Composites Recycling: Market Opportunity Analysis

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Introduction

Recycling of composites waste is the popular demand around the globe by the environmentalist, industrialist and the so called “civic society”. Day by day composites usage is increasing with the excellent market penetration so that the concern for recycling of these materials has also increased. Engineers and researchers are developing ways to recycle these materials. The main issue persists in thermoset composites recycling due to its cross linking (3D Crystalline) structure while thermoplastic composites can be easily recycled by grinding finished parts into small particles and further these particles can be used as a filler with virgin materials, even fed into an injection molding machine and compression molding processes together with virgin thermoplastic composite materials. Contrary to thermoplastic composites, thermoset cannot be reshaped again by heating so that for the recycling, special equipment is required where the reinforcing fibres are separated from the resin and filler part. The glass fibre waste is recycled by cutting it into short fibre lengths and used in thermoplastic composites. Currently available techniques include regrinding, incineration, pyrolysis, solvolysis, catalytic conversion and acid digestion. The incineration and acid digestion techniques are impractical in terms of environmental pollution, whereas incineration by the process destroys valuable amount of carbon and aramid fibres during the burning process and creates pollution, while acid digestion uses harsh chemicals and conditions to dissolve the composites, during this process a mixture of hydrocarbons and acid is formed that needs further processing. The regrinding technique is very popular due to its low cost and low technical inputs; basically it is a secondary recycling process in which composite waste is ground to suitable sizes to be reused as fillers. For thermoplastic composites, the resulting materials are used in injection molding and compression molding processes whereas for the thermoset composites the resultant recycled materials are used as fillers for SMC, bulk molding, or reinforced concrete. Developmental work on the recycling of reaction injection molded (RIM) polyurethane automotive scrap parts shows that the ground RIM parts can be used as filler in other molding processes. A study by Owens-Corning Fiberglass on the recycling of SMC composites demonstrates that the milled and ground SMC powder can be used as fillers and reinforcements in BMC and thermoplastic polyolefin molding compounds. By the industry point of view, pyrolysis is more acceptable technique (tertiary recycling process) where thermoset composites is thermally decomposed at elevated temperatures in the absence of oxygen, during this process

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fibres are separated from composites waste and reused as fillers or reinforcements.

The active step has been taken by the USA and European countries but Asia-Pacific is lagging behind, exceptionally Japan is doing a tremendous Job. Below, prominent associations/ organizations are mentioned which leads to research and development (R&D) and the market for the composites recycling.

Aircraft Fleet Recycling Association/ AFRA (Washington, DC, USA)

It was founded in 2005, and now has 41 active members within the aircraft industry. The Best Management Practices guides and an accreditation path have been developed by the organization for more effective, safe and green aircraft dismantlement, parts recovery, and materials recycling. It has member companies in 10 different countries which currently scrap an estimated 30% of the world's end-of-life fleet aircraft.

The Boeing Co (Chicago, Illinois, USA)

Boeing has commitment to boost the amount of recycled aircraft material from 70% today to 90% by 2016. The company began CFRP recycling from retired F-18A military planes in 2005, carried this through 777 composite components and even used 787 pre-production scrap from a fuselage test article to prototype a seat arm rest and composite lay-up tool. Among Aircraft Fleet Recycling Association (AFRA) members that Boeing has worked with directly in developing CFRP recycling technologies, there are Milled Carbon/Recycled Carbon Fibre, Adherent Technologies, and the University of Nottingham.

Airbus Industries (Toulousse, France)

It has mission to enhance the eco-efficiency of new aircraft so that 85-95% of components and materials could be recycled, reused or recovered, and to establish new standards for green management in the disposal of end-of-life aircraft. For the carbon fibre recycling, Airbus is working with CFK-Valley Stade Recycling GmbH & Co KG of Stade, Germany to develop a 1000 ton/year pyrolysis-based recycling plant from both CFRP manufacturing scrap and decommissioned Airbus aircraft.

University of Nottingham (UK)

The University of Nottingham is engaged in carbon fibre recycling research and development (R&D) work particularly in the fluidized bed process and more recently, involving supercritical fluids such as propanol. Researchers have created nonwoven mats with CFRP recyclate as they are developing a convergent flow slurry process to enhance fibre alignment and achieve higher fibre volumes.

The European Composites Recycling Services Company (ECRC, Europe)

Behind this company (founded in 2003), there was a joint vision and afford by number of key players in the composites industry, including Inoplast, MCI (formerly Menzolit-Fibron), Owens Corning, Vetrotex, Johns Manville, Reichhold, DSM, Polynt (formerly Lonza) and the European Composites Industry Association (EuCIA). Its mission is to provide cost effective recycling solutions that will enable the composites industry to meet its environmental responsibilities and initial focus will meet the demands of the recently implemented European Union (EU) Directive on end-of-life vehicles (ELV).

Recycled Carbon Fibre Ltd (RCF, West Midlands, UK)

It is formed by the Milled Carbon Limited's technical assistance and started first commercial operations in October 2008, truly first commercial carbon fibre recycler (producer), with current capacity for recycling CFRP scrap at 1200 ton/per year.

Rationale for Composites Recycling

The largest market for composite consumption is automotive, construction, wind energy, and aerospace & defense industry and simultaneously year on year the penetration of composites continues grows with every new model products. The automotive industry is one of the largest users of composites today whereas in wind energy the turbine size is growing, so more amount of materials needed for the blades. For example, a 7.5 megawatt (MW) turbine would translate into 75 tons of blade material. Currently, modern turbines are 100 times the size of those in 1980 as well as rotor diameters have increased eight-fold, with turbine blades surpassing 60 m in length. The aerospace and defense industry has also the same scenario as the uses of composites is increasing from 10% to 50% in such as Boeing 787 and Airbus 380 models.

It is predicated that all above end products (Wind, aerospace & defense, construction) to have a lifecycle of around 25-30 years. The question is what to do with them afterwards. We will have only three possible routes: landfill, incineration or recycling. The first option is largely on its way out with countries seeking to reduce landfill mass. Germany, for example, introduced a landfill disposal ban on glass fibre reinforced plastics (GRP) in June 2005, due to their high (30%) organics content such as resin and wood. The most common route is incineration, but it has limitations due to the presence of inorganic loads in composites and 60% of the scrap left behind as ash which may be pollutant and inorganic loads also lead to the emission of hazardous flue gasses in that the small glass fibre spares may cause problems to the flue gas cleaning steps, mainly at the dust filter devices. It is forecasted that from 2040, 380,000 tons of fibre composites will have to be disposed of each year:

It is predicted that by 2034, around 225,000 tons of rotor blade material are up to be recycled per year worldwide. It is estimated that in USA 3000 tons of carbon fibre composite (CFRP) scrap generated annually and in Europe, some 6000 to 8000 commercial planes expected to reach end-of-life dismantlement by 2030, and the production of virgin carbon fibre (VCF) on the rise toward 100 000-plus tons annually by 2018.

In European Union (EU) directive on end-of-life vehicles (ELV) is implemented which states that vehicles must have a minimal impact on the environment at the end of their usable life. End-of-life vehicles generate around 9 million tons of waste each year so reuse, recovery and recycling are important issues. As of January 2006, this legislation has required that 80% of the vehicle weight must be reused and recycled, and this figure will increase to 85% by 2015.

Companies, including airframers and other original equipment manufacturers (OEMs), are seeking alternatives to present landfill and incineration practices. There are even signs of an emerging disposal supply chain. The only alternative is recycling either mechanical recycling or thermal recycling in the form of reuse of composite materials. The composite recycling is going to become more important not only for environmental reasons, but also for economic reasons. It will bridge the demand and supply gap of carbon fibre materials. On the other hand, global warming, carbon footprint issue, land filling, incineration, municipality solid waste

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(MSW), and environmental issues can be solved by the composites waste recycling in a unique way.

Key drivers for recycling of composites waste:

- High scrap levels in excess of 40%
- Carbon footprint issue
- Green house gas emissions
- Booming wind energy industry
- Approx 6000 to 8000 commercial planes expected to reach end-of-life dismantlement by 2030
- New environmental legislation

Challenges for recycling of composites waste:

- Finding volume markets for the composites recyclate
- Proper supply of composites waste
- Feasibility and economically viable
- Low cost research and development (R&D)

Applications

The recycled composite materials are used in various applications and having good industrial demand. It is obvious that recycled composites materials possess low quality compared to virgin materials but higher mechanical properties can be optimized with addition of additives and other chemicals. If we talk about carbon fibre recyclate it retains 90% or higher properties compared to virgin carbon fibres and even enhanced surface properties and electrical properties.

Product forms include chopped, milled and pelletised fibres, CFRP recyclate are used in antistatic flooring, industrial paints, cement, conducting polymers, fuel cells, consumer goods, industrial paints, non-woven, road surfacing, EMI shielding, industrial coatings, flotation devices, wooden and metal frames, high temperature insulation, rubber reinforcement and tooling moulds. The breakdown products of the resin can be recycled into glue for the production of plywood.

Recycled composite materials are used in an additive market as filler with injection molding, compression molding, SMC and BMC techniques. Processors and OEMs can use a proportion of recyclate as filler or reinforcement in their new products, thereby reducing their input costs as well as satisfying environmental objectives.

Market Analysis

From the market prospects, the recycling of glass fibre is not viable due to its low cost (<$1/lbs) and ample supply of virgin glass fibre materials but recycled carbon fibre has decent demand in market and economically viable so that here we are considering only recycled carbon fibre composite materials' market demand. There are two growth drivers for the recycled carbon fibres, firstly is demand and supply gap for the virgin carbon fibres whereas It is predicated that its market to be 100,000 plus tons annually by 2018, secondly is lower price ($ 5/lbs) comparison to the higher ($10-15/lbs) of virgin carbon fibres.

The carbon fibre recyclate that retains 90% or higher properties even enhanced surface properties and electrical properties compared to virgin carbon fibres on the consideration that 50% of CFRP manufacturing waste comes from woven prepreg generated during pattern cutting. This fabric waste can arrive at a recycler in forms ranging from a fresh, tacky entangled material to a hard, compressed bale of overaged and cured scrap.

The current (In 2009-2010) market value for recycled cabon fibre is $25 million with a potential value of $ 54 million by 2016 with 17 % compounded annual growth rate. The Europe retains number one user (62% by market value) including highest market growth in Germany, France and UK, while USA keeps second position (37% by market value) and rest is Asia-Pacific region (1%) which makes Japan as a leading foray.

Above all, Aircraft OEMs play a critical role in making CFRP recycling viable, as do government agencies, industry organizations, and universities in enhancing R&D and project cost sharing. The composites waste producer (Fabricator/Molder) and recycler should go hand in hand and establish a good co-ordination for the making of composites recycling business as a profitable venture.

Conclusion

The composites recycling is in demand due to too much dismantling of aerospace and defense products, turbine blades, automotive products and others. The pending legislation in Europe to ban landfill disposal of composites will have significant impact in the next 3-5 years. Companies in the airplane maintenance and end-of-service business sectors (especially in Europe and Japan) are going to adopt recycling method in spite of landfill and incineration processes.

The composite recycling is going to become more important not only for environmental reasons, but also for economic reasons. It will bridge the demand and supply gap of carbon fibre materials. On the other hand global warming, carbon footprint issue, land filling, incineration, municipality solid waste (MSW), and environmental issues can be solved by the composites recycling in a unique way.

The composite recycling is not free from challenges including consistent scrap availability, process parameters, infrastructure for secondary operations such as material collection at a manufacturer's site, and eventually, creation of standardized recyclate product properties. No doubt, development of a CFRP recycling industry is in its infancy and expensive but in the next 3-5 years it is going to be in a commendable position.

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