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*Material and energy
recovery of composite
waste by incineration*

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Material and energy recovery of composite waste by incineration

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Abstract

This report presents a study of combined energy and mechanical recycling from composite waste by incineration. Composite production waste (epoxy-carbon fibre) from the aircraft industry was combusted in a fluidised bed-cleaning unit. The epoxy matrix was volatilised at 450°C and the carbon fibres could be collected. The mechanical properties of the fibres decreased, but process optimisation of the combustion should yield better properties of the fibres. Fluidized bed-cleaning is currently used industrially for the removal of plastic and paint from metal parts. Due to its compact size, this type of equipment could be used by the composite industry for the treatment of composite production waste on site.

Keywords: composite waste, fluidised bed, incineration, recycling

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Contents

	Page
1. Introduction	3
2. Method	3
3. Results	5
4. Conclusion	7
6. Acknowledgements	6
7. References	7

1. Introduction

Recycling of composite materials has been considered to be difficult, due to the complex composition of these materials. High fibre content, various types of fibres and polymer matrices, metallic inserts and their use in very different applications are some factors which make recycling difficult. The composite industry is however forced to search for a viable recycling technology, because of recent legislation actions and customer demands.

There are three possible recycling technologies for polymer composites: mechanical recycling, feedstock recycling and energy recovery. Mechanical recycling by grinding the composite waste has been demonstrated already by several. It is possible to incorporate ground fractions of composite waste in new composite products without sacrifice in properties. Energy recovery of the polymer matrix has as well been demonstrated; in this case the reinforcement will remain as ash, which must be disposed. In feedstock recycling the waste is decomposed to chemical raw materials, which then is used in production of new products. Feedstock recycling of composites has not been demonstrated in a larger scale.

An additional option is a combination of energy recovery and material recycling. This has for example been recently described by the University of Nottingham. (1)

This report presents a study where a combination of energy recovery and mechanical recycling is done. Composite production waste (epoxy-carbon fibre) from the aero industry has been combusted in a fluidised bed-cleaning unit. The used carbon fibre reinforcement could be collected. This type of equipment is currently used for the removal of plastic and paint from metal parts. Due to its compact size this type of equipment could be used by the composite industry for the treatment of composite production waste at the production site.

2. Method

2.1. Materials

Production waste containing epoxy-carbon fibre prepreg and aluminium was used in the combustion trials. This waste was provided by SAAB AB, Sweden, and it consisted of cut trimmings from the manufacturing of sandwich aircraft parts. This type of production waste is typically produced when clean-cutting the edges of the products. The fibre content was 70 wt-%, and the aluminium foil was used as a core material (see Figure 1).

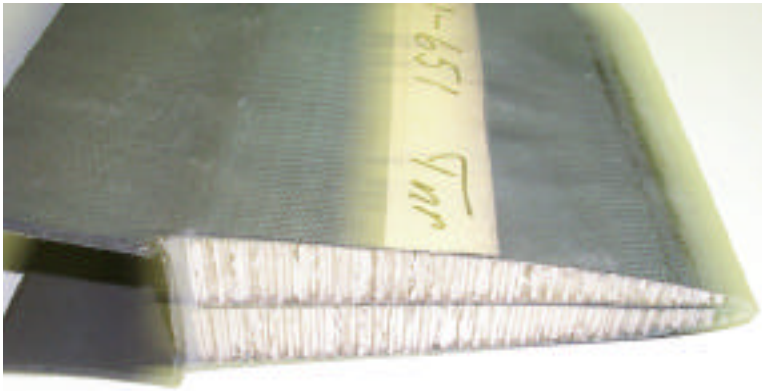


Figure 1. Epoxy-carbon fibre production waste.

2.2. Fluidized bed combustion of composite waste

The composite waste was treated with a SEGHERS fluid Clean B3111 fluidized bed cleaning system. (2) The fluidised bed contains silica sand, and the sand particles are brought into a bubbling state by injecting air from the bottom. A flame shield at the top of the reactor surface directly heats the reactor until the operating temperature is reached. (See Figure 2)

The composite waste was placed into a basket (See Figure 3), which was then submerged into the bubbling sand, preheated to 480°C. Three combustion trials were done, first two for 1 h, and then one for 2 h.

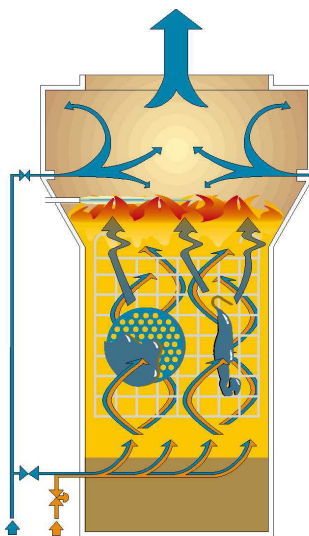


Figure 2. Operating principle for the SEGHERS fluid Clean.



Figure 3. SEGHERS fluid Clean. The composite waste is loaded into the basket, and placed into the fluidised bed.

2.3. Characterization of recycled carbon fibres

The tensile properties of the recycled carbon fibres were determined. Fibre diameter measurement was made by electron microscopy and image analysis. The by combustion received biaxial carbon fibres fabric were manually cleaned.

3. Results

The combustion of the epoxy matrix proceeded easily at 480°C. By weighing the material before and after the combustion, it could be confirmed that all epoxy matrix had been combusted. The remaining fibre was clean, and the fabric structure was still intact. (See Figure 4)



Figure 4. Recovered carbon fibres and aluminium core material.

The SEM analysis shows, that the diameter of the recycled carbon fibre is reduced compared to virgin carbon fibres (from Tenax Fiber GmbH & Co), see Figure 5.

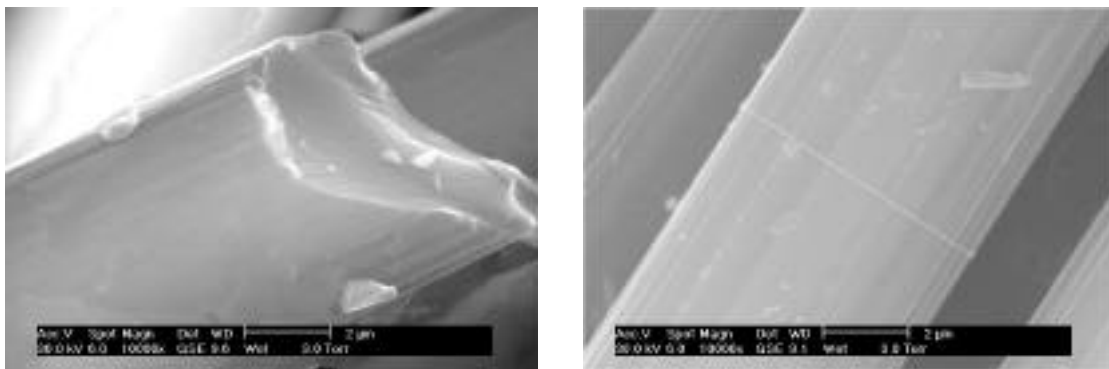


Figure 5. a) E-SEM picture of recycled carbon fibre. b) Virgin carbon fibre.

The diameter decreased from 7 mm for the virgin fibres to 6.5 mm for the recycled fibres. Metal inserts (see Figure 6) remain in the recovered carbon fibre fabric, and these can be a problem when using the recovered fibre.



Figure 6. Recycled carbon fabric with mounting metal pin.

Table 1 shows the tensile properties for the recycled fibres. The measurements were made on 1000 fibres. As expected the tensile properties are decreasing during the recycling process. The density also seems to decrease.

Table 1. Characteristics for carbon fibre before and after recycling.

	Original fibre1)	Recycled fibre
Density (g/cm ²)	1.77	1.4
Tensile strength (MPa)	2765	1300
Tensile modulus (GPa)	167	80
Elongation at break (%)	1.55	2.4
Filament diameter (mm)	7	6.5

1) Data from the fibre supplier.

4. Conclusion

This study shows that it is possible to recover carbon fibres from epoxy-prepreg production waste. A controlled combustion of the epoxy matrix in a fluidised bed, gives carbon fibres possible to use in composite. The mechanical properties of the fibres will however decrease, but process optimisation of the combustion should yield better properties of the fibres.

5. Acknowledgements

This study was done within the VAMP-18 project supported by VINNOVA. Mr Toni Reftman and Mr Johan Persson, Lund University, are acknowledged for the fibre characterization.

6. References

- 1) Pickering, S.J., Kelly, R.M., Kennerley, J.R., Rudd, C.D. and Fenwick, N.J., Composites Science and Technology 60 (2000) 509-523
- 2) <http://www.fluidisedbed.com>