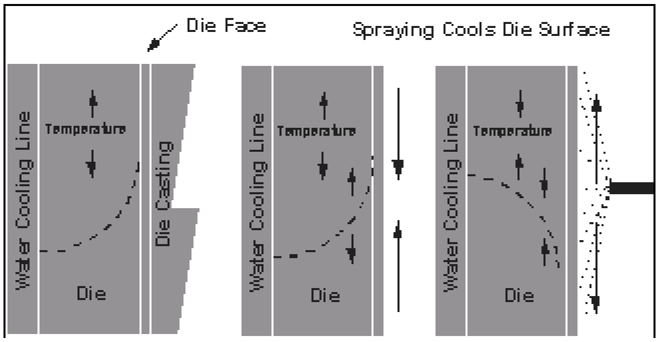
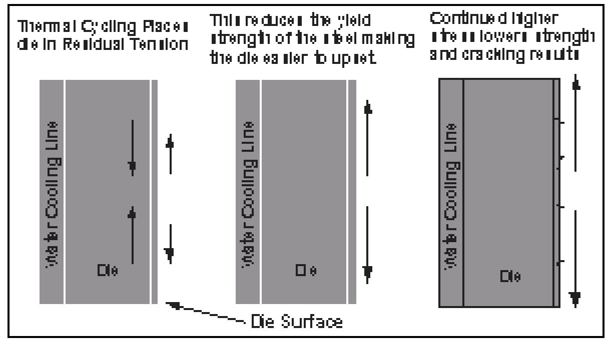
Badger Metal Tech, Inc. N60 W15088 Bobolink Ave. Menomonee Falls, WI 53051 262-252-3804 FAX 262-252-3956 TOLL FREE in the United States and Canada - 800-366-1973

Volume 4 Issue 3	Modes & Causes of Die Failure Part 3	March 1997



THIS CAN LEAD TO THIS



Our examination of the modes and causes of die failure due to cracking have shown two types of failure -heat checking and gross cracking. The Figure 1 schematic shows a cross section of a die and the stress physics associated with thermal or heat check cracking. Molten metal contacts the die and causes the surface temperature to increase more than the interior of the die. The **die face** (Diagram1) **starts to expand**, however, the cooler underlying layer resists. This creates a **temporary compressive** stress layer. When the casting is removed, the die surface starts to cool (Diagram 2) and as it does, the **surface shrinks.** The surface cools more quickly, however, than the interior of the die which places the die's sub-surface in **residual tension stress which** is exacerbated (Diagram 3) by the application of die lubricant. The curved dotted line in each drawing shows the relative difference in temperature for the interior of the die.

Continued cycling of the die, as shown in Figure 2, eventually **reduces the yield strength** of the tool which causes subsequent **higher residual tensile stresses** to develop and along with this, the initiation of the all too common thermal stress cracks. This type of cracking is more prevalent in aluminum and brass die casting tools due to the high contact temperature and resulting thermal shock of the molten metal and alloys used. Premature escalating heat checking is averted by good steel selection, proper heat treatment, and preventative maintenance measures. Periodic heat stress tempering is usually performed at 50 degrees F (1050 to 1000 degrees F) below the last temper to remove the cyclical residual tensile stresses. **Subsurface compressive stress attributes also need to be maintained** to counter the subsequent build-up of tensile stresses on the

Tool Steel Properties for Die Casting Dies

- Resistance to thermal fatigue cracking
- Higher fracture toughness to reduce gross cracking.

Other properties such as erosion reduction, and soldering resistance are also important, but can be influenced more by improvements in the die filling conditions.

If we summarize the two previous bulletins, the steel properties shown at left become critical to assuring maximum die cast tool life and protection against die thermal fatigue and gross cracking.

After steel selection and tooling of the die, **proper heat treatment** is the most important step to assuring long tool life. **The Jan/Feb issue of Die Casting Engineer has an excellent article by FPM's John A. Fitzgerald on page 34. We recommend this as required reading for all die casters concerned about premature die failures.** Preventive and corrective action to remove residual stress build-up and minimize softening of the die's surface contribute to a high level of resistance to fatigue failure from thermal stresses. The preventative maintenance should include regular heat stress tempering, and **MetalLife®**

application should be done when the die is **NEW** after final sample approval and then periodically throughout the life of the tool. A review of the **"K"** value formula presented by Professor John Wallace from Case Western Reserve University shows that a high yield strength at temperature results in a higher "K" value which is one of the proven benefits of **MetalLife®**.

High K value improves Thermal Fatigue Resistance

$$K = \frac{\text{Thermal Conductivity} \times \text{Yield Strength at High Temperature}}{\text{Thermal Expansion} \times \text{Modulus of Elasticity}}$$

- High Thermal Conductivity
  Molybdenum Good, Martensite Fair, Austenite Poor
- High Yield Strength
- Low Thermal Expansion
  Molybdenum Good, Martensite Fair, Austenite Poor
- Low Modulus of Elasticity
  Difficult to do much about this property

In our next special issue in **April**, we will discuss other considerations to **obtaining a high "K"** value and show how **MetalLife®** assists in some of these areas. **Future issues**, will discuss some new and important developments for **alternatives to H-13** tool steel, along with the results of initial **studies on the use of coatings** to help control the second largest cause of die deterioration - **Soldering and**

Compressive Stress Topography. Initial	**Chemical Attack.**

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