TALKING TIMBER

PUTTING THE SQUEEZE ON WOOD

***Martin Ansell** reviews the availability and commercial applications of densified wood*

A paper by Jianwei Song and co-authors on "processing bulk natural wood into a high-performance structural material" was published in Nature on February 8. They report on processes for densifying wood which result in a more than 10-fold increase in properties including strength, toughness and ballistic resistance with associated enhanced dimensional stability.

In the light of these findings it is worthwhile reviewing the availability and commercial applications of densified wood.

Compreg is currently manufactured in Poland. Beech or birch veneers are soaked in phenolic resin which penetrates the cellular structure and plasticises the wood. Unidirectional or cross-laminated layers of veneer are typically compressed at 7 MPa (1,000 psi) at 150°C. A specific gravity of 1.35 is achieved compared with a value of ~0.65 for the uncompressed wood at 12% moisture content.

Compreg enjoys enhanced dimensional stability, hardness and wear resistance and has found applications including aircraft propeller blades, insulating fishplates for railway track, silently running gears, pulleys, aluminium drawing and forming dies and even musical instruments.

Permali densified wood products are well known in the UK. Although still marketed in Gloucester they are now manufactured in Germany and the Czech Republic under the name of Permali Deho.

Permali Densified Wood Laminate (DWL) is impregnated under vacuum with synthetic resin and densified with heat and pressure to form sheets, which can be machined into rings, rods and complex parts. High electrical resistance and dielectric strength lead to many electrical, railway, cryogenic and general engineering applications. DWLs have also been employed as flitch plates for timber connections.

Permawood developed for transformer cores and Hydulignum (high durability wood) are non-impregnated products where beech veneers are interleaved with resin impregnated paper and compressed at high temperature and pressure to form laminated boards. Current applications include wear-resistant components for the textile industry, propeller blades and underbody skid boards for F1 cars.

So how do the densified wood materials developed by Song *et al* differ from the well proven Compreg and Permali products?

Subjecting bulk wood to treatment with steam or liquid ammonia is well known to plasticise wood and compressing wood following plasticisation leads to some densification.

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However, in the latest research, some of the lignin and hemicellulose is removed by boiling in an aqueous solution of sodium hydroxide and sodium sulphite followed by pressing. The cell cavities in the wood are completely collapsed and the cellulose microfibrils in the cell wall become well aligned, resulting in a similar density to commercial densified wood but in an adhesiveless process.

The authors claim specific strengths (strength divided by density) greater than most structural metals and alloys, including high specific strength steel and lightweight titanium alloys. Compared with unmodified wood, strength is improved by a factor of 12 and work of fracture by a factor of 10. Cross-laminated densified wood has outstanding ballistic resistance.

How likely is it that the new densified wood will become commercially important?

Cellulose is nature's stiffest molecule with an elastic modulus of ~140 GPa compared to ~210 GPa for mild steel. So the densified wood will not achieve the high elastic stiffness of many metal alloys. The chemical processing of wood by boiling is a barrier to the production of large structural components, although a veneer-based route is more feasible.

Applications appear to be restricted to specialist components similar to those made from densified wood rather than large structural glulam beams or CLT. ■

Below: Permali Hydulignum products

The Wood Technology Society

A Division of the Institute of Materials, Minerals and Mining