



DISTORTION & CRACKING HEAT TREATMENT OF **H-13**

The heat-treat requirements of H-13 for aluminum die cast dies have greatly changed over the past few years. Today's specifications such as NADCA #207-2003, General Motors DC-9999-1, and Ford AMTD-DC2010 require very rapid quench rates, which were not even possible in a vacuum furnace until recently. While these specifications require a 50°F per minute minimum quench rate from the austenitizing temperature to 1000°F, much faster quench rates are necessary to ensure that the required Charpy V-notch test results are achieved.

Increased quench rates increase the risk of severe distortion or cracking. Cracks are nothing more than the distortion in its most severe form. When a large H-13 die is quenched (rapidly cooled) size change takes place by two different modes: one shrinking and the other growing. During the first phase of the cooling cycle, the die is shrinking because of thermal contraction. The thinner sections, edges, and corners cool much more rapidly than the thicker, center section areas do and, therefore, shrink quicker. The faster the quench rate the more pronounced is this effect. On further cooling a phase change takes place (Martensite). Martensite is larger than the previous material phase, thus the die now starts to grow. This growth starts slightly below 700°F. On rapidly cooled dies it is not uncommon for thick sections to be still very hot in the core while thinner sections, corners, and edges are below the Martensite start temperature. There is now a situation where some areas on the die are shrinking and some growing at the same time. This sets up a condition where there is considerable stress and possible distortion or cracking. Remember the untempered Martensite being formed on the outside thinner sections of the die is very brittle and will be stressed as the thicker, core material transforms to Martensite and grows.

DISTORTION RULES TO FOLLOW:

- **Thick sections tend to bulge. A large cube starts to look like a ball.**
- **Valleys tend to open.**
- **Holes tend to close.**
- **Areas of rapid transformation from big to small will distort more.**
- **Very thin sections attached to thick sections may not be strong enough to support the severe stresses that will occur when the thin sections are brittle and growing and the thick sections are shrinking.**

RECOMMENDED MACHINING GUIDELINES:

- **Allow a machining allowance of .005 per inch length of the major dimension.**
- **Inside corners at sections size require a generous radius. The larger the section change the larger the radius required. A slight section change may require only 1/4" radius. A larger section may require a 1/2" radius.**
- **Drilled holes in thick sections will no longer be perpendicular to the finished ground face. Allowances must be factored in.**
- **Very thin sections (knife edges) attached to thick sections should be avoided.**

