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RETRACKING
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RETRACKING PROJECT

Verso l'economia circolare: tracciabilità dei manufatti in Compositi Fibro Rinforzati

Krožni ekonomiji naproti: sledljivost izdelkov iz kompozitov, ojačanih s steklenimi vlakni

Towards the Circular Economy: The Traceability of Fibre Reinforced Composite Products

Catalogo dei rifiuti dell'area di programma / Katalog odpadkov programskega območja

The Waste Catalogue of the Programme Area

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1. Introduction

The main objective of this deliverable is to develop an unique catalogue of glass fibre reinforced composite (FRC) products / wastes for the purpose of better identification and waste management of these products / waste in programme area. Catalogue is mainly intended to waste holders (general public, industry) as well as waste collectors, e.g. utility services, in order to appropriately separate and collect FRC based wastes for better recycling.

With such catalogue it is expected that better management routes for FRC waste will be established towards their recycling in programme area.

2. Identification of FRC based products / wastes

2.1. General characteristics of FRC products and FRC waste formation

Fibre reinforced composites (FRC), also called fibre reinforced polymer or fibre reinforced plastic, is a composite material made of polymer matric reinforced with different types of fibres (glass, carbon, aramid, natural fibres…). In the present catalogue, focus is given to glass fibre reinforced composites, for which FRC acronym is used. FRC products are usually used in marine, construction, automotive and other industries. Their main advantages are increased strength, but at the same time relative light and thin structure. Such products are also relatively easy to manufacture and can be shaped in variety of different shapes.

The annual production of FRC in Europe is around 1.1 ktones (Figure 1). Geographically Germany is the largest producer of FRC, followed by Eastern Europe, France, Ireland and the UK, Italy, Portugal and Spain. Trends for the future are expected to grow in already existing markets as well as new markets and as such FRC industry remains important employer in Europe. On the other hand, FRC based waste, is difficult to recycle due to their multiphase nature therefore the end-of-life challenge of FRC is remaining important environmental issue in Europe.

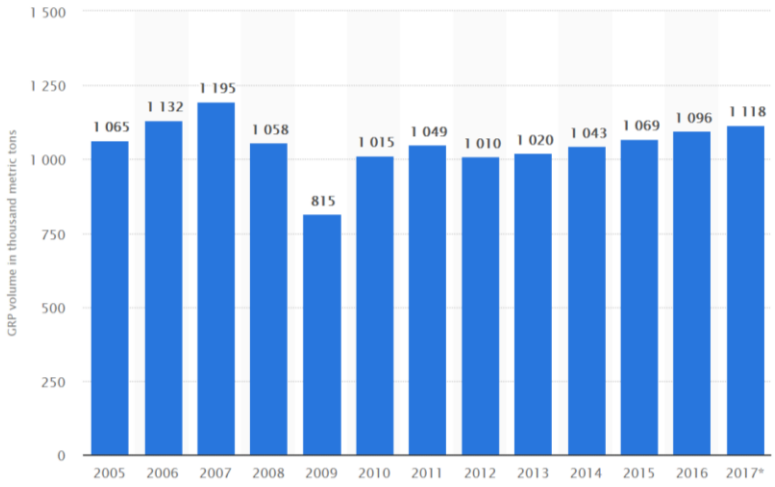


Figure 1: Production volume of FRC in Europe from 2005 to 2015 (in 1,000 metric tons) (source: www.statista.com).

2.2. Forming of the FRC based products

The most important forming processes of fibre reinforced composites (FRC), including glass fibre reinforced composites, sometimes also called glass reinforced plastics (GFP), are presented below. We described the forming principles and their applicability. It is worth to mention that fibre reinforced composites forming is wide range set of technologies. They could be complementary or very distinguishing.

The most common and probably the oldest forming process is so called "Hand lay-up" (Figure 2). Hand Lay-up starts with the fibreglass fabrics is manually laid and wet with resin in mould coated with releasing agent. After curing the product is extracted from a mould. Hand Lay-up is widely used for small series products or for large products of complicated shapes.

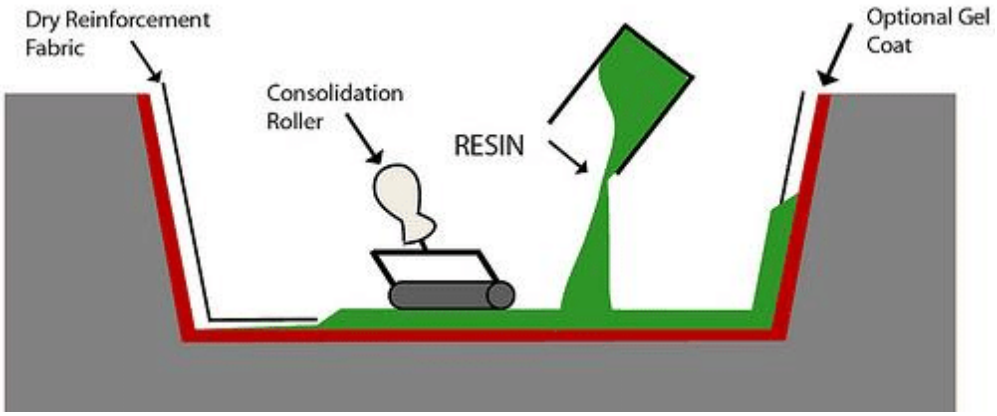


Figure 2: A simplified sketch of Hand lay-up forming process of FRC production (source: Vadivelvivek 2013)

As Hand Lay-up process, which is employed for at least 50 years, has been upgraded with addition of new production phases which assure the better properties of final products FRC composites, i.e. vacuum bag and autoclave moulding (Figure 3).

Figure 3: Types of FRC forming processes. Left: Vacuum bag moulding of FRC products (source: www.reynoldsam.com). Right: An example of autoclave moulding (source: www.reinforcedplastics.com)

"Vacuum bag moulding" is a process where the atmosphere pressure is exploited to secure contact with the mould and to expel air during curing. The sheets of fiberglass fabrics are laid-up and placed in an open mould. The material is covered with release film, breather material to enable flow of the resin over the product and the vacuum bag. The lay-up is

cured with a continuous vacuum to extract entrapped gasses from laminate. This is a very common process in the boat and aerospace industries as it enables precise control over moulding due to a slow cure cycle that is anywhere from one to several hours. The process assures the forming of high quality products, but it is also slow and labour-intensive.

Another step forward presents "Autoclave moulding". For further product improvement, beside vacuum, also the external pressure for curing is applied. After evacuating the bag in a pressure vessel, an overpressure of typically 1,5 MPa is generated. Even though process is refinement of the Vacuum bag moulding, its application can be limited by the size of the pressure vessel.

Presented processes have in common a lot of manual work especially the lay-up. However the "Filament winding" (Figure 4) is mainly machined process. The filament winder take care for winding the resin impregnated continuous fabrics or fibres onto the mandrel in specific orientations. The mandrel is often of circular cross section and two main types of winding orientations - helical and polar are often applied. Products are often cured at room temperature. After curing the mandrel is usually extracted, leaving a final product. Such processing is suitable for the production of large, constant cross section products like pipes with diameters of above 3 m.

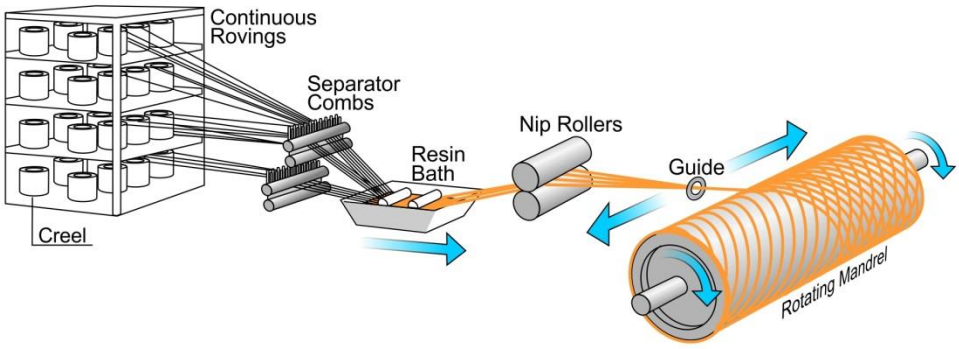


Figure 4: Schematic presentation of filament winding process in FRC production (Source: www.nuplex.com).

For the production of small parts reinforced with chopped fibers and of close tolerances the "Resin infusion" (Figure 5) is applied. Forming starts with the fiberglass fabrics assembled, preformed and closed in a mould into which the resin is injected. Such formation proceeds at elevated temperature and pressure between the matching male and female dies.

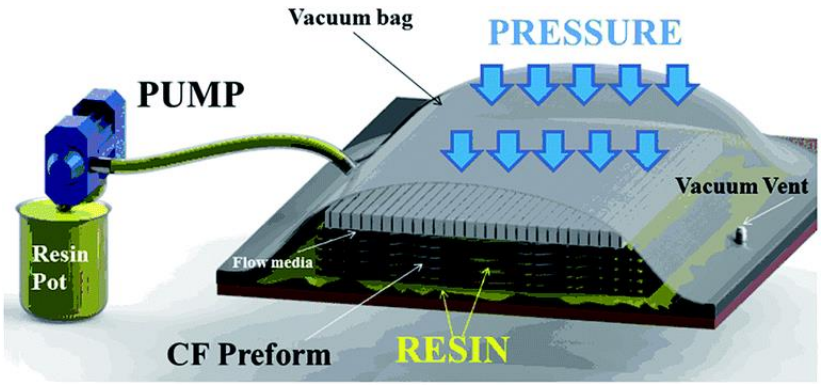


Figure 5: An example of resin infusion production of FRC (source: Guadagno et al. 2015)

Opposing to the all as presented batch processes, the “Poltrusion” (Figure 6) is continuous process. Fibre bundles and / or fabrics are wet with resin in a bath and extruded from a heated closed die curing while being continuously pulled through die forming the rough part shape. The poltrusion is very efficient process of production anisotropic, constant cross-section components. Poltrusion is employed for creation of various products like ladders, handrail systems tank, pipes, etc.

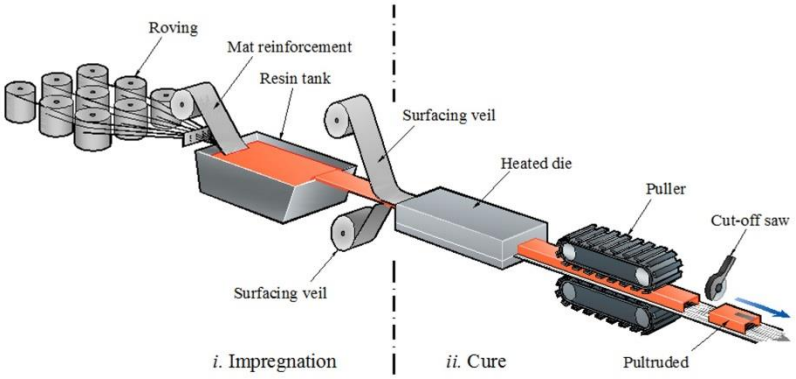


Figure 6: Schematic presentation of pultrusion process of FRC production (Source: Landesmann et al. 2015).

Finally, it is also worth to mention the “Chopper gun lay-up” process (Figure 7) of FRC production. Here the fibreglass bundles are pushed through a hand-held gun that both chops the strands and wet them with resin. The wetted fibres are shot onto the arbitrary shaped mould surface. The thickness of the lay-up is controlled by the human operator. This process is applicable for large products like vessels and it is also cost effective. On the other hand such products have poor dimensional tolerance.

Figure 7: Example of Chopper gun lay-up process usually used for reinforcing of large FRC products, like vessels.

Presented fibre reinforced composite forming processes are just a small part of suitable processes, which are not all applicable to all products. Some processes can be also easily combined and adapted to the new.

2.3. How do we identify FRC based waste?

For the reliable identification of the glass FRC or any other plastics, the complex analytical technics as Infrared Spectroscopy (FTIR), Raman Spectroscopy, UV-vis spectroscopy, Differential Scanning Calorimetry (DSC) and others shall be employed. However, for the purpose of initial identification and knowledge building an overview of basic FRC characteristics and ways of identification are given.

Most typical physical characteristic of FRC is its substantial density, i.e. around 1.8 g/cm^3, which is considerable more as most of other plastic (PE, PP, PC, PMMA, ABS,…) which all tapping at about 1 g/cm^3. Further on, the FRC products are often laminated. Lamination as production technology enable us the production of huge products like pipes (Figure 8) with diameters of 3 cm, but on the other hand the surface of such products is uneven - matt. The most visual characteristic of FRC is presence of fibres of different lengths. Figures 8 and 9 presents two typical surfaces of FRC products obtained with camera under the daylight conditions with visible fibres. Figure 10 represents an scanning electron microscope (SEM) image, captured at relative low magnification.

Further, in some cases the FRC products can be distinguished from majority of other plastic, due to their specific translucency. In Figure 8, stack of FRC pipes are presented and one can easily observe their translucency, especially for pipes on the top of the stack as they are directly exposed to the sunlight.

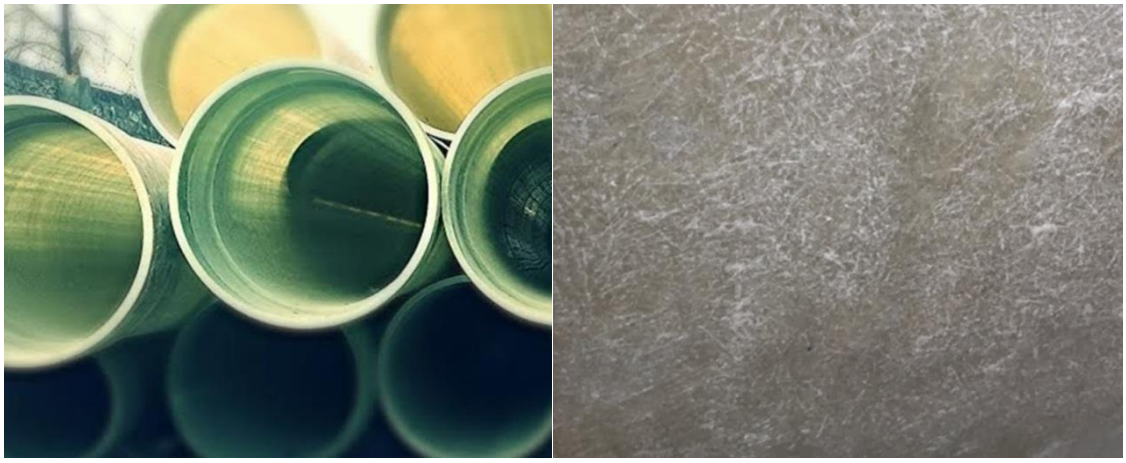


Figure 8: An example of FRC product. Left: the stack of the FRC pipes. Right: Detail view of the pipe surface (Photo: J. Bernard).

Figure 9: An example of FRC product. Left: Slide. Right: Detail view of the slide's back surface (Photo: A. Mauko Pranjić).

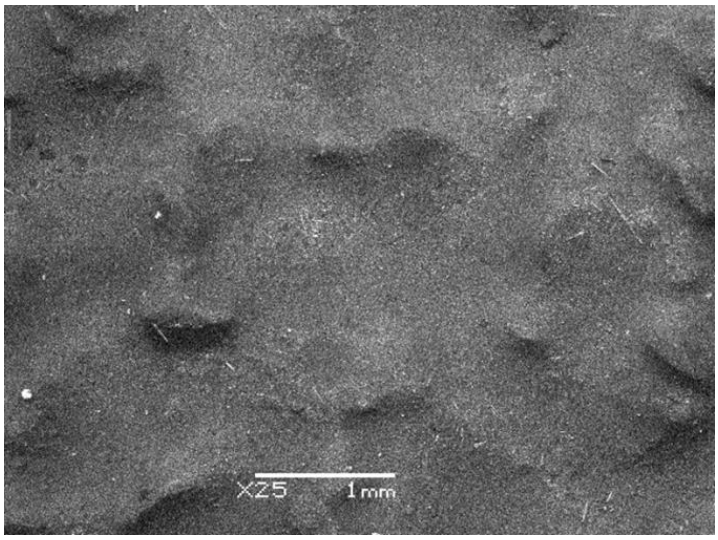


Figure 10: Surfaces of FRC pipe obtained with Scanning Electron Microscope under 25x magnification (Photo: J. Bernard).

3. FRC Based Waste Catalogue

3.1. Methodology

Typical FRC based wastes are divided in the catalogue according to the type of products, where they are expected to form and according to the unique waste qualification number. This is not official waste classification but classification developed based on later state of the art and best knowledge of the project participants. FRC based wastes which might be classified under hazardous wastes are excluded from catalogue.

Name	Picture	Waste number	Short description of waste
Waste group 12 WASTES FROM SHAPING AND PHYSICAL AND MECHANICAL SURFACE TREATMENT OF METALS AND PLASTIC			
FRC plastics shavings and turnings		12 01 05	Remainings of FRC from production in the form of shaving, turnings and other processes

Name	Picture	Waste number	Short description of waste
Waste group 15 WASTE PACKAGING; ABSORBENTS, WIPING CLOTHS, FILTER MATERIALS AND PROTECTIVE CLOTHING NOT OTHERWISE SPECIFIED			
Composite packaging		15 01 05	Remainings of packaging. It is forseen that FRC based packaging can also be found in other subgroups of group 15.
Pallets		15 01 05	Waste FRC pallets, used for transportation of different products.

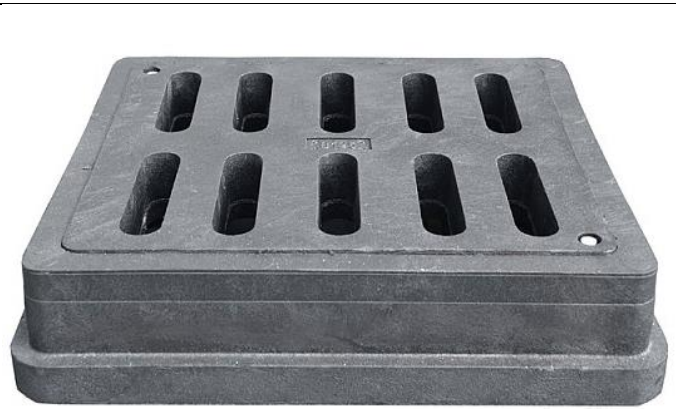
Name	Picture	Waste number	Short description of waste
Liquid tanks		15 01 05	Waste transport tanks for different types of liquids.
Waste group 17 CONSTRUCTION AND DEMOLITION WASTES (INCLUDING EXCAVATED SOIL FROM CONTAMINATED SITES)			
Pipes		17 02 03	Different types of end of life pipes.

Name	Picture	Waste number	Short description of waste
Water reservoirs		17 02 0 3	Different types of obsolete water reservoirs, including waste water reservoirs, water treatment reservoirs etc.
Plastic roofing and fencing		17 02 03	Waste FRC roofing plates, roofing tiles, FRC fencing.

Name	Picture	Waste number	Short description of waste
Anti-noise wals		17 02 03	Different elements of waste anti-noise walls
Floorings		17 02 03	Waste flooring panels made of FRC, usually used for exterior.

Name	Picture	Waste number	Short description of waste
Fibre reinforced adhesive tapes		17 02 03	Waste FRC adhesive tapes.
Bathroom and kitchen sinks, baths		17 02 03	Waste FRC kitchen sinks, vanity tops, baths and other similar products.

Name	Picture	Waste number	Short description of waste
FRC reinforcement for concrete		17 02 03	Waste FRC reinforcement for concrete, used instead of steal reinforcements.
Support for raised or suspended floors/ceilings		17 02 03	Waste FRC carriers, supporters for raised and suspended floors/ceilings.

Name	Picture	Waste number	Short description of waste
Sewage /pavement grittings		17 02 03	Waste gritting as part of sewage system, pavement and similar products.
Traffic signs and equipment for signalization		17 02 03	Waste traffic signs and different equipment for signalization.

Name	Picture	Waste number	Short description of waste
Group 19 WASTES FROM WASTE MANAGEMENT FACILITIES, OFF-SITE WASTE WATER TREATMENT PLANTS AND THE PREPARATION OF WATER INTENDED FOR HUMAN CONSUMPTION AND WATER FOR INDUSTRIAL USE			
Water, sewage reservoirs		17 02 03	Different types of obsolete water reservoirs, including waste water reservoirs, water treatment reservoirs etc.

Name	Picture	Waste number	Short description of waste
Group 20 MUNICIPAL WASTES (HOUSEHOLD WASTE AND SIMILAR COMMERCIAL, INDUSTRIAL AND INSTITUTIONAL WASTES) INCLUDING SEPARATELY COLLECTED FRACTIONS			
Sport equipment		20 01 39	Waste sport equipment e.g. obsolete skies, tennis rackets…
Obsolete boats		20 01 39	Obsolete vessels, boats, part of boats.

Name	Picture	Waste number	Short description of waste
Car trunks		20 01 39	Obsolete trunks
Slides and other equipment for children and sport playgrounds		20 01 39	Different articles and equipment for children and sport playgrounds.

Name	Picture	Waste number	Short description of waste
Swimming pools		20 01 39	Obsolete swimming pools and other equipment.
FR hoses		20 01 39	FRC hoses for irrigation and other obsolete irrigation products.

Name	Picture	Waste number	Short description of waste
Containers for agriculture and households		20 01 39	Tanks, vats and similar equipment used in different agricultural fields and households.

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