Convective Industrial Textile Dryers: Analysis, Modelling, and Simulation

F. F. Ferro[1,2] **M. Rampazzo**[1] **A. Beghi**[1]

[1] Department of Information Engineering, University of Padova, Italy

[2] Santex Rimar Group, Trissino (VI), Italy

Abstract

Modelling and simulation tools offer new possibilities to dominate the increasing complexity of industrial processes and they enable to accelerate innovation cycles, rapidly exploring and exploiting quickly new possible solutions. In this research, we focus on the drying process of porous materials in the textile industry. In particular, we derive a mathematical model for a convective industrial textile dryer and we develop a simulation environment accordingly.

Motivations

- Drying is essential in the textile industry to eliminate or reduce the water from the fibers, yarns, and fabrics following wet processes.
- Drying processes are time-consuming and energy-intensive and they strongly influence the cost of the textile finishing operations.
- The efficient operation of a drying process is of great importance for getting the full benefits of it.
- Computer Aided Control Systems Design (CACSD) tools are useful to design advanced control systems.

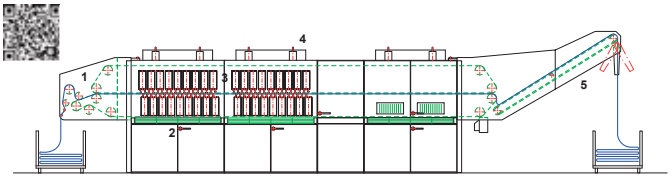
Textile materials may be dried at several stages in the production sequence.

Main Objectives

1. Modelling of a convective industrial textile dryer.
2. Development of a simulation environment.
3. Simulation of the convective drying process.
4. Design and test of effective and efficient control strategies.

The Convective Textile Dryer

The machine consists of several chambers preceded by a feeding unit and followed by an exit unit, that cools down the fabric before plaiting. The number of chambers is chosen according to the required drying capacity and production rate and they are heated through direct gas, steam or thermal oil. The air, once heated thanks to the heating system, is guided towards the nozzles and it is then sprayed through the fabric.

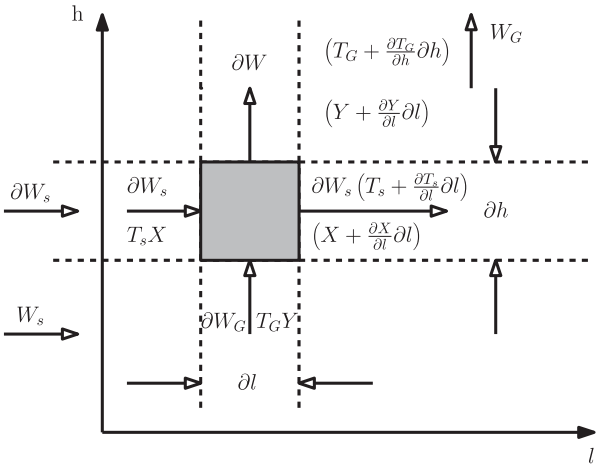


Methods & Tools

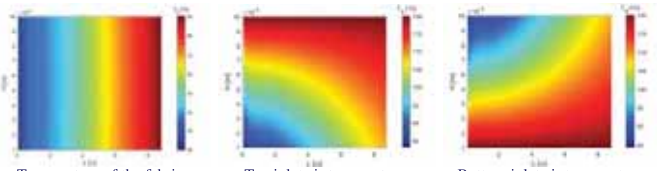
- First-Principle Data-Driven (FPDD) modelling approach (which ensures a compromise between accuracy and complexity) by exploiting both:
  - ✓ knowledge about drying phenomena;
  - ✓ data collected from the drying process.
- Simulation softwares: ANSYS Student, OpenFOAM, and Matlab.

Modelling

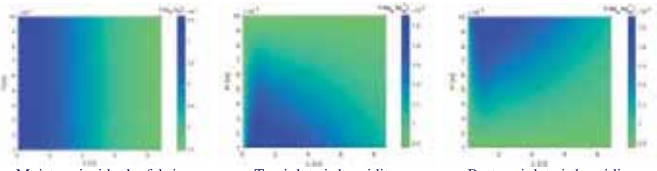
- Ingredients
  - ✓ Mass and energy balances.
  - ✓ Properties of the moist air.
  - ✓ A two-phase cross-flow ($2D$)-configuration.
  - ✓ First order PDEs.
  - ✓ The Watson's equation.
  - ✓ The modified Chung&Pfost's equation.



Simulation Examples



Temperature of the fabric. Top inlet air temperature. Bottom inlet air temperature.



Moisture inside the fabric. Top inlet air humidity. Bottom inlet air humidity.

2D (l-h) simulations.

Conclusions

- ✓ A FPDD model of a convective textile dryer has been derived and validated.
- ✓ A simulation environment has been designed.
- ✓ The simulation environment can be used to design and test control strategies.

fabianafederica.ferro@phd.unipd.it