Maximising spline flexibility for Hewland

By introducing a spline machining route based on groove milling using Horn tooling, Maidenhead-based motor sport transmissions specialist Hewland Engineering Ltd has gained significant production benefits. Compared with spline hobbing the milling route is more flexible, easier to set up and allows consolidation of second operations such as oil hole drilling or engraving.

At the time of its introduction spline milling was also much faster than hobbing though subsequent investment by Hewland in new hobbing machines has reduced this advantage. However the milling route requires a comparatively inexpensive but highly flexible machining centre (sub £100k) whereas hobbing requires use of a costly (£350k plus) specialised machine.

Hewland Engineering is a famous name in motorsport. During the 1970s and early 1980s its transmissions – often paired with the Cosworth DFV engine - helped to win the majority of Formula One Grands Prix races as well as numerous other motor sports events.

Today the company supplies the whole spectrum of motor sport from clubman, through the likes of Formula 3 and Nascar to sophisticated World Rally Cars. The company supplies not only in the UK but throughout the world, particularly to prestigious customers in the USA, France, Italy and Japan.

This embraces a wide range of transmission components from single gear sets, sold over-the-counter from stock, to complete, bespoke, WRC transmission assemblies supplied direct to teams and vehicle builders, and worth around £50k each. Operations director David Radley observes. “We have a very wide product range but unit component volumes are relatively small. We also work in a sector where the highest engineering standards must be adhered to but cost effectiveness remains important, as is the need to provide rapid fulfilment of orders.”

Hewland’s quest is essentially to develop the lightest and most compact possible transmission consistent with the need to withstand the duty cycle placed upon it. Precision and high standards of finish are needed to achieve these aims. Components are machined to a general tolerance of 25 microns and ground to around 10 microns. Many internal parts are heat treated and shot peened or electro polished to maximise strength and eliminate stress raisers.

Much of the company's machining work and heat treatment is completed in-house using modern plant and equipment arranged in flexible cells catering for family of parts production. Though some finishing work is subcontracted, Hewland's business is very much delivery driven so investment is directed to areas where it can retain control of core quality and delivery priorities. Costs are important though the emphasis is on making the work flow through the factory.

By necessity Hewland makes a range of around 300 splined shafts ranging in diameter from 20 mm to 35 mm and from 150 mm to 400 mm in length; batch quantities range from 5 to 30-off. Most have splines running along almost the entire length. These are almost all rough machined from a Hewland-specific variety of EN36 which is then heat treated to around HRc61 and finish machined in the hard state. Many require a number of additional operations to complete, including cross drilling, ID engraving and machining of key slots and other features.

Mr Radley recalls. "The spline machining process came about as a response to a number of production issues. Firstly we wanted to consolidate the number of separate machining set ups needed to complete machining of certain shafts. Secondly we had need to produce shafts which exceeded the length capacity of our then existing hobbing machines. Thirdly we had need to generate splines which finished close to increases in the cross section of the shaft – particularly on pinion shafts. In addition there were quality issues relating to our then existing hobbing machines relating accuracy and surface finish."

Hewland began by performing trials to test the viability of a milling route for spline generation. These utilised high speed steel cutters but allowed prove-out of the basic set-up. This entails mounting the shaft between a horizontal precision indexer/tailstock set up on the table of a vertical machining centre. Machining is then carried out at the 3 o-clock position.

Michael Mack, Hewland's senior production engineer, was closely involved with the trials. He adds. "Once we had the basics in place we looked to Horn to supply tooling that would allow us to 'productionise' the process; we already had a lot of experience with Horn groove turning tools and felt they were well qualified for the task."

All shafts are semi-finish machined but following heat treatment to HRc60 some are machined to a finish while others are ground. The solution developed with Horn uses a Type 380 inserted cutter body with three Type 314 inserts for the roughing/semi finishing operation.

Roughing is carried out in a single pass at 400 m/min with 2 mm depth of cut at around 1000 mm/min feed rate – though this reduces to 350 mm/min on the ramp entry and exit.

The semi finish machining cycle is carried out in two passes with much reduced depth of cut at 3000 mm/min feed. A specialised form tool based on the Horn Type M313 insert is used. This finalises the basic form of the spline walls and also has a concave radius on the leading edge. It profiles a 'hump' on the bottom of the spline groove which is not pronounced but is enough to prevent the grinding wheel (used to finish the spline walls on some components after heat treatment) from bogging down in the bottom corners and causing potentially disastrous wheel burn. The tool is set on the machine using a laser probe to ensure that the radius is exactly centred prior to machining.

"We expected to need specially coated inserts for these operations but in fact we've been able to use standard TiN coated 314 inserts, with Futura coating on the form tool." Mr Mack remarked. "Compared with hobbing, at the time we introduced the groove milling route we were reducing the machining cycle on comparable components from 30 minutes to ten minutes, including an on-machine deburring cycle; moreover all of the second operation work is completed in the same set-up. It also proved to be highly accurate; pitch accuracy, straightness, form and surface finish are all well within our limits."

For those components which are finish machined after heat treatment to HRc60, Horn produces an Extreme coated version of the Type M313 form tool. It differs dimensionally from the semi-finish derivative as it conforms exactly to the finished profile of the spline groove. Again it is laser-set prior to machining; cutting data for this operation is 100 m/min surface speed with 300 mm/min feed in one pass.

"The Horn tooling performs extremely well." Mr Mack remarked. "It exhibits very good tool life even though we ask a lot of it in terms of cutting data." Mr Radley added. "Overall the milling route has provided us with a great deal of flexibility on spline production, virtually eliminating design constraints with regard to proximity of splines to 'obstructions' such as pinions or flanges."

The route has also improved the production economics on smaller batches of challenging components. Although Hewland does not formally cost its production against the value of the machine or tooling, being able to consolidate a high proportion of the machining operations for these components onto a relatively low cost machine using proprietary tooling must have a positive effect on the bottom line.

The exercise has certainly encouraged use of groove milling on other components. Hewland is in the late stages of finalising a machining route for a family of selector forks. About 1000 of these components are needed per annum. Here an EN24 casting is palletised once for a three stage machining operation including machining of a groove, which locates over the rim of the drive dogs (the majority of Hewland transmissions are sequential). The pre-cast groove is machined in two roughing and two finishing passes on a high speed machining centre. Speed is 450 m/min at 2 mm depth of cut using a standard Horn Type 328 TiN coated cutter; the same cutter is used for roughing and finishing.

"We've been very pleased with the performance of the Horn tooling and the response we've had on the specials." Mr Radley concluded. "The tooling has assisted us in achieving well engineered machining solutions that improve our flexibility and delivery performance, helping us to offer more competitive solutions to our customers."