Management, recycling and reuse of waste composites

Part 1: Management of waste composites

- An introduction to composite recycling

→ The resin chemistry employed in polymer matrix composite materials can be divided into two types, thermoplastic and thermosetting.

↳ Composite material types

Moulage par injection (injection moulding) →
- short fibre reinforced TP injection moulding grades
- Bulk moulding compound or dough moulding compound

Moulage par compression (compression moulding) →
- Sheet moulding compound
- Glass mat TP (GMT)
- Long fibre technology (LFT)

Traitement stratifié (laminate processing) →
- Hand lay up
- RTM
- Vacuum RTM
- Pre-preg material vacuum bagging or autoclave

↳ Technical suitability

Waste type : two types of waste → post-industrial and post-consumers

Typically, post-industrial recycling can be done in-line with an existing ongoing production process - an example could be the introduction of TP LFT moulded component waste off-cuts back into a continuous direct extrusion/compression process for re-extrusion. End of life waste is obviously difficult to assure in terms of age, usage, history and contamination.

Recoverability: of the composite material within a given component, to resin recovery and fiber recovery → Nowaday, integration path is followed without consideration towards design for disassemble ⇒ these present a significant challenge to a prospective dismantler. Resin recovery from heavily glass filled materials such as SMC is very difficult. Fibre recovery can be much simpler, particulary for glass and carbon fibres, but here the limit can be recyclate market demand.

Contamination -> This is a major issue for general plastic recycling, for composite materials, this is less so, owing to the fewer material options and grade available.

Reliable feedstock -> they are still relatively niche compared with mainstream materials. This is exacerbated by the long lifetime of these materials in operation => this could create an unreliable feedstock for long term planning.

↳ Financial suitability -> Governments are able to stimulate markets by legislative means i.e. subsidies or penalties. Moreover, recycling plant, infrastructure(...) require a large amount of initial investment => Capital investment can take the form of assistance from local or national government or direct investment from industry
Material costs often driving the value of the resultant recyclate. Indeed, materials with a high initial raw material value often have a strong economic driver for recycling as long as there is potential for a high value recyclate product, even if the re-processing costs are high.
↳ Confidence, supply and demand on the markets and legislation also have a strong impact on recycling.

↳ Recycling methods

Landfill disposal (discharge): once a material is destined for landfill it is considered to be of no value. Furthermore, this option is growing politically less favourable. On the bright side, the low volumes of composites uses => very small volumes of landfill waste.

Incineration: when combined with energy recovery, incineration can be viewed as a recycling technique which are dependant on the composite's composition => High glass filled materials with large inorganic filler content as SMC contain very little inflammable material and will burn poorly and will be therefore of little value. Other materials, such as those with an flammable thermoplastic matrix will burn readily and have a large calorific value.

Chemical techniques: either chemical de-polymerisation of the matrix into oils which also frees the fibres for futher recycling, or chemical removal of the matrix which also free up high value fibres, such as carbon. Techniques in the dvlp stage and hardly employed

Thermomechanical processes: the most widely used to re-process both composites and other materials. Generally confined to TP, plants performing TP reprocessing are able to re-process other thermoplastic materials, which increases throughput volumes and therefore significantly improves the eco. viability of the business.

Mechanical processes: low value option that can be employed in the case of materials where no recycling use approches exist other than disposal. Materials such as highly filled thermosetting composites can be ground and use as filler in virgin materials (ex: 25% of SMC regrind could be introduced into new SMC/BMC formulations without any performance penalty).

Biomaterials: TP natural fibre composites can be thermomechanically reprocessed in the same way as other TP composites. Both TP and TS natural fibre composites are attractive for incineration with energy recovery due to their lack of inorganic content - they are combustible in their entirety. Using certain biopolymers in conjuction with natural fibres can result in a completely biodegradable composite material system. These biomaterials would be suitable for end of life composite material system. These biomaterials would be suitable for end-of-life composting, given the correct environmental conditions (European Bioplastics organisation, 2008)