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Coating and Materials Handling Technologies for Prepregs

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Today the use of coated products for prepregs is growing rapidly. This increasing demand has resulted in the development of new and highly innovative impregnation and coating machinery concepts for prepregs at Coatema Coating Machinery GmbH.

The world wide trend in prepreg machinery is favouring flexible, multifunctional systems for the production of various products made from rovings, textiles and multiaxial structures. The combination of fibres like carbon, glass and Kevlar[®] with epoxies for the use in reinforced plastics for light-weight products in the aerospace, sports and automotive industries is gaining more and more importance.

The design of specialized coating technologies and the effective treatment of the fibre materials for prepreg products present a number of mechanical engineering challenges. Generally prepregs are temperature activated intermediate products with tailor made properties. Application advantages for the use of prepregs are:

- superior stiffness
- high tensile strength
- low density
- corrosion resistance
- high vibration resistance
- low heat elongation
- low weight
- extraordinary fatigue resistance
- easy installation in use
- low maintenance costs in use

For the machinery solution in general it is necessary to apply epoxy resin or phenol resin chemistry on a variety of substrates made of different material type.

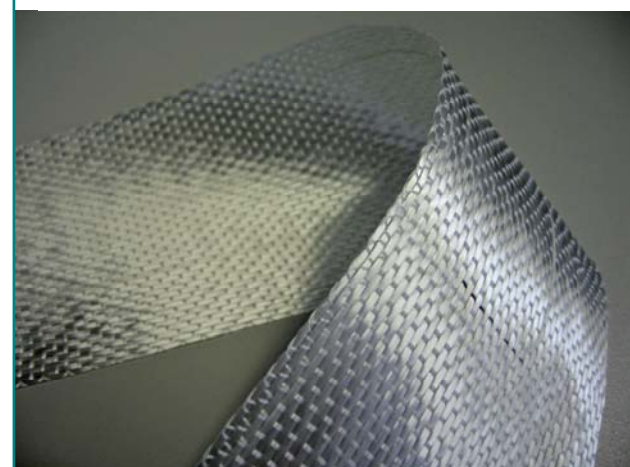
Difficulties in handling various products must be evaluated for winding, material guiding, coating and drying processes. Depending on the substrate, the coating chemistry and the end product it is necessary to perform a detailed evaluation of each piece of



Carbon substrates



Glass fibre rovings



Glass woven fabric

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equipment proposed for coating and impregnating lines.

Material Types and Product Design

Coatema has considerable experience handling prepreg fiber materials, which are mainly:

- carbon fibers
- glass fibers
- Kevlar[®] fibers
- graphite fibers
- other man-made fibers

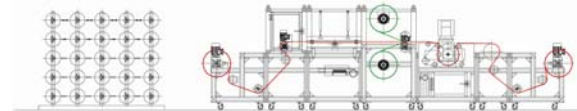
There are also differences in the layouts of fibre products including:

- woven fabric
- uni-, bi- and multidirectional fibre constructions
- products that have more than one orientation depending of the desired strength direction

Depending on the material structure it is necessary to define the handling technology in winding off via creels or roll winders.

Depending on the number of rovings to be coated, creels of different sizes are used to wind off the rovings in parallel and feed them to the coating process. The control of tensile strength is essential, as both too tense rovings as well as sagging ones cause problems. Both could result in an uneven coat and thus become unusable product due to poor quality.

Mainly low slippage resistance creates problems in handling of woven or multiaxial substrates. Very precise tension adjustments must be assured. Each disarranged fibre influences the resulting force distribution in the structural component part.



Click&Coat™ concept as flexible layout for prepreg production



Different winding technologies

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Chemical Solution and Coating Technologies

An additional requirement for special handling of products for prepreg materials is influenced by the use of chemical solutions. Resins (matrix) as coating materials can include:

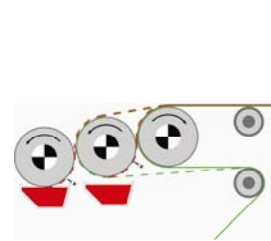
- solvent or water based epoxy resins
- powder like materials
- hotmelt resin
- phenol systems
- polyester/vinyl ester/acrylic resin systems

The substrate must be brought into the optimal position using guiding systems before coating. The substrates must be fed to the coating system and subsequent drying process without displacing fibres in the rovings or woven fabrics. The slippage resistance of woven substrates are very low and very often cause problems. There is nearly no physical adhesion between the fibre bundles so the substrate has to be guided very carefully into the coating process by guiding rollers with very smooth surfaces.

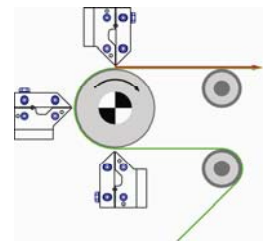
There are a variety technologies available for filament coatings, with dipping technology and heated knife coating generally being the preferred. Filament coating possibilities include:

- dipping systems
- knife coating technologies (often heated)
- roller systems
- slot die technologies
- powder scattering
- hotmelt-technologies

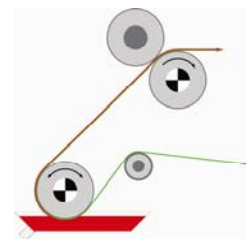
Some of these coating systems are shown in the following pictures and drawings. The choice of the right coating system must be determined in consideration of the chemistry, the application weight and the viscosity of the coating material among other factors. Furthermore the differentiation in complete impregnation or only single side coating influences the choice of the coating system.



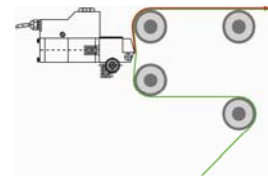
3-Roller Combi System



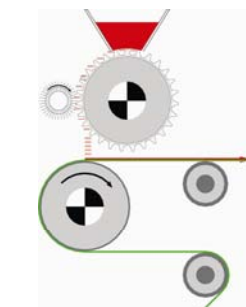
Slot Die System



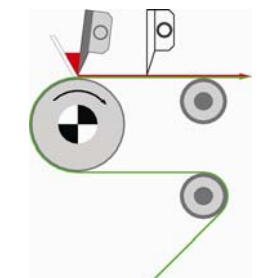
Dipping System



Hotmelt System



Powder Scattering System



Knife System



Drying/Curing via IR

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Problems of handling of the products are often due to:

- breakable fibres
- the need for complete coverage of the fibres if single rovings or closed substrates need to be coated
- critical damp during the drying process like formaldehyde, phenol chemistry compounds

Drying Technology

The coating technology is necessarily followed by drying, a very important feature of a prepreg coating line. In general precise adjustments of the drying or curing processes must be realized for a high quality end product. Available techniques are:

- drying via hot air
- drying via IR

Depending on the coating material and the thickness of the layer, both drying methods can be used. Convective dryers are used with solvent-based raw materials and when very consistent air control is necessary. IR-technology accelerates the drying process as the radiation warms the substrate from inside and the heat is quickly adsorbed by the substrate. This is the ideal drying method for high production speeds and for water-based coating materials. Because the heat migrates from inside the substrate to the outside, the product can dry much faster.

Plant Concepts and Summary

Important parameters for coating plants for prepreg handling result in specialized plant layout such as:

- various winding technology with perfect tension control
- various coating technologies depending on the coating weight and the coating chemistry viscosity and delivery
- drying technology depending on the coating chemistry (water or solvent based)
- appropriate exhaust technology



Drying via hot air



Drying/Curing via IR



Installed coating plant for prepreg products

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End users choose composite materials due to the characteristics of weight, strength and economy of use. As a result of the extreme differences in individual products, expectations from production machines are very high. With decades of experience Coatema Coating Machinery GmbH is in a position to offer highly innovative and economical prepreg machine concepts. These concepts need to be tailored to each customer's specific needs.

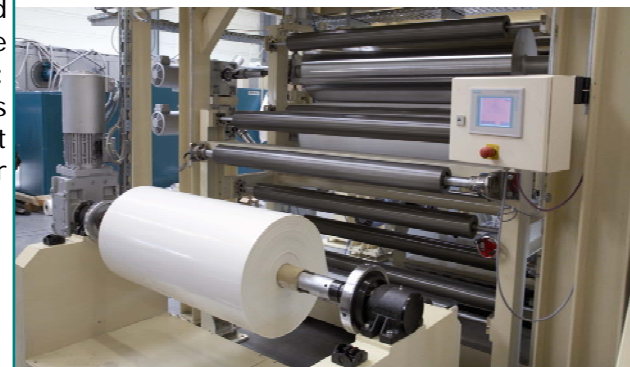
Coatema Coating Machinery Prepreg Systems

Driven by the need for improved fuel economy the demand for advanced composite materials is taking off, literally and figuratively, in the transportation industry. Designers of airplanes, automobiles, buses and even passenger trains are looking to composites for energy saving weight reductions without sacrificing durability, safety and production costs.

Prepreg manufacturers are looking to companies like Coatema Coating Machinery, Dormagen, Germany, for possible solutions to problems created by burgeoning demands for more, newer and less costly products. Coatema's design and manufacturing team has responded with a combination of traditional and innovative coating, laminating and handling technology

Coatema's Top Ten Ideas for Prepreg Manufacturing Systems

- 1) Coatema prepreg systems, from lab scale to turn-key production plants, have as much automation and continuous running capability as is practical for the application and machine budget. This can include: automated roll or bobbin changes with accumulators and splicers; closed-loop monitoring and adjustment of warp and weft parameters and impregnation or coating loading and thicknesses controls.
- 2) Coatema's Microsoft based visualization hardware and software provides master stations with complete access to all machine functions plus an interface to the manufacturing system. Satellite visualization and control stations, which access only the information needed locally, can be located at critical points in the process.



Details of the installed coating plant for prepreg products

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- 3) Critical systems are designed to address the nature of the materials being processed for simplified and safe maintenance and cleaning. This can include special machine surface treatments and coatings, removable maintenance intensive modules and ease of access features.
- 4) Robust and flexible resin and epoxy materials preparation, delivery and circulation systems meet the most demanding requirement for product purity and longevity. They can be equipped to continuously monitor and make automatic adjustments for fluid level, temperature and viscosity.
- 5) Total web or warp management systems can include floatation, roller, belt or tenter supported transportation with precise tension control, material guiding, pre-cleaning, pre-heating and weft alignment.
- 6) Temperature and air flow control systems, which can be built to explosion proof standards, are available in Coatema patented vertical and horizontal configurations for curing, drying, and cooling. The heated systems can function with jets of air or radiant heat from a wide range of energy sources including hot oil, steam, gas, electric or by burning recovered solvents.
- 7) All Coatema prepreg lines include continuous monitoring for potentially hazardous situations with automatic and manual emergency shut-off and lock-out features. All guarding, alarms, safety and environmental protection standards necessary to comply with international and local environmental and safety standards are included.
- 8) A complete offering of finishing processes can be built-in including calendering, slitting, slip sheeting, roll reduction, wrapping and packaging ready for shipment to the end user.
- 9) World class service and support begins with acceptance testing before and after delivery, installation and start-up assistance with operator and maintenance training. Post installation service includes remote help, with built-in modems and diagnostics software, plus on-site maintenance, repairs and upgrading.

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- 10) Coatema's Dormagen, Germany R&D center is a complete production scale laboratory that has been especially valuable for prepreg production R&D. In addition to offering the opportunity to test machines and application methods the center is staffed with experts in materials selection and preparation. Coatema has established a satellite R&D center in Asia.