Sheet no 5005

BEET BUILDING SYSTEM

THE MANUFACTURING OF PULTRUDED BEET PROFILES

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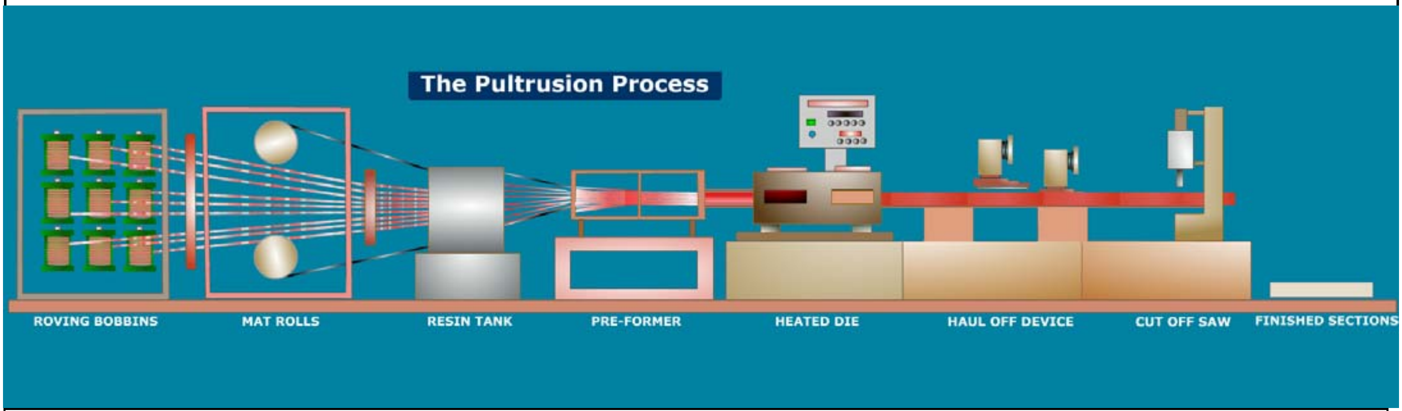
WAY COMPOSITE PROFILES?

Pultruded composite profiles are increasing being used in a variety of applications. With the high strength, low weight, non-corrosive features, fibre reinforced polymer (FRP) materials are rapidly growing in demand, and FRP pultrusions are leading the way.

The manufacturing of pultruded profiles is the most efficient method of forming composite materials with consistent high quality and low scrap. The continuous process of FRP pultrusion allows high strength composite products to be produced at the absolute lowest cost.



HOW PULTRUSION WORKS:

Developed in the 1950's by the person considered by many to be “the father of composites,” W. Brant Goldsworthy, pultrusion is the process of "pulling" raw composites through a heated die creating a continuous composite profile.

The term pultrusion combines the words, "pull" and "extrusion". Extrusion is the pushing of material, such as a billet of aluminium, through a shaped die. Where as pultrusion, is the pulling of material, such as fiberglass and resin, through a shaped die.

The pultrusion process starts with racks or creels holding rolls of fibre mat or doffs of fiber roving. Most often the reinforcement is fiberglass, but it can be carbon, aramid, or a mixture. This raw fiber is pulled off the racks and guided through a resin bath or resin impregnation system. Resin can also be injected directly into the die in some pultrusion systems.

The raw resin is almost always a thermosetting resin, and is sometimes combined with fillers, catalysts, and pigments. The fiber reinforcement becomes fully impregnated (wetted-out) with the resin such that all the fiber filaments are thoroughly saturated with the resin mixture.

As the resin rich fiber exits the resin impregnation system, the un-cured composite material is guided through a series of tooling. This custom tooling helps arrange and organize the fiber into the correct shape, while excess resin is squeezed out, also known as “debunking.” This tooling is known as a “pre-former.” Often continuous strand mat and surface veils are added in this step to increase structure and surface finish.

Once the resin impregnated fiber is organized and removed of excess resin, the composite will pass through a heated steel die. Precisely machined and often chromed, the die is heated to a constant temperature, and may have several zones of temperature through-out its length, which will cure the thermosetting resin. The profile that exits the die is now a cured pultruded Fiber Reinforced Polymer (FRP) composite.

This FRP profile is pinched and pulled by a “gripper” system. Either caterpillar tracks or hydraulic clamps are used to pull the composite through the pultrusion die on a continuous basis.

At the end of this pultrusion machine is a cut-off saw. The pultruded profiles are cut to the specific length and stacked for delivery.

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ADVANTAGES OF USING PULTRUSION

Pultrusion has a number of benefits over other composite processing systems. Some of the lowest cost, highest quality composite profiles are created by this process. This is because it is automated and has very little manual interface. A manufacturer can be assured the 1st ten-meters of pultrusion will have the same quality and consistency as the 100th ten-meters of pultrusion. Human interface is eliminated, as required in most other processes, such as melding and hand-lay-up. Quality is not a function of motivation of factory technicians.

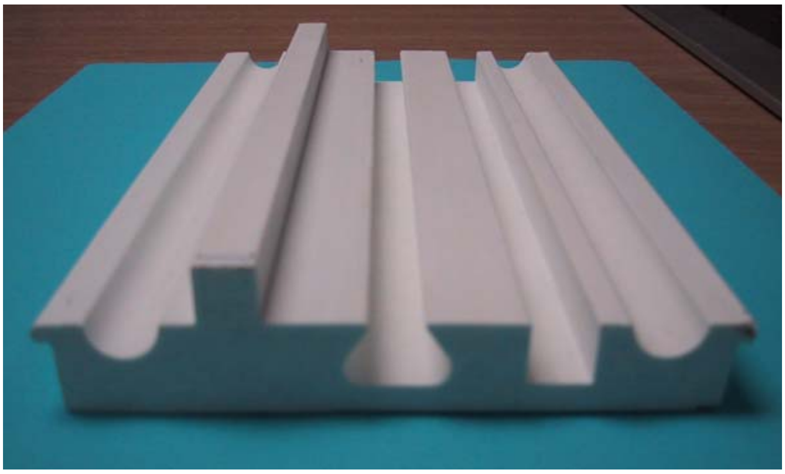
Another distinct advantage of the pultrusion process is cost. It is not unusual to find 80-90% of the cost of pultrusion profiles are the raw material costs. The amortized machine costs and the labour to run pultrusion machines is a small portion of the total factory costs. This has been a primary driver for pultrusion being one of the fastest growing and accepted manufacturing processes in the composites industry.

PULTRUSION ADVANTAGES:

1—Increased Strength (fiber processed under tension)
2—High Fiber Content
3—Highly Automated
4—Consistent Quality
5—High Production
6—Low Labour Required
7—Low Cost

FRP pultruded products are often stronger then a similar product manufactured by hand-lay up, vacuum bag infusion, and other composite processing methods. During the pultrusion process, the many fiber bundles are pulled downstream using hydraulic or caterpillar grippers. Due to this pulling, the fiber filaments are in tension when curing in the heated die.

When in tension, the fibers have higher strength values and are better aligned allowing good compaction, with more fibers fitting into a given volume. Fibre density is extremely high, as all excess resin is squeezed out before entering the die. Standard pultrusions can have fiber content of 50% by volume, 70% by weight, creating an extremely strong FRP composite.



BEET PROFIL B100

One of the major attractions of the pultrusion process is the simplicity of tooling and low labour requirements. At first look, pultrusion seems like a straight forward process: fiber reinforcement is saturated with a thermosetting resin matrix, and pulled through a heated die. Sounds simple enough…… right?

However, there are many "tricks of the trade" in manufacturing pultrusions where knowledge can only be found through experience. Listed below are some needed tips one must learn in order to become a successful pultruder.

DIE SHAPE, LENGTH, MOUNTING

Before one plans to pultrude, a pultrusion die must be manufactured to precise dimensions. Harden steel is ground down to the correct tolerance and is chrome plated to reduce friction. In designing the die, one must decide on the length. This will effect the time the pultrusion will be exposed to the heat, it will also effect the inside surface area, friction, and production line speed.

Once the die is manufactured to specific length, mounting to the heating plate can sometimes require special shoes, depending on the die shape. As well, if the pultrusion is hollow, a floating mandrel must be correctly installed.

Machining of dies and tooling set-up are generally the largest fixed cost in an individual pultrusion run.

FIBER REINFORCEMENT/DENSITY/ORGANIZATION

Depending on the end application and through use of finite element analysis (FEA), the pultruder must decide on the appropriate "ply schedule." What type of fiber is to be used, unidirectional, woven or stitched fabric, what weight fabric, and how many layers to use are all questions which must be addressed. The decision to use continuous strand matting and surfacing veils must be taken into account as well.

Once the given reinforcement is determined, organizing and preforming tools must be fabricated and installed. This ensures the fiber stays in the proper location without folding, creasing, or jamming in the die.

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RESIN MIXTURE

This discussion is limited to thermoset resins, by far the most utilized resin in the pultrusion process. The resin chosen for a particular pultrusion is not as simple as mixing two simple parts. Fillers, pigments, and other additives such as fire retardants all need to be mixed with the desired ratio. Pot life of the resin needs to be taken into consideration, as well as the resin viscosity. Viscosity is important to ensure proper wet-out of the reinforcement, and will also affect line speed.

Resins in thermoset have the draw-back of containing styrene, if polyester or vinylester are used, whereas epoxy -based and urethane resins do not. Pot life is less with epoxy and urethanes and these are used almost exclusively with die-injection techniques. Polyester or vinyl ester resins are sometimes “open bath” systems, but be sure to check local emissions regulations before committing to this approach.

PULTRUSION DIE TEMPERATURE

Die temperature is extremely important. Too low of temperature and the composite will not fully cure. Too high a temperature and the composite could blister, crack, or worse, the composite could get stuck in the die. There is an ideal temperature for every profile, ply schedule, and resin matrix. Line speed, die length, and the exothermic properties of the resin need to be taken into account as well. It is no surprise pultruders take detailed notes during every run.

PULTRUSION LINE SPEED

Finally there is line speed. Every manufacturer wants its pultrusion machines to run as fast as possible. Line speed is the rate at which the pultruded profile is produced, and is most often measured in feet-per-minute or meters-per-minute.

When calculating the optimum line speed, one must take into account the profile thickness, die length, die temperature, and resin formulation. Once again, experience is the key to line speed optimization with quality pultrusions.

In conclusion, the process of pultrusion is not nearly as basic as it may appear. Experience and trial and error is the only true method of mastering the manufacturing of pultrusions.

Stay tuned is we will be placing new “tricks of the trade” periodically on www.pultrusions.org.

Sandefjord 22. may 1997

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