



Discover the Benefits Of A Precision Forged Heatsink

The Thermal Management Industry has historically been dominated by extruded and die cast heat sinks. As electronic packaging becomes more compact and processing power continues to increase, engineers are looking for alternatives that provide more efficient thermal transfer in a smaller space. Forged heat sinks are becoming a popular alternative in meeting today's thermal challenges due to the unique characteristics that are discussed in this article.

In general heat sinks that are fabricated from a solid piece of metal will outperform heat sinks where the fins are bonded to the base as thermal transfer is inhibited by the bonding agent. The most common manufacturing methods that can produce more efficient heat sinks from a solid piece of metal include:

- Die Casting
- Machining
- Forging

Key characteristics of each method are discussed below. Heat sinks can also be machined from a solid piece of metal but are not included in this analysis because the cycle time and associated cost are generally not economically viable for production volumes. Machining is most appropriate for prototypes, short run and low volume production; and the performance characteristics will be similar to a forged heat sink.

1. Thermal Conductivity

Diecasting is an effective method for forming complex shapes; however as the molten metal cools in the die, it inherently expands creating voids. The porous interior weakens the structure, inhibits thermal performance and is difficult to machine.

Extruding is most effective for creating linear shapes. The metal is heated to allow the material to be formed by the die and the grain structure cannot be controlled evenly. These factors combine to reduce thermal performance.

Forging is the most effective method to form complex shapes and also offers unique thermal advantages. Forging is a cold process. The part is formed under high pressure which controls the grain structure and results in improved thermal performance.



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The chart below compares the thermal performance of three identical shapes; one formed by die casting, one formed by extruding and one formed by forging.

Manufacturing Method	Material	Sample Dimension	Testing Temperature (degrees C)	Thermal Conductivity (W/m•K) ± 3%
Die Cast	Au 356	70X70X3 mm	20	117.00
Extrusion	Au 6063			167.10
Forge	Au 6063			190.60
Extrusion	Cu 1100			266.80
Forge	Cu 1100			286.90

The data indicates that the forged heat sink has superior thermal conductivity when compared to the die cast and extruded equivalents. The cold forging process results in a heat sink that yields a 14% improvement over the extruded counterpart and a 62% improvement over the die cast counterpart.

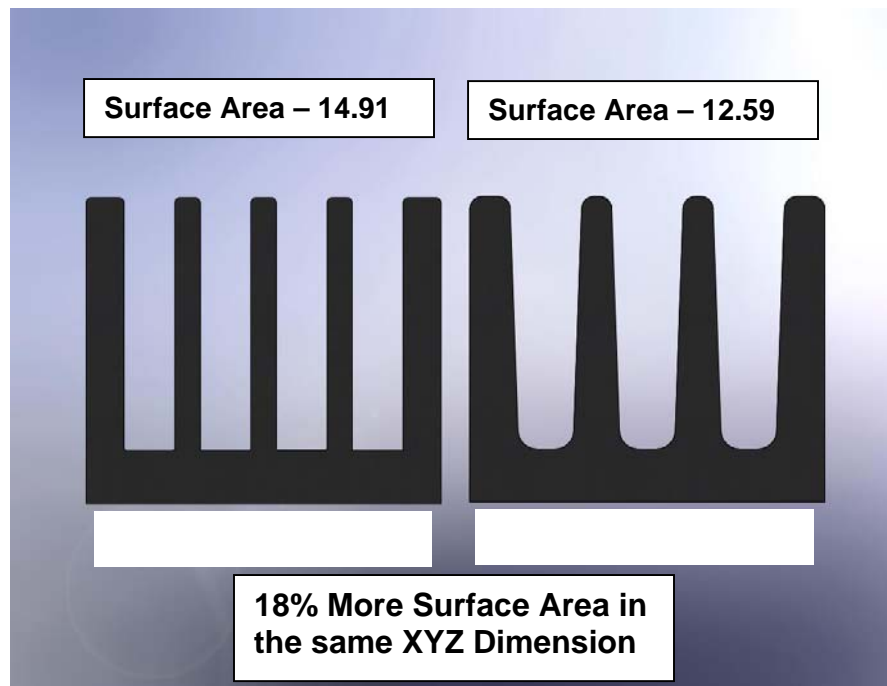
2. Increased Surface Area

An increase to the surface area of a heat sink will almost always result in improved thermal performance. This may not be true if fins are so close together that they inhibit air flow.

Extruded fins must be tapered so that the material will pass through the tool without breaking. The number of fins in an extrusion will always be limited by the width at the base and the aspect ratio of the fins. These restrictions inherently limit the surface area.

Forged fins can be made almost perfectly straight allowing for more fins per square inch. The fins can also be formed into an elliptical shape. The resulting increase in surface area can also be an important factor in improving thermal performance. The pictures below illustrate this concept.

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The forged heat sink pictured above increases the surface area by 18% without increasing size or weight. The result is increased thermal performance.

3. Reduced Secondary Operations → Reduced Cost

Secondary machining operations increase cycle time and add to the cost.

As previously indicated, the extrusion process is linear and this limits the design of the heat sink. Secondary machining operations can be used to add features such as holes, chamfers, pins, etc.; however these operations increase cycle time and the cost of the finished part.

The forging process has few limitations to forming shapes and complex fin designs. A forged part is formed in two dimensions within the tool to create complex shapes without the need for secondary operations. Holes, chamfers, pins, elliptical fins, steps, etc. are created in the tool in a single operation.

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The diagram pictured below illustrates this advantage.



SECONDARY OPERATIONS	
Required to Manufacture the Part Pictured Above	
Extruded	Forged
1. Straighten	Machine Top for Flatness
2. Cut to Length	Machine Bottom for Flatness
3. Machine Top for Flatness	Drill Screw Holes
4. Cross Cut	Insert Stand-offs
5. Machine Cavities for Screw Holes	
6. Drill Screw Holes	
7. Machine Cavity for Copper Spreader Plate	
8. Cut Spreader Plate to Size	
9. Solder Spreader Plate in Cavity	
10. Machine Bottom for Flatness	
11. Insert Stand-offs	

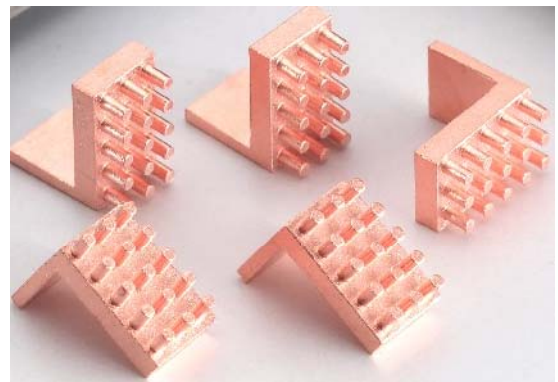
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In the part pictured above, the copper spreader plate is inserted with the block of aluminum into the tool. As pressure is applied the softer aluminum forms around the copper creating a mechanically fused, void free bond that offers improved thermal spreading resulting in improved thermal performance.

The forged heat sinks pictured below provide additional illustrations of the unique shapes and fin designs that can be achieved in the forge tool in a single operation.



**Highly Compact Curved Fins
Maximize Surface Area**



**Material can be formed in
multiple dimensions**



**Round Pins, holes and
standoffs formed in the tool in a
single operation**



**Round Shapes
(ideally suited for LED Cooling)**



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Conclusion

Precision forged heat sinks offer several important advantages over their machined, die cast and extruded counterparts. The increased thermal performance coupled with the ability to expand the surface area without increasing the size of the heat sink are unique advantages. These factors are especially critical when space is limited and/or weight reduction is critical to the product.

Precision forging can also produce complex shapes such as elliptical fins, staggered fins, round pin arrays, steps, etc. within the tool. These features cannot be achieved in an extruded or die cast part.

Finally, precision forged heat sinks can often be manufactured at a lower cost because most operations can be performed in the tool and secondary operations are reduced.

Forging is also the most effective method for forming copper. Copper is difficult to extrude because it must be heated to high temperatures to soften the metal. This can damage the extrusion tool. Secondary machining operations also result in expensive waste. Forging is a cold process, and copper heat sinks can be formed with minimal waste.

Cooliance offers a wide range of standard and custom precision forged solutions to meet your most challenging thermal management problems. Our goal is to provide the optimal solution at the lowest cost. Depending on the requirements of the application, we also manufacture die cast, extruded, and machined heat sinks.