AN IMPROVEMENT OF FLOW FRONT COMPUTATION THROUGH BÉZIER SHAPE DEFORMATION GUARANTEEING MASS CONSERVATION LAW

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ABSTRACT: This paper aims to define the flow front as a continuous curve, in particular a Bézier curve, to reduce the inaccuracies generated by classical Finite Elements (FEM) in the flow front definition. The flow front is used in LCM processes for optimization algorithms, on-line control systems, PPI index and in general for whatever design and correction task. In these algorithms it is commonly used FEM simulation where the flow front is represented as a set of discrete points. This fact introduces an inaccuracy with the real flow front, because is continuous. In addition, the shape of the flow front obtained by FEM simulation differs in a great manner from the smooth shape of the real flow front. This concept was solved in our previous research, [7], where, using a mathematical technique, a Bézier curve is deformed and moved using velocity vectors. This technique is called Bézier Shape Deformation. This work improved the flow front representation but also introduced inaccuracies. In particular, the area enclosed between two Bézier curves, the flow front in different time instants, do not corresponds to the resins amount introduced in this range of time. To solve it, in the present research it is guaranteed the mass conservation law. Hence, it is introduced the required enclosed area in the mathematical technique to guarantee that not only velocity vectors has an influence in the Bézier curve deformation.

KEYWORDS: FEM, NEM, RTM, LCM, flow front, Bézier curves, numerical simulation.

1 INTRODUCTION.

The Liquid Composite Molding is the process most used in the production of aeronautic, naval industry, etc. This kind of process uses a mould to manufacture some pieces. After closing the mould is impregnated the preform (a special fiber) by injecting resin. The geometric line between the dry and wet area of the preform is defined as the flow front. It is a common tool to take decisions on-line during the filling of the mould. Usually numerical tools are used to simulate the flow front like Finite Elements Methods. This method introduces inaccuracies because the flow front is represented as a set of discrete points. The shape of the resin's flow obtained by FEM simulation differs in a great manner from the smooth shape of the real flow front. Actually it is a continuous curve. In general, the relevance of a proper representation of the domain was analyzed in other works like [1],[2],[3]. The idea is represent it as a continuous curve. The parametric curves are widely used for geometry description in CAGD (Computer Aided Graphic Design) because its mathematical properties are interesting. This fact has induced new numerical techniques to obtain a better representation of the computational domain with parametric curves, for examples, Bézier, B-Splines, NURBS, etc. In [4] introduced isogeometric analysis based on NURBS. The entire domain is defined as a NURBS surface where the simulation is computed. It produces an accurate representation of the flow front but with an inacceptable computational cost. To reduce it, in [5] is combined NURBS-Enhance Finite Element Method (NEFEM) with Discontinuous Galerkin Formulation, FEM. Only the mould contour is defined as a NURBS curve and inside the domain reducing the computational costs. This investigation improves the FE simulation results in the contour but not in the flow front because it is defined as a set of points like in FEM. In [6], the mesh of the domain is obtained by Bézier triangles. Although these works improve the FEM techniques, are not focused in the proper flow front representation. In this sense, it must be a continuous curve. This curve must be moved by velocity vectors obtained in the FEM simulation. This concept was developed in our previous research [7], where a Bézier curve was moved and deformed by velocity vectors.

2 PREVIOUS WORK: BÉZIER SHAPE DEFORMATION. DEFINITIONS AND PROPERTIES.

Definition 1 *A Bézier curve of degree n can be represented as:*

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