Master's Thesis Engineering Technology

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The impact of multiple production cycles/the introduction of recycled material on the properties of Expanded Polypropylene

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Introduction

The chemical company Kaneka Belgium N.V. produces polypropylene based foamed particles, used to produce moulded parts which can be applied in different sectors. Today, their customers are striving for sustainability following the European guidelines for 2030, which directly involves recycling of end products. In this context, it is compulsory for KB to start re-introducing a fraction of reprocessed material and to provide materials from a combination of pure and recycled foamed particles. This thesis is sustainability driven and focusses on the effect of the introduction of recycled foamed particles into virgin material and the effect of going through different extrusion cycles on the material properties, ultimately creating a circular economy.

Extrusion

The formed recipes are heated and put through the die, creating polymer strands. The strands are cut into pellets of a certain size, forming the base component for the following expansion process. The main pellet property is viscosity, expressed as MFI (Melt flow index).

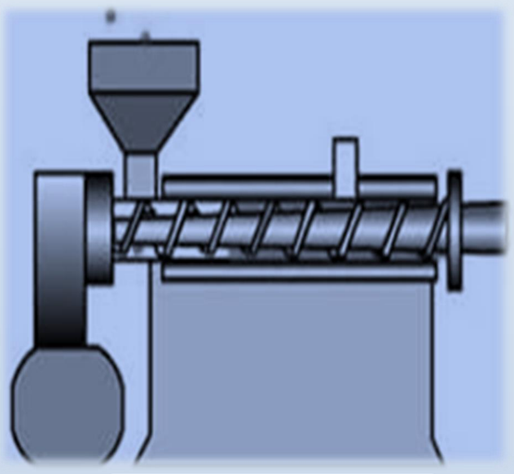


Figure 1: Extruder [1]

MFI results: Reprocessing

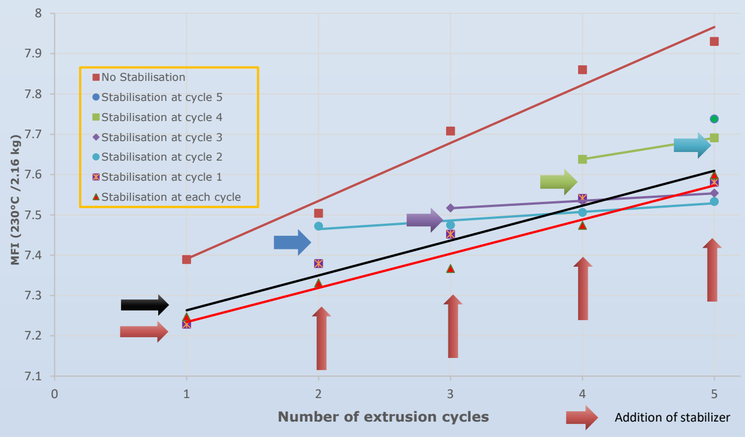


Figure 3: MFI of Reprocessed EPP with addition of stabilizer in function of the number of extrusion cycles

Table 1: DSC Results

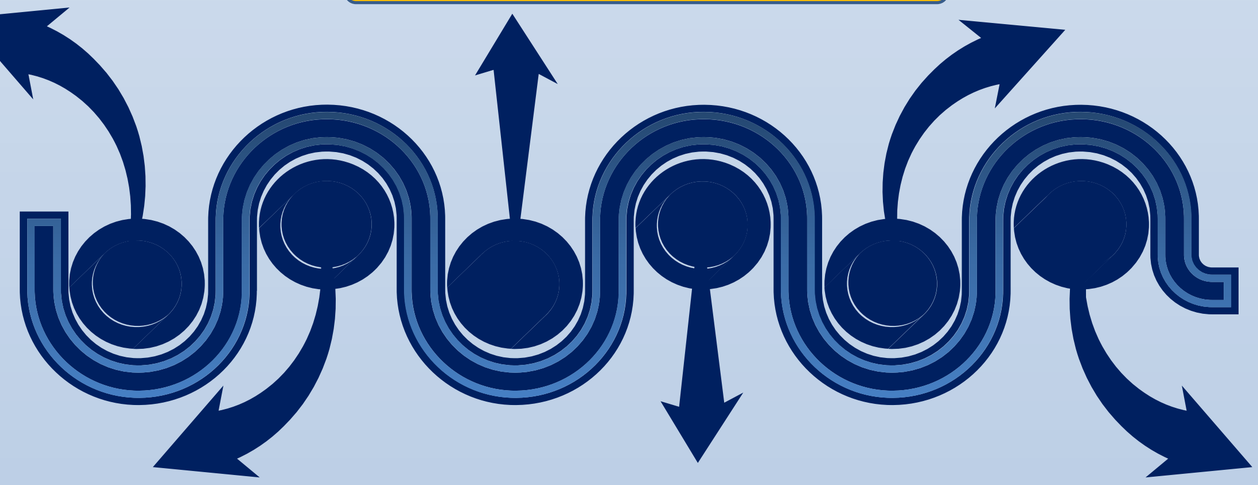
Parameter	Td difference cycle 5 – cycle 1 (°C)	Crystallinity in/decrease (%)
Recipe A	1.36	/
Recipe B	2.6	+5.7
Recipe C	-0.9	+21.2
Recipe D	1.2	+16.3

DSC Analysis

When comparing the change in enthalpy of the crystallization peaks of the different produced foam particles, it is clear that all recipes undergo an increase in crystallinity by increasing the amount of extrusion cycles. The most notable increase is found at recipe C.

Start: Preparing the recipe

Four different recipes are created, all differing in the amount and type of stabilizer added. Recipe A consists of no stabilizers. Recipe B is the standard recipe with stabilizers. Recipe C consists of 25% recycled material and 75% recipe B. Recipe D is a modification of recipe C, replacing the standard added stabilizers by a new recycling stabilizer. In addition, extra stabilizer will be added at different extrusion cycles to indicate its effect.



End: Rotational Rheometer

By performing a frequency sweep using the rheometer, data of the G', G" and η^* of all samples was gathered. These confirmed the MFI results, but indicated that the recycling stabilizer was not as effective as thought in terms of degradation decrease.

Expansion

A 20L autoclave reactor, CO2, N2, water, dispersants and wash water are needed to expand the pellets into foamed particles under high pressure and temperature.

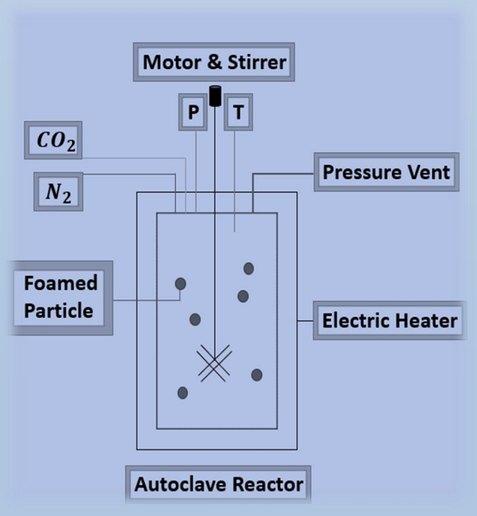


Figure 2: Schematic diagram of the batch autoclave reactor system [2]

MFI results: Recycling

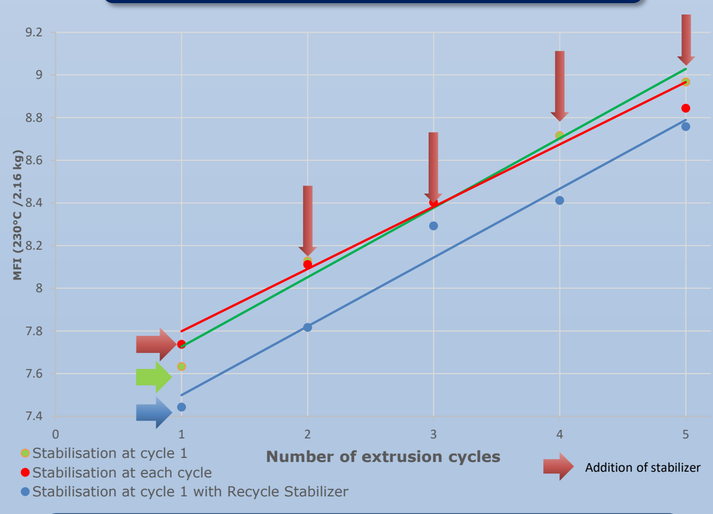


Figure 3: MFI of Reprocessed EPP with addition of 25% of recycled material at each cycle comparing both stabilizers

Table 2: Results of changing mechanical properties

Parameter	Compression	Elongation at break	Tensile stress
Recipe B	↘	↘	→
Recipe C	↘	↗	↘
Recipe D	↘	↗	↘

Property Analysis

The mechanical tests indicated a decrease in elongation at break and compression strength for the non-recycled recipes. The recycled recipes saw an increase in the ductility, but a larger drop in compression strength and tensile strength, resulting in the non-usability of these samples after 5 cycles.

Conclusion

The MFI results indicated a decrease in viscosity, caused by a decrease in chain length. Adding the recycling stabilizer minimized this decrease. Secondly, the DSC curves indicated a rise in crystallinity caused by the small cut-off chain fragments. Furthermore, all mechanical properties decreased apart from the elongation at break for the recycled recipes. Finally, the rotational rheometer confirmed the already formed conclusions in terms of viscosity. Generally, it can be concluded that the reprocessed samples remained stable with favourable properties in contrast to the recycled products.

Supervisors / Co-supervisors / Advisors

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References

[1] Golden Far East Machinery , "How to operate extruder machine?," 15 04 2020. [Online]. Available: https://www.jydjx.com/news/how-to-operate-extruder-machine.html. [Accessed 15 03 2021].

[2] M. Hossain, "Production of H2 from microalgae biomass in supercritical water using a Ni/La-γAl2O3 catalyst," Energy Procedia, no. 110, pp. 384-389, 2017.

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