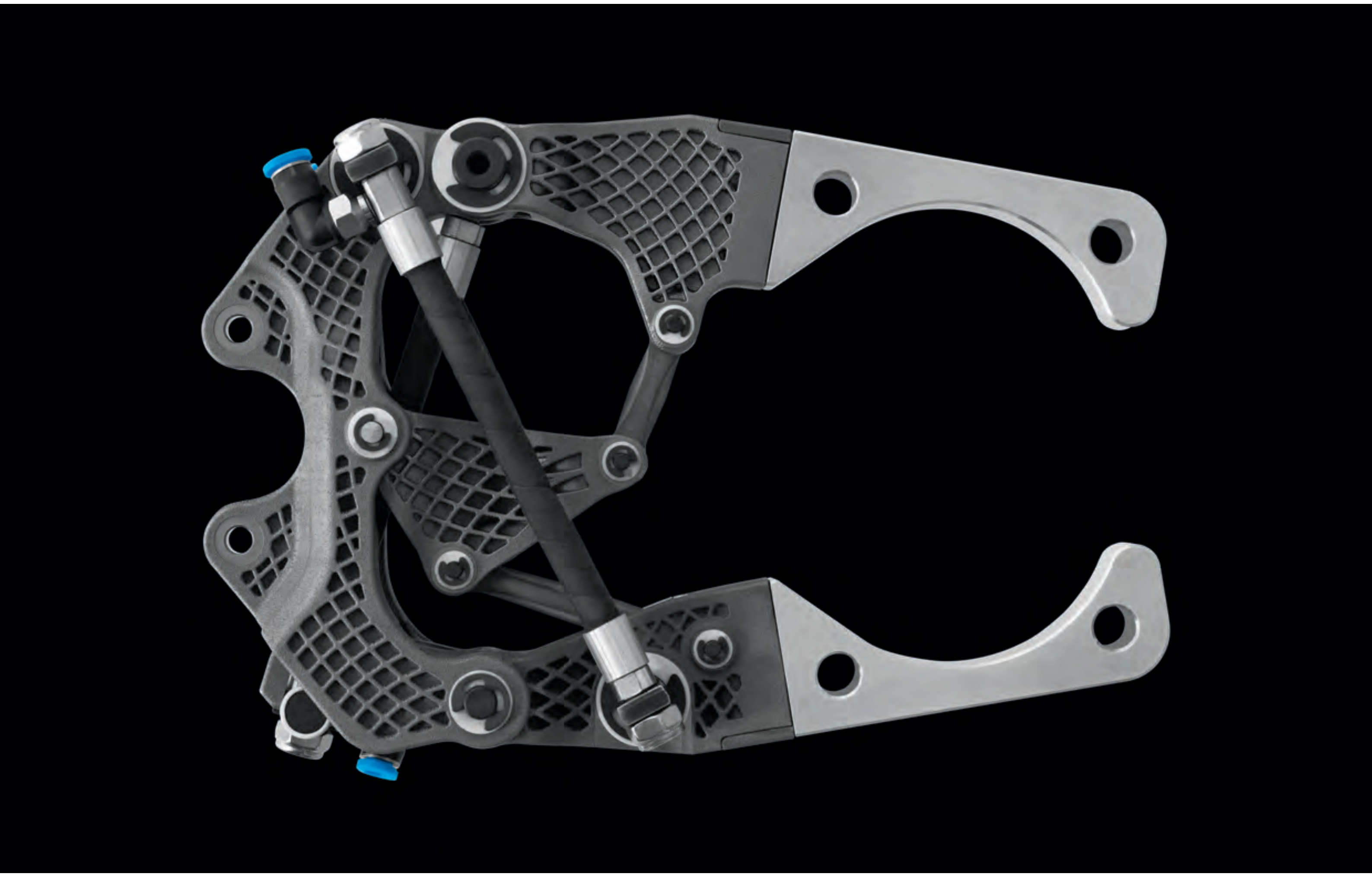
PowerGripper



Grasping concept
on the model
of the bird

Research project for the development of new gripper systems

PowerGripper is a university project conducted as part of the Bionic Learning Network. Together with renowned educational establishments, institutes and development companies, Festo is investigating the transfer of biological principles to technology in order to generate innovative solutions for industry.

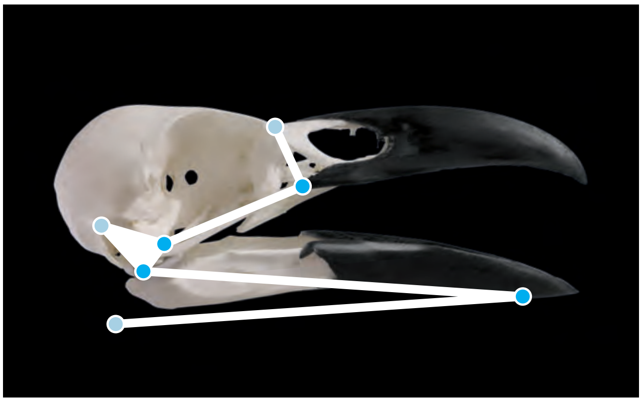
Kinematics of the bird's skull
The concept of the PowerGripper dates back to a lecture by Prof. Dr. Martin Fischer, Professor of Systematic Zoology and Evolutionary Biology at the Friedrich Schiller University of Jena. In his presentation on the topic of gripping systems in biology he discussed, among other things, the complex kinematics of the bird's beak, which had been described in 1994 by Dr. Cornelius Schilling and Dr. Klaus Zimmermann, both of the Ilmenau University of Technology.

In mechanical terms, this kinematic principle is referred to as Watt's linkage. It provided the basis for the consideration of gripper systems: the variants that were realised took the form of planar grippers, spatial grippers and point grippers. The following is a description of the planar gripper.

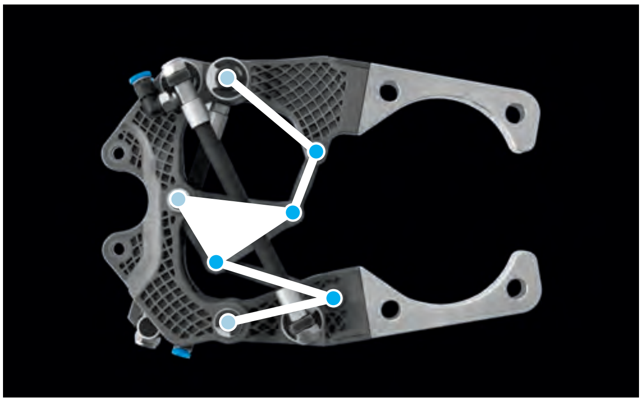
Bionic principles and new production processes
In the PowerGripper project, the developers implemented this bionic principle using the Fluidic Muscle from Festo and combined it with the production technique of metal laser sintering.

Realisation with the pneumatic muscle
The DMSP-5 Fluidic Muscle is the driving force behind the gripper concept. It employs the principle of antagonistic muscles, in which flexor and extensor muscles operate in pairs. When the pneumatic muscle is filled with air, it increases in diameter and is contracted in length. The muscle allows flowing, elastic movement for implementation of the principle of Watt's linkage.

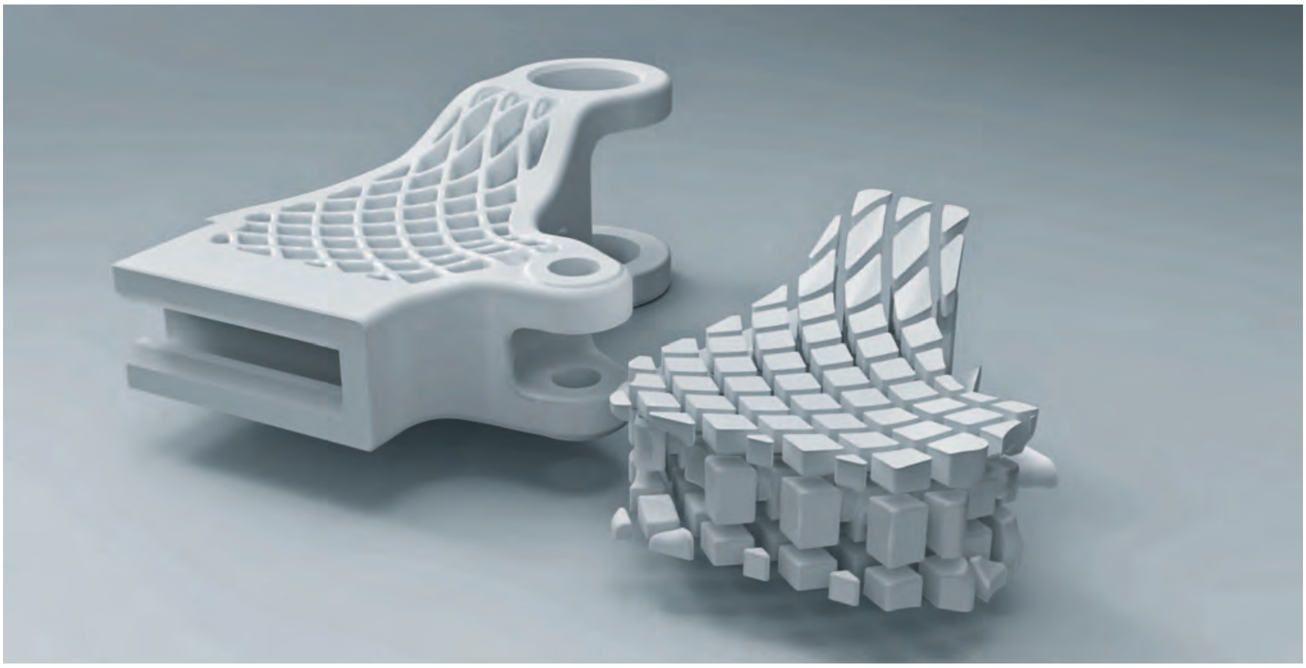
Optimised force-to-weight ratio
With this Watt's linkage, relatively large opening strokes can be realised within a highly compact installation space. Thanks to the lightweight structure, along with the the very light pneumatic muscle and a titanium alloy (Ti6Al-4V) as the material for the basic components, the PowerGripper from Festo attains a very favourable force-to-weight ratio.



Bird-skull kinematics: model for the PowerGripper



Transfer to technology: the gripping principle of Watt's linkage



Lightweight structure with optimised force flow: reduced tare weight and material savings with the laser-melting process

Unique form-finding with generative manufacturing
The lightweight structures on the interior and exterior of the PowerGripper are designed in accordance with the forces acting on the component and can only be produced in this form by means of the metal laser sintering process, in which the metallic powder is melted, layer by layer, by means of a laser beam controlled by 3D CAD data. This provides unique opportunities in form-finding and allows individualised 3D printing of complex products.

Mechanical kinematics of the Watt's linkage
The mechanical components of the PowerGripper comprise a basic element, two finger elements, a push and traction rod and a deflection triangle; these constitute the kinematic elements of the Watt's linkage.

On the underside of the basic element, two holes are provided for mounting the gripper – for example to a robot. Mounted on the top are three axis mounts for the finger elements and the deflection triangle, along with the recesses that ensure freedom of movement for the opening of the fingers and for deflection of the triangle. The three axis mounts also form an imaginary triangle as the fixed points of the Watt's linkage.

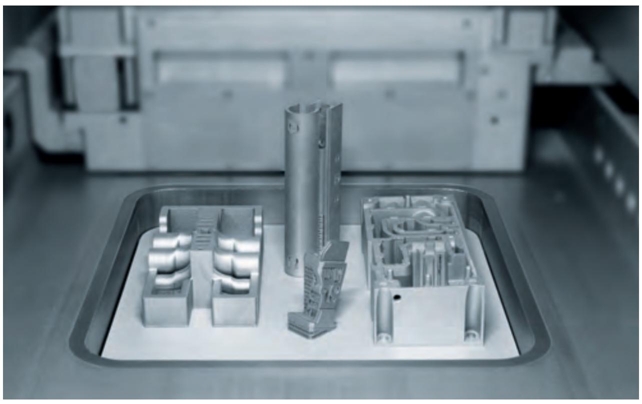
Reduced tare weight and maximum opening stroke
The PowerGripper is 200 mm high, 123 mm wide and 39 mm deep. Its maximum opening stroke is 56 mm. The use of the titanium alloy for the mechanical components has enabled the developers to achieve a tare weight of only 482 g.

Flexible choice of gripper fingers for versatile application
The two finger elements are provided with a standard T-slot for the multi-purpose accommodation of various different fingers; they thus permit a wide range of practical applications for gripping light to medium-heavy objects.

Impetus for new gripper concepts
As a research project, the PowerGripper from Festo demonstrates a great number of opportunities for the development of new gripper systems. Thanks to the lightweight and yet highly stable superstructure of the gripper, the entire system could also be produced in lightweight design; this in turn makes for more energy-efficient operation. To date, this had been difficult to achieve in conventional grippers in view of their less favourable ratio of gripping force to tare weight.

Moreover, with a conventional gripper the wide opening and closing stroke can only be achieved with a larger overall design. The consumption of compressed air is substantially lower than with a conventional gripper, in view of the use of muscle drive in connection with the highly efficient kinematics.

Thanks to the wide opening stroke, components of different sizes can be handled using one and the same gripper. In addition, a variety of different gripper jaws can be mounted to the interface provided for this purpose; differently shaped workpieces from various areas can thus be handled.



Metal laser sintering process: generative production of diverse components

Technical data

- Height: 200 mm
- Width: 123 mm
- Depth: 39 mm

- Maximum opening: 56 mm
- Weight: 482 g

- Production: metal laser sintering process
- Material: titanium (Ti6Al-4V)
- 3 DMSP-5 pneumatic muscles with QSML-M3-4 ports

Project partners

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Idea and presentation first published in 1994 by
Dr. Cornelius Schilling and Prof. Dr. Klaus Zimmermann, both of
TU Ilmenau, published in Rundschreiben der Gesellschaft für
Technische Biologie und Bionik, No. 13, 10/1994

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