Plastics Topics – Wood-plastic composites (WPCs)

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1. What are wood-plastic composites?

Wood-plastics composites (WPC) are a new group of materials that are generating interest in both the UK and overseas. The term 'WPC' covers an extremely wide range of composite materials using plastics ranging from polypropylene to PVC and binders/fillers ranging from wood flour to flax. These new materials extend the current concept of 'wood composites' from the traditional compressed materials such as particle-board and medium density fibreboard (MDF) into new areas and, more importantly, a new generation of high-performance products.

The first generation of 'wood composites' were a combination of recycled wood flour or chips and binders. These were ideal for relatively undemanding applications. The new and rapidly developing generation of WPC 'wood composites' have good mechanical properties, high dimensional stability and can be used to produce complex shapes. They are tough, stable and can be extruded to high dimensional tolerances. The new WPC materials are high technology products for the most demanding applications.

The most common types of the new WPCs are produced by mixing wood flour and plastics to produce a material that can be processed just like a plastic but has the best features of wood and plastics.

The wood can be from sawdust and scrap wood products. This means that no additional wood resources are depleted in WPCs, waste products that currently cost money for disposal are now a valuable resource – recycling can be both profitable and ethical. The plastic can be from recycled plastic bags and recycled battery case materials although in demanding applications new plastics materials are used. The recycling ethos is to use materials recovered from short life cycle applications in long life cycle applications.

The concept of wood-plastics composites (WPC) generating interest as new methods of combining the materials are developed.

The WPC market is expanding in the USA and other parts of the world

2. The benefits of WPCs

WPCs can produce the final shape through extrusion processing. This maximises resource efficiency and gives design flexibility for improved fastening, stiffening, reinforcement, finishing and joining.

WPCs are wood products that need no further processing.

WPCs are weather, water and mould resistant for outdoor applications where untreated timber products are unsuitable.

WPCs are plastic products with exceptional environmental credential and performance.

WPCs have a wide range of applications. They can cost-effectively replace wood products in applications such as furniture, doorframes, decorative profiles, in fact anywhere wood shapes are used. They can cost-effectively replace plastic products in applications such as window frames, cable trunking, roofline products and cladding, in fact anywhere that plastics shapes are used.

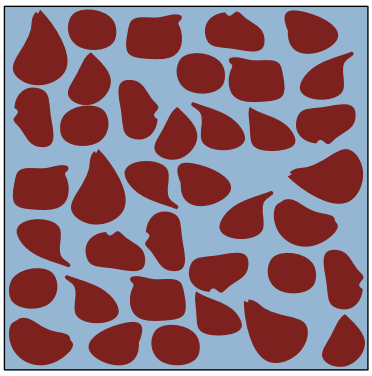
WPCs have many benefits:

- They are true hybrid materials and combine the best properties of both wood and plastics.
- They use low-cost and plentiful raw materials. Wood waste and recycled plastics become assets instead of liabilities.
- They are competitively priced and are competitive with traditional materials such as timber, MDF and PVC-U.
- They are easily produced and easily fabricated using traditional wood processing techniques.
- They are available in a broad range of finishes and appearances.
- They are easily recycled after use.

WPCs combine the best features of wood and plastics

3. WPC properties

WPCs are true composite materials and have properties of both materials. They have stiffness and strength between those for plastic or wood, but the density is generally higher than either. The properties of WPCs come directly from their structure: they are intimate mixes of wood particles and plastic. The plastic effectively coats the wood particle as a thin layer. The structure is shown below:



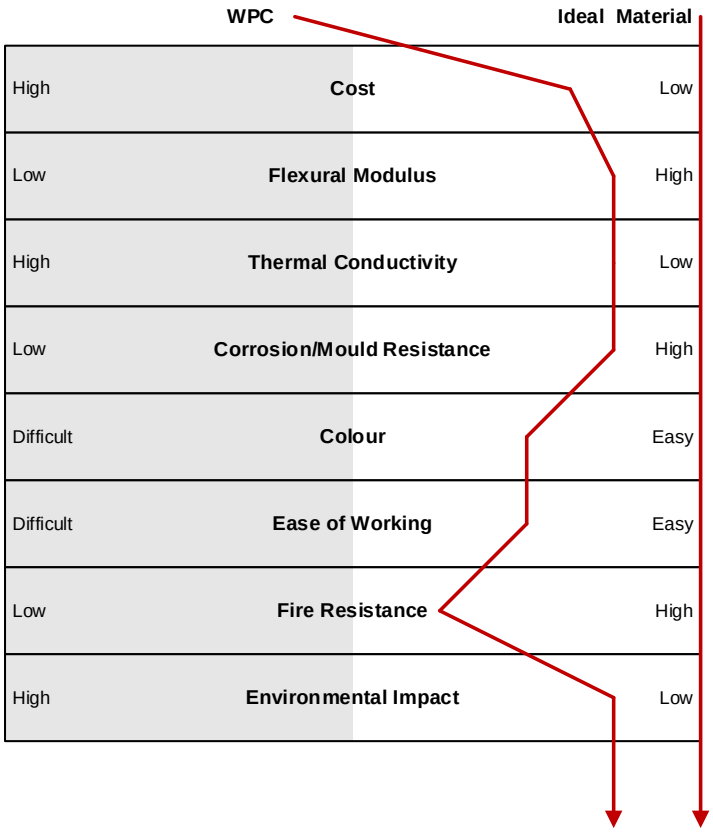
The wood particles are completely coated with plastic

The high moisture resistance of WPCs (water absorption of 0.7% compared to 17.2% for pine) is a direct result of the structure. Moisture can only be absorbed into the exposed sections of wood and is not transmitted across the plastic boundaries. The result is that WPCs are extremely moisture resistant, have little thickness swell in water and do not suffer from fungal or insect attack.

The properties of WPCs can be tailored to meet the product requirements by varying the type of wood or the type of plastic – the PE based products are cheaper and have a higher heat distortion temperature than the PVC based products but the PVC products are easier to paint and post treat.

Pigments, UV stabilisers and fire retardants can all be added to the WPC raw material before extrusion to improve specific properties. WPCs have:

- Good stiffness and impact resistance.
- Dimensional stability.
- Resistance to rot.
- Excellent thermal properties.
- Low moisture absorption.



WPC properties are ideal for many applications.

4. WPCs and fire

General experience shows that WPCs have a fire behaviour very similar to, or better, than that of comparable timber products.

Fire tests relate to either flammability or 'ignitability' which considers the ease with which a material will catch fire and sustain burning and 'spread of flame' which considers the propagation of fire by the material being tested.

Most of the fire testing of WPCs has been carried out in the USA using ASTM standards and these cannot be directly translated into the relevant British and European standards. This information is therefore provided for guidance only.

As a general rule, the presence of the plastic matrix appears to improve the fire performance of the wood component in WPCs. Many plastics, e.g., PVC-U, have good ignitability and spread of flame performance and this appears to be transferred to the WPC when they are used as the plastic component.

WPCs show good results in ignitability tests and these are similar to the results for wood with similar density.

WPCs show good results in spread of flame testing and the results can actually be better that those of wood with a similar density.

The fire performance of WPCs can be modified and improved by the addition of flame and smoke retardants to the raw material before processing.

5. WPCs and the environment

One of the main reasons for using WPCs is environmental. The environmental pressures on industry in terms of recycling and sustainability are growing daily. There is a clear need to extend the life cycle

of traditional building materials such as wood. This resource efficient use of materials that are currently seen as waste supports the developing concept of sustainable development.

For users of plastics products there is a need to reduce the dependence on petrochemicals with their rising and cyclical raw materials costs.

For users of wood products there is a need to improve the resource efficiency and to recycle the raw materials waste that inevitably occurs. WPCs increase the efficiency of wood usage by up to 40% compared to traditional wood processing.

WPCs provide other environmental benefits such as:

- There is negligible waste and any that is produced reused.
- WPCs contain no formaldehyde or volatile organic compounds.
- WPCs are recyclable and can be reground and reused after their service life.
- WPCs are considered non-hazardous waste and can be disposed of by standard methods. The basic material structure of WPCs means that leaching from WPCs is minimal to non-existent.

WPCs are environmentally friendly materials.

6. Processing WPCs

WPCs are made using a variety of raw materials. The basic wood and plastic mix must be modified with process and property additives to improve processing or the final properties of the WPC.

One of the major concerns with WPCs in the past has been the difficulty in combining plastics intimately with the wood flour. The general technique is to use a ‘compatibiliser’ or ‘coupling agent’ to improve the blending of the two materials. A typical compatibiliser is MAAP, which is used to treat the basic wood and plastic mix to improve the processing and mechanical strength of the final product.

The basic wood product is a fine sawdust in the 40 to 60-mesh range and this is dry blended with the various plastics and modifiers. The mix is extruded to a dough-like consistency through a simple die with none of the calibration problems of conventional extrusion. The flow properties and thermal characteristics of the WPC blend means that simple dies can be used, even for the most complex profile. The die design and construction and the lack of calibration tooling means that tooling manufacture lead times are short (6 to 8 weeks from design to production).

A standard simple water bath is used for cooling and the haul-off also uses standard parts. After haul-off, the engineered net shape is complete and ready for use.

Low processing temperatures (less than 150˚C) give high processing rates, low energy consumption and improved safety around the extruders.

Processing WPCs is an expert task but the results can meet the most demanding customer requirements

7. Working and finishing WPCs

WPCs can be processed using conventional woodworking tools and have similar to wood or MDF. The uniform density of the products even makes processing easier than with traditional wood products and the net shape extrusion means that many normal processes are not needed.

The table shows some of the finishing and treating options currently available.

The effectiveness of welding with WPCs varies with the exact WPC used. If the wood content is low then radio frequency welding can give good results.

WPCs can be cut finished and fastened just like wood

Fastening	Machining	Finishing	Sealing & Filling
• Nail • Screw • Glue • Staple • Dowel	• Turn • Mill • Drill • Sand • Saw • Mitre • Rout • Plane	• Prime • Paint • Integral colour • Emboss • Veneer Wrap • Laminate • Varnish • Lacquer	• Silicone seal • Acrylic seal • Wood fillers

8. Product design for WPCs

A major benefit of extruded WPCs is that the final product form can be produced in a single step. For the first time accurate net shapes are available for wood products. This is timber without the waste. The fine control on profile dimensions also means improved product performance and reduced material usage.

Exterior profile walls can range in thickness from 4 mm to 6 mm, interior walls range can range from 2.5 mm to 3.5 mm. Additionally it is possible to extrude intricate internal details to tolerances of less than +/- 0.2 mm.

Net shape profile production allows products to be designed with stiffening legs, internal hooks, internal dividers, snap fittings and internal strengthening walls – all the features of plastic profile design but in wood. This means profile weight (and cost) can be reduced and reduced material content also helps profile cooling to increase production speeds.

Profiles can be designed with connectors to allow product systems to be developed – a concept previously not possible with wood products.

Designers can add previously unobtainable value to wood products by using precisely formed products with internal hollows, strengthening ribs and re-entrant angles.

The possibilities of wood products can be expanded to use all of the advantages of plastics processing.

WPCs give finished shapes without the need for additional processing or waste

9. WPC applications

Current applications for WPCs are largely in finished products such as decking, cladding and window frames. In the USA, the market for WPC products has grown at a rate of 100% per year for the last 5 years and this is increasing as new applications are found for the materials. A particular growth area is in structural engineering applications that use the physical properties of WPC to the limits.

WPCs can be used for products traditionally manufactured from timber and PVC-U and typical applications are:

- Door frames and components
- Window frames and components
- Exterior vertical and horizontal cladding
- Fascias, soffits and barge boards

- Decking, docks and railings
- Dado rails
- Skirting boards
- Stairs and hand rails
- Coving
- Balustrades
- Work tops
- Planking and pre-finished floorboards
- Shelving
- Cable trunking
- Fencing and fence posts.
- Garden furniture and architecture.
- Kitchen cabinets and worktops
- Office furniture
- Sound proofing cladding

10. The future for WPCs

WPCs represent a new era of materials development that combines the old with the new to deliver an exciting new option for the end user. The range of materials being developed is wide and exciting and progress is rapid. The new WPC materials cover a wide range of polymer matrix types as well as a wide range of fillers and stiffeners.

WPC materials reduce costs, increase production rates and offer a wide range of benefits to the end user.

One of the virtuous areas is that the more wood flour that is added, the lower the price of the raw material and also the higher the stiffness of the raw material. Lowering the cost can actually improve the performance.

WPCs are only slowly gaining acceptance in the UK, despite huge commercial success in the USA. Despite research into this area since 1990 the UK plastics industry has largely ignored the development of WPCs. UK plastics processors could well be missing the start of the next generation of materials.

The future for WPCs is bright but it appears that the users will recognise the benefits before the manufacturers.

WPCs are strong, dimensionally stable and moisture resistant.

They also cost less

The future for WPCs is bright