A revolution in materials is shaping the future of manufacturing

Awareness of latest material trends is essential

New materials enable engineers to create stronger, tougher, lighter, higher-performing components and assemblies. This can be seen today with materials such as composites, new light-weight metal alloys and graphene, and there is certain to be no let-up moving forward. Driven by demands from sectors such as aerospace and automotive, the frontiers of material development will be pushed to even more extreme levels.

The rise of composites
Take the aerospace industry, for example, which is constantly looking ahead to materials that can offer greater strength, lighter weight and higher heat resistance in order to achieve desirables such as higher speeds, lower fuel consumption and fewer emissions. Today, composites are proving to be the material of choice for aerospace engineers. Over the past 30 years, composites content in passenger airliners has grown from just 5 to 6% to 50% in the latest commercial models such as Boeing's Dreamliner.

Carbon fibre composites offer more strength than steel at just 20% of the weight. In a large passenger aircraft, weight savings of this magnitude can make a huge contribution to cost savings in fuel, experts estimate that just one kilogram (2.2 pounds) in reduced weight can save up to €3,000 per year in fuel.

But it's not just the aerospace industry that is benefiting; composite materials are becoming increasingly prevalent in sectors such as automotive, marine and energy. A recently developed vehicle such as BMW's electric i3 can travel as far as 160 kilometres on a single charge thanks to its extensive use of composites, resulting in a lighter weight vehicle. While Lamborghini's Veneno Roadster can accelerate from 0 to 100 km/hr. in 2.9 seconds, as a result of using these innovative lightweight materials.

Although design engineers can take delight in the extended possibilities delivered by the advent of composites, particularly as they become cheaper to produce and more widespread; production engineers are faced with the inevitable challenge of machining them.

"Drilling in composites is particularly challenging," says Dr Eleanor Merson, who researches composite machining for Sandvik Coromant. "The material is very abrasive, and this means that carbon fibres quickly wear out the drills. In addition, a typical aircraft has tens of thousands of holes."

Graphene and quasicrystals
The machining challenge also applies to other materials that are currently in development. Quasicrystals and graphene, for example, potentially hold even greater promise for designers seeking higher toughness levels. Some predict it could even revolutionize industrial design.

In 2015, a Chinese company incorporated grains of graphene into its cell phones to improve conductivity, while flakes of quasicrystals have been moulded into frying pans and metal surgical instruments to increase durability. Although it could well be a number of years before practical engineering applications emerge, heavy investment is being made into graphene research as developers push to realize its potential. Astonishingly, despite being the thinnest material on earth (1 million times thinner than a human hair), graphene is 200 times stronger than steel.

Of course, although there is ample excitement surrounding new materials, plenty of research continues on improving existing materials and techniques. For instance, lightweight aluminium alloys have now replaced high-strength steel in automotive bumper systems, crash ring components and intrusion. Similarly, aircraft engines can now take advantage of super-hard alloys that are resistant to extreme temperatures. As a result, these alloys are helping to improve energy conversion and reduce fuel costs.

Coatings harder than steel
With improvements in product materials comes the requirement for higher performing cutting tools. Coating processes such as physical vapour deposition (PVD) and chemical vapour deposition (CVD) allow cutting tool

manufacturers to harden the surface of their cutting inserts with an extremely thin, heat-resistant film. To help illustrate the gains that are possible, consider an insert where the substrate is made of cemented carbide comprising principally of tungsten carbide and cobalt.

"Add a two- to 10 μm layer of PVD and the insert's life span increases by a factor of 100," says Dr Mats Ahlgren, an expert in material physics and head of the PVD Department at Sandvik Coromant. "Not only is tool life extended greatly, but productivity is increased by being able to machine at much higher speeds and feeds."

Current research at Sandvik Coromant is focussing on making the coatings for cutting tools even tougher to meet growing demand for durable component materials.

"We have recently further developed our ability to control the process of making new coatings," says Ahlgren. "Using microscopes, we can see the insert's structure virtually down to an atomic level, which helps us assess the potential of new solutions before pressing ahead with full commercial development."

To provide a recent example of the company's' R&D success, in 2013 Sandvik Coromant patented its Inveio™ CVD coating. With crystals made to point in a uniform direction, Inveio is a leap forward in durability and hardness. The tightly-packed uni-directional crystals create a strong barrier towards the cutting zone and chip, which greatly improves resistance to crater and flank wear. Another effect is that heat is more rapidly led away from the cutting zone, helping the cutting edge stay in shape for longer time in cut.

Large scale recycling
With new material developments, the question of recycling emerges. For metallic materials, the recycling options are relatively straightforward, but what about composites? Many such materials are made with adhesive binders that are difficult to separate and reuse.

It's certainly a challenge, and one that has become a driving force in sectors such as automotive. In Europe, governments require all cars to be built in such a way that 85% of their materials can be reused, a demand that is generating imaginative solutions. For instance, Ford has reportedly started using wheat straw and soy products in its interior design, and is researching the potential of using coconut husks, carrots and corn-based plastics. The company has a vision to produce interiors that are 100% biodegradable.

"Finding alternative materials is an important industry strategy, as is creating cost-efficient substitution and recycling processes," says Dr Anna Hultin Stigenberg, who is the principal R&D expert at Sandvik Coromant. Until recently, Stigenberg chaired the Knowledge and Innovation Community (KIC) for raw materials, an international steering committee that brings together more than 100 companies and research facilities to promote sustainable material development.

Atomic level solutions
Along with sustainability, another trend for the future will be the development of materials on an atomic level, where understanding material structures and compositions in increasing detail could lead to huge leaps in capabilities.

"We are getting much better at designing new materials on an atomic level with the help of modern, high-magnification microscopes and computer-modelled calculations," says Stigenberg.

In the future, it is even conceivable that composites will be further strengthened by fibres that have been developed at nanoscale levels. For example, specialists at German chemical company, Altana AG, say that tiny carbon nanotubes can be made 400 times stronger than steel and 20 times stronger than conventional carbon fibres.

It is obviously difficult to predict exactly what lies ahead for the industrial community in regards to the materials of the future. However, what can be said, is that their effect on human development and society as a whole may be much greater than what we imagine today.