ZA ALLOY MACHINING GUIDELINES

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INTRODUCTION

The enclosed machining recommendations were developed for ZA-12 gravity castings. Machining parameters, therefore, will vary somewhat for ZA-8 and ZA-27 and for castings made by different processes. The recommendations should be viewed as conservative starting points for the machining of the alloys. In many cases, machining rates considerably higher than those suggested have been employed. We thank the International Lead Zinc Research Organization, Inc. for funding the machining studies which produced the information contained herein.

Note: A generous application of a cutting fluid is recommended for all machining operations. Emulsifiable cutting oils mixed with water in a ratio of 20:1 by volume are preferred. Flood cooling keeps cutting tools and work piece cool and prevents possible welding of ZA metal onto cutting edges. As a general rule, heat generating tool profiles must be avoided to preclude "gumming" of cutting tools.

The machining data developed found that high speed steel tooling was acceptable for all machining operations. However, tool wear problems have recently been experienced with machining of ZA die casting, possibly due to the "skin" effect or the fine grain size of a die casting. Carbide cutting tools and inserts, therefore, are recommended for any long-run machining of ZA castings and particularly when ZA die castings are to be machined. Diamond tipped tools are also being used with excellent performance results.

DRILLING

ZA alloys drill well. For shallow holes (up to 4x drill diameter), the material can be machined dry without lubricants; however, a generous application of cutting fluid is highly recommended for all machining operations.

Drill Design: Keep cutting edges sharp. Avoid "hand" resharpening and use fine grinding wheels. Do not grind flats on the lips and avoid web-thinning unless care is taken to maintain smooth flute surfaces. Use drills which have large, smooth flutes and thin webs (such as slow spiral and fast spiral--designed for non-ferrous work--

as opposed to general purpose jobber designs). Standard drill point geometries of 118° point angle and 12-14° lip relief angle are suggested for general drilling. Variations can be used for special applications.

Cutting Fluid: The generous application of a cutting fluid (emulsifiable oils) is recommended. Its importance increases with depth drilled. Flood cooling under pressure to insure coolant reaching the cutting edges is recommended for deep hole drilling.

Feed Rates: Avoid feed rate dwells during drilling. Dwells rapidly generate heat due to friction and can lead to galling and burring. The following feed rates should provide good results.

Hole Diameter in (mm)	Feed Rate in/rev (mm/rev.)
1/8 (3 18)	0.004 (0.10)
1/4 (6.35)	0.008 (0.20)
3/8 (9.53)	0.011 (0.28)
1/2 (12.70)	0.013 (0.33)
3/4 (19.05)	0.016 (0.41)

Because of the high machinability of ZA casting alloys, reasonable variations from these feed rates will also provide acceptable results.

Speeds: Drill surface speeds in the range of 200 to 300 feet per minute (60 to 90 meters per minute) can be used.

Uniform Torque Depth (UTD): UTD is the depth to which the drill penetrates before "smooth" uniform torque drilling ends and galling begins. The slow spiral drill combined with lower feed rates produces higher depths of stable penetration (approx. 4-6 drill diameters).

Deep Hole Drilling: Drilling holes to depths beyond approximately 6 drill diameters will require intermittent withdrawal to permit cutting fluids to reach drill tip for cooling and lubrication. When deep hole drilling, always flood with a cutting fluid. Oil hole drills, although not examined, would probably work well. Slow spiral drills are preferred for drilling deep holes.

For deep hole drilling using slow spiral drills, feed rates and speeds recommended above should be reduced by approximately 50%. For sand cast ZA-12, medium to high speeds (200-300 SFM) are recommended. Low to medium speeds (150 SFM) should be used with permanent mold castings.

Dry Drilling: Slow spiral drills are preferred for dry drilling shallow holes (up to 4 drill diameters). Lower speed (200 SFM) may improve waste form and reduce burr formation.

TAPPING

Tapping results in excellent thread quality over a wide range of tapping conditions. All recommended taps can be purchased directly from the manufacturer and used in the as received condition.

Tap Design: High speed steel or carbide taps are used in production applications. Taps having ground threads and smooth, large flutes should be used. Sharp cutting edges should be maintained. "Spiral point" taps (2 & 3 flutes) should be used when feasible. These taps are designed to push cutting wastes through the hole ahead of the advancing tap and therefore are seldom employed on blind holes. When spiral point taps cannot be used, the "special aluminum" tap (4 flute) geometry is preferred. The special aluminum tap differs from the standard tap in its positive rake angle which often improves the cutting action in non-ferrous alloys. Acceptable results can also be obtained with the "standard" tap geometry (4 flutes). Ensure that all taps have sufficient relief to permit chips to be removed from the cutting edge.

Tapping Speeds: Cutting speeds up to 200 SFM (61 m/min) and possibly higher can be used.

Cutting Fluid: A generous application of emulsifiable cutting oils mixed with water (20:1) is recommended for tapping.

Pre-drilled Hole Diameters: The following are examples of pre-drilled hole sizes used and resultant thread yield:

#7	drill	for	1/4-20 tap	yields	70% thread
#3	drill	for	1/4-28 tap	yields	72% thread
27/64 in.	drill	for	1/2-13 tap	yields	73% thread
29/64 in.	drill	for	1/2-20 tap	yields	65% thread

REAMING

Reaming results in very clean, smooth surface finishes with uniform hole diameters over a wide range of machining conditions.

Reamer Design: As in drilling and tapping, the cutting tools should have sharp cutting edges and large, smooth flutes. The common reamer design, having six flutes, 45° lead chamfer, and 0° radial rake angles, performs well. The right hand spiral fluted reamer performs best while left hand reamers are a second choice.

A recent problem has occurred during reaming or drilling of ZA die castings. Occasionally "spring back" of reamed holes has resulted in undersized hole diameters. The causes of this phenomenon are not yet totally understood but seem to be associated with the high toughness of ZA die castings. This behavior is currently under study.

Cutting Fluid: Generous application of an emulsifiable oil cutting fluid is recommended in reaming the zinc alloys (20:1 dilution).

Depth of Cut: Shallow depths of cut are preferred for best surface finish. Use predrilled holes of approximately 97.6% of the reamer diameter. The following table can be used as a general guide to reaming.

Reamer Dia (mm)	Hole Dia. Prior to Reaming (mm)
1/8 (3.18)	0.122 (3.10)
1/4 (6.35)	0.244 (6.20)
3/8 (9.53)	0.366 (9.30)
1/2 (12.70)	0.488 (12.40)
3/4 (19.05)	0.732 (18.81)

Feed Rate: High feed rates are preferred for better diameter control. The feed rates could be increased by 0.001 to 0.002 in/rev (0.025 to .051 mm/rev) for greater productivity in the reaming of shallow holes, while slight reductions in feed rate can be considered for the reaming of deep holes.

Cutting Speed: Cutting speed of 100 and 200 SFM (30 and 60 meters per minute) give good results.

TURNING

ZA alloys provide a clean smooth machined finish. While cutting fluid has little effect on finish, tool life and chip formation are improved. Therefore, an emulsified cutting oil is recommended for all turning operations. Chip formation will tend to be stringy compared to brass and cast iron.

Cutting Oil: Flood cutting area with emulsified cutting oils.

Lathe Tool Design: Cutting tools should have sharp cutting edges and smooth rake and clearance surfaces. Tools should be held firmly on center. Tools with high clearance angles (10°-15°) and high positive side rake angles (10°-15°) are recommended. Positive back rake angles will lead to some improvement in surface finish. Larger clearance angles (15°) reduce heat and edge build-up formation on tools.

Feed Rates: Low feed rates are preferred for best finishes on the final pass. On the other hand, high feed rates give better chip formation.

Speed: Cutting High cutting speeds of 100-300 SFM give good surface finishes while chip formation improves with lower speeds.

Form Tools: Wide form tools will result in a continuous waste form which is difficult to break. Problems can develop when the waste form is confined such as in blind holes.

MILLING

Common right hand spiral fluted end mills or the "special aluminum" polished large flute design provide good results in end milling. Non-standard high helix and "helical aluminum" cutters are preferred for plain milling due to their lower number of flutes and higher helix angles. Down or climb milling provides improved chip flow and disposal, improved cooling and lubrication, and reduced burr formation.

Shallow finishing cuts (.025 in.) are preferred after deep passes. Cutter speed of 350 SFM is a general recommendation but if deep cuts are made, speed should be decreased to as low as 100 SFM. Lower speed produces less burr formation. However, low-speed, high-feed combinations cause high cutter forces which may be detrimental when using small cutters. High table feeds are recommended for both end and plain milling.

FORM TAPPING

Form tapping is attractive for small diameter holes where potential tap breakage due to weaker fluted taps exists, and the absence of cutting wastes is a benefit. Disadvantages include high tool cost, poorer thread shape, and the need for accurate hole diameters. Form tapping is suitable for ZA gravity casting and provides good results over a wide range of tapping conditions. To date, no trials have been conducted on die castings. Cutting fluids should be used to minimize heat build up due to the frictional forces involved in form tapping.

BELT GRINDING

The coarsest grit belt consistent with an acceptable surface finish is recommended to minimize loading. Experience has shown a 40 grit belt to be acceptable. Heavy pressures should be avoided and the use of a paraffin wax lubricant is recommended when heavy grinding is necessary. Belt speeds in the range of 1950 SFM are acceptable.

STAKING

Staking tool geometry normally used for other metals should be acceptable for the ZA alloys. In most cases, both low-speed hydraulic or high-speed mechanical presses can be successfully used. Use of a lubricant is recommended when deformation is large. Room temperature staking provides good results, but if cracking is a problem, staking at 100°C has been found to decrease cracking of ZA-12. Staking of gravity cast ZA-27 is expected to be superior to ZA-12. Staking trials on ZA die castings have yet to be conducted, but the range of elongation of ZA die castings may require additional care in developing successful staking parameters.

KNURLING

Cross-slide bump type knurling rollers have been used successfully to knurl the ZA alloys.

BAND SAWING

Blades of common design run at high speeds are recommended and coarse pitches are preferred. A pitch of three to four teeth per inch is recommended for heavy sections. At least two teeth should be in contact with the work at all times. For longer production service, bimetallic blades should be considered. Cutting speeds of 300-400 SFM should be used and cutting fluids are highly recommended.

NOTE: While the technical information and suggestions for use contained herein are believed to be accurate and reliable, nothing stated in this bulletin is to be taken as a warranty either expressed or implied.

To assist your product evaluations, please contact Eastern Alloys for the latest available technical data on the proper application of the ZA alloys.

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