

Media communiqué

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Flexible and yet strong: compliant systems

«Clever» Materials Just Bend!

Empa researchers once wanted to build aircraft wings based on compliant systems, which would continually change shape in response to the air flow resistance, obviating the need for rigid flap and rudder surfaces. A range of different industries are interested in so-called “smart” systems because they can be used to make low-maintenance (and therefore economic) products such as medical tools and robot gripper arms.

Those who witnessed the first takeoff of an Airbus A380 Superjumbo from Zurich airport at the end of January know that elegant is not the right word for the aircraft. On the other hand it is perfect to describe a crane as it leaves the ground, rising in a seemingly weightless fashion. This is not just because of the difference in size and weight – the bird uses its flying surfaces in a completely different manner to the machine. It steers itself by continually varying the geometry of its wings. Flavio Campanile, head of a research group in Empa's Mechanics for Modeling and Simulation Laboratory, is convinced that aircraft can be made which move more elegantly and, above all, more economically through the air. “Sooner or later it will be possible to make wings without ailerons, flaps and thousands of individual parts. They will have in principle only one component, which continually changes shape.” Biomimetic wings – that is, those based on designs seen in nature – adapt perfectly to the airflow around them, and are light and energy efficient.

In order to put his ideas into practice, Campanile developed so-called «compliant systems» at Empa and the ETH, initially by himself and thereafter with a team of twelve colleagues. But aerodynamic surface design is not the only field in which the engineer is active. Campanile also intends to tackle concrete problems facing industry by making use of compliant systems. “Wherever machines are at work, compliant structures can be used to bring improvements,” Campanile is convinced. In order to persuade industry of the gains to be made by using compliant systems, he has been financially supported by the Gebert Ruef Foundation for three years.

Solutions to industrial problems

As a result of his efforts, Campanile has succeeded in convincing diverse industrial partners from the medical technology and robotics fields of the advantages in using these novel systems based on innovative materials. In cooperation with these companies he has developed a range of solutions for instruments and tools which are made in one piece and therefore superior to the conventional devices they replace which use

joints and hinges. The latter are complicated and expensive to produce and assemble, and also not cheap to maintain.

Compliant systems made of materials such as plastics, metal and composites are so designed that they transmit forces without using joints. They change shape because the material from which they are made undergoes elastic deformation, not through the use of rigid components which slide or roll over each other. This means that the new instruments suffer less wear and tear.

A robot gripper arm developed by Campanile's team consists of only 32 individual parts, is 60 per cent lighter than a conventional equivalent and costs about 98 per cent less to manufacture. "These figures must make car designers and mechanical engineers ears' prick up. To date they have made use of hardly any compliant structures," maintains Campanile.

Success and the next steps

Michael Sauter, a colleague of Flavio Campanile, is one person who has successfully used the new technology. In a feasibility study he showed how a special bed using compliant structures could be used to prevent bedridden patients from developing bed sores. His idea has already won him several awards. Sauter is now working in his Empa spin-off firm, compliant concept GmbH, to bringing the nursing bed to the market in the near future.

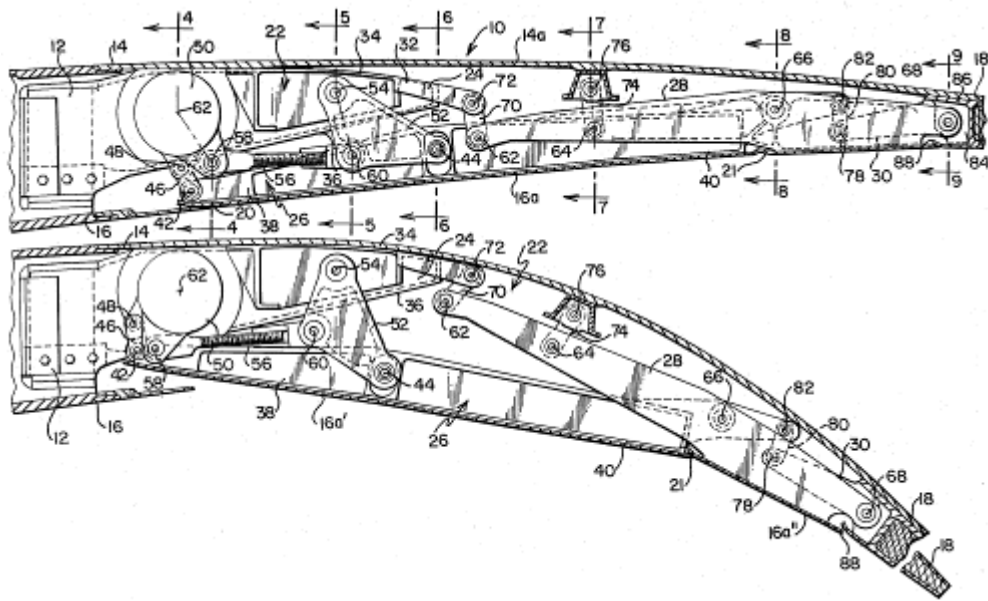
Campanile himself prefers to carry on his research. "Designers and manufacturers expect a great deal, and the solutions are often very complex," he explains. Currently two of his co-workers are working on doctoral dissertations at the ETH Zurich's Centre of Structure Technologies under the guidance of Paolo Ermanni. One is investigating ways to combine compliancy and lightweight construction techniques; the other is developing "active aeroelastic" wings which adapt to aerodynamic flow by changing shape, requiring practically no external energy to do so.

Further information

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Construction drawing of a wing which adapts its shape to suit the airflow, designed using conventional mechanical engineering technologies. This kind of device was never manufactured. (US Patent, 26.01.1982, 4,312,486)



An adaptive wing support structure can be constructed using compliant systems. It can be molded in one piece.



Economic machine tools can be made using intelligent, compliant material systems. The gripper arm on this robot is also manufactured from a single mold.

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