CASE STUDY

A 2023 Grand Prize winner in the Medical/Dental category for metal additive manufactured components

Surgical Implement Articulation Joint and Pivot

Process:
Metal Additive Manufacturing (AM)

Material:
17-4 PH stainless steel

General Tolerances:
+/- 100μm

End Use and Function
The articulation joint and pivot assembly is part of a surgical implement for performing laparoscopic heart surgery. The instrument is used to gently lift the heart, granting access to the surgeon to the back of the heart. The instrument consists of a paddle mounted on a laterally pivoting beveled nut, which is inserted up underneath the heart through an incision made below the ribcage, and a jointed shaft onto which the nut is threaded, which is inserted into the patient from the front, between the ribs. The ideal pressure distribution for gently lifting the heart and minimizing tissue bruising can be achieved between the forward/backward pitch, controllable by an adjustment knob on the instrument, and the yaw degree of freedom of the paddle on the nut.

Fabrication
This three-part assembly is built by depositing 100μm layers of powder, bonded uniformly edge-to-edge, and then machine the features on a per-layer basis until the parts are fully built. Once part printing is complete, parts are separated from supporting surrounding material and staged for sintering.

After sintering, secondary operations include machining threads between the distal side and camming pivot component, to align the angle of articulation and degree of freedom of pivot. The customer performs final assembly, which includes reaming holes and installing pivot pins, laser welding the proximal end portion of the joint to a shaft and grinding the pivoting joint assembly to its finished diameter.

These components are difficult to produce with high yields in traditional manufacturing methods given the need for timed threads, internal channel clearances, and precisely matched mating features to provide a robust connection and the mechanical rigidity needed for the intended function in the hands of surgeons. A hybrid manufacturing process that starts with printed parts which are then processed in a repeatable manner produces high strength parts economically, and pairs well with downstream processing steps needed.

Results
Metal additive manufacturing was selected over prior production techniques due to the difficulty and complexity of producing the complex internal part geometry needed to facilitate the joint, and the timing of the threads between the nut and distal end of the joint assembly.

The annual volume for this component was above the cost effectiveness in machining, but not sufficient to justify MIM tooling. It also increased supplier resilience/diversity for the customer. The AM assembly is simply easier, faster, and cheaper to produce than the machined version, while performing to the same rigorous quality standards.