The beautiful race

Menard Competition Technologies' £1.8 million high tech piston manufacturing cell is in line to provide parts for a new racing car formula activity. Andrew Allcock reports

With the winning of the engine contract for the new Superleague Formula (see box item, right), Menard Competition Technologies (MCT) will be putting its recently acquired automated piston manufacturing cell to good use. The £1.8 million facility was officially unveiled earlier this year, but has been working and developing for some two years. It is centred on two Matsuura MAM72-35V 5-axis machining centres and a Takisawa TPS-3100S piston lathe.

You may not know MCT well, but you will almost certainly have heard of it in a former incarnation – TWR. MCT is the ex-manufacturing and racing arms of TWR, which was purchased by Forbes-listed American John Menard (see box item, page 21) in 2003.

As MCT manufacturing manager Nigel Eames explains, the MCT project team – as a "ghost partner" in engine design and build – came to the notice of John Menard when it was supplying engines to a competing Indy Racing League series team. Impressed with the engine's performance, Mr Menard

MCT managing director Charlie Bamber: inhouse piston manufacture has been a signficant investment from a time perspective but the technology and quality that we are now able to offer are second to none

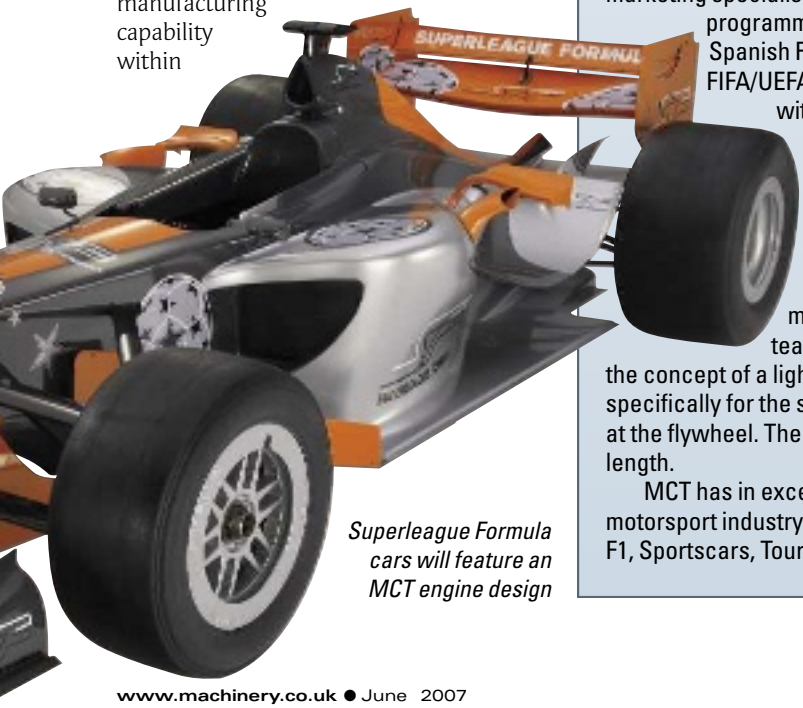
subsequently purchased key elements of ailing TWR.

In addition, he snapped up the spacious Leafield Technical Centre, near Burford, Oxfordshire, once the design and engineering centre for TWR and the Arrows F1 team, where cars such as the Aston Martin DB7 and Vanquish, the Jaguar XJ220 and Renault Sport Clio V6 were developed, and where 750 people once worked. MCT occupies just a small part of the Centre's space, with other automotive racing companies taking space in the building, including the Super Aguri F1 operation.

COMPETITIVE INFLUENCE

Since its purchase by John Menard, MCT has concentrated on the US market, supplying engine parts to support the owner's various racecar interests. But with the winning of the Superleague Formula contract for a bespoke V12 engine and another European engine design and manufacture contract for an unnamed party involving an initial 20-off 8-cylinder engines, the company is once again growing its business and re-establishing a European presence, while efforts are being made to offer its piston manufacturing capability within Europe, spearheaded by Iain Graham.

As Mr Eames highlights, this concentration on the US market with the need to be competitive with an unfavourable $/£ exchange rate, has focused attention on efficient, and where possible, automated manufacture with its existing two Matsuura verticals (MC-1000VG) and one horizontal machining centre (MC-900HG-PC6, 6-pallet horizontal), which were relocated from the original TWR machine shop at nearby Kidlington. So all have large tool magazines, Renishaw laser tool breakage and probing, and in-built tool management features, while one of the verticals has had a fourth axis and cube fixture added to support unmanned machining. Heads, blocks, covers, con-rods and plate-like parts are tackled by these machines while camshafts, valve spings and valves are bought in. A minimally manned philosophy was key when the company decided to bring the



Superleague Formula cars will feature an MCT engine design

Superleague Formula

Tagged 'The beautiful race', Superleague Formula is a motorsport series for identical high-performance single-seaters bearing the colours of leading football teams. AC Milan, PSV Eindhoven, FC Porto and Olympiacos have confirmed.

Series organisers are also negotiating with Real Madrid, FC Barcelona and Valencia (Spain); Inter Milan (Italy), Olympique Lyonnais and Olympique de Marseilles (France); Borussia Dortmund and FC Schalke 04 (Germany); Basel (Switzerland); Galatasaray (Turkey); Anderlecht (Belgium), Göteborg (Sweden) Moscow Lokomotiv (Russia); Boca Juniors (Argentina); Flamengo (Brazil); Club America (Mexico); Shanghai Shenua (China) and Samsung Bluewings (Korea) to take their place on the grid.

Discussions are underway with several clubs in the UK and the USA to complete a full 20-car field for the first race of the championship in August, 2008.

The championship is spearheaded by Spaniard Alex Andreu, a sports marketing specialist who developed innovative media/communications programmes for the 1992 Olympic Games, World Skiing Championships, Spanish Football league and National Spanish Team, FINA and FIFA/UEFA; and Englishman Robin Webb, a former financial executive with many years of hands-on motorsport experience.

The core of the new series is a single-seater car built by Élan Motorsport Technologies in the US. It will be powered by a 750bhp 4.2-litre V12 engine designed by MCT. For each round, competitors will battle for a weekend purse of more than €1 million in prize money.

Given a blank sheet of paper and a brief to "ignite motorsport and footballing passions across the world", MCT's team of world championship-winning designers came up with the concept of a lightweight V12 engine. A compact 4.2 litre unit was penned specifically for the series, the engine producing in excess of 750 hp at 11,750 rpm, at the flywheel. The unit weighs in at 140 kg, measuring just under 700 mm in length.

MCT has in excess of 30 years' experience at the pinnacle of the world motorsport industry. Its management team boasts championship success across F1, Sportscars, Touring cars, IRL, CART and NASCAR.

manufacture of pistons in-house.

The reason to invest in its own facility is given by Charlie Bamber, managing director of MCT: "Previously when designing and building engines, we struggled with the procurement of pistons, particularly in terms of lead-times and finding the level of quality we demanded. We decided two years ago to set up our own cell for 2007, necessitating almost two years of development in order to perfect the processes. It's been a significant investment from a time perspective but the technology and quality that we are now able to offer are second to none."

And with an emphasis on the design and development of individual parts rather than on complete engines under new ownership, pistons came even more under the spotlight, as they are high value, prestigious parts, offers Mr Eames, who explains further why unmanned machining is a core MCT manufacturing philosophy: "In the past we have tried to run two and three-shift systems. But with the nature of the work we undertake, usually prototype and usually very low volumes, we have never found this to be successful. It was always a problem at shift changeover in terms of effective communication. So when we started this business [MCT], we invested in technology and try and use that technology to give us 24 hour, lights-out production, supported by a manned 8-/10-hour day. And on the multi-pallet, machining centres in the piston cell, we have been successful in achieving that."

Pistons are typically around 100 mm in diameter, although designs up to 150 mm diameter can be made, with lengths varying from 50 mm to 150 mm depending on requirement. To minimise costs, bespoke forgings are used or if these are not suitable, upset billet forgings are available.

Now, as the manufacturing manager points out, when you decide to start making pistons, no one is going to tell you how to do it. MCT knew the designs, the materials and the quality requirements, but the manufacturing approach was an unknown. As regards grounds of complexity. An investigative conversation with Matsuura, an established supplier to MCT, saw the company pointed at the MAM72-35V: "And we looked no further as it was the ideal machine. Even the number of pallets [32] was divisible by eight: we make mostly eight-cylinder engines, so we can process 16 first operations and 16 second operations, which is what we do," says Mr Eames.

Typical production runs vary from one to 10 engine sets – so from eight to 80 pistons before a design change is made. Pistons are a constantly evolving part, explains Mr Eames, and are designed to fit the race format. But as engines wear during the season, bores are opened up and remachined so piston diameters need to be increased .

"Generally, if we have a reasonable run of pistons of a similar design, then we can achieve 24-hour running five or six days a week. And because of that, we can be very competitive: the hourly rate that you would expect to be returned over an eight-hour shift is now divided by three. So, instead of £75/hour, we are able to achieve £25/hour, which for such a large investment is competitive. And this is what allows us to compete effectively in the American market. We are price-competitive with local suppliers, and that's quite an achievement."

The piston manufacturing cell is housed in a small self-contained unit and the two Matsuura 5-axis MAM72-35Vs almost fill the main area. Alongside them is a small temperature-controlled facility which houses a CMM and the piston turning machine – turning to within 0.003 mm is "comfortably achieved". MCT's other Matsuura production machines are beyond a wall next door, with a small toolroom-like operation in

John Menard

John R Menard Jr, born in 1940, is an American entrepreneur who is the founder and owner of Menards, a major Midwestern DIY store chain. Menard is a partner in Robby Gordon Motorsports with NASCAR owner/driver Robby Gordon, and is the father of NASCAR driver Paul Menard, who is a driver of the No 15 Menards Chevrolet in the NASCAR NEXTEL Cup Series for Dale Earnhardt Inc. The 2006 Forbes list puts 66-year-old Mr Menard's net worth at above $5 billion.

turned features and particularly the obround skirt and high accuracy ring grooves, there is only one recognised supplier of this technology in the F1 world: Takisawa – so that choice was a given. But aside from that, the thought was that mill-turn would be ideal to support piston manufacture.

LOOK NO FURTHER

This would allow the machining to be undertaken in one hit with any in-process movement of the raw forging neatly taken care of as it was machined. However, the requirement to load and unload raw piston forgings automatically did not lend itself to lights-out manufacturing, except with robots, which were not viewed favourably on

Manufacturing manager Nigel Eames: Even the number of pallets was divisible by eight – we make eight cylinder engines

The two Matsuura machines almost fill the available space. In adjacent temperature-controlled room, the Takisawa CNC lathe comfortably achieves 0.003 mm

another small room beyond that.

The two Matsuuras are not only employed on piston manufacture, however; the benefits of unmanned production on these machines has been extended to other engine components such as steel rockers, steel finger followers, aluminium piston cooling jets – all machined from solid. "Because we design parts, we can make sure that these are designed so that we can take advantage of the automated process. We machine a lot of parts from solid, simply holding billets in a three-jaw chuck."

With race engine piston manufacture, demand is seasonal and so capacity required for their manufacture varies. With the NASCAR season just having started, piston requirements have been fulfilled which means that capacity is available for other production parts. Development pistons are being run through the cell, but these are manufactured during the manned day shift when the company has "technical knowhow available," Mr Eames explains. Proven parts are loaded and then set to run overnight, thus obtaining the economically all-important unmanned running.

Achieving the lights-out capability was not all plain sailing, however. "For example, we have had to develop sensible tool management techniques," Mr Eames explains. "You set parameters against each tool to note, via laser tool measurement, whether the tool has worn, broken or has extended its length – meaning it has been pulled out of its collet – and instruct the machine to change the tool to a sister tool under prescribed conditions. Now for some tools we didn't have sister tooling because we didn't think that we would actually need them. We didn't think, for example, that a 20 mm U-drill would either break or wear out within the duty cycle we had planned for it. However, what we found was that we could have problems with through-tool coolant still dribbling when the tool is measured. This was interpreted as a tool that was over length and so it would be 'parked' and the machine would stop. Drills are also susceptible to swarf sticking in the flutes and this would signal an increase in diameter or length."

HYDRAULIC TOOLHOLDERS

To get round these issues, certain parameters were "switched off". While most of these issues were solved in a month or so, other similar issues pop up from time to time that need to be noted and resolved. A resolution to tool pull-out has been solved by using Schunk hydraulic toolholders, for example. "Not cheap, but better than having a machine stopped or compromising cycle time."

A particular challenge on pistons has been achieving the flatness of the top piston ring groove, machined after the two Matsuura milling operations. The nature of a forging is that it moves when machined – hence the attraction of mill-turn – and this meant that the initial process required an additional crown preturning operation to remove as much material as possible prior to first operation milling of the crown details and then an additional process in the second milling operation on the MAM72-35V to machine location features for the finish turning operation. Flatness of around better than 0.002 mm is now being achieved – better than sub-5 micron being required. A lengthy iterative approach achieved this astonishingly high level of quality, underlines Mr Eames.

But apart from fine-tuning the manufacturing process, there has also been a move over the last year towards the use of standard design features, and the use of a standard set of 60 tools on both machines (the machines have a magazine capacity of 200). This has reduced the manufacturing response time "quite considerably", particularly on the programming side with standard tooling and machining approaches, reports Mr Eames.

MCT's off-machine programming approach using UG software keeps spindles running and producing rather than stopped while parts are programmed at the shopfloor. A next step is to review programming further with a view to applying a more automated feature-led, standardised programming approach to reduce further the time required to introduce new piston designs.

Standard features have also supported the introduction of in-house designed fixturing, with this allowing any piston to be located on the Matsuura and the Takisawa without fixture change.

Capacity of the piston cell is reckoned to be 16,000 pistons per year in a production environment, although current capacity is probably nearer 8,000 due to the frequent design changes. Throughput is not at that level at the moment, though, hence the machining of non-piston parts. But capacity could soon start to fill up with the new engine work plus piston-only production orders. A third MAM72-35V machine would then be the route to further extend what is clearly a world-class piston manufacturing set-up.□

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