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On the Performance of Multi-step Cooling Systems in Profile Extrusion

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During the production of extruded profiles, the calibrator should cool down the profile both swiftly and uniformly. The main difficulty to be faced in the design of these tools arises from the fact that these two objectives are conflicting, i.e., conditions leading to a lower average temperature generally promote a lower homogeneity and vice-versa. There are few ways to improve simultaneously both criteria. As shown in previous works, the most effective alternative is the division of the cooling length into several cooling units separated by annealing zones. In these zones the profile temperature distribution homogenizes and, as a consequence, its surface temperature increases (increasing also the thermal energy removal in the subsequent cooling unit), hence leading to improvements in both conflicting objectives. However, there are some questions that still need to be studied, namely: Which is the optimum number of cooling units? Which is the optimum length distribution of both the cooling units and the annealing zones? Which is the optimum cooling fluid temperature in each cooling unit? In this work a computer code that is being developed by the authors with the objective to automatically optimize the thermal efficiency of the calibration stage, is presented and used to contribute to a better knowledge of the process and to automatically maximize its performance. This code results from the coupling of numerical modeling and optimization routines. The numerical modeling routines are based on the finite volume method and are able to account for the heat transfer along and between several domains (e.g., polymer and metal), thus being adequate to model the cooling stage of extruded profiles. To control the optimization process, an improved version of the objective function, used to evaluate the performance of each trial layout, is also proposed.