Modern Solutions for Modern Materials
Once a technology only used in laboratory research projects in a few state universities, Easy Machining of Hard Materials is the first commercially available laser assisted machining of ceramics system on the market. High labor costs, tool wear, and low material removal rates are all issues that have plagued the machining of hard materials. Easy Machining of Hard Materials focuses on improving these issues by reducing cutting forces to increase material removal rates and decrease tool wear when machining these hard materials. By using a laser to preheat these materials prior to turning, cutting forces are reduced making single point machining a possibility. Turning of these hard materials results in lower cost, higher productivity, and require a single set up as opposed to diamond wheel grinding.
What is Easy Machining of Hard Materials?

Easy Machining of Hard Materials (EMHM) is a laser assisted machining process that can make the post sintered machining of hard materials a cost effective alternative to traditional diamond wheel grinding. The system integrates a fiber diode laser with a CNC lathe. The laser preheats the material to soften it, which reduces the cutting forces required for machining.

Benefits of EMHM include:

• Reduced machining times due to increased material removal rates
• Less down time due to tool changes
• Eliminates the need for diamond wheel grinding
• Creates features such as threads not possible with diamond grinding
• Reduces some need for pre-sintering molds which may reduce mold charges
• Complex features such as multiple radii are possible
• Can be integrated with existing lathes
• No coolant and associated overhead and environmental expenses required

Heating of the surface locally raises the temperature of the glassy ground boundary phase, which is the remainder of the oxide sintering aids used to obtain liquid phase sintering. The system applies sufficient heat to soften the grain boundary phase and produce the desired ductile deformation to allow machining using a single point cutting tool. This ductile deformation enables reduced cutting forces, high material removal rates, minimal surface damage, and long tool life.

Faster Than Diamond Wheel Grinding?

In-house trials have proven that EMHM reduces machining time of silicon nitride by over 80% compared to conventional diamond grinding. Figure 1 shows the results of these in-house trials. The material removal rate was drastically improved with EMHM, resulting in a total machine time of 14.75 hours compared to 113 hours for the same amount of material removed with diamond grinding.

Machine Time for EMHM and Diamond Grinding*

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Figure 1

What are the Benefits of EMHM?

Ceramics offer unique physical properties. In certain applications they can provide many benefits that traditional materials such as steel and super alloys cannot offer. Despite their many benefits, ceramics remain extremely difficult materials to machine due to their high hardness and brittle nature. The expensive cutting tools and long machining times that are required to machine these materials make them cost prohibitive in all but the most demanding applications. Regardless of these challenges ceramics remain a desirable alternative for metal components.

The ability to machine ceramics easily and cost effectively can be a monumental leap in industries where critical material properties for resisting extreme environments is a must. EMHM helps mitigate some of the costs associated with these materials and makes them a more affordable solution for current applications, as well as applications where cost of machining was previously a barrier.

Some of the characteristics that make these materials so desirable are:

• Lower weight than steel components
• High compressive strength
• Requires little lubrication
• Electrically insulating
• Wear resistant
• Chemical/corrosion resistant

Who Can Benefit?

Due to the various benefits that technical ceramics offer they are used in a wide range of industries and applications. Some of these industries/applications include but are not limited to:

• Automotive
  • Cylindrical rollers
  • Bearing Cage rollers
  • Fuel Pump rollers
  • Ball bearings
• Military/Defense
  • Body armor
  • Missile radomes
  • Jet engine igniter insulators
  • Bearings
• Industrial Applications
  • Industrial wear applications
  • Bearing rolling elements
  • Ball bearings
  • Metal forming rolls
  • Sandblast nozzle liners
  • Aluminium casting products
  • Thermocouple sheaths
  • Welding nozzles
  • Welding tips
  • Glow plugs
• Oil and Gas
  • Thrust bearings
  • Shaft seals

Who Can Benefit?

Integration Made Easy

In production environments that currently use diamond grinding to machine ceramics, EMHM will be a comfortable addition to the shop floor. If you are currently using a CNC lathe in your process, you can integrate a system with your existing machining center as long as there is adequate cabinet space to contain the unit. If a CNC lathe is not currently part of your process, we work with our machine center supplier to provide you with a lathe that is a perfect fit for your size operation.

In addition to designing a custom system for your operation we will also install the system at your facility and train your staff how to operate the machining center. This will ensure that your system is working as quickly as possible and you are receiving the benefits of EMHM as quickly as possible.
EMHM Makes it Better

Improved Surface Quality

Testing was performed with samples provided by two leading suppliers of silicon nitride. These samples were tested under five different surface conditions. For ceramic rod B the conditions were: As received, diamond ground (800 grit), laser only, and laser assisted machined. For ceramic rod K the conditions were: As received, diamond ground (100 grit), and laser assisted machined.

While improving surface finish is definitely important, it is the consistency of that finish that leads to a better performing part, especially in applications where reducing friction is key. Refer to figure 3 and 4. Weibull analysis of the two silicon nitride samples that were tested show us that the spread between the upper and lower bounds (Ra) for laser-assisted machining are much tighter than they are for the samples machined using diamond wheel grinding. This means that overall a better and more consistent surface finish was achieved by laser assisted machining. This can be visually observed in figures 5 and 6 where digital moire contour testing of the samples show that overall EMHM creates less peaks and valleys, and where there is contrast there are smoother peaks and shallower valleys than those that were produced by diamond wheel grinding. This can have a significant impact on reducing friction and enabling the part to perform more efficiently.

Even Stronger Than Before

These samples were analyzed for surface finish using the advanced digital moire contouring method. A total of 27 images were taken for each of the two ceramic samples. Weibull analysis of the results of these tests can be seen in figures 3 and 4. The results from surface analysis indicate that EMHM provides the best results in terms of surface finish.

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Visit us on the web at www.niu.edu/ceet/emhm
or
Watch our video at http://youtu.be/lumb2ouDUdQ

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

Figure 8

Northern Illinois University
Department of Mechanical Engineering

The central mission of Northern Illinois University, founded in 1895, is the transmission, expansion, and application of knowledge through teaching, research, and public service. Within this framework, the mission of the Mechanical Engineering Department is to provide a high-quality, visionary engineering education that reflects professional engineering standards and prepares competent engineers and leaders to recognize and formulate solutions for today’s and tomorrow’s problems and challenges in local, regional and international communities; to conduct quality research by developing and/or applying engineering knowledge and tools to address society’s technical needs and challenges; and to provide quality professional and public services to our communities.

Reliance Tool and Manufacturing Co.
For over 60 years Reliance Tool has been serving its customers with quality products. We are a full service design, die building, metal stamping, and rubber and plastic mold builder who can assemble many varieties of sub assemblies and finished parts.

Our company serves many industries, including automotive, aerospace, oil seal, rubber and plastic molders, can manufacturers, and any industry that needs precision tools, dies, molds or stampings. We have a full service modern machining center of over 30,000 square feet and over 50,000 square feet devoted to stamping and subassembly to accommodate these industries.

EMHM Patent pending applied for by Northern Illinois University
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