Numerical modelling and analysis of microwave heating of polymers

Topic:
In order to advance the reactive extrusion process applied to polymers, we propose replacing traditional electric heating with microwave heating. This technique could offer the dual advantage of efficiently heating the material in the bulk and improving polymer's reaction kinetics.
Before ultimately considering the design of processing tools operating entirely under microwaves, this thesis aims first to equip an existing batch process with microwave technology, with the primary objective of melting a polymer in granule or powder form as quickly as possible in the chosen process. To achieve this, it is essential to understand the physics of microwave interaction with the material, first in the solid state if the material is granules or polymer powder, and then to model it. In a second phase, using already molten polymer systems, microwave coupling will be considered to efficiently activate chemical reactions and modify polymer materials.

Thesis Objectives:
- Numerical Simulation of the Process
The thesis will aim to establish models for the numerical simulation of heat transfer in thermoplastic polymer materials under a microwave field during a reactive mixing process.
The targeted numerical simulation will therefore require a 3D study of a polymer mixer as an extruder component, based on thermal heating models to be established to accurately understand heat transfer in polymer materials and in the entire system (tanks and rotating mixers), by coupling the different heat transfer modes and phase changes that occur.

- Wave-polymer Interaction
Quantifying the polymers dielectric parameters evolution as a function of temperature is a prerequisite. The work involves adapting a laboratory experimental bench to experimentally quantify microwave-polymer interaction and measure the dielectric constants of these materials as a function of temperature.

The objective at the end of this section will be to be able to model the heating of a set of solid granular polymer in motion and to establish a link between chosen heating rate and the characteristics of the microwaves in a controlled condition.

The work will therefore consist of conducting a literature review to model and analyze:
- Microwave/polymer interaction, focusing on the two expected effects (thermal and rheological).
- Characterization of microwave absorption and their associated models.
- Heating and reaction kinetic models of an overall system associated with the problem.
- The state of the art of the reactive microwave extrusion process.
- In-situ temperature measurement techniques.

The second phase of the project will focus on:

- Theoretical modelling of microwave heating and kinetics reaction on model polymer systems.
- Measurements of microwave/material interaction: microwave energy absorption rate and reaction progress as a function of temperature and emitted power, in a laboratory experiment to be developed.

The candidate should have confirmed skills in numerical modelling, polymer materials, rheology, heat transfer, good skills in numerical handling of differential equations (finite elements), and a passion for experimental measurements

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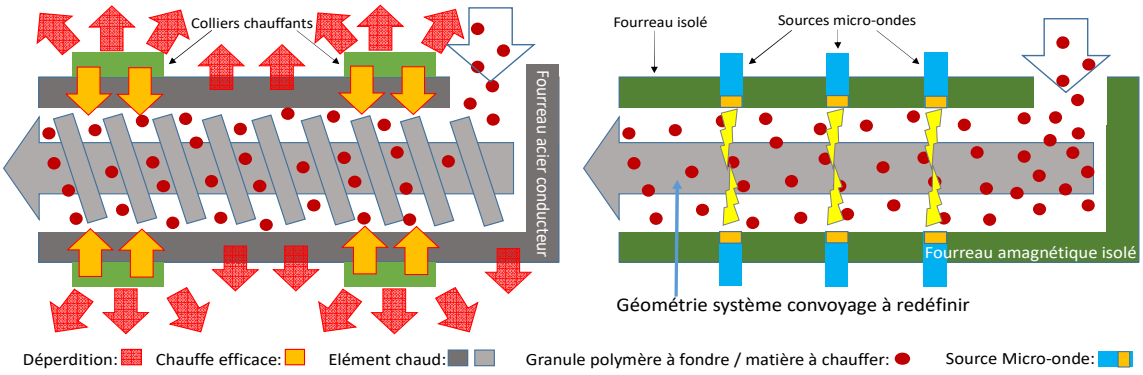

Premières zones d'une extrudeuse bivis (vue de profil)

Extrudeuse TRADITIONNELLE — Extrudeuse MICRO-ONDES

Traditional extruder — Expected Miro-wave Extruder