IN-SITU STRUCTURAL EVALUATION DURING THE FIBRE DEPOSITION PROCESS OF COMPOSITE MANUFACTURING

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Abstract

Contemporary composite part development and manufacturing, in particular of high performance light weight structures, is still requiring a high effort in order to find optimal process parameters and to meet required qualities and tolerances. In case of the fibre deposition the processes of pick and place, tape placement or fibre placement are industrially applied enabling a high degree of automation, while meeting high structural requirements. However, depending on the complexity of the part as well as on the selected process technology and material type the resulting semi-finished products still contain different manufacturing deviations that are to be considered. Already in case of simple fibre deposition onto flat surfaces tolerances of fibre orientations, ply contours or ply thickness as well as gaps or overlaps may appear. In case of more complex shaped geometries or fibre steering tapered gaps and overlaps cannot be avoided, and process difficulties may lead to fibre waviness, wrinkles or twisted tows. In order to balance these tolerances and to avoid defects during fibre deposition optimum process parameters are usually determined for each specific application taking into account prior defined structural requirements. Depending on the complexity of the part this requires a high effort, and yet certain risks for manufacturing defects still remain. Furthermore, structural requirements are often derived from simplified and conservative rules, while neglecting possible reserves of individual applications. This conservatism comprises two drawbacks: On the one hand structural reserves are often not exploited, and on the other hand non-added value manufacturing and rework processes unnecessarily increase manufacturing costs.

Within the European funded project ECOMISE a new approach for composite manufacturing is developed. This approach provides key technologies for industry 4.0 in order to maximize process efficiency at reduced cost and time while maintaining structural requirements. In detail, process simulation methods, online process monitoring systems as well as methods for in-situ structural evaluation and process adjustment in case of process deviations are implemented and linked via databases. This paper describes the new overall concept as well as the specific in-situ structural evaluation approach, exemplarily applied to the fibre deposition process. Prior to manufacturing typical manufacturing features such as locally varying fibre orientation, gaps and overlaps are studied based on given knowledge from previous manufacturing as well as from process simulation. From this a categorization of these manufacturing features is proposed and their effects on the structural properties are investigated for the expected parameter ranges. The real detected features are provided by an online monitoring system during the fibre deposition process. Based on these results an in-situ structural evaluation of detected features is performed already during manufacturing in combination with a decision making with respect to required part correction. The developed key technologies and tools for the in-situ evaluation process are presented in detail, and their prototype application is shown during manufacturing of an aeronautic wing cover demonstrator.

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