AMRC ADVANCED MANUFACTURING RESEARCH CENTRE

The University Of Sheffield.

Design and Prototyping Group
Case Study

Design of components with critical part geometry for testing of new manufacturing processes

The AMRC Design and Prototyping Group (DPG) outlines a method for streamlining part family verification for AM processes developed as part of the Horizon 2020 Symbionica project.

Additive manufacture (AM) can offer advantages when compared to traditional machining processes. The AM process can produce components with complex form, providing flexibility that allows frequent changes to component design and offers reduced lead times for certain component geometries.

Deviations from CAD nominal geometry can occur when producing components using AM; but the AMRC has trialled methods for correcting small build deformations in AM components, with good results. While correction methods work well for single components, many thousands of unique combinations of variables may exist for a single part family, and traditionally each unique combination would require verification using the AM process.

The AMRC DPG are a consortium partner in the Symbionica project, which aims to develop a new type of AM process; allowing the rapid manufacture of personalised smart prosthetics. As part of Symbionica, personalised versions of hip, knee and spinal implants, as well as a foot exoprosthesis are to be produced using the newly developed AM process.

Certain prostheses parameters can be set to exact values to suit individual patients; effectively creating part families with infinite unique combinations. As production and verification of every possible prosthetic would be impossible, DPG have developed a method of combining key component geometries to create test components.

The prostheses considered as part of the Symbionica project contain multiple parts with a variety of materials. Individual components were grouped based on their material and key geometries selected from each component. Key geometries were combined to create new test components, each comprised of a single material.

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The collection of developed test components were designated a Round Robin Part Family Description (RRP). The RRP was used to evaluate the performance of the Symbionica process during development, and is currently being used in commissioning trials of the new machine.

Details of how geometries were combined to create RRP components can be seen below.

Designed by **DPG**

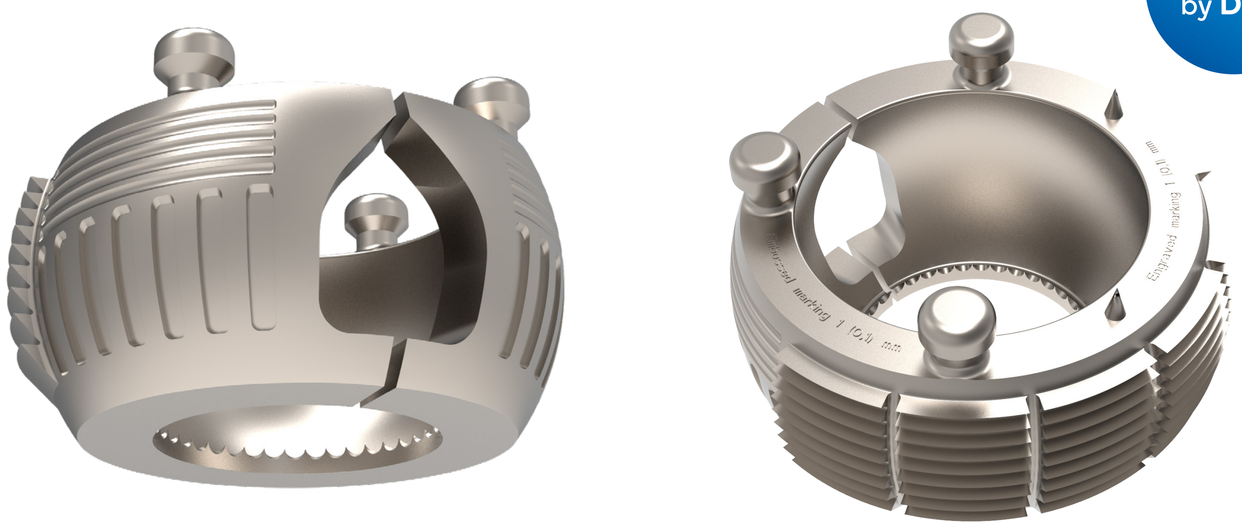

Figure 1: **Ti6Al4V RRP**

The Ti6Al4V RRP **(Figure 1)**, has been designed from key characteristics from four products:
the UKA Tibial Fixed Baseplate, Versafit Cup, Fermoral Stem and a Spine Implant.

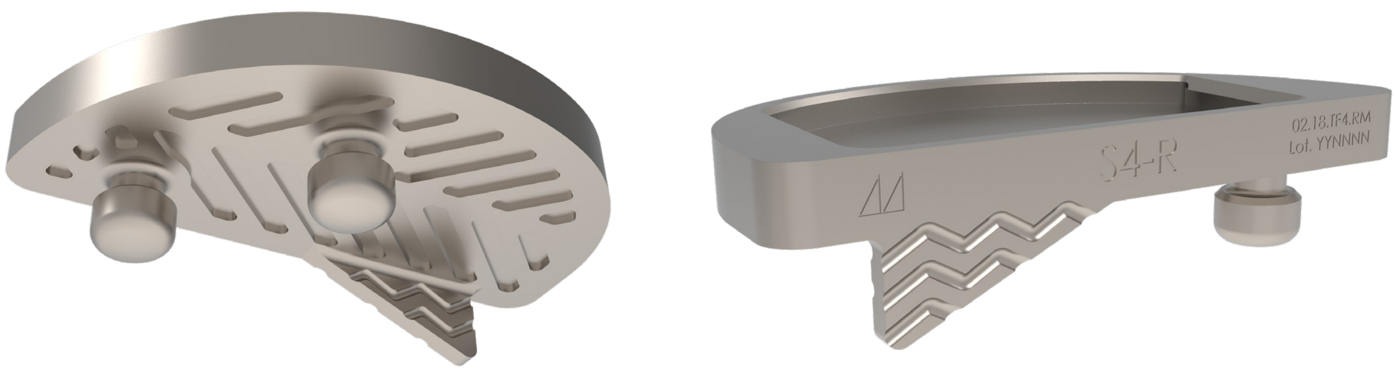

Figure 2: **UKA Tibial Fixed Baseplate**

Characteristics taken from the **UKA Tibial Fixed Baseplate (Figure 2)** include:
Macrostructures for bone cement fixation, engraved marking and features for fixation of the insert.

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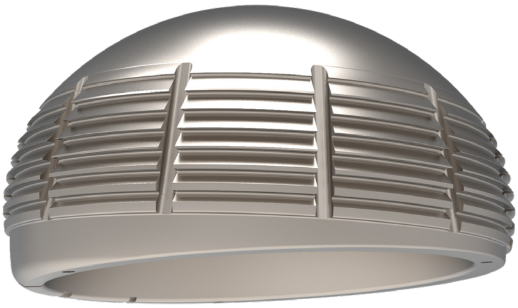

Figure 3: **Versafit Cup**

Figure 4: **Fermoral Stem**

The main characteristics taken from the **Versafit Cup (Figure 3)** and the **Fermoral Stem (Figure 4)** were the 3D pyramidal net structures for optimal bone anchorage, including the slots in the net structure.

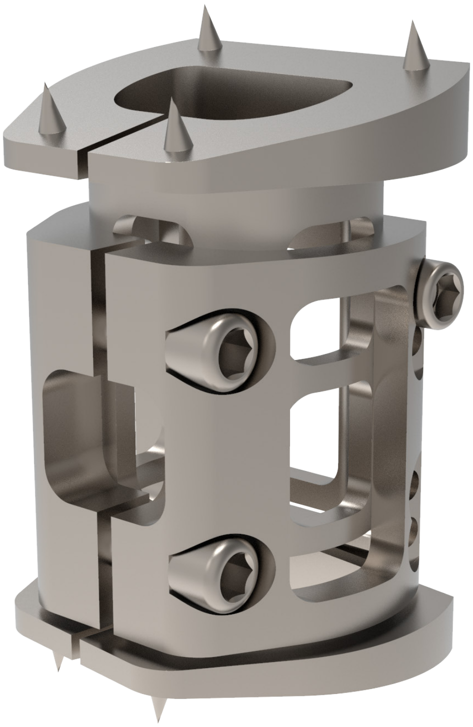

Figure 5: **Spine Implant**

Characteristics taken from the **Spine Implant (Figure 5)** include: Split throughout the front of the component for fixation, spikes for anchorage, longitudinal pass-through channel to bone ingrowth;and openings for bone substance filling.

Designed by **DPG**

Figure 6: **CoCrMo RRP**

The **CoCrMo RRP (Figure 6)** has been designed from key characteristics from two products: the UKA Femoral Component and the Fermoral Head.

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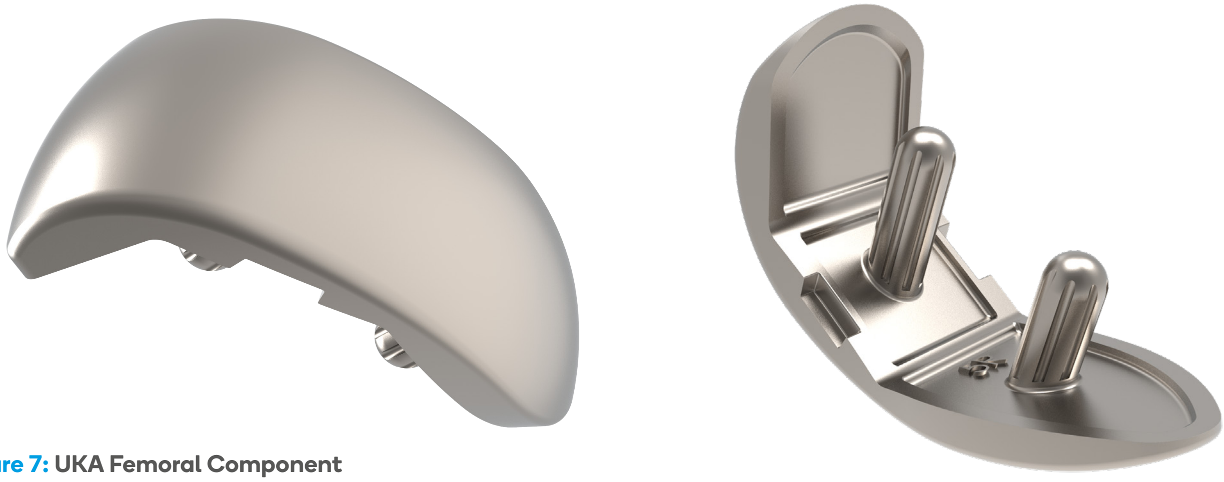

Figure 7: **UKA Femoral Component**

Characteristics taken from the **UKA Fermoral Component (Figure 7)** include: recessed feature on the sides aiding implant positioning and/or removal, flat internal pockets for bone cement fixation, rounded edges, microstructures on pegs for greater fixation and a complex freeform surface with mirror polish for smooth movement.

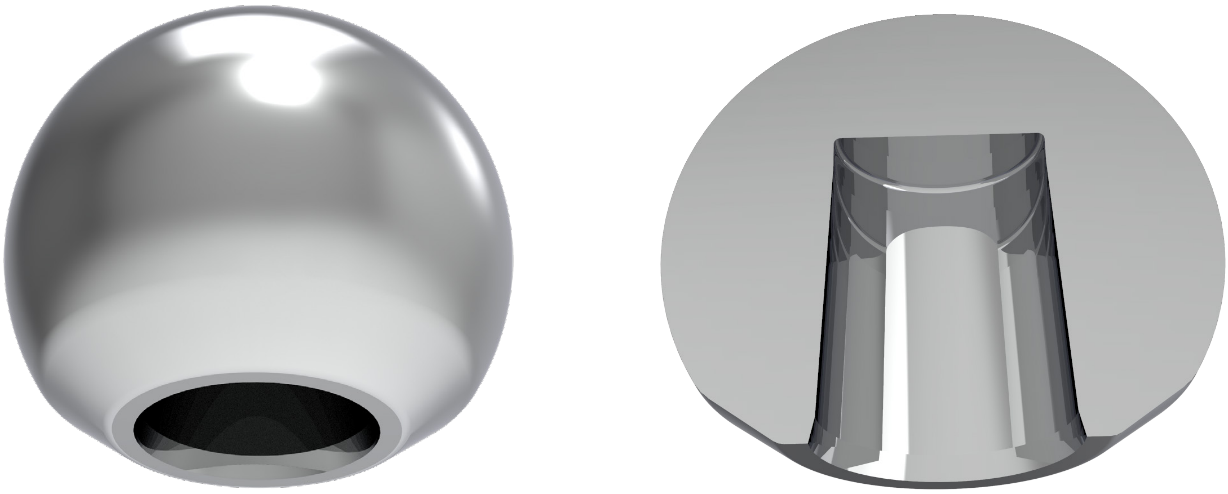

Figure 8: **Fermoral Head**

Characteristics taken from the **Fermoral Head (Figure 8)** include: smooth external surface, tapered hole and the parallel hole.

The RRP's detailed above are being used in the first stage of commissioning trials for single material components. It is hoped, however, that the process can be developed sufficiently to eventually produce multi-material components.

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DPG has also developed a concept design for a multi-material RRP component.

This is a three material RRP (PEEK, CoCrMo and Ti6Al4V) which combines all critical geometries from the prostheses components manufactured in those materials. **See Figure 9.**

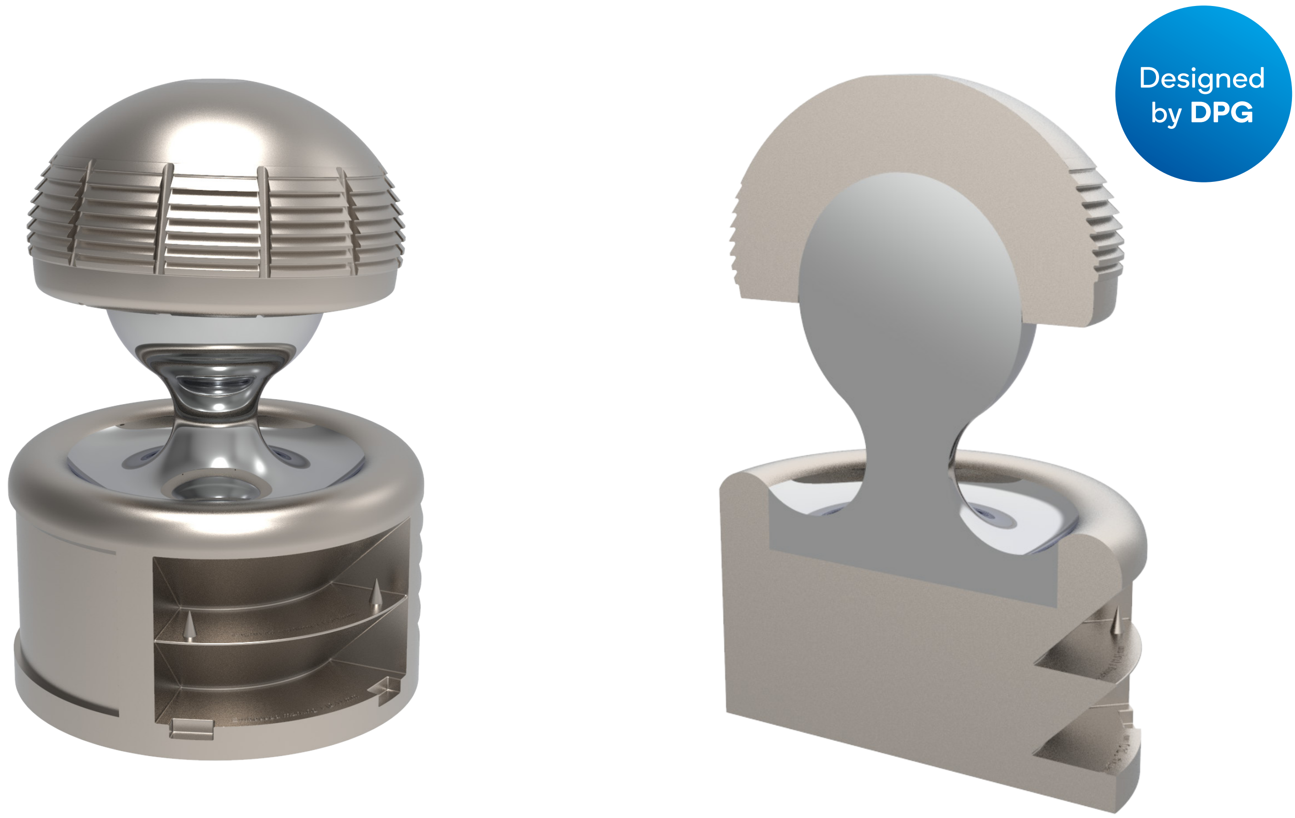

Figure 9: PEEK, CoCrMo, Ti6Al4V RRP

Although the process detailed here was developed specifically to validate new AM processes for prostheses, it is thought that it is general enough to be applied across other industries.

As the adoption of AM processes increases, it is thought that the number of personalised and part family type components will increase. The process outlined here could present a viable streamlined route for the verification of AM processes for production of these part families.

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