Research of impregnated carbon fiber tow quality for 3D composites printing

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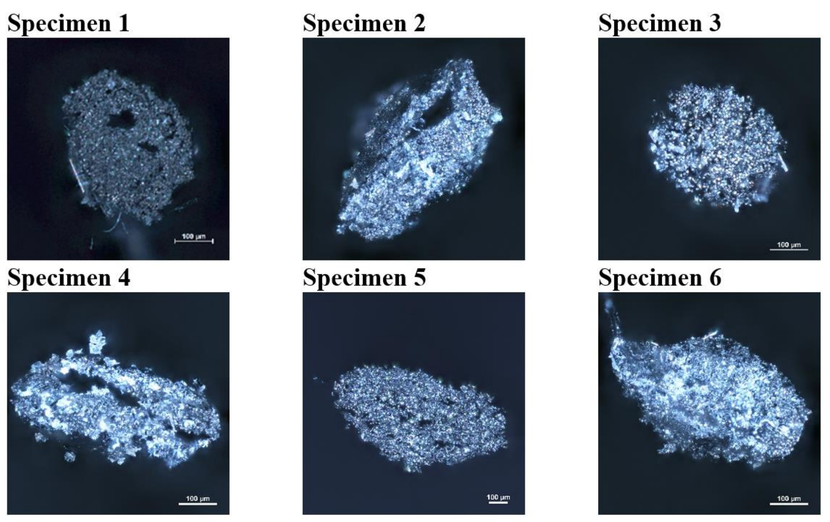
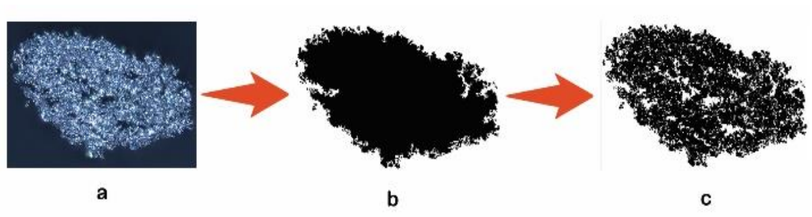
ABSTRACT

Time nowadays becoming more and more important resource in our life. Additive manufacturing technologies allow to produce very complex shapes of products reducing product development time. Moreover additive manufacturing of composite parts allows to produce structural parts with perfect mechanical properties. Though production of composites is still very complicated because reinforcement material needs to be prepared for the process. Moreover preparation process can significantly influence on quality of produced part. This article focusing on preparation procedure of continuous carbon fiber (CCF) tow for 3D printing of composite structures. Visual analysis of impregnated CCF showed that internal air voids area in the analysed cross sections fluctuates from 11.1% to 22.8%. Meanwhile after pull-out test significant effect of impregnation on adhesion was observed. Non impregnated CCF was pulled-out at force 38 N, however impregnated CCF was not pulled-out at force 138 N.

QUALITY ANALYSIS OF IMPREGNATED CARBON TOW: VISUAL ANALYSIS



In order to get better adhesion between matrix and carbon fiber tow continuous carbon fiber should be processed. During this study CCF tow was impregnated with PLA 10%wt and dichloromethane solution. Mechanical properties directly depends on soliution concentration i.e. the higher the concentrations in which carbon fiber was impregnated, the higher the tensile strength of composite structure. Therefore impregnation process and quality of tow depends on various parameters such as pulling speed, solution preparation, used chemical components, diameter of inlet and outlet, drying temperature, and others. For the visual analysis six specimens of impregnated CCF tow was prepared by cutting randomly from impregnated CCF spool.

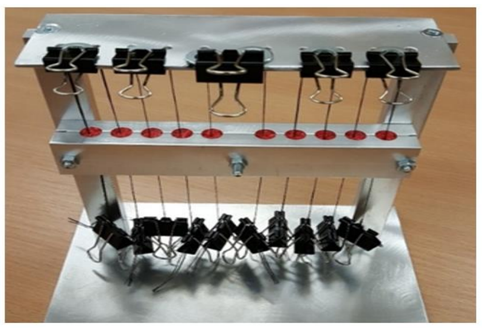


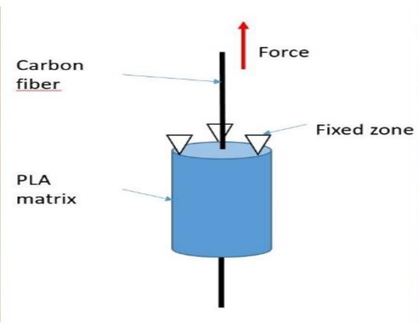
Visual analysis was performed with ImageJ2x software. Quality of impregnated CCF is defined by measuring ratio of internal percentage impregnated area and voids area. Photo of cross section (a) is inserted into program, then full cross - section area is calculated (b). Later empty zones (air voids) is extracted from cross section (c).

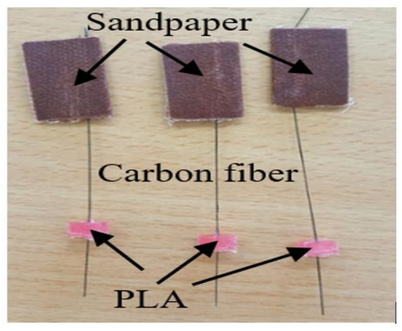
Specimen	1	2	3	4	5	6
Impregnated area, %	81.3	80.4	78.6	77.2	83.7	88.9
Area of internal air voids, %	18.7	19.6	21.4	22.8	16.3	11.1

Visual analysis results showed that impregnated area is fluctuating from **77.2 to 88.9** percent. Internal air void area respectively fluctuates from **11.1 to 22.8** percent.
Average of impregnated area - **82 %**
Average of internal air voids – **18 %**

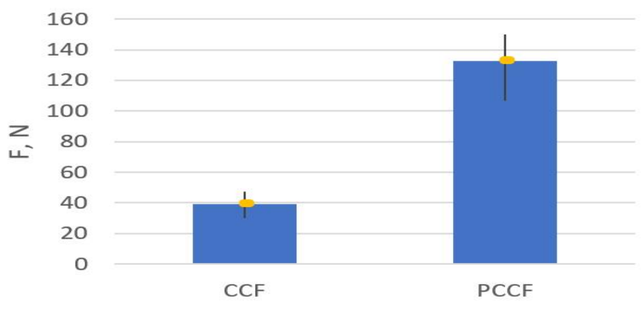
QUALITY ANALYSIS OF IMPREGNATED CARBON TOW: ADHESION DETERMINATION

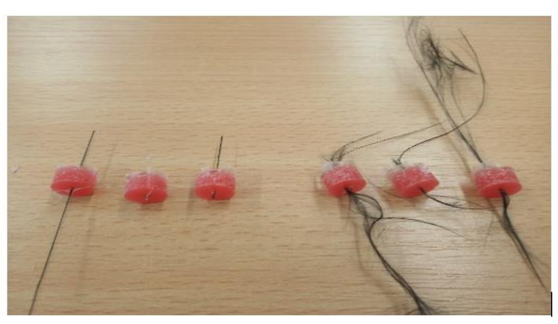






Adhesion determination was done by performing tow pull out test from matrix material. Specimens were prepared by melting matrix material and filling it to cylindrical form. In the center of the form CCF was inserted.





Impregnated carbon fiber pull out force from matrix average is more than **three times higher** than unprepared CCF.

CONCLUSIONS

All the completed tests for impregnated carbon fiber quality analysis showed, that impregnation process is very important not only to increase printability of composite structures with CCF, mechanical properties but also adhesion force between matrix and reinforcement from 38 N to 138 N. Also visual analysis showed that averages of impregnated area is 82 % and internal air voids is 18 %, then fiber is impregnated with PLA 10%wt and dichloromethane solution.