Designing a safety shoe demonstrator from recycled glass / PP

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Introduction

The interest for thermoplastic composite (TPC) parts is growing and the material is increasingly being used. This is due to their favourable properties, such as impact strength and rapid processing. The resulting waste, first production and later end-of-life, is interesting to recycle for economic, legal and environmental reasons.
In collaboration with partners the research group of Lightweight structures developed a method to recycle glass / PP [1]. Together with Cato CI they started developing a safety shoe nose made of recycled glass /PP to test the designed recycling route.

Objective

The objective for this research is to answer the following question and reach the set end goal:

'Can recycled glass/PP be used for the production of a safety shoe nose that meets the standards?'

End goal: Demonstrate if the already developed recycling route is suitable for processing recycled glass/PP into a safety shoe nose and test according to standards.

Method

The recycle process, figure 1, starts with reducing the material in size. Then the material is mixed with a low shear mixer with rotating bars at 5 or 10 RPM (10 min at 230˚C). After mixing the material can be placed inside the mould and noses can be pressed. Different materials were used to produce noses: LFT pellets with a fiber mass fraction (W_f) of 40% / 60%, recycled W_f 40% and LFT pellets with UD glass / PP tape inserts.

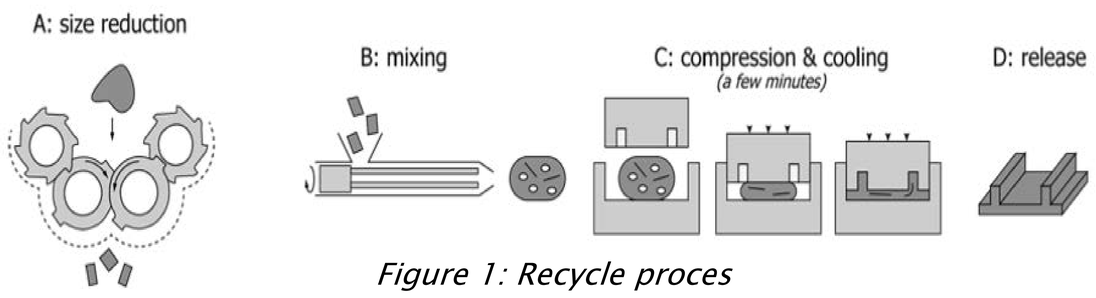

Figure 1: Recycle proces

The noses were tested according to nen-iso 20344 2004. The norm states the following about the nose:

- Impact test: Impact energy 200 J ± 4 J;
- Compression test: Load of 15 kN ± 0,1 kN.

After the test the minimal internal height of the nose has to be 14,5 mm or more and no light may get through any of the tears in the material [2].

References

[1] Thomas A. de Bruijn, Guillaume Vincent, Ferrie W.J. van Hattum, "Influence of low shear mixing settings on the mechanical properties of long glass fibre polypropylene", SAMPE europe Conference, 2017
[2] "Personal protective equipment – Test methods for footwear" ISO 20344, 2004

Results

During production various kind of noses were made. What stood out was that how higher the W_f, the harder it was to process the material. This resulted into a higher standard deviation in the noses with 60% W_f, and in noses with a thickened front.

Figure 2: Produced safety shoe noses (left: W_f 40%, right: W_f 40% + insert)

Apart from the five types of produced noses, a Cofra nose was bought to compare the noses with what is available on the market. All the noses were tested according to the standard. An overview of the results is given in figure 3, only the noses with the thickened front and the bought noses passed all the tests. The other noses failed on one or multiple points.

	Impact test	Compression test	Average weight(g)	St. dev.(g)	V_f (%)	Past standard?
W_f 40%	X	X	43,1	1,5	19	No
W_f 60%	✓	X	54,8	2,6	35	No
Recyl. W_f 40%	X	X	43,5	0,4	19	No
W_f 40% + insert	X	X	41,5	1,7	19	No
Cofra	✓	✓	69,1	1,4	52	Yes
W_f 60% thickend front	✓	✓	61,9	4,8	35	Yes

Figure 3:Overview results noses

Conclusions

It is possible to produce noses with this process, to produce noses from recycled glass /PP and to produce noses that meet the set standards.
But the combination of these three points has not yet been achieved. It is expected by implementing a number of changes that this can be achieved: by thickening the front of the nose and increasing the W_f, it is expected that recycled glass/PP noses can be produced that meet all the standards set for this. Further optimization is possible with increasing the ratio insert/nose.
The produced noses are still lighter than the bought noses. This means that at this point there is still room to improve the noses and compete with what is currently available on the market.

Acknowledgements

This research is co-financed by Regieorgaan SIA, part of the dutch organisation of scientific research (NWO).

Graduation Project

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