TECHNOLOGICAL PRACTICE CASE STUDY | NOVEMBER 2008

HARD MATERIALS TECHNOLOGY | YEARS 11-13

PULLING THE RIGHT STRINGS

From humble beginnings 25 years ago, Gisborne-based manufacturer Pultron Composites Ltd has grown to employ approximately 80 people and export millions of dollars of high-tech fibreglass pultruded products. This case study looks at the business and explains pultrusion technology.

FOCUS POINTS INCLUDE

Characteristics of Technology

- Interdisciplinary practice

Technological Products

- Forming, manipulating and/ or transforming materials to enhance the fitness for purpose of a technological product

ADDITIONAL SUPPORT MATERIAL

- www.pultron.co.nz

Curriculum related activity:

- Focus questions to promote classroom discussion on aspects of the Technological Products component of the Technological Knowledge strand are on page 3.

PULLING THE RIGHT STRINGS

Gisborne may be one of New Zealand's most isolated regional centres, but this has not stopped it from becoming home to Pultron Composites Ltd – one of the world's leading makers of products using pultrusion technology. Richard Worrall talks to the company's founder and Technical Director.

Pultron Composites is a classic example of one man's Kiwi ingenuity growing into a major export business. From humble beginnings 25 years ago, the Gisborne-based manufacturer has grown to employ approximately 80 people and export millions of dollars of high-tech fibreglass pultruded products. A combination of leading-edge technology and constant process and product improvement gives the company an edge over its offshore rivals, and it now boasts a customer base spread across 60 countries and expansion upwards of 30% per annum.

Soon the company will open its first offshore manufacturing plant in the United Arab Emirates to cash in on the booming Middle East civil construction sector and eliminate the lag between receiving orders in Gisborne and shipping the finished product to the Arabian Peninsula. The Kiwi way

One-time farmer and agricultural contractor, Peter Holdsworth FIPENZ founded Pultron Composites in 1982. He'd shown an interest in engineering from a young age, so it was probably only a matter of time before his natural instincts took over and he found himself drawn back into the world of engineering. He completed an electrical engineering degree at the University of Canterbury and began experimenting with pultrusions, initially intending to make wind turbine blades so he could design and manufacture his own wind turbines for rural applications. However, the time wasn't right for small-scale wind turbines, so he turned his attention to something more down-to-earth and of immediate use – developing more robust and durable fence posts.

However, pultrusion technology was virtually unheard of in New Zealand and the cost to import manufacturing plant was prohibitive, so Mr Holdsworth began to develop his own, fabricating all the necessary equipment and designing the processes required to turn the strands of fibreglass into composite materials. Using a combination of scrap steel, old hydraulic rams and pumps, and much trial-anderror, he developed a recipe to polymerize the resins and couple them to the glass fibres successfully. This meant getting the resin mix and temperature just right, and calculating the correct speed to pull the fibres through the heated die. He also made good use of his farm tractor, which was the initial motive power to pull the resin and fibreglass through his home-grown heated die.

Within eight months, he perfected his own pultrusion process and began turning out 10-millimetre-diameter electric fence posts, and almost immediately, he took on two staff to keep production up with demand. Thanks to the small scale of the fibreglass sector in New Zealand, interest in his production process soon spread and he began to diversify his product base.

WHAT are PULTRUSIONS?

NAMED AFTER THE WORDS PULL AND EXTRUSION, pultrusions are reinforced composite structural profiles such as rods, tubes or channel sections made from fibreglass, aramid (an exceptionally strong and lightweight synthetic fibre), carbon or even jute, and a matrix formed from resins such as polyester, polyurethane or epoxy. The combination is extruded through a heated die to polymerize the resin and shape it to the desired profile.

DIVERSITY AND MULTIPLICITY

Today Pultron Composites fabricates thousands of products for applications in defence, electrical engineering, civil construction, sewage and water supply infrastructure, mining and petroleum exploration, and recreation. Aside from electric fence posts, products range from tent poles and trampoline springs through to sail battens, rock bolts for mine and tunnel supports, reinforcing re-bars, marine mooring whips, walkways and walkway gratings, pier ladders, tool handles, cables, antennas, power pole cross arms and separator rods.

MANUFACTURING a PULTRUSION

TO TURN FIBREGLASS INTO A TOUGH, durable product such as a reinforcing bar, Pultron Composites starts with literally thousands of separate fibreglass strands. To produce a 10-millimetre-diameter rod, for example, requires no less than 80,000 separate fibre filaments drawn together, each only 20 microns in diameter.

Fibreglass arrives at the factory in large rounds called "cheeses", each weighing roughly 20 kilograms. Each cheese has a "tow" – 4,000 fibreglass filaments combined into a single strand that pulls from the cheese's centre. The cheeses are stored in 10 roving bays (essentially racks), with up to 1,200 cheeses per bay. Special islets guide the tows to the end of the bay and into the manufacturing process.

Prior to entering the heated die, sensing devices measure the tension of the running tows. A "wet-out" occurs when the glass fibres become soaked with the resin prior to entering the curing section inside the heated die. Feeding additional cross-bound fibres (like a woven mat) into the heated die along with the tows gives varying degrees of axial or transverse strength.

The hot pultrusion profiles emerge from the die fully cured. Once the profiles cool sufficiently to manipulate, an extraction machine pulls – rather than pushes – the profiles from the die to prevent the fibres becoming misaligned. The puller uses twin reciprocating hydraulic clamping patterns with a 16-tonne clamping pressure and a six-tonne pulling force. These combine to extract the profiles in a hand-over-hand pulling process.

A flying cut-off saw cuts the profiles to length. From there they move to finishing, where a grinding or over-moulding machine shapes them to the final application.

Such application and product diversity is only possible because pultrusions offer a unique combination of properties. When compared with aluminium, brass, steel and stainless steel, pultrusions offer greater durability and resistance to corrosive chemicals, have an excellent strength-to-weight ratio, and are three times stronger than mild steel under tension, with a much lower modulus making it more flexible. It also has a quarter the density of steel.

Pultrusions can withstand up to five times as much stretch under the same load, making them ideal for spring applications in chairs or trampolines, or any other application that requires a specialized structural profile. The ultimate tensile strength of a unidirectional pultrusion can be over 1,200 megapascals with a modulus over 50 gigapascals, depending on the construction.

Pultrusions also offer excellent insulation properties, which is why they are ideal for use in electrical engineering applications. A pultrusion can act as 200-kilovolt insulator, for example, and at the same time withstand a heavy structural load. Similarly, the ladders used by lines crews around New Zealand to service electricity lines are made from Pultron's pultrusions because they offer better electrical safety should a crew member accidentally touch live wires. Pultron Composite's re-bars for concrete reinforcing are used for specialist applications. For example, a construction project in the Marshall Islands where the concrete was mixed using salt water rather than fresh water. In this situation, steel re-bars would last less that a year, whereas pultruded re-bars are immune to this corrosive environment.

RESEARCH AND DEVELOPMENT

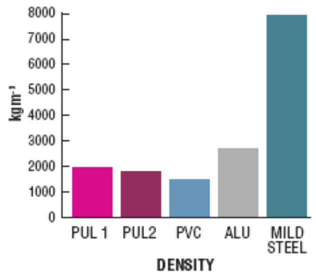
Pultron Composites specialises in the design of high-performance rods, springs and small cavity profiles.

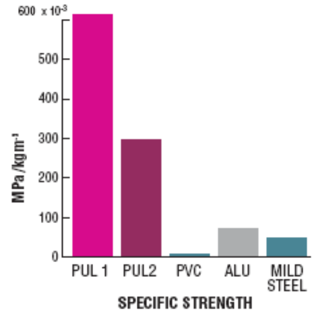
Mr Holdsworth views research and development as simply a matter of survival. "The business has always been very research orientated – we are almost a research organisation. If we give up on research we won't be able to move on and develop the technology and retain customers."

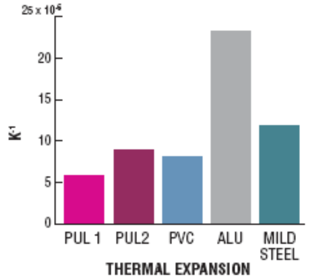
He says that this attitude reflects the variety and growth of his customers' requirements. "Many pultrusion applications have demanding technical issues which need to be addressed. The specifications for structural profiles of most materials are becoming more and more specific to the required duty, and

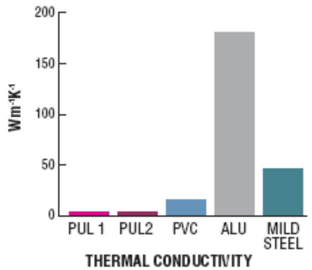
Technical data:
The properties of Pultron pultrusions compared with PVC, aluminium and mild steel
PUL1 = Linear Glass
PUL2 = Bi-Directional Glass

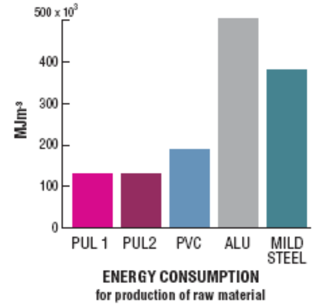
From:
www.pultron.co.nz/index.php/pultrusion-advantage/comparisons-with-traditional-materials.html

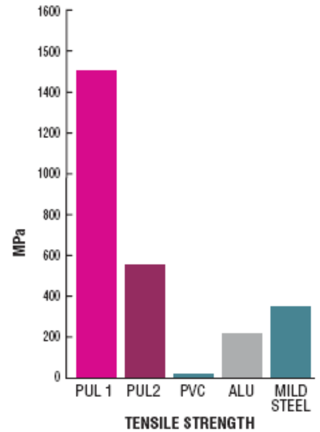












pultrusions – in some instances – are a cost effective option." With research and development so crucial to the success of the business, Mr Holdsworth dedicates up to 15% of turnover and a team of 15-20 physicists, material scientists, programmers, mechanical and electrical engineers, and fitters to refining the production process and product finishing, and finding ways to adapt pultrusions for new uses. You might think he would need to locate such a specialised manufacturing business in a large centre, but he says he has had no problems attracting the broad cross-section of skills required to Gisborne. In addition, he has been able to draw on the solid base of engineering-orientated skills in the district to help keep the business thriving.

Pultron Composites divides its research into four areas. A mechanical research department is equipped with CNC equipment, which engineers use to design and build the specialist shaping and altering machines that manufacture each type of pultrusion, while the die and tooling department develops the specialised tooling required to manufacture the pultruded profiles. The electronics department designs, builds and programs the automated devices that control the manufacturing machines and the production process. A composite materials research laboratory operates an array of test instrumentation, such as a modulated differential scanning calorimeter and a dynamic mechanical thermal analyzer for tensile testing.

NEW SOLUTIONS TO OLD PROBLEMS

The company recently developed a reinforced pultruded cable for underground pipe inspections. The challenge was to produce a product stiff enough to be pushed up a pipe but flexible enough to negotiate bends and resist abrasion. A specialised protective sheathing surrounds the cable and houses wires that the operator can use to detect and locate faults, or link to a tiny front-end camera to carry out pipe inspections. The company's efforts paid off and the cable is now used extensively throughout New Zealand and in other countries overseas.

With an almost endless range of uses for pultrusions and the global resources boom making inroads into the cost competitiveness of rival products made from metal, Pultron Composites looks likely to keep growing and proving New Zealand companies can overcome isolation with a strong commitment to research and innovation.

Richard Worrall is a Christchurch-based freelance journalist.

Curriculum Links

TECHNOLOGICAL KNOWLEDGE

Technological Products

In this component, the focus is on understanding the physical nature of a technological outcome as viewed as a product, and therefore material understandings are key to this component.

Technological products are defined as material objects that result from technological practice, and as such have been designed by people to exist in order to fulfil an intended function. The key concepts underpinning the technological product component relate to the identification, description, use and development of materials with reference to how materials help make a product fit for the purpose for which it was designed.

The inherent qualities of a material are determined by its composition (the type and arrangements of particles that make up the material) and can be described as structural (conductive, ductile etc) or sensory (colour, texture etc) in nature. Together, these define the material's overall performance properties.

Material selection is based on matching the desired performance criteria of a technological product with the performance properties of the materials available to ensure the material selected will be adequate for use in the product. Material evaluation plays a critical role in material selection making decisions that can be justified in terms of the material not only being adequate, but be the optimal material for use when all factors are considered.

Material innovation refers to making available new performance properties through either transformation of materials to formulate a new material or through the use of existing materials in a new way. The contemporary field of material innovation is crossing many traditional disciplines and showing increasingly diverse and exciting possibilities for material performance properties, and therefore the types of functions that a technological product may have.

FOCUS QUESTIONS

The Gisborne based company Pultron Composites is one of the world's leading makers of products using pultrusion technology:

- Explain how composite materials are produced using pultrusion technology and what makes this technology so versatile.

Pultrusion products come in a range of standard profiles and sizes and, as the Pultron website states, can be used in a wide variety of contexts including: mining; recreation; water supply and sewerage; defence; electrical; marine; construction; agriculture and horticulture:

- From the company website – www.pultron.co.nz – list some of the applications of pultrusion products in each of these areas.
- Identify the required key attributes of the materials for each application (such as strength-to-weight ratio, corrosion/chemical resistance, electrical conductivity, thermal conductivity, electomagnetic transparency), explaining why they are critical in determining the choice of materials used.

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