Machinery and technology development for coating plants as a result of a close relationship between plant supplier and user

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Introduction:
Coatema is producing customer made machinery solution for coating and laminating processes. Our market fields are machinery equipment for textiles, films, foils as well glass plates. Coating lines for small substrates like yarns, filaments and belts are playing an increasing part. Also the use of technical textiles for high performance products is constantly increasing. In this connection, the coating of textiles with functional layers is an indispensable process to meet the growing requirements on technical textiles.

Coating lines are used for the following products.

Picture 1: Application areas for coated substrates

In some cases, even filaments, yarns and belts need to be coated, which means covering them with a functional layer, which adds certain properties like stability, abrasion resistance, smoothness or unevenness, colour or design effects or chemical resistance.

Fundamentals for coating of small substrates

Filament coating often poses a challenge to the supplier of the coating technology as far as winding technology, coating and drying of the filaments is concerned.

Small substrates can be used in different designs.

Filaments
- Mono-Filaments
- Multi-Filaments

Yarns
- Ring spin yarns
- Rotor spin yarns

Twisted yarns
Rovings
Ropes
- twisted
- plaited

Belts

The products are used for:
- Artificial hair
- Medical sewing threads
- Ropes for sport, ship navigation and fixation
- Bands and belts for fixation and for reinforcement
- Row material for fiber reinforced plastics (GFC, CFC)
- Coated yarns for further used in woven and knitted fabrics as well as for embroidery

It is necessary to reach defined properties for the different using areas. Depending on the end use the following characteristics and qualities shall or can be reached.
- complete encapsulation with a functional layer
- partly complete penetration through the fiber compound
- reaching of substrate specific features like
  - tensile strength
  - water density or stability
  - abrasion resistance
  - smoothness
  - roughness
  - colour and design effects
  - chemical resistance

As in contrast to roll-to-roll coatings the coating of filaments requires only little tensile strength and completely different processes, experiences in roll-to-roll coatings are of no avail. Moreover, the filament must be completely covered and cannot be coated on only one side.

Special demands on the process technology are requested for

- winding technology
- coating technology
- drying technology
- substrate tension, guiding and handling during the different process steps.

The following aggregates are necessary to grant the optimized handling of the filament in a filament coating machine:

1. Winding-off unit

In general, the filaments are wound off coils of different designs, but mostly conical crosswound bobbins are used. Depending on the number of filaments to be coated, creels of different sizes are used to wind the filaments off in parallel and feed it to the coating process. The control of the tensile strength is essential, as both too tense filaments as well as sagging ones cause problems: Both would result in an uneven coat and thus perhaps in an unusable product because of its poor quality.

If the filament is too tense, it would overstretch during the coating and drying process. After the cooling, this overexpansion would be fixed and entail a very hard filament or the flaking of the coating after the drying process.

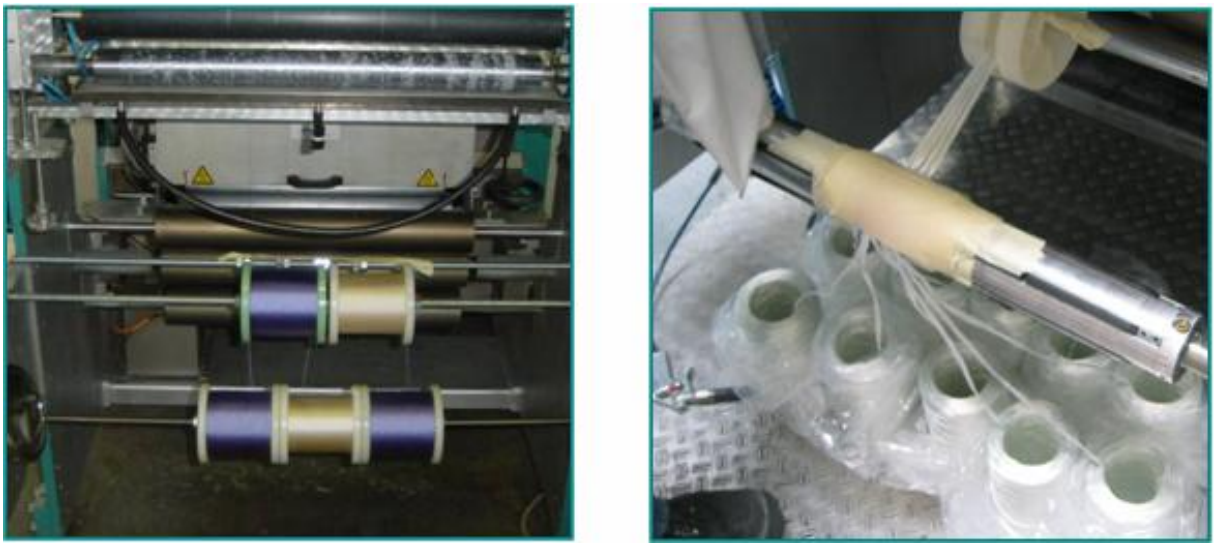
Picture 2: Creel in a filament coating machine

If the filament is too loose, it would cause an uneven coating, as a sagging filament might twist inside the coating unit.

Moreover, loose filaments stick to each other easily and could break.

This is why mechanically braked creels with a fine-tuning adjustment of the braking force are essential.

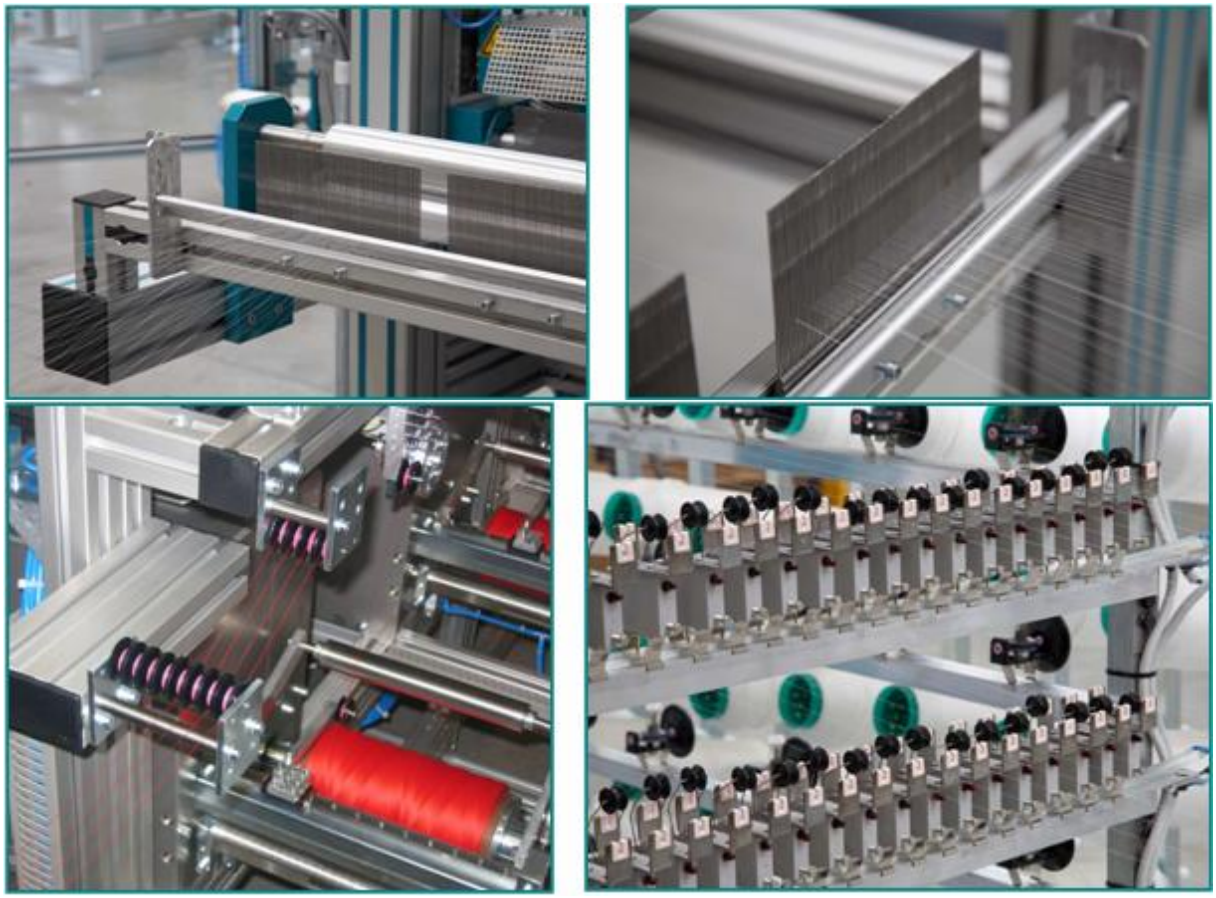
An other technology will be the winding from bobbins directly. This technology is mostly used if only a small number of bobbins is necessary or has to be handled.



Picture 3: Winding off from bobbins

2. Guiding systems

Before the coating process, the filaments must be brought into the optimized position by the filament guiding equipment. In doing so, the filaments must be fed to the coating as well as to the subsequent drying process, avoiding a contact of the particular filaments to each other.



Picture 4: guiding by combs and ceramic eyes and rolls

Different to sizing processes an contact between the different yarns or filaments have to be avoided. Each contact is critical for the evenness of the coating layer and the surface of the coated substrate.

3. Coating technologies

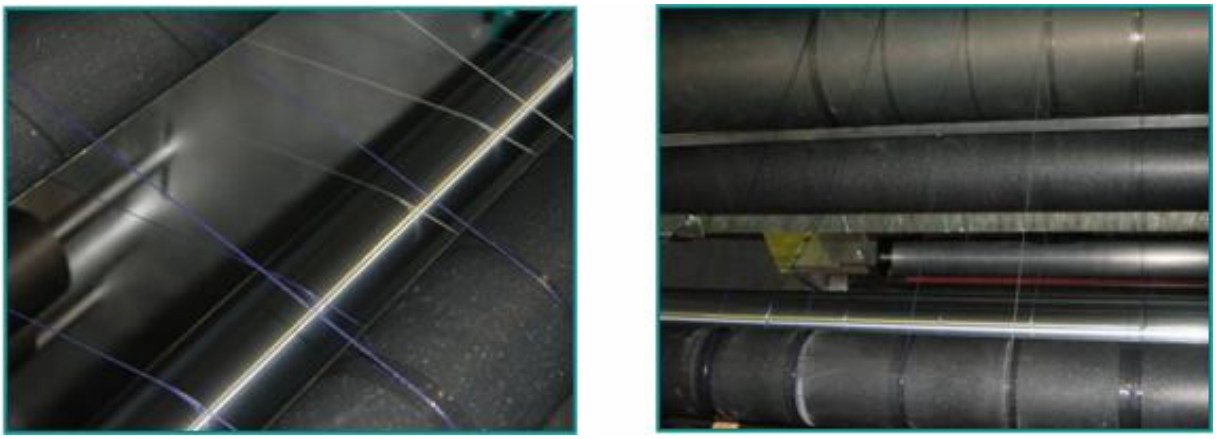
There are generally different technologies for filament coatings, with the dipping technology and roller coating being the preferred ones.

Picture 5: Coating by dipping

When the dipping technology is used, the filaments are dipped into a bath and are then exactly squeezed. This means that the filaments are led through two rollers which are in an opposite position to each other and which strip the surplus coating material off the filaments. This enables the exact definition of the amount of coating material that has to remain on the filaments.

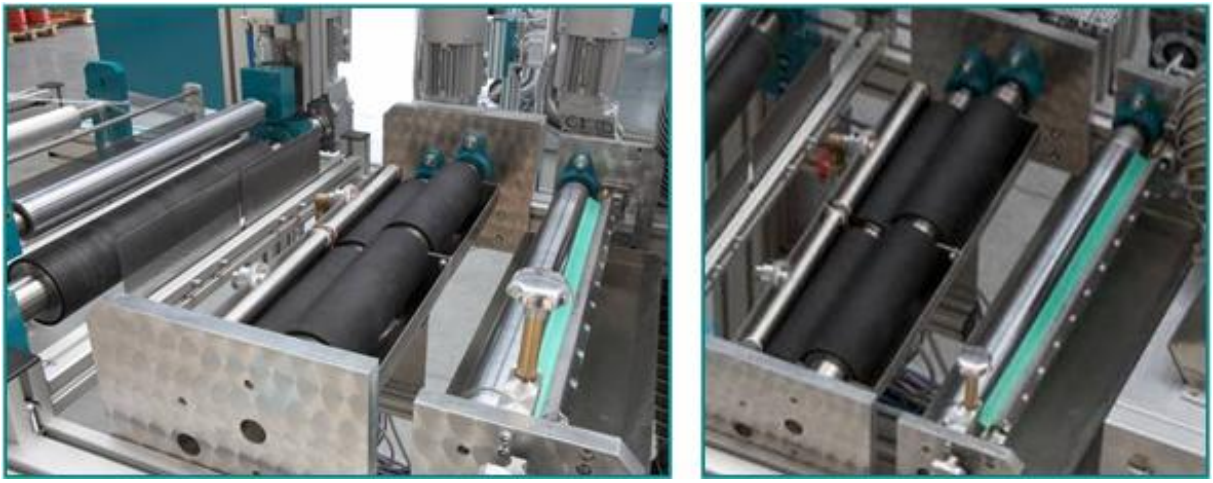
The disadvantage of this coating system is the complete dipping of the filaments: If the filament material is very hydrophilic, the filaments may absorb too much liquid which causes a very long drying process.

In order to avoid this disadvantage, roller coating systems were introduced. They facilitate a superficial application of the coating material. These roller coating systems work according to a simple operating mode.



Picture 6: Coating with heated rollers

The application roller takes up the raw material from a bath and applies it either directly onto the filaments or onto a second roller which then coats the filaments. The amount of raw material to be applied can be exactly determined by the velocity control of the application roller.



Picture 7: Coating with specialized two roller application systems

If the application roller rotates quickly, more coating material is applied, if it rotates slowly, it applies accordingly less raw material. The contact of the filaments to the application roller can also be determined by guide rods or guide rollers, which also determine the amount of applied raw material.

Independent of the coating system, the aim is a regular covering of the filament with the coating material.

As alternative method also the extrusion technology can be used. In this case the filament or yarn will be taken through a small extrusion die and coated very everywhere around the substrate with melted hotmelts. Behind the advantage of a very fats process without any drying technology the thermal stress to the substrate could be very high. In any case a special cooling process by water or cooled air have to be realised directly behind the filament or yarn is coming out of the extrusion die.

Picture 8: Coating by extrusion with hotmelts

4. Drying technologies

A constant drying after the coating is vital for a high-quality product. It can be done by a convective air flow or by IR drying.

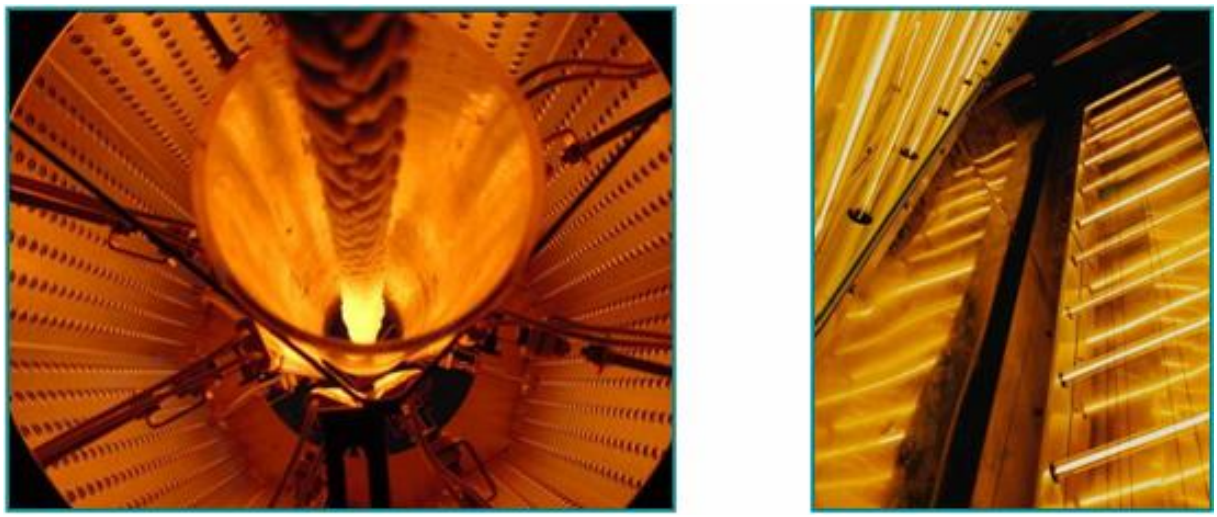
It is important to dry the filaments with the optimal tensile strength and thus to avoid that too high tensions in the substrate, produced by too high traction forces, are fixed during the drying process.

Picture 9: Drying with hot air

Depending on the coating raw material and the thickness of the layer, both drying methods are used. Convective dryers are applied with solvent-based raw materials and when a very constant air guiding is necessary.

Picture 10: Drying with IR

The IR-technology accelerates the drying process as the radiation warms the substrate from inside and the heat is quickly being brought into the substrate. This is the ideal drying method for high production speeds and for water-based coating materials. As the heating works from inside the substrate to the outside, the product can dry much faster.



Picture 11: Drying with special designed IR units

Depending on the substrate design different kinds of IR units are possible. Drying with IR units in spiral form or flat

In general the following demands are requested from the drying process:

- even drying / across drying into the inside of ropes and other high volume substrates
- explosion proofed layout in case of solvent based coating chemistry
- fast air penetration into the inside with IR technology
- convection air dryer partly as flotation dryer in case of sensible filaments and tension instable substrates.

4. Winding on technologies

At the end of the coating process, the product must be wound-up in an ideal way.

Depending on the further application of the product, the yarn is wound up in parallel onto so-called warp beams, as a group of filaments by hanks or each filament onto individual coils. The subsequent operating of the warp beams is done by weaving machines. The individually wound up filaments are then finished in different ways.

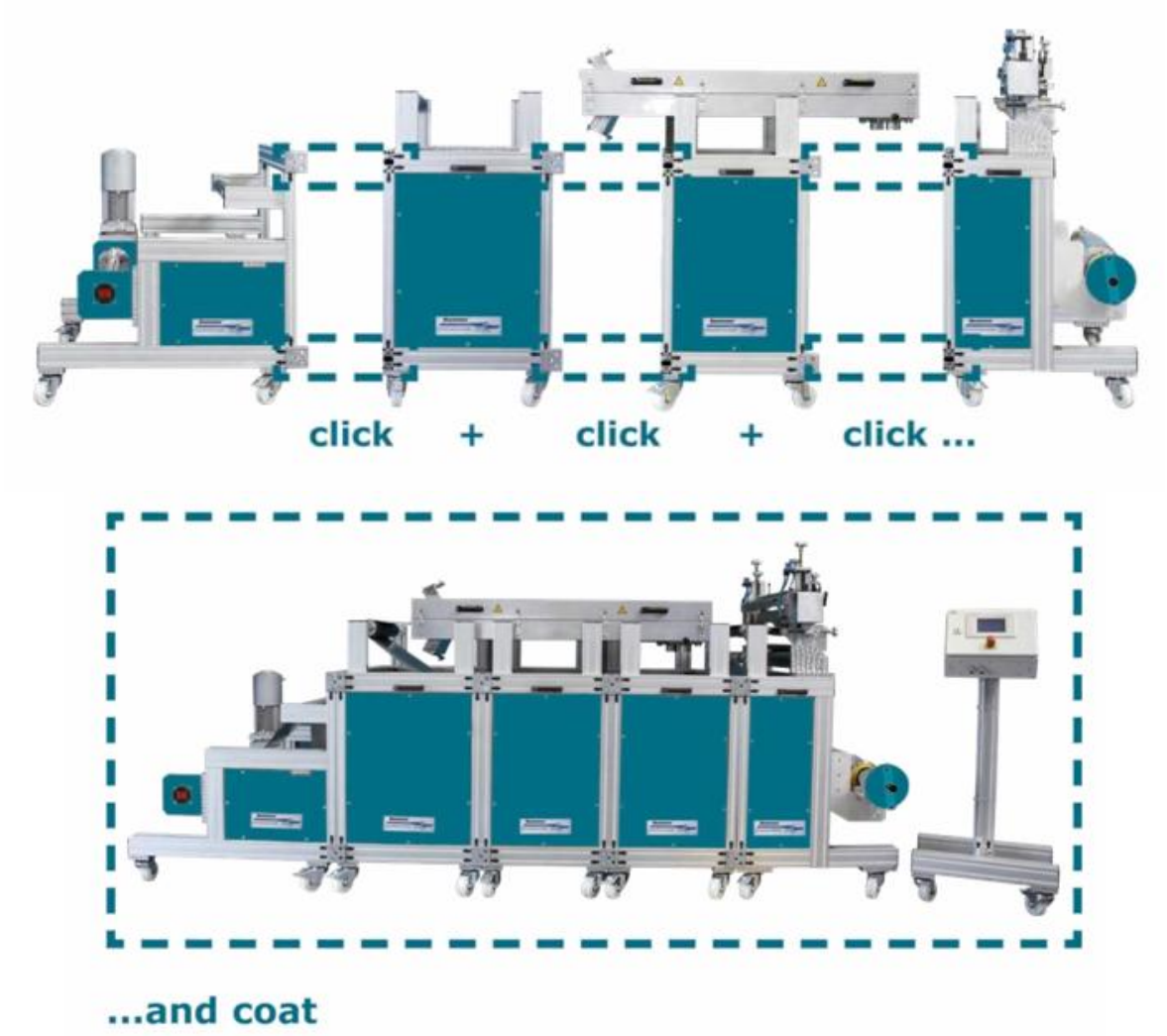
Picture 12: Winding on on single bobbin coil units or a creel

The perfect tensile strength is also essential for the winding process to avoid an overstretching of the filaments and thus the destruction of the filaments by micro-cracks. Picture 13 shows the winding-up onto a hank.

Picture 13: Winding-up coated filaments by a hank

Coating line concepts for a flexible process arrangement

In order to create a flexible process arrangement Coatema developed the so called Click&Coat™ system.



Picture 14: The idea of Click&Coat

Different units like winding technology, coating and drying technology (convection, IR, UV) can be located variable after each other to create a coating line according the necessity in different process steps. With this technology a highest degree of flexibility is given.

Summary:
Today, there is an increasing use of coated filaments for the production of functional technical textiles. These filaments can then be woven, knitted or directly be used for e.g. artificial hair: Their application is almost unlimited. The development of adequate coating technologies and the ideal treatment of the substrate „filament“ poses a challenge to the mechanical engineering. Messrs. Coatema Coating offers you technical solutions resulting from the large number of plant layouts they have realised during their 30 years of experience in manufacturing coating plants.