Unmanned operation — high-

Programmable gauges help to create the ultimate automation cell for bearing machining and part sorting

The American company Conroe Machine is doing what most machine shops only dream of: the round-the-clock hard-turning of a family of parts in an unmanned cell that operates a 'self-controlled' process.

The cell incorporates a Fanuc robot, a Renishaw Equator gauging system and Renishaw EZ-IO software (www.renishaw.com) to provide simple yet comprehensive communication functions for 100% part inspection and automatic size compensation for a twin-spindle Okuma 2SP-250 lathe. The cell also boxes and palletises finished parts.

Conroe says the turning cell paid for itself in just 18 days and any company can achieve similar results if it is ready to use the talents of today's young automation experts, which in Conroe's case include CNC programmer James Wardell and robotics technician Jeff Buck. This automation team has also developed an unmanned part-measuring/sorting cell for a customer; it combines two Equators, a Fanuc robot, a vision system and multiple lanes of low-profile conveyor.

In both applications, the Equator demonstrates the benefits of programmable comparative inspection by quickly measuring a family of bearing races, doing it cost-effectively and without fixturing — or the problems associated with measuring in a shopfloor environment.

Oil and gas industry

Conroe Machine is a relatively young company, founded by Murray Touchette in 2000 with the expressed objective of producing parts with the best manufacturing technology available. The company grew rapidly to about 150 employees, operating in a climate-controlled 65,000ft^2 plant. Although it is a general-purpose shop, Conroe's location near Houston results in a high percentage of business from the oil and gas industry, principally for drilling components. Indeed, one of the company's continuously running jobs is the manufacture of thrust bearing races for down-hole 'mud motors'.

These parts are produced by the thousand each week, with their production running 'round the clock'. The bearings are currently rough-machined on four Doosan Puma lathes that originally did both roughing and finishing and were tended by four operators. These machines are now split into two cells that are loaded and unloaded by Fanuc robots and undertake only the roughing operation (these cells were among Conroe's earlier automation projects). The parts are sent out to be case-hardened before being finish-turned.

Mr Wardell says: "Our production plateaued at 800-1,000 parts per day, with each cell producing 400-500. We had a single operator loading the machines and inspecting the parts. However, you can not rely on an operator to correctly inspect every part with this kind of volume — and we needed even more output.

"For our next step up, we conceived a fully automated process for the finish-machining, with automatic part loading, post-process meas-

An automated FANUC robot boxes and palletises parts

urement, automatic tool compensation, part engraving, and boxing/palletising of the parts. We had a pretty good idea of the components we needed to build such a system, except for the part measurement technology, CNC type and software for tool compensation. Inspection must be fast to keep up with the cycle times, which can be as short as 98sec. Originally, we looked at white-light laser inspection because of its speed, but our parts are too reflective. We also looked at hard-gauging and shopfloor CMMs.

"Hard-gauging was very expensive and required set-up attention, and the CMM gave no speed advantage. While we were working with Renishaw on other projects, the company's regional manager — Sheila Schermerhorn — introduced us to the Equator as a possible solution."

Flexible alternative

Equator is a low-cost, flexible alternative to dedicated gauging that uses the comparison method of measuring. A master part with known measurements (taken on a CMM) is used to 'master' the Equator, with all subsequent measurements compared to the master. Repeatability is 0.002mm immediately after mastering, although to compensate for shop temperature changes, the Equator can be re-mastered at any time.

The Equator uses an SP25 probe for touch and scanning data collection at speeds up to 1,000 points per sec. Styli are stored in an integral six-port changing rack, and the system is programmed using Modus Equator software. While the Equator can be used manually, it can also be integrated into automated systems using Renishaw's EZ-IO software, as is the case at Conroe.

Mr Wardell says: "In early 2012, we attended an Open House at Hartwig — the largest distributor of machines and inspection equipment in the Midwest and Mountain states — and saw the Equator in action, along with an Okuma twin-spindle dual-gantry lathe. As well as this lathe being automation-ready for parts of our type, its Windows-based OSP dual-path control has an open architecture and PC-based operating platform, which was important in our plan for developing our own auto-compensation software."

Mssrs Wardell and Buck went on to install a cell consisting of an Okuma 2SP-250H, a single Equator, an engraving machine, and a Fanuc M20iA six-axis robot. The lathe's pair of part carousels are loaded with raw workpieces (about 300 parts). From here, the lathe's dual gantry loaders feed the spindles and place each finished part on a chute leading to a conveyor for pick-up by the robot and transfer to the Equator to be measured. If the part is acceptable, the robot transfers it to the engraving machine; the robot also boxes/palletises finished parts.

"We developed our own tool compensation software to run on the OSP control," says Mr Wardell. "This software uses measuring results from the Equator, transmitted in the form of a CSV file, to offset the tools when the part deviates from tolerance."

Machining removes about 0.38mm from each side of the part, with the tightest tolerance 0.025mm and the surface finish 0.5µm. Parts range in diameter from about 75 to 150mm. "Our ODs and IDs stay 'spot on'. We batch parts by size, so change-overs of chuck jaws and other tooling are minimised. The Equator's speed allows it to easily keep pace with the process, and we are re-mastering only once a day, as our shop is climate-controlled to 22.2°C."

Simple methodology

The measuring methodology for Conroe's parts is surprisingly simple, as Mr Wardell explains: "We made an aluminium block with a hole in the centre, and this is placed centrally on the Equator fixture plate. We use it to determine our centre and set our co-ordinate system, and each part is placed in the centre of the block. We touch to get a centre on the part, then surface-scan for all the other data we need. We planned the measurement process to work without a part fixture or stylus change. The robot chooses — through the EZ-IO automation software on the Equator — which measuring program to run for each type of part. We know the critical features we must measure to ensure that the part is within tolerance."

The hard-turning cell currently produces about 600-700 finished parts a day, so only one cell is now needed — compared to two before. The success of this application led to a follow-up project involving a cell for a customer. Based on a concept sketched out by Mr Touchette, Mssrs Wardell and Buck are developing a measurement and sorting cell for used mud-motor thrust-bearing races.

In oil-field service shops, used motors are disassembled, refurbished and put back into service. "The customer was visually inspecting used races to determine if the parts were re-usable, and they knew they were throwing away some good parts — and money," says Mr Wardell. "We wanted to give them a plug-and-play measurement and sorting system that takes human judgement out of the process, so more good races can be salvaged."

When completed, the cell will consist of two Equators, a Fanuc LRMate 200iC six-axis robot, multiple lanes of low-profile conveyor, a Fanuc iR Vision system and an ATI quick tool-changer for the robot's end-effectors. The vision system tells the Equator what part number is being presented and what measurement program to run. Good parts are subsequently placed on the appropriate conveyor, and bad parts are placed on a scrap conveyor. "We designed this system to be 'trucked in' for delivery as a unit, and to be user-friendly for the motor-shop people — just turn on the power and load parts onto the conveyor," says Mr Buck. "We hope that our venture into cell integration for a customer opens a new business avenue in this area for the company."

CNC programmer James Wardell and robotics technician Jeff Buck of Conroe Machine