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ABSTRACT
The applicability of common reed as a natural fibre reinforcement for polypropylene (PP), polyethylene (PE) polymers is highlighted through the development of a new multi-purpose container. The multi-purpose container is versatile; hence it can be used over a wide range of commodity applications. The product design follows the conventional design process guidelines, while the development includes injection moulding process parameter optimisation using plastic melt flow simulation, prototyping, and a product manufacturing. The optimised part design is used to conduct the cool, fill, pack and warp analyses during the melt flow simulation. The simulated process parameters that led to a good dimensional accuracy are used as baseline settings during the actual injection moulding process.

INTRODUCTION
Product design and development is an iterative process which contains the concept, embodiment, detail design, the product specification and development stages (Ashby, 2016). Nowadays, sustainability is becoming a key drive in a new product development. The sustainability dimension encompasses the design, material selection, development, the product life, and end-of-life treatment aspects (Mengistu, 2024); hence strongly connected to all design and development stages. To ensure sustainability, the material selection is at the core of the development processes.
In this work, we present the use of common reed fibre-reinforced polymers to produce a new multipurpose container. The low-density polyethylene (LDPE) and PP matrices are reinforced with a 20 % reed fibre loading. Our previous study on the mechanical properties of the reed fibre-reinforced LDPE (Linderbäck, 2024) indicated that the Young's modulus and yield strength of the material were improved. Our motivation to use the reed fibre-reinforced polymers for the product partly stems from the enhancements of the tensile properties. The gross dimensions of the product are: length L= 125 mm, depth d= 42 mm, and width w= 72 mm, while the minimum wall thickness t = 1mm. To predict key quality dimensions associated with the actual injection moulding, the melt flow analysis was made using SolidWorks Plastic. The cool, fill, pack and warp simulations were selected during the analysis. Fig. 1 presents the settings of the melt flow analyses, and the actual injection moulding.

Fill

Parameters	Values
Melt temperature	200°C – 220°C
Screw speed	42 mm/s
Mould temperature	40°C – 50°C
V/P Switchover	99%

Pack

Parameters	Values
Packing pressure	300 – 450 bars
Packing time	4 – 6 sec
Pure cooling time	10 – 12 sec

Cool

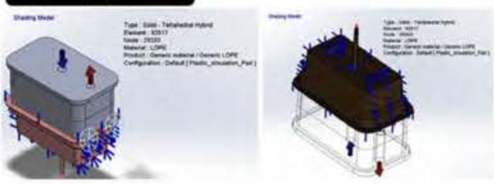
Parameters	Values
Coolant	water
Flow rate	50 cc/s
Coolant temperature	30°C – 40°C

Materials

LDPE

PP

Model preparation



Actual injection moulding parameters

Parameters	Materials	
	PE+ 20% reed	PP+ 20% reed
Melt temperature	200°C – 210°C	200°C – 210°C
Injection speed	26 mm/s	22 mm/s
Packing pressure	450 bars	250 bars
Packing time	8 sec	5 sec
Cooling time	12 sec	15 sec
Switchover (V/P)	7 ccm	7 ccm
Clamping	375 kN	375 kN

Fig. 1 Settings for the plastic flow simulation and actual injection moulding process parameters.

RESULTS AND CONCLUSIONS

The settings that led to the optimum results of the volumetric shrinkage, part temperature during ejection, shear rate, clamping force, sink mark, and maximum displacement are used for the actual injection moulding processes (Gebrehiwot, 2022). Fig.2 presents the simulation process, the obtained results, and the actual injection moulded product using the reed fibre-reinforced PP and PE.

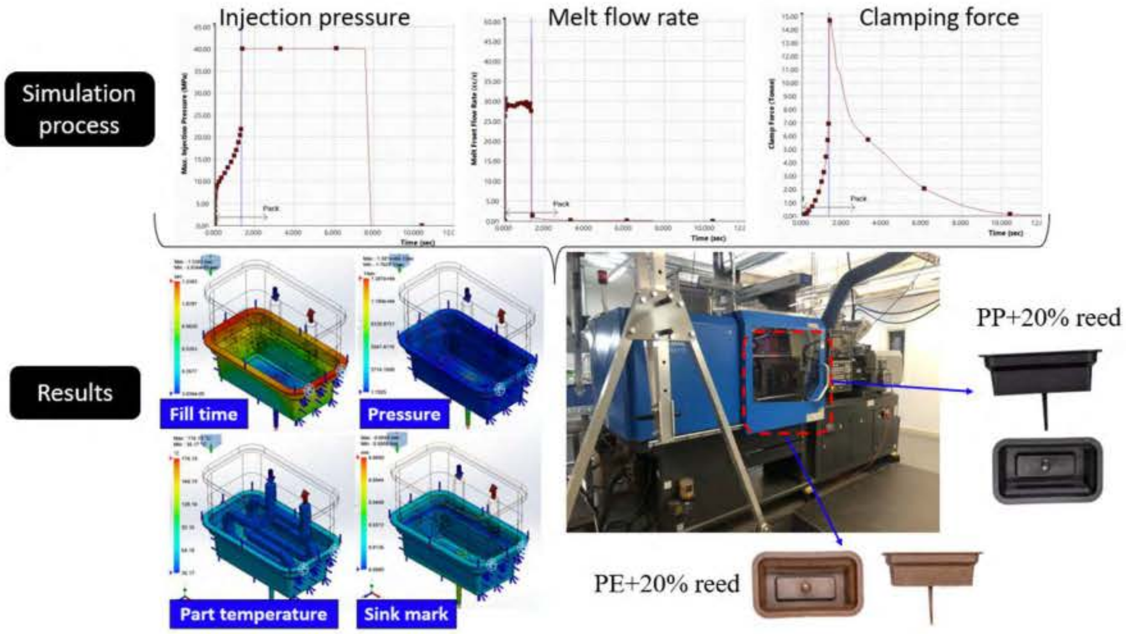


Fig.2 SolidWorks plastic simulation and the actually injection moulding process.

The simulation results are good, but merely applicable to the materials in their pristine forms. Comparing the simulation and actual injection process parameters, the reed fibre-reinforced PE can be successfully injection moulded by decreasing the injection speed, and increasing the packing pressure, packing and cooling times, and clamping force. On the other hand, decreasing the injection speed and packing pressure, while increasing the cooling time and clamping force leads to a good reed fibre-reinforced PP product.

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