Astronomical accuracy

A Mitsui Seiki machining centre has been chosen for precise machining of telescope mirror segments for the James Webb infrared optimised Space Telescope. *Machinery* reports

The largest lightweight beryllium optic ever made which will form a central element in the James Webb infrared optimised Space Telescope (JWST), due for launch in June 2013 to study phases in the history of our universe, has been machined in the USA using a custom-built Mitsui Seiki horizontal machining centre.

The JWST is to be Tthe premier observatory for the next decade, allowing astronomers worldwide to study every phase in the history of our universe from the first luminous glows after the 'Big Bang' to the formation of solar systems capable of supporting life on planets such as Earth, to the evolution of our own solar system.

The telescope is an international collaboration between NASA, the European Space Agency and the Canadian Space Agency, with Northrop Grumman Space Technologies appointed as the prime contractor. Following its launch, JWST will be operated by the Space Telescope Science Institute.

The Mitsui Seiki HS6A (600 Centre) is one of eight installed in a climate-controlled factory at Axsys Technologies Inc, Cullman, Alabama, and has the ability to position to microns within the 1,300 by 1,000 by 1,000 mm machining envelope. Each of the 18 beryllium segments, some 1.5 m across, takes around a year to process with each production sequence involving rough and finish machining, chemical milling, heat treatment and inspection.

The components form one of the most critical areas of the segmented 6.5 m diameter folding primary mirror that will be adjusted, along with a sunshield the size of a tennis court, and positioned once the JWST is in orbit about one million miles from earth.

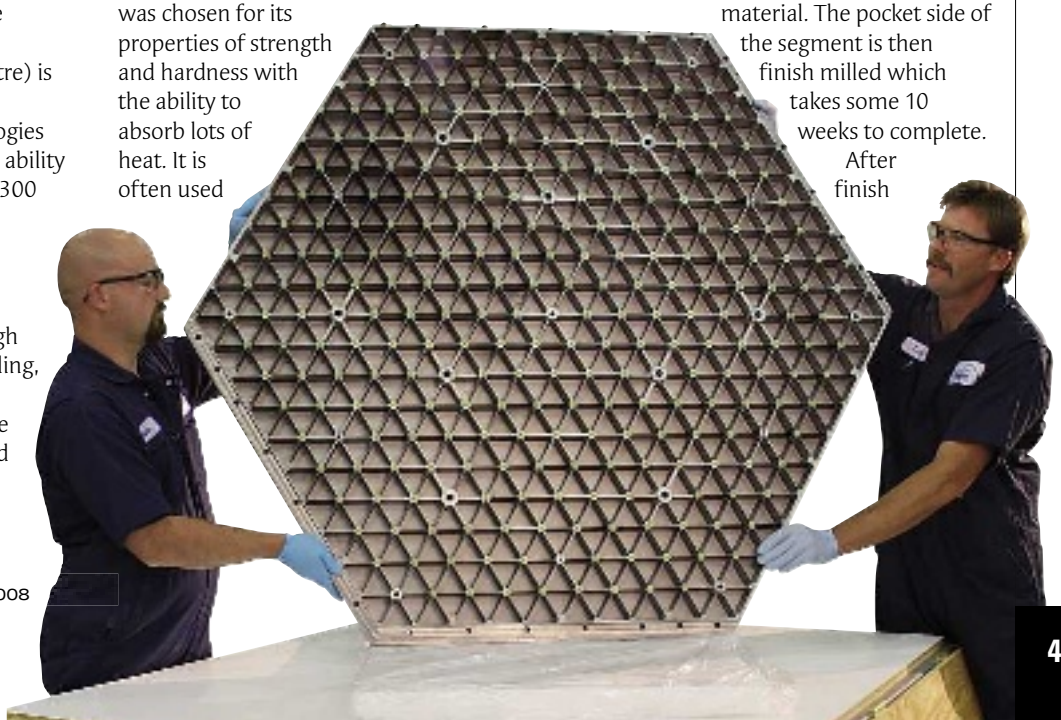
A Mitsui Seiki horizontal machining centre is to process 18 mirror segments, each 1,5 m across

Beryllium is very light but brittle and was chosen for its properties of strength and hardness with the ability to absorb lots of heat. It is often used in computer X-ray windows and cathode-ray tubes for converting short-wave rays to visible light.

Each of the 18 segments is produced from a 250 kg billet of beryllium set on an angle plate on the table of the horizontal spindle machine. The billet is 100 mm thick, 1.4 m across and 1.6 m from point to point. The reverse side of each mirror segment has 600 pockets (see below) each 62 mm square and there are 22 mounting pads and 249 holes to reduce weight.

10 WEEKS OF FINISHING

During pocket milling alone, some 120 kg of material is removed and the segment is then heat treated to remove any stress. The mirror side is then rough machined and a further stress relieving operation performed. During the rough machining, the circular cutting path originates from the centre and progressively feeds outwards removing a further 27 kg of material. The pocket side of the segment is then finish milled which takes some 10 weeks to complete. After finish



DIY FMS is flexible and cost-effective

In less than four years the prismatic machining capability of Lancashire sub-contractor Clitheroe Light Engineering has progressed dramatically from manned vertical machining centres to include horizontal machining centres (HMCs) working largely unattended, 16 hours a day, seven days a week. A stand-alone, seven-pallet HMC started operation in 2004 and in October 2006, a 36-pallet flexible manufacturing system (FMS) comprising three more HMCs was installed.

"The change has been unbelievable," says Chris Wilkinson, a director and one of five family members working at Clitheroe Light. "The investments have greatly increased production output and made us more competitive, without the expense of putting on a third shift and moving to 24-hour operation."

When the sub-contractor originally installed its first two horizontal-spindle machines with twin pallet changers from Daewoo, it achieved dramatic reductions in labour costs and lead times as well as improved cashflow, as parts could be invoiced more quickly. A couple of years ago, Clitheroe Light moved ahead with automation by retrofitting a seven-pallet pool to one of the Daewoo machines, an HM500.

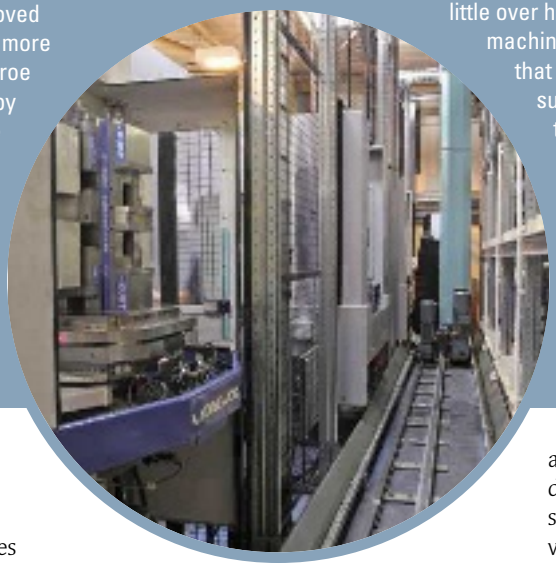
Now the company has taken things a major step further by investing in an automated Fastems system for storing and retrieving machine pallets, and two Mori Seiki NH5000 twin-APC HMCs which, together with the original HC400 APC Daewoo and a load/unload station, form the three-machine FMS. The other major system component is a Zero Point sub-plate system from Wixroyd; this avoids having to buy 36 expensive machine pallets and also makes the FMS more versatile.

The Fastems store houses 36 pallets on three levels. With cost cutting in mind, the sub-contractor chose not to buy 24 Mori Seiki pallets and 12 Daewoo pallets for around £95,000. Instead it went to Wixroyd which supplied six receiving plates each fitted with four Zero Point fixturing pots.

The plates are mounted on the machine tool pallets and stay permanently in the three twin-APC machines. The receiving plates accept any one of 36 sub-plates carrying a fabricated tombstone fixture on top and four Zero Point pull studs on the underside that locate in the pots.

Total cost of this solution was £17,000 per machine; a little over half that of buying the proprietary machine pallets. It has the added advantage that components fixtured on any of the 36 sub-plates can be directed to either of the Mori Seiki machines, whereas Daewoo machine pallets could not have been accommodated.

Even though the Daewoo HMC can only accept 12 designated sub-plates owing to tombstone height restriction in the machine, the overall set-up is much more flexible than it otherwise would have been.



machining and a further chemical milling process, the thickness of the pocket wall varies in size between 0.5 and 7.6 mm. The finish milling cycles for the mirror, pocket sides and location hubs then follow, with tolerances having to be maintained within 5 microns and a true position held within 2.5 microns between the inside and outside of hubs on each segment and 0.12 mm around a 1.2 m pitch circle for bolt holes. The mirror surface has a dimensional thickness of just 2.5 mm that has to be maintained within a profile tolerance of +0.05 mm.

During the final machining cycle 30, 6.35 mm holes are produced, each with slots on the edge that are process toleranced to 5 microns. This is to ensure location datums for tooling balls so that the exact profile of the mirror can be maintained during final polishing.

MONOCOQUE STRUCTURE

The Mitsui Seiki HS6A is a travelling-column machine developed for high precision, heavy duty applications. The bed is an unusual T-shaped single monocoque structure that weighs over 20 tonnes to minimise deflection, bending and torsional stresses. It has hardened and ground rectangular steel slideways and any overhang in X and Z axes is totally eliminated giving a dynamically superior structure. The spindle head is mounted within a double walled column that weighs some 11 tonnes and is able to uniformly distribute cutting forces into the sides of the structure.

The table is carried on a cast iron saddle with direct drive ballscrews and the rotary table uses a large diameter Hirth coupling with rotary Inductosyn scales and hydraulic clamping for maximum rigidity. The spindle temperature is maintained using chilled oil around the cartridge and throughout the gearbox and is powered by an 18.5 kW motor delivering between 15 and 4,600 rpm. The spindle taper is a rigid ISO 50.□