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News and Views
Material witness: No nails
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Glue is marvellous stuff, but there are benefits of doing without it. For one thing, glues may contain toxic solvents. And they need time to set or cure — sometimes it takes hours or even days for the bonded interface to reach full strength. (The 'glue' of ancient buildings, lime mortar, could take many years to fully harden.)

That's one reason why industrial engineers have developed 'dry welding' techniques for joining plastics. Many plastic automobile parts, such as bumpers, fuel tanks and instrument panels, contain components bonded by friction welding. Two thermoplastics, which can be chemically dissimilar, are brought together and rubbed against each other, either by linear back-and-forth vibration or rotary motion, until the surfaces melt. This typically takes just seconds, after which the surfaces are held together under pressure while the materials re-solidify to form a bond that can be almost as strong as the parent materials.

The method works for metals too, obviating the need for brazing filler material at the join. Friction welding is just one of the 'solid-state' processes for uniting metals, which also include (pressure-induced) cold welding, diffusion welding and explosion welding. The aerospace, automotive and nautical engineering industries all use these techniques.

Now friction welding is being extended to a seemingly unlikely material: wood. Researchers at the IBOIS group of the Swiss Federal Institute of Technology in Lausanne (EPFL) found in 2000 that sheets of wood can be laminated without glue, nails or screws, just by rubbing them together in a rotary fashion to induce 'melting'. The process takes less than a minute, and the join is permanent and secure.

How does wood 'melt'? The secrets of wood welding are now starting to be uncovered by Bernhard Stamm and his colleagues at Lausanne (B. Stamm *et al. Holz Roh-Werkstoff* **63**, 313–320 & 388–389; 2005). Their tests on spruce and beech show that the wood starts to soften after a few seconds of rotary rubbing, as the temperature at the interface rises to about 320–350 °C. At this point, the surfaces start to smoke. The temperature peaks at 420–450 °C, when the surface wood is fully 'molten'. At that stage the interface can be allowed to cool.

Wood consists of fibrous cells, made primarily of cellulose, embedded in a resinous, glassy polymer matrix of lignin and polysugars. This cellular structure collapses at the bonded interface, and the lignin melts — but only the polysugars (particularly xylose) seem to undergo significant thermal degredation. In other words, although some details remain unclear, the welded join is apparently held together by solidified resin (lignin) and burnt sugar.

Stamm and his colleagues have tested the strength of this bond, and find that for beech wood it can withstand shear forces of up to 4.2 MPa. That is about a third of the strength of the natural wood itself, and is certainly sufficient for holding chairs, tables and shelves together; it might even be adequate for some applications in timber construction.