Lecture 5.5: Pultrusion

Pultrusion is a type of continuous automated closed molding, composite processing method. The basic mechanism of pultrusion system is same as that of the metal extrusion process. The only difference is that in extrusion process, material is pushed through the dies whereas in pultrusion, material is pulled through the dies. Reinforcement in terms of continuous rovings or fiber mats is unrolled from creel holding rolls and passes through a resin tank. In resin tank, fibers are dipped thoroughly to get completely wetted fibers. Now, these resin saturated fibers are guided to the hot die where the desired profile is given to these resin impregnated fibers with the help of dies. Curing of the composite also takes place in this section due to heating. Now, the cured composite profile is pulled with the help of gripper coming from the hot dies. Finally, putruded profiles are cut with the help of a cutter which is inbuilt after the pulling mechanism in the pultrusion system. The schematic of pultrusion system is shown in figure 1. Sometimes, in the resin tank, some filler materials are added which also go with the fiber roving. Though, excess resin is removed in the hot die portion due to pressure, but in some pultrusion systems, a pre-former is used in between the resin tank and hot die. In the pre-former, excess polymer is squeezed out and uncured composite is generated which is then passed through hot die section. The pultrusion process is generally used and is suitable for thermoset polymer composites and a constant cross section profile of the composite product is produced on a continuous basis. As the cross section of product is uniform, the fiber distribution and alignment and resin impregnation is good in this process. Though rate of production is high but a large variation in area of cross-section is difficult to achieve. The expenditure requirement to start pultrusion process is low as compared to other costly and complex molding processes.

Important components of pultrusion process:

There are mainly six components in the pultrusion system which govern the processing of composites. These components are:
1. Fiber Creels
2. Preformer
3. Resin impregnation systems
4. Hot dies
5. Pulling mechanism
6. Cut off saws
The creel should be located in such a way that it should provide uniform and controlled tension to roving while transferring to the pultrusion system. For continuous and uninterrupted supply of the roving strand, a second back-up roving package is also provided besides running package. The shape and size of creel is decided on the basis of number of roving packages to be handled and its dimension and the distance to be maintained in between the strands. Preform plates are critical component of pultrusion system as it properly aligns and feeds the reinforcement to the heated die. If pre-forming system is not properly functioning, it may lead to bad quality output and failure of pultrusion system. Resin impregnation system has a resin bath tank. The size of the tank depends upon the volume of resin to be handled. Resin impregnation system may have a heating arrangement for the resin to enhance fiber wetting but the working life of bath is decreased due to heating system. The commonly used resin impregnation system is dip bath system which is also known as open bath. It allows the reinforcement travelling from the creels down into the bath and the resin coated fibers comes out through a guided bar located into the bath. Heating dies are the main component of any pultrusion system where part to be produced is given shape and is cured. Pulling system pulls the product from the heated dies on a continuous basis. Generally, a caterpillar belt is used in the pulling system. The last unit of pultrusion system is cut off saw which cut the pultruded product in desired size. Most commonly, a flying type of cut off saws are used in the pultrusion system. A flying cut off is movable unit which moves with the same speed as the pultruded product moves. The advantage of this movement is that the cutting edge of the component is square and straight. Sometimes, water is used as coolant and lubricant for cutting blades during cutting which is known as a wet saw. It also flushes the dust and debris generated during cutting to the filter. A dry-cut saw uses a continuous rim diamond blade which does not require any coolant or lubrication during cutting and it gives clean cut of the product.
Figure 1 Pultrusion system.

**Raw materials used in the pultrusion system:**
A wide variety of reinforcement and resin systems are used to fabricate composite materials with exceptional properties. The reinforcing materials used are: glass (E-glass and S-glass), carbon, aramid fibers in the form of roving strands, mat (continuous filament mat, chopped strand mat) and fabrics. Specific properties can be achieved by altering the design of the fabric reinforcement. Sometimes veils are also used in pultrusion system to achieve high quality surface layer of the pultruded component. These veils may have pre-printed designs and logos that appear in the final product. Generally, unsaturated polyester, epoxy, vinyl ester resin and phenolic resins are used as matrix materials. The fillers and additives are also incorporated during composite fabrication as per the design requirement.

**Application:**
1. Products like solid rods, tubing, and long flat sheets are easily fabricated with pultrusion process.
2. Simple and constant cross sectional structural sections such as channels, angled and flanged beams.
3. Tool handles for high voltage work, and third rail covers for subways.

**Advantages of pultrusion system:**
1. This is a low cost automated system where human involvement is least which produces high quality products.
2. The surface finish of the product is high as compared to other composite processing methods.
3. The production rate is high as it is a continuous production process.
4. It is a straightforward and simple process which does not require specific labour skills.
5. Easy handling and low maintenance.

**Disadvantages of pultrusion system:**

1. The process is mainly suitable for constant cross sectional areas. Tapered and complex shapes cannot be produced with this method.
2. Control of fiber orientation is not possible in the pultrusion system.
3. Thin wall parts cannot be produced with this system.