Model-based control of a twin screw extruder

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1 Introduction

Hot-melt extrusion is a popular forming method in the industry. In this thermo-mechanical technique, several solid materials are conveyed through the extruder thanks to the screw rotation and are transformed into a specific uniform product [1]. A variety of extruded products are manufactured in sectors as diverse as food, drug, plastics, etc.

In this work, the use of a simplified distributed parameter model is considered as a predictor in a model-based control strategy. The control objective is to ensure appropriate mixing between a polymeric matrix and an active pharmaceutical ingredient (API) while regulating the outflow of material and its viscosity. The simplified model is inferred from a detailed model developed in [3], and inspired by [2].

2 Dynamic modeling

In [3], a dynamic model based on mass and energy balance partial differential equations, has been proposed to determine the material flow and the API concentration evolutions. This model considers that the system involves a partially filled zone achieving the transportation of the material and a completely filled zone achieving material mixing (see figure 1). Influences of the barrel temperature T_b and the screw rotation N are taken into account to calculate the variation of the completely filled zone length l_m. The numerical simulation of this model is however computationally expensive and simplifications are required for model-based control purposes.

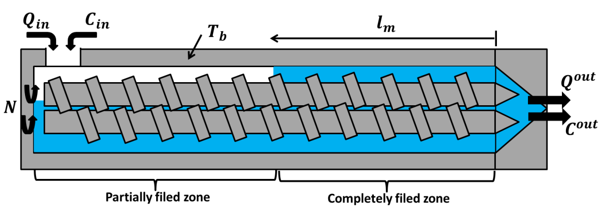

Figure 1: Configuration and variables of the model

3 Application of the control strategy

The control problem is characterized by the presence of a significant material transportation delay, input-output couplings, nonlinear temperature effects, and actuator limitations.

A model predictive control (NMPC) strategy seems adequate to regulate the outlet API concentration C^{out} and the outlet flow Q^{out} using the feed flow rates Q_{in}, the screw rotation speed N, the barrel temperature T_b and the inlet API concentration C_{in} as manipulated variables.

The contribution of this work is to investigate the best trade-off between model complexity and computational efficiency.

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