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Ph.D. thesis (2019-2022)
LGP2
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Understanding of the wrinkles formation during the coating functionalization of fibrous material: a multiscale approach

Compréhension des phénomènes physiques relatifs à l'apparition de plis générés lors de la fonctionnalisation de surface par enduction des matériaux fibreux : une approche multi-échelles

Context

Paper industry :

- Reduction of grammages with constant mechanical properties.
- Functionalization of papers in order to obtain specific surface properties and for new applications for thin paper

But, it is mandatory to keep the quality of the paper:

- Wrinkles may appear during functionalization of low grammage papers.
- Non-conformities and downgrading of the products.



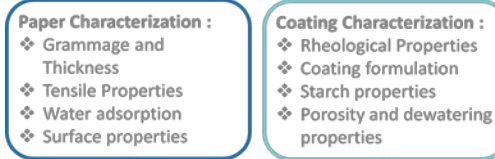
Objectives:

- Obtaining fibrous supports with known characteristics
- Development of multi-scale techniques for wrinkles characterization
- Technologic development for the control of the web tension in the cross direction
- Process simulation – modeling

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Methods

Paper - coating characterization:



Coated Paper

Process analysis:

- Process monitoring
- Creation of a database with all process parameters

Understanding of the wrinkles formation:

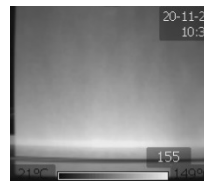
- Microscopic tools: MEB...
- Macroscopic tools: Computer stereo vision and image analysis...



Appearance of wrinkles

Modelling and simulation:

- Study of the heat flow
- Understand the wrinkling process



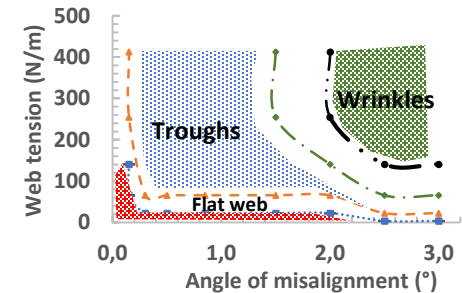
IR pictures taking with Flir-i7



Fiji software for image processing

Results

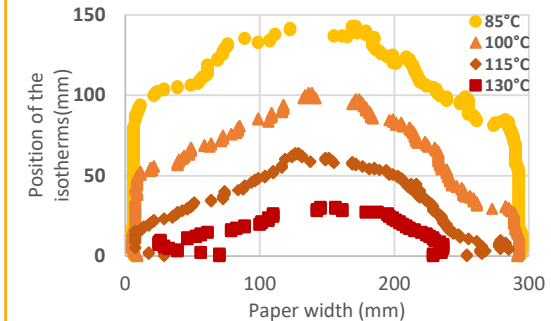
Understanding of the wrinkles formation:



- Impact of critical web tension T_{cr} and misalignment angle θ on wrinkle appearance:

$$T_{cr} = \frac{2t_f^2}{\mu L} \sqrt{\frac{E_x E_z}{3(1-\nu_x \nu_z)}} \quad \theta = \frac{6\tau_{cr} a^2}{E_x L^2}$$

Process monitoring:



Isotherms after an IR dryer (web speed = 5 m.min⁻¹)

- Temperature heterogeneity and un-flat isotherm profiles
- Care must be taken in the temperature measurements for a good monitoring of the pilot.