83 minutes saved on aluminium aero engine component machining

Use of a Horn Type 313 groove milling insert located on a tungsten alloy heavy metal toolholder, in place of a Woodruff type high speed steel cutter, reduced a single machining operation cycle time from 90 minutes to 6 minutes 30 seconds at Lucas Aerospace, Birmingham. The overall operation cycle time concerned has, as a result, reduced from c. 7 hours to 5.5 hours per component. Because the part is machined in batches of five or ten, the cumulative time saving over a batch is between one and two eight hour machine shifts on a costly four axis horizontal machining centre.

Lucas Aerospace, an operating division of LucasVarity, is a world leading supplier of high integrity systems and equipment to the global aerospace industry. The Shaftmoor Lane plant in Birmingham manufactures engine fuel control systems and fuel-powered hydraulic actuators for many of the world's leading aero engine manufacturers.

These comprise a combination of mechanical, electromechanical and electronic components which are shipped as ready-to-fit entities. Paramount considerations in design and manufacture are light weight, compact dimensions and total reliability in service.

In recent years the company has sought to parallel the quality of its end products in the efficiency of its manufacturing facilities. There has been heavy investment in advanced CNC machine tools to replace older CNC and manual equipment.

The Horn tooling application, for instance, is on a CNC horizontal machining centre; operating as a cell comprising a second identical machine and a five axis vertical machining centre, these three have replaced over twenty older machine tools.

Mike Mallett, one of Lucas Aerospace's manufacturing engineers explains. "These machines in themselves have provided major improvements in efficiency by combining multiple operations into single set-ups. However the company has embarked on optimising the manufacturing processes; that entails a lot of tooling development work as there is a wide variety of relatively small volume components involved."

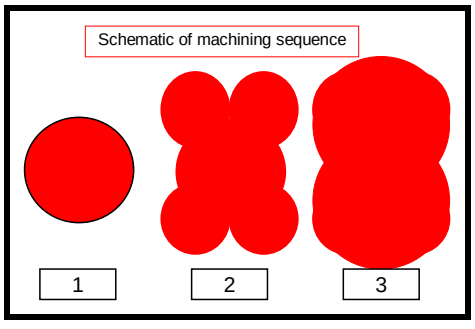
The Horn tooling is applied to a single machining operation on a family of fuel metering unit bodies. This component is manufactured from a rectangular billet of low silicon aerospace grade aluminium which is subject to facing, milling, drilling, boring and threading or tapping on all six faces . The machining operations reduce workpiece weight by around 50 per cent, producing a highly complicated component with a labyrinth of intersecting bores and chambers.

The machining sequence is as follows:-

1. Two operations on the four axis machines with the billet located on a cuboid fixture. Op 1 provides the primary location features which are used to align the part for all subsequent machining.
2. Two five-axis operations which produce all angled holes from the front and back faces.
3. A so-called 'Spinner' operation in which the component is located on top of a cuboid fixture for machining of all side features. This entails use of the machine's fourth axis for positioning in 90 degree increments.

Many of the higher volume metering units incorporate an 'ovoid' passage - the shape resembles an opened out figure 8 with flats at the 12, 3, 6 and 9 o-clock positions - which is accessed for machining purposes through a threaded hole. The passage is about four inches long and intersects a wider, circular section bore at right angles. Two pre-drilled small diameter holes intersect the ovoid passage from above and below at points along its length.

Limited access precludes the passage being machined by drilling/boring a pair of intersecting holes. Instead the method adopted to produce this feature is to drill a through hole (See 1 below) which is then single point bored to the minimum diameter across the flats. Material is then removed at the top and bottom of the circle in an operation that results in a cross section that approximates to diagram 2 below. More material is then removed to profile the passage to the final form (3).



Mr Mallett explains. "The tooling that we used initially was inherited from the previous production process. Poor tool rigidity and single point cutting limited feed rate and spindle speed to 25 mm/min and 200 revs/minute. We were almost polishing the passage to shape which is why we had a 90 minute cycle."

The operation was a prime candidate for the programme of tooling improvement currently in hand at Lucas Aerospace. Experience with Horn grooving tools on turning operations elsewhere in the factory led to Horn UK being approached to suggest a solution for this operation. No-one was quite prepared for the impact that the Type 313 groove milling insert/high rigidity bar combination had on the task.

"When we first tried the Horn tooling a significant improvement was expected but I couldn't believe how fast it did the job." Mr Mallett recalls. "From 25 mm/min and 200 rev/min we went to 550 mm/min feed and 2300 rev/min in a single jump, resulting in cycle time saving of over 90 per cent. Moreover, insert edge life is excellent so tooling cost is very low."

Type 313 inserts are designed for circular interpolative groove milling applications, and are of 21.7 mm overall diameter with three cutting edges. The inserts are TiN coated and locate in the holder by a single, central screw. A moulded-in drive dog arrangement engages the insert in the end of tool shank to ensure full transmission of spindle torque.

The sequence of operations preceding use of Horn Type 313 is to drill and bore the basic hole diameter as before. For this application the Horn tool is initially used to plunge cut the four 'corners'; and the same cutter is then applied to finish profile the 'figure 8'. Finish profiling uses a macro within the CNC program which repeats along the passage in 2 mm increments, building up the passage as a series of overlapping grooves. The cutter edge overlap thus provided ensures very smooth surface finish. Through-tool soluble oil based coolant is used throughout at standard machine pressure of c.10 bar, and to facilitate swarf evacuation ahead of the tool, Lucas Aerospace has modified the machining sequence so that the bore with which the passage intersects is now machined first.

Mr Mallett concluded. "The Type 313 tool rendered an immediate, major improvement in productivity on this operation, and quality is at least comparable to that achieved with the former set-up. The success of this exercise has encouraged us to examine a number of other areas where Horn tooling might be of use."