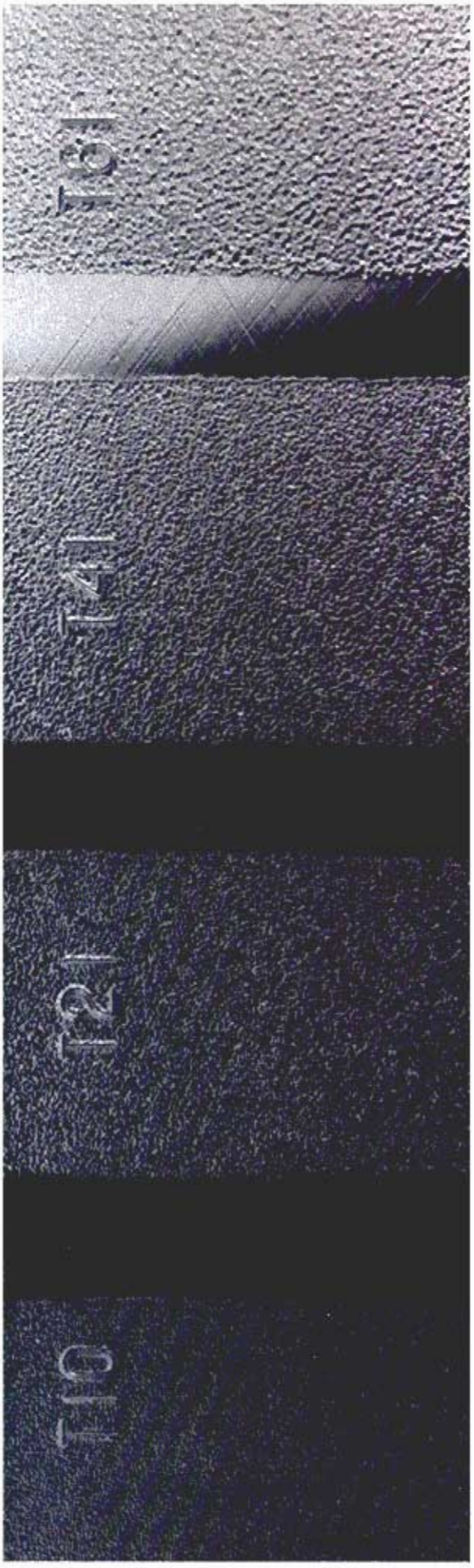

Badger Metal Tech, Inc.

Surface Technology For New & Used Hot Work Steels

MetaLLife®

COMPRESSIVE STRESS TEXTURING

Surface Treatment To Extend Die Casting Die Life

NOW THERE IS AN ESTABLISHED PROCEDURE TO HELP RESOLVE ONE OF THE DIE CASTERS' BIGGEST PROBLEMS - DIE THERMAL FATIGUE & HEAT CHECKING. In addition to being able to retard initial heat checking on **NEW** tooling, *MetaLLife* has the ability to help close and keep closed the thermal stress cracks that develop on **USED** tooling. The surface treatment also removes the small surface inclusions, pitting, and polish/grinding marks that allow initial heat checks to propagate. This is illustrated by the photos in **Figure 1**. The process is not a coating, plating, or chemical treatment that can jeopardize the initial heat treatment. The operation can be applied as often as needed without affecting the weldability or machinability of the die.

PREVENT IT NOW

RESTORE IT LATER

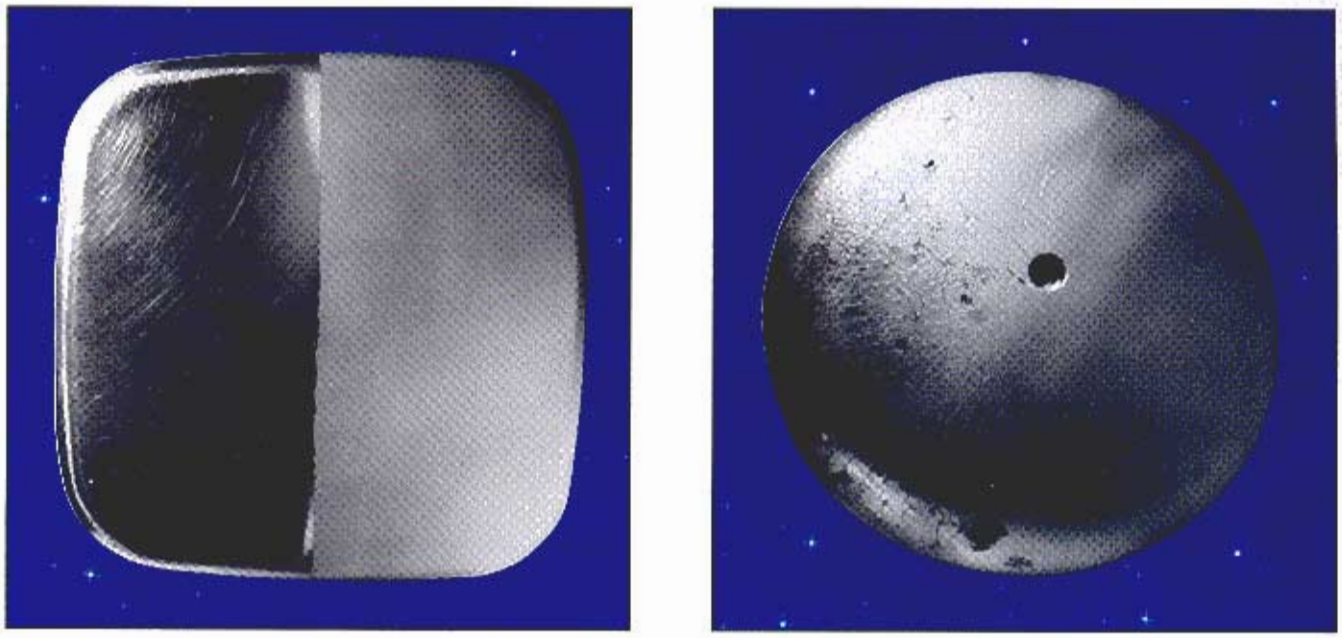

FIGURE 1

Left Photo: A new tool that was processed on one half. Polish marks are obliterated.
Right Photo: A used tool that was processed on one half. Cracks are closed in compressive stress layer.

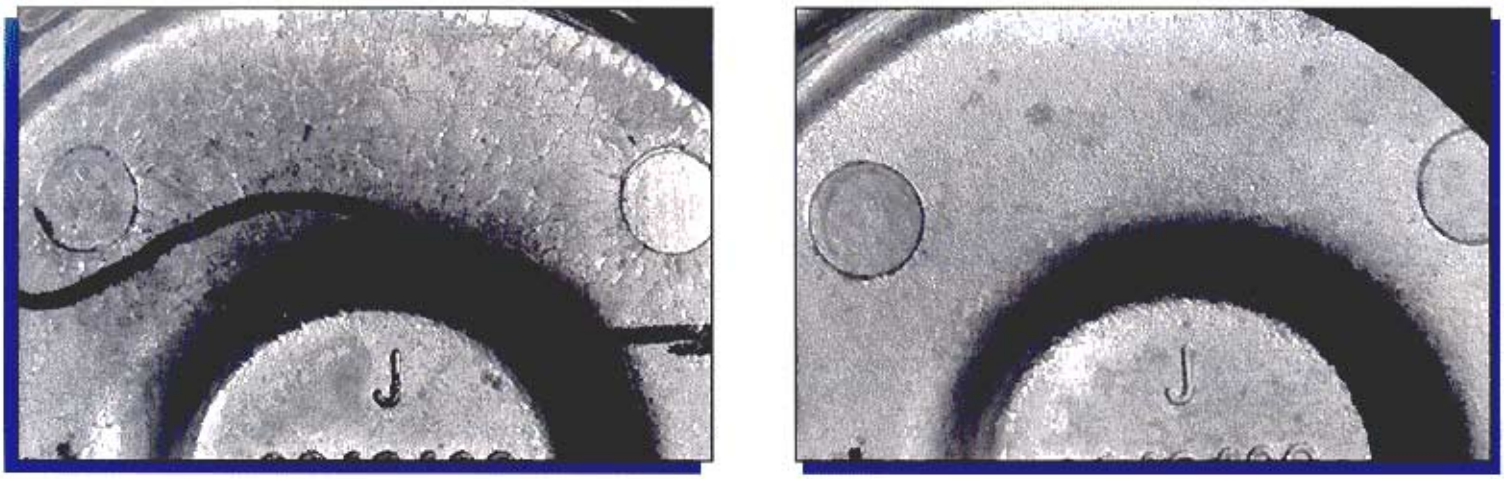

FIGURE 2

Left Photo: After 6,000 shots - die insert for cavity was left unprocessed.
Right Photo: After 400,000 shots - die received process when new and after every 50,000 shots.

The recommended frequency of application for **NEW** tooling is immediately after final sample approval and then every 30,000 to 70,000 shots. Photos in **Figure 2** show a test result that was obtained by applying the process on such a **NEW** tool. Normally this customer averaged 150,000 shots from their tooling. Metalife® now is incorporated as a preventative maintenance procedure on all of their dies and provides an average of 400,000 shots on their tooling.

Metalife® can be done in conjunction with initial stress relieving and either before or after subsequent stress temperings. More than just a cosmetic surface treatment, the process actually changes the stress profile of the die surface by encapsulating the working surface of the die in a layer of residual compressive stress. The resulting residual compressive stress retards the initiation of primary heat checks and stops the propagation of the even larger existing cracks that are not closed during the process. Metalife® has been lab and field tested for over 10 years.

Defined

Metalife. is a licensed proprietary process. Under rigid control criteria, the die's casting surface is impacted with special media. At the instant of impaction to the die's steel surface, there is a plastic flow of material that allows the metal to seek its normalized equilibrium state. This is what dynamically causes the minor heat checks, cracks, and surface inclusions to close or be obliterated. The impaction to the die surface causes a kinetic energy transfer that converts harmful residual surface tensile stresses left after finish EDMing, machining, grinding, and heat treating to advantageous compressive stress.

This induced residual compressive stress layer has a sub-surface penetration of .010" to .015" of an inch on dies that have not been nitrided and whose Rockwell is between 44-48 on the "C" scale. The impaction process also contributes to a slight work hardening of the surface which elevates the effective yield strength of the die as much as 25% to 30%.

STOPS CRACK PROPAGATION.. A well known principle of metallurgy states that crack propagation or initiation CANNOT develop in a compressively stressed zone unless the effective yield strength of the steel is exceeded. Nearly all cracks originate at the surface. If a surface is in compression, thermal cracks cannot start, or heat check cracks that exist cannot propagate further unless the steel is stressed beyond it's greater effective yield strength. Due to the .010" to .015" depth of the zone, it is also possible to afterwards polish the tool surface to achieve the sometimes required hardware finishes without the loss of benefits.

REMOVES SURFACE INCLUSIONS AND POLISH MARKS.. Intra and intergranular oxides on the die surface also contribute to the initiation and propagation of heat checks. These oxides occupy a larger volume than the metal that was previously present and can start a wedging action between the cast molten metal and the die material. This allows cracks to begin and propagate. Metalife® removes these small surface scratches, inclusions, and oxides that can induce heat checking through corrosion. The photo in **Figure 3** illustrates this by showing a treated and untreated section.

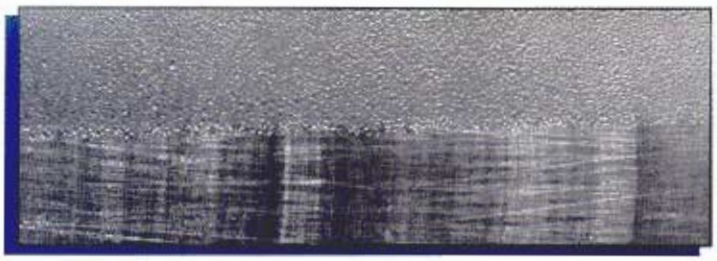

FIGURE 3
Upper half treated with Metalife.
Grind and polish marks which contribute to initial thermal cracking are no longer present.

After processing, the die surface is left in a slightly textured state. The texturing that is necessary to close cracks on **USED** heat checked tooling is directly proportional to the degree of existing heat checking. Sometimes the configuration of the tool will also have a bearing on the texture specified by the customer. The photo in **Figure 4** shows a bar of Vicount 44 steel that received the four surface finishes that are available and was then nickel chrome plated. **In the case of NEW or limited heat checked tooling any one of the T21, T41, or T61 textures can be specified.** The **T10** process is applied only on zinc dies or core pins where heat checking is very limited or non-existent or in cases of small pitting problems.

T61 finish is applied to **USED** dies that are considerably heat checked or **NEW** tools that have no stringent surface finish requirement. A **NEW** tool or one that has little heat checking may need only a **T21** finish, while a severely heat checked die may require the **T61** finish to close up the larger cracks. If a superior casting finish is required, the tool may be subsequently polished without an appreciable loss of the compressive stress benefits. For instance, a 70-140 micro die finish will polish to a 40-65 or better finish. There are also improved metal flow characteristics from Metalife® that impart a better surface finish to the casting. This renders a casting finish that is usually one step lower than the die finish. For instance a **T41** die finish produces a casting finish of about **T21**.

Other Benefits

BETTER HEAT DISSIPATION.. Heat checking is accelerated by expansion and contraction of the die's surface due to rapid changes in temperatures. The micro sized uniform depressions that are formed on the surface increase the effective surface area of the tool without changing tolerances. This affords the Metalife® surface a more efficient heat sinking characteristic which in turn influences thermal gradient temperatures. The result is a decreased Δ "T" operating parameter of the die. Lowering the Δ "T" is one of the factors necessary to reduce heat checking.

INCREASED LUBRICITY.. Maintaining lubrication helps prevent oxides from forming on the die surface which could lead to chemical soldering. The uniform surface created by the texturing, tends to hold and retain the lubricant on the die surface. The non-linear surface also increases the effective lubricating area which allows greater lube retention. Metalife® enhances casting release and in most cases will not cause drag problems unless the **T41** or **T61** has been applied to an area with little or no draft angle. In these cases it may be necessary to slightly polish these areas if extensive heat checking is present. In the case of **NEW** tooling, a lighter texture may be specified. The Metalife® surface texture should not be confused with an EDM type surface texture which may be damaging to the die.

LESS POROSITY AND IMPROVED METAL FLOW.. Gate design is crucial to a die's performance with regard to washout and proper fill. Texturing to this area helps to improve the flow of metal into the die allowing a more even and uniform fill while reducing the tendency of washout in the gate area of the die. Because of this, the Metalife® process automatically includes the runner section on both the cover and ejector sides of the cavity. It is this improved flow that causes the die cast surface finish to not mirror the finish of the die. For instance, a die with a Metalife® 70-90 micro finish will normally produce a casting with a smoother 20-60 average micro finish. **Figure 5** illustrates this effect.

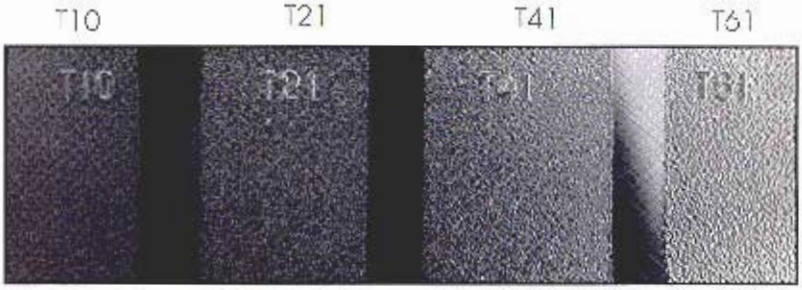

FIGURE 4

FINISH	TYPICAL APPLICATION	DIE RMS	CASTING RMS
T10	Core Pins or Zinc Die	40-70	15-25
T21	Standard	70-90	20-60
T41	Heavy	90-100	40-80
T61	Maximum	110-190	70-140

FIGURE 5

Left Photo: Die INSERT *before.*
Right Photo: Die INSERT *after* T21 Metalife process.

Left Photo: Die CASTING *before.*
Right Photo: Die CASTING *after* T21 Metalife process.

Process Limitations

1. The desired **DIE HARDNESS** for application of the process to hot work steels is anywhere from 35 Rc to an upward limit of 48 Rc. Harder rockwell maraging steels, because of their low carbon content, can also be effectively processed. Anything that compromises the upper surface hardness limit requirements will have a negating effect on the compressive stress depth of penetration and texturing along with limiting the crack closure ability of the process. Examples of this include uneven or improper heat treatments, work hardening of the die, hard weld areas, or other prior surface treatments that set up a hardened skin surface such as nitriding. Some of these states can be harmful to a die's life. If such a limitation exists but is not evident to the die caster, Metalife® will show exactly where these conditions prevail. This provides a distinct method for checking the die surface integrity and hardness.

2. Previous conditions where metal has been displaced from the die, also known as **BREAKOUT**, will still have the breakout condition after processing. This is also true of any large pitted areas on the tool's surface. Sometimes poorly welded areas will become more visible due to an existing but previous undetected breakout condition surrounding the welded area. This is shown in the **Figure 6** photo.

3. **LARGE CRACKS** that are more than .020" wide or .020" in depth will sometimes not close even though the die surface is in the desired hardness range. Heat checking is a very subjective topic. To help determine the various levels of cracking that may be present on a die in relation to our ability to close them, we are providing, as a reference guide, a set of six actual size photos as shown in **Figure 7.** Compare these actual photos with the present condition of your die. If your die has a "2"or"1" rating, all the cracks should close with the T21 or higher texture. Heat checks that fall in the range of "3" will require at least the T41 finish. As mentioned earlier, cracks that are wider than .020" of an inch will not close. Examples of these are some of the cracks as illustrated in "4", "5", and "6". If the die heat checking falls in any of these ranges, T61 should be used, however, the larger cracks will not close. In such a case welding, resinking, or replacement of the die should be considered prior to processing. This situation can be improved by taking Metalife® preventative measures earlier in a die's life.

4. **EXTENDED HIGH HEAT** conditions that are close to the annealing temperature of the steel, such as seen in brass die casting, have a tendency to remove some of the compressive stress benefits. In order for the process to be effective where pour temperatures may reach or exceed 1,900 degrees F, steps must be taken to reduce the tool's operating temperature and degree of thermal shock. Brass customers that have such controls are seeing excellent results. Periodic stress tempering may be performed either prior to or after sending the tool for processing.

FIGURE 6
Arrows indicate die regions with hard weld , pre-existing breakout, and pitted areas.

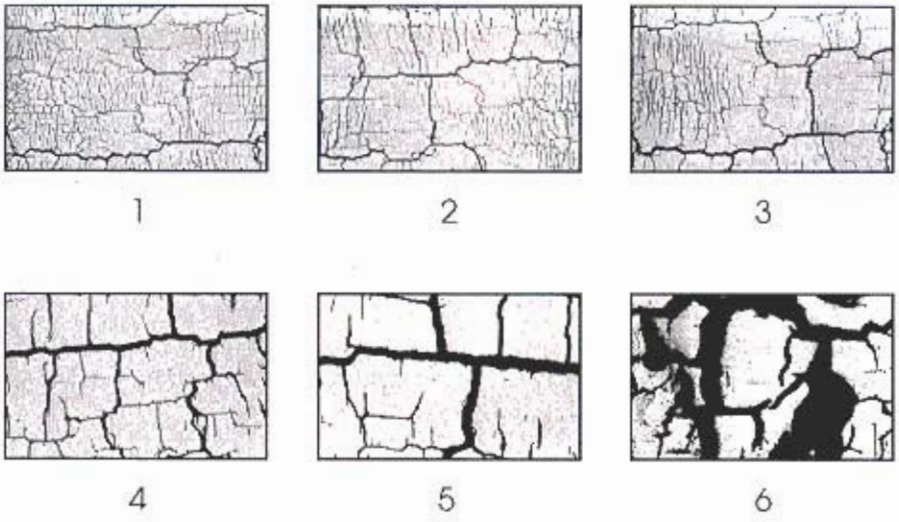

FIGURE 7
Heat Checking Reference Guide Scale

A FEW WORDS ABOUT EDM SURFACES

The melting and rapid solidification of the tool surface by this machining method reduces a die's thermal fatigue strength which can lead to earlier failures and shorter than normal tool life. For more information on this topic, see our brochure that further explains **"EDM EFFECTS ON H13 STEEL"**.

MARAGING STEELS

Maraging, like any hot work steel, in time develops tensile stresses which contribute to unanticipated failure. Unlike H13, however, periodic heat stress tempering cannot be used to relieve these stresses. Metalife®, since it is performed at room ambient conditions is a recommended way of effectively removing these surface tensile stresses and inclusions. Even though the steel tempers to a range of 48-52 Rc, the absence of the carbon hardness allows Metalife® to still close cracks in these harder maraging die surfaces.

$$$ Savings $$$

The graphs in **Figure 8** substantiate that the raw tooling cost savings alone are significant enough to justify the investment in the process. The bottom bar graph shows what the total raw tooling cost would be to get 300,000 shots out of a representative large automotive aluminum die that is estimated to have a life of 150,000 shots. In this instance, two dies would have to be built for a total cost of $200,000. The top graph, however, shows that by using Metalife®, only one die is necessary to obtain the desired 300,000 shots. Metalife® is applied a total of six times to this die at a cost of $4,000 per application. The process is done after final sample approval and then every 50,000 shots. The resulting savings in tooling cost alone is $76,000.

Add to this other tangible cost factors such as **INCREASED CASTING RATE, BETTER CASTING APPEARANCE, REDUCED SCRAP RATE, DECREASED DOWNTIME, AND INCREASED PRODUCTIVITY** and one can see the total significant **$$$$$$$ SAVINGS** that show on the bottom line. It easy to see why many cost conscious progressive die casters are making Metalife® a regular preventative maintenance procedure on their **NEW** tooling.

For **USED** tooling it is not unusual to take a tool that was considered scrap and have Metalife® add enough extended life to allow the die to run an additional 20,000 to 30,000 parts. This provides crucial extra production time until a new die is completed to replace it. Sometimes it is applied to tooling for service parts to help maintain acceptable casting appearance requirements.

Besides the extended tool life benefit, Metalife® is being utilized in applications where poor fill characteristics are causing casting porosity problems. The resulting textured surface also enhances paint adhesion characteristics. The process is applied to dies that have only a few thousand shots on them but are already starting to show heat checking or small pitting. It has been employed as an

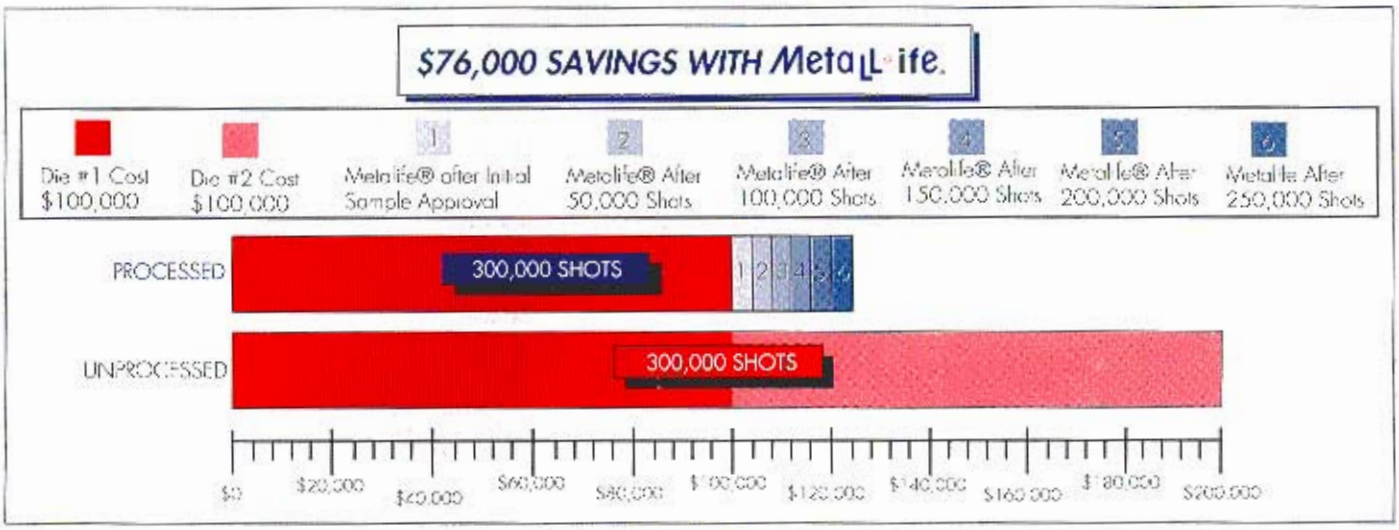

FIGURE 8

alternative to building a new tool when a customer complains about inferior casting appearance. Stuck castings and die soldering that cause a high scrap rate are additional applications addressed by the process. Zinc dies tend not to develop much heat checking but do sometimes start to pit. By applying Metalife® to these dies and then polishing for the desired finish, this problem can be eliminated.

PREPARING THE TOOL

Prior to sending the tool for processing, the following items should be addressed to assure the desired results.

1. The die, if **NEW**, should be completely sample approved with all required engineering changes made to the tool. In addition, any required heat treat stress tempering may be done before sending the tool to us.

2. If the die is **USED** and needs stress tempering, this may be done either prior to or after our processing the tool.

3. Since Metalife® is not an abrasive process, it is imperative that all solder be totally **REMOVED** from the cavity and runner area before sending it for processing.

4. The die should be **DISASSEMBLED** to only its insert, slide, and large core configurations. This allows access to all surfaces that need processing. All core and ejector pins should be removed if they are not to be processed. These holes are plugged prior to processing.

5. If desired, nothing heavier than a light coat of rust preventative oil should be **APPLIED** to the die surface. The process is selective and is applied to the total cast surface and runner area of the inserts.

LET MetaLife CAST YOUR FUTURE GIVE US A SHOT

Although not a panacea for all your manufacturing concerns, Metalife® is proving itself on a daily basis as a common sense approach for extending the life of **NEW** tooling and by being much more than just a cosmetic repair for problems that relate to **USED** tooling.

If you would like to get a quotation for applying Metalife® to one of your dies, just send us a casting from the die along with the maximum LENGTH, WIDTH, and HEIGHT dimensions for each applicable insert/core/slide. Also tell us the number of cavities involved. Badger Metal Tech will then determine the cost of treating your die by calculating the set-up charge plus the square inches of necessary casting area that are required to be processed for each piece. We will Fax you our quotation within 24 hours from receipt of your castings. Badger Metal Tech understands the need for urgency in the die casting industry and can turn your dies around in a very brief period of time. We encourage you to call us on our TOLL FREE number (1-800-366-1973) if you have any questions or require more information regarding Metalife® and the benefits you can expect.

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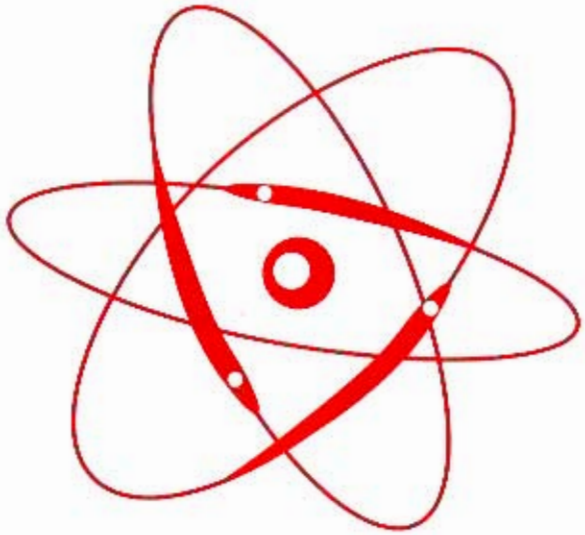

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