PhD thesis

Title: Experimental and numerical investigation of the mould filling during compression process of unfilled polymers and filled polymers.

Keywords: Polymers, mould filling, experimental tests, numerical modelling.

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Context

The manufacturing process with polymers and their composites have been widely developed in recent years: such as injection moulding process, compression moulding process, casting process and so on. The filling of the macro and micro cavities in the die mould is an essential step in these processes, because the filling ratio dominates the replication efficiency of the manufacturing structure. Polymers are considered as important materials in micro replication process due to their low cost and to their wide range of physical properties. It shows excellent integration and wide application of polymer based materials in electrical and mechanical engineering field. Even though a lot of polymer based components have been elaborated by using these processes, the numerical modelling approach associated with their mechanical behaviour is still lacking. The main scientific issues of the thesis are:

- Identification of the materials' viscoelastic and viscoplastic constitutive laws of unfilled and filled polymers to predict their deformation during the compression process.
- Analysis of the processing parameters, such as embossing temperature, compression pressure, mould wall friction, maintain pressure, maintain time, cooling temperature, demoulding temperature... to improve the filling efficiency of the mould die cavities.
- Numerical simulation of the whole compression process and analysis of the processing parameters sensitivity on the filling efficiency of mould with different geometry and dimensions.
- Experimental validation and optimization of the compression process.

Objectives

The objective of this PhD thesis is to optimise the thermoplastic compression moulding process to elaborate competitive polymer based products. The research work will start by the characterization of the thermal and mechanical properties of the material, then the viscoelastic and viscoplastic constitutive laws based on integer and fractional order will be used to describe the materials' deformation during the compression process. The numerical simulation of the compression process will be achieved using finite element method. The die mould with specific geometry and dimension will be designed and fabricated, and then used to elaborate the polymer based components. The comparison between the experimental and simulation results will be performed to analyse the processing parameters' sensibility on the filling efficiency of the die mould cavities. The main objective of this project is to propose the efficient numerical tool allowing optimisation of the compression process.

Work program

The project, planned over 3 years, will be structured as follows:

Academic year	Research work description
1st year	– State of art on the polymer viscoelastic and viscoplastic behaviour. – Practice the experimental and numerical tools. – Compression process simulation with simple material models.
2nd year	– Characterisation of materials' behaviour. – Identification of the material constitutive law in compression process. – Analysis of the material parameters' sensibility by numerical simulations.
3rd year	– Mould design for the compression process. – Optimisation the process with simulation approach. – Investigation of the possibility to filling mould with complex geometry. – Experimental validation of numerical predictions. – Writing the Ph.D. thesis.

Equipments involved

- Compression moulding equipment
- Tensile-compression test equipment
- DSC and DMA equipment
- Profilometre for the metrology of component
- Abaqus, Anysis, Solidworks and Matlab softwares

Collaboration

This work will be conducted in collaboration with:
Professor Thierry BARRIERE
Univ. Bourgogne Franche-Comté, FEMTO-ST Institute, CNRS/UFC/ENSMM/UTBM,
Department of Applied Mechanics, 25000 BESANÇON-FR

Candidate profil:

- Knowledge of finite element method
- Knowledge in material modelling and simulation
- Good experimental skills
- Intermediate English level (minimum B1)
- Autonomy and dynamic

References

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