NC STATE UNIVERSITY

JTATM

JOURNAL OF TEXTILE AND APPAREL, TECHNOLOGY AND MANAGEMENT

Volume3, Issue 1, Summer 2003

WEAVING TECHNOLOGY: ADVANCES AND CHALLENGES II

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ABSTRACT

This paper reviews the recent advances in weaving industry and addresses the challenges that face the weaving industry. The paper sheds the light on how the weaving machine manufacturers and woven fabric producers might strengthen the weaving industry by further advance the technology and taking advantages of the current and new advances in weaving technologies.

KEYWORDS: Weaving, Automation, Jacquard, Pattern Change.

INTRODUCTION

Recently weaving machine producers introduced to the woven fabric manufacturers a sizeable number of technological advances. Examples of such advances are higher speeds than seen before, a higher level of automation, a new Jacquard shedding concept, waste reduction, and on-line quality monitoring. These advances may enable the developed nations to drastically lower the labor cost and may be able to compete in the commodity fabric markets. Despite these significant development in weaving, weavers in the developed and developing nations are faced with serious competition from other fabric forming systems such as needlepunching and hydroentanglement nonwoven technologies. These nonwoven technologies established themselves in numerous markets and are expected to seriously compete with weaving industry in carpet and apparel markets. This paper reviews the recent advances in weaving industry. Additionally, it addresses the challenges that face the weaving industry and how the weaving machine manufacturers and woven fabric producers might strengthen the weaving industry by further advance the technology and taking advantages of the current and new advances in weaving technologies and supporting systems.

ADVANCES IN WEAVING

Weaving Speeds

At recent machinery shows (ITMA' 99, ATME-I' 2001), weaving machine manufacturers showed a broad range of machines with higher speed and rate of filling insertion (RFI) than seen before. The fabric quality, which is significantly impacted by efficiency, is a must for the fabric manufacturers to stay competitive. The interrelationships between machine speed, weaving efficiency, fabric construction parameters and fabric quality must be considered when acquiring new machines. In the following sections, the fastest weaving machines that were exhibited at ITMA' 99 and ATME-I' 2001 are reported.

Fastest Air Jet Machines

RFI of 2,000 m/min. of air jet weaving used to be the limit a few years ago. Recently, this limit has been overcome by several air jet weaving machine manufacturers. At ITMA' 99 Dornier showed the widest (4.30 m) air jet machine (LWV8/J) weaving sheeting fabric at 600 picks/min equivalent to 2,520 m/min RFI. The machine was equipped with Staubli Jacquard head model LX 3200 with 9800 hooks. Dornier also showed their 3.8 m wide type LWV2/E4 machine with new gantry (designed to hold 1600 mm warp beam) weaving work wear twill fabric at 600 picks/min (2,002 m/min RFI). At the same show, Picanol featured a wide range of air jet machines. Four machines exceeded the 2,000 m/min RFI barrier. Table 1 shows the data of these machines. At ATME-I' 2001, Picanol introduced for the first time their new 3.4 m and 1.9 m wide OmniPlus air jet machines. The 3.4 m machine was producing percale sheeting with two different filling yarns at 850 picks/min and 750 picks/min or 2,890 m/min and 2,550 m/min RFI. The 1.9 m machine with Jacquard head was weaving three different filling yarns: chenille, filament, and slub yarns [4]. At ITMA' 99, Somet showed a 3.4 m wide Clipper machine weaving Voile fabric at 650 picks/min (2,048 m/min RFI). The machine ran at higher speed of 750 picks/min (2,363 m/min RFI) when the pick density was reduced from 28 to 25 picks/cm. This example demonstrates how the loom speed is impacted by fabric construction. At ATME-I' 2001, the Italian Company Promatech (Produces Somet and Vamatex weaving machines) showed their 3.4 m wide Mythos weaving bed sheeting at 630 picks/min or 2,142 m/min RFI [4]. Toyoda featured six air jet machines with one weaving at RFI higher than 2,000 m/min; the JA2S-390DE-MT-T610. The machine was weaving two panels suiting dobby fabric of 1.75 m width in reed at speed of 600 picks/min (2,100 m/min RFI). At ITMA' 99, Tsudakoma showed four air jet machines with over 2,000 m/min RFI. The fastest they showed is their ultrahigh speed ZAX-190-2C machine of 1.9 m width. The machine is equipped with a new automatic filling insertion control, a positive let-off, and improved beat-up motion. This combination allowed the machine to weave a fine filament fabric at 1,800 picks/min or 3,222 m/min RFI. Their second fastest is the ZAX-390-2C-C4 machine running 2 panel sheeting fabric (bed sheet and pillow case) at 800 picks/min or 2,952 m/min RFI. The ZAX-340-6C-D16 was constructing a Voile Curtain with variable pick density at 700 picks/min corresponding to 2,170 m/min RFI. The ZAX-340-8C-J was weaving four panels of bath towel fabric at speed of 700 picks/min equivalent to 2,128 m/min RFI. At ATME-I' 2001, the company exhibited their ZAX-340-2C-C4 air jet machine with 303 cm width in reed running at 850 picks/min or 2576 m/min RFI [4].

Table 1. Picanol Fastest Air Jet Machines [1]

Machine Type	Fabric	Speed, picks/min	RFI, m/min
Omni-F-2-E 190	Acetate Lining	1,600	2,384
Omni-F-2-P 340	Voile	750	2,340
Omni-4-P 380	Two Panels Sheeting	720	2,722
Omni-4-J 250	Mattress Ticking	950	2,090

Fastest Water Jet Machines

At ITMA' 99, Toyoda exhibited their ultra high speed LW1F-190CS-EF-602 machine with crank shedding motion constructing taffeta nylon fabric of 1.73 m at 1,500 picks/min (2,595 m/min RFI). Tsudakoma showed two water jet machines with one that exceeded the 2,000 m/min RFI; the ZW405C—190-1C-4S. The machine was running a taffeta fabric at 1,600 picks/min or 2,720 m/min RFI.

Fastest Projectile Machines

Sulzer was the only company that showed this type of weaving machines at ITMA' 99. The fastest is their 3.9 m machine type P7300 B 390 N 2 EP R D1 weaving a stretch denim cloth at 360 picks/min corresponding to 1,400 m/min RFI.

Fastest Rapier Machines

At ITMA' 99, Dornier exhibited a new 1.9 m wide machine type PTV4/S16 with Staubli dobby model 2861 running fancy shirting fabric at 570 x 2 picks/min corresponding to 2000 m/min rate of filling insertion. Picanol showed six new rapier machines of width range of 1.9 m – 3.4 m., from these, the two fastest are the Gamma-8-R 190 and the Gamma-4-R 340 machines. They were weaving shirting and fancy voile at 700 picks/min (1,316 m/min RFI) and 440 picks/min (1,373 m/min RFI), respectively. Somet featured seven of Thema Super Excel machines of width range of 1.9 m – 3.6 m. The fastest of these is their widest machine that was weaving an apparel fabric at 430 picks/min (1,505 m/min RFI). Sulzer showed thirteen of their rapier machines. The fastest is their 2 m wide type G6300 B 200 N 8 SP20 machine producing ladies' wear at speed of 700 picks/min (1,330 m/min RFI). Sulzer continued to show their G6300 machines at ATME-I' 2001 with wider range of applications and higher speed. Their 2.2 m machine was running at 650 picks/min or 1,430 m/min RFI. At ITMA' 99 Vamatex, which is specialized in rapier machine making, showed sixteen machines (more rapier machines than any other manufacturer). The fastest machine was the Leonardo h. 3600, which is 3.6 m wide, producing cotton clothing at 430 picks/min equivalent to 1,550 m/min RFI.

Multiphase Weaving

The Sulzer Textil's M8300 multiphase weaving machine, which was revealed for the first time at ITMA '95, continued to be one of the main attractions at ITMA '99. Two machines were shown. One was producing plain weave Cretonne fabric of width in reed of 1.885 m at a speed of 3230 picks/min (6,088 m/min rate of filling insertion). The second machine was weaving a 2X1 twill (for the first time) work wear fabric of width in reed of 1.695 m at a speed of 2,430 picks/min (4,118 m/min rate of filling insertion). At ATMI' 2001, the M8300 was shown weaving 2X1 twill apparel fabric at 4,770 m/min RFI [4].

Significant improvements in production and efficiency of the M8300 machines were noticed at the ITMA' 99 and ATME-I' 2001 as compared to those shown at ITMA' 95 and OTEMAS' 97. For example, at OTEMAS' 97 one machine was weaving the Cretonne fabric at 5315 m/min rate of filling insertion. This translates to almost 15% increase in speed alone. Several improvements have been done to reduce the friction on the warp yarns, which led to the improvements in production and efficiency. The author believes that the speed limit of the M8300 has not been reached yet and there is a room for further improvement. The M8300, however, will be limited to the production of commodity fabrics of simple weaves due to the design of the shedding mechanism.

At such high production rates of the M8300, the labor cost is dramatically reduced. This qualifies the machine for weavers in developed countries where the labor wage is high. Weavers in USA and Europe have realized this fact and acquired M8300 machines to compete with low wage weavers in developing countries. Sulzer Textil has sold M8300 multiphase weaving machines to three companies in USA and Europe: Filatures & Tissages de Saulxures of France, Elmer & Zweifel of Germany, and Ramtex Inc. of USA. Additionally, a significant number of M8300 machines are now installed in pilot plants around the world indication of its maturity and acceptance [4].

New Jacquard Concept

Grosse and Staubli exhibited completely new approaches in Jacquard shed formation. The two approaches are different. They have, however, common goals: reduction in the Jacquard engine parts and elimination of the gantry. While the machines are still in Prototype Stage, the author believes the new Jacquard technologies would allow weavers to produce intricate fabrics with manufacturing cost close to commodity fabric cost.

Grosse UNISHED

Grosse showed their patented UNISHED positive electronic Jacquard head for the first time at ITMA' 99, Figure 1. The dimensions of the Jacquard head and the individual control of each heddle (warp end) allow the heddle wires to be set vertically. These settings permit the elimination of harness cords, hooks, magnets, pulleys, pull down springs and more significantly the gantry. This results in lower building and air conditioning costs. The Jacquard head is mounted directly on the side frames of the weaving machine thus allowing Quick Style Change (QSC) for the first time in Jacquard weaving. In this system, QSC can be conducted by changing the Jacquard head and heddles. The UNISHED was mounted on Dornier LWV6/J air jet weaving machine. The machine was weaving Cotton/Polyester Upholstery fabric and running at 800 picks/min or RFI of 1,136.

Figure 1 Grosse's UNISHED Jacquard Head [1]

Staubli UNIVAL 100
At ITMA' 99, Staubli introduced for the first time their UNIVAL 100 electronic Jacquard shedding mechanism. The shed formation is achieved through controlling each individual warp end by a stepping motor. The harness cord/warp end selection is performed electronically and hence fabric design is achieved in the same way as any electronic Jacquard system. The dimension of the Jacquard head (the Jacquard head and tie width is the same as the width in reed) and the control of individual warp end by a stepping motor permit the harness cords to be set vertically, (Figure 2). The design of the UNVAL 100 permits the elimination of hooks, knives, and the gantry. The UNIVAL 100 was running on Picanol Omni-4-J 250 air jet machine. The machine was producing mattress ticking fabric with 2.2 m width in reed at 950 picks/min or 2,090 m/min RFI. The total number of warp yarns was 7,100 controlled by 7,100 stepping motors.

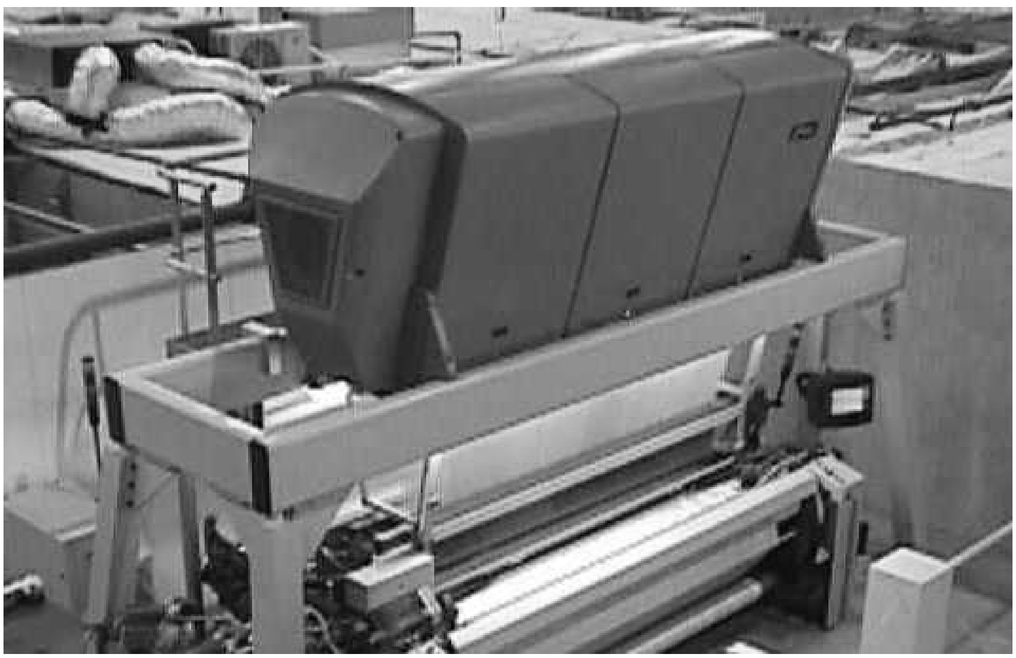


Figure 2 Staubli's UNIVAL 100 Jacquard Head [1]

Versatility

Machine makers have continued to compete to offer the weavers innovative weaving machinery for versatile operation. In this section the most significant innovations for versatility shown at ITMA '99 and ATME-I' 2001 are reviewed.

Quick Style Change (QSC)
Dornier conducted, at ITMA' 99, a quick style change from a fine worsted fabric to a pure cashmere fabric in less than 30 min. An improved QSC system with new pneumatic shaft and self-centering hook-up of the harnesses was used. Almost all major weaving machine makers offer their own version of QSC, which is a must system for versatile weaving operation as well as high-speed machines.

Automatic Pattern Change
At ITMA' 99, Dornier demonstrated an on-the-fly automatic pattern change on their air jet LWV8/J machine, which is equipped with Staubli electronic Jacquard head model

LX 3200. The machine was switched from sheeting to napery fabric without stop. Beside versatility, automatic pattern change has caused the removal of the pattern change task from the list of downtime items.

Pneumatic Tuck-In Motions

Several companies showed new tuck-in motions based on pneumatic. The principle of the pneumatic tucking-in is the use of air to hold the filling end then force the filling end to be tucked-in into the next shed by air. At ITMA' 99 show, Dornier exhibited their PneumaTucker on two air jet machines (LTNF8/J and LWV2/E4), Tsudakoma showed their ZNT "needle-less" tuck-in on two air jet machines (ZAX-210-6C-D16 and ZAX-340-8C-J) and Somet showed their patented tuck-in motion on a Clipper air jet machine. Tsudakoma continued to show their pneumatic tuck-in motion on several ZAX machines at ATME-I' 2001.

Due to the elimination of the tuck-in needle and the mechanical elements that drive it, pneumatic tuck-in motions can run much faster as compared to those traditional mechanical tuck-in devices. With this development, air jet machines can now produce fabrics with tucked-in selvage since the speed of selvage formation is compatible with air jet weaving speed. Additional advantages of using pneumatic tuck-in are the elimination of reed damage as a result of malfunctioning of mechanical elements and wear of warp ends at the fabric edges due to friction between yarns and tuck-in needle.

For cosmetic reasons, tuck-in selvages are required for certain types of fabrics such as worsted and suiting fabrics, tablecloth, sheeting, and towels. The pneumatic tuck-in motions allowed the air jet weaving technologies to compete for these markets. Dornier, Somet and Tsudakoma have shown their machines with pneumatic tuckers weaving examples for these markets.

Variable Pick Density

At ITMA' 99 and ATME-I' 2001, many exhibitors demonstrated machines with variable pick density control system. The variation in pick density can be programmed as desired through controlling electronic let-off and take-up mechanisms via microprocessor. Such development provides fabric producers with a tool to create fancy effects in the filling directions.

Picanol's Sumo Motor

The Sumo motor is a new development by Picanol. It was shown at ITMA'99 running Gamma rapier looms. At ATME-I' 2001, Picanol showed their new TERRYplus (for terry fabric production) and OmniPlus air jet weaving machines with Sumo motors [4]. With such motor, the machine can be derived directly without belt or clutch. The starting torque is very powerful and adjustable. The beat-up force is constant from the start through out the entire weaving process. The use of Sumo motors may eliminate some start marks. The Sumo motor can be programmed to run at different speeds as desired. This option is useful in case of weaving different filling yarns of different qualities. Another situation is a quality problem with a certain length of warp, the motor may run slower to avoid excessive stops.

CHALLENGES

There is no doubt that weaving machine manufacturers brought exciting new developments that covered many aspects in weaving in recent years. The weaving industry, however, is facing tough competition from nonwovens' industry. Perhaps, the toughest competition comes from needlepunching and hydroentanglement nonwovens.

Needlepunching

The needlepunching industry was once considered a "waste products" industry, but has now successfully established itself in numerous high-tech markets where high quality and consistency are must. Recent classification showed that there are eighteen markets of needlepunched products. These include: automotive (headliner, door trim) filtration, furniture and bedding, geotextiles, roofing, aerospace (shuttle tiles, brake pads), agriculture, advanced composites, industrial (belting, roller linings), insulators, marine, medical (blood filters, bandages), paper making felts, protective clothing, sports felts (floor covering, tennis ball covers), synthetic leather/shoes, wall coverings, and miscellaneous (carpet underlay, car wash brushes, oil sorbents, office products) [2].

The success of the industry can be attributed to low manufacturing cost and the flexibility of the needlepunching technology to tailor products to meet a variety of end use requirements. The increasing demand for needled fabrics prompted machine manufacturers to construct high-speed/high performance needle looms. Today's needle looms are capable of running at speeds of up to 3,000 strokes/min. with working width of up to 15 meters which translates to several hundred meter squared per minute. Needlepunched fabrics with intricate designs and color effects can be produced. Figure 3 shows examples of needlepunched fabric designs. The fabric design creation is possible by an additional punching stage that uses special needles. The design capability of needlepunching technology is limited compared to the weaving technology. Needlepunching technology, however, is still in its early stage compared to the weaving technology. The weavers are expected to face even tougher competition from needlepunching especially in the carpeting and home furnishing markets.

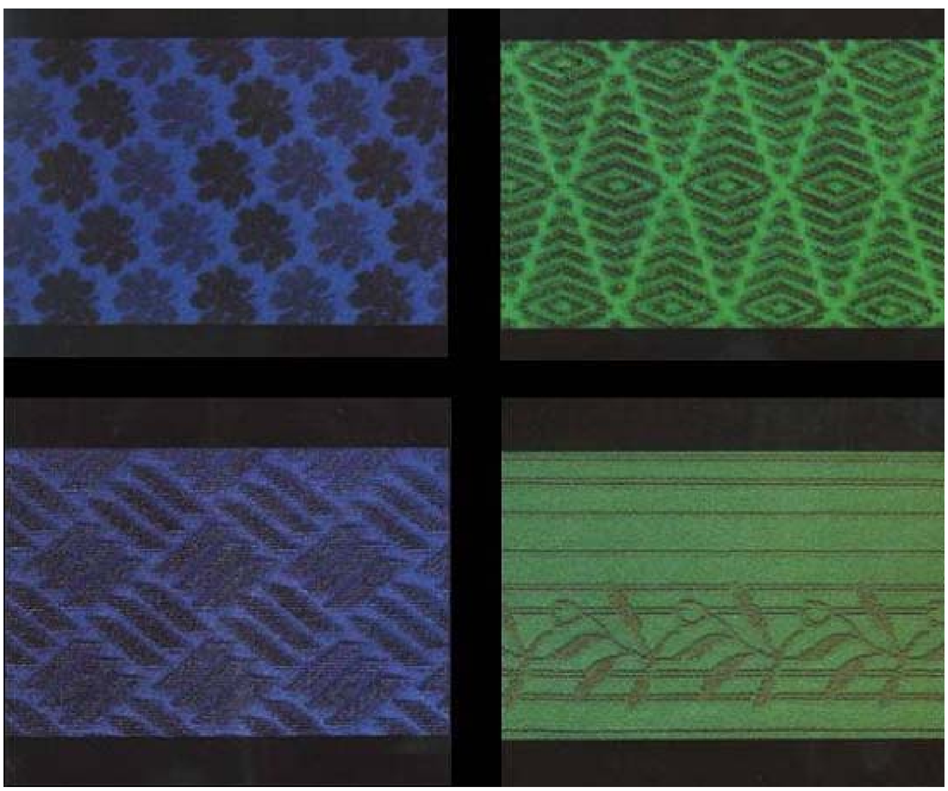
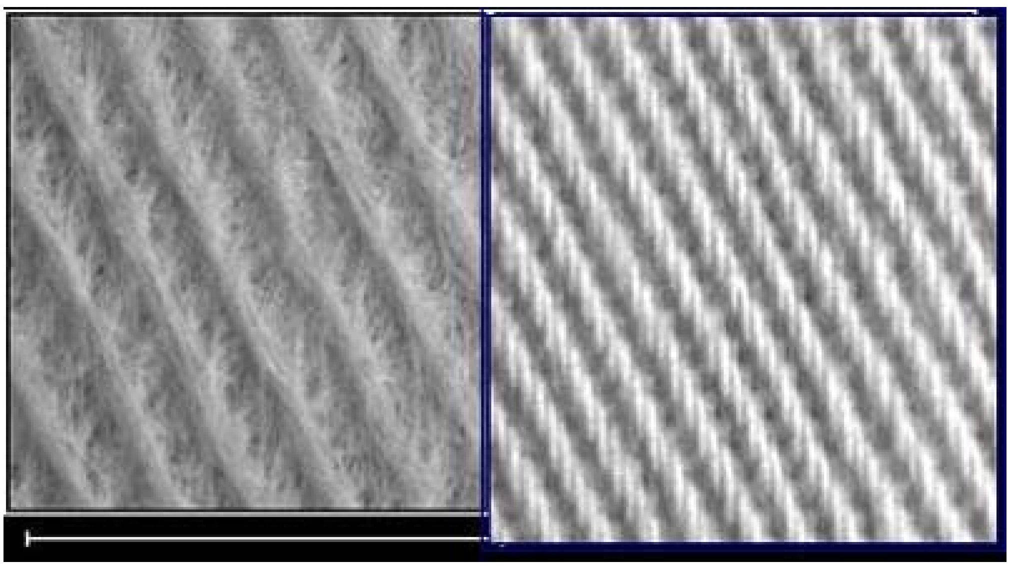


Figure 3. Patterned needlepunched fabrics
(Source: Fehrer's Literature titled "Structuring Needle Punching Machines")

Hydroentanglement

The process of entangling fiber assemblies using water energy was established by Du Pont in 1968. The principle of the hydroentanglement (or spunlace) process is directing high energy fine jets of water through fiberweb that is supported by a forming belt (usually woven) to impinge on the pattern of the supporting belt. As a result of the high water energy, the fibers entangle together thus forming an integrated web with its fibers held by frictional forces. The goal of the hydroentanglement process is thus to produce fabrics with aesthetics and performance indistinguishable from comparable woven or knits at the manufacturing cost of nonwovens. Figure 4 shows an image of hydroentangled fabric.



Hydroentangled Woven

Figure 4. Comparison between hydroentangled and woven fabrics

A typical production line of hydroentangled (or spunlace) fabrics consists of fiber feed, web forming (usually carding and cross-lapping technologies or wet lay web former), hydroentanglement unit, and dryer. The advantages of hydroentanglement technology are:

- There is no fiber damage.
- The technology is capable of producing composite structures (such as interlacing of fibers with reinforced scrim).
- The process is environmentally friendly.
- The space requirement of hydroentanglement production line is less demanding than weaving or knitting facilities for a given production rate.
- The technology is not limited to certain types of fibers or fiber length.
- The technology is the fastest fabric forming system (300 m/min – 600 m/min [3]).

During the last three decades, the hydroentanglement process has been a rapidly growing segment of the nonwoven technology complex because of its ability to achieve excellent fabric properties. The advances in the process can be seen in terms of: (a) high annual growth in the US and (b) increase in investment by machine producers in developing more versatile process with less energy consumption. This technology is penetrating new markets. Today hydroentangled fabrics are primarily used in the USA for aseptic barriers, medical sponges and dressings, wiping cloths, and specialty fabrics (Figure 5). In Japan, spunlace fabrics are also used for hygiene barriers in diapers and sanitary napkins. With the recent developments of Miratec® spunlace fabrics by PGI and EVOLON® spunlace fabrics by Freudenberg, the hydroentangled fabrics are expected to claim a significant market share in the clothing commodity markets.

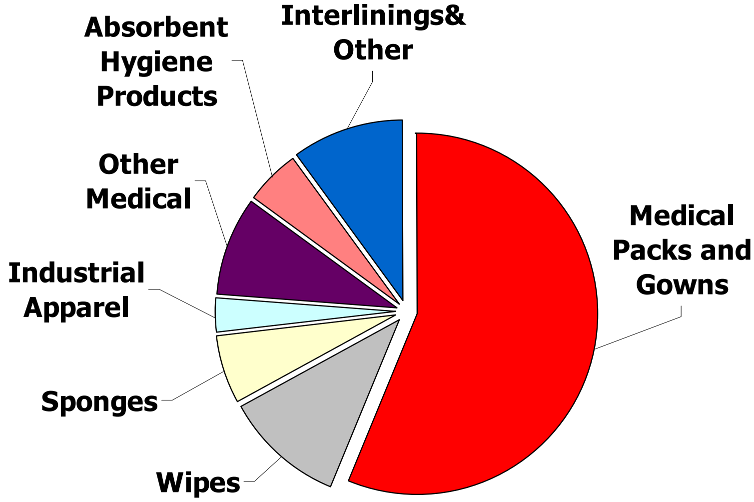


Figure 5. End use of hydroentangled fabrics
(Source: Nonwoven Fabric Handbook-INDA, 1999)

FACING THE CHALLENGES

While the new developments in weaving are significant, the demand for more is needed. Many developments are still needed to allow the weaving industry to face the tough nonwovens' competition. Machine manufacturers should continue to improve the current technologies and introduce new technologies to farther their capabilities and versatilities. Among these developments are:

- Elimination of drop wires as mean of monitoring warp end breaks through enhancing warp quality and/or smart sensors.
- Fully automated start mark mechanism that does not need labor intervention.
- Reduce/eliminate selvage waste.
- Fully automated style change.
- Multiphase weaving machine with Dobby and Jacquard shedding motions.
- Automation of warp yarn breaks.
- Develop smart interface of Imaging and CAD systems.

Weavers will have to continue developing new attractive fabrics with multi-color designs by taking the advantage of newly developed Jacquard technology that allow them to individually control warp yarns. The new advances permit weavers to produce such attractive fabrics in extremely short runs; advantages that the nonwoven technologies are not currently set for.

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