Ski Poles by Multilayer Technology

Hybrid Technology with Braided Preforms. Modern plastic technology, if intelligently applied and developed, offers the possibility of injection moulding thermoplastics with endless-fibre reinforcement. These plastic-plastic hybrids can solve problems of conventional designs and replace traditional composites in selected applications.

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Thermoplastic materials with endless fibre reinforcement are principally used in the field of transportation. Leisure and sports applications, however, are rapidly gaining in importance, as is shown by the example of the development of a ski pole.

Ski poles are currently available in a seemingly unlimited variety of designs. A basic distinction is made between cross-country and downhill ski poles. Unlike downhill ski poles, cross-country poles are usually straight. The materials used are aluminium and fibre reinforced plastics (FRP). In addition to the market for new skiers, there is also a large market share for repurchasing when the poles break, for example during an accident.

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FRP poles made by conventional methods present a considerable risk of injury as a result of sharp fibre ends in the fracture surface. An important development aim is therefore to reduce the risk of injury by choosing the basic materials and their arrangement in the laminate. It must also be possible to print the surface without secondary operations. The first development stage with thermoset matrix material consists in developing a cross-country ski pole that meets the specification.

Specification and Resulting Structure

Ski poles are standardised according to DIN 7884 and must satisfy various requirements [1]. Under an eccentric, quasi-static axial compressive load of, for example, 500 N at a length of more than 1100 mm, they undergo neither structural failure nor permanent deformation. The ski pole must also buckle under a compressive load of 937 N. This corresponds to a contact pressure of 0.375 N/mm^2 on the top of the handle. Additional specific safety requirements must also be observed. The standard includes a reference to the risk of splintering, but only refers to a minimum compressive force. There are no specifications for higher loads and the failure case. In addition to the mechanical properties, the pole shaft surface must also be directly printable. This allows an additional production step to be avoided and the production costs reduced. For the required surface quality, it is necessary to work in a closed outer mould and because of the geometrical specifications, to use an internal mandrel.

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Prototype construction

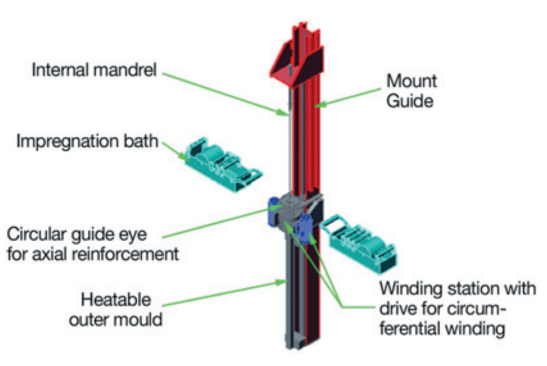

Fig. 1. Laboratory line for developing manufacturing processes and producing the first prototypes

Fig. 2. Prototype of a complete GRP cross-country ski pole

Fig. 3. The handle is plugged onto the upper cylindrical shaft part

Because of the mechanical stresses, the reinforcing fibres are aligned lengthwise along the shaft. To eliminate failure under compressive loads as a consequence of transversal contraction, appropriate circumferential reinforcement should be provided, which also prevents splintering on fracture. The short cycle time of about 60 s per pole can only be achieved with a resin system with a release agent modified for this application.

Preliminary Development and Manufacture by Thermoset Techniques

After completion of the preliminary considerations and the necessary preparatory work, a laboratory-scale unit was set up to produce the first prototypes (Fig. 1). In principle, the process used is based on a combination of discontinuous pultrusion, pulforming and winding technology. The axial fibres, guided through a circular guide eye, are joined to the bottom end of the inner mandrel outside the outer mould. The mandrel then travels vertically while at the same time being provided with circumferential reinforcement by means of rotating bobbins. The unit comprising the inner mandrel and laminate is introduced into the heated outer mould, where it is cured. Demoulding takes place in the reverse sequence.

On a laboratory scale, the curing time took 120 to 150 s with a residual styrene content of less than 1 %. The total cycle time took less than 240 s. In mass production, using a four-cavity mould, this permits a cycle time of maximum 60 s and an annual production of 1 million ski poles.

In the first development stage, the ski pole consists of glass and polyester fibres embedded in a thermoset matrix. The arrangement and combination of fibres ensure the required strength and stiffness. In addition, the risk of injury on fracture is lower. The use of a closed outer mould provides the shaft with a smooth surface which can be printed directly. The pole is cylindrical at the ends and tapers conically from the larger to the smaller diameter (Fig. 2). The handle and disk with integrated spike are put on (Figs. 3 and 4).

In the final planning of the mass production plant, the necessary degree of automation resulted in production costs that were on the borderline of what was acceptable on the market. In addition, the process developed can only be used for producing straight ski poles. It also does not address the important market segment of alpine (e. g. curved) ski poles. This can be covered by a development using adapted specialised injection moulding technologies [2].

Multilayer Processes for Hybrid Ski Poles

For parts with a complex outer geometry, injection moulding allows considerable assembly steps to be eliminated and additional functions to be integrated by employing combinations of properties. This is made possible for example by the multicomponent process together with gas assist or foam technology. A broader approach has been pursued in the last four years by a European consortium with associated network partners [3]. The aim is to implement an intelligent hybrid technology comprising sandwich injection moulding and preform technology (Fig. 5).

The preforms comprise braided hoses. They are thermally preconsolidated to provide the stiffness for processing by injection moulding. They are suitable for use as reinforcing and functional ele-

Fig. 4. The disc with integrated spike is plugged onto the lower cylindrical shaft part

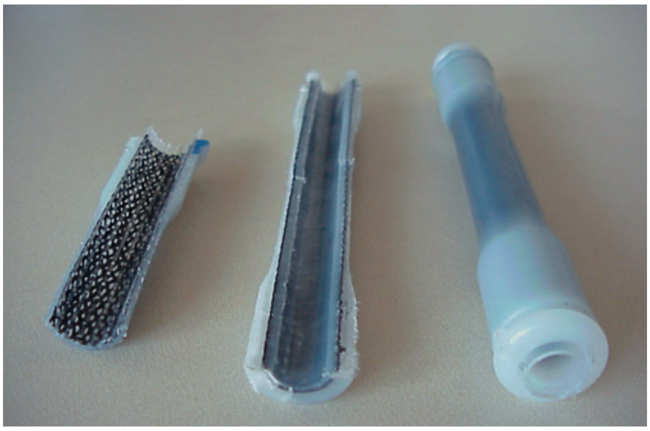

Fig. 5. Test specimen of the hybrid process for reinforced layer structures

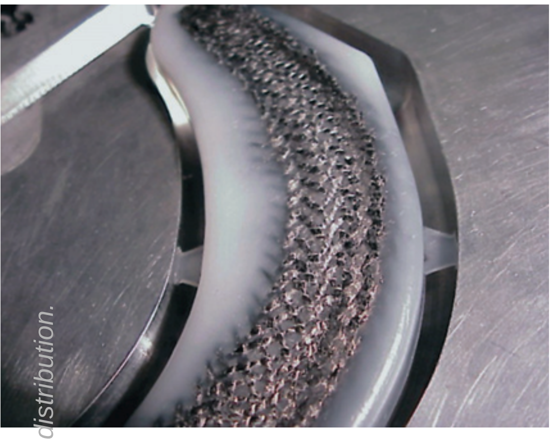

Fig. 6. Preform overmoulded with functional layer

ments when overmoulded in a multistage process (Fig. 6).

The insert technology, with up to six sub-processes and different thermoplastics as outer skin, achieves a high functional density in the part. Specific tailored properties are thus produced in localised areas, with sandwich injection moulding being used to build up a layer structure for improved adhesion. The quality of the new composites are principally determined by boundary surface adhesion between the preform and matrix, and their impregnation.

	ComTec GmbH	StructoForm GmbH
Research & Development	Fibre-composite technology	Special injection moulding processes
Competence	Designing Testing Fibre-composite applications	Process development Process optimisation Thermoplastic applications

Service Offering
- Concept development, consulting and engineering
- Component development
- Designing of components
- Process development and feasibility studies
- Mould development and optimisation
- Development and design of special machines and equipment
- Development and adaptation of modular machine components for combined processes
- Pre-production and special-model production after completion of development
- Material and component testing (incl. non-destructive testing) with associated optimisation loops
- Applying for, conducting and coordinating EU-funded basic development based on approx. 10 years of successful project work at EU level

Table 1. The partners' development cooperation

In the consortium's pilot plant, a modular 200-tonne machine for simultaneous injection moulding of up to four thermoplastic matrix materials is available for experiments with the new process [4]. The mould technology for the new hybrid process makes use of tried-and-tested concepts from multicomponent technology and special tooling for clamping the preform. Applications with wound hollow geometries such as the alpine ski pole can be generated by means of combined gas-assist technology.

Summary

The development of hybrid structures from tailored thermoplastics and high-strength fibre preforms is realised with the novel multilayer process, which embeds the preforms in matrix layers. Endless fibre reinforcement of thermoplastics opens up an alternative to thermoset or die-cast and light-metal parts.

Users and customers from the aeronautical, automotive, rail-vehicle and marine engineering sectors, machinery and sports articles industries have long been using composite materials as problem solvers, especially for low-weight parts. This technology is valuable not only because of the potential weight saving, but also owing to the pay-off between price, performance and fulfilling the specifications. Properties such as durability, corrosion resistance and ease of maintenance can be achieved.

The development cooperation between the two companies ComTec of Aachen/Germany and StructoForm of Aachen/Germany has the aim, in league with the industry, of developing new thermoplastic lightweight components and subsequently preparing the technology for mass production and implementing this (Table 1). For the second stage of the ski-pole project, users or OEMs are currently being sought, who are interested in a financial shareholding and in the subsequent transfer to mass production. ■

REFERENCES

1 DIN 7884 Winter sports equipment – Ski poles for alpine skiing – Safety requirements, testing
2 Becker, H. and Schneider, H.: Project report on the development of a thermoplastic hybrid ski pole by the multilayer process, 09/2003
3 European Commission, FP5RTD: HYJECT, Contract No: G5RD-CT-1999-00047
4 Becker; H. et. al.: Tailored thermoplastics with layer structures and endless fibre reinforcement, Kunststoffe plast europe 9/2003, pp. 44–47

DEDICATION

The authors dedicate this article to Professor Georg Menges on the occasion of his 80th birthday, with best wishes for continued health and happiness. We are grateful for his ability to convey his visions about the versatility of plastics as materials to his employees. The enthusiasm he inspired in us has been a motor for new developments, which he still actively supports with generally appreciated good advice.

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