MACHINE LEARNING PROPOSAL FOR FIBER ORIENTATION PREDICTION IN LARGE FORMAT EXTRUSION ADDITIVE MANUFACTURING

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Abstract
This paper proposes a methodology for the measurement of short fiber orientation in Large Format EXtrusion Additive Manufacturing parts using a neural network NN). The material used as an example is an ABS reinforced with 20% short carbon fibers. Since a large number of images is required to train the neural network, a synthetic data generation method is chosen. The open source software MD code LAMMPS is used. The results show a high similarity to traditional measurement methods, being a much more computationally efficient method.

Introduction

Large Format EXtrusion Additive Manufacturing (MEX-AM) is a polymer extrusion additive manufacturing technology that enables the manufacture of large components for the automotive, aerospace or wind energy industries. It is used for both final part manufacture and composite tooling. The parts produced by this process require a final finish in the milling machine or by hand polishing so that their geometry is very close to the final part. The production speed is over 200% faster than conventional systems, making it very suitable for the manufacture of moulds for the composites industry.

Fiber orientation in composites is a very critical factor for mechanical, thermal or electrical properties and is strongly influenced by the manufacturing process and process variables. In EXtrusion Additive Manufacturing (MEX-AM) processes, it is influenced by nozzle diameter, temperature, flow rate, material type, etc. In many cases the material used is a short fiber reinforced thermoplastic pellet. These short fibers are approximately 0.2mm long and are oriented according to the preferred flow direction of the polymer. The orientation of the fibers is very important in the mechanical properties of the final part, so its study, verification and control is of industrial relevance [1] . A number of CFD models have been developed to predict fiber orientation, mostly in two dimensions. Two-dimensional models give good results for composites with low volume fractions or relatively low orientation variations. [2] .
The theoretical framework for these models has been described by Advani and Tucker (1987) [3] . For MEX-AM processes, the 2D models can be considered to be sufficiently accurate as the orientation is strongly influenced by the direction of material deposition and the fiber ratio is around 20. It has been observed that in MEX, 95% of the fibers are oriented in the extrusion direction, which doubles the stiffness of the material. In addition, in the case of carbon fiber, heat transfer has the preferred direction of the fibers. In this type of process, thermodynamics

is a key factor in the process as it affects the final quality of the part, its mechanical properties and the economy of the process as energy consumption can be very high.

Methodology

A database of images developed using open source software will be used to train the neural network. [4]. These images must take into account volume fraction, matrix type and orientation. Eighty per cent of the images are used to train the algorithm and the rest to verify its performance.

Experiments

Specimens will be fabricated for microscopic observation with different process conditions to verify the proposed model. The samples will be fabricated to maximise interlayer adhesion and the fabrication sequence will be recorded with a thermal camera to verify that the heat transfer has a preferential direction in the flow direction.

Results

The developed model should correctly predict the fiber orientation. The results should show the influence of manufacturing parameters such as temperature, flow rate, time per layer or thickness on the fiber orientation.

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