SOMETHING OUT OF NOTHING

Chris Pickering looks into a revolutionary welding process that makes the impossible possible

WOULDN'T it be great if you could summon something out of nothing? Surfaces worn away over the years magically reinstated, areas ravaged by corrosion miraculously restored and holes plugged – all without having to replace the component itself.

It sounds fanciful, but that's not so far from the truth when it comes to laser welding. We first heard about this technique being used to rebuild material on historic cars during a visit to the Jim Stokes Workshops Ltd (JSWL) last year. At the time, owner Jim Stokes gave the example of a gearbox shaft that had run a bearing; using laser welding it was possible to build up the surface again and then grind it down to a completely seamless repair.

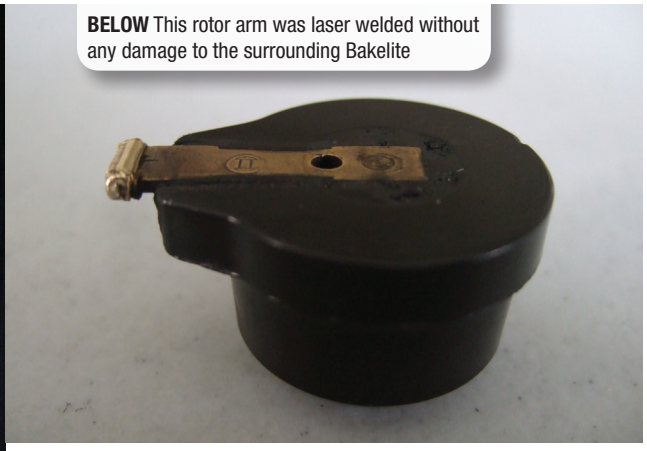
However, that's only the tip of the iceberg – piston crowns damaged by detonation, scoring on cylinder heads, cracks and corrosion damage, even clean breaks where lugs or fittings have detached completely. There isn't much you can't fill, plug or re-attach with laser welding.

Of course, welding parts is nothing new, but this revolutionary technique eliminates some of the traditional drawbacks and opens up a whole new range of options. To find out more we've returned to JSWL.

"The beauty of this approach is that it allows you to recover parts that might not otherwise have been salvageable," explains Stokes. "We recently had a cutter break during the repair on a competition steering box. It's quite a complex part so you really don't want to scrap it and start again. Instead, we had a bit of laser welding done to build up the material again. Once it has been re-machined you won't even know it's there, but the best thing is that it doesn't add temperature into the job."

That last part is key. This particular method is known as pulsed laser welding, and it works by firing a stream of laser pulses at the part you wish to weld and then feeding in new material in the form of a wire. At that precise point the surface of the metal

ABOVE Laser welding was used to repair the cylinder heads on this Ferrari 156 F1 Sharknose recreation built by JSWL



BELOW This rotor arm was laser welded without any damage to the surrounding Bakelite

Another major advantage is access. Due to the nature of the equipment you can reach places that would be utterly impossible with a TIG gun, such as the inside diameter of deep, narrow holes.

EMP

To get a better idea of what is involved we head over to JSWL's welding contractor, EMP. Originally known as Emsworth Mould Polishers, this family-run business first began using laser welding on the tool pieces for injection moulding.

"We'd already done bits of polishing for Jim [Stokes]," explains EMP director, Alan Barker. "When we got the first laser he came straight over to have a look and started asking us questions about how it could be applied to automotive applications."

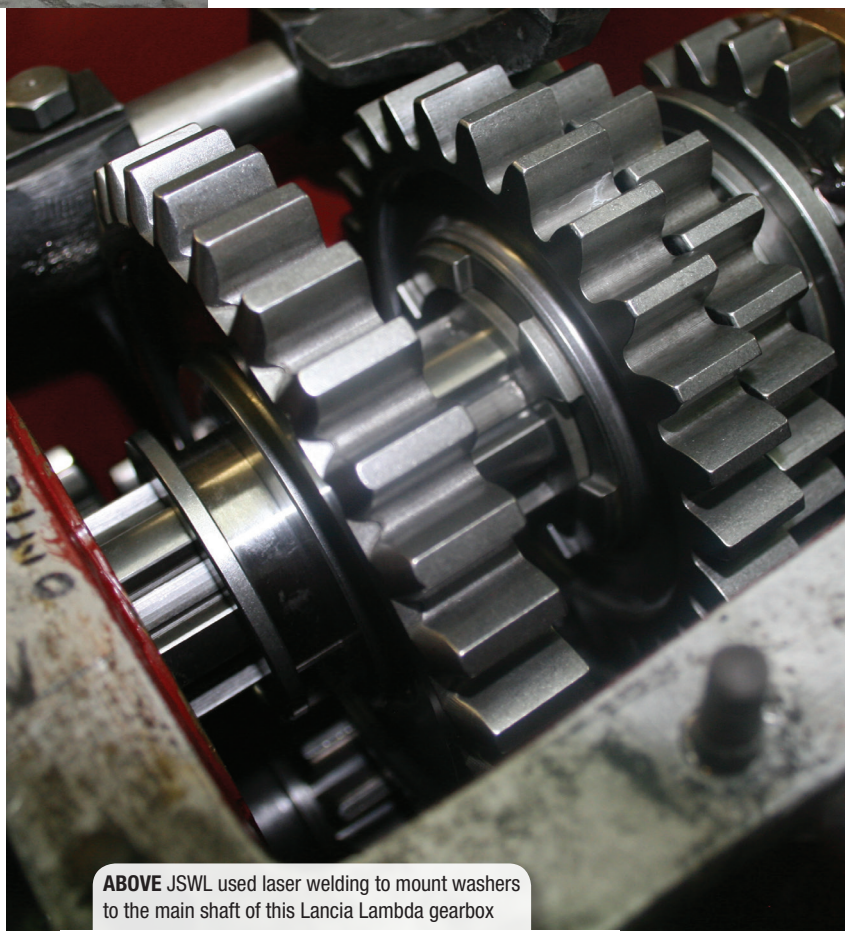
Since then laser welding has come on in leaps ▶

gets extremely hot (somewhere in the region of 3,000°C), but each pulse of the laser is applied to such a small area over such a short space of time that the total amount of heat energy is negligible – something I will later discover for myself in a very hands-on demonstration.

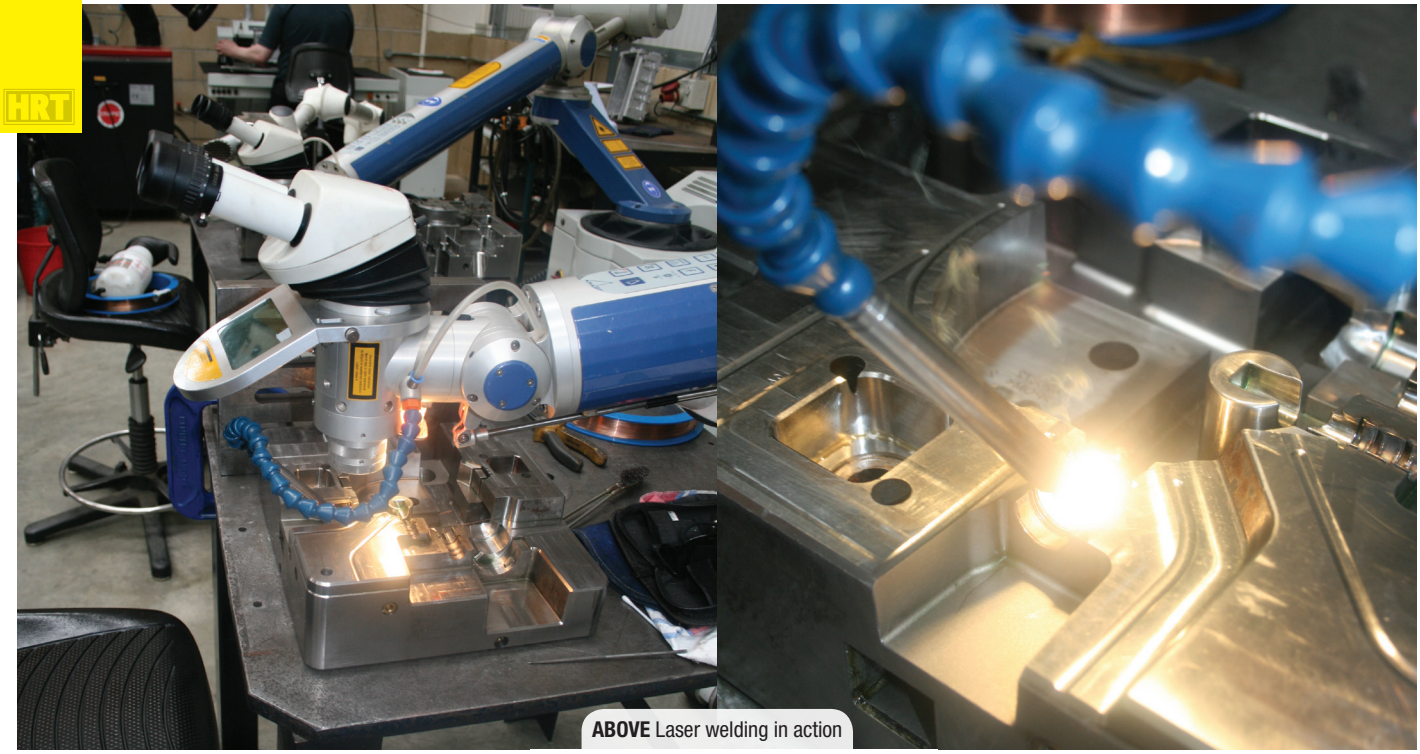
"Heat distortion is virtually zero," explains JSWL workshop manager Tim Sanders. Unlike TIG welding, the parts never have to be heated to prevent distortion and it opens up repairs you simply wouldn't be able to do with conventional methods.

"One of the strangest things we've done with laser welding was a rotor arm," Sanders continues. "The original was completely unobtainable so we had the brass electrode welded back into the centre of the arm. The joint had to be able to conduct and we couldn't get the surrounding Bakelite hot so there wasn't really anything else we could use."

Because the process puts so little heat into the part it also means the heat treatment is unaffected. Using the right wire, it's possible to put down material with a hardness of up to 66 Rockwell – comparable to top-end tool steel – so there's no need to re-apply the heat treatment. Conversely, there's nothing to stop you matching the hardness of the underlying part and then heat treating the whole thing once the welding has been carried out.



ABOVE JSWL used laser welding to mount washers to the main shaft of this Lancia Lambda gearbox



ABOVE Laser welding in action

and bounds. EMP has been using the technique for around 15 years now and Barker says that previously uneconomical repairs have now become viable. "A job that would have taken us six hours to complete on our first laser would be under an hour now," he comments.

Just about any ferrous or non-ferrous metal can be laser welded. Cast-iron, tool steel, aluminium, Inconel, brass, copper, titanium and bronze are all possible. With specialist equipment, some firms can even weld glass and plastics.

"Half the time we don't know exactly what the material is, but it's not a big issue. We know what tends to work with each family of materials," says Barker. "Generally we keep them fairly similar to the base material, but you can do some really wacky stuff – I worked on a Formula 1 engine where we welded copper to aluminium. The important thing is to find a bridging material that will weld to both; because laser welding is so localised you never really get all three metals mixing."

Recently JSWL and EMP have been working together to develop techniques for welding magnesium, which is notoriously tricky with conventional methods. With a laser it is still one of the more difficult mediums to tackle, but the reduced heat soak makes things considerably easier.

At first glance, the laser welding stations in EMP's workshop resemble a brace of robot arms. Each has a base unit that supports the rig and controls its movement, while the 'arm' itself contains the laser. The beam is reflected down a series of mirrors and focused through a lens at the end to fire downwards onto the workpiece, while separate flexible hose pumps inert argon gas onto the joint. Above, connected to the end of the arm, sits what looks like a microscope. This acts like a gunsight allowing the operator to target the weld with pinpoint precision.

The basic act of operating the machine is actually remarkably straightforward and almost clinical in its approach. Once everything is lined up in the crosshairs, a foot pedal is used to fire the laser and the wire can either be fed in by hand or dispensed by a machine. Meanwhile a small joystick is used to move the gun over the part. Outwardly, things couldn't be simpler.

The skill lies not in manual dexterity but in knowing what wire to use and how to configure the laser. There's a faintly bewildering array of settings, including voltage, beam diameter, focal length, pulse duration and frequency. Just to make things more confusing, the various parameters all interact and the same results can often be achieved through different means. For example, increasing the frequency or the duration of each individual pulse can have much the same outcome as upping the voltage. Similarly, if you reduce the beam diameter it focuses the energy onto a small area and the laser effectively becomes more intense.

"After a while you get a feel for it," explains Barker. "I can tell if the settings are right by looking under the scope and listening to the sound. You get to know what works well for a particular material and wire thickness."

Providing there's enough room to insert the wire – possibly from a different route – you can weld anything within line of sight. That includes the bottom of deep, narrow drillings such as bolt holes or water channels. Of course, there are often alternatives, such as opening out the hole and fitting a sleeve or filling it completely and re-cutting the bore, but it's amazing what you can achieve with welding alone.

Incredibly, it's even possible to weld round corners under certain circumstances. Using diamond-polished copper plates you can bounce the laser beam through different angles, like light travelling through a periscope. That way, as long you can bend the wire to follow an equally circuitous route (or feed it in from an alternative angle), it becomes feasible to weld seemingly impossible jobs.

We don't witness anything quite that complicated, but in order to demonstrate the technique, Barker grabs a piece of scrap metal and sits down at one of the welding stations. A line of tiny spots promptly makes its way across the surface as each pulse hits home. The instant his foot comes off the pedal he ▶

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hands me the steel block and encourages me to run my finger over the weld. I can't deny I'm a little hesitant at first, but sure enough, the weld is close to room temperature a matter of seconds after we saw it being formed.

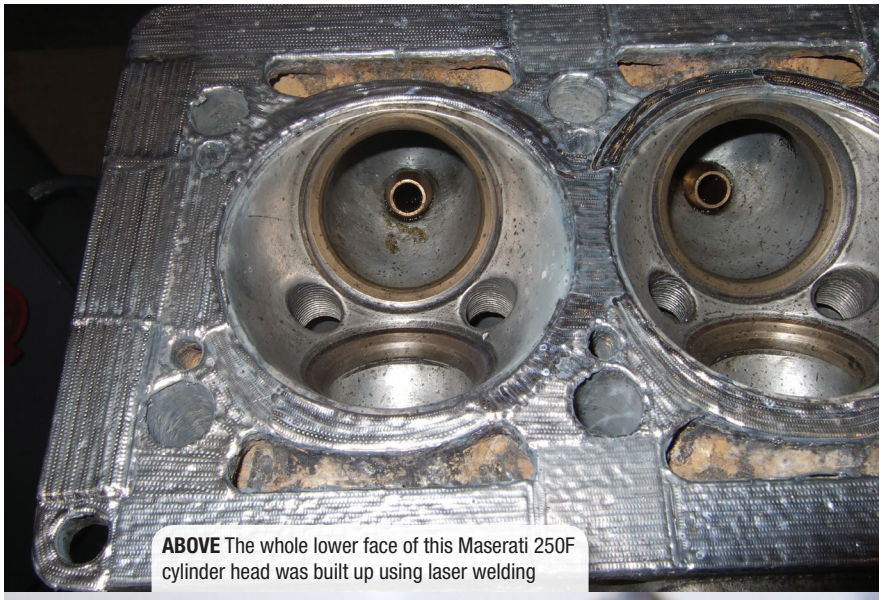
For the more intricate jobs, EMP tends to operate the lasers manually, but the technique does lend itself quite nicely to CNC control, at least for simple operations like rotating cylindrical parts or building up square pads.

"We did a Maserati 250F cylinder head. The whole of the lower face of the cylinder head needed building up to a depth of several millimetres and there was a sealing groove running right the way round the opposing face on the cylinder block that needed filling," Barker recalls. "The underside of the head was a very large area with relatively simple geometry, so it was definitely worth CNC programming."

However, even with the use of automation it wasn't going to be a cheap operation. "When the owner came in I warned him the cost might be prohibitive, but he said 'try me'.

"The base material was so poor we had to run the laser over the surface to re-melt it before we could go back and put the new weld down. Some areas that looked quite good just collapsed into voids when we began welding."

The final bill ran into the thousands, but it was still around a tenth of the cost of a new one-off cylinder head – and more importantly, it allowed the owner to retain the original casting with virtually no trace of the work that had been carried out.



ABOVE The whole lower face of this Maserati 250F cylinder head was built up using laser welding

ABOVE Using laser welding it is possible to replace worn material on an original camshaft or even change its profile

MYRIAD APPLICATIONS

At times, laser welding can even be used like a coating. For example, applying a layer of ultra-hard D2 tool steel onto the edge of a mild steel part. It's also compatible with anodised materials and most traditional surface treatments.

"We've used it to build up material on camshafts quite a bit over the years," explains Barker. "Generally these are case hardened and we can go straight on with a hard material to match the original surface. In one instance we've even been asked to build up the surface so the cam can be re-ground to a new profile."

The process also works well with other treatments. On older cylinder head castings where porosity can be an issue, JSWL often combines laser welding and ceramic sealing. Likewise, on occasions where TIG welding is more cost-effective for the bulk of the job, a laser can be used to touch up any blow holes.

It is not just for substantial chunks, either. Thanks to its low heat distortion, laser welding works beautifully on thin-wall fabricated parts. A couple of the examples EMP has tackled include vintage mudguards and a set of F1 intake trumpets that came to the workshop in a variety of pieces. In all these cases the new material can then be ground, machined, milled or polished just like any other metal.

As Sanders points out, "laser welding is a fix-all solution." So where's the catch? Predictably, it's cost, but not to the extent you might imagine. In some instances, the upfront cost can actually be lower than TIG welding. Other times the welding itself can be as much as 10 times more, but that's often cancelled out by the fact that you don't have to spend additional money preventing or correcting distortion. Then, of course, there are the times when traditional methods simply wouldn't be possible.

"Some of the most challenging examples are cylinder head cracks," says Sanders. "An original cylinder head is such a valuable component and you're talking tens of thousands if you have to re-cast the whole thing. Even something small like a damaged tooth on a crown wheel and pinion set could be upwards of £2,000 to replace, but a laser repair might only cost £100."

So it's not quite something from nothing, but in the context of the value of, say, an original Maserati 250F cylinder head or a Bugatti Brescia gearbox it's really not that far off. HRT