New Approach to Aluminum Component Manufacturing

Researchers introduce a metal forming process for complex geometric structures, with excellent structural and surface quality and minimal material waste.

A new manufacturing process developed by the Singapore Institute of Manufacturing Technology (SIMTech) reportedly makes it possible to manufacture more “intricate and structurally superior” products than are possible with diecasting or extrusion. With the memorable label “Liquid Forging,” this new process involves a liquid melt of wrought aluminum alloys that is formed into a range of products that SIMTech says demonstrate a) better structural integrity; b) higher aspect ratio; and c) more efficient use of raw materials than those other manufacturing processes.

SIMTech contends that its Liquid Forging process helps deliver a cost-effective, efficient way to process high-quality aluminum alloy products.

Currently, many products are produced using a mixture of manufacturing processes. A part with complex design details might be formed as a diecasting or extrusion, but those methods must be followed by machining to remove excess metal and to define the final shape. Producing aluminum alloy parts in multiple stages (with substantial secondary processing) can be expensive. For example, in diecasting a lot of material is wasted with the use of gating and runners as part of its mold design.

Manufacturers rely too much on existing processes to produce aluminum alloy parts, according to SIMTech. In particular, certain limitations of diecasting and extrusion contribute to escalating costs, lower-quality products, and lack of differentiation in parts design. These include:

- Material wastage in gating and runners in diecasting;
- Porosity in the microstructure of diecast parts;
- Surface cracking from high-temperature or high-speed extrusion;
- Inability to create three-dimensional extrusion products;
- Low aspect ratio (<30:1) from existing metal forming processes;
- Extensive machining required for certain intricate parts and higher press tonnage required for cold forging.

Liquid Forging allows complex geometries to be produced with pore-free parts that minimize material waste. This process uses a predetermined volume of molten metal that is poured into a die cavity and squeezed under pressure during solidification. This means that the final shape of aluminum alloys parts are formed with a single step.

The process produces parts that are able to achieve optimal design details with less material (e.g. lighter heat sinks), resulting in substantial savings. It also requires minimal machining for cost-effective manufacturing. Moreover, according to the developers, it is a “green” process that increases recycling of aluminum alloys into new products.

Liquid Forging was developed to address porosity in diecastings, the two-dimensional limitations of extrusion, and other drawbacks of current manufacturing processes. And, according to SIMTech, the new process can be scaled for high output industrial production. It is comprised of four steps:

Step 1 — Aluminum alloys are heated in a furnace at 680°C to create a molten melt that is poured into a preheated die. Step 2 — A...
These aluminum heat sinks show the variety of design capabilities for SIMTech’s new process.

Custom-fitted mold closes with direct pressure to create the near-final shape of the final product. Step 3 — The die mold and punch are held together until the shape of the final product is fully formed. Step 4 — Once the product is cooled, the punch is lifted and the final product is ejected from the mold.

Liquid Forging offers product designers more flexibility for a broad range of shapes and components than any of the competing manufacturing techniques, the developers assert. Product designs can be enhanced by using aluminum instead of heavier or more expensive materials to manufacture parts that other conventional manufacturing processes are unable to accomplish. It’s capable of achieving high aspect ratio features up to 40:1 with draft angle as low as 0.5° (impossible with diecasting, according to SIMTech.) Internal features such as ribs and variable wall thicknesses for electronic casings also can be formed. And, aluminum alloys allow production of parts with better strength and thermal conductivity than many competing materials can achieve.

In diecasting, wrought aluminum alloys exhibit poor diefilling characteristics and hot tearing tendencies when melted. Liquid Forging makes it possible to use such aluminum alloys in a liquid state to form complex parts with intricate features. High direct-melt pressure helps eliminate hot tearing and creates products with superior mechanical properties and features.

Wrought aluminum alloy billets represent a lower raw material cost than extrusion billet or sheet material used in many forming processes. It is also a choice material in terms of thermal conductivity and mechanical strength.

The mold design identified for Liquid Forging is flexible, with interchangeable inserts that make it possible to create products in a single stage rather than joining individual parts via multiple steps (e.g., solders, rivets, and screws), thus improving strength and thermal performance.

In addition, Liquid Forging products are heat treatable, to allow further improvements in mechanical properties, and they can be anodized to achieve more aesthetic appeal and better performance.

Liquid Forging products achieve greater tensile strength with zero porosity because direct high pressure on the melt prevents trapped air bubbles, improving the strength and thermal performance of finished products. And, a shorter cooling and solidification time creates finer-grained metal structures with better mechanical properties.

SIMTech argues that adopting a flexible design process will allow manufacturers to create products of various shapes and sizes for the automotive, aerospace, precision engineering, biomedical, and electronic industries. A primary example is a series of heat sinks for LED lighting, which require high aspect ratios in order to maintain the necessary cooling function. It’s also possible to form a heat sink with the light fixture in a single process, according to SIMTech.

Other aluminum alloy parts can be manufactured efficiently, too, with minimal wasted raw material according to the process developers. For more information about the Liquid Forging process, contact tech-offer@exploit-tech.com or visit www.exploit-tech.com/SE00110.