

Sustainable Injection Moulding

Energy Optimisation and Recycling Cycles for Resource-Saving Production

Graduate



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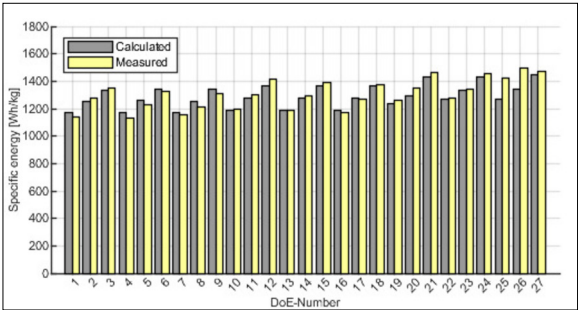
Initial Situation: Injection moulding is one of the most widely used polymer-processing technologies, yet its electricity demand is substantial and often insufficiently transparent at the level of individual process phases (plasticising, filling/packing, tempering, auxiliaries). In parallel, mechanical recycling is increasingly applied to polyolefins, however, repeated processing cycles alter rheology and stabilisation states and can ultimately degrade part performance, complicating robust process settings.

Objective: This thesis addresses two decoupled topics: (i) energy calculation—the development and validation of a practical, data-driven yet physically interpretable methodology to calculate and visualise injection-moulding energy consumption as a set of sub-energies, to validate the approach against measured machine data, and to compare established formulations, and (ii) closed-loop recycling—the investigation of three polypropylene grades (1: homopolymer, 2: heterophasic copolymer, and 3: a PP regranulate containing a PE fraction) processed through up to 20 recycling loops, with comprehensive characterisation of the resulting material changes.

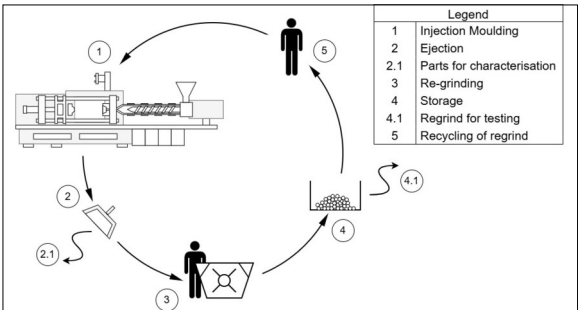
Conclusion: An energy calculation method and a web-based software were established, enabling import of DoE datasets and automated computation of phase-resolved energies. After optimisation the model shows close agreement with measured energy trends across process settings and materials, achieving a total error of 2.49% for PP and 2.99% for PA, and identifying the dominant levers for energy reduction, most notably cycle-time-dependent terms and heating-related components. Material characterisation across multiple recycling loops demonstrates how degradation-driven shifts (e.g., molecular weight

reduction and stabilisation effects) translate into altered processing behaviour and changes in mechanical, rheological, and chemical properties. Across all PP grades, ductility-related properties were particularly sensitive. Several degradation assessment approaches were analysed and evaluated, including FTIR-based carbonyl index evaluation, Mw-MFR correlations, and crossover-shift analysis from plate rheometry.

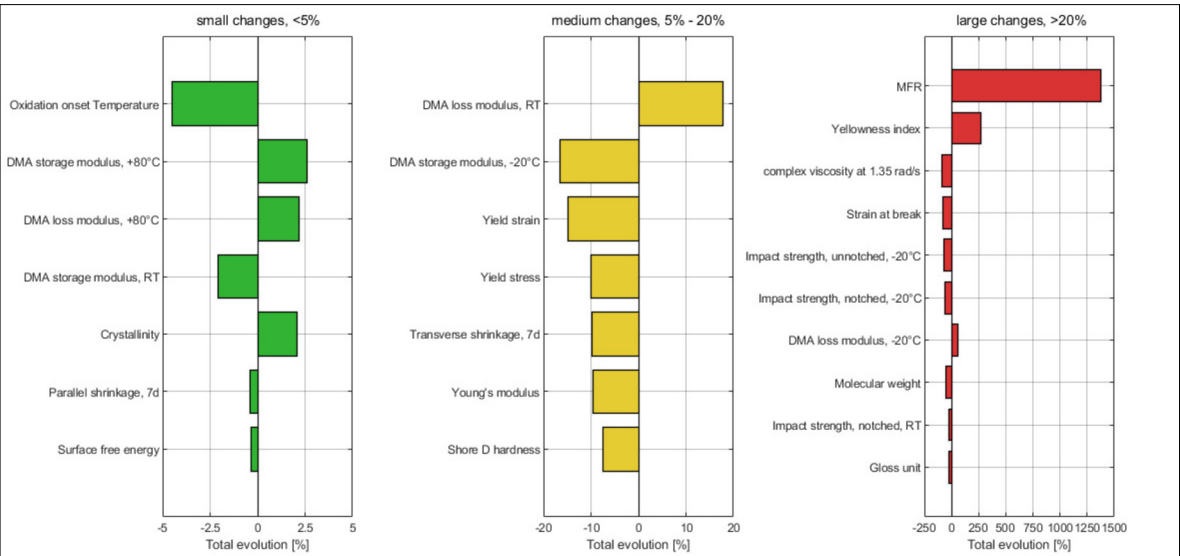
Total specific energy for PP: Deviation of calculated and measured values for all DoE settings after optimisation
Own presentation



Closed-loop recycling scheme
Own presentation



Total evolution in various material properties after 20 closed-loop recycling cycles for the PP copolymer
Own presentation



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Subject Area

Plastics Technology

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