Pearson BTEC Levels 4 Higher Nationals in Engineering (RQF)

Unit 14: Production Engineering for Manufacture

Unit Workbook 2

in a series of 4 for this unit

Learning Outcome 2

Production Processes

In this we will use the terms “casts” and dies”, both do the same job, as something that is used to make the shape of the product, however, a cast will typically be made of sand, as they are designed to produce one product before being destroyed, whereas a die is more permanent and will not perish.

When considering the processes that are available to create a product, we need to consider a number of factors:

- Is the process suitable for the material we are using?
- Is the lead time for the product suitable for the volume we are producing (i.e. are we spending too much for a small volume of products?)
- Will it produce a high-quality product, as is it necessary to have the highest quality product for the application?
- How much material will the product waste, and can this waste be recycled?

We will first discuss the manufacturing techniques that are involved in creating a product, including how you can attach them together in assembly. We will then discuss how we choose the best method for the product we want to make.

2.1 Ceramic Manufacturing Processes:

Theory Ceramics are one of the largest groups of materials, they have the properties of non-metals and are made by firing or burning. In terms of their starting materials, ceramics are cheap. Their electrical, magnetic properties are valuable to the electronics industry. Relative to metals, ceramics are lightweight and can retain their strength up to $1000^{\circ}C$, whereas most metals would be significantly weaker.

2.1.1 Powdered Sintering

Sintering is a process where the ceramic is heated until it almost reaches the melting point. This helps to eliminate any pores and voids in the ceramic, the ceramic is then cooled. If there are any large voids in the ceramic that sintering has not eliminated, the product will be very fragile and will probably collapse when handled. Sintering is typically used to create products in high volumes, as it is quick and easy process.

2.1.2 Hot pressing

Similar to sintering, but this also incorporates the application of high pressures, this is only useful for simple shapes and gives a rough surface finish which will need to be corrected by diamond grinding.

2.1.3 Chemical Vapour Deposition

Chemical vapour deposition (CVD) is the result of the chemical reaction of a gas on a heated substrate, the reaction leaves a ceramic deposit, this method is typically used to produce freestanding thick-walled structures.

2.1.4 Reaction Bonding

Reaction bonding (or reaction sintering) is a means of producing dense covalent ceramics. It is usually for silicon-based ceramics such as reaction-bonded silicon nitride or reaction bonded silicon carbide. Silicon nitride is made from silicon powders that are already shaped, they are then put in a furnace reaching $1{,}200^{\circ}C$ in a nitrogen/hydrogen or nitrogen/helium atmosphere. The nitrogen permeates and gets inside the pores to react with the silicon to form silicon-nitride. The piece is then heated to $1{,}400^{\circ}C$, which is just below the

2.2 Composite Manufacturing Processes

Theory Composites are lightweight and advanced non-metal materials. A composite is built up in layers of fibres bonded together with a resin (or "matrix"), for a stronger composite, you can change the material of the fibres. and bonding resin, or you can change the direction the layers of fibre are placed. The most common point of failure in composites is grains along the fibre, by adding fibres facing a different direction, you can brace the material in more than one direction, shown in Fig.2.1. The ceramic making process can be either done by hand or automated,

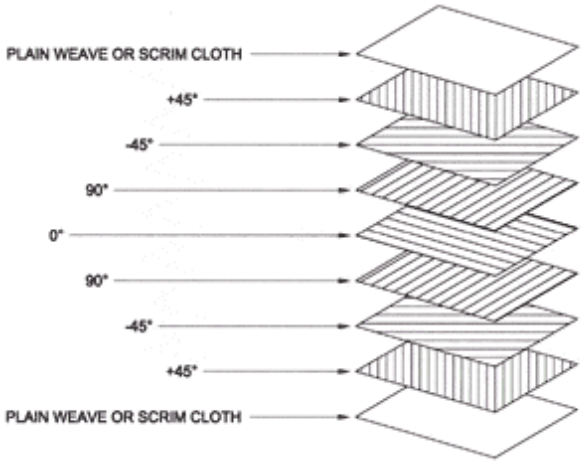

Fig.2.1: A composite manufactured with a 45° overlay

2.2.1 Hand Layup

The simplest composite manufacturing technique and used in low-volume production for large products. A pigmented gel coat is sprayed onto the mould to give a high-quality surface. When the coat has cured the fibres are placed onto the mould, before the catalysed resin is added (by pouring, spraying or brushing it on). Someone then rolls the resin in manually, this will also remove any entrapped air, compact the composite and thoroughly wets the fibres with the resin. The resin is catalysed in order to accelerate the bonding process, and also remove the demand for external heat to be applied.

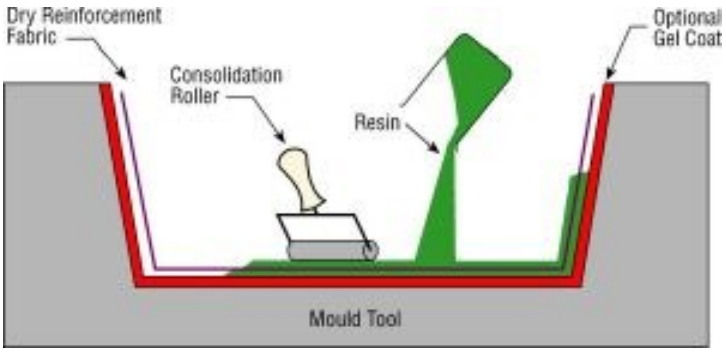

Fig.2.2: Hand lay-up method

2.2.2 Spray Up

Spray up is similar to the hand layup technique, but the process has become more automated by the incorporation of the spray to apply the ingredients. The fibres are chopped into smaller $(25 - 50\ mm)$ and

then sprayed by an air jet with the bonding resin at a ratio which has already been predetermined for the application. Fig.2.3 shows a diagram of a spray up process.

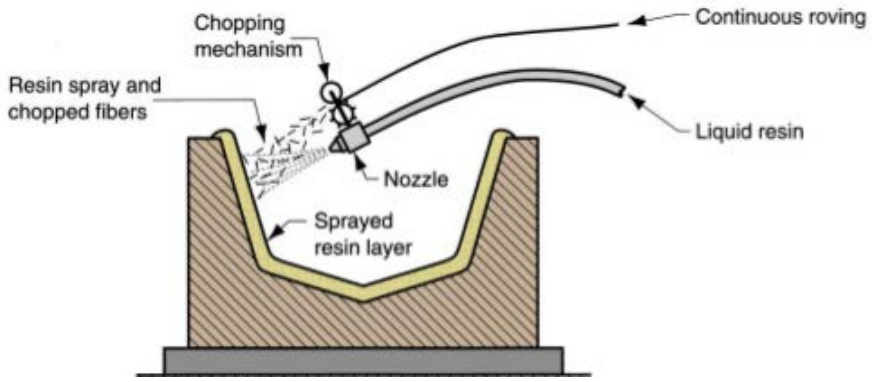

Fig.2.3: Spray up method.

2.2.3 Filament Winding

Video

A continuous filament of reinforcing material is wound onto a rotating mandrel in layers. If a liquid resin is applied to the filament prior to winding it is known as wet filament winding. If the resin is sprayed onto the mandrel with the wound filament, the process is called dry filament winding. This is used when creating round or cylindrical shapes The URL below explains the filament winding process in full.

https://www.youtube.com/watch?v=ign6W5ENJAA

2.2.4 Pultrusion

Video

The fibres are pulled from a "creel" and directly into a resin bath, where they are impregnated with the liquid resin. The wet fibres exit the bath and into a "pre-former" where any excess resin is removed from the fibres and shaped. The preformed fibres then pass through a heated die when the final cross-sectional dimensions are determined, and the resin begins to cure. Once the resin is cured the required length is removed by the cut-off saw. The URL below will show a video about the pultrusion process.

https://www.youtube.com/watch?v=4MoHNZB5b_Y

2.2.5 Resin Transfer Moulding

Video

Resin transfer moulding (RTM) requires a pre-shaped fibre skeleton (otherwise known as the preform). The preform is then placed into a die. The resin is then injected into the die and the part will remain there until it is cured. Once cured the die will be opened and the part will be removed. The URL below shows the resin transfer moulding process.

https://www.youtube.com/watch?v=NzpHCjL_AnE

2.2.6 Prepreg

A prepreg is used as a term for a composite which has already been pre-impregnated with resin. The resin also includes the curing agent, so once the prepreg is placed into the mould, the product simply just needs to be cured. It is difficult to store prepregs for an extended period of time, as the curing agent will be working