

CER-MAC, INC. GUIDE TO THE TOOLS AND PROCESSES OF MACHINING INCONEL

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Cer-Mac has years of experience in machining Inconel and other high nickel alloys. Whether your requirement is drilling, milling, turning, or EDM, we have the right equipment and staff to manufacture Inconel products to your specifications.

Inconel is a high temperature, high nickel alloy that exhibits superior oxidation and corrosion resistance as well as tolerance to extreme environments of pressure and heat without loss of material strength. For this reason, Inconel is attractive for use in gas turbine, marine equipment, nuclear reactors, petrochemical plants and a host of other applications where sustained exposure to extreme heat, pressure, and / or corrosive environments are the norm.

The qualities which make Inconel so attractive, however, make it a real challenge to machine and will put any machinist and process engineer to the test. The avoidance of work hardening is crucial to the successful machining of Inconel. Work hardening occurs when the metal ahead of the cutting tool becomes plastically deformed. The resultant hardened layer is very difficult to machine in subsequent passes or following operations. This leads to deformed or broken tooling as well as machined surfaces that are sucked in, gouged, and glazed over.

At roughly \$40.00 per pound, Inconel's high material cost as well as high tooling costs combined with the inherent machining challenges can lead to huge losses for the shop if proper precautions are not taken.

TOOLING

Understanding tool limitations is the key parameter which must be controlled in order to prevent failures when machining Inconel. Avoiding work hardening becomes the key to success. This requires advanced planning as well as a thorough understanding of the limitations of the various tooling being used. The average tool life is typically 30 minutes while generating a cutting process or chips. In general, an ongoing 30 minute cycle plan needs to be in place to remove and replace the tool as the part is worked. This must be done in consideration of the various operations required to produce the finished part. It is often considered impractical to stop and change a tool in the middle of an operation without negatively affecting the quality of the finished piece. In practice, however, there are times when this must be done, and the shop will need to engineer this strategy in advance of the machining process. In summary, each

cutting tool should have a planned replacement cycle of use and then be re-sharpened or discarded.

TOOLING RECOMMENDATIONS

Machining Inconel properly requires a complete understanding of the tooling being used. There are many factors to consider including type of tooling material, optimal cutting angle, speed, feed rate, coolant flow, and depth of cut. Ignorance of any of these factors will invariably lead to failures. The following recommendations may be used as a guide when considering the various tooling options.

CENTER DRILLS: Use spot drills as opposed to standard contour drills. Do not thin the webbing. Sharpen after 20-50 holes. Cobalt is preferred over carbide.

DRILLS: We use a 118 degree drill point. Do not thin the webbing. Sharpen after 20-50 holes. Cobalt is preferred over carbide.

THREAD MILLS: At Cer-,Mac we choose to thread mill first and avoid tapping at all costs. We typically use 3-8 passes per hole at approximately 60 sfm.

TAPS: Only use taps as a last resort. Often we will use one tap for one hole. The tapping process often leads to failure. We repair holes with taps only in cases where the thread mill has broken.

TURNING TOOLS: We use carbide insert tooling using a slightly positive primary cutting angle to zero. We do not use negative tools! At 40 - 80 sfm expect a 20 – 40 minute tool life.

SQUARE MILLS AND BALL MILLS: At 60 sfm expect a 20 – 40 minute tool life. This will become a major cost driver in producing parts. They will chip and wear approximately every 20 – 40 minutes so plan ahead!

WIRE AND RAM EDM Cer-Mac uses the EDM procedure as often as possible. The EDM process does not cause the material to work harden! In addition, the EDM process has no time limit in producing machined surfaces.

A great added value would be to have a tool sharpening system. At Cer-Mac we use the Darex XT 3000 tool sharpening system to sharpen center drills and drills. Please visit the manufacturer's website at www.darex.com for more information. This ability to sharpen our own tools is one of our keys to success in machining Inconel.

In closing, Cer-Mac has years of experience in machining Inconel. Tools and tool life are the main factor in determining the overall cost of supplying Inconel parts. Therefore, a tooling plan is essential to the successful production of Inconel parts. This requires advanced planning and a thorough knowledge of material and tooling limitations. Failure to implement a proper tooling plan leads to part damage, costing your shop money and delaying delivery to the customer. Cer-Mac employs a customized tooling plan for each Inconel part we produce. Consider Cer-Mac in supplying your Inconel and high nickel alloy parts.