Making skis strong enough for Olympians

By Marc Zupan, The Conversation

Olympians expect top-notch performance from their minds and bodies, but they get crucial advantages from the very best equipment for their sports and the weather conditions they're competing in. Skis, for example, must stand up to near-constant changes in stress during races.

The ideal ski provides a stiff and rigid platform for skiers' boots to attach to, flexes to carve through turns, doesn't break under the pressure of jumps and landings and is light enough not to slow the athlete down. But that's not all: Skis must resist damage from collisions, absorb vibrations from icy conditions and withstand the temperature extremes and intense sunlight common in mountain environments.

That's a lot to ask of a single item. The first skis were made of strong, flexible ash wood, but technology has found ways to do much better. Today's materials design and construction processes are closely guarded industrial secrets, specific to individual ski companies. But I and other materials experts know that the essential components and methods are very similar: All skis are like sandwiches, stacking separate layers of different materials with all those separate properties into a single item, a competition-class ski.



Elite ski racers rely on state-of-the-art equipment. Photo Copyright 2018 Carolyn E. Wright

Advanced materials for extreme conditions

Ultra-high molecular weight polyethylene is a highly engineered plastic often used in high-strength ropes as well as in artificial hip and knee implants. It’s tough, bends and flexes a lot without breaking, resists scratches, retains its properties across a range of temperatures and has tiny microscopic pores across its surface. When it’s used as the base layer of a ski, those microscopic pores act like a sponge into which racing wax is melted to fine-tune the ski’s contact with whatever the snow conditions are.

The sides of the ski base are made of high-strength steel

alloys that are heated and processed to meet the demanding conditions of skiing. These processes make the steel resistant to rust and able to be sharpened like a knife. The steel needs to hold its edge to carve through snow and ice while flexing with the rest of the ski without cracking or breaking.

Inside the ski

On top of the base is a complex layer in the ski sandwich, an element itself called a “sandwich panel,” made of similar materials and with the same techniques as those used to build spacecraft, aircraft and performance race cars. The center of the sandwich is a core material surrounded by fiber-reinforced composites.

The cores of ski sandwich panels can be lightweight titanium alloys, polymer foams similar to Styrofoam coffee cups or different kinds of woods – such as maple, oak, aspen or poplar. These different plastic, wood and metal materials are layered and combined to tune the ski to the desired levels of strength, stiffness, ability to twist and vibration-damping, all with as little weight as possible.

The outer layers of the sandwich panel are made from epoxy resins – high-performance glues – into and onto which are laid engineered fabrics like carbon fibers, fiberglass and Kevlar. These resin-fiber layers hold the sandwich core structure together and make all of the different material types work as one.

Like the core, these composite layers vary in thickness and makeup along the ski. They’re even applied at different angles to the ski itself to improve ski stiffness and strength.

The sandwich panel ski makes turning quicker and helps the ski ride smoothly over bumps and ruts in the terrain. It’s more responsive to the skier and more stable at high speeds than less advanced designs because it can take advantage of the best aspects of all its ingredients. Overall, the sandwich

panel is built to be stiffest under the binding area where the boot attaches, and more flexible near the ski tips, to glide more easily over uneven terrain. Each ski's sandwich panel is designed and built to optimize performance in a specific skiing event – such as downhill racing, snowcross or jumping – or even a particular skier's preferences.

Rapid improvement

The ski industry, and particularly its competitive elements, are willing to take risks and push limits, exploring the most advanced materials concepts to achieve optimum performance. As a result, decades of research have improved Olympic skiers' times significantly over the years.

That work has also spread benefits well beyond the Olympic medal podium and into the recreational market. Amateur skiers can explore more advanced terrain and more challenging slopes with help from the tuned spring response, vibration damping and light weight of their skis. Recreational skiers can also go faster in changing snow conditions and steer more easily through turns because their skis are adaptable and responsive to individual skiers' strengths, as well as slope conditions. The materials advancements help recreational skiers ski well on terrain previously accessible only by superior athletes.

All these advances happen very quickly. Before the next Winter Olympic Games, consumers will likely be able to easily purchase the same kinds of skis and snowboards that the 2018 Olympians competed on – and the 2022 Olympians will be using even better materials that help them go faster, higher and stronger than ever before.

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