

Effect of water-jet on quality improvement of various laser material processing modalities

Yuvraj kumar madhukar

Mechanical Engineering Department, IIT Kharagpur, India

Abstract

The laser material removal process involves the integrated effect of heating, melting and vaporization by a high power laser and mechanical force often applied with the help of an assist gas to remove molten material and debris. Some of the undesirable effects in gas assisted laser processing are large heat affected zone, oxide layer formation, recast, spatters, crack formation in brittle materials, and residuals in paint removal, etc. Laser processing with water-jet assist may alleviate some of these deleterious effects as water-jet can provide relatively high mechanical force and cooling effect. This dissertation is devoted on investigating the water-jet assisted laser processing of some typical metals, semiconductor and polymer. An Yb-fiber laser which has low absorption in water has been used in this study. A hybrid laser processing head and associated sub-system were designed and developed in-house to deliver the laser beam on the workpiece along with the co-axial water-jet.

The first set of experiments was conducted to study the water-jet assisted laser cutting of thin sheets of two different metals, mild steel and titanium which have very different thermo-physical properties. Effects of various process parameters were investigated to improve the cut quality in terms of minimum kerf, dross, surface roughness and HAZ; and compared with the gas assisted laser cutting process. Next, water-jet assisted laser grooving of silicon was investigated for obtaining grooves of uniform shape, free from micro-cracks, spatter and recast. Compared to gas assisted laser grooving, this produced grooves with much better quality. For studying the effect of water-jet on laser processing of polymeric material, laser paint removal with water-jet assist was investigated. This produced much cleaner surface than gas assisted laser paint removal process which always left some residual ashes on the surface.

Quality improvement in various water-jet assisted laser processing modalities was at the cost of some marginal increase in the specific energy due to the absorption loss of laser energy in water. Owing to quality improvement, nevertheless the water-jet assisted laser processing will be attractive in many applications where quality is a matter of concern and post-processing is not desired.

Key words: water-jet assisted, fiber laser, cutting, grooving, paint removal