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Project title: "Fibre-friendly carbon fibre production and processing through innovative godet surface design". - CarboGerd -

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Rauschert GmbH & Co. KG, Scheßlitz (associated partner)
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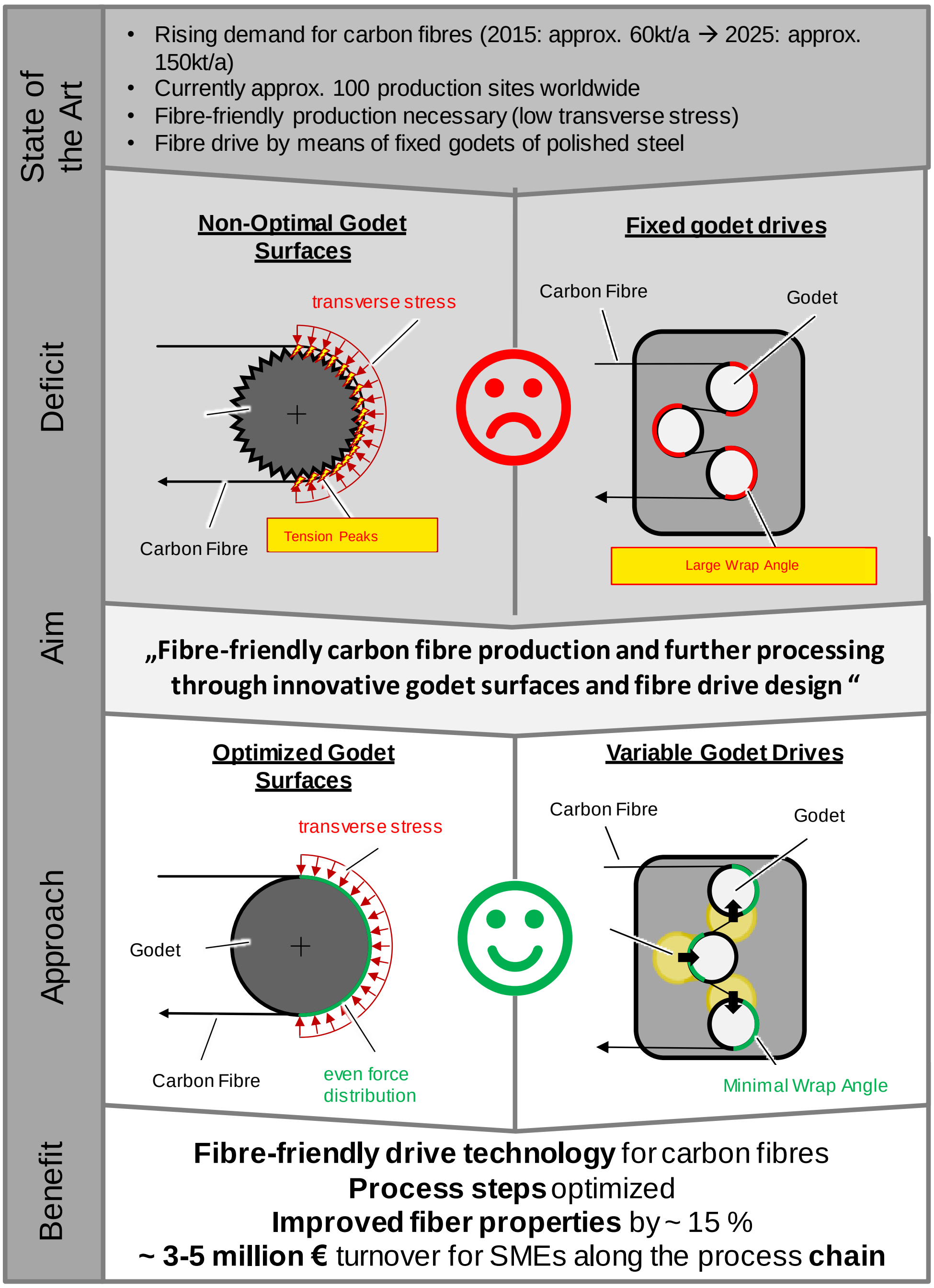

Issue

At a low density of 1.4 g/cm³, carbon fibres have excellent mechanical properties (tensile strength up to 7 GPa). Responsible for the mechanical properties are the hexagonal graphene molecules aligned in the direction of the fibres. In order to orientate them, the carbon fibres are stretched by up to 20 % during the manufacturing process. High forces are applied to the fiber during this process. While the carbon fibre can easily absorb forces in the fibre direction, it is extremely sensitive to transverse stress due to its anisotropic material behaviour.

A sufficient static friction between the fibre and the godet is generated by several godet-wrappings and thus a force is applied to the fibre. However, the wrappings induce unavoidable transverse stresses in the fibre, which can damage or destroy individual filaments of the roving. The demand for a surface that is not damaging to the fibres is opposed by the required static friction between the fibre and the godet in order to realise the drive of the fibre and to avoid a relative movement between fibre and godet. A relative movement between fibre and shaft is undesirable, as the tribological load that arises here can damage the carbon fibre, which is sensitive to lateral forces. The requirements for the surface of the drive godet are therefore a high coefficient of static friction μ_{static} while applying low damage to the fibres

Aim and Approach

The aim of the research project applied for here is therefore the development and validation of an optimal godet coating for a fibre-friendly and quality assurance carbon fibre production. In particular, an optimized coating for both drive and deflection godets (or shafts) will be developed for all stages of the carbon fibre production process (stabilization, carbonization and aftertreatment). The requirements for the desired godet coating are:

1. sufficiently high static coefficient of friction μ_{static}
2. low fibre damage
    - For drive godets: without relative movement
    - for deflecting godets: with occurrence of relative movement

According to conventional friction theory, both requirements are in conflict to each other, since high friction coefficients are usually achieved by high surface roughness, which in contact with carbon fibres leads to severe filament damage. An exception is the topocrome coating, which has already been tested in the Chromosphere and Carbonsophere research projects, and which can counteract this conflict of objectives by means of a suitable surface topography.

Economic Significance and Benefits

The global carbon fibre market currently has an annual volume of approximately € 2,500 million. The annual growth rate is 13 %. In 2016 the worldwide demand was approx. 64,000 tons. Forecasts show that demand will more than double by 2025.

The main drivers are the market for wind turbines and automotive applications. The worldwide demand is currently served by about 10 different large companies, which hold more than 95% of the worldwide production capacity. In order to meet the growing demand for carbon fibres, established manufacturers are increasing their production capacities. With an average line capacity of approx. 1,500 t/a, this corresponds to approx. 23 additional production lines, which have been and will be installed between 2016 and 2018 alone. A fibre control system for a carbon fibre production line costs between

€ 2 and 3 million. Based on 23 installed lines between 2016 and 2018, this corresponds to an average total market of approx. 20 million per year just for fibre guiding technolog.

Solution

In order to identify a suitable coating, the widest possible spectrum of materials is used to comprehensively investigate the tribological problems. Typical coatings (ceramic, topocrome coatings) as well as unconventional solutions (elastomer, PACVD coatings) are considered.

The static friction coefficient is tested on the in-house tribological test bench "Tribometer according to Lünenschloss". The static friction coefficient is determined for different process stages of the carbon fibre (precursor, different stabilization stages, different stages of carbonization) and different coatings (ceramic, chrome, elastomer, PVD/ PACVD coatings, ...). The determination of the coefficient of static friction instead of the coefficient of sliding friction is purposeful, since in the production process a relative movement between carbon fibre and godet must be avoided and therefore does not occur. The values determined on the test bench are therefore more realistic and can be more easily transferred to a real production plant in the further course of the project.

The influence of the shear force on the quality of the carbon fibre is tested on another tribological test bench, the "ITA Tribometer". For this purpose, the test bench is modified by suitable motor and sensor technology so that forces relevant to carbon fibres can be mapped. In addition, the test specimen holder is rotatably mounted so that the coated test specimens rotate during the tribological tests and no relative movement occurs. The measured fibre damage can thus be attributed to the interaction between the coating and the occurring transverse forces and is thus a measure of the fibre damage caused by the coating.

For each coating class, different variants are tested. The most suitable coating determined in the tests is varied in a second step by the coater within the limits specified by the coater in order to identify the optimum structure of a variant. Finally, the determined optimal structures of the variants are validated and compared with each other for all process stages of the carbon fibre on the carbon fibre production plant of ITA.

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