Application Summary Sheet 12

Title: Recycling FRP waste

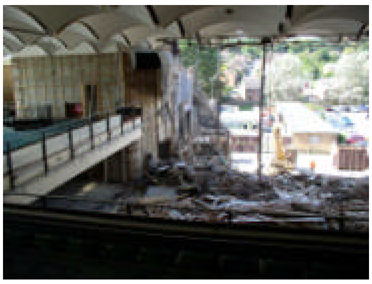
Target Audience: All groups

Keywords:

Overview of application / summary

Fibre reinforced polymer composites (FRPs) are increasingly being used in construction due to their low weight, durability and tailor made properties. The UK composites industry currently produces 240,000 tonnes of composite products a year with 11% of this being for the construction sector. Although widely considered to be un-recyclable, several recycling options have been developed for this material including reintroduction of ground FRP waste into the production process, pyrolysis to generate fuel gas and fluidised bed recovery of glass fibres. Waste FRP has also been used experimentally in the production of wood/plastic composites, road asphalt and concrete. Incineration with energy recovery or in combination with the production of cement is also an option. The main barrier to the uptake of recycling remains lack of market for waste material.

Unlike post consumer waste plastic such as polythene which can be melted and is relatively easy to reprocess, FRP is thermoset and contains a considerable fraction of glass fibre and filler such as calcium carbonate and sand. Polymer composite products are often highly engineered. However, generally, the value of the material constituents and hence any waste or recovered demolition material is low. Composite materials have high strength and stiffness. This is a disadvantage during reprocessing since it means that heavy machinery is required for shredding and grinding. Polymer composite products are also often bulky and lightweight, being engineered sections or profiles, which makes transport of non-ground waste uneconomic. There are no FRP recycling facilities in the UK at present, and the most common disposal method is landfill.



Demolition scrap– all GRP internal roofing went to landfill

Current and impending waste management legislation will put more pressure on the industry to address the options available for dealing with composites waste. EU waste management directives on landfill, incineration, construction and demolition waste, end-of-life vehicles, electrical and electronic equipment, and UK government policy such as the Waste Strategy 2000, the sustainable construction strategy, the landfill tax, and local government policy could all influence the composites industry. Such waste legislation focuses on dealing with waste through the waste hierarchy and will therefore put more pressure on solving fibre reinforced polymer composites waste management through recycling and reuse. The end-of-life vehicle directive is the most significant policy change relating to the use of FRPs and has some bearing on the composite industry concerned with vehicle component manufacture. Although it has no immediate bearing on the construction sector, it could influence attitudes towards composites in purchasing policies and in future legislation. There are often, however, significant technical, environmental, safety and cost benefits in using polymer composite products.

Research:

RRECOM Project – Recycling and Recovery from Composite Materials

The aim of the research was to stimulate growth in the use of thermoset polymer composites through the development of technology for the recycling of scrap material. Two approaches were taken:

1. Brunel University focused on strategies and technology for the re-use of suitably comminuted (ground) thermoset recyclate as a functional filler for polymers leading to products with added value (especially suitable for recycling pure and uncontaminated scrap material). Important factors include reducing the size of the thermoset scrap to a form suitable for incorporation into the host polymer matrix; economics of the comminution procedure; and identification of filler characteristics which may add value to the host matrix by influencing its physical or chemical properties. An integrated process technology was developed to combine necessary functional steps within a unified continuous conversion procedure. Moisture and volatiles were removed during the comminution stage aided by vacuum extraction. The recyclate was combined with the polymer matrix ensuring that effective dispersion and wet-out occurred. A range of polymer compositions were created containing fibre-reinforced polyester and phenolic recyclate derived from industrial scrap. The thermoset recyclate fillers have been successfully incorporated into polypropylene and it is possible to enhance mechanical properties relative to unfilled polymer, especially in the case of phenolic material which has a higher glass content and greater fibre integrity than the polyester waste used. Reinforced phenolic recyclate has been successfully incorporated into polyester resin and it is evident that the presence of this recyclate can increase fire performance (reduction of smoke emission) relative to unfilled polyester resin.

2. The University of Nottingham focused on the use of fluidised bed thermal processing techniques to recover energy and fibres in a form suitable for recycling into high value products (suitable for contaminated and mixed scrap

material from end-of-life applications, e.g. from the automotive industry). Initial investigations were conducted using a typical industrial sheet moulding compound based on polyester resin. The optimum process temperature was 450°C as glass fibres suffer a reduction in strength during processing at higher temperatures. At 450°C the recovered fibres (in the form of short individual filaments) had the same stiffness but 50% of the strength of virgin glass fibres. The fibres were of good quality (purity over 80%) with little surface contamination thus the fluidised bed process effectively cleaned the fibres of the polymer matrix. Two opportunities for reuse of the recovered glass fibres in applications where they could obtain high value were demonstrated. In the production of a glass veil product and as a direct substitute for virgin glass fibre in a thermoset moulding compound. A key aim of the project was to demonstrate that the fluidised bed process was capable of recycling end-of-life components especially those of large volumes that may arise from the automotive industry. A painted car boot lid made from a double skin glass reinforced plastic, based on a polyester resin with a polyurethane foam core and metal inserts was processed in the fluidised bed at 450°C. This mixed and contaminated feed was processed in the same way as the other GRP materials and the recovered glass fibres were no different in quality to fibres recovered when pure composites were processed. The fluidised bed process has also been shown to be able to process scrap carbon fibre composites and yield good quality carbon fibres that are potentially of high value. An economic analysis of the fluidised bed recycling process showed that an operation recycling in excess of 10 000 tonnes per year of glass fibre composite material would enable the process to be commercially viable. These are quantities that do not exist in the UK at present. A carbon fibre recycling plant has the potential to be viable at much lower annual throughputs and may show a more favourable prospect of being viable in the short term.

RECOMP Project - Development of a Novel Recycling Process for the Recovery of Plastic Composite Materials

Reference: British Plastic Federation, Composites Group Management Seminar, London, 15th November 2001

Pera Technology are leading the project management team consisting of representatives from each of the partners together with representatives of the DTI and EPSRC.

The project aims to address the problem of composites recycling by developing a process that combines pyrolysis to liberate the composite components with physical separation processes to achieve recyclable materials in their optimum form. The materials produced will be fully assessed for reuse in a range of applications. The overall aim of this research is to develop a recycling process that will give a commercially viable route towards sustainable manufacture of composite products.

The project and developed technology aim to raise the profile of composites as fully recyclable materials to enable them to continue to bring performance, cost and environmental benefits to a wide range of applications and products.

The final benefit will be a substantial reduction in the quantity of composite waste being disposed of to landfill.

The evolving technology of pyrolysis can be considered to offer a potentially favourable route for the recovery and reuse of both the hydrocarbon and inorganic content of the composites with the capability of producing recovered streams in the optimum condition for reuse. In particular, the process temperature and subsequent separation stage can be tailored to liberate the component materials whilst minimising thermal degradation. It is anticipated that the pyrolysis-based recycle route would be applicable to all composite wastes. The materials recovered will be optimised and their recycling and reuse fully evaluated to achieve viable and sustainable recycle routes with the potential for commercial uptake

'UK Polymer Composites Sector: Foresight Study and Competitive Analysis' – NPL and NetComposites 2001

Reference: Sims G, Bishop, G (2001)

The document details that the overall revenue of the UK composite industry is estimated to be £510 million, against shipments of 240,000 tonnes. Of this 11% of the UK composites finished product tonnages is used by the construction sector. The UK composite industry is forecast to grow at an average of 3.7% per annum to 2005.

Environmental factors are seen to be probably the most critical factor affecting the composites industry, with the issue of recycling having the greatest impact. This is due to the lack of clear, developed recycling routes (logistics, infrastructure and recycling technologies) relative to other materials industries, and the lack of clear end products for recycled composite materials. Legislation on recycling will have a major effect on the use of composites, and in some cases may suppress their use in favour of more easily recyclable materials. Factors affecting the composites industry have been prioritised according to their relative importance and the industry ability to affect them, environmental and regulatory issues were ranked second in this list. The report states that the composites industry should further strengthen its ability to negotiate collectively and centrally with regulators and to provide input into European bodies such as GPRMC (via the BPF) on regulatory aspects. As part of this it was recommended that the industry should develop a primary reference point on recycling issues and should publish validated information on the opportunities for end-of-life reuse and disposal of composites.

In Europe the trend in transportation is towards thermoplastics, almost to the exclusion of thermosets. The end-of-life Vehicle Directive places strong emphasis on recyclability (even at the expense of through-life environmental impact), and it is likely that this will significantly affect the use of thermoset composite components in vehicles.

There is forecast to be a dramatic increase in the number of companies using GMT (glass mat thermoplastic) materials as opposed to SMC (sheet moulding compound) and BMC/DMC (Bulk/dough moulding compound). This reflects the emergence of recycling as an issue for the automotive industry, the major customer for these high-volume processes. Outside of the UK, there is a further trend towards Long-Fibre Reinforced Thermoplastics (LFTs) due to their combination of cost, processability and recyclability. Most of the work in this area is being carried out in Germany and France, and there is little in the UK as yet.

Properties of artificial woods using FRP powder.
Demura K, Ohama Y, Satoh T.
Disposal and Recycling of Organic and Polymeric Construction Materials. Proceedings of the International RILEM Workshop, Tokyo, 26-28 March 1995, p.169-178

The paper details properties of artificial woods and wood-like materials which were manufactured from waste FRP powder. The bulk density of the GRP artificial wood was found higher than that of (alternative) calcium silicate-based wood-like materials. The flexural and compressive strengths were also higher. In addition, the FRP based material could be nailed and sawed like natural wood.

Catalytic Process for the Reclamation of Carbon Fibers from Carbon/Epoxy Composites
Ronald E. Allred, Lincoln D. Busselle, and John M. Shoemaker
Adherent Technologies, Inc.
SPE Annual Recycling Conference 1999
http://www.plasticsresource.com/recycling/ARC99/Allred.htm

Websites:

The UK Polymer Recycling Network
http://www.warwick.ac.uk/atc/materials/recyclecentre/network.html

Society of Plastics Engineers - Plastics Recycling Division
http://www.sperecycling.org/Papers/Papers.htm

Links - Polymer Composites - School4M - University of Nottingham
http://www.nottingham.ac.uk/%7Eeazwww/composite/Links.htm

PERA http://www.pera.com/

CFA Regulatory and Compliance Topics
http://www.cfa-hq.org/regulatory.htm

Products:
Seawolf Industries produce a waste FRP grinder designed to reduce breakage of the glass fibre reinforcement. The ground material is then mixed with a polyester based syntactic foam and the combined material re-applied using a specially designed spray gun.
http://www.seawolfindustries.com/recycle.htm