Heat Sink Design – Aluminum Extrusions

1.) Overview

The purpose of this technical brief is to give the new designer or engineer the basics in the limitations of designing an aluminum extrusion. Extrusions are 2 dimension shapes that can be fabricated after manufacture to produce net shape parts. To help minimize cost and maximize efficiency extruded aluminum heat sink need to be low in weight, high in exposed surface area and simple in design. Violation of these basic design criteria will result in less than optimized heat sinks for the specific application.

2.) Tolerances

In general an extruded shape has a wider tolerance than a machined part. In many machined aluminum parts holding feature tolerances can be done at +/- 0.005 inches or better. In extrusion, due to the nature of the process, these feature tolerances can be up to +/- 0.100 inches or more depending on the overall size of the profile and it's technical complexity. Most extruders, including Thermshield, LLC, comply with The Aluminum Association standard tolerance listings which vary allowable tolerances based on the overall circle size of the extrusion. In most cases the following tolerances apply to given dimensions:

+/- tolerance in inches

	Up to 10" circle	Greater than 10" circle
Less than 0.125"	0.006	0.014
0.125 to 0.249	0.007	0.015
0.250 to 0.499	0.008	0.016
0.500 to 0.749	0.009	0.017
0.750 to 0.999	0.010	0.018
1.000 to 1.499	0.012	0.019
1.500 to 1.999	0.014	0.024
2.000 to 3.999	0.024	0.034

4.000 to 5.999	0.034	0.044
6.000 to 7.999	0.044	0.054
8.000 to 9.999	0.054	0.064
10.00 to 11.99	------	0.074
12.00 to 13.99	------	0.084
14.00 to 15.99	------	0.094
16.00 to 17.99	------	0.104

3.) Circle Sizes

Most extrusions are made in large hydraulic presses that use a specifically shaped tool to form parts. The size of the press is designated by the number of tons of force it can apply and the maximum circle size of the tooling. The circle size of the tool limits the overall size of the maximum extrusion profile that can be made by a given press. This largest allowable size is the combination of width and height that will fit within the given circumscribed diameter. Press circle sizes range from 2.0 inches to as large as 30.0 inches. In general the larger the tool size the fewer presses are available in the world.

4.) Extrusion Ratios

One of the limiting factors in the extrusion process is the ratio of fin height to minimum air gap between fins. This air gap between fins represents the amount to tool steel material used in the production die that helps to hold back the flow of heated aluminum during the extrusion process. If the distance between fins is too narrow and tall the result will be die failure. Die failure can be either fin thickness that "shift" changing the width of the air gap setting fin thickness out of tolerance. The other failure mode is breaking of the steel resulting in redesign and remanufacture of the die.

The limitation on extrusion ratios varies with the overall size of the extrusion profile. Extrusion ratios of 14 to 1 are common place for dies that are less than 4 inches in diameter. Ratios of only 10:1 or less are more typical for dies that are 10.0 inches and above. Some manufacturers can produce ratios of up to 22:1 depending on many factors. There is no set limitation on ratios that can be calculated. The limit of the ratio depends on many factors including the type of

extrusion press, the skill of the operator, the alloy being pressed and many other details.

5.) Physical Properties

The most common aluminum alloy used for extrusion is 6063, 98.9 % aluminum.. The most common temper is T5. This alloy has excellent physical characteristics, can be made in various tempers and is relatively low in cost. Following are typical properties:

Coef. Thermal Expansion	13X10-6 inch/inch
Thermal conductivity	209 W/MK
Electrical Resistivity	3.1 X 10-6 ohm – CM
Melting temp	616 C
Density	2.7 g/cc
Tensile strength, yield	145 Mpa

For further information please contact:

Christopher A. Soule
Engineering Director
Thermshield, LLC
(603) 524-3714
csoule@thermshield