picture, we can guess that the nonwoven is made of polypropylene fibers (no color, very thin) and wood pulp (flat, yellow-greenish).

Figure 19 (x 40): These fibers are thermobonded to a film.

Conclusions

This technique provides a relatively quick and inexpensive way to have a qualitative analysis of a nonwoven sample, indicating the composition of the fibers as well as some production problems encountered during the manufacturing of a nonwoven product.

Acknowledgements
The author wants to thank Jeff Panara, who did all the photographic work on the pictures generated from the microscope camera.

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This paper was presented at the TAPPI Nonwovens 99 Conference (Orlando, Florida, March 15-17, 1999). It was awarded the Best Paper.

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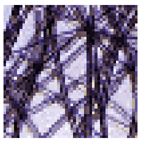

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INTERNATIONAL NONWOVENS Journal

ORIGINAL PAPER/Peer Reviewed

Cotton-Surfaced Nonwovens For Short-Wear-Cycle Apparel

*By Larry C. Wadsworth, Hannah Suh, Textiles and Nonwovens Development Center, The University of Tennessee-Knoxville, Knoxville, TN, and H. Charles Allen. Jr., Cotton Incorporated, Raleigh, NC**

Abstract
Cotton-surfaced nonwovens have been developed with cotton on one side or both sides of a core structure in which the cotton content varies from 41-75% of the fabric weight. The thermally bonded two or three layered laminates are soft but strong and have a hand similar to cotton knits or hydroentangled fabrics. The fabrics have also demonstrated excellent wetting, wicking rates, water adsorption and water retention properties. Although these novel fabrics have notable flexibility and extensibility as produced, a post-treatment process provides the fabrics with instantaneous elastic recoveries ranging from 83-93% from an extension of 50%. The fabrics exhibit minimal linting characteristics and would be suitable as medical isolation gowns, head covers and shoe covers, bed sheets, pillow cases and for consumer applications such as disposable underwear, towels, wipers and personal hygiene products.

Background
Disposable nonwovens entered the medical field over four decades ago, beginning with basic paper-like facemasks and proceeding through sterilization wrap and specialty drapes and gowns to become close to a $2.5 billion market. These medical nonwovens have proven to be invaluable in products ranging from drape sheets to surgical gowns to adult pads and underpads by utilizing a gamut of nonwoven structures. The combining of nonwoven technologies has enabled the industry to offer products with properties hitherto thought impossible.

The ease of tailoring nonwovens for specific end uses has facilitated great convenience in storage and identification, leading to savings benefits in equipment, labor and inventory. Further savings are provided by the energy that may be recycled from incineration of the medical waste. Forecasting of needs has also improved since it is simpler to monitor used products. [1]

Nonwovens now have almost complete acceptance in U.S. hospitals for applications such as surgical caps, masks and shoes covers and 90-100% penetration in operating room usage has resulted because nonwoven provides relatively inexpensive, lightweight and effective protection. [2] Nonwovens have now outpaced wovens in uses such as surgical gowns and drapes, wherein they have about 60-70% share of the market. With the majority of the medical community being convinced that nonwoven disposables give double benefits of superior barrier protection and ease of use, it is only the psychological barrier that needs to be overcome before nonwovens achieve 80-90% penetration in the operating room market.

Now that cotton has successfully re-established itself as a major fiber in the conventional textile market, it is believed that the nonwoven field will also experience a resurgence of interest for it beyond the original use of cotton linters and waste fibers in nonwovens. With the possible exception of hydroentangled fabrics, which are produced by an energy extensive and relatively expensive process, nonwovens lack the strength, esthetics and comfort of woven and knitted fabrics. Cotton's probability for growth in nonwovens should be high because there are very few products making use of cotton and it has a great potential in end use markets such as medical surgical products and sanitary products.

Cotton, by virtue of its unusual chemistry and structure, offers a set of properties including high tensile strength, exceptional absorbency, high efficient wicking, natural resistance to electrostatic charge build-up, excellent heat resistance and good processability, all of which are important to the manufacture and performance of medical and health care products. Cotton is now economically available because of innovations being introduced by Cotton Incorporated and cotton suppliers, such as continuous scouring and bleaching processes. Suppliers have also improved the processability of cotton to meet the stringent requirements of nonwoven manufacturers not just by increasing the openness of the fiber, but also by improving types of finishes available, the application of finish and consistency of quality from lot to lot. This has made cotton extremely versatile in terms of processability and has made it possible to be used in most of the nonwoven processes, with only processes requiring thermoplasticity such a melt extrusion being exceptions.

Preliminary research was performed at the Textiles and Nonwovens Development Center (TANDEC) at the University of Tennessee to develop laminates containing bleached carded cotton cores without layers of meltblown (MB) webs (meltblown/cotton/meltblown or MCM laminates). The MB webs serve as binder fiber materials during the subsequent thermal point bonding step and together with the cotton fibers impact both strength and barrier properties to the laminates. U.S. Patent No 5, 683,794 was issued on November 4, 1997 to The University of Tennessee Research Corporation embodying concepts of cotton core laminates employing a range of nonwoven out layers, with the inventors being L.C. Wadsworth, K.E. Duckett and V. Balasubramanian. The cotton core laminates were developed for applications such as absorbent pads, towels and wipes, sanitary napkins, diapers and wound dressings and, when treated with a repellent finish, may also be used for protective apparel such as surgical drapes and gowns.

In applications where greater strength is required, spunbond webs are used on one side in place of MB webs to produce spunbond/cotton/meltblown (SCM) laminates. Although cotton serves efficiently as an absorbent core, these laminates still lack aesthetics that could be attained if cotton was on the surface. However, research has found it is extremely difficult to produce thermally bonded laminates of cotton/spunbond (CS) or cotton/spunbond/cotton (CSC) laminate, because the cotton fibers in unbonded or loosely bonded webs could not be efficiently transfer heat to the inner spunbond (SB) or meltblown (MB) webs, and instead the cotton fibers would wrap around the steel thermal calendar rolls. Another drawback of the thermal bonded MCM, SCM, and SCS laminates was their lack of extensibility. However, it was demonstrated that they could be subsequently made elastic by subjecting them to a controlled heating and stretching process invented by Hassenboehler and Wadsworth. [3-8]

Nevertheless, it was desirable to produce in one step a laminate with cotton on one or both surfaces, which also had a degree of extensibility. Thus, it was proposed by L.C. Wadsworth and H.C. Allen that it may also be possible to achieve strength in laminates by laying webs containing loosely bonded cotton fibers on one side or both sides of unbonded spunbond webs so that the cotton fibers could "sink" into the open space between the unbonded SB filaments. This would better entrap the cotton fibers between SB filaments so that thermal bonding in the calendar tip would tie the cotton fibers down and render them less likely pull out or lint. In addition, the thermally bonded fabric would have much more flexibility and strength than if pre-bonded SB laminates were utilized to prepare the thermally bonded laminates. It was also noted that if the thermally bonded cotton (TC) and SB webs were not stretchable enough, they could be subsequently subjected to the "consolidation" (heating and stretching) processing developed at TANDEC. [3-8]

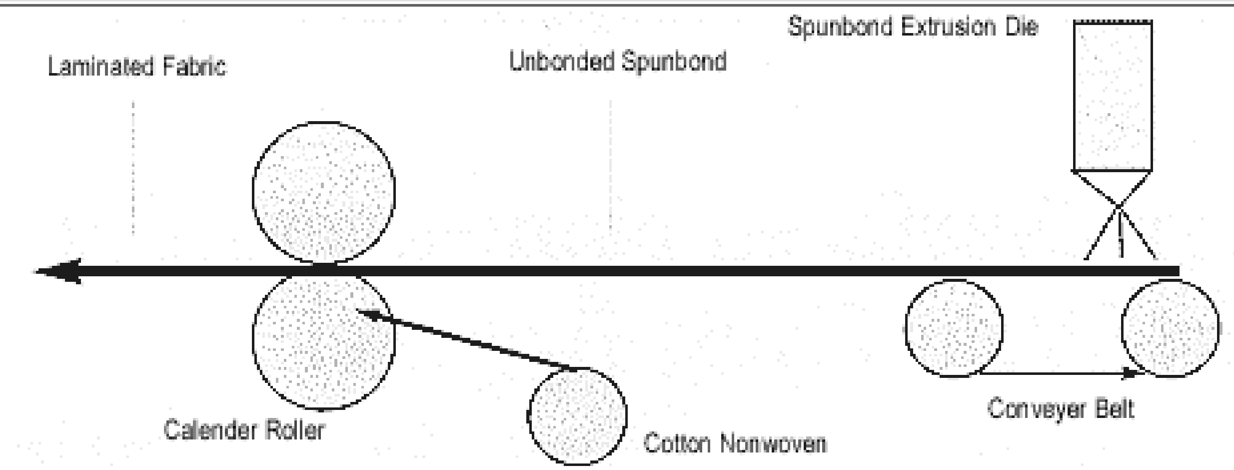


Figure 1
LAMINATION ON THE SPUNBOND LINE

Experimental
A trial was made to fabricate cotton and SB laminates on the SB line. Two types of cotton nonwoven fabrics were used: 100% cotton chemical bonded fabric and thermal bonded 60% cotton/40% polypropylene fabrics. While producing SB web, the cotton fabrics were fed into the calendar at the end of the SB line; both were passed through the calendar *(Figure 1)*. The chemical bonded web did not bond to the spunbond, but the thermal bonded fabrics did. This allows for on-line production of a cotton-spunbond laminate, which can be used as the basic fabric to produce the stretchable fabric. Seven laminates were produced using this method *(see Table 1)*. It should be noted that the samples #2 (SB2-TCPP1) and #3 (TCPP1-SB2) have the same composition, except that during the thermal laminating step, the SB web was placed on top in #2 so that it contacted the upper steel diamond heated roller.

Table 1
SAMPLE DESIGNATION, BASISWEIGHT AND THICKNESS RESULTS OF THE LAMINATES PRODUCES ON SPUNBOND LINE

Samples	**Sample**		**Basis Weight**		**Thickness**
No.	**Designation***	**Layers**	**Targeted**	**Actual**	**mm**
		oz./yd.^{2}	**oz./yd.^{2}**	**oz./yd.^{2} (g/m^2)**	
1	SB1-TCPP1	1.0/0.7	1.7	1.64 (61)	0.572
2	SB2-TCPP1	0.5/0.7	1.2	1.26 (47)	0.509
3	TCPP1-SB2	0.7/.05	1.2	1.50 (56)	0.497
4	SB2-TCPP2	0.5/0.6	1.1	1.05 (39)	0.361

5	SB2-TCPP3	0.5/1.5	2.0	1.88 (70)	0.536
6	TCPP1-SB1-TCPP1	1.7/1.0/0.7	2.4	2.45 (91)	0.804
7	TCPP1-SB2-TCPP1	0.7/0.5/0.7	1.9	1.91 (71)	0.753

Notes:
SB1-1.0 oz./yd2 Polypropylene (PP) SB web. :
SB2-0.5 oz./yd2 Polypropylene (PP) SB web:
TCPP1-Thermal bonded 60/40 cotton/PP with 0.7 oz./yd2 basis weight, 18% bond area and 36" width.
TCPP2-Thermal bonded 60/40 cotton/PP with 0.6 oz./yd2 basis weight, 40% bond area and 20" width.
TCPP3-Thermal bonded 60/40 cotton/PP with 1.5 oz./yd2 basis weight, 20% bond area and 20" width.

Table 2
STRETCHING PROCESS CONDITIONS AND FABRIC PROPERTIES AFTER PROCESSING

		Stretch Processing Conditions		**Weight**		**Thickness**	**Elastic Recovery in CD Direction at 50 Extension (%)**	
Sample No.	**Sample1 Top-Bottom**	**Oven Temp. (F°)**	**Draw Ratio[2]**	**oz./yd[2]**	**g/m[2]**	**mm**	**Instantaneous[3]**	**Time Dependent[4]**
1	SB1-TCPP1	283	2.0	3.2	107	0.867	90	75
2	SB2-TCPP1	300	1.4	2.7	93	0.732	93	77
3	TCPP1-SB2	300	1.4	2.5	86	0.707	88	76
4	SB2-TCPP2	296	1.3	2.3	78	0.515	91	73
6A	TCPP1-SB1-TCPP1	306	1.4	4.7	161	1.023	89	73
6B		300	1.4	4.3	146	1.039	85	70
6C		295	1.4	4.0	137	1.025	84	68
7A	TCPP1-SB2-TCPP1	295	1.6	3.7	125	1.056	85	68
7B		300	1.6	3.7	125	1.060	83	70

Notes:
1. Sample designation, see Table 1.
2. Draw ratio = wind speed/unwind speed.
3. Instantaneous extension and release and one minute recovery time.
4. Instantaneous extension, three minutes constant loading and one minute recovery time

On the other hand, in the sample #3 the SB web was against the lower smooth steel heated roller. SEM

Figure 2
CROSS-SECTIONAL SEM PHOTOGRAPH OF LAMINATE, SAMPLE #1 (SB1-TCPP1)

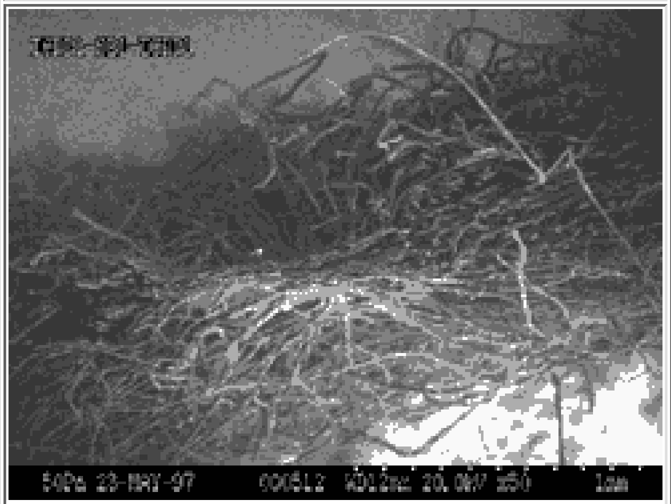
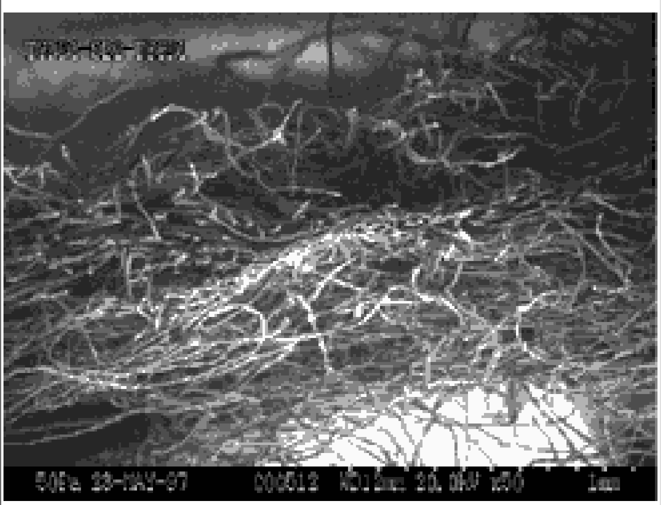


Figure 3
CROSS-SECTIONAL SEM PHOTOGRAPH OF LAMINATE, SAMPLE #6 (TCPP1-SB1-TCPP1)



photographs clearly show the fabrics (1-5) containing two layers are bonded to each other at the bonding points, with sample #1, which contained the heavier weight spunbond, having a more defined bond *(Figure 2)*. The three layered sample #6, also containing the heavier spunbond web, was observed by SEM to have clear bonding points *(Figure 3)*. The SEM of the other three layered laminates #7 showed the outer layers were not bonded with the center layer *(Figure 4)*.

Although these fabrics have notable extensibility than could have been obtained by laminating the outer cotton nonwovens to pre-bonded SB fabrics, it was believed that their stretchablility could be substantially improved by subjecting them to the TANDEC "Web Consolidation" process. Thus these fabrics were post-treated by the process, which heats the fabric while it is being drafted in the machine direction (MD) or conversely, while the fabric is being stretched in the cross-machine direction (CD), if MD elasticity is desired. *Table 2* shows the processing conditions for the stretching process and the properties of the fabrics produced.

In order to determine the relative wettability (and liquid holding capacity) of the cotton-surfaced laminates, a strike-through test using a simulated urine solution was performed on the samples. A Lenzing Lister Strike-Through-Time Instrument with a SR 232 PC Interface was utilized. The cotton-surfaced sides of the laminates were placed on the paper layers. Whenever the SB side was tested, it was placed on the paper layers.

Results

1. The stretching process increased the basic weight of the fabrics *(Tables 1 and 2)*.
2. The stretching process increased the fabric thickness.
3. Instantaneous elastic recovery at 50% extension and one-minute recovery time was in the range of 83-93% *(Table 2)*
4. Time dependent elastic recovery at 50% extension with three minutes under fixed length and one-minute recovery time, was in the range of 68-77%.
5. Although the strike-through times greatly exceed those of diaper coverstocks, for which the test was designed, it appeared that useful wettability data were

Figure 4
CROSS-SECTIONAL SEM PHOTOGRAPH OF LAMINATE, SAMPLE #7 (TCPP1-SB2-TCPP1)

obtained *(Figure 5)*.

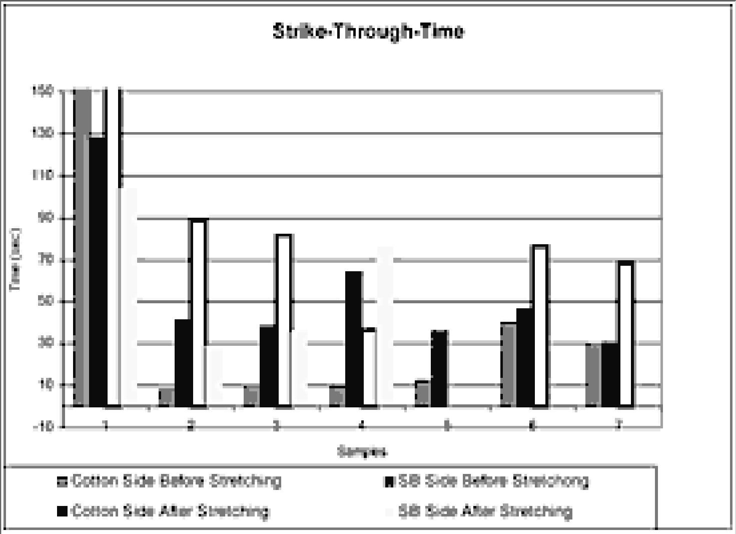
a. Sample #1 (SB1-TCPP1) had phenomenally high strike-through times as determined with the cotton surface against backup paper, both before and after "Web Consolidation." Testing with SB layer against the backup paper also results in very high strike-through times. This sample, which has the lowest cotton content of 41%, also appears to have the lowest tendency to lint compared to all of the other samples.
b. The two component laminate samples #2, #3 and #4 resulted in increases in strike-through times as measured with the cotton side against the backup paper, after "Web Consolidation" of 4X to 10X, indicating that water absorbing properties of the stretchable laminates were greatly improved.
c. Strike-through times of TCPP/SB/TCPP laminates generally increased after "Web Consolidation," proportional to the increase in basis weight. However, it would be expected that greater strike-through time, even before "Web Consolidation," would result during the test due to the total increase in absorption capacity of laminates with cotton on both sides.

The results were very encouraging. Especially, since this was the first attempt at producing a cotton laminate with a spunbond, on-line. It is also the first time that these fabrics have been through the stretching process, There is ongoing work to determine the processing conditions that will yield optimum fabric performance. These fabrics would be suitable for medical isolation gowns, head covers, bed sheets, and pillowcases. They could also be used for consumer applications such as disposable underwear, towels, wipers and personal hygiene products.

Conclusions
Stretchable cotton containing nonwovens were produced having good elastic recovery. The composite base fabrics can be produced on-line by using standard spunbond equipment. A post-treatment is used to create elasticity in the cross machine direction of the fabrics. It appeared that the computer interfacial "strike-through" test may be another useful tool in determining the effects of laminate fiber compassion and

of "Web Consolidation" on the wettability properties of the fabrics.

Cotton is an important component of these fabrics because of its soft hand, comfort, water holding capacity, moisture vapor transfer, wet strength, and consumer appeal. Finally, it appears that an inexpensive technology has been developed which, with additional refinement, could hasten the consumers' ready acceptance of nonwovens as highly desirable textile appeal.



#1: SB1-TCPP1; #2: SB2-TCPP1; #3: TCPP2-SB2; #4: SB2-TCPP2; 5#: SB2-TCPP3; #6: TCPP1-SB1-TCPP1; #7: TCPP1-SB2-TCPP1

Figure 5
STRIKE-THROUGH-TIMES OF THE LAMINATES

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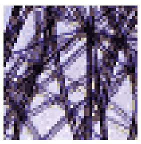

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INTERNATIONAL NONWOVENS Journal

ORIGINAL PAPER/Peer Reviewed

Pore Size and Air Permeability Of Four Nonwoven Fabrics

By Helen H. Epps and Karen K. Leonas, The University of Georgia, Athens, GA

Abstract
The relationship between pore size and air permeability in two spunlaced fabrics and two spunbonded/meltblown/spunbonded (SMS) fabrics were investigated. Minimum, maximum and mean flow pore sizes were determined using liquid porosimetry. The influence of fabric weight and thickness on air permeability and pore sizes was also evaluated. For the spunlaced fabrics, air permeability was most highly correlated with mean flow pore size, while there was a significant correlation between air permeability and maximum pore size for the SMS fabrics. Liquid porosimetry is a useful technique in assessing pore sizes of nonwoven fabrics and can also aid in understanding the mechanism of air permeability.

Key words: air permeability, liquid porosimetry, porosity, pore size, porometer, spunbonded, meltblown, spunlaced

Introduction

Thermal insulation, filter media, and fluid barriers are among the nonwoven end-use applications that are influenced by the void volume within nonwoven materials. In most applications both the void volume and its accessibility to the passage of air or other fluids are important. Although the terms "porosity" and "permeability" are sometimes used interchangeably, it is important to distinguish between the two properties. This paper presents a brief overview of research on relationships between structural characteristics, porosity and air permeability of nonwovens, reviews some of the methods of pore measurement and explores relationships between porosity and air permeability measurements of four nonwoven fabrics.

Air permeability is defined as "the rate of air flow through a material under a differential pressure between the two fabric surfaces." [1] Porosity can be defined as the total volume of void space contained within the boundaries of a material. In discussing the relationship between porosity and permeability, Scheidegger [2] prefers the term "pore structure," claiming that there can be no general correlation between porosity and permeability because the permeability of a material is influenced by the capillary pressure curves and the internal surface area of the pores within the material, rather than the actual volume of the open space. Scheidegger maintains that even "pore size" is difficult to characterize accurately because the pore system within a material typically forms a very complicated pore surface that is geometrically irregular. The term "diameter" is typically used in describing pore size, but Scheidegger notes that this term is inappropriate because pores usually are not spherical, or even tube-shaped.

Calculated Porosity
A theoretical, calculated value for porosity can be determined, and has been defined as the ratio of air space to the total volume of the fabric, expressed as a percentage. [3] The terms used in this calculation are the specific gravity of the component fibers and the weight and thickness of the specimen, as indicated in the formula [4]:

$P = 100 - P_a/P_b$

where P_a is the fabric density and P_b is the fiber density. Fabric density, P_a, expressed in grams per cubic centimeter (g/cc), is calculated by dividing the fabric weight (g/cm^2) by the fabric thickness (cm):

$Pa = (g/cm^2)/cm$.

Previous Research
Several previous studies have addressed the relationship between air permeability and structural characteristics of nonwovens, including fabric weight, thickness, density and fiber diameter. [5,6,7,8,9] Generally, these studies have shown that air permeability decreases nonlinearly as thickness, weight or fabric density increases. However, in a study of 80 nonwoven filters, air permeability declined linearly with increases in thickness. The same study also showed that fabric density had a more significant influence on air permeability than either thickness or fiber size. [5]

In a study designed to determine how the method of conversion of a fiber web into a nonwoven fabric influenced air permeability, Kothari and Newton [6] found that among the needlepunched, stitchbonded and adhesive bonded fabrics that were evaluated, weight per unit area was a stronger determinant of air permeability than either thickness or fabric density. Evaluating the same data, Dent [7] maintained that the second most important factor was fabric density.

Atwal [8] studied 140 needlepunched fabrics constructed from 16 different fibers. A wind tunnel was used to determine fabric air resistance, the reciprocal of air permeability. Air resistance increased with fabric thickness and fabric weight per unit area, but decreased with fiber fineness.

Since nonwovens often are constructed from a blend of fibers, Subramaniam et al [9] investigated 48 needlepunched fabrics composed of various proportions of different fibers, including jute, wool, acrylic and polypropylene. It was concluded that fiber volume fraction, defined as fabric density divided by fiber density, was an important factor in air permeability of these structures.

It has been said that there is no general correlation between air permeability and porosity [2] or between air permeability and liquid permeability. [10] The geometric configurations of any porous medium are complex and difficult to quantify. In the case of a nonrigid, flexible material, such as a nonwoven fabric, pore configurations can be even more complex and can change as the structure is deformed during the measurement process. Although the irregularity of pore geometry complicates measurement, pore size measurements of textile fabrics were reported as early as 1949. [11,12] Even earlier, Clayton [13] addressed the relationship between air permeability and porosity, identifying three factors in the relationship: 1) cross-sectional area of each pore; 2) depth of each pore, or the thickness of the fabric;

and 3) the number of pores per unit area.

The early research in fabric porosity relied almost exclusively on mercury intrusion. Mercury porosimetry methods require measurement of mercury intrusion and extrusion under pressure in the evacuated specimen. [14] Developed in the field of petroleum technology, mercury intrusion/extrusion methods have proven effective in measuring pores in rigid solids. However, mercury has a high surface tension, requiring a high pressure to force it into pores. Consequently, when used in measuring flexible materials such as fabrics, the high pressure can distort the geometry of the pores that it attempts to characterize. [4,15] Using a lower pressure modification of the mercury intrusion technique, Burleigh et al [11] found a direct correlation between interfiber pore spaces and air permeability, and employing a similar technique, Wakeham et al [12] found porosity data useful in explaining differences in air permeability among a series of fabrics.

Miller and Tyomkin [15,16] developed a liquid extrusion method of pore analysis that can utilize any liquid that completely wets the material. The specimen is saturated with the liquid, then the liquid is extruded as a pressure gradient is applied across the specimen and the extrusion is monitored gravimetrically. Accurate in measuring pore diameters as small as 0.5 micrometers, the method measures the "effective radius" of pores, defined as the minimum distance between the surfaces within a pore, regardless of how irregularly shaped the pore is.

Miller and Tyomkin indicated that this method is particularly applicable for predicting liquid absorption or retention by the material, but it may not be the best method to use in assessing barrier performance because it does not give a complete pore size distribution.

Although there has been only limited research on the relationship between porosity and air permeability, Hassenboehler [17] actually proposed the use of air permeability measurements over a range of pressure drop in analyzing fabric pore structure. Previous work has demonstrated a nonlinear relationship between air permeability measurements and the pressure differential at which the test is performed. [18,19,20] This relationship was also noted in later research [21] and is addressed in a recent paper. [22] Building on this nonlinear relationship, Hassenboehler proposed that changes in the slope of the pressure drop/permeability curve marked the onset of nonlinear air flow, or turbulence in the initial flow channels, and the addition of discrete air flow in separate, smaller channels. As the pressure differential is gradually increased, air flow is initiated through successively smaller pores.

The liquid extrusion method that forms the basis of ASTM method E 1294-89 [23] for porosimetry of membrane filters has been successfully used to evaluate porosity of textile materials, including nonwovens. The specimen is wetted with a liquid of low surface tension and the liquid is extruded under increasing air pressure. The maximum pore size is determined according to the first air flow, identified as the bubble point. Air flow thorough the specimen increases as successively smaller pores empty, and the air flow is recorded as a function of air pressure. The results are compared with the flow rate through the dry sample and the data are used to determine pore size distribution for the sample. The liquid employed in the test may be the commercial product Porofil®, or isopropyl alcohol, water, or mineral oil. When Porofil® is used, the pore size measurement range of the porometer specified in the method is 0.05 to 300 µM. Pore "size" represents pore diameter. Neither specimen thickness nor the complexity of the pore structure are considered in pore size measurement using the liquid extrusion method. However, a "tortuosity factor," defined as the reciprocal of porosity, may be specified in the test. The tortuosity factor is a rough indication of the complexity of the flow path, or the deviation from the theoretical cylindrical flow path. [24] The flow paths in some nonwovens may indeed be more complex than those of woven fabrics. The increased complexity may be due to the randomness of some nonwoven structures, or the method of bonding, such as the random hydroentanglement of spunlaced fabrics.

Experimental

Although it is logical to expect that air permeability of nonwovens is dependent on porosity, there is limited experimental evidence in the literature of an attempt to correlate the two parameters. This study represents an attempt to characterize the relationship between air permeability and porosity determinations for two types of nonwovens.

Table 1
FABRIC CHARACTERISTICS

Fabric	**Type**	**Composition**	**Weight g/m^2 Mean (s.d.)**	**Thickness µm Mean (s.d.)**	**Bulk Density g/cc**
A	spunlaced	wood pulp/polyester	74.7 (3.7)	287 (17.7)	26.02
B	spunlaced	wood pulp/polyester	64.0 (1.4)	264 (13.2)	24.24
C	SMS	polypropylene	61.5 (8.1)	325 (61.1)	18.92
D	SMS	polypropylene	87.3 (8.8)	423 (33.5)	20.64

Four nonwoven fabrics commonly found in commercially available surgical gowns were used in the study. Fabric and fiber types and physical characteristics are listed in *Table 1*. Fabrics A and B were spunlaced and fabrics C and D were spunbonded/meltblown/spunbonded (SMS) structures. SMS is a three-layer composite with a meltblown nonwoven sandwiched between spunbonded fabrics. Information on the proportion of spunbonded to meltblown in the SMS fabric, and data on fiber size were not available from the manufacturer, nor was it possible to extract fibers from the fabric for measurement, since the fabric manufacturing process alters the structure.

Weights and thicknesses shown in *Table 1* are means of five measurements taken using standard ASTM procedures. Bulk density values were calculated from weight and thickness data.

Percent porosity values, included in *Table 2,* were calculated from fabric density and specific gravity of the components, as described in the literature. [3,4] Air permeability was measured using a Frazier high pressure air permeometer, as specified in ASTM D7371, using a pressure differential of 12.7 mm of water. Ten measurements were taken of each fabric.

Table 2
PERMEABILITY AND POROSITY RESULTS

Fabric	**Calculated Porosity (%)**	**Air Permeability (cm3/cm2/s) Mean (s.d.)**	**Mean Flow Pore Size (µm) Mean (s.d.)**	**Min Pore Size (µm) Mean (s.d**	**Max. Pore Size (µm) Mean(s.d.)**
A	81.28	41.94 (1.21)	27.99 (4.35)	19.24 (2.16)	46.77 (4.29)
B	82.56	19.46 (0.25)	35.00 (2.05)	20.05 (0.96)	44.16 (1.34)
C	80.29	38.66 (1.24)	15.40 (0.89)	12.03 (0.36)	23.83 (1.73)
D	78.50	13.86 (0.22)	15.40 (1.65)	11.89 (0.71)	22.17 (1.32)

A Coulter Porometer II was used to measure pore size characteristics as specified in ASTM E1294-89.

The commercial reagent Porofil® was used as the wetting agent. Ten specimens of each fabric, taken from the regions that had been used for air permeability measurement, were tested after conditioning. Minimum pore size, maximum pore size and mean flow pore size, derived from wet and dry pressure/flow curves were obtained, as described by Batchu. [24]

Table 3
CORRELATION BETWEEN VARIABLES

Variables	Correlation			
	Spunlaced		SMS	
	r	P>r	r	P>r
Air Perm & Mean Flow Pore Size	-.791	.0001	NSC[a]	
Air Perm & Min. Pore Size	NSC		NSC	
Air Perm & Max. Pore Size	NSC		.466	.0318
Air Perm & Calculated Porosity	NSC		.986	.0001
Air Perm & Weight	NSC		-.986	.0001
Air Perm & Thickness	NSC		-.986	.0001
Mean Flow Pore Size & Min. Pore Size	.741	.0002	.615	.0039
Mean Flow Pore Size & Max. Pore Size	NSC		NSC	
Mean Flow Pore Size & Calculated Porosity	.736	.0002	NSC	
Mean Flow Pore Size & Weight	-.740	.0002	NSC	
Mean Flow Pore Size & Thickness	-.746	.0002	NSC	
Min. Pore Size & Max. Pore Size	NSC		NSC	
Min. Pore Size & Calculated Porosity	NSC		NSC	
Min. Pore Size & Weight	NSC		NSC	
Min. Pore Size & Thickness	NSC		NSC	
Max. Pore Size & Calculated Porosity	NSC		.492	.0276
Max. Pore Size & Weight	NSC		-.491	.0276
Max. Pore Size & Thickness	NSC		-.492	.0275

[a]NSC - no significant correlation; P>.05

Results

The calculated porosity values and results of air permeability and pore size measurements are shown in *Table 2*. Means and standard deviations from 10 measurements per fabric are presented for air permeability, mean flow pore size, minimum pore size and maximum pore size.

With respect to calculated theoretical porosity, the four fabrics represented only a narrow range of values. Spunlaced fabric B, which had the highest calculated porosity, also had the highest mean flow pore size, and the highest minimum pore size. Fabric A, also spunlaced, had the highest air permeability and the highest maximum pore size. Fabric D, an SMS structure, had the lowest values for calculated porosity, air permeability, minimum and maximum pore size and tied with fabric C for the lowest mean flow pore size.

Coefficients of correlation were calculated between the variables air permeability, mean flow pore size, minimum pore size and maximum pore size. Correlations between each of these variables and calculated porosities, fabric weight and thickness were also determined using SAS. [25] Because of the different structural types, the spunlaced and the SMS fabrics were analyzed separately. The correlation coefficients and corresponding significance levels are listed in *Table 3*.

The highest correlations among all of the variables occurred in the analysis of the SMS data and included a correlation coefficient of .986 between air permeability and calculated porosity, and negative correlations of the same level between air permeability and fabric weight and between air permeability and thickness, all significant at the .0001 level. There was also a significant correlation between air permeability and maximum pore size for the SMS fabrics. It is expected that the practical significance of this finding is that at the pressure differential of 12.7 mm used in the air permeability test, the larger fabric pores are involved in the air flow in the SMS fabrics. If a higher pressure differential were used in the air permeability test, there likely would be significant correlations between the air permeability data and mean flow pore size or minimum pore size for the SMS fabrics.

For the spunlaced fabrics, the only significant correlation with air permeability was a negative correlation of -.791 with mean flow pore size, indicating that as the mean flow pore size increased, air permeability decreased. In the case of the spunlaced fabrics, the fact that mean flow pore size was highly correlated with air permeability, while neither minimum nor maximum pore size were, shows that the mean flow pore sizes involved in the porometry test were also the size pores that were most heavily involved in air permeability of these fabrics. At the standard pressure differential used in the air permeability test, neither the minimum size pores nor the maximum size pores were primarily responsible for air flow.

Other important relationships include significant correlations between mean flow pore size and minimum pore size for both sets of data, and between mean flow pore size and calculated porosity for the spunlaced fabrics. Also, both weight and thickness were negatively correlated with mean flow pore size for the spunlaced fabrics and with maximum pore size for the SMS fabrics.

Conclusions

In agreement with previous research on a range of nonwoven fabrics, fabric weight and thickness were both inversely proportional to air permeability. However, this relationship was statistically significant for only the SMS fabrics. Weight and thickness were also significantly and negatively correlated with some of the pore size measurements.

Liquid porosimetry can be used in evaluating fluid flow and barrier performance, and may also be useful in understanding air permeability. The relationship between air permeability and pore size of nonwovens is complex. Statistical correlations between pore size measurements and air permeability have been demonstrated and it has been suggested that the level of significance of correlation between air permeability and mean flow pore size for the spunlaced fabrics and between air permeability and maximum pore size for the SMS fabrics may be an indication of the pore size that is primarily involved in air flow in the air permeability test.

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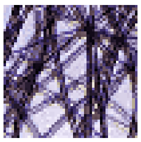

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INTERNATIONAL NONWOVENS Journal

ORIGINAL PAPER/PEER-REVIEWED

Analysis of Roofing Mat Structure

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Abstract
We describe hardware and software features of an image analysis-based instrument developed in our laboratory to characterize web structure. The potential value of detailed web analysis that is possible today using image analysis is illustrated for a small number of roofing mat webs by characterizing basis weight (small area) uniformity, fiber bundle orientation (directionality control) and fiber bundle diameter (dispersion quality). From this analysis, we show that it is possible to observe differences in web structure between the top and wire sides of webs, built-up roofing and shingle mat webs, production with hydraulic pressurized (closed) and atmospheric (open) headboxes, production with and without a flow synchronizer, and web basis weight.

Introduction
Properties of nonwoven webs, like the properties of any fibrous material, result from two general things - the properties of fibers in the web and the way fibers are assembled in the web (web structure). In other words, knowledge of web structure is necessary to understand web properties. It is also necessary to have knowledge of the variation in web structure to understand some web properties (e.g., strength). It is also generally desirable to measure web structure when evaluating changes in web production processes.

Detailed structural information is not usually obtained for nonwoven webs and variations in web structure are measured even less often. An important reason for this is that analytical tools used to characterize web structure are generally lacking. However, remarkable advancements have occurred during the last decade in technological areas that support the broad area of analysis. These include personal computers, video cameras and motion control devices. These advances have lead to the development of computer vision systems for analysis in diverse areas such as advertising and weapons applications. The successes of these applications suggest that vision techniques may be used to characterize web structure in the off-line laboratory environment as well as the on-line production environment.

Advances seen during the last decade in desktop computer and imaging hardware are expected to continue in the future. It is reasonable to expect that computer-based vision systems will continue to become less expensive, more widely available, more familiar, more powerful and easier to operate. Similarly, computer software intended for widespread use (e.g., computer operating systems) will continue to become more sophisticated, more powerful and easier to operate. On the other hand, application-specific software that does not enjoy widespread public use must be developed by workers in the application field. Ten years ago, we began to develop software specifically to characterize structure in nonwoven webs. This work has resulted in a good foundation of basic software techniques useful for web structural characterization.

Nonwoven web analysis is more difficult than analysis of many materials. Web structural patterns are not reproducible as they are in many vision applications such as inspecting labels on food boxes. Nonwoven webs also are relatively nonplanar. That is, analysis of many web features (e.g., single fiber diameter) requires a large enough magnification during image acquisition that the web is thick and three-dimensional compared to the depth-of-field provided by the lens. Analysis of nonwoven webs is also complicated by the fact that they often exhibit poor structural uniformity. For example, basis weight may vary substantially in the MD (machine direction) and CD (cross direction) so web areas must be analyzed from many locations along the MD and CD to obtain reliable and objective structural information. Analysis is even more demanding for web defects since a large web area must be examined with no missed area and no overlap. These difficulties lead us to conclude that manually preparing enough samples representing an adequate web area and manually repositioning each sample between measurements is simply impractical and often accompanied by mistakes. From a practical standpoint, automating the analysis process should be an important functional element of a web analysis instrument.

Our laboratory has designed and developed a fully computer-controlled multifunction instrument dedicated to nonwoven web analysis using image analysis-based techniques [1]. Manual analytical tools limit analysis time, but automated systems encourage users to sample webs extensively enough to obtain good analysis results. For example, manually measuring the fiber orientation distribution in only a small area of an individual web often requires an entire day. Automated image analysis-based measurements can measure the orientation directions of several thousand fibers and plot the full orientation distribution in a few minutes.

The instrument we developed features powerful multifunction capability, flexible control and automated sampling. It has proven to be efficient, convenient and flexible for analyzing nonwoven web structure. We can place a fairly large web sample (up to 50cm x 50cm or 15cm x 91cm) on the instrument, input settings for a test (total number of images to be acquired, web locations of acquired images, etc.) and then start the program. Once analysis begins, it continues without human intervention until analysis is completed and then a statistical summary of analysis results and a data chart are ready to print. In view of the wealth of structural information available in images, a single image analysis-based instrument has the potential to replace several other instruments used to characterize web structure. This makes the instrument economical because several analysis modules share hardware and software resources.

We briefly discuss hardware and software features of the instrument developed in our laboratory and then present analysis results for roofing mat samples obtained from different manufacturers using variations on the wetlay nonwovens process [2]. In particular, the samples were produced using different headbox systems. The number of available samples and our knowledge of roofing mat production were both quite limited, so our data cannot be used to reach definitive conclusions about web manufacture. However, we illustrate the potential value of web analysis that is available today by examining possible relationships between web structure and web production systems.

Experimental

Hardware

Our system was assembled using relatively inexpensive hardware components.

Figure 1 shows a schematic illustration of the basic hardware system. This system consists of a desktop personal computer, system (computer) monitor to input analysis commands, printer for statistical summary and data chart printing, monochrome CCD video camera, monochrome video monitor to observe images from the camera, monochrome frame grabber board installed in the computer to digitize images from the camera, motorized XY table to move webs during analysis, modified microscope with motorized focusing, illumination sources and various lenses. Most of these items were purchased from commercial vendors off-the-shelf.

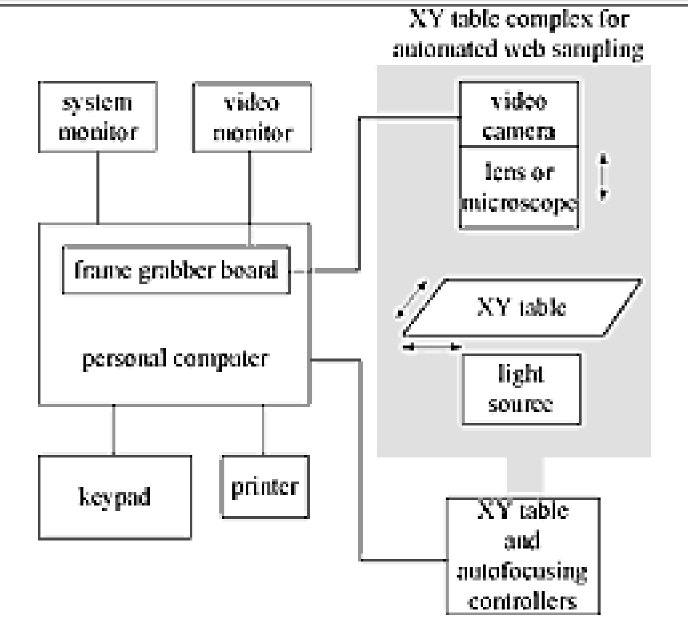


Figure 1
INSTRUMENT HARDWARE CONFIGURATION

Software

The software developed in our laboratory is based on image processing and pattern recognition techniques and was designed to be used in inexpensive personal computers. Once an image is acquired, the objects of interest must be detected and this usually is the most important and difficult task in image processing if it is performed accurately. Steps typically required include smoothing, edge detection, thresholding and image cleaning. Once the objects of interest are detected, each one is usually described in terms of its size, shape and orientation direction.

Table 1
STRUCTURE MEASURED BY
WEB ANALYSIS INSTRUMENT

Structural Feature	Measurement
Pores (thin webs)	Size distribution
	Shape distribution
	Orientation distribution
	Number per unit web area
	Pore cover percent
Fiber Bundles	Orientation distribution
	Diameter distribution
	Percent of fibers near MD
	Percent of fibers near CD
	MD/CD fiber ratio
Single Fiber	Diameter Distribution

Our software was designed to characterize six major structural features of nonwoven webs as summarized in *Table 1*. This table shows that an impressive amount of web structural information can be obtained using a single image analysis-based instrument. Since software based on the same hardware could be developed to measure numerous other web structural features, an image analysis system is a cost effective analytical tool having substantial growth potential.

Roofing Mat Samples

A total of seven roofing mat samples were obtained from different manufacturers. Several specimens measuring about 30cm x 30cm were supplied for each sample. The availability of several specimens allowed us to compute means and standard deviations of measurements among the specimens

Diameter (thin webs)	Mean diameter Coefficient of diameter variation
Basis Weight Uniformity	MD, CD and TOTAL uniformity spectra
Bright & Dark Defects	Size distributions Intensity distributions Numbers per unit web area Defect cover percent
Shot (meltblown webs)	Size distribution Shape distribution Number per unit web area Shot cover percent

analyzed for each of the seven samples. All mat production equipment was the inclined wire type and included both built-up roofing (BUR) and shingle mat (SM) processes. Five webs were made with and two were made without a flow synchronizer. A short description of each sample and the number of specimens analyzed are summarized in *Table 2*.

Description of Web Measurements

Small Area Basis Weight Uniformity

When webs are illuminated with uniform diffused light, local web areas having heavier basis weight transmit less light and appear darker than web areas having lighter basis weight. Both theory and practical experiments have shown that basis weight may be estimated from the optical density of images [3]. Basis weight uniformity can be expressed in terms of the variation in optical density by computing the coefficient of brightness (gray level) variation (CV%), the gray level standard deviation among image areas divided by the mean gray level of all areas.

To increase the usefulness of basis weight measurements, the CV% can be automatically computed for image areas that vary in size from whole images to individual pixels. This information is summarized in plots of CV% versus size resolution, which we call basis weight uniformity spectra. Uniformity spectra were measured in this study for areas varying in size from 28mm x 28mm to 50mm x 50mm. Spectral values for sizes at the extremes of this range are reported in data tables since they represent formation uniformity (28mm x 28mm) and dispersion uniformity (50mm x 50mm) in roofing mat webs. Measurements for sizes that represent large area uniformity (>> 28mm x 28mm) were not measured because of limited sample availability.

To further increase the usefulness of basis weight measurements, image areas can be organized spatially three different ways when computing CV% and three different basis weight uniformity spectra may be generated. The total web uniformity spectrum represents basis weight uniformity without regard to direction. The machine direction uniformity spectrum represents basis weight uniformity only in the MD. The cross machine direction uniformity spectrum represents basis weight uniformity only in the CD.

Fiber Bundle Orientation

Entanglement of single fibers into fiber bundles is an important phenomenon since fiber bundle size influences many properties (e.g., web stiffness) and bundle orientation influences other properties (e.g., tensile strength). For analysis purposes, fiber bundles include any cohesive fiber unit ranging from single fibers to large groups of tightly bunched fibers [4]. Fiber bundle orientation measurements represent directionality control for roofing mat webs.

Many locations in each acquired image are randomly selected and the nearest identifiable bundle is located. Enough images are acquired so that a total of several thousand bundles are measured. The orientation direction of each fiber bundle is automatically measured and results for all measurements are presented as the fiber orientation distribution. Several types of distributions exist, but we measure a diameter-based orientation distribution, which shows the percentage of fiber diameter oriented at angles through 180º. We believe that a diameter-based distribution generally correlates with mechanical properties better than a more traditional number-based distribution since fiber bundle diameters typically vary over a substantial size range in most webs [4].

To simplify orientation data, other measures of fiber orientation also are computed. These include the percentage of fiber bundles that are oriented near the MD (MD +/-20º), the percentage of fiber diameter oriented near the CD (CD +/-20º), and the ratio of these (%MD/%CD).

Fiber Bundle Diameter
At the same time fiber bundle orientation is measured, the diameter of each fiber bundle can be measured [4]. Bundle diameter measurements are presented as a bundle diameter distribution. Again, measurements are presented other ways to increase their usefulness. These include computing the average (mean) diameter of all bundles measured and the maximum bundle diameter detected. These measurements represent dispersion quality for roofing mat webs. Our system was assembled using relatively inexpensive hardware components. **Analysis Results**
The samples described in *Table 2* allowed us to make comparisons of four different parameters in a fairly restricted manner. These parameters and columns in the following data tables that are compared during the subsequent discussion are

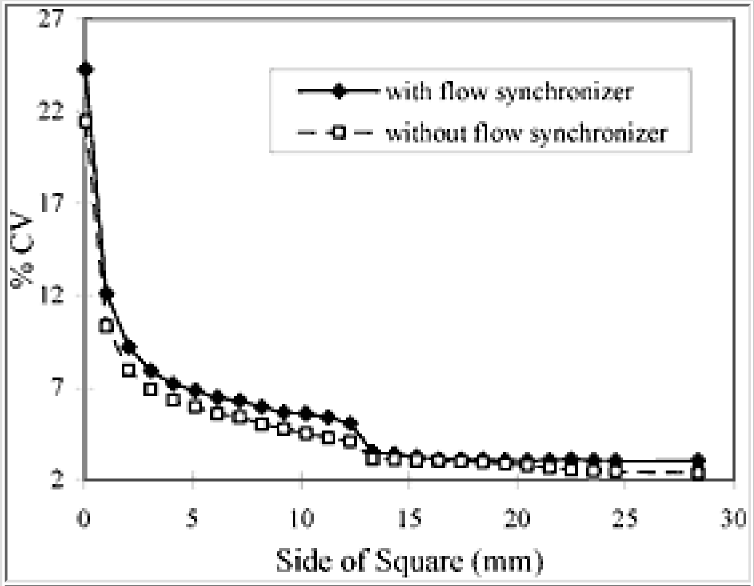
(a) Built-up roofing versus shingle mat processing line (compare data table columns 3 vs. 5 and 4 vs. 6),

(b) Hydraulic pressurized (closed) headbox versus atmospheric (open) headbox (compare data table columns 3 vs. 4 and 5 vs. 6),

(c) Headbox with and without a flow synchronizer (compare table columns 6 vs. 7), and

(d) 2.1 versus 1.8 lb/100ft2 basis weight (compare table columns 1 vs. 3).

Small Area Basis Weight Uniformity
For each web specimen, uniformity spectra were computed after acquiring 64 images, each measuring



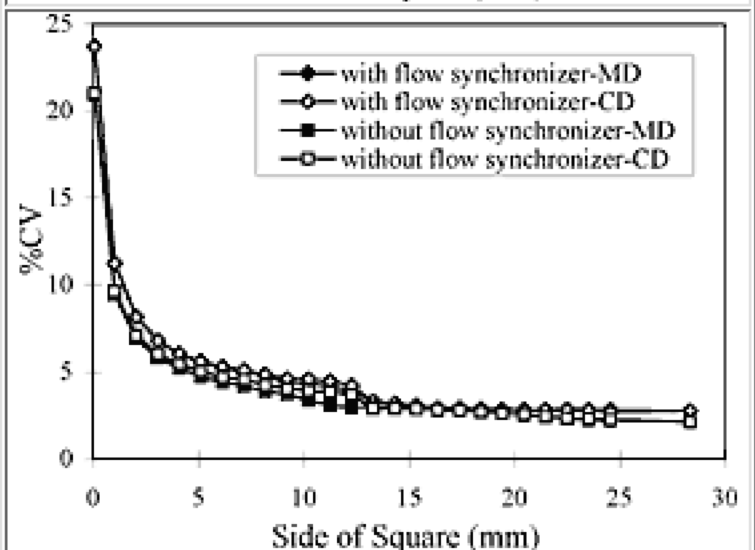


Figure 2
BASIS WEIGHT UNIFORMITY FOR ONE SPECIMEN:(A) TOTAL UNIFORMITY (TOP) AND (B) MD AND CD UNIFORMITY (BOTTOM)

about 28mm x 33mm. Uniformity was expressed as the coefficient of variation (CV%) computed for web areas varying from 28mm x 28mm to 50mm x 50mm.

Experimental Hardware

(a) total uniformity (top) and (b) md and cd uniformity (bottom)

Examples of these results are shown in *Figure 2* for one specimen that is included in the data for column 6 (1.8 shingle mat atmospheric headbox) and one specimen that is included in the data for column 7 (1.8 shingle mat no synchronizer headbox) of *Table 3.* *Figure 2* shows that basis weight uniformity of both web specimens generally increased (basis weight variation decreased) as the size of the web area analyzed increased. This general trend is observed for most webs since structural variations that exist within smaller web areas are physically averaged when larger areas are evaluated.

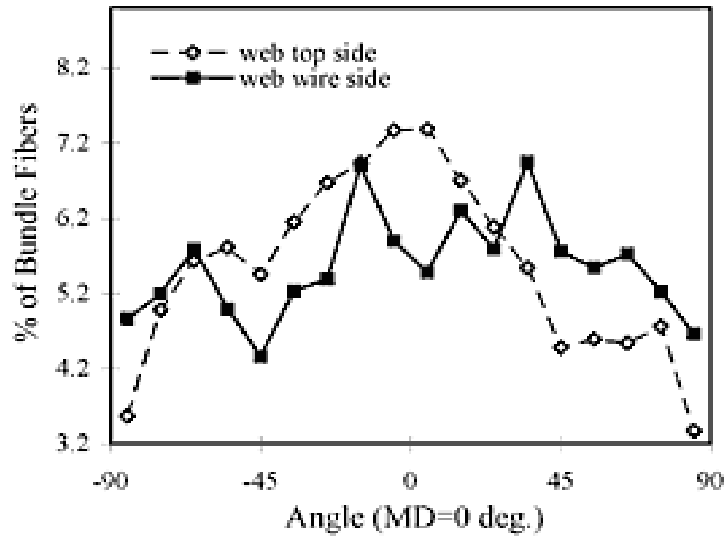


Figure 3
FIBER BUNDLE ORIENTATION DISTRIBUTIONS FOR ONE SPECIMEN'S TOP AND WIRE SIDES

Table 2
DESCRIPTION OF ROOFING MAT SAMPLES

Mat Type	Headbox	Basis Weight (lb/100ft2)	Number of Specimens	Column in Data Tables
BUR	Hydraulic Pressurized (closed)	2.1	6	1
BUR	Inclined Wire but no synchronizer (open)	2.0	5	2
BUR	Hydraulic Pressurized (closed)	1.8	6	3
BUR	Atmospheric (open)	1.8	4	4
SM	Hydraulic Pressurized (closed)	1.8	6	5
SM	Atmospheric (open)	1.8	10	6
SM	Inclined Wire but no synchronizer (open)	1.8	5	7

Table 3
SMALL AREA BASIS WEIGHT UNIFORMITY

Measurement	1 2.1 BURHP HP (Closed)	2 2.0 BUR NS (Open)	3 1.8 BUR HP (Closed)	4 1.8 BUR AT (Open)	5 1.8 SM HP (Closed)	6 1.8 SM AT (Open)	7 1.8 SM NS (Open)
Total Max CV (%) Mean	23.77	25.00	23.57	21.40	25.90	24.46	22.44
Std Dev	0.09	0.66	0.16	0.12	1.27	0.15	0.99
Min CV (%) Mean	2.23	2.64	1.98	2.13	1.93	3.05	2.38
Std Dev	0.29	0.14	0.21	0.15	0.17	0.38	0.13
MD Max CV (%) Mean	23.23	24.54	23.20	21.00	25.53	23.94	21.94
Std Dev	0.07	0.65	0.16	0.12	1.31	0.12	0.99
Min CV (%) Mean	2.05	2.40	1.67	1.78	1.77	2.65	2.12
Std Dev	0.20	0.17	0.14	0.08	0.18	0.36	0.12
CD Max CV (%) Mean	23.17	24.50	23.15	20.90	25.45	23.86	22.04
Std Dev	0.09	0.70	0.15	0.12	1.29	0.14	0.94
Min CV (%) Mean	2.03	2.44	1.78	1.90	1.63	2.78	2.06
Std Dev	0.29	0.23	0.21	0.12	0.16	0.34	0.16

See Table 2 for a description of samples. Mean and Std. Dev were computed among web specimens for each sample.

Figure 2a shows the total web uniformity (uniformity computed without regard for web direction). Basis weight is more uniform for the web produced without a flow synchronizer than for the web produced with a synchronizer. Uniformity differences between these two webs are most pronounced for areas smaller than 13mm x 13mm. Web uniformity was quite similar for larger web areas. *Figure 2b* shows MD and CD uniformity spectra for these same two web specimens. When each web is considered separately, its MD basis weight uniformity was quite similar to its CD uniformity. That is, web uniformity did not generally depend on web direction for either web. The web produced without a flow synchronizer, however, was slightly more uniform in its MD than in its CD through the size range from about 10mm to 13mm.

Figure 2 showed uniformity data for only two specimens. Uniformity data for all specimens were averaged for each of the seven webs and is summarized in *Table 3*. The seven columns in *Table 3* correspond to the seven webs described in *Table 2*. Means and standard deviations among web specimens are reported for each of the seven webs. Since it is difficult to summarize data through their entire spectra, only the maximum (50mm x 50mm web area) and minimum (28mm x 28mm web area) CV% values are shown in this table.

The two most basic ways to interpret the data in *Table 3* are as follows: (1) A web having uniform basis weight should exhibit small local basis weight variations; consequently, the mean CV% for each uniformity spectrum should be small. (2) A web having basis weight that is distributed uniformly through the web should exhibit similar mean CV% values among different specimens from the web; consequently, the standard deviation among specimen measurements should be small for each uniformity spectrum.

The following conclusions can be reached from these interpretations of *Table 3*.

(a) Built-up roofing webs generally exhibited more uniform basis weight than shingle mat webs, especially for the atmospheric (open) headbox.

(b) At smaller size resolutions, atmospheric (open) headbox webs exhibited more uniform basis weight than hydraulic pressurized (closed) headbox webs. At larger size resolutions, hydraulic pressurized (closed) headbox webs generally exhibited more uniform basis weight than atmospheric (open) headbox webs.

(c) Webs produced without a flow synchronizer generally exhibited more uniform basis weight than webs produced with a flow synchronizer, especially at larger size resolutions.

(d) At smaller size resolutions, basis weight uniformity did not vary with web basis weight. At larger size resolutions, lighter basis weight webs exhibited more uniform basis weight than heavier basis weight webs.

Fiber Bundle Orientation

For each web specimen, 100 images were acquired with each image measuring about 3.8mm x 5.1mm. This resulted in a total of 4,000-8,000 fiber bundles being measured for the top side of each web specimen and then repeated separately for the wire side. Examples of bundle orientation distributions are shown in *Figure 3* for the top and wire sides of one specimen that is included in the data for column 2 of *Tables 4 and 5*. In this figure, the MD was defined as the 0º angle. *Figure 3* shows that fiber bundles in this specimen were not randomly oriented on either the top or wire side of the web and one can see substantially more MD orientation on the top side than the wire side

Table 4
FIBER BUNDLE ORIENTATION: TOP SIDE OF WEB

	1	**2**	**3**	**4**	**5**	**6**	**7**
	2.1 BURHP	**2.0 BUR**	**1.8 BUR**	**1.8 BUR**	**1.8 SM**	**1.8 SM**	**1.8 SM**
Measurement	**HP (Closed)**	**NS (Open)**	**HP (Closed)**	**AT (Open)**	**HP (Closed)**	**AT (Open)**	**NS (Open)**
% bundles in MD							
+/-20º Mean	23.32	26.12	21.68	26.15	22.05	22.39	28.26
Std Dev	1.80	2.39	2.08	2.89	0.76	2.67	3.70
% bundles in CD							
+/-20º Mean	20.72	18.32	22.10	18.85	22.23	21.79	16.94
Std Dev	1.30	1.58	1.75	2.04	0.76	2.61	2.63
%MD/%CD Mean	1.12	1.46	0.98	1.40	0.98	1.06	1.72

Std Dev	0.16	0.24	0.15	0.27	0.08	0.23	0.45

See Table 2 for a description of samples. Mean and Std Dev were computed among web specimens for each sample

Table 5
FIBER BUNDLE ORIENTATION: WIRE SIDE OF WEB

Measurement	**1** **2.1 BURHP** HP (Closed)	**2** **2.0 BUR** NS (Open)	**3** **1.8 BUR** HP (Closed)	**4** **1.8 BUR** AT (Open)	**5** **1.8 SM** HP (Closed)	**6** **1.8 SM** AT (Open)	**7** **1.8 SM** NS (Open)
% Bundles in MD							
+/-20º Mean	21.83	26.38	20.32	24.63	21.08	21.30	28.44
Std Dev	1.74	2.09	2.05	2.59	1.54	1.16	2.45
% Bundles in CD							
+/-20º Mean	22.17	18.60	23.57	20.38	22.83	23.03	17.08
Std Dev	1.53	1.64	2.30	2.48	1.48	1.59	2.00
%MD/%CD Mean	1.01	1.42	0.87	1.25	0.92	0.95	1.70
Std Dev	0.16	0.23	0.16	0.31	0.12	0.12	0.34

See Table 2 for a description of samples. Mean and Std Dev were computed among web specimens for each sample

Bundle orientation data for all web specimens were averaged for each of the seven samples and is summarized in *Tables 4* for the top side and *Table 5* for the wire side of webs. The seven columns in these tables correspond to the seven webs described in *Table 2*. Means and standard deviations among web specimens are reported for each of the seven webs. Since it is difficult to summarize data through its entire distribution, only the percentage of bundles oriented near the MD, the percentage of bundles oriented near the CD and the ratio of these are provided in the tables.

The two most basic ways to interpret the data in these tables are as follows: (1) A web having random fiber orientation should exhibit the same number of fiber bundles oriented in both the MD and CD; consequently, one would expect that %MD/%CD = 1.0. Values of this ratio > 1.0 indicate overall MD orientation whereas values <1.0 indicate overall CD orientation. (2) A web having bundle orientation that is uniform through the web should exhibit similar orientation measurements among different specimens from a web; consequently, the standard deviation among specimen measurements should be small.

The following conclusions can be reached from these interpretations of *Tables 4 and 5.*

(a) The top sides of all webs exhibited more MD orientation than their wire sides.

(b) Built-up roofing and shingle mat webs did not differ consistently with respect to fiber bundle orientation. However, orientation was more uniform for shingle mat webs than for built-up roofing webs.

(c) Atmospheric (open) headbox webs exhibited more MD orientation than hydraulic pressurized (closed) headbox webs. This was especially true on the top side and for built-up roofing webs. The bundle orientation for hydraulic pressurized (closed) headbox webs was oriented in the CD on the wire side but nearly randomly on the top side. Bundle orientation was generally more uniform for hydraulic pressurized webs than for atmospheric webs, especially for their top side.

(d) Shingle mat webs produced without a flow synchronizer exhibited substantial MD orientation whereas shingle mat webs produced with a flow synchronizer exhibited approximately random fiber orientation. Bundle orientation was more uniform for webs produced with a synchronizer than without a flow synchronizer.

(e) Heavier basis weight webs exhibited more MD orientation than lighter basis weight webs. Bundle orientation was more uniform for heavier weight webs than for lighter weight webs.

Fiber Bundle Diameter

Measurements of fiber bundle diameter were made at the same time fiber bundle orientation was measured. An example of bundle diameter data is shown in *Figure 4* for one specimen that is included in the data for column 6 of *Table 6*. This figure shows the size distribution for about 6,500 bundles that were detected in the 100 images acquired for this specimen. The most common bundle diameter detected was about 65 mm. Nearly all fiber bundles had diameters less than 250 mm, but a small number of larger bundles (up to 365 mm) were detected. This is shown more clearly in *Figure 5*, which includes the same data as *Figure 4* but only for bundle diameters larger than 200 mm.

Table 6

FIBER BUNDLE DIAMETER: TOP SIDE OF WEB

Measurement	**1** **2.1 BURHP** **HP (Closed)**	**2** **2.0 BUR** **NS (Open)**	**3** **1.8 BUR** **HP (Closed)**	**4** **1.8 BUR** **AT (Open)**	**5** **1.8 SM** **HP (Closed)**	**6** **1.8 SM** **AT (Open)**	**7** **1.8 SM** **NS (Open)**
Avg Diameter (µm) Mean	68.35	70.60	76.78	75.53	72.28	74.61	76.00
Std Dev	1.20	1.31	1.06	0.26	1.04	0.77	2.10
Max Diameter (µm) Mean	286.70	312.24	302.07	312.40	302.22	305.99	324.76
Std Dev	19.12	13.05	15.13	29.55	33.86	26.88	16.55

See Table 2 for a description of samples. Mean and Std Dev were computed among web specimens for each sample

Table 7
FIBER BUNDLE DIAMETER: WIRE SIDE OF WEB

Measurement	**1** **2.1 BURHP** **HP (Closed)**	**2** **2.0 BUR** **NS (Open)**	**3** **1.8 BUR** **HP (Closed)**	**4** **1.8 BUR** **AT (Open)**	**5** **1.8 SM** **HP (Closed)**	**6** **1.8 SM** **AT (Open)**	**7** **1.8 SM** **NS (Open)**
Avg Diameter (µm) Mean	67.15	69.86	74.90	75.00	69.10	73.82	75.64
Std Dev	1.39	1.50	1.03	0.75	0.86	1.04	1.89
Max Diameter (µm) Mean	319.45	305.94	311.92	305.48	307.82	314.62	307.52
Std Dev	24.24	11.36	16.88	6.18	32.38	25.41	13.14

See Table 2 for a description of samples. Mean and Std Dev were computed among web specimens for each sample

Figures 4-5 showed bundle diameter data for only one specimen. Data for all specimens were averaged and is summarized in *Table 6* for the top side of each of web and *Table 7* for their wire side. Quantities included in this table are the mean bundle diameter and the maximum bundle diameter detected. The seven columns in these tables correspond to the seven webs described in *Table 2*. Means and standard deviations among web specimens are reported for each of the seven webs. The two most basic ways to interpret this data are as follows: (1) A web having smaller bundles should exhibit a smaller average bundle diameter. (2) A web having bundle sizes that are distributed uniformly through the web should exhibit similar average bundle diameters among different specimens from the web; consequently, the standard deviation among specimen measurements should be small.

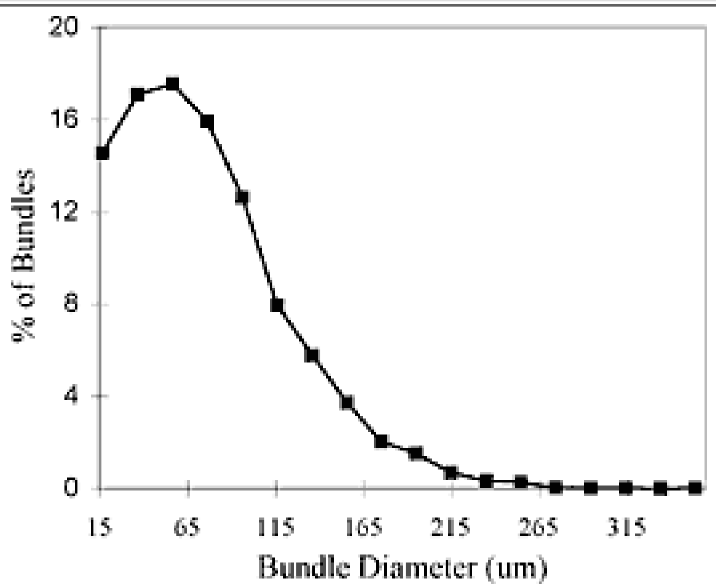


Figure 4
FIBER BUNDLE DIAMETER DISTRIBUTION

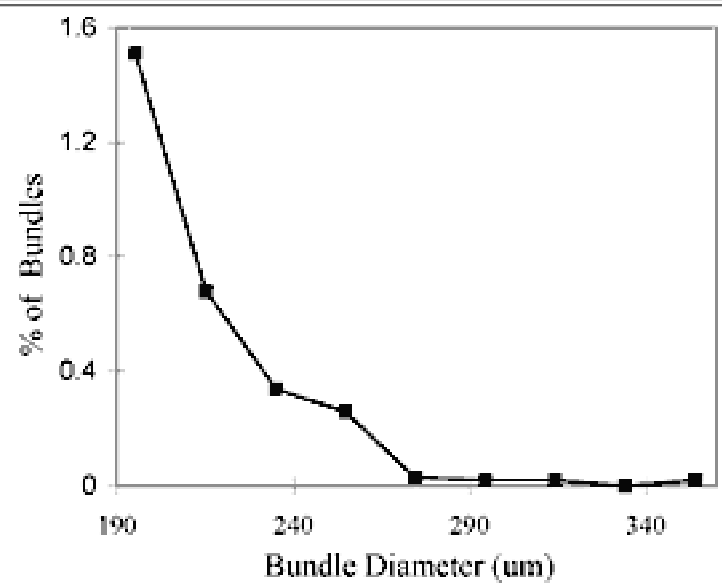


Figure 5
FIBER BUNDLE DIAMETER DISTRIBUTION

FOR ONE SPECIMEN	FOR BUNDLE SIZES ≥200 MM

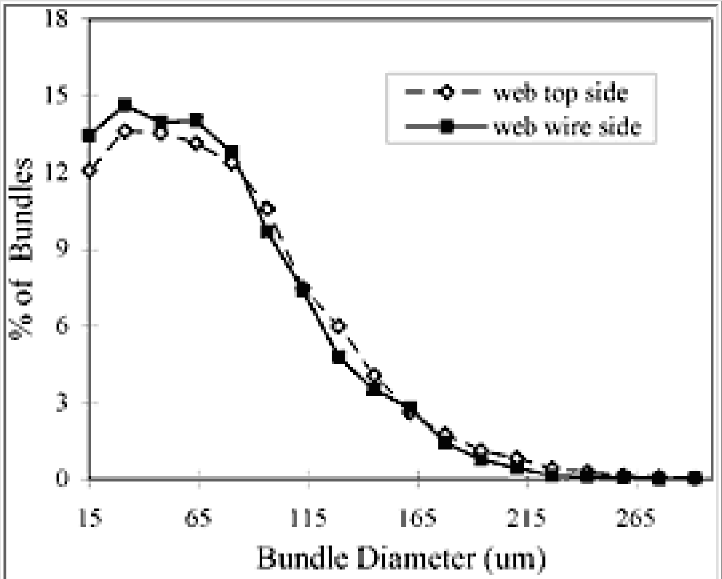


Figure 6
FIBER BUNDLE DIAMETER DISTRIBUTION FOR ONE SPECIMEN'S TOP AND WIRE SIDES

The following conclusions can be reached from these interpretations of *Tables 6 and 7.*

(a) The wire sides of all webs had slightly smaller bundles than their top sides. The difference in bundle size is easiest seen when the whole distribution is compared for top and wire sides. *Figure 6* shows bundle size distributions for the top and wire sides of one web specimen. The wire side exhibits a larger percentage of bundles at small diameters and a smaller percentage of bundles at larger diameters compared to the top side.

(b) Built-up roofing webs had larger bundles than shingle mat webs.

(c) No consistent difference in bundle size was observed between hydraulic pressurized (closed) headbox webs and atmospheric (open) headbox webs.

(d) Shingle mat webs produced with a flow synchronizer had smaller bundles than shingle mat webs produced without a flow synchronizer on both the top and wire sides. The spatial distribution of bundle size was more uniform for shingle mat webs produced without a flow synchronizer than for shingle mat webs produced with a flow synchronizer.

(e) Heavier basis weight webs had smaller bundles than lighter basis weight webs on both their top and wire sides. The spatial distribution of bundle size was more uniform for lighter basis weight webs than for heavier weight webs on both the top and wire sides.

(f) No consistent trends were observed for any of the webs with respect to the maximum bundle size detected.

Conclusions

An image analysis-based instrument was used to characterize the structure of a limited number of roofing mat webs. From this analysis, differences in web structure were found for different variations of the wetlay web formation process. Specifically, we observed differences in structure between the top and wire sides of webs, built-up roofing and shingle mat webs, hydraulic pressurized (closed) and atmospheric (open) headbox webs, production with and without a flow synchronizer, and web basis weight.

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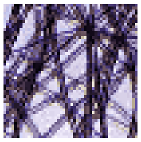

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INTERNATIONAL NONWOVENS Journal

ORIGINAL PAPER/PEER-REVIEWED

A Study of the Airflow and Fiber Dynamics in the Transport Chamber of a Sifting Air-laying System: Part 1

By A. Pourmohammadi and S.J. Russell, Nonwovens Research Group, School of Textile Industries, and R. Brandean. D.B. Ingham and X. Wen. Centre for CFD, University of Leeds, U.K.

Abstract
The structural architecture of air-laid webs produced from short fibres is largely dependent on the manner in which fibres are assembled together during the web formation process. An improved understanding of the behaviour of fibres during air-laying is essential to provide a basis for more effective engineering of the structure and properties of resulting fabrics. This two part paper presents the results of a preliminary experimental study of the airflow and the fibre dynamics in a sifting air-laying process using LDV and high-speed photographic techniques. In Part 1 of the paper the airflow characteristics are investigated using Laser Doppler Velocimetry. In a commercially representative sifting air-laying machine it was established that the air velocity varies along the length and the height of the transport chamber. The variation is markedly increased by the rotation of the blades in the dispersing zone. Generally, the air velocity was found to increase from the top to the bottom of the transport chamber. With the rotating blades in operation the trend in the airflow velocity was characterised by a 'V' shaped profile along the length of the chamber and was independent of the height of the chamber. *(Part 2 of this paper will appear in the Fall, 2000 issue of the International Nonwovens Journal*.)

Introduction
To obtain high quality web structures with fibres evenly distributed in the web, a solid knowledge of the basic principals of the fibre behaviour in the air-lay process is required. Various air-laying machine designs have been introduced which can be broadly classified as roller-based and sifting-based.

In this study, a sifting air-laying process of the Kroyer type [U.S. Patent 4,144,619] suitable for processing short fibres (2-12 mm) in the manufacture of air-laid material was used. In addition to the use of conventional pulp and fibre blend products this work has been concerned with the processing of short fibre waste using this approach. In the air-laying process fibres are transported through an air stream and the airflow characteristics are therefore very important in determining the final web structure.To elucidate the airflow behaviour, Laser Doppler Velocimetry (LDV) was employed. Using this technique it was possible to obtain information on the airflow characteristics, which then can be used for understanding the fibre dynamics in the system during web formation.

General Description of the Experimental Machine

A schematic view of the experimental machine used in this study is shown in *Figure 1*. The machine employs a sifting mechanism in which short fibres are dispersed by rotor blades and are drawn by suction through a mesh screen (top grid) and finally deposited on the surface of a moving conveyor belt. The dispersion of fibres in the airflow provides the opportunity for randomisation of the fibre arrangement in the landing area on the belt and allows orientation of some fibres perpendicular to the belt surface. The fibres are introduced in the upper chamber (fibre dispersing zone) of the machine and are circulated using two pairs of rotor blades. Each pair of blades has a rapid rotational motion (of c. 1240 rpm) around their axes and a slowerrotational motion (300 rpm) around a fixed axis situated vertically at either side of the machine's centre. Owing to the location of the suction system beneath the machine *(Figure 3)*, the fibres in the upper chamber penetrate the top grid and pass into the lower chamber (fibre transporting zone), where they are transported downwards by the airflow. At the base of the lower chamber there is a moving mesh conveyor belt onto which the fibres are deposited to form the web structure.

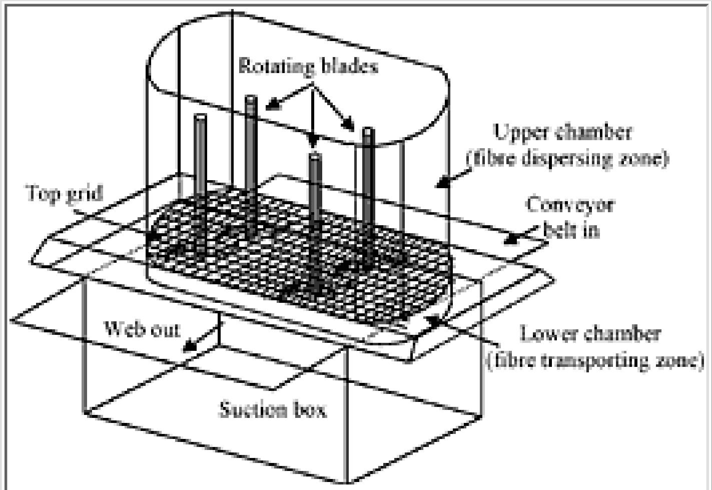


Figure 1
A SCHEMATIC VIEW OF THE AIR-LAYING MACHINE

Table 1
SUMMARY OF PROCESSING CONDITIONS USED ON THE AIR-LAYING MACHINE

Blade Speed (rev/min)	1240
Top Grid Dimensions (mm)	Mesh aperture size :1.8 Plain weave (square sett) Wire diameter: 0.3
Fibre Feeding rate	
Upper Chamber (g/min)	10.0
Air Velocity (fan induced) (m/sec)	0.35
Conveyor Grid	
Dimensions (mm)	Mesh aperture size :0.2 Plain weave (square sett) Wire diameter: 0.15
Conveyor Linear Speed	
(m/min)	0.2

The machine settings used for this experimental work were typical of those normally used and are summarised in *Table 1*.

Experimental Studies

In this section, as a prelude to direct studies of the fibre dynamics, Laser Doppler Velocimetry was used to elucidate the airflow characteristics in the air-laying machine.

Air Velocity Measurement Procedure

Laser Doppler Velocimetry (LDV) has been used extensively to measure velocity fields [Drust 1976] and with new developments, its application in textiles has extended to the measurement of fibre velocity in carding [Lauber and Wulfhorst 1995] and fluid transport in fibrous assemblies [Howaldy and Yoganathan 1983]. The primary feature that allows this is the absence of a physical probe in the flow field, thereby allowing non-intrusive measurements. Operation of the LDV is based on the Doppler principle. When a laser beam is passed through a fluid such as air, light is scattered by the particles suspended in the fluid. The scattered light contains a Doppler frequency shift that is directly proportional to the particle velocity. The LDV uses two incident beams that intersect to form the measuring volume.

The velocity of the air in the transport chamber of the air-laying machine was measured by means of a TSI Inc., 350 mW Argon-ion laser. The measuring volume was ellipsoidal with a length of 1.55 mm and a diameter of 81.41 microns, using a lens with a 350 mm focal length.

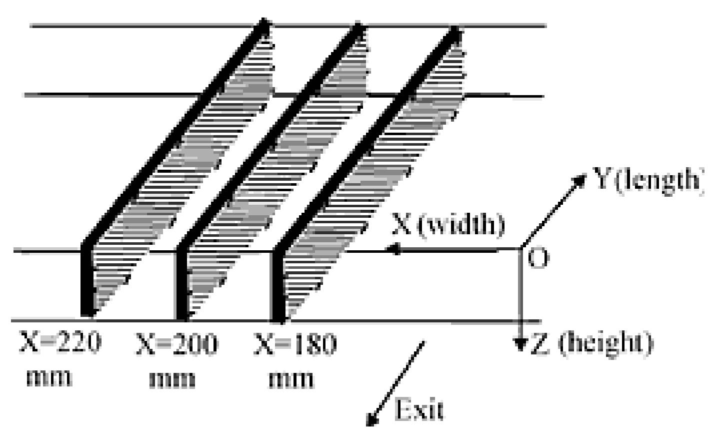


Figure 2
CARTESIAN COORDINATES FOR AIR VELOCITY MEASUREMENT

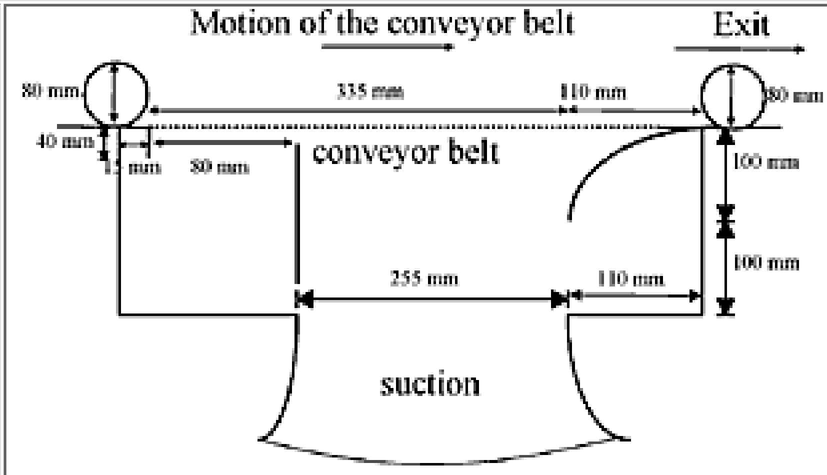


Figure 3
GEOMETRY OF THE SUCTION CHAMBER UNDER THE CONVEYOR BELT

To measure the air velocity in different positions in the transport chamber, Cartesian coordinates were defined (O,X,Y,Z), *(Figure 2)* as follows :

O: origin of the axes at the exit point of the chamber,

X: Axis along the width of the transport chamber,

Y: Axis along the length of the transport chamber

Z: Axis along the height of the transport chamber.

It is reasonable to expect that the geometry of the suction system situated under the conveyor belt to influence the flow regime in the transport chamber. This parameter was fixed by the manufacturer and therefore was not accessible for study *(Figure 3)*.

Air Velocity Profile in the Transport Chamber
The airflow characteristics inside the transport chamber affect fibre dynamics and the geometry of the web, thus it was important to establish the airflow velocity in the machine.

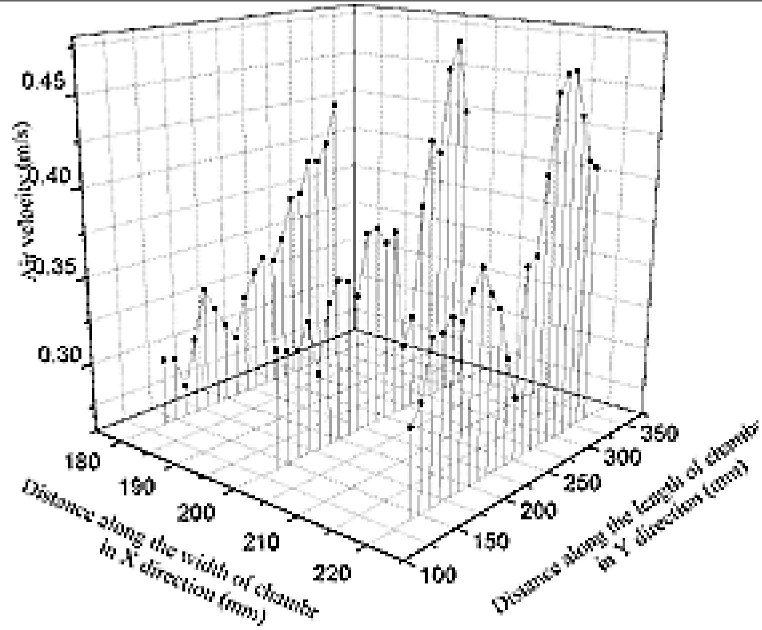


Figure 4
MAGNITUDE OF THE RESULTANT VELOCITY 10 MM BELOW THE TOP GRID (WITHOUT ROTATING BLADES IN OPERATION)

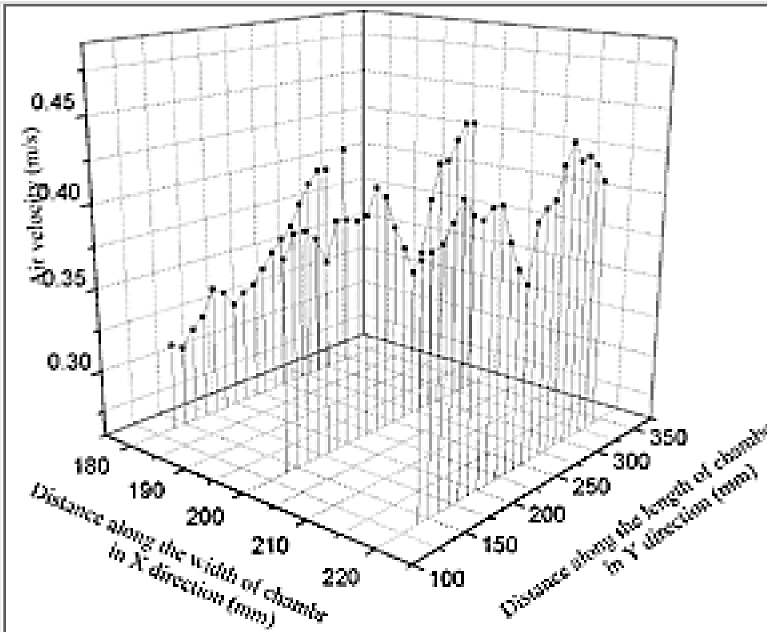


Figure 5
MAGNITUDE OF THE RESULTANT VELOCITY 30MM BELOW THE TOP GRID (WITHOUT ROTATING BLADES IN OPERATION)

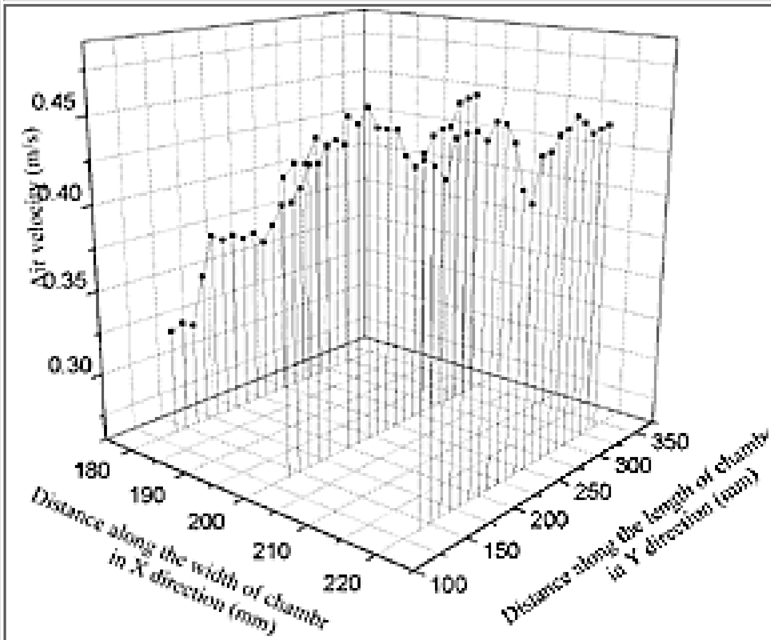


Figure 6

MAGNITUDE OF THE RESULTANT VELOCITY 50 MM BELOW THE TOP GRID (WITHOUT ROTATING BLADES IN OPERATION)

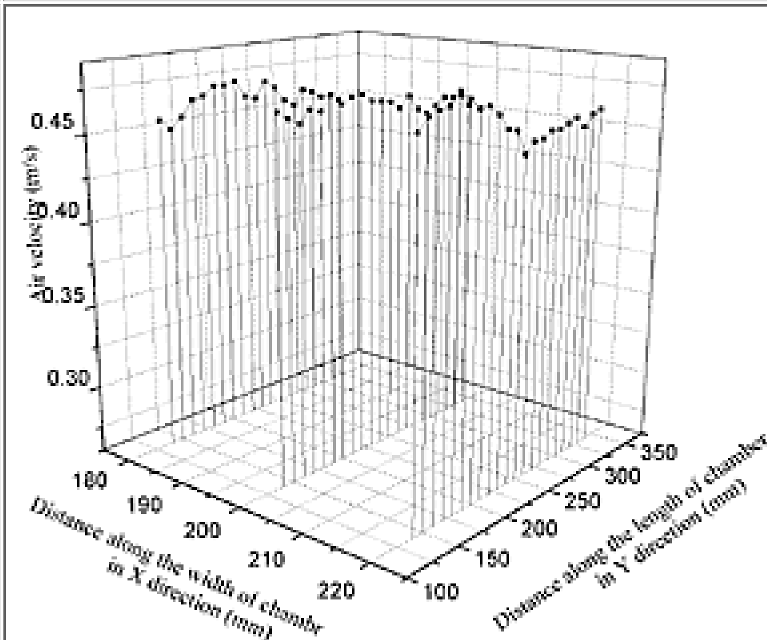


Figure 7
MAGNITUDE OF THE RESULTANT VELOCITY 70 MM BELOW THE TOP GRID (WITHOUT ROTATING BLADES IN OPERATION)

Firstly, the air velocity in the machine due only to the suction was obtained. The suction level was set to the maximum level available producing about 0.35 m^3/s air flux. The resulting air velocity was measured along the width (in the X direction), the length (in the Y direction) and the height (in the Z direction) of the chamber. The results of these measurements are shown in *Figures 4, 5, 6 and 7.* As illustrated, it is clear that the air velocity is not uniform along the length of the chamber (in the Y direction) and that just below the top grid (10 mm below) it changes markedly with position *(Figure 4)*. The air velocity becomes more uniform and independent of position near the fibre landing area (increasing distance from the top grid) *(Figure 7),* where the velocity profile along the chamber is reasonably constant (at around 0.44-0.48 m/s). In practice, a web can only be formed if the rotating blades are in operation and therefore the combined effect of both the blades and the suction on the airflow were obtained. The air velocity results obtained using the same suction in the plane X=220 mm with the blades in operation are shown in *Figure 8*. The rotation of the blades has a marked influence on the air velocity profile, making it less uniform along the length of transport chamber. Two distinguishable regions are apparent in the air velocity profile in *Figure 8.* In the first region from position Y=140 mm to Y=230 mm along the length of the chamber, (excluding the area near the top grid where the high rotational speed of the blades causes serious disturbance of the flow) the resultant velocity increases in the Z direction from the top to the bottom of the chamber and decreases along the length of the chamber (in the Y direction). The second region from Y= 240-350 mm where the air velocity increases up the height (in the Z direction) and along the length (in the Y direction) of the chamber.

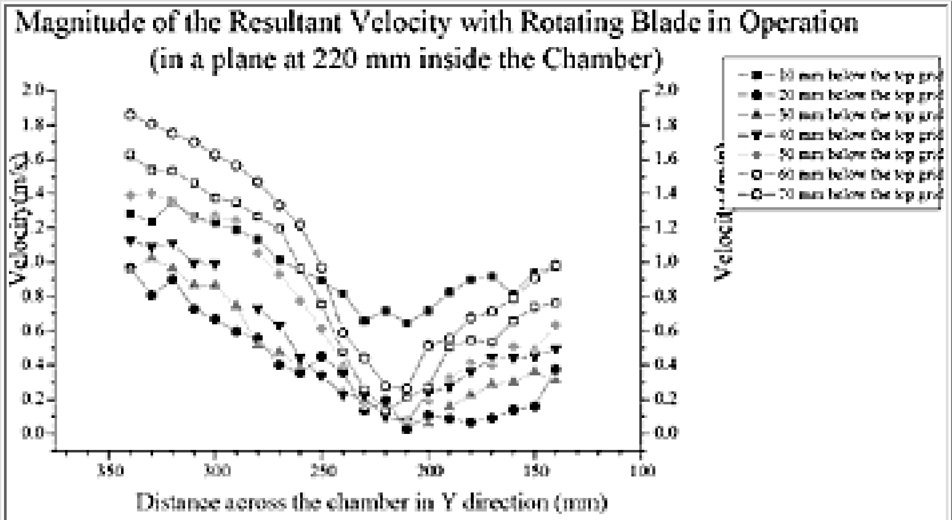
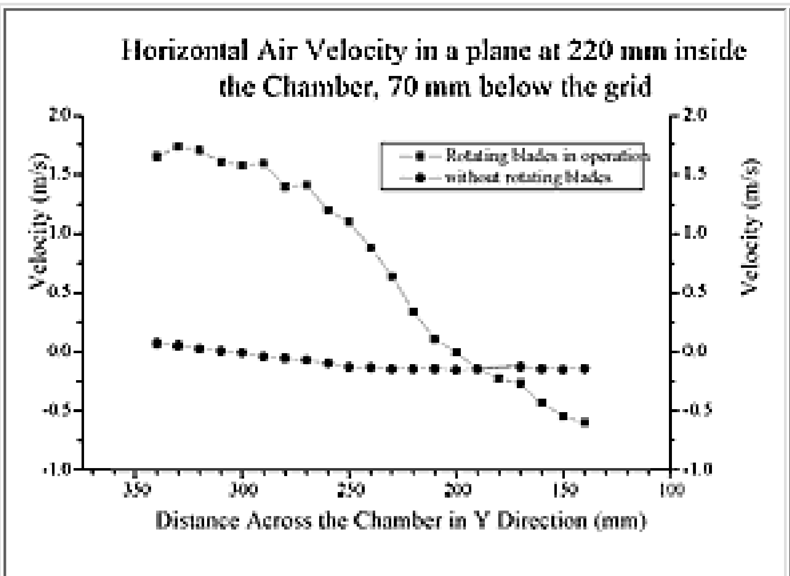


Figure 8
THE AIRFLOW VELOCITY MEASURED BY LDV IN X=220 MM PLANE WITH ROTATING BLADES IN OPERATION

Effect of Rotating Blades on Components of Air Velocity

It is interesting to compare the horizontal and vertical components of air velocity with and without the blades in operation. The point nearest to the conveyor belt (landing area, at position Z=70 mm) was used for this comparison.



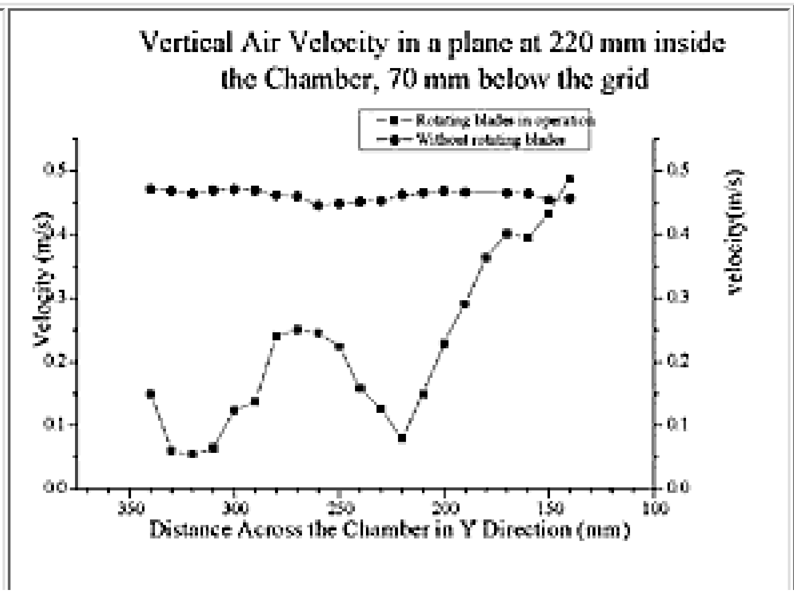


Figure 9 THE HORIZONTAL COMPONENT OF THE AIRFLOW VELOCITY MEASURED BY LDV IN X=220 MM PLANE	**Figure 10** THE VERTICAL COMPONENT OF THE AIRFLOW VELOCITY MEASURED BY LDV IN X=220 MM PLANE

Figures 9 and 10 show the components of the horizontal and vertical velocities respectively. In *Figure 9* it is clear that the blades increase the horizontal velocity along the length of the chamber (i.e. as Y increases) and negative velocity values are obtained between the positions Y=140 mm to about Y=200 mm indicating that the airflow is subject to a velocity in the opposite direction to that of conveyor belt. In Figure 9, from Y=200 mm onwards, the horizontal velocity increases to about 1.75 m/s. It should be noted that when the blades are not in operation, the horizontal velocity is virtually constant and nearly zero along the length of the transport chamber. Additionally, the vertical air velocity (Figure 10) is generally higher along the length of the chamber when the blades are not used and the variation in air velocity is much smaller.

In summary it was discovered that at the particular suction setting used, the airflow velocity changes from about 1.85 m/s at the entry of the chamber (Y=350 mm) to about 1.0 m/s at the exit point (Y=140 mm). Following these findings it was aimed to establish how the fibre dynamics in the machine were influenced by these airflow characteristics. This study was undertaken using high-speed photography and is reported in Part 2 of this paper.

Conclusions

The airflow behaviour in the transport chamber of a sifting air-laying system was investigated using LDV. The results showed that the rotating blades (used for dispersing fibres) decreases the uniformity of the airflow velocity in all three dimensions (X, Y, Z). Two distinguishable regions along the length of the chamber (in the Y direction) were identified irrespective of the height position (i.e. Z) in the transport chamber. Comparing the horizontal and vertical components of airflow velocity showed that the effect of rotating blades is to increase the horizontal velocity (from 0 to 1.75 m/s) and to fluctuate the vertical velocity markedly along the length of the chamber. Negative values for horizontal velocity were also obtained, indicating that fibres are subject to a velocity in the opposite direction to that of conveyor belt. With the rotating blades in operation the trend in the airflow velocity was characterised by a ‘V’ shaped profile along the length of the chamber and was independent of the height of the chamber. The resultant velocity generally increased from the top to the bottom of the transport chamber which would be expected to accelerate the fibre velocity from top to the bottom of the chamber.

Acknowledgements

The authors gratefully acknowledge the support provided by EPSRC and to our collaborating industrial partners (ConvaTec Ltd Wound Healing Research Institute and Ulster Carpet Mills). Thanks are also due to our colleague Mr. M. Phillips of the Nonwovens Research Group.

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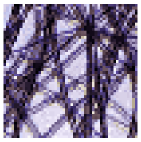

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INTERNATIONAL NONWOVENS Journal

ORIGINAL PAPER/PEER-REVIEWED

Performance Of Nonwoven Cellulosic Composites For Automotive Interiors

By D.V. Parikh, T.A. Calamari, USDA, ARS, SRRC, New Orleans, LA and J.C. Myatt, Janesville Products, a Unit of Jason, Inc., Norfolk, OH

Abstract
Finding methods to provide a quiet passenger compartment in a car are highly sought after by automobile manufacturers. The ability to reduce noise inside the vehicle enhances the perceived value of the vehicle to the consumer and offers a competitive advantage to the manufacturer.

Several methods to reduce noise and its sources are employed, one of which reduces noise in the passenger compartment using sound absorbing materials attached to various components such as doors, quarter panels, trunk sides and floors, headliners and others.

This study attempts to quantify the characteristics of several cellulosic-based nonwovens to act as efficient absorbers, reducing the overall sound level in the passenger compartment as measured by ASTM C-384 "Impedance and Absorption of Acoustic Materials by the Impedance Tube Method."

The results of testing demonstrate that each of the cellulosic-based nonwoven composites contribute to the absorptive properties of the components and are effective for overall noise reduction in the vehicle. The individual acoustic characteristics of the various vehicles determine the type and amount of material required to provide the best results.

Introduction
Various blends of cellulosic-based nonwovens manufactured by the carding and needlepunch process are tested for their ability to absorb sound energy. They are compared to targets of acoustic absorption established by automotive manufacturers for use with vehicle interior trim components such as door absorbers, headliners, trunk liners and others with the goal of reducing the noise level in the vehicle.

Discussion
The ability of a nonwoven material to absorb sound or unwanted noise in the passenger compartment of the vehicle is based on dissipation of the energy of the sound wave upon passing through the material and being redirected by the fibers, and also upon conversion of some of the energy into heat. The amount of original energy less the remaining unabsorbed energy results in the measurement referred to as the absorption coefficient. This absorption coefficient is often used to rank the order of different materials to

reduce the noise level in the vehicle when composites of these materials are attached to various components in the car, such as doors, pillars, headliners and trunk compartments.

These components are typically placed between the sound sources (such as vibrating steel panels, windows passing air and tires) and the receivers (occupants of the vehicle). While it is commonly accepted that the most effective way to reduce sound is at its source, several issues, such as cost, smooth ride and vehicle weight, make it necessary to use sound absorbing materials as "bandages" for noisy interiors.

Table 1
CELLULOSIC-BASED NONWOVENS PRODUCED BY THE CARDING/NEEDLEPUNCH PROCESS FOR MEASUREMENT USING ASTM C-384

Sample	Material	Blend Ratio	Thickness	Weight
A	Flax/PP	50:50	12 mm	698 gpsm
B	Jute/PP	50:50	12 mm	686 gpsm
C	Kenaff/PP	50:50	12 mm	670 gpsm
D	Cotton/PET/PP	35:35:30	11 mm	770 gpsm

Table 2
TARGET ABSORPTION REFERENCES FOR NONWOVEN AUTOMOTIVE NOISE REDUCTION AND RESULTS OBTAINED BY ASTM C-384

Acoustical Properties-Absorption

		A	**B**	**C**	**D**
	Target	**Flax/**	**Jute/**	**Kenaf/**	**Cotton/**
Frequency	**%**	**PP**	**PP**	**PP**	**PET/PP**
800 Hz	9	15	15	17	18
1000 Hz	16	20	20	20	25
1600 Hz	35	32	35	34	36
2000 Hz	51	53	66	63	52

For this study, the low cost, renewability, biodegradability and recyclability of the natural cellulosic fibers as the matrix materials, make them attractive as a potential sound-absorbing nonwoven. The carding and needlepunch structuring process was chosen to produce the samples because it has long been used to make padding that can be molded into shapes for attaching to the components in the vehicle (*Table 1*). Polypropylene fiber in the cellulosic composites make the nonwovens moldable. "Seconds" quality of polypropylene was used in the present set of experiments to produce products at lower cost.

The cellulosic fibers chosen for the nonwovens were flax, jute, kenaf and cotton. Polypropylene was added as a carrying material in the carding and needlepunch process and can be varied in proportion with the cellulosic fibers. The weight and thickness targeted were picked based on the normal practice where glass and synthetic-based materials were used in vehicles (*Table 2*).

After processing the samples, each were cut into parts and inserted into the impedance tube for rank order absorption testing against commonly accepted levels for such "absorbent" materials. While each vehicle may have unique noise characteristics, the rank order of the materials is a good precursor to subsequent, more detailed, engineering of the individual materials for specific components (*Figure 1)*.

The ASTM C-384 impedance tube testing method utilizes a tube with the nonwoven test piece at one end and a loudspeaker at the other. A microphone is moved along the length of the tube during the test, measuring the sound wave at various frequencies, calculating the amount of sound reflected by the sample compared to the original wave amplitude. The greater amount of sound absorbed results in a better material for noise reduction purposes in the vehicle (*Figure 2*).

The frequencies chosen for testing are those that are typically represented by the various types of noise, such as low frequency vehicle structural noise and high frequency wind or tire noise.

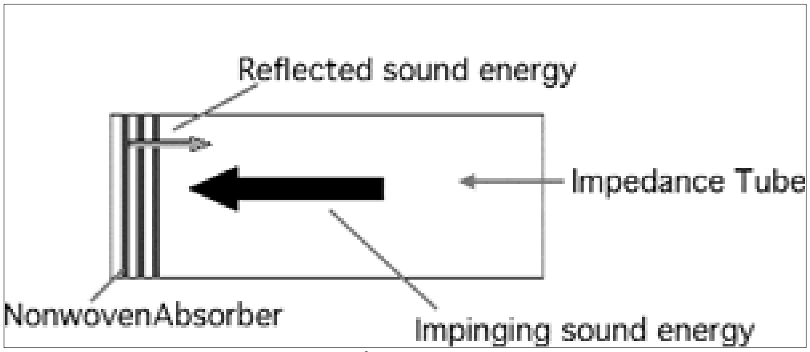

Figure 1
IMPEDANCE TUBE FOR ASTM C-384 SOUND ABSORPTION TESTING

In each of the cellulosic-based samples tested, we see that the amount of absorption recorded, at the frequencies targeted, meet or exceed the targets, save for the flax-based and kenaf-based at the 1600 Hz frequency, and this by a relatively small (3-10%) amount. In practice, these minor differences are often made up by a small reduction in the amount of needlepunching to increase thickness (which often helps increase absorption). Other ways to increase the absorptive properties include using finer diameter fibers, lower modulus fibers and various coatings or sizings.

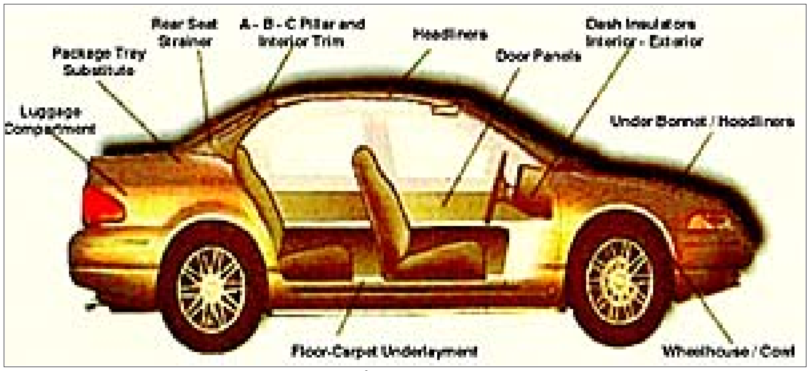

Figure 2
VEHICLE COMPONENT SOUND ABSORBING MATERIALS

Summary
By using the ASTM C-384 Standard Test Method for Impedance and Absorption of Acoustical Materials by the Impedance Tube Method, it has been shown that several cellulosic-based nonwovens can be produced that have sound absorbing properties suitable for use as noise reducing components. These components can be used in the manufacture of cars that provide the quiet interior passenger compartment that the consumer desires.

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