

# Apium P220

Cost- and time-efficient production  
of a clutch hub via 3D printing

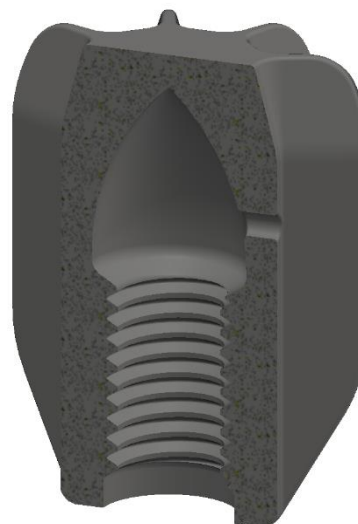
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Case Study

INFORS **HT**



PRODUCTION &  
ASSEMBLY

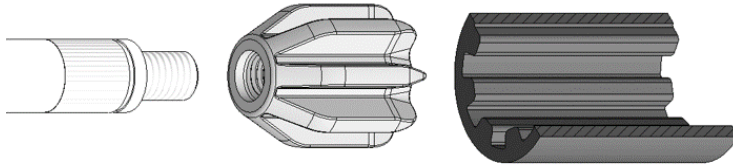


**Apium**  
Additive Technologies GmbH

## Description and results

### Topic

The present bioreactor coupling hub is currently made of stainless steel (316L) using the SLM process (Selective Laser Melting, metallic 3D printing). For economical reasons, an alternative manufacturing process is strongly recommended.



*Image 1: Installation position of the coupling hub with a shaft and a coupling socket*

The component must meet the following requirements:

#### *Geometric requirements:*

- Standard-compliant M8 internal left-hand thread for connecting the stirrer shaft
- Exact gear geometry to ensure clean form fit with coupling socket

#### *Mechanical requirements:*

- Fatigue strength of the gear at least as high as that of the coupling socket made of polyurethane
- Minimum tolerable pull-out torque of the M8 thread: 4 Nm
- Surface pressure at the contact surface to the stirrer shaft within the permissible range

#### *Thermal requirements:*

- No deterioration in the mechanical properties during repeated autoclaving (up to 500 cycles at 121 °C with wet steam for 30 min each)

#### *Further material requirements:*

- Corrosion resistance, especially due to autoclaving cycles
- Abrasion resistance when pairing with coupling socket

Both the **FFF process** (Fused Filament Fabrication) and injection moulding are suitable for the production of the machine component. For this reason, it is necessary to determine which process offers the greatest cost-saving potential for a given number of parts. Due to the mechanical and thermal loads as well as the potential need of reworkability for thread cutting, **30% carbon fibre reinforced PEEK** (CFR-PEEK) is identified as a suitable material. By integrating the thread into the 3D printing process, reworking can be reduced or ideally completely avoided.

In order to create a clean thread, a standard M8 left-hand thread slightly undersized is printed with the Apium P220 machine. With minor post-treatment it is possible to achieve the correct thread size for the machine component.

## Results

The **pull-out torque** is measured to determine the mechanical load capacity of the thread at **19 Nm**, which is far above the requirements. In order to analyse the surface pressure and the creep behaviour of the coupling hub at the critical contact surface to the stirrer shaft, a load test is carried out over 72 hours with a torque of 4 Nm. **No significant deformation** of the material can be detected. The **abrasion resistance** is verified after a 30-day endurance test under real operating conditions.



*Image 2: Micrographs of the 3D-printed clutch hub*

With the help of microsections, the inside of the clutch hub can be analyzed and potential air inclusions identified. Small pores are visible around the overhangs. In the rest of the component, the material structure is very dense and without significant inclusions. It is conceivable that by optimizing the geometry, the number and size of pores in the entire component can be reduced if this is necessary for the component functionality.

## Cost comparison of manufacturing processes

Figure 3 shows the manufacturing costs of the coupling hub as a function of the total number of units for different types of production. SRM AG has calculated the costs for the production of the machine component using machining and FFF processes. The SLM and injection moulding costs are calculated by Infors HT and its external suppliers. For each manufacturing process, a suitable material is individually selected for the specified requirements.

It has been shown that the FFF process offers significant savings potential compared to the SLM process, especially in the area of small to medium quantities. Furthermore, due to the high mould costs for this component, injection moulding only has economic advantages over the FFF process in the area of a total volume of more than 1000 units. For small batches of up to 100 pieces, the FFF process also has **significant cost savings** potential in relation to machining processes, especially for complex component geometries. This is due to the low set-up costs, such as the preparation of the G code and the machine preparation time, as well as the optimum material utilization.

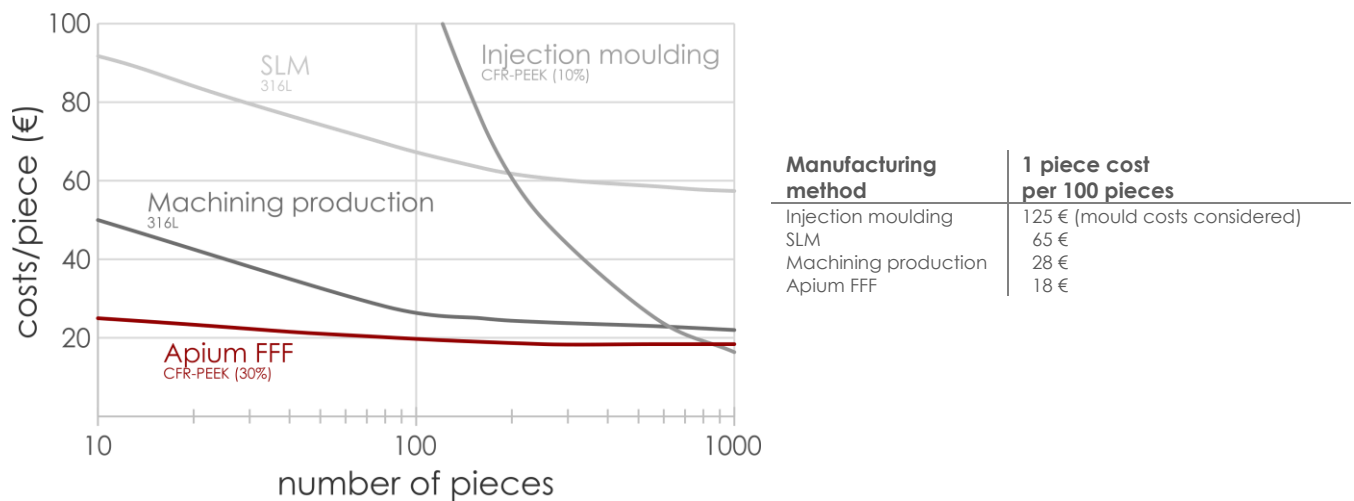


Image 3: component costs of the respective processes

## Conclusion

This case study illustrates the advantages of additive manufacturing with high-performance polymers using the FFF process for producing relatively simple machine components in small to medium quantities. For the present clutch hub, the **superior profitability** of the FFF process over the other manufacturing technologies is obvious, especially over injection moulding, which only pays off for this component once reached the production of approx. 1000 pieces and without the flexibility of a component modification during the production process. It is to be expected that the cost savings with the FFF process will offer even **greater potential** for much more **complex components**.

Whether a component is suitable for additive manufacturing with high-performance polymers must be identified on the basis of the loads and requirements, material selection and design. As soon as the 3D printed part can meet the geometric and physical requirements, an **economically attractive overall package** results.

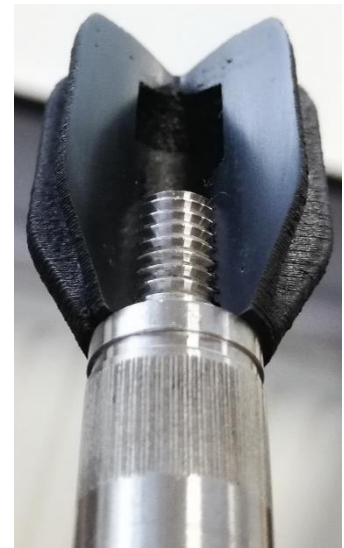


Illustration 4: ¾-cross section in mounting position

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