Oldland CNC favours the Hermle five-axis vertical machining centre for its mineral casting bed and the rugged construction of its swivelling trunnion, which is an integral part of the machine construction

Five-axis machining

Aerospace sub-contractor discusses the merits of this process, plus the importance of volumetric accuracy

Bristol-based Oldland CNC was already an established user of five-axis machining for the production of medium-sized aerospace parts, but at the beginning of 2006 the company saw the need to extend its use of this technology to the manufacture of smaller components falling within a nominal half-metre cube. From a short-list of five 40-taper machines, Oldland chose a Hermle C 600 U vertical-spindle machine with a 600 × 450 × 450mm work envelope and a 30-tool magazine. It was supplied in March last year by the German machine manufacturer's sole UK agent, George Kingsbury Machine Tools Ltd, Gosport (Tel: 023 9258 0371).

Although Oldland makes extensive use of fully interpolative five-axis profiling for producing aircraft parts that incorporate complex surfaces, full five-axis machining on the Hermle accounts for only 10% of its production. The remaining 90% is 3+2-axis work, with two axes clamped while the others perform the cutting cycle.

Managing director John Tucker says: "Smaller aluminium brackets on aircraft do not generally include complicated features needing full five-axis machining. However, simpler geometries benefit just as much from being milled on five sides in one hit using a five-axis machining centre, rather than in several set-ups on a three-axis machine.

"We regularly evaluate components being produced on our three-axis machines, looking for parts that will benefit from being positioned under CNC in a sequence of compound angles on the Hermle and milled using the other three axes. This approach can save one or two re-clampings and subsequent operations, leading to significant savings in production costs, particularly for larger-batch work."

Engineering manager Steve Hayes suggests that moving all five axes simultaneously should be a last resort, as any five-axis machine will run more productively in three axis mode. "The complex calculations that the control has to carry out prevent the use of fast feed rates in full five-axis profiling. Furthermore, the machine is only as quick as its slowest axis — usually the rotation of the table. If that is one of the axes that are clamped, machining speed is increased."

Assured precision

High accuracy is a priority at Oldland, which is why a co-ordinate measuring machine is used to inspect every component before it is delivered. However, accuracy comes from the machine, not from verification of its results. A feature of the Hermle machine that Mr Tucker particularly likes, because "it promotes precision machining", is the mineral casting that forms the bed. The material used provides dynamic stability and up to 10-times better vibration-damping characteristics than steel or cast iron, especially at high spindle speeds and feeds.

"Moreover, it is not a finely powdered mineral. If you look at a cut-away section of the bed, as we did when visiting the

Oldland uses its Hermle C 600 U to machine this aircraft gearbox bracket on five sides and from solid, in one hit

Hermle factory, you can see large pieces of granite embedded in the compressed matrix."

Another design attribute highlighted by Mr Tucker is Hermle's patented arrangement of three staggered Y-axis guideways, one of which is positioned between two outer ways and further back. This layout effectively halves the span and gives stable traverse, thanks to a three-point support combined with a single drive that is in line with the central carriage on the gantry.

Volumetric accuracy

Mr Tucker says that the name of the game when producing high-accuracy components, especially large ones, is not the repeatability of the machine tool but its volumetric accuracy. "Manufacturers are often reluctant to disclose this accuracy, being content to quote positional accuracy and repeatability. For all our machines, we measure volumetric accuracy ourselves, using a calibration ball in conjunction with a probe in the spindle. It is the only way to determine how accurate the features in a component will be — relative to one another — if they are machined in diametrically opposite corners of the working area. When we checked the C 600 U, it had a total volumetric accuracy of 50μm over the entire machining envelope, which I regard as excellent for a machine of this size moving in five axes."

Much of the work going through Oldland's machine shop is for the Airbus family of aircraft — A300/310, A320, A330/340 and A380. Round-the-clock operation continues from 6am on Monday until 4pm on Friday. The Hermle's maximum spindle speed of 16,000rev/min is frequently used, although 12,000-14,000rev/min is more usual, the elevated speeds allowing cutting feed rates of 5-10m/min and high rates of metal removal (a 40,000rev/min spindle is an option for this machine). Also enhancing productivity are an acceleration of 5m/sec^2, a rapid-traverse rate of 35m/min (on all three linear axes) and a tool-change chip-to-chip time of 5.5sec.

Other factors influencing Mr Tucker's selection of the Hermle, rather than one of the other machining centres on his short-list, include the fact that the ±115deg swivelling trunnion carrying the 280mm-diameter rotary table is an integral part of the machine construction, with the trunnion bearings set directly into the sides of the bed casting (some other machines offered a less robust solution involving a two-axis compound table bolted to the bed).

Furthermore, all of the 24 machining centres that Oldland had when selecting a new five-axis machine had Heidenhain controls (to allow operators to swap easily between machines), so the Hermle also had to be fitted with a control from that supplier — in this case, an Ethernet-enabled Heidenhain iTNC 530. Programs for this are generated and verified by systems that include Catia V5 CAD, MasterCam and CG Tech's Vericut for simulation and tool-path veification.