

*Lightweight Matters...***Flexible Design with Industrial Origami**

Inspired by the ancient Japanese art of paper folding, Industrial Origami, Inc. (IOI) developed a patented technology that allows users to fold aluminum or steel sheet and thick plate in a way similar to what can be accomplished with cardboard packaging. The sheet can be bent into accurate, complex, and high load-bearing shapes and structures—from items such as electrical enclosures (Figure 1) and cabinet drawers to solar mounting systems and car chassis.

IOI is a privately owned start-up that was founded in San Francisco, CA, by Max Durney, and incorporated in 2002 after the issuance of its first Industrial Origami method patent. Since then, the company has amassed over 140 patents and pending patents relating to sheet material design and manufacturing technology. Industrial Origami licenses its technology, as well as a suite of development tools, to manufacturers in multiple industries. The company maintains no manufacturing capabilities of its own, rather it helps companies develop products more efficiently and with less waste, complexity, weight, and cost, while providing equivalent strength to existing forming processes.

Folding Architecture

The forming of complex metal shapes often requires the use of either labor intensive welding or fastening of a number of different components. IOI's solution to complex forming was the development of a process by which sheet metal could be easily folded. The key to this process is the company's patented technology, which uses laser cutting or stamping to create curved divots that form a fold line and takes into account the strap mechanics of the fold. The IOI technique has been used on a number of different aluminum alloys, such as 6000, 5000, and 7000 alloys, however, the most typical alloy used is 5052.

A set of patented techniques and tooling was developed for the laser cutting, CNC punching, and stamping and blanking services required for the process. This included an inventory of specialized CNC tooling (made available for loan to clients for fast prototype manufacturing), as well as hard tool-

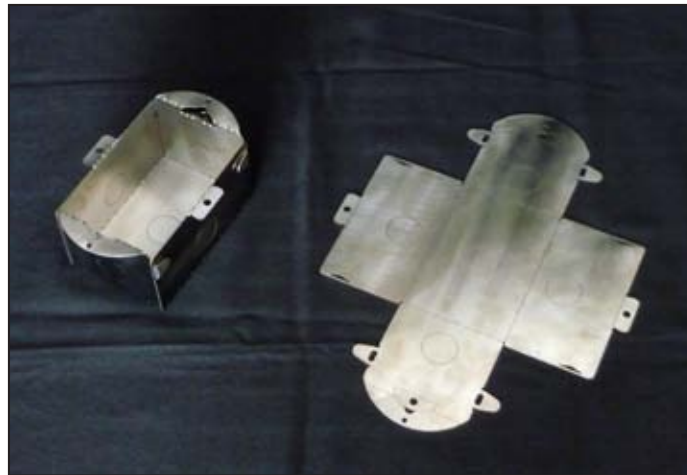


Figure 1. An electrical enclosure developed by IOI, shown in its flat and folded forms.

ing with male punch inserts and female cavities for single station or progressive dies on blanking presses.

One of the great benefits of the IOI technology is that following laser cutting or stamping operations, the manufactured parts are virtually flat (depending on the features of the product), which allows for flat stacking. This reduces the floor space required for storage, as well as shipping costs. Folding of the part upon arrival at its destination can be done by hand or by automated pneumatic or robotic folding.

Shaping Innovation

IOI empowers innovative product design, while allowing for increased strength, higher fatigue resistance, a reduction in welding and fastening requirements, and low cost manufacturing.

Curved Beams for Wing Reinforcement: Military planes are repaired at a central location, therefore they require a temporary wing repair in order to be able to fly back to base for maintenance. The IOI curved beam (Figure 2) can be used to reinforce and provide a support to wrap aluminum around in order to temporarily repair damaged wings. The flexibility of the part, as achieved by IOI, is a necessary element of the design, allowing it to fit each of the many different types of wing shapes without having to store a vast number of different kinds of parts in the field.

Solar Racking: Based on the ability to use geometry and scale to form structural elements, IOI designed a system for solar mounting that bears the same weight and uses less material. According to IOI, with this system, the supply chains are shorter than current designs and the total fabrication costs are significantly lower for a given structure. Therefore, the same

solar panels can have supports with the same features and benefits, but at 25% the cost of traditionally formed structures. Also, this system can be installed at scale with fewer pieces and formed closer to the job shop, thus reducing installation labor and time, as well as reducing freight costs.

Car Chassis: As a technology demonstration, IOI developed a car chassis constructed entirely of IOI foldable sheet. The chassis design is based on an existing vehicle (for which the company was engaged in concept car development) that

used over 250 parts in its construction, whereas the IOI chassis uses a mere 64 total parts. A weight savings of approximately 10% is possible with the design, but the most significant savings are the reduced joining costs based on the reduced part count. According to IOI, depending on the model of car, the chassis has the potential to save hundreds of dollars per vehicle, while also enabling the opportunity to use higher tensile materials due to the ability to form geometries without material degradation and minimized welding requirements.



Figure 2. A curved beam used for wing reinforcement in aircraft.

Editor's Note: For more information on IOI, contact Noel Berk-Rauch by email: berkrauch@iointerwork.com, or visit the company website at: www.industrialorigami.com.