

LASER FORMING: A REALISTIC SHORT-RUN OPTION?

Laser energy can be used to create bends in a metal workpiece by inducing differential thermal expansion/contraction in the material. Lately, researchers have been trying to convert laser forming into a practical production process -- and not just for creating simple straight bends, but for complex parts as well. A University of Liverpool researcher explains the basics of LF and points out its practical potential for both prototyping and short-run production for sheetmetal forming.

High-Powered Laser Forming of Metallic Components

Laser forming has become a viable process for the shaping of metallic components and as a means for rapid prototyping. The laser-forming process is of significant value to industries that previously relied on expensive stamping dies and presses for prototype evaluations. Relevant industries include aerospace, automotive, and microelectronics.

In contrast with conventional forming techniques, this method requires no mechanical contact and thus promotes the idea of "Virtual Tooling." It also offers many of the advantages of process flexibility associated with other laser manufacturing techniques, such as laser cutting and marking.

Laser forming can produce predetermined shapes with minimal distortion. The process is similar to the well-established torch flame bending used on large sheet material in the shipbuilding industry; however, a great deal more control of the final product can be achieved.

Process overview

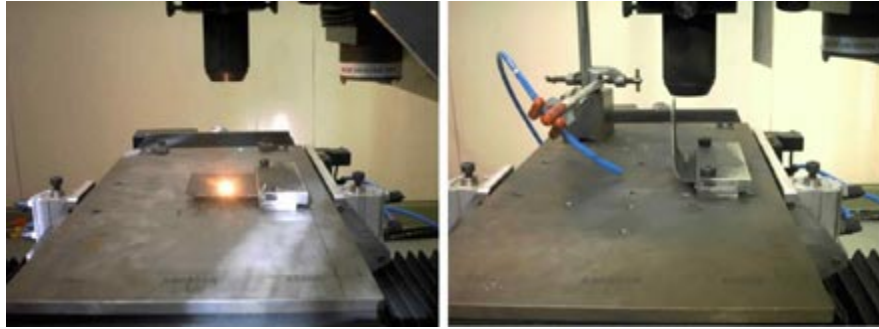
The laser-forming process is realized by introducing thermal stresses (without melting) into the surface of a workpiece with a high-power laser beam. These internal stresses induce plastic strains that bend the material or result in local elastic/plastic buckling.

The laser-forming process is principally used at the macro level to form metallic sheet material. Current research at the University of Liverpool (UK) and other research groups has shown that it can produce parts with 2-D bends or 3-D formed parts. Research is also ongoing on the use of the process to remove unwanted distortion in conventionally formed parts, as well as the distortion due to welding operations. (In addition, research is ongoing in the use of lower-powered lasers to align micro-electronic components and actuators.)

The principle behind the process for sheetmetal uses a laser beam that's guided across the sheet surface (shown in Fig. 1a, below left). The path of the laser is dependent on the desired forming result. In the simplest case it may be a point; in other cases it may be a straight line across the whole part. And, for spatially formed parts and extrusions, the paths may be very sophisticated radial and tangential lines.

Process mechanisms

There are several distinct mechanisms of laser forming, depending on the process setup. With the "Temperature Gradient Mechanism," using a small spot size and fast traverse speed, the thermal expansion of the upper surface of sheet metal as the laser beam is guided over it is hindered by the surrounding material. This results in an upsetting, or plastic compression, of the heated material.



After cooling, the material at the surface is shorter than the material below, bending the sheet towards the laser beam, typically on the order of 1° per pass (Fig. 1b, above right). However, larger bends per pass are possible, depending on the thickness and strength of the material and the energy parameters used.

Materials

The range of metals that can be laser formed is considerable, as there's only localized heating involved, below the melting temperature. The bulk properties aren't altered and good metallurgical properties are retained in the irradiated area.

Materials of particular interest are specialty high-strength alloys, including titanium and aluminum alloys. These materials are widely used in the aerospace industry, where the implementation of laser bending as a replacement for existing low-volume manufacturing processes is under investigation, as well as in other industry areas where inexpensive prototype evaluation parts prior to die manufacture would be useful.

Due to the progressive nature of the process, high accuracy can be achieved. In addition, small bends can be produced in parts that wouldn't be possible with conventional techniques, due to the springback of the material.



Fig. 2: Two examples of laser-formed parts. The part at left was formed from a 250 x 100 mm, 2-mm gauge aluminum blank; the other was from 400 x 200 mm, 1.5-mm gauge mild steel. Both were formed from flat sheet with no additional tooling or restraint (save the attachment to the CNC bed).

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