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FIBER SPRAYING – BREAKTHROUGH FOR BIO-HYBRID FIBER COMPOSITE MATERIALS

Brand new bio-hybrid fiber composite materials allow thinking in totally new directions especially for lightweight construction with respect to value engineering.

A new fiber spraying process combines diverse natural and synthetic fibers with different polymers into versatile, tailored composites, which can themselves withstand high loads as parts. This has become possible in a single, continuous and thus significantly shortened process. At the same time, the high proportion of natural raw materials reduces the ecological footprint. The process was jointly developed and piloted by the Fraunhofer Institute for Wood Research WKI and Schmidt & Heinzmann GmbH.

Schmidt & Heinzmann

COMPOSITE EQUIPMENT & MACHINERY

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The two development partners mastered the three biggest challenges in the manufacture of bio-hybrid fiber composite materials in this Fraunhofer project:

1. processing different fibers in only one process

2. reliable fiber spraying of the threads with a high proportion of natural fibers

3. method validation for a process ready for series production

Robotic fiber spraying machine
With an innovative fiber spraying machine from Schmidt & Heinzmann, natural and technical fibers can be cut and sprayed with a resin-hardener blend in only one industrial process.

(Photo Schmidt & Heinzmann)

Tailored bio-composites in only one process

Natural fibers such as flax, hemp or jute are differentiated from technical, high-performance fibers by completely different and also fluctuating properties. But nevertheless it is possible in the new fiber-spraying machine to combine natural fibers with glass, carbon, aramid or polyamide and viscose fibers into a permanently robust fiber composite material of consistently higher quality.

Carsten Aßhoff, scientific employee in the application center HOFZET at the Fraunhofer WKI, explains: "The increased use of renewable raw materials is one of the goals of our projects, where technical, ecological and economic aspects are equally in the focus. Both are possible with this new technology as it allows materials from natural and synthetic fibers with differently viscous polymers including additives and reinforcing agents to be combined precisely depending on part geometry. That means that each individual composite material is tailored and is characterized by its individual surface weight and the individual fiber types, cut lengths and orientation. At the same time, this process, developed jointly with the project partner Schmidt & Heinzmann, reduces operating costs as it requires fewer production steps than for conventional processes".

New cutting technology for constantly cleanly cut bio rovings

Natural fibers normally exhibit a high level of residual moisture, they swell and easily fray. Therefore, natural fibers up to now were not very suitable for industrial applications from a process perspective.

To achieve this, two fixed blades flank the knife rotating in the opposite direction "The fiber cut length can be freely programmed from 1 mm, and the tolerance is minimal" is how Carsten Aßhoff describes the technical possibilities of the cutting unit.

Cutting unit of the fiber spraying machine
The cutting unit combines a centrally rotating knife with two fixed counter-blades. "In this way, we also achieve clean and reproducible cuts with natural fibers" reports Carsten Aßhoff, scientific employee in the application center HOFZET at the Fraunhofer WKI.

(Photo Schmidt & Heinzmann)

Dr. Tobias Fürst, Process Technology Manager at Schmidt & Heinzmann, describes the technical challenge as follows:

"Traditional cutting of natural fibers leads more often to unsatisfactory results or simply cannot be implemented. Additionally, cutting residues often contaminate the knife, which leads to unwanted disruptions. Our innovative and patented FiDo-Cut cutting head guarantees reproducible, clean cuts in an automated process, even with fiber lengths variably set in the process."

Hybrid composite materials fiber fly (CAD)
The sequence of cutting, wetting with resin mixture and spraying follows in one reproducible, continuous work process.

Fiber-matrix semi-finished products with individual, physical properties

Even for technically highly demanding applications, from now, lightweight construction can use these bio-fiber composite structures, as the areas of the part that are particularly loaded are specifically stabilized. For this purpose, in the highly loaded primary structures, load-path oriented, high-performance fibers are sprayed, and in the secondary structures, cellulose-based fibers are included for, for example, better vibration properties. Furthermore, the physical properties of the part can be influenced and additional functions integrated. This includes, for example, directly adding screw elements or specifically targeting the electrical or thermal conductivity in the part.
In the stream of air, the prepared rovings are then wetted with a fine spray of resin/hardener before being sprayed on the shaping tool. Depending on the application, the fibers are previously aligned (targeted fiber orientation) for higher material stability. Schmidt & Heinzmann developed a special fiber feed unit for this purpose. At the moment, there are no comparable machines of this type on the market.

Intuitively operated visualization makes tool setup easier

The flexibility of the processes is achieved by targeting each individual system, whose respective process parameters are managed in transparent data structures and which is optimized and started with a large, central touch display or a portable operating panel. The findings can be summarized as follows: The machine allows an easily controllable implementation of different process versions, such as simultaneous or alternate cutting and spraying of fibers on the tool. The process variations are cross-location via a secure access. This remote access also allows continuous monitoring of the process status as the process data can be called up at any time.

Validated method for a high-grade, flexible process that is series-ready

Industries with high compliance demands such as automotive or aerospace expect series-ready processes that can be easily integrated into their existing production lines. High production variance is assumed today. For the laboratory installation, a 6-axis robot ensures the required process reliability with its constantly precise processes. It moves the cutting and spraying units completely freely via the mold located on a 2-axis rotating/swivel table. Whether flat or exhibiting a 3D geometry is of no importance. The robot moves over the defined contour or produces the required wall thickness. If necessary, for this purpose it moves to selected zones multiple times in order to apply more material in a targeted manner.
The cleaning unit belonging to the machine finishes the process at the end of the shift and prepares for tooling setup.

The intensive cooperation between the researchers at Fraunhofer WKI and project partner Schmidt & Heinzmann was successful. The machine manufacturer produced the system individually according to the requirements of the Fraunhofer Institute and optimized it in numerous tests. This included wet tests with resin, natural and carbon fibers. Finally, the machine was tested by the Fraunhofer employees and adjusted.

Fiber spraying machine on the OHLF research campus
The new fiber spraying machine produces 3D contours and allows a simpler function integration as well as the improvement of the force flow for heavily loaded parts.

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