Industry Day Theme # {Advanced Material}

IIT DELHI INDUSTRY DAY 2019

Title of poster (Electrostatic Spray Coated towpreg for Thermoplastic Composites)

Presenter's Details (Vijay Goud, PhD Research Scholar)

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Abstract

A method for production of flexible towpregs for thorough infusion of resin into fibers using electrostatic spray gun, which involves powder coating a bundle of filaments is designed and developed. An investigation into the flexural properties of unidirectional composites (UDC) produced from blending of carbon fiber and polypropylene (PP) matrix in varying forms of fiber, powder and film are reported. Further, pre-impregnation techniques such as Dr. Ernst Fehrer (DREF) spinning and electrostatic powder coating are used for production of hybrid yarns, the pre-formed yarns are woven into 2D and 3D fabrics (angle inter-lock and orthogonal weave), which are then post-impregnated and consolidated to yield two variation of 2D and four variations of 3D composites. Analysis by micro-computed tomography, and scanning electron microscopy indicate better impregnation of PP powder despite higher viscosity of PP powder than PP fiber. The thermoplastic composites produced using powder coated towpregs can be used in production of sporting goods like tennis rackets, golf shafts, mountain bike parts etc.

Introduction

Thermoplastics are the class of polymers that are often employed in polymeric composites. Despite its environmental friendly property, thermoplastic based composites are less preferred given the processing challenges arising from its inherent high viscosity. To overcome the processing challenges, several techniques of pre-deposition of matrix onto the reinforcement have gained attention. Notable few among these techniques are: Dr. Ernst Fehrer (DREF) spinning and powder coating. These techniques have the potential to yield flexible towpregs. In this study, unidirectional composites (UDC) with carbon fiber reinforcement and polypropylene (PP) thermoplastic was manufactured using three different methods. In the first method, PP matrix was combined with carbon tow to form DREF spun hybrid yarn. A stack of yarns was consolidated to yield UDC-D composite. In the second method, PP powders were electrostatically coated over carbon tow and later consolidated to form UDC-P. In the third method, PP films were stacked between carbon tows and consolidated to form UDC-F. The net fiber volume fraction was ~50% in all the three UDCs. A comparison of mechanical properties of the three composites was taken up to understand the efficiency of matrix wetting and impregnation.

Further, the preformed yarns from Dr. Ernst Fehrer (DREF) spinning and electrostatic spray coating are woven into 2D and 3D fabrics (angle inter-lock and orthogonal weave), which are then consolidated to yield 2D and 3D composites.

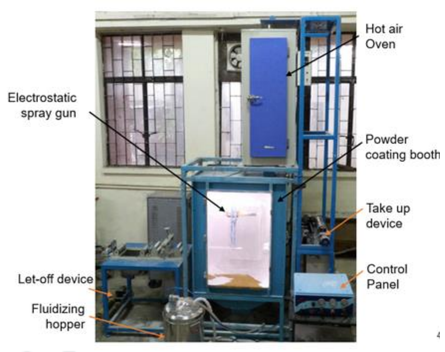
Materials and Methods

Carbon fibers of 7 μm diameter procured from Toray, Japan (UKN – 350 6K) is used for reinforcement. Cryogenically ground PP powder was obtained from Newgen Specialty Plastics Limited, Noida, India.

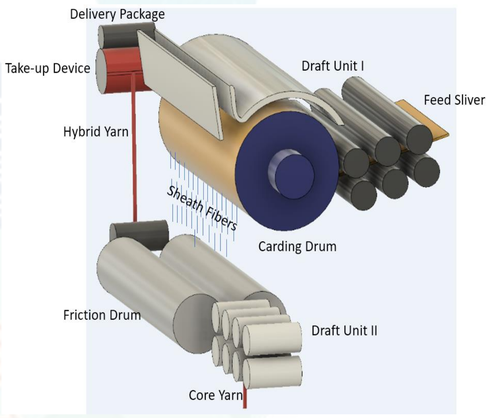
An electrostatic spray coating set up was designed and fabricated in-house to yield a thorough impregnation of PP powder on carbon fiber tow.

Similar core sheath yarn was produced by process of DREF spinning which utilizes PP fiber to be wrapped around the carbon core.

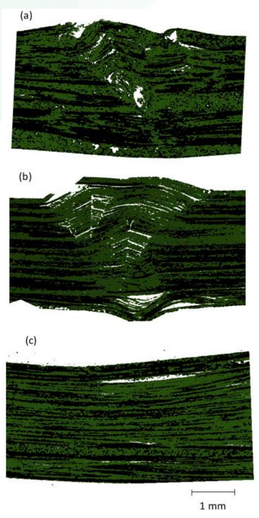
Result



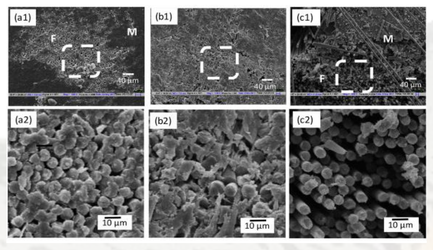
Developed electrostatic spray coating set-up



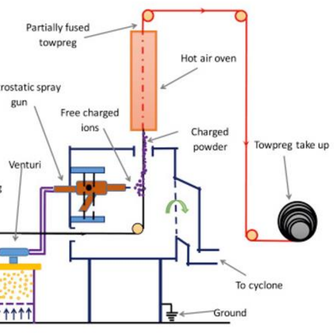
DREF III Spinning Process



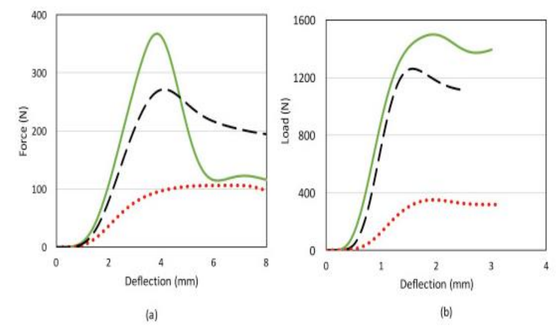
Micro-CT images of (a) DREF unidirectional composites, (b) powder coated towpreg composites (c) Film stacked unidirectional composites



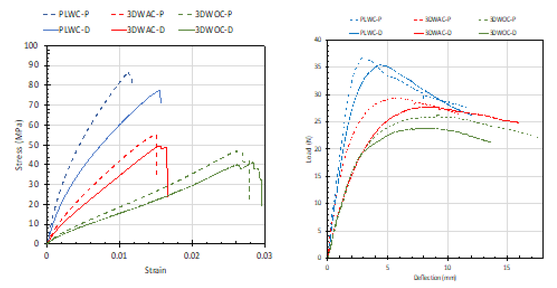
SEM images of (a1, a2) DREF unidirectional composites, (b1, b2) powder coated towpreg unidirectional composites (c1, c2) Film stacked unidirectional composites



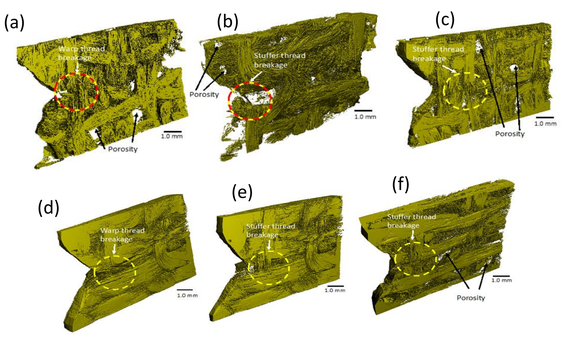
Schematic of developed electrostatic spray coating set-up



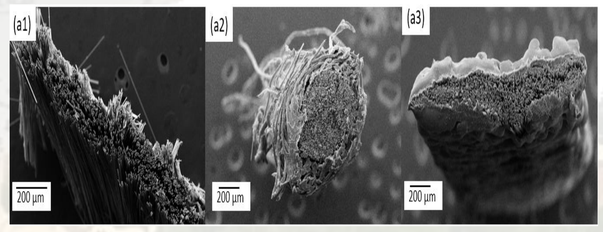
3 point bend and interlaminar shear properties



Tensile and Flexural Properties for 2D and 3D woven Composites



Micro-CT images of post notch-test samples of 2D and 3D woven composites from DREF spun hybrid yarn; 2DWC-D (a) sectioned slice showing fiber breakage and porosity; 3DWAC-D (b) sectioned slice showing fiber breakage and porosity; 3DWOC-D (c) sectioned slice showing fiber breakage and porosity, 2DWC-P (d) sectioned slice showing fiber breakage and porosity; 3DWAC-P (e) sectioned slice showing fiber breakage and porosity; 3DWOC-P (f)sectioned slice showing fiber breakage and porosity.



SEM images of (a1) Carbon tow, (a2) DREF spun hybrid yarn, (a3) powder coated towpreg

Conclusions

- Analysis by micro-computed tomography, and scanning electron microscopy indicate better impregnation of PP powder in UDC-P despite higher viscosity of PP powder than PP fiber, and thereby higher interlaminar strength.
- Composites made from powder coated towpregs show better matrix impregnation and less porosity compared to composites made from DREF hybrid yarns. And hence the use of powder coating technique helps in overcoming the disadvantages of the type of weave.

Industrial Significance

- A variety of combination of reinforcement and matrix can be used for production of towpreg thereby wide range of applications can be covered.
- The machine can be automated with ease to meet the demanding needs of industry.
- The industry can be benefitted as a result of lower investment involved in the installation of powder coating line.
- The technical know how and skills required by the labour for the operation of the machine are minimal.
- The maintenance required and spare part consumption for the machine is minimal.

Technology Readiness Level: The machine is successfully designed, developed, installed and coating successfully for conductive as well as non-conductive yarns.

References

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