

Simulation-based Analysis of Flexible Manufacturing Systems

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Introduction



- This study aims to demonstrate the industrial suitability of a food 3D-printing technology, developed into an academic context.
- The project proposes an integration between food 3D printing technology and Flexible Manufacturing System (FMS).
- In addition, the line has been performed with the aim to provide a networked production, exceeding geographical constraints.
- The line has been developed thanks to the collaboration of several companies such as Omron and Bosch Rexroth, which provided the control and the transport systems, respectively.



Figure.1 Chocolate 3D-printer

Method

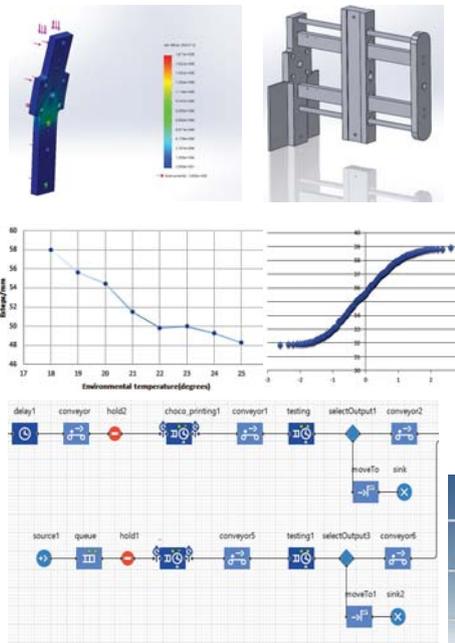
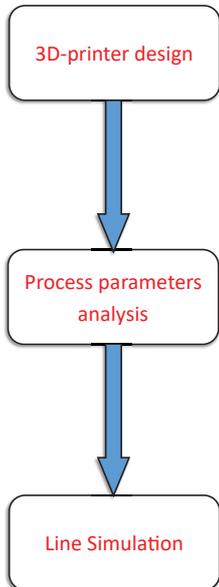


Figure.2 Simulation model

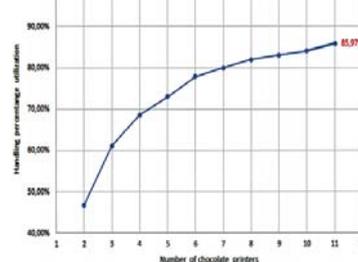
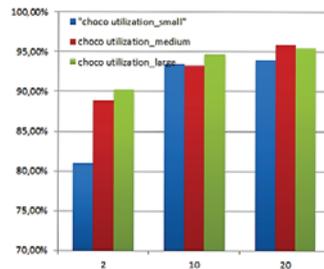
- The printer has been designed through the use of a CAD tool (Solidworks).
- Mechanical couplings' design has been integrated with simulation, according to the structural specificities of the line.
- Several experiments have been performed in order to reach the correct machine setting.
- The critical machine features (extruder motor's steps, speed and acceleration along the 3 axes) were parametrized taking into account the external environmental conditions.
- It was conducted an empirical collection of printing time, through the processing of custom shapes imported from CAD and translated into g-code language by the slicing tool. Starting from the collected data sample, statistical analysis have been performed (chi square goodness-of-fit test).
- The whole system has been simulated through discrete event simulation model, following a strictly operational flow. Thus, respect for precedence constraints and production requirements of the pilot system were ensured.



Figure.3 3D layout of the line

Results

- The graph shows results in terms of saturation, expressed in percentage, of both print and handling system, according to the different generated scenarios.
- It has been shown that the technology can be used, under certain conditions, in industrial applications. In fact, it is possible to reach a high line saturation that allows a safety margin for possible breakdown to which the machines are subject, hence ensuring the operational continuity.



Further work

- Once demonstrated the potential of the line in an industrial environment, several points can be improved.:
 - Development of a simulation model based on a networked multi-batches approach.
 - Web interface: means the ability to manage orders and their specific customization features, directly from the web.
 - Integration with ERP systems to manage the entire contract lifecycle, from digital order arrival until order delivery.
 - Implementation of networked production chain.

