A TOPOLOGICAL APPROACH FOR THE FLOW BEHAVIOUR CHARACTERIZATION IN LCM PROCESSES

N.Montés, F.Sánchez*, A.Falco

[1]Escuela Superior de Enseñanzas Técnicas
University CEU Cardenal Herrera, Valencia, Spain

ABSTRACT: In this work we propose a topological approach to explain the dynamical behaviour of a LCM flow. To this end we shall use a class of homotopy maps in order to characterize an idealized mould filling process. By means this benchmark model we can construct a functional that can be used to give the reference in an on-line control system. In our previous work, [1], is proposed the use of the artificial vision technique to sense the mould as a discretized mesh that can be simulated off-line and used as a benchmark model in real-time control systems. The resulting FEM simulation represents theoretical flow behaviour. In this sense, the ideal flow behaviour must be defined based on the optimal criterion. For instance in [2], [3], the flow front in each time instant is desirable to be vent-oriented for dry spot prevention. Whatever of these optimal laws can be defined as a homotopy map where the flow front is defined as a parametric curve that moves with the flow. In order to reduce the sampling rate control system, the homotopy map is defined in a Flow Pattern Configuration Space (FPCS). This tool permits to represent the mould filling in an alternative space representation developed with the optimal criterion [5-7]. Using this space, the homotopy map is defined as a mono-dimensional parametric function for whatever mould dimension. Some numerical examples are given at the end of the paper.

KEYWORDS: Homotopy map, LCM processes, parametric curves, CAGD

1 INTRODUCTION

In the last decades, control strategies were developed for LCM processes in order to obtain a proper mould filling. Off-line control strategies or passive control systems is one of the first possibilities developed for an efficient RTM filling process, [8-10]. However, passive control systems cannot ensure complete success and full reliability. The first proposal concerning on-line control systems was presented in [11] also for RTM processes. In this work, pressure manipulation and flow rate conditions are used as a control parameters. An RTM flow monitoring and control system is reported in [12] where flow simulations were previously computed for a number of pre-defined scenarios. A genetic based optimization approach is introduced for an RTM control system in [13] for the design stage. During the filling process, at constant flow rate, the sensor information is introduced in the optimization algorithm. This optimization algorithm uses on-line simulations where it must be fast enough to match mould filling times. In this sense, some researches works to obtain a fast numerical simulation to predict flow progression called proxy simulators, [14] [15].
The use of on-line control strategies in RTM processes is required for the on-line correction of disturbances like race tracking, changes in fibre permeability characterization, etc. In RI process, the use of on-line control techniques becomes critical because the preform thickness cannot be controlled in advance. It is due to the top half of the mould can be made of a flexible material. Therefore, on-line control strategies in RI processes are introduced recently, [16-19]. In this works, also fast on-line simulations are used to predict the flow behaviour. As in RI, the top half of the mould can be transparent, the use of cameras as sensor of the RI process is introduced in [18], [19].

A typical closed-loop control system is composed by the controller and the process in a feedback structure. Actuators and sensors are also required in order to force and to measure system variables respectively. The desired output of a process is called the reference. The sampling rates, *Ts, Tr, Tc* and *Te* define the number of samples per time taken from a continuous signal to generate a discrete signal, see Figure 1. The sampling rate is an important concept to take into account. In LCM processes, the flow velocity determines this sampling rate for reliable control laws. In general, the computational cost of the control loop task must be as low as possible.

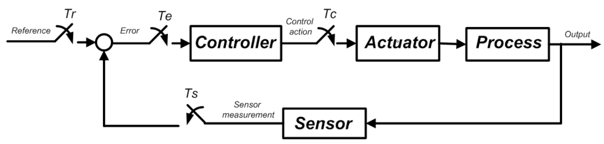

Figure 1: *Closed control loop*

* Corresponding author: San Bartolomé 55, Alfara del Patriarca, Valencia, Spain 46115, fernando.sanchez@uch.ceu.es