Makers Leverage Innovative Laser Technology

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The rise of maker culture is closely connected with the development of 3D printing because it empowers individuals to easily create physical objects from digital files, without the need for expertise in traditional manufacturing techniques, such as machining or welding. However, 3D printing technology is severely limited in terms of the materials that it can work with, and the maximum size of parts that it can produce. Small laser prototyping tools have long provided an alternative fabrication methodology, but have also been limited to working with non-metals. This situation has now completely changed with the advent of a new generation of compact laser machine tools that can fabricate high precision parts from metals, plastics and many other materials, thus overcoming these limitations. This article examines how this technology has been employed at the Autodesk Workshop at Pier 9, the company's facility for digital fabrication and traditional manufacturing on the San Francisco waterfront.

Next Generation Laser Cutting Tools

Traditional carbon dioxide (CO_2) laser systems are divided into two extremes. The first are relatively compact tools built around sealed, waveguide CO_2 lasers. With output powers of typically less than 150W, these systems are good for cutting and engraving a variety of organic materials, such as plastics, fabrics, leather, wood, paper and thin films, at modest speeds. However, these lasers are not powerful enough for cutting metal. The small size of these tools, coupled with their low operating costs and quiet operation, make them well suited for use in small commercial operations, such as rubber stamp and plastic sign making, as well as product development labs.

At the other extreme are laser machine tools for heavy industry built using multi-kilowatt, flowing gas CO_2 lasers. This power level is sufficient for processing metals at relatively high speeds. However, these brute force systems are physically large, generate substantial noise, and also have high consumables and maintenance costs, as well as frequent downtime. Although widely used in industries such as white goods (appliances) and automotives, these systems are totally overkill for the needs of makers and prototypers.

The advent of sealed, slab discharge CO_2 lasers, with output powers between 150W and 1 kW, has radically changed this situation. Like lower power waveguide lasers, slab discharge design yields a physically small laser with low operating and consumables costs, together with high reliability and uptime. However, the output from a properly designed slab discharge laser is a high quality Gaussian beam, which can be focused to a very small spot – the optical analogy of a very sharp blade. Plus, the output can be delivered in square wave shaped pulses having very rapid rise and fall times.

These efficiency factors give the beam enhanced "piercing power," thus allowing it to cut metal. In fact, a given slab discharge laser can often cut metal as fast as a flowing gas laser having more than twice its output power. Based on this technology, machine builders like Coherent have developed a new breed of compact, quiet, reliable laser cutting tools that can process both metals and organics at high speeds.

The Autodesk Workshop at Pier 9

As a leading producer of design software, such as AutoCAD, Autodesk considers it critical to understand the entire process of product creation, from design through fabrication. And, the company realizes that achieving this end requires direct, hands-on experience. To meet this need, they created the Workshop at Pier 9, an extensively equipped fabrication facility located in San Francisco, CA.

The Workshop production capabilities include 3D printers, CNC routers, several laser cutting machines, woodworking and metal shops, an electronics lab, a sewing center, and even a test kitchen. The facility is open to Autodesk employees, who can use it to refine and improve the software they develop for machine control, as well as to a group of Artists in Residence (AiRs). The aiRs use the equipment in creative and unexpected ways for a diverse range of projects, helping to push the boundaries of what is thought to be possible, thus spurring innovation. While Pier 9 has had three laser systems based on 120W waveguide CO_2 lasers for some time, they recently added a Coherent METAbeam 400 (based on a 400W slab discharge CO_2 laser). According to J. Sassaman, the Pier 9 Shop Manager, "Our goal is to provide our users with the broadest range of options in order to deliver unlimited creative potential. The METAbeam 400 helps us towards that because it offers much greater flexibility than the smaller laser systems we already possessed. Those smaller systems have a 3 foot x 2 foot cutting bed, and can only cut materials up to ⅜ inch thick. And, they can't process metals.

The Coherent system can cut everything from ¾ inch plywood and acrylics to sheet metal, which our users have employed to make everything from armatures to tree house parts. Also, it has a 4 foot x 4 foot cutting area, which allows a half sheet of plywood to be directly loaded into the machine. But, the Coherent Laser Cutting Machine is still relatively compact and light weight, which was a consideration because of its placement on the second floor."

Parametric Lamp Project

One current AiR, Matt Hutchinson, is an Adjunct Professor of Architecture at the California College of the Arts; he also has his own design and fabrication studio, called PATH. Hutchinson is particularly interested in exploring the relationship between design and fabrication, with a focus on the convergence of traditional techniques and digital processes. Understanding the capabilities of the laser cutter, in particular, was one of Hutchinson's goals when he entered Pier 9 as an Artist in Residence. This was one of his motivations when he embarked on his parametric lamp project, which involves making a complex 3D assembly out of flat plastic parts.

Figure 1. Hutchinson's assembled parametric lamp.

The lamp project was actually adapted from a larger version he had made previously in plywood. Since the shape of that first lamp was generated with parametric equations, it was relatively straightforward for him to alter and scale it. The overall shape was brought into Autodesk 123D Make and manipulated there to transform it into a series of 60, thin, vertical radial slices, and two horizontal slices. The horizontal slices are rings which have a series of notches into which all the vertical slices ultimately fit.

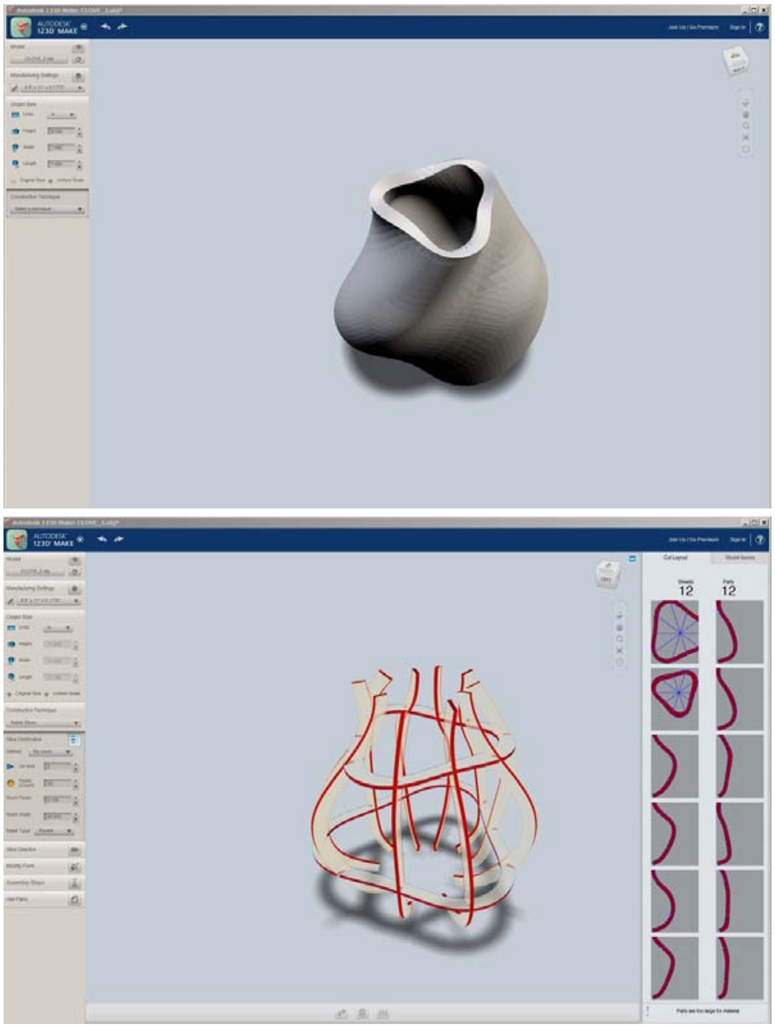

Figure 2. The overall shape (left) for Matt Hutchinson's parametric lamp was imported into 123D Make, and then (right) broken down into a series of radial slices.

Getting the right fit on these slots was crucial. Too tight, and the lamp would be impossible to assemble, and too loose, and its intended shape wouldn't be reproduced properly. Hutchinson notes that, "As a test, I made a 'comb' of slightly different sized notches and then tried fitting a matching part into each one to determine what gave the best results. The METAbeam cuts very fast, so it didn't take long to do all the testing I needed to determine the optimum cutting parameters. Plus, the kerf width it produces is quite small, which takes a lot of the guesswork out of it."

Hutchinson reports that the system then cut all 62 pieces for the lamps in under 10 minutes, and that most of this time was actually spent engraving the small sequence numbers he put on each part in order to facilitate assembly.

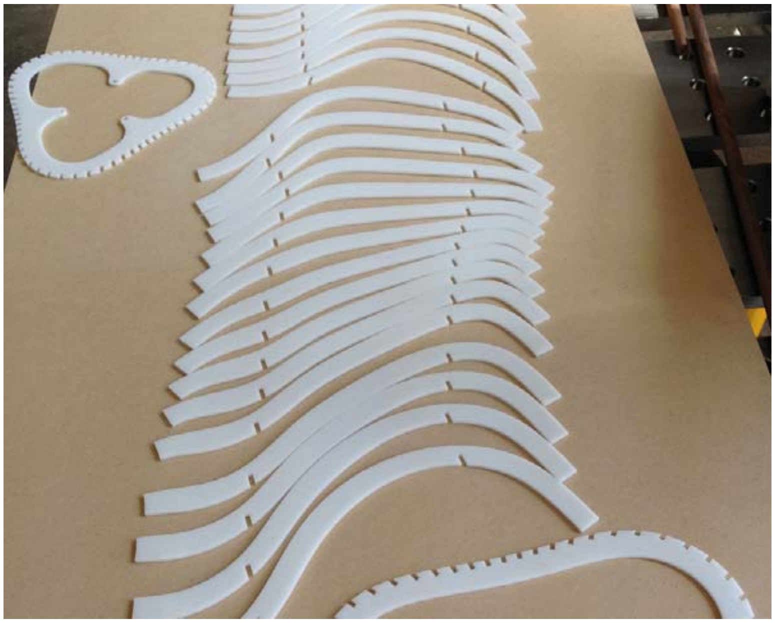

Figure 3. The laser cutter produced all the slices in less than 10 minutes. Most of that time was spent engraving a sequence number on each part to aid in assembly.

What do product development professionals have to learn from makers' experiences with this laser cutting tool at Pier 9? According to Matt Hutchinson, "I see a place for systems like this in many architectural and industrial design firms where prototyping is an important part of the process. Specifically, the ability to seamlessly switch from cutting wood or plastic to metals, together with the fast speed of the system, could reduce prototyping lead times tremendously. Plus, the METAbeam can cut with sufficiently tight tolerances so that the prototype accurately represents what a production unit might look like. So, even if you're working with tight tolerance parts, such as for aerospace applications, you can transition the design from prototype to production with confidence."

Makers and many industrial prototypers share a common need for tools that can economically create 3D objects from digital files with high quality and fidelity. For years, the available, compact laser tools were limited in terms of the thickness of materials with which they could work, and were completely precluded from sheet metal work. This has now changed with the advent of machine tools based on slab discharge CO_2 lasers. Now, the only limit to what can be produced is the maker's imagination.