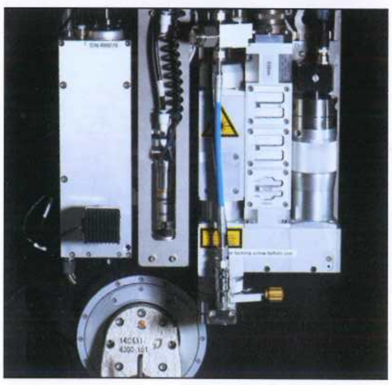

Wetter is Better

New Developments in Wet Laser Machining for Industrial Diamond Tools

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INTRODUCTION

With a traditional dry laser, the machining is either carried out completely dry or under a gas atmosphere. Under such dry conditions, heat can build in the work piece, thermal expansion can result in distortions, brittle materials may crack and a large heat affected zone (HAZ) and oxidation may also result. A gas may give a better atmosphere but it does not have sufficient thermal capacity for adequate cooling. Last but not least, the cut produced by a dry, focused laser beam is "V" shaped – the kerf is wider at the entry side of the cut than at the laser's focal point at bottom of the cut.

A wet laser is very different. It works by first focusing the laser onto the aperture of a water jet nozzle. The water jet is typically 50 microns in diameter and up to 50mm in length before it turns to droplets. The laser pulses travel down this liquid optical 'fibre' by total internal reflection. The laser-water-jet cuts the workpiece by repeatedly scanning the required cutting pattern so deepening the trench. As a result, the cut produced is parallel sided rather than 'V' shaped and it is constantly cooled and cleaned of debris by the 300 bar water jet (Figure 1).

There are many application areas for the wet laser from drilling holes in ceramic coated, superalloy turbine blades to cutting gears for luxury watches. Various lasers can be employed but for the diamond industry, a Nd:YAG laser at a wavelength of 532nm and a pulse frequency of the order of a few kHz has been found to be the most appropriate. Water is particularly transparent to light of this wavelength. The scanning speed used is typically of the order of 10-20mm/sec and the amount of material removed at each pass is of the order of 20-50µm. In the following case studies, the various advantages of wet laser machining will become clear.

Over the last 2 years, there has been significant uptake of the wet laser in the gem diamond industry. Over 30 wet lasers[1] are now running for 'sawing' gem diamond in India, Belgium, Thailand, Russia and South Africa. Figure 2(a) shows a 200ct gem stone being cut into the required primary parts. More recently[2], the wet laser manufacturer has started to develop the techniques to expand applications and cut the major facets (Figure 2(b)) on stones so as minimize the amount of polishing required.

In comparison to dry lasers, the benefits of wet lasers for the gem diamond industry can be summarised as:

1. Increased yield (stone weight) via reduced breakage rate of stressed stones
2. Increased yield due to the narrower, parallel sided kerf
3. Faster cutting rates and higher productivity at higher laser powers without thermal damage
4. A simpler planning process as the kerf is not V shaped
5. Easier cutting as double sawing is not necessary – cuts 25mm deep achieved from one side
6. Flatter, more accurate facets ready for final polishing
7. Minimal sub-surface damage

A most interesting capability of the wet laser is to make parallel sided holes in difficult materials or alternatively, the wet laser can be used to produce rods of any shape such as triangular, square or round cylinders. In Figure 3, a diamond rod 1mm diameter and 8 mm long has been cut from a natural diamond stone in less than 8 minutes. The end to end diameter of the rod produced was within ±2 microns.

Case Study 3: Cutting Synthetic, HPHT Diamond

One of the most common methods for single crystal diamond tool manufacture, be they natural or synthetic diamond, is to first braze the diamond to a tool body using a

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