



Composites Recycling Made Easy





we know
THE WORLD OF COMPOSITES



Composite solutions that last

Composite materials provide solutions for mechanical strength and protection in many market segments such as transportation, electrical, building and infrastructure, industrial and energy. These materials have a track record of providing useful benefits including high durability, mechanical performance, design freedom, low weight, and ease of manufacturing.

Composites can be easily recycled. Additionally, composites have demonstrated to often have a better Ecological footprint than traditional materials like steel, aluminium and concrete. This brochure provides an insight into the established recycling routes for composites, and their positive impact on the environment.

Recycling of Composites makes business sense and it is environmentally beneficial

The recycling of glass fibre reinforced thermosets has been studied extensively since many years. Fundamentally, three recycling technologies have been researched and yield potential waste management solutions: material recycling, chemical recycling and co-processing. Co-processing composites through the cement kiln route is considered the best recycling option (Reference: Joint industry position paper on Glass fibre reinforced thermosets: recyclable and compliant with the EU legislation, June 2011, by EuCIA, ECRC, EuPC, Cefic”).

The recycling of glass fibre-based composite regrind through co-processing in cement kilns is proving to be highly cost effective, is generating valuable materials, and is helping to improve the ecological footprint of cement manufacturing. For these reasons, this recycling route is becoming increasingly popular across Europe.

Co-processing is the simultaneous use of composite regrind as raw material and as a source of energy in cement manufacturing, to replace natural mineral resources (material recycling) and fossil fuels such as coal, petroleum and gas (energy recovery). In this process, the composites regrind used for co-processing is both an alternative fuel and raw material (AFR).



Fig.1 : Unloading of windmill blades at processing site
Courtesy: Zajons, Melbeck



Fig.2 : Part storage prior to mechanical treatment
Courtesy: Zajons, Melbeck



Fig.3 : Mobile sawing equipment to reduce transport costs
Courtesy: Zajons, Melbeck



Fig.4 : Typical composite regrind, made from ground windmill blade
Courtesy: Zajons, Melbeck

Composites recycling through Co-Processing: technically possible and cost effective

Glass fibre thermoset composite parts - originating from part manufacturing or end-of-life components - are cut in smaller sections and processed into small chunks. The resulting regrind is combined with other feedstock materials into an input stream with consistent composition and caloric value.

FACTS	BACKGROUND
Composites are recyclable	Recycling through co-processing in cement kilns has been technically and commercially demonstrated. Today, companies are setting up logistics and supply chains for ensuring proper handling of regrind and quality consistency of cement manufacturing. Therefore, recycling through co-processing in cement kilns is increasingly used for managing composite regrind because of its technological potential, environmental benefits and cost effectiveness.
Thermoset composites cannot be easily converted into their original raw materials	Composite materials are designed to provide mechanical strength, chemical resistance, and durability. Consequently, by definition they cannot be easily re-converted into their original raw materials.
Composites can contribute significantly to the reduction of Eco-footprint and CO2 Emissions	Composite structures tend to have a better Eco-footprint compared to their equivalent in traditional materials like steel or aluminium. Reduced emissions through lower weight in transportation, easier installation and reduced maintenance in construction, and continuity of operation in industrial applications all contribute to this great performance. After their useful life saving energy and helping to reduce Eco-footprint in many applications, composite regrind can reduce Eco-footprint and CO2 emissions of cement manufacturing.
Co-processing in cement kilns is clearly different from incineration	Co-processing glass fibre thermoset composites regrind allows the inorganic fraction to act as valuable raw material, while the organic fraction acts as efficient fuel for the calcination process. In the incineration of composite regrind, the inorganic fraction is not re-used, and therefore incineration cannot be considered recycling. In addition the heat generated in incineration cannot be used as efficiently to reduce the amount of fuel required.
Composite recycling through co-processing in cement kilns is compliant with the EU legislation	Recycling through co-processing in cement kilns is fully compliant with the European Waste Framework Directive (WFD) 2008/98/EC providing viable waste management route for the composites industry. Co-processing is both recycling and energy recovery.

Fig. 5 : Facts about Composites Recycling

European recognition for composites recycling

Recently the European Commission released a Guidance document on the interpretation of Waste Framework Directive WFD 2008/98/EC. The document is intended to help national authorities and companies interpret the Directive.

Among other specifications, co-processing in cement manufacturing is included in the definition of waste prevention and of waste-management options, both under recovery and recycling (Chapter 1.4). The Guidance notes that:

"In certain production processes such as co-processing, waste can be used in an operation combining two waste management recovery options at the same time. The energy content of the waste is recovered (R1 operation) as thermal energy, thus substituting fuels, while the mineral fraction of the waste can be integrated (hence recycled) in the matrix of the product or material produced, e.g. cement clinker, steel or aluminium [...]" (Subchapter 1.4.5).

Source: Guidance on the interpretation of key provisions of Directive 2008/98/EC on waste, European Commission, June 2012

Embracing life cycle thinking

The European Composites Industry embraces Life Cycle Thinking (LCT) throughout its value chain with the objective of maintaining a sustainable and competitive business environment for the future.

With the support of the European Composites Industry Association (EuCIA), the composites industry is working towards the use of life cycle assessments to evaluate the environmental benefits of composite materials throughout their life cycle. The concept of Life Cycle Thinking (LCT) integrates existing consumption and production strategies towards a coherent policy making, employing a bundle of life cycle based approaches and tools.

Using LCA as key tool

Life Cycle Assessment (LCA)

is an internationally standardized methodology (ISO 14040 ff) to quantify the environmental pressures related to specific goods and services (products). The LCA results help to understand the environmental benefits, the trade-offs and areas for achieving improvements taking into account the full life-cycle of the product. (Source: European Platform on Life Cycle Assessment (LCA), European Commission)

Carbon Footprint (CF) also named Carbon profile

- is the overall amount of carbon dioxide (CO₂) and other greenhouse gas (GHG) emissions (e.g. methane, nitrous oxide, etc.) associated with a product, along (parts of) its supply-chain and potentially including emissions from use and end-of-life recovery and disposal. The carbon footprint is quantified using indicators such as the Global Warming Potential (GWP). (Source: Joint Research Center, European Commission).

The Ecological Footprint is a measure of how much area of biologically productive land and water an individual, population or activity requires to produce all the resources it consumes and to absorb the waste it generates, using prevailing technology and resource management practices. The Ecological Footprint is usually measured in global hectares. Ecological Footprint is often referred to in short form as Footprint. (Source: Global Footprint Network)

Composites provide a low Carbon Footprint

In January 2012, the Composite industry released an LCA study on parts made from SMC/BMC Light Weight Composites, providing a quantitative assessment of the carbon footprint and Ecological footprint of Composites with other materials. (Source: Study done by European Alliance for SMC/BMC through LCS Life Cycle Simulation GmbH).

A representative composite part (stationary application) made of different materials was evaluated during the LCA, for a useful part life with a life expectation of 30 years. To ensure the quality of the LCA study the results were reviewed by independent experts according to the requirements of International Standards (ISO 14040 and ISO 14044 standards). Some of the key model assumptions are listed in the table below.

KEY MODEL ASSUMPTIONS	
Material types	SMC, Steel, Aluminium
Part type used for modelling	1 m ² panel
Investigated processes (SMC)	Production, forming, recycling
Investigated processes (Steel, Aluminium)	Production, forming (1 step), surface treatment (painting), painting during service life (each 5 years), recycling

MATERIAL COMPARISON	THICKNESS _(mm)	DENSITY _(g/cm³)	WEIGHT _(kg)
SMC	2.25	1.85	4.163
Steel	0.80	7.85	6.280
Aluminium	2.20	2.70	3.240

Reduced Carbon Footprint of Composites

The results have clearly shown that composites can outperform steel and aluminium when it comes to Global Warming Potential (GWP in kg CO₂-equivalent per Functional Unit). The graph below represents the outcome of such calculations.

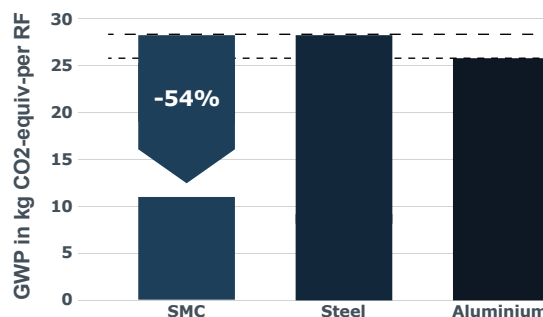


Fig.6 : LCA results for a stationary application with more than 30-yr lifetime warranty, comparing composites with steel and aluminium
Courtesy: European Alliance for SMC/BMC

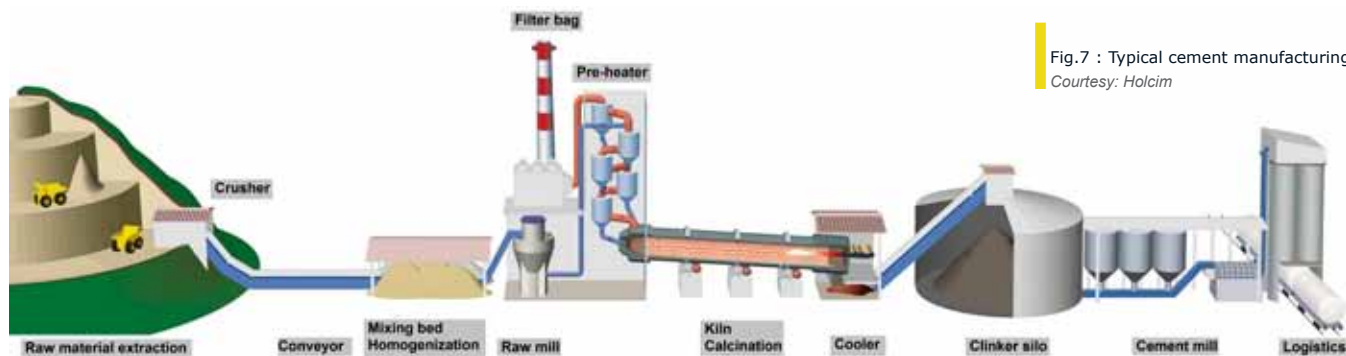


Fig.7 : Typical cement manufacturing process
Courtesy: Holcim

The process of cement manufacturing

In the cement manufacturing process several raw material fractions are combined with an energy source and heated up to 1450 °C for making cement clinkers. The clinkers consist of four basic oxides in a specific proportion: calcium oxide (65%), silicon oxide or silica (20%), aluminium oxide (10%) and iron oxide (5%). Gypsum (calcium sulphate) and possibly additional cementitious compounds (such as blast furnace slag, coal fly ash, natural pozzolanas, etc.) or inert materials (limestone) are added to the clinker. All constituents are ground into a fine and homogenous powder called cement.

By the very nature of this process, a fair amount of CO₂ is generated. The Cement industry has made significant steps to improve sustainability and the carbon footprint by replacing the traditional fuels such as oil, gas and coal with alternative fuels in clinker production.

Glass fibre thermoset regrind is an ideal raw material for cement manufacturing. The mineral composition of the regrind is consistent with the optimum ratio between calcium oxide, silica, and aluminium oxide. Additionally, the organic fraction supplies fuel for the reaction heat, right at the spot where it is needed most.

Life Cycle Assessment of Clinker

Together with the Swiss Federal Institute of Technology (ETH) in Zürich, Switzerland, a detailed LCA model has been developed describing the clinker manufacturing process. The objective was to better understand the improvements that can be made in terms of carbon footprint by replacing the traditional fuels in clinker production.

Key assumptions for this specific case study on composite regrind co-processing in cement manufacturing are listed right.

KLIN TECHNOLOGY

Kiln type	Precalciner
DeNOx installation	SNCR (Selective Non Catalytic Reduction)
Dust filter	E-Precipitator

COMPOSITE RIGRIND CHARACTERISTICS

Calorific Value	15.3 MJ / kg
CO ₂ emission factor	87.4 kg / GJ
Carbon Content	36.6%
Ash content	46.1%
Electricity consumption for waste preparation	0.04 kWh/kg
Transport distance	119 km

FUEL SUBSTITUTED

Coal	26.05 MJ/ kg
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Reduced Carbon Footprint of cement by using composite regrind

By using Composite regrind in co-processing a significant reduction of CO₂ emission of the clinker manufacturing process can be obtained. Depending on the quantity of composite regrind included and the specific cement plant technology, the reduction can be as high as 16 %.

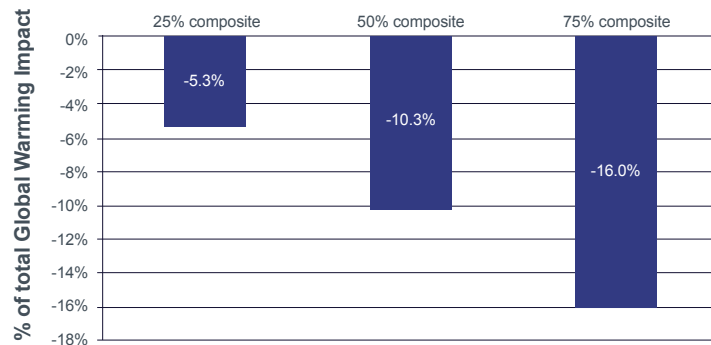


Fig.8 : Reduction of CO₂ footprint for this specific clinker manufacturing plant with glass reinforced composite regrind, in comparison to a process without alternative fuels based on coal as fuel.

Courtesy: Holcim

The transportation of composite regrind from its source to the cement kiln will obviously influence the calculation of the Eco-footprint. Nevertheless, it has been confirmed that the impact of transportation is fairly limited on the total CO₂ footprint of the clinker manufacturing process.

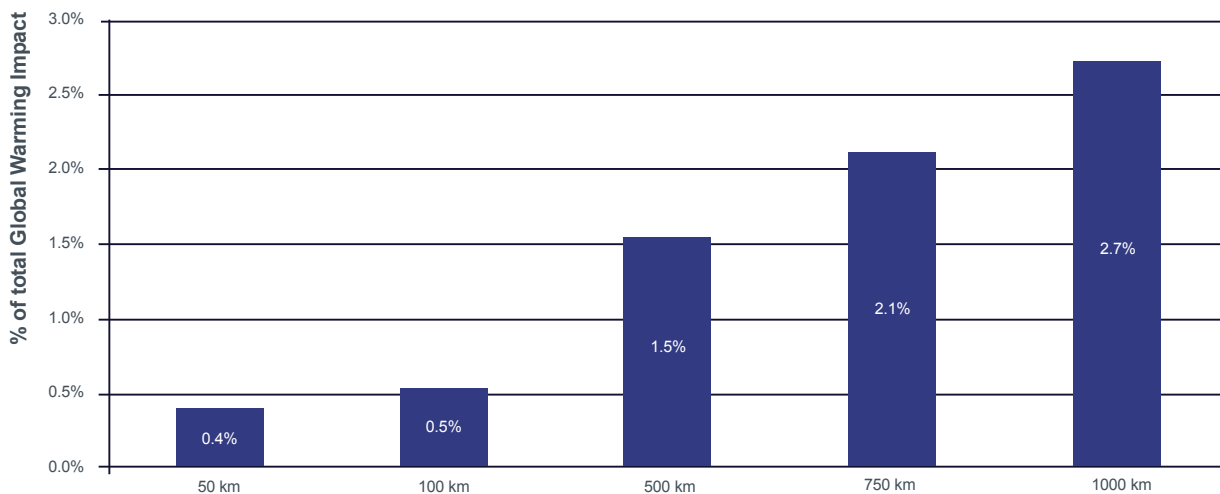


Fig.9 : Contribution of CO₂ footprint associated with composite regrind transportation as a percentage of the total CO₂ footprint for this specific clinker manufacturing plant, as a function of transportation distance.

Courtesy: Holcim

Significant emission reduction through use of glass reinforced composites

0.9 kg CO₂-eq/kg composite

1.8 kg CO₂-eq/kg resin



Fig.10 : Composite recycling in process
Courtesy: Zajons, Melbeck

EuCIA Committed to Sustainability

The European Composites Industry Association (EuCIA) aisbl and its members are committed to making Sustainability an integral part of their business strategy, simultaneously taking care of the environment, society and continued business growth in the composite value chain. The industry provides solutions for reducing carbon emissions in mobility, renewable energy, eco-friendly constructions, and sound waste management practices.

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