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Innovation in Composite Formation Technologies at ITMA 2023

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Introduction

A fiber-reinforced composite is made up of at least two components that possess significantly different physical and chemical properties which when combined forms a material that possess advantageous properties of all the base components. In textile reinforced composite, the two components are matrix, which is a polymeric bonding component and textile, which is a reinforcement. The resultant composite benefits from tensile strength of the textile reinforcement and compressive strength of the matrix. Common fibers used are carbon, glass, basalt, aramid, or natural fibers to provide strength to the material whereas, matrix resins include materials like epoxy, Polyurethane (PU) and others which function as glue to hold the reinforcement in place (Romeo RIM, n.d.). Braiding, nonwovens, knitting, weaving production techniques can be used to obtain reinforcement architecture. Composites have infinite applications including automotive, sports, aerospace, medicine, construction, and many others (Karaduman et al., 2017). The composite manufacturing process usually includes (a) prepreg – fiber architecture achieved through careful placement of fibers also called tape laying, (b) impregnation - fibers and resins are commingled to form a composite, and (c) consolidation – intimate contact is made between layers of fibers or lamina. Composites can also use fillers, additives, and surface finish coatings depending on end use applications. Lamination technique or process is another class of composite which involves manufacturing a material with multiple layers to achieve end use properties like appearance and strength. A popular multilayer composite material is artificial leather (Figure 1) which consists of a textile coated with a polymeric layer(s). It has similar applications to leather e.g., shoe making, handbags, car seats etc. but has many advantages like low cost, robustness, easy to clean, and can be waterproof. (Friedl, n.d.).

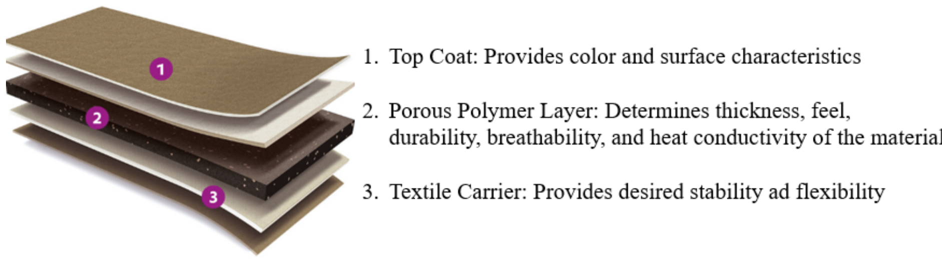


Figure 1: Artificial leather is a multilayered composite where each layer provides different properties (Friedl, n.d.)

This paper deals with the innovation in machines used for producing various components of composites. The three major sections are technical textile reinforcement structures; impregnation, coating, laminations lines; and accessories for the same. The stalls for the above at ITMA 2023 were well attended by the visitors.

Technical Textile Reinforcement Structures

Braided reinforcement structures: Braided composites are at the forefront of the composite market due to their structural integrity and cost efficiency. The Interreg North-West Europe (NEW) Program supported COBRACOMP project aims to develop, test, and validate a new automated textile braiding process to produce preforms for composite materials reinforcement. They displayed a section of their braider shown in Figure 2. a. where the red arrows show the tube to introduce a third axial in the conventional braid. Higher mechanical performance is achieved by the innovative multilayer 3-Dimensional (3D) axial braid assembly with more axial yarn, fiber fraction, and homogeneity. Figure 2. b. shows the new architecture invented by Mr. G. Cahuzac which has no gaps between Unidirectional (UD) fibers, bias to UD ratio is 5:4 which equals 80% and introduces 4 UD sections per layer. Figure 2. c. is a sample of the newly invented braid architecture. Front crash cone, shown in Figure 2. d. is an application which shows that this braid can absorb significant energy due to the presence of UD yarns which help resist crack propagation by reducing resin rich areas.

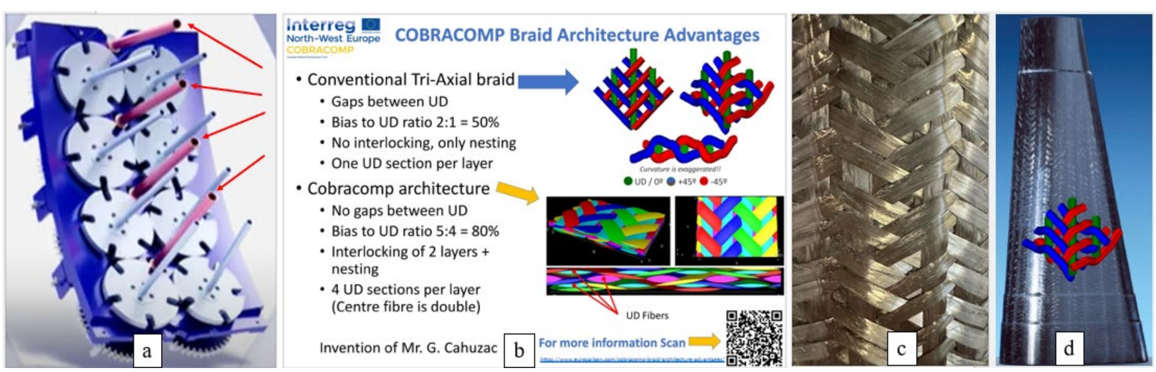


Figure 2: (a) Part of braider showing tubes for introducing third axial (Cobracomp : New Braiding Machine Technology - YouTube, n.d.), (b) COBRACOMP braid architecture advantages (COBRACOMP - Braided Textiles to Improve the Competitiveness of Composite Materials Industry in NWE | Interreg NWE, n.d.), (c) COBRACOMP braid (Source: Picture taken from COBRACOMP stall at ITMA 2023), (d) Front crash cone (COBRACOMP - Braided Textiles to Improve the Competitiveness of Composite Materials Industry in NWE | Interreg NWE, n.d.)

Zhejiang Benfa Technology Co., Ltd. established in 1998 had a hose braiding machine at their stall. The braids produced from this braider are used as high-pressure wire hose, Teflon hose, high pressure rubber hose, car air-conditioning hose etc. Their braiders can braid with stainless steel and aluminum wire as well as nylon, polyethylene, and composite yarn material. See Figure 3.

Figure 3: Braider at Benfa Technology Co. (Source: Pictures taken from at Benfa Technology Co. Ltd. stall at ITMA 2023)

HERZOG displayed SE 1/32-432 and SE 1/32-266 rope braiding machines. Their GF 1/32-120 glass fiber braiding machine along with the take-up is used for producing fiberglass sleeving and for overbraiding hoses with fiberglass (HERZOG, 2023). See Figure 4.

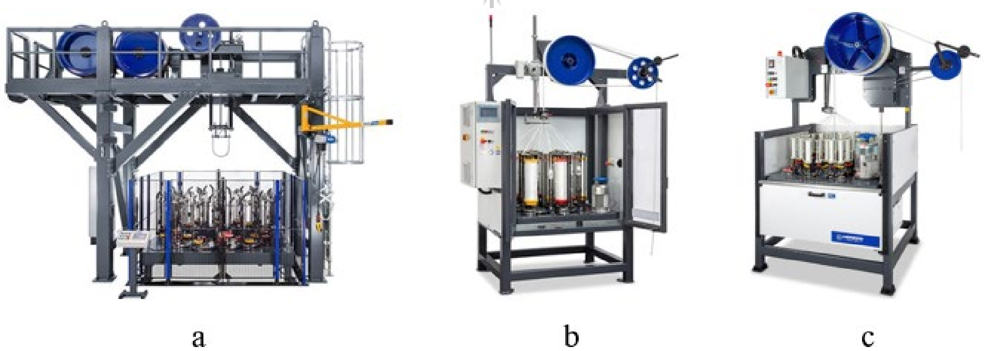


Figure 4: (a) SE 1/32-432, (b) SE 1/32-266 rope braiding machines, (c) GF 1/32-120 glass fiber braiding machine (HERZOG, 2023)

Nonwoven reinforcement structures: AUTEFA Solutions from Germany converts carbon fiber waste by recycling carbon fibers to carbon fiber nonwovens. If the waste is resin free it can directly be processed on AUTEFA Solutions, if not, the resin needs to be removed by pyrolysis. Aerodynamic Web forming Machine Airlay K 12 can produce a nonwoven with isotropic fiber orientation and medium fiber separation. AUTEFA Solutions Carbon Card can produce incredibly good fiber separation with UD orientation. The fiber orientation, surface weight and width of the nonwoven can be adjusted using Crosslapper TOPLINER in combination with the card. Their Needle Loom Stylus can process 100% carbon fibers and enable mechanical web bonding. By adding thermoplastic, thermal bonded nonwovens can be produced using Thermobonding Oven HiPerTherm. They are the key supplier for carded-crosslapped needlepunch lines, aerodynamic web forming technology, thermobonding lines and spun lace lines (AUTEFA Solutions, 2023).

Dilo Group demonstrated brand new MicroPunch technology (alternative to hydroentangling) which is a green needling technology for lightweight nonwovens right from bale opening to final winding step. This technology is classified green because the trimmed material can be recycled within the process therefore, there is no fiber loss, and no water is consumed. These lightweight (30-40 gram/ m^2) nonwovens are used for applications like artificial leather and automotive parts etc. Dilo's inventions, Hyperpunch and Cyclopunch, have speed of 150 m/min and stroke frequency of 3,000/minute. Dilo demonstrated the needle density of 45,000 needles/m^2/board, barb depth: 20–40-micron, throughput speed up to 140 m/min at 2,000 strokes/min. Dilo Group machines can also process aramid, glass fiber, P84®, Polypropylene (PP) etc.

Woven reinforcement structures: Lindauer DORNIER GmbH's A2 air-jet weaving machine debuted at ITMA 2023 hence, their stall was too busy. This new machine provides improved efficiency and enhanced flexibility and reliability to the technical textile. Electronically controlled systems monitor and control reliable weft insertion (Lindauer DORNIER GmbH, 2023). DORNIER Composite Systems® manufactures high quality reinforcement fabrics. One of the worldwide renowned machines is the P2 roving weaving machine which produces reinforcement fabrics using carbon, glass, and aramid fibers. Tritos® PP equipment can manufacture multilayer textiles with complex structures for composite reinforcements using digital weave patterning, rapid rapier motion for low filamentation, and flexible shed geometry. Protos® TW is a tape weaving machine which can process strip-like materials such as fiber reinforcement tapes and films using zero twist feeder. Lastly, Protos® TP machine is used for UD tape which can either be coated with a binder or impregnated with thermoplastic resin (Lindauer DORNIER GmbH, 2023).

The Jacob Muller Group exhibited the Narrow Fabric Loom NFM 53 2/130 which can make spacer fabrics, tapes, webbing rigid and elastic ribbons with controlled thread transports suitable for all yarn types. See Figure 5. NFMJ 53 4/66 576 is capable of producing tapes, light webbing and ribbons for technical applications using the electronic jacquard control functions (Jakob Müller AG, n.d.).

Figure 5: Narrow Fabric Loom NFM 53 2/130 (Jakob Müller AG, n.d.)

Knit reinforcement structures: COMEZ International, a member of Jacob Muller Group presented DNBF/EL-800, an electronically controlled Raschel type warp knitting machine with two needle bars that can produce 3D knitted fabrics, tubular fabrics and nets for the automotive industry. It operates at a higher speed compared to the previous models. Jacob Muller Group has NH2 53 8/27 needle loom that uses the Z6 weaving system which makes spacer fabrics suitable as reinforcements in lightweight composite materials and can provide good compressive stability by incorporating monofilaments.

Karl Mayer's stall was one of the busiest. They showed new digital developments and applications of artificial intelligence to change patterns without making manual adjustments. They demonstrated HKS 3-M ON which is the fastest three-bar tricot machine and compact warp knitting machine. Another one is the warp knitting machine with magazine weft insertion to produce technical textiles with reduced weft yarn waste and increased working speed and width. The KM.ON dashboard is user-friendly and tackles the issue of global shortage of skilled workers. MULTI-MATIC® 32 Compact was the highlight in the warp preparation area (KARL MAYER, 2023).

Karl Mayer also has composite machines for producing biaxial and multiaxial textiles, fiber spreading lines, and fiber reinforced thermoplastic tapes. BIAXTRONIC® II can produce biaxial layer structures, COP MAX 4 can produce multilayer, multi-axial structures, MAXTRONIC® can produce high performance glass fiber composites and, COP MAX 5 can process carbon fibers and lightweight textiles. UD 500 and UD 700 are fiber spreading machines which can produce fiber tapes from continuous filament yarns. SIM.PLY UD can produce tapes up to a width of 800 mm. It operates at high speeds to produce fiber composite tapes with continuous fiber-reinforcement and thermoplastic matrix systems (KARL MAYER, n.d.).

Impregnation, Coating, Lamination Lines for Prepregs and Composites

IPCO highlighted ThermoPress Systems and Scattering Systems. IPCO's scatter system can deposit powder, granular, fibrous materials onto a carrier material. They can be 1800 mm wide used for applications like composites, nonwovens, and textiles (IPCO, n.d.). ScatterPro F details are shown in Figure 6. a. It can scatter glass fibers and carbon fibers uniformly with key features like special agitator for uniform distribution, optimized scattering roller to hold the fibers, rigid or adjustable doctor blade, easy change of brush roller and scattering roller with digital position display to adjust the distance between the two.

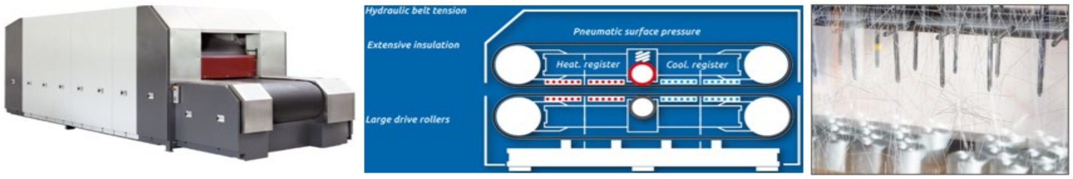
IPCO is one of the leading manufacturers of double belt presses to make composites. Their presses include ThermoPress TB (Figure 6. b.) which have Teflon®-coated belts and counter pressure elements to make multi-layered materials, mixed thermoplastics, carbon fiber, glass fiber, and composite sandwich sheets. ThermoPress CB (Figure 6. c.) also has Teflon®-coated belts with the ability to apply higher pressure via steel belt modules in the consolidation section. These are used in making fiber-metal composites. Lastly, ThermoPress SB (Figure 6. d.) is a high-pressure steel belt-based double belt press technology which has a series of heating, cooling, and pressure zones, with temperatures up to 350 °C and is used to make high performance metal-plastic composites (IPCO, n.d.). They also focused on their center of excellence which is a 1600 square meter testing center in Germany which has a full range of processes from impregnation, lamination, and consolidation to tempering and cooling. They can consolidate pre-laminate sheets and impregnate fibers with resin which can be applied in liquid, film, or powder form on a felt or non-woven material. More information can be found at https://ipco.com/.

Figure 6: (a) ScatterPro F - Fiber scattering unit with rotating brush-off system, (b) ThermoPressTB, (c) ThermoPress CB, (d) ThermoPress SB (Source: IPCO brochures)

BRÜCKNER, a top supplier of production lines and at ITMA 2023 exhibited highlights for textile coating and finishes. The finishing line for glass mesh fabric and for construction reinforcements is the Techno-line TT glass fiber finishing line. OPTI-COAT KA/KC coating unit has a simple and compact design with combined floating knife-/ knife against cylinder unit. The knife against the cylinder can apply larger qualities of coating (approximately 2000 grams/ m^2) as well as low quantities using the floating knife (working width up to 3400 mm). Woven and knitted fabrics can be processed for end use applications like technical lightweight protection materials and air bags etc.

Since 1949, Meyer has been making fusing, laminating, scattering machines and presses. At their stall Mr. Matthias, Technical Sales mentioned that they have bonding technology for composites like honeycomb sandwich sheets, fiber reinforcement composites and for technical textiles like powder coating and impregnation. For prepregs, the flow behavior of the thermoplastic adhesive is important as the fibers need to encapsulate in it optimally. Prepreg makes semi-finished products for end use components. For this application they have laminating machines that can generate high pressure linearly as well as surface wise. Their heating and cooling elements are made of steel and can transfer higher forces as compared to conventional standard machines. These prepregs can be used in televisions (TV), notebooks, mobile phones, aviation, and automotive industry and for lightweight construction components. The KFK-P is the high pressure at elevated temperatures laminator used for processing fiber reinforced composites and other composites. See Figure 7. a. and b. Some technical highlights include hydraulic belt tension, hydraulic pressure by the means of pressure rollers and pneumatic surface pressure (MEYER, n.d.).

They also have a production line to make glass mats from glass rovings with the help of a cutting unit which cuts the roving into a defined length and spreads them evenly on a conveyor belt (Figure 7. c). The powder scatter distributes the adhesive powder. An infrared preheating station helps fast melting of the adhesive to increase the production speed. Applications of the lamination and scattering machines are tempering and sintering of UD-/Machine Direction (MD)-layers, coating of UD-tapes, thermoconsolidation of UD-/MD-layers, connecting of single UD-tapes to large-area layers and, production of UD-/MD tapes in different effective direction (MEYER, n.d.)



a b c

Figure 7: (a) KFK-P high pressure double belt press, (b) Technical elements diagram of the same, (c) Glass fiber scattering (Source: Meyer brochure and (MEYER, n.d.))

Their thermoconsolidation press is suitable for carbon layers or any other material which requires high processing temperatures. The temperature can go up to 400 °C (MEYER, n.d.).

Matex has expertise in coating and finishing machines since 1973. At ITMA 2023 they showed a reverse cylinder coating head with features like independent driving system, tension control for adjustments with lightweight materials, trays for continuous recirculation, gap control using digital display, removable roller and cleaning tray which help with easy maintenance. The machines can do direct coating and transfer coating with a knife or rotating cylinder. Rototextile is a direct coater whereas Rotocoat is a transfer coater, and Rotosplit is a transfer coater for split leather. Matex also has impregnation equipment such as Rotocomp for impregnation of composite substrates with carbon, glass, or aramid fibers. The lamination lines are Rotocoat, Rotomark, Rotopharm, and Rotosplit. End use applications include soundproof material for office, automotive, and filtration.

Zappa Macchine was founded in Italy in 1860 and the first ever coating head was produced in Como. Due to their long history, they have experience and knowledge in hot melt lamination, coating, impregnation, calendaring, flock, prepreg, and powder scattering. They demonstrated coating lines for synthetic leather. They can produce breathable fabrics like GORE-TEX using a hot roller. They coat one fabric first then laminate it with another. Coating is the first step of a huge line.

"Antonio & Fratelli Zappa" has designed and manufactured coating heads and complete coating lines for over 70 years, selling and evaluating them in Italy and abroad. With coating head mod: HSM-2, blade in air and blade over roll coating is feasible as shown in Figure 8. a. These are used in applications like prepregs, technical textiles and traditional textiles. This head can be customized as per the customer's requirements and has accurate blade gap settings. Width is 500 – 6000 mm, mechanical speed is 0-40 m/min. They also mentioned the Rotogravure head which can coat different water-based resin on the fabric for the 'Brinatura effect'. It can apply micro-dots of resin through different engraved rollers. It can also be the basis for the application of special effects such as lamination with metallized film. The web width of this machine is 1600 – 3600 mm and mechanical speed of 0 – 40 m/min.

They developed their hot-melt lamination machine in the year 2000. These machines use full-cover coating and gravure technology. Model PUR-4 was presented at ITMA 2023 which is a sophisticated and advanced model, especially breathable membrane lamination which was their highlight. See Figure 8. b. The machine is equipped with a drum melter for reactive polyurethanes, in 200 liters barrels. Other models they have are PUR-3, TM-Coat, D-Coat, and TMP-Coat.

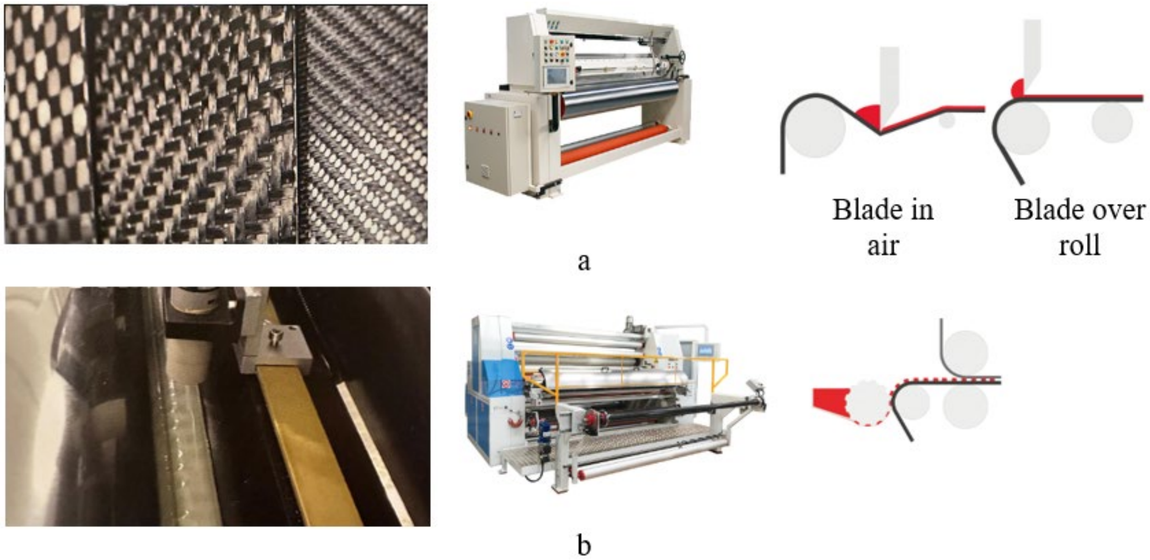


Figure 8: (a) Coating head – model: HSM-2 for prepregs and composite materials (b) Model PUR-4 Gravure hot-melt lamination machine for technical textiles (Source: Zappa Macchine brochure)

COS.T.A. designs industrial lines for applications like synthetic leather, tannery, carbon fiber dip coating and furniture edge banding businesses. Their TOP LEATHER technology is a three-phase process that involves spraying, coating, and hot calendar. It establishes a full grain finish for the shoe and fashion industry. They mentioned their high-performance coating, embossing, and printing line for synthetic leather at ITMA 2023. COS.T.A. is a protagonist in prepreg preparation with the high-performance dip coating for carbon fiber, fiberglass, and Kevlar. Apart from these technologies, they have lab lines for research and development, self-adhesive technology, technical textile laminations and hot melt lines.

Monforts has been a leader in innovations since 1884. They presented the Montex®Coat coating unit which can coat using air knife, roller knife, magnetic doctor blade, rotary screen printing, paste and foam coatings, hence, can offer a lot of tailor-made solutions from one source (Monforts Textilmaschinen GmbH & Co. KG, n.d.). It has improved features including saving setting time, hand-held control device, and automatic edge limiters for immediate adaptation to changing coating widths.

Van Wees entered the composite industry in 1994. They are based in the southern Netherlands and are proud to be the only company to offer UD and multi-axial cross-ply technology. They manufacture UD thermoplastic resin impregnation machines, fabric prepreg (thermoset) impregnation machines, cross-ply machines, lamination lines, creels, and other custom-built machines. They also have testing and consultation services at their Research and Technology Center (R&TC). They have the ability to produce tailored roles from fibers/polymers and composite from tow. The end products are used in applications like bullet proof vests (cross-ply machines) and batteries in Electric Vehicle (EV) cars. Lightweight composites using UD tapes and Direct Long Fiber Thermoplastics (D-LFT) have replaced the aluminum/steel that was used to protect the batteries in cars due to high strength to weight ratios.

Van Wees displayed a variety of samples at ITMA shown in Figure 9. Figure 9. a. is glass fiber PP, Figure 9. b. is a cross-ply roll of carbon fiber PP, Figure 9. c. and d. are materials used for soft applications such as sailcloth and flexible protection materials (bullet resistant vests), Figure 9. e. is a flax fiber reinforced polymer (PP). At Van Wees, they have a spreading section, impregnation section, and final winding using tension control on every yarn. Samples can be ordered at info@vanwees.nl. The fibers used on these machines are glass, carbon, aramid fibers and Ultra High Molecular Weight Polyethylene (UHMWPE) and are converted to UD tapes using dispersion resin. These tapes are then used as raw materials to the multiaxial UD or cross-ply machines to make composites with various fiber orientation and layers.

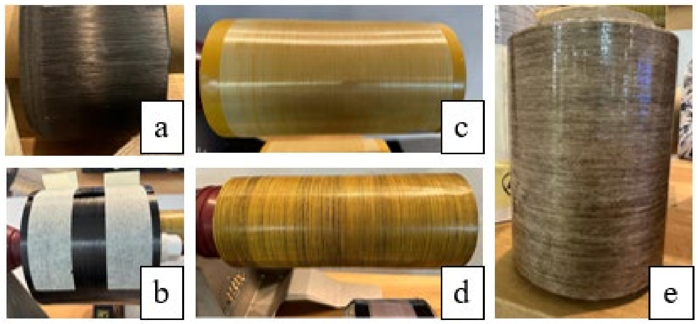


Figure 9: Van Wees spools made from high performance fibers for production of composites. (a) Glass fiber PP, (b) Cross-ply roll of carbon fiber PP, (c) and (d) Materials used for soft applications such as sailcloth and flexible protection materials (bullet resistant vests), (e) Flax fiber reinforced polymer (PP) (Source: Pictures taken from Van Wees stall at ITMA 2023)

The three machines Van Wees has for impregnation of fibers and fabrics are, dispersion impregnation, thermoset impregnation by reverse roller coater, and thermoplastic resin impregnation with inline extruder. The dispersion impregnation is stable with high impregnation due to easy penetration at the speed of 20 m/min. The thermoset prepregs are made in a one step process by reverse roller coater at a speed of 3-10 m/min range. For impregnation of thermoplastic resins, the film is made by melting the polymer in an extruder and metering the film thickness on the impregnation roller at a speed of 3-15 m/min range (Van Wees, n.d.). See Figure 10. a. Cross-ply material is a multidirectional laminate made up of a minimum of two layers as shown in Figure 10. b. Two different processes possible are the single layer process and multiple and multi-axial process. The single layer process is used for the ballistics industry where the UD tapes are oriented in 90 degrees. The second layer is applied in the second pass or the impregnation machine. For the multiple layer process, the second layer is included in the cross-ply machine at an angle of 45 to 90 degrees. Multiple rolls can be consolidated, and it is possible to cut the material and consolidate it in a mold or before molding by infrared heating. For making wider cross-ply laminates and tailored blanks, multiple UD tapes can be placed next to each other as 0-degree layers. This equipment operates at 10 m/min depending on the width. These materials are consolidated using Van Wees laminating lines (Van Wees, n.d.). See Figure 10. c.

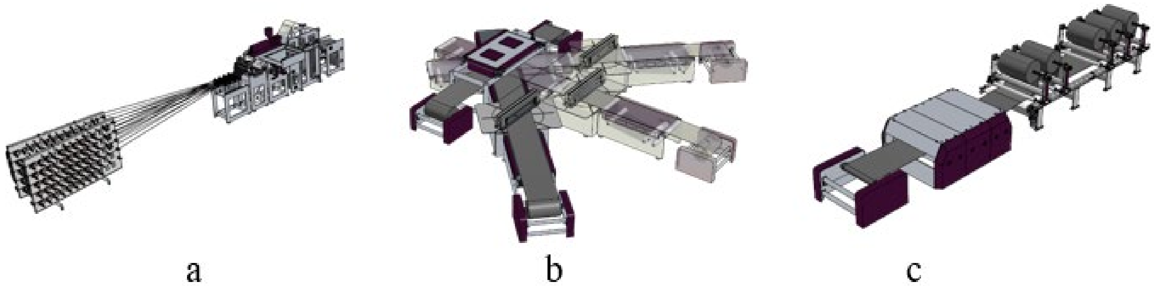


Figure 10: (a) Impregnation (b) cross-ply and (c) lamination machines at Van Wees (Van Wees, n.d.)

Van Wees have equipment for making flakes, which can be compression molded on a press to make products. For flat panels, it has heated tables on which the material is consolidated using vacuum pressure only. All the equipment used in house is commercially available (Van Wees, n.d.).

Accessories for Enhancing the Production of Composites

Creels are placed behind the warping or weaving machines to make warp beams for weaving looms. Texmer GmbH & Co. KG specializes in developing and supplying creels for all winding materials that can be pulled off both tangentially and overhead. The modular creel from Texmer has a motor for every bobbin that calculates and controls tension from full bobbin to empty bobbin for individual positions. They have patented tension balancing systems which provide a substantial number of adjusting possibilities. Texmer has experience with high-quality pneumatically braked creels which are characterized by short response times, high operational safety, and extremely low wear. Diameter control secures trouble-free operations. These are made for technical yarns and tapes as shown in Figure 11. They also sell POLYPAD® to reduce vibrations.

Composite fibers such as carbon fibers or glass fibers are susceptible to damage due to friction. Therefore, the coefficient of friction of the guide elements needs to be low enough to avoid damaging these fibers. Coated guide elements can help reduce carbon fiber damage to a minimum and increase process reliability. It is particularly important for low yarn tension glass roving creels to have exact control. Pneumatic mandrels have unrolling solutions for glass fiber roving without a twist. The yarn comes in minimum contact with the Texmer creel and can be drawn as far as possible without deflection. Polyacrylonitrile (PAN) precursor creel can hold bobbins with diameter up to 1000 nm and weight up to 500 kg. All positions are individually controlled. Once the controlling unit of the electronically controlled creels is adjusted it will maintain a required thread tension by accelerating or decelerating the motor during operation (Texmer GmbH, n.d.).

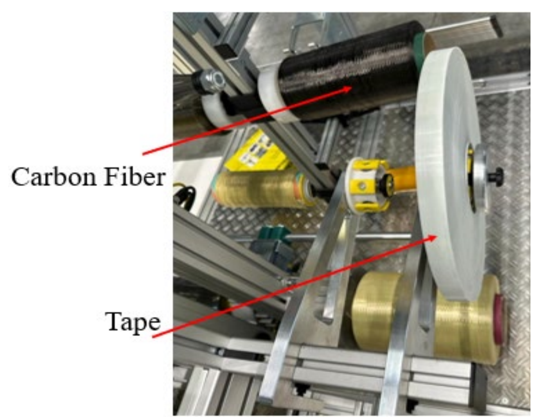


Figure 11: Texmer creel (Source: Pictures taken from Texmer stall at ITMA 2023)

Topocrom GmbH is a small company of about forty-five employees based in Germany. Topocrom® surface structure provides benefits like wear and corrosion protection which helps in extending the service life of the parts. It is challenging to process technical fibers such as carbon, aramid, glass, basalt and composite fibers as they can be very abrasive. If the fiber filaments break, tear, stick or splice it can lead to interruptions in the automated operations which often happens due to unsuitable surfaces of the guiding element. Rough surface has low friction. Therefore, Topocrom® layers are produced by using chrome electroplating process using closed reactor principle. Chromium trioxide is used but only in closed reactors for which approval recommendation is issued by The European Chemical Agency (ECHA) for 12 years. This is a reproducible process and the structured chromium surface properties can be adjustable as per the customer's need. Base materials suitable for chrome plating are steel, steel alloys, cast iron, stainless steel, copper, copper alloys, titanium, and titanium alloys. The roughness of the surface can be changed by altering the current. Therefore, Topocrom® coating can prevent splicing, wrapping, adhesion of filaments, reduce dust formation, and increase wear resistance. Customers are from the processing industries, steel mills, and automotive industries. Topocrom® coated molds and dies are also used in the plastic injection industry for better heat distribution and smooth surfaces. See Figure 12.

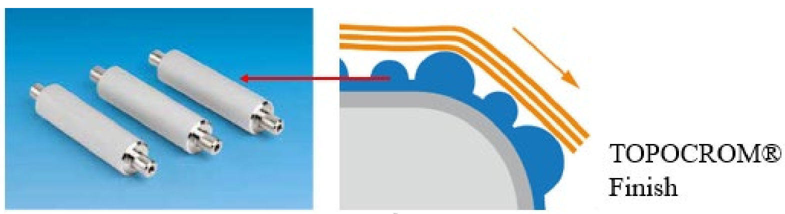


Figure 12: Topocrom® finished parts (Carbonprocessing, n.d.)

Van Wees also develops creels which have features like regulated yarn tension with manual or automated adjustment for each row individually or the entire creel. This is helpful for yarns like polyamide, polyester, aramids, and UHMWPE. In the case of carbon fiber there are special eyelets to avoid twisting the tows. Twisting of the tows is not good because it causes the fibers to tilt leading to low contribution of individual fibers to the total strength of the tow. This can in turn lead to low performance of the overall preforms and resultant composites. Twisting of the tows can add thickness due to bundling up of the filaments. This can create air voids which can make a resin rich area in a composite. These areas can cause failure as they have a tendency to start crack propagation. The glass roving creel can take heavy rolls up to twenty-five kilograms (Van Wees, n.d.).

To increase the surface adhesion with the resin in a composite, the air voids need to be reduced in order to increase the fiber volume fraction. Hair on the surface of a fabric which comes from spun yarns can create uneven surfaces and make air voids. Singeing can burn off these projecting hairiness and fuzz to improve the surface adhesion with resin and increase the fiber volume fraction. Osthoff-Senge, a leader in singeing (Figure 13) and pretreatment demonstrated one of their singeing machines which is mostly the first step in finishing. Woven and knitted fabrics with cotton, viscose, and glass fibers can be treated. It was five feet wide, two bricks with a slit in between and runs at a speed of 100 m/min. Singeing is important for printing as it is difficult to correct a singeing mark. They also build impregnating compartments for fabric contents of 10, 15, 20 m (osthoff-senge, n.d.)

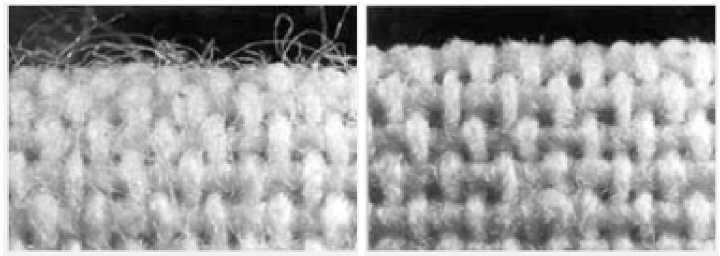


Figure 13: Effect of Singeing (osthoff-senge, n.d.)

Conclusion

Textile composites play a significant role in the world moving toward innovating lightweight performance materials whether it be sleeves for EV batteries or artificial leather for high-end fashion brands. ITMA 2023 focused on 'Transforming the World of Textiles' which had twenty sectors including composites. However, there were still not many composite companies as compared to conventional textile processing companies. Van Wees presented composite expertise while majority companies focused on fiber or textile manufacturing such as braid, nonwovens, knit, and woven reinforcement. Several companies also demonstrated the ability to process high performance fibers on their machines, provide research and development consultation and testing, and contract manufacturing for the benefit of well-established as well as startup companies (a new CEMATEX initiative). Apart from this there were numerous companies focusing on material laboratory testing as well. Overall, this year's ITMA unveiled remarkable advancements in improving the sustainability of the process by reducing waste and adding smart and faster technologies to make machines automated and efficient.

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