Matéria

Materials

Forging ahead

Manufacturers are increasingly working with new, game-changing ingredients

IT IS SMALL enough to be held in your hand and looks like an unremarkable chunk of metal perforated with tiny holes, but it is fiendishly hard to make. That is because it must spin 12,000 times a minute under high pressure at a temperature of 1,600°C, 200°C above the melting point of the material it is made from. And it must survive that twisting inferno long enough to propel an airliner for 24m km (15m miles) before being replaced. In all, 66 of these stubby blades are used in the rear turbine of a Rolls-Royce Trent 1000 engine, and the British company makes hundreds of thousands of these blades a year.

American and European firms have sought salvation in high-end manufacturing from the onslaught of low-cost producers. That increasingly involves becoming more inventive with materials. This article will look at a number of such innovations, including the special casting system for the Rolls-Royce turbine blades as well as the use of carbon fibre, recycled plastic waste, new battery technology and others.

As developing countries become richer and more sophisticated, they too want to make things like aircraft, jet engines and high-performance sports cars. In some cases Western firms subcontract part of the production work to firms in countries trying to build up the capabilities of their industries, usually when those countries are placing big orders. But some things are not for sharing because they are too important to preserve a product's competitive advantage.

For Rolls-Royce, turbine blades are one of those key technologies. The magic that creates them depends on a deep understanding of materials science and production technology. When metals solidify after casting they normally contain lots of microscopic crystals. That would still leave them strong enough for most things, but it is a potential weakness in a turbine blade. So Rolls-Royce uses a unique system which casts the blade in a nickel-based super-alloy with a continuous and unbroken crystalline structure. This ensures there will be no structural defects.

Air circulates through the blade's hollow centre and out through precisely positioned holes, formed by a special electronic process because no conventional drill is accurate enough. The holes create a film of air which flows across the surface to prevent the blade from melting. The blade is also covered with a heat-resistant ceramic coating. The makers go to such lengths because a rugged and heat-resistant blade allows a jet engine to run hotter, improving combustion and reducing fuel consumption.

Don't just sit there, invent something

The new factory in Derby, where Rolls-Royce makes the turbine blades, is also somewhat unusual. Designers, engineers and production staff are housed under one roof rather than in different buildings or even different countries. They were brought together because Rolls-Royce believes that proximity will lead to a better understanding of each other's roles and greater inventiveness. That will be crucial in the years to come, says Hamid Mughal, Rolls-Royce's head of manufacturing engineering: "Product technology is the key to survival, and manufacturing excellence provides one of the biggest opportunities in

• the future." That combination, Mr Mughal believes, is the only way to keep coming up with breakthroughs: "Incremental increases won't do it."

Much the same thinking can be found at **GE**. It also makes jet engines and has businesses that include energy, lighting, railways and health care. "It became clear to us a number of years ago that we needed to merge materials research and manufacturing technologies," says Mr Idelchik, its research chief. New products used to begin with design, proceed to materials selection and then to manufacture. "Now it is done simultaneously."

One product of these efforts is a new industrial battery. This began with research into making a battery tough enough to be used in a hybrid locomotive. A chemistry based on nickel and salt provided the required energy density and robustness. Yet making it work in the laboratory is one thing, commercialising the tricky processes involved to mass-produce the battery quite another. So **GE** sets up pilot production lines to learn how to put promising ideas into action before building a factory. Some ideas fail at this stage, others fly.

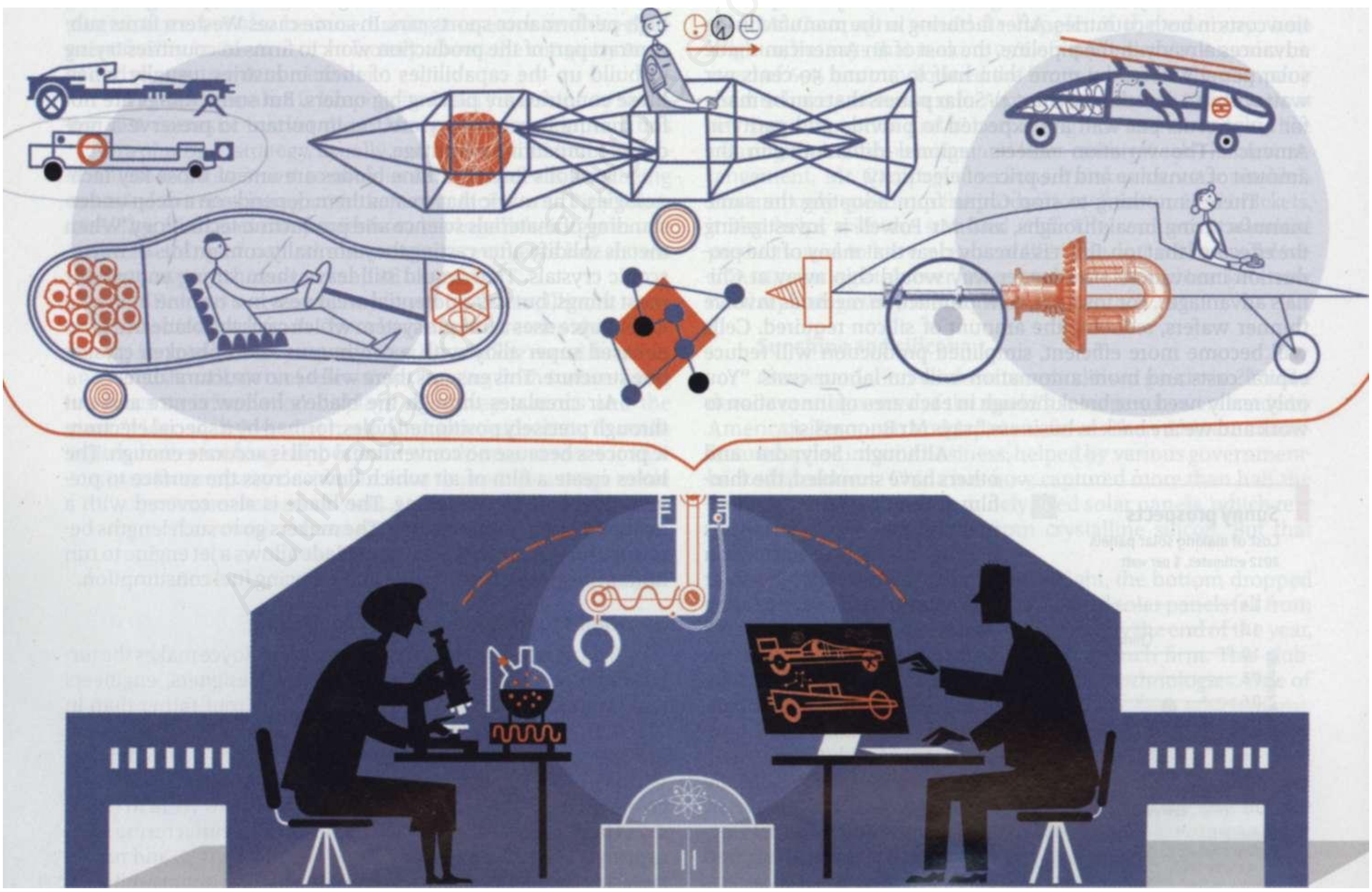
The battery is one that has taken off. Besides hybrid trains it is also suitable for other hybrid vehicles, such as fork lifts, as well as applications like providing back-up power for data centres and to power telecoms masts in remote places. It will be made in a new $100m facility near Niskayuna so that researchers are on hand to continue development. The battery itself consists of a set of standard cells which go into modules that can be connected together for different applications. The modules take up half the space of an equivalent lead-acid battery, are only about a quarter of the weight, will last for 20 years without servicing and work well in freezing or extremely hot conditions, says Glen Merfeld, in charge of energy-storage systems at **GE'S** laboratory.

One material that particularly interests **GE** and other manufacturers is carbon fibre. This is already being used to make the large fan blades at the front of some jet engines. It is flexible as a raw material, but when a carbon-fibre cloth is impregnated with epoxy resin, shaped and cured, it can be as strong as steel and only half the weight. That strength comes from the powerful chemical bonds that form between carbon atoms. The fibres can be aligned in different directions, allowing engineers to tailor the strength and flexibility of a composite structure precisely.

The large-scale use of carbon fibre began in aerospace. Both Airbus and Boeing aircraft use it extensively instead of aluminium. Not only is it lighter, there is also a big manufacturing advantage: large sections, like the main area of a wing, can be made in one go rather than being riveted together from lots of individual components.

Look, no hands

It is the strength, lightness and potential saving on manual labour offered by carbon fibre that makes the material attractive for a variety of products. McLaren, a British Formula 1 **(F1)** team, was the first to use an **F1** car with a carbon-fibre structure. John Watson drove it to win the 1981 British Grand Prix at Silverstone. Later that year, in dramatic fashion, he demonstrated its ability to withstand crashes when he emerged unharmed from a pile-up at Monza. Within a few years every **F1** team was racing carbon- ••



• based cars. But building them, largely by hand, could take 3,000 man-hours.

Now it takes just four hours to build the carbon-fibre chassis and underbody of the MP4-12C, a $275,000 sports car which McLaren launched in 2011 to compete with arch-rival Ferrari on the road as well as on the track. The MP4-12C is built in a clinically clean new factory built next to McLaren's base in Woking, west of London. Eventually the company will manufacture a range of road cars using carbon fibre. It will get there faster thanks to the development of a partly automated technique for pressing the material in a mould and injecting epoxy resin into it under pressure. This was pioneered jointly with Carbo Tech, an Austrian firm that specialises in composites.

Like many technologies pioneered by motor sport, carbon fibre is now trickling down from supercars into more everyday models, BMW, for one, is launching a new range of electric and hybrid models which use carbon-fibre bodies. The first, a small urban electric car called the BMW i3, will be assembled at a new factory in Leipzig from next year. A carbon-fibre car, being lightweight, will get more mileage out of its battery than a heavier steel one. It might even prove stronger in crash tests.

Another surprisingly strong material could be made from what people throw out. Arthur Huang, the co-founder of Miniwiz Sustainable Energy Development, based in Taiwan, trained as an architect in America. He is making building materials from re-engineered rubbish. One product, Polli-Brick, is a block resembling a square bottle made from recycled PET plastic, which is widely used to make food and drink containers. Because of their shape, Polli-Bricks can lock together without any adhesive to form structures such as walls. These, says Mr Huang, are strong enough to withstand a hurricane, but greatly reduce the carbon footprint of a building and are about a quarter of the price of traditional building materials. Moreover, as they are translucent they can have LED lighting incorporated in them.

Increasingly, product engineering will begin at the nanoscale. Nanotechnology is already used to enhance some products

A concrete advantage

Another of Mr Huang's materials is a natural bonding agent extracted from discarded rice husks. This can also be added to help set concrete. The idea is not exactly new; as Mr Huang points out, something similar was added to the mortar used to build the Great Wall of China. He thinks mainland China with its building boom could once again be a big market for this product. A similar material can be extracted from the barley husks left over from brewing. Mr Huang's vision is for the system to be used in local communities to turn rubbish into useful products.

Increasingly, product engineering will begin at the nanoscale. Nanotechnology is already used to enhance some products. Titanium dioxide, for instance, is used to produce self-cleaning glass in buildings. A film of it only a few nanometres thick is thin enough to be seen through yet powerful enough to react with sunlight to break down organic dirt. The material is also hydrophilic, attracting rain as a sheet of water that washes off the residue. Pilkington, a British company, was the first to launch self-cleaning glass using this technology in 2001.

A trawl through the research laboratories at MIT provides many more examples of future products that might use nanoparticles. Among the things Kripa Varanasi and his colleagues are looking at are materials that are extremely water-repellent. These can be used to make superhydrophobic coatings that would greatly improve the efficiency and durability of machines like steam turbines and desalination plants, says Mr Varanasi. Such coatings might also be applied to existing steam turbines, which generate most of the world's electricity. That could become a big retrofit business, reckons Mr Varanasi.

Nature already uses materials with nanoscale structures to great effect. The fossils that attracted the interest of Angela Belcher were formed some 500m years ago when soft-bodied organisms in the sea began using minerals to grow hard materials in the form of shells and bone. These natural products contain exquisite nanostructures, like the iridescent shells of abalone, says Ms Belcher. If creatures have the ability to make materials like that in their DNA, she concluded, it should be possible to emulate it. That is what her research group at MIT is now trying to do, using genetic engineering.

Odd though it may seem, one of Ms Belcher's projects involves using viruses to make batteries. Viruses-usually the sort that infect bacteria and are harmless to humans—are a fairly common tool in genetic engineering. To begin with, Ms Belcher and her colleagues genetically engineer the viruses to interact or bind with materials they are interested in. As they do not have millions of years to wait, they employ what amounts to a high-speed Darwinian process: making a billion viruses at a time, selecting those with promise and repeating the process until they get a strain capable of doing what they want.

The team has developed viruses that can produce the elements of a battery, such as the cathode and anode, and used them to make small button-cells, like those that power a watch, but the process has the potential to be scaled up. What makes the technology so attractive, says Ms Belcher, is that it is cheap, uses non-toxic materials and is environmentally friendly.

Two companies founded by Ms Belcher are already making things with viruses. Cambrios Technologies is producing transparent coatings for touch screens and Siluria Technologies (Ms Belcher likes to name her companies after geological time spans) is using viruses to develop catalysts for turning natural gas into oil and plastics. There are also potential applications in solar cells, medical diagnostics and cancer treatment. And all that from an idea inspired by a sea shell.

One of the people at MIT with whom Ms Belcher is working is Gerbrand Ceder, a battery expert who felt that there had to be an easier way to find out about materials than the present long-winded process. The information on ten different properties of a material might be scattered in ten different places. To bring it all together in one place, Mr Ceder and his colleagues, in conjunction with the Lawrence Berkeley National Laboratory, late last year launched a free online service called the Materials Project to catalogue the properties of substances. By March this year it contained details of almost 20,000 different compounds.

The database is designed to allow scientists quickly to identify suitable new materials and predict how they might react together. This promises to speed up the development of new materials in manufacturing. Some new substances can take a decade or more to reach the market. "Because it takes so long, people are wary about investing in it," says Mr Ceder. "So we have to make the process faster."

Fonte: The Economist, London, v. 403, n. 8781, p. 11-13, 21 a 27 Apr. 2012.