From the very first days of aviation, textiles’ appeal had always been due to their combination of great flexibility with light weight — and weight has always been one of the major problems facing the sector. From hot air balloons to airships and biplanes, early aircraft of all kinds used silk or canvas for the balloon envelope and panels for wings and fuselages. Over time, other materials such as wood, aluminium and artificial textiles became more widespread. However, in the last few years, highly developed speciality textiles have been rediscovered for use in building aircraft, spacecraft, cars, and ships. When you examine current developments in the automotive, nautical and aerospace industries, it quickly becomes clear that high-performance textiles are an essential component of the manufacturing process that we could not live without.

A trade-off between weight and strength

The early years of aviation were marked by the necessity to keep the weight of aircraft as low as possible. At the same time, wings and fuselages needed to be built in an aerodynamically effective manner. As such, early aircraft were produced with fabric coverings for many years. Before the invention of ailerons and flaps, the only way to change the direction of an aircraft was by twisting the exposed surfaces. Both wood and metal would have been unsuitable for designs of this kind. However, the demands placed on aircraft construction grew as the technology developed, with higher speeds and greater agility increasing the forces that components were required to bear. As such, wood and metal constructions were the primary methods used during the 1930s and 1940s to deal with these increasing demands. With the arrival of jet engines and the associated increase in speed, aluminium became the dominant choice of material for the aerospace industry. New materials such as carbon fibre and other plastics have made increasing inroads in aircraft construction since the turn of the millennium, however. Only in the last two decades have manufacturers discovered
the benefits of developments in the field of textiles for industry and mobile applications, extending beyond the aerospace industry into shipbuilding and the automotive sector. For instance, the Bavarian car manufacturer, BMW, presented its GINA concept a few years ago: a car with no metal or plastic bodywork. Instead, it had an exoskeleton that was covered with a special fabric skin, with actuators that allowed the exoskeleton to change its shape.

A vehicle covered in a flexible yet tough fabric of this kind could be transformed from a coupé into an estate car in a few seconds. By using special, electrically conductive fabrics, it would even be possible to change the car's colour by adjusting the amount of electrical current. Further applications can be found inside the car, where it would be possible to use pure induction charging to power a smartphone, simply by placing the phone onto a console coated in the appropriate fabric. While prototypes of this kind are not yet ready for mass production, they demonstrate the possibilities that are afforded by modern materials.

Bionics and a new approach to construction

Sharkskin construction, replicating the scales of a shark, is relatively well known. Shipbuilders and aircraft manufacturers had long worked on the basis that the smoothest surface possible would ensure the minimal possible air or water resistance. Research into sharks, however, showed that these fish had a skin structure that allowed them to glide through the water very quickly and efficiently. Their skin resembled extremely fine sandpaper, with a serrated upper surface. Under the microscope, ultra-fine structures became visible, and these structures proved highly effective at reducing frictional resistance. As a result, it became clear that, when compared with smooth surfaces, sharkskin is much more aerodynamic because the tiny structures optimise the flow of turbulence in the air or water. Today, it's possible to make use of specialist textiles that use nanotechnology to simulate sharkskin for the aviation and shipbuilding industries, resulting in significant energy savings due to reduced air and water resistance. To put it simply, this results in higher speeds and/or lower fuel consumption. The use of nature's biological designs to create modern technology is known as bionics. However, translating theory into practice remains problematic, as the process of applying artificially produced sharkskin to a surface is difficult, particularly in respect of complex, three-dimensional structures. Currently, special paints are being developed with a view to solving this problem for the aviation industry. The principle is more straightforward to apply to textiles, with swimming costumes and diving suits featuring the characteristics of sharkskin already being available to purchase. The results are so effective that the use of these fabrics has been prohibited at sporting events. We have discussed the topic of sharkskin as a model for aviation applications in greater detail in another article.
Shipowners benefit from the same principle, with reduced fuel consumption generating significant financial and environmental benefits. It is already the norm in the aviation industry to wrap the outer skin of an aircraft’s fuselage with special materials, either entirely or at key points. You can find out more about the topic of bionics in our article: Bionics – Learn from Nature.

Impossible to imagine an aircraft interior without textiles

The inside of aircraft and spacecraft also depend on the use of many different textile developments. The industry is constantly developing more sophisticated and ever more rugged cables that, unlike rubber or plastics, are coated in hardwearing textiles. They often provide higher levels of durability and resilience. Drive belts are used in engines in the automotive sector as well as aircraft, spacecraft, and onboard ships. While they were primarily made of rubber or flexible plastic in the past, textile mixtures have demonstrated durability in many applications. When fitting out an interior, fabrics have always been part of the landscape – and these hard-wearing, yet comfortable and safe fabrics are vital for covering aircraft and automotive seats. They must demonstrate qualities that matter in everyday use, and it’s just as important for them to be easy to clean as to be fire-resistant and free of pollutants that could evaporate and pollute the air. This last issue was a problem in the 1970s and 1980s when there were hardly any restrictions on the use of synthetic fabrics and dyes. Modern materials such as microfibres, nanotechnology, and new plastics have revolutionised the
The use of textiles in the industry is constantly evolving – © Airbus SAS 2017

Leatherette that neither looks or feels noticeably different from real leather, or sustainably sourced hemp padding for use in upholstery or on the inner linings of armrests and consoles are now technically feasible. Even completely vegan interiors are now becoming possible via the use of high-tech textile products. From refits using high-end materials to factory production that comes straight from the production line, upholstery for aircraft, cars, and other transportation methods has never been as demanding as it is today.

Spider silk could revolutionise the world of engineering

Research into specialist textiles continues to expand, and we may be on the cusp of developments that, though they are still gathering momentum, are already progressing at breakneck pace. Scientists have long been researching potential applications for artificially produced spider silk, which should achieve extremely high take-up rates in industry. Once again, bionics make the decisive difference. Spiders produce an extremely tough thread, which is significantly stronger than steel fibre of the same thickness, yet with equal elasticity. If the scientists succeed in creating a cable made of spider silk that is as thick as a steel cable, the load-bearing and tensile strength, as well as the flexibility, would significantly exceed the equivalent values in steel. In other words, this means that applications that so far have required extremely thick steel cables could achieve significant weight savings by using spider silk. In bridge construction alone, countless tonnes of steel could be
saved, while maintaining the same overall strength. However, steel cables are also used in aircraft and ships, and as such, it may be possible to make use of bionics to achieve more efficient designs. Even in the age of fly-by-wire, where traditional cable and hydraulics-based systems are no longer needed, spider silk could be incorporated into other textile products. Seat frames could become thinner and lighter without reducing their strength, and functional clothing could also benefit from this potential new material.

**Why astronauts depend on functional clothing, day in, day out**

Functional clothing can be bought from high-street nowadays – microfiber T-shirts or shoes with active breathing have become routine, but for astronauts and pilots, clothing of this kind is often a matter of health and even of life and death, due to the low gravitational pull that is felt in space. If an astronaut sweats while working or training, the usual evaporation effect does not occur as it would on earth. Normal functional clothing does not absorb the sweat directly; it remains on the surface of the skin and cannot achieve the necessary cooling effect, with overheating being a possible consequence for the astronaut in question. Special clothing has been designed for use in a weightless environment to address the issue and demonstrates characteristics that make it possible to capture sweat, and the associated odours, on space stations and in spacecraft. On longer missions, such as Mars voyages, specialist textiles will continue to play a major role, not only in forming part of the structure of functional clothing and space suits but also in fitting out the habitats that will need to be built. Once again, weight is vital.
Every kilogramme that needs to be launched in a spacecraft increases both fuel consumption and costs. For that reason, tough textile materials are used wherever space and weight savings are particularly important, such as future accommodation for Mars astronauts that will need to be easy to transport and construct. Like a tent on a campsite, they will unfold to reveal flexible options for their inhabitants. In such a hostile environment as Mars, it goes without saying that the accommodation needs to be 100% safe, both to build and to live in. No one can afford to make any mistakes, and that’s another reason why the development of new technologies in the field of textiles is so exciting. Products that we wear at the gym and in everyday life almost always owe their origins to aviation and space research. Pilots are also dependent on special clothing, such as anti G-force trousers, which prevent the blood from sinking into the lower extremities, or fireproof underwear, which can even be liquid cooled if required in the specific application; without developments such as these, the space and aviation sectors would still be in their infancy, especially in terms of test flights.

The beginnings of an exciting development

The future of modern textiles in the aviation sector, in aeroplane interiors and bodies, as well as in functional clothing, will be vital for the future development of high-performance aircraft and spacecraft. Low weight, high strength, cost efficiency, ease of working with the materials, and safety are all parameters that can only be achieved using other materials with difficulty, if at all. Innovations, such as incorporating bionics into the development of new textile solutions, will open completely new solutions for engineers and scientists. Before the theory can be put into practice, the challenge of developing efficient production processes will always remain, so that ideas such as versatile spider silk can be transformed into a practical reality.

Already, aircraft and cars are being built using fabric panels that demonstrate strength and stability that is comparable to metal. This greater flexibility is made possible by construction techniques that would scarcely have been practical in the past. Weight reduction, corrosion resistance and energy saving (e.g. by reducing friction) are aspects that are financially, environmentally, and politically important. The less fuel that an aircraft or ship uses, the more efficiently it operates – and the better the outcome for the environment.

ARTS is also involved in researching and developing new innovations and provides experts with the opportunity to successfully take part in the process. Our network enables us to assign dream jobs to passionate engineers and other specialists who can enhance our team with their fresh ideas. Upholsterers, fitters and process mechanics benefit from deployment options at ARTS as well as textile and fibre composite engineers. Visit our job board, apply for a role, and work with us to bring the industry’s goals a step closer.

Sources: avronline.de | ESA | INGENIEUR.de | Lindenfarb | SWR
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