Optimize Metal Removal process Through Improving machine ability of Nickel and its Alloys

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Abstract: this paper concerned and presents the results of a series improving machining of nickel that were Performed to duplicate parts and produced quality products. particularly the improvements concerned with cutting force, heat generated, tool-work contact and chip serration as a function of cutting variables. Produced results that matched the overall trend of the experimental data, and showed Reasonable accuracy for calculated cutting force and chip serration and were highly dependent on the cutting parameters highlighted.

Key terms: Cutting Force, wear, machine ability speed, Feed, Rake, Relief, End cutting Angle, Cutting tool Material

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PART ONE

1. INTRODUCTION

1.1 Background

Nickel has a lower mp (1452 0C) than iron (1535)the metal and size alloy in general, more difficult to machine than iron & steel. Nickel is very ductile metal with face and body center. Unlike iron it does not undergo transform motion at basic crystal stature up to its melting point .

Commercially pure nickel is poor machine inability on the basis of all criteria, Tool life tends to be short and the maximum pre miscibility of metal removal is Low.

Nickel is also extremely corrosion resistant across a wide range of temperatures .Although nickel is found in many applications most notable is its use in the aerospace and medical industries. Nickel is commonly used in the aerospace industry in airframe and engine applications. Its high strength to weight ratio makes it ideal for use in landing gear and fan blade applications, where the reduction in weight causes the overall efficiency of the aircraft to increase. Nickel is also used in medical implants, specifically for the ball joint in replacement of hip joints.

In machining difficult materials, such as hardened alloy steels, titanium alloys, and nickel-base super alloys, dynamic material instability in the cutting process occur as the cutting speed is varied. The consequence is localized shear, poor quality and cyclic chip formation. An understanding of the criteria for shear instability and the conditions leading to shear localization are important considerations in our quest for improving productivity, tool life, and part quality as the overall efficiency of machining process. Due to their unique chemical, physical, and mechanical properties, these-materials are now finding a wide variety of applications. Identifying the factors that determine the susceptibility or resistance of materials to the initiation and propagation of localized shear deformation has clear practical significance. If the hard materials are used as machine components, the material instability can increase the machining speed; if the hard and strong materials are used as cutting tools, the shear band should be avoided to increase the tool life. Besides, hard and strong materials are now considered as possible replacement of depleted-uranium projectiles, which also requires deep investigation of the material instability.

Although the influences of many individual material properties on shear banding, such as strain hardening and rate sensitivity, are understood, no well-developed criterion is available for the comparison of the relative susceptibilities to shear localization of different materials. The difficulty arises partly because different materials have different combinations of properties. The lack of a criterion for the comparison of the relative resistance to shear failure is an issue in the design of structures and the selection of materials. Due to different factors most materials like nickel difficult to machine. Machine inability of the nickel and its alloys is generally rated as extremely difficult. Main difficulty in machining of nickel-alloy arises due to the high toughness and work hardening behavior of these metals.

In this paper have to search and find out problems that influence machine inability of nickel and improve its machine inability by using different mechanisms.

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1.2 Statement of the problem

As observation and experience show the productivity of the product and its profit increase due to effective machining and quality products. However poor machine ability is being the failure and rejections of the products .poor machine ability is causes due to the hardness, strength of metals (like nickel).

Many researchers have attempted to devise the means to improve machine ability of nickel. Some problems influence machine ability of nickel are

- Temperature /heat generated during machining
- Strength and hardness of nickel
- Improper machining process
- Machine types are influence the machining of nickel

The main focuses of this paper is to direct out the machining improvement of nickel and increase the quality of the product.

1.3 Objectives

The objectives of this paper are to understand the mechanical and thermal aspects of the material removal process in machining of nickel and its alloys and to improve mach inability using different cutting tools . The paper would be to establish a methodology for prediction of cutting forces, temperatures, stresses and cyclical serrated chip formation in machining nickel And there alloys. Friction and heat flow at tool-chip-work piece interfaces for various tool edge micro-geometry will be identified by conducting cutting tests. Wear rate models that relate predicted process variables and contact conditions to tool wear under realistic machining of nickel will be developed. This improvement will be utilized in determining optimum machine inability and improvement of nickel will be applied by improving of machining cutting variables. Experimental testing will be performed in to validate improved machine inability and tool life at low and high speed machining regimes of nickel. It is expected that this cutting tool design, cooling mechanism, unconventional machining processes capability would reduce the cost in product design and development and improve productivity in aerospace, automotive, military, chemical and medical device industry where nickel alloys are utilized

1.4 Significant of the study

1 In finishing, the primary objective is to control the form error within the tolerance and to obtain satisfactory surface roughness/finish.

2. Chip segmentation is dependent on the cutting conditions employed and to a greater extent on the coolant supply pressure /improves this

3. Improve Reactive forces generated by the high-pressure coolant jet increase with increasing coolant pressure and also with increased cutting speed due to increased dynamic forces.

4. The component forces decreased with increasing coolant pressure, suggesting that a higher-pressure coolant jet is able to penetrate the cutting interface, thus providing efficient cooling as well as lubrication. 5. The minimum surface damage during machining of nickel.

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1.5 Scope of the paper

The title of the paper is very wide which needs to analysis different parameters relative to machining of Nickel and effect of cutting parameters on cutting conditions. Here in this paper the analysis carried out only improve machine ability of nickel for different cutting conditions.

PART TWO

2. Review of related literature

This section deals with views of different authors on machining of nickel

The causes of machining of nickel are

According to Deloro Stellite is in the unique position of being able to offer a multitude of solutions for the wear and corrosion problems that plague the refining industry due to the hardness of metals .

According to(Professor Narutaki) Hard and strong metals is almost impossible to keep cutting conditions exactly constant in practical machining.

Even if it were possible, it would be found that tool life and failure are phenomena based
on probability. Fluctuations cannot be avoided in these. However, the range of fluctuations

is influenced by the damage mechanism. It is easy to imagine larger fluctuations when
chipping, or fracture rather than abrasion is the main mechanism.

As tool damage, by wear or fracture, increases, the surface roughness and accuracy of the Machined surface deteriorates.

(S. Ramalingam in the USA) Machining characteristics of a low alloy and a semi-free-cutting nickel
thermal properties: diffusivity, conductivity and heat capacity. By both thermal and stress
severity criteria, the difficult metals to machine nickel and its alloys. The most difficult to machine are austenitic steels, nickel heat resistant alloys and titanium Alloys stresses and temperatures increasing with carbon content and hardness.

Mallock was clear that chip formation occurred by shearing the metal influence the surface finish of the products. He argued hat friction between the chip and tool was of great importance in determining the deformation
in the chip quality of the work. He commented that lubricants acted by reducing the friction between
the chip and the tool and improve machine ability of nickel .

Liu et al. (2005) investigated the feasibility of fabricating high
Nickel alloy using micro-EDM, and micro-holes were successfully fabricated in high nickel Alloy.

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PART THREE

EXPERIMENTS TO improve machine ability of Nickel

Machine ability is usually a function of four factors consisting of

1. The surface finish and integrity of the machined part,
2. The tool life,
3. The force and power requirements, and
4. Chip control.
5. Tool material

Generally speaking commercially pure Nickel and Nickel alloys are known having poor mach inability. The main problem arises from the short tool life and low rates of metal removal that are typical seen during machining of nickel. The low tool life is usually attributed in part to the high cutting temperatures that are seen due to Nickel’s low thermal conductivity .Temperatures in the flow zone and a second cause of the low tool life is that Nickel tends to have a high chemical reactivity with the material of the cutting tool, which produces adhesion of the cutting tool to the work piece material .This leads to adhesion wear of the tool as the regions of adhesion between the tool and work piece are fractured from the tool face as the chip is removed. Although typically considered to have poor mach inability Nickel does have lower tool forces and power requirements than typically seen when cutting iron, and copper.

This tends to cause Nickel chips to be thin. The low forces resultant on the tool are caused by a much smaller contact area on the tool's rake face by the chip when Compared with the cutting of other materials. The small contact area increases the shear plane angle, resulting in the formation of a thin chip that is typically only slightly bigger than the feed of the tool .

The chips that are formed when machining Nickel are typically continuous, but experience segmentation (see Figure 1 below,). The segmentation of the chip is characterized by "narrow bands of intensely sheared metal being separated by broader zones only lightly sheared".

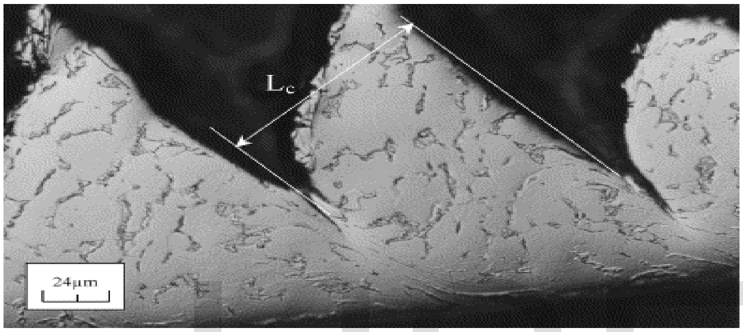

Fig 1 Nickel Chip Segmentation.

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Nickel alloys work harden rapidly, and the high pressures produced during machining cause a hardening effect that slows further machining and may also cause warping in small parts. Using cold-drawn stress-relieved material is preferable for machining.

Hot-rolled is less desirable and annealed is least preferred for most applications. Careful machining practices are a must.

Use sharp tools with positive rake angles (to cut the metal rather than push it). Sufficient feed rate and depth of cut are necessary and tools

should not be allowed to rub the work. Even under the best conditions, stresses may be produced which may cause distortion of the work. For maximum dimensional stability, it is best to rough out the part almost to size, stress relieve it, and then finish it to size.

Stress relieving has little effect on dimensions, but may affect mechanical properties.

3.1 Classification of Alloys:

For purposes of machining nickel alloys are classified in four groups and two subgroups:

•Group A: Consists of alloys containing 95% or more nickel. These alloys have moderate mechanical strength and high toughness.

They are hardened only by cold work. The alloys are quite gummy in the annealed and the hot-worked condition,

and cold-drawn
material is recommended for best mach inability and smoothest finish. These alloys include nickel 200, 201, 205, 212, 222.

•Group B: Consists of most of the nickel-copper alloys. The alloys in this group have higher strength and slightly lower toughness than those in group A. They are hardened only by cold work. Cold drawn or cold-drawn and stress-relieved material gives the best mach inability and smoothest finish. These alloys include monel 400, 401, 450, ferry alloy, invar 36, 48, kovar, and inco alloy MS250.

•Group C: Consists largely of the solid-solution nickel-chromium-iron alloys, which are similar to the austenitic stainless steels.

They are hardened only by cold work and are machined most readily in the cold-drawn or cold-drawn and stress-relieved condition.

These alloys include nickel 270, monel K-500 (unaged), inconel 600, 601, 690, nimonic 75, 86, incoloy 800, 800HT, 802, 825, DS,inco 330, 020.

•Group D: Consists primarily of the age-harden able alloys, has two subgroups.

Group D-1 consists of alloys in the unagedcondition and includes duranickel 301 (unaged), incoloy 925, MA 956, and ni-span-c 902 (unaged).

Group D-2 consists of the alloys of group D-1 in the aged condition, plus several other alloys in both the aged and unaged conditions and includes duranickel 301
(aged), monel K-500 (aged), inconel 617, 625, 706, 718, X-750, 751, MA 754, nimonic 80A, 81, 90, 105, 115, 263, 901, PE11, PE16,PK50, incoloy 903, 907, 909 ni-span-c 902 (aged),incoG-3, C-276, HX.

•Group E: Contains Monel R-405 only. This alloy is designed for high production rates in automatic bar and chucking machines.

Monel R-405 combines the toughness, strength, and corrosion resistance of Monel 400 with excellent machinability. Howeversurface finish quality is not as good as Monel 400.

The mach inability of nickel and its alloy improve in different machining operations by using different methods. The improvement is done either the proper design of cutting tool, by using cutting fluids, testing of the process; monitoring and using newer machines etc are some mechanisms that improve machining of nickel. Some operations and methods that improve merchantability of nickel are as follows

3.2 Turning of Nickel Alloy

Single-point turning tools used for cutting nickel alloys must have positive rake angles so that the metal is cut instead of pushed, as would occur if negative rake angles were used. A secondary function of the rake angle is to guide the chip away from the finished surface. The side cutting edge angle is second in importance only to the rake angle. It must be large enough to provide clearance, but small enough to give adequate support to the cutting edge. The nose radius, which joins the end and side cutting edges,

Strengthens the tool nose and helps to dissipate the heat generated in cutting. Nose radii are given with other recommended tool angles

3.2.1 Chip Control:

Nickel alloys present a minimum of chip disposal problems when cut with tools that have properly designed chip curlers or breakers. High-speed steel (HSS) tools require chip curlers, commonly referred to as lipped tools. The lip should include the proper rake angles for the alloy and should be wide and deep enough to cause the chip to curl and break but not to force it into a wad or tight knot. Carbide tools should have chip breakers. With these devices, tool rake angles are plane surfaces that terminate at the chip breaker wall. The radius joining the wall of the chip breaker and the rake angle plane must be kept very small.

The angle between the two surfaces must be 125" to 135". A small radius and the proper angle will usually prevent the chip from welding in the chip breaker. Width and depth of the chip breaker depend on the feed rate used.

3.2.2 Tool Material:

Carbide tools permit the highest cutting rates are recommended for most turning operations involving uninterrupted cuts. Cast alloy tools are recommended for tuning group A nickel alloys at optimum cutting rates. As with carbide tools, interrupted cutting is not include in this recommendation. High-speed steel tools should be used for interrupted cuts such as occur in the roughing of an uneven surface. They are also used for finishing closing tolerances, finishing to the smoothest surfaces, and cutting with the least work hardening.

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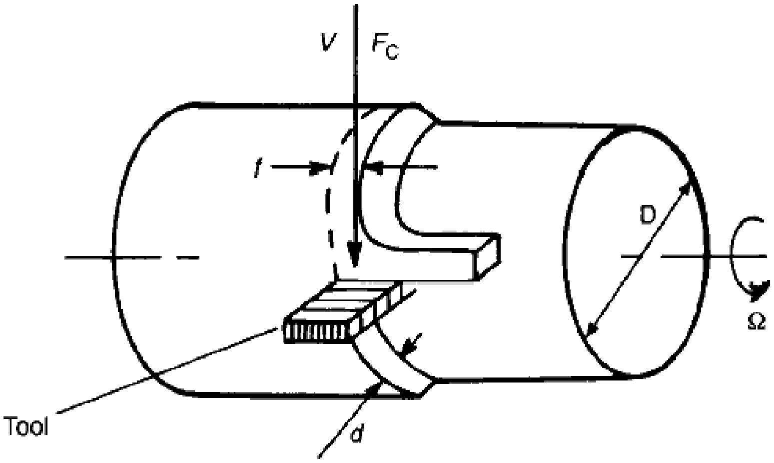

Fig 2 Turning of Nickel

3.2.3 Cutting parameters

Table **1** Rake, Relief & End cutting angle

Angle	Roughing	Finishing
Back Rake angle	0	8
End Relief angle	6	8
Side Relief angle	6	8
End Cutting Edge angle	6	60
Side Cutting Edge angle	To 45	To 45

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Table **2** Design of Depth of Cut , Nose Radius, Ratio of Diameter to Length for turning of nickel using Single-Point Tools

Depth of Cut	Nose Radius	Ratio of Diameter to Length	Nose Radius
1 / 32 "	0.013"	1:30	0.010"
1 / 16 "	0.020"	1:25	0.012"
3 / 32 "	0.031"	1:20	0.015"
1 / 8 "	0.035"	1:15	0.018"
3 / 16 "	0.040"	1:10	0.023"
1 / 4 "	0.062"	1:5	0.029"

Table3 Feed Rate (in/min), Depth, Width

Feed Rate (in/min)	Depth	Width
0.005"	0.015"	0.060"
0.010"	0.020"	0.080"
0.020"	0.030"	0.150"

3.3 Planning and Shaping of Nickel Alloy

The tools used for planning and shaping are similar to lathe tools. For rough planning, the top rake angle of the tool is the most

important; it must be positive and of large magnitude to achieve good cutting action. The optimum chip, resulting from a suitable

combination of side cutting edge angle and rake angle, is a small curl that curves over ahead of the tool and breaks as it hits the work.

The gooseneck type of planer tool should be used for finishing. Its spring action makes smooth dusts. the cutting edge of gooseneck tool should be behind the center line of the clapper-box pin so that the tool will spring away from the cut and not dig in.

Cutting fluids are not essential for roughing, but sulfur zed oil should be applied to the work piece for smooth finishing cuts. Speeds are generally 80 to 85% of those used for turning. Heavy sections can be parted in a planer with the aid of a gooseneck finishing tool. Only light cuts 0.005"/stroke to 0.010"/stroke may be taken to machine nickel. Continuous soluble-oil lubrication should be provided. Practice for shaping operations is similar to that forplanning.

3.4 Drilling of Nickel Alloy

In drilling nickel alloys, steady feed rates should be used. If the drill is allowed to dwell, excessive work hardening of the metal at the bottom of the hole will make it difficult to resume cutting and may result in breaking of the drill when it does take hold.

The setup should be as rigid as possible. Stub drills are recommended. Drill jigs should be used whenever possible. Standard high-speed steel drills are satisfactory for general-purpose drilling of group A and B alloys. Heavy-duty high-speed steel drills with a heavy web are recommended for drilling group C and D alloys. Cobalt-bearing high-speed steel drills give longer tool life. Cutting Pressures are reduced and a positive effective rake maintained if the web is thinned at the chisel point.

Increasing the point angle to135 degree is helpful to improve mach inability of nickel. Crankshaft drills are useful for producing deep holes. These drills have a heavy web and a helix angle slightly higher than normal; the web is thinned at the chisel point. Cutting action with drills larger than ¾” in diameter will be improved by grinding several small grooves through the lip, extending back along the lip clearance. The spacing of the grooves should be staggered between the two cutting edges. The effect of this serration will be to produce narrow chips with fewer tendencies to foul in the helical flutes.

Spade drills are regularly used for deep-hole and heavy drilling — 1½” in diameter and greater. The drill is secured in a steel head, which is attached to a rigid bar, with bearing support between the work and tailstock. Spade drills are made of high-speed steel;

the cutting edges should be tipped with carbide. Lead holes should be made with a drill having a point smaller than that of the spade drill.

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Gun drills are primarily used for producing deep holes up to and including 2" in diameter, but they are occasionally used for holes as large as 2½” in diameter. A highly sulfur zed oil is recommended for gun drilling and other deep-hole drilling and finishing.

Cutting fluid pressure should be about 800 psi for 3/16" holes, decreasing to about 200psi for 2" holes.

3.5 Grinding of Nickel Alloy

Methods of grinding nickel and alloys do not differ greatly form the practices used for steel. When only a small amount of metal must be removed, the finishing operation can be done on a grinding machine, using a rough and then a fine grind. If an extremely accurate ground finish is required, particularly on material of hard temper, the work should be allowed to cool to room temperature after the final roughing cut or grind.

This allows redistribution of internal stresses, and the resulting distortion, if any, can be corrected in the final grinding operation.

For best results, the alloys should be ground wet. A solution of 25 gallons of water and 1 lb of salt soda, or a solution of 50 parts water to 1 part soluble oil, is a suitable grinding lubricant for operations other than crush form and thread grinding. A good grinding oil is the best lubricant for crush form and thread grinding. Sodium chromate can be added to salt soda solutions to inhibit corrosion of the equipment.

In general, silicon carbide grinding wheels give best results on alloys of groups A, B, D-1 and E; aluminum oxide wheels are best for alloys of groups C and D-2. Grinding pressures should be great enough to cause slight wheel breakdown. Because of the many variables encountered in grinding, the wheel manufacturer should be consulted for information on specific applications.

For surface grinding coarse grit (46 to 60) aluminum oxide wheels produce the best finishes in surface grinding. To avoid warping during grinding, the work piece should be in the stress-equalized condition. Low wheel contact and low pressure help prevent distortion during grinding, especially with annealed material. Reciprocating tables are preferred to rotary tables. Reciprocating tables

reduce wheel contact, generate less heat, and cause less distortion of the work.

Center less grinding should be done with a wheel having a face that will break down during operation and prevent the work piece from becoming out of round. The breakdown of the wheel face depends on the diameter of the work, in feed per pass, and the angle and speed of the regulating wheel. Diamond-dressed wheels are more prone to cause ova laity of the work than are wheels dressed on a Ross dressing device. This dresser produces a sharp wheel face similar to one that has been crushed-dressed. By taking light cuts on the material, finish grinding can be done without redressing the wheel after the roughing operation.

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For crush form grinding, vitrified-bond, medium-grade aluminum oxide wheels having medium-to-open structures produce good results. High-grade grinding oil is recommended and should be continuously filtered through all operations.

Abrasive belts (cloth belts coated with aluminum oxide) can be used for finishing group D alloys. One procedure used for the abrasive-belt finishing of precision-forged airfoil turbine blades consists of rough grinding with 80 grit, followed by semi finishing with 120 to 150 grit and final finishing with 180 to 220 grit. Rough grinding can be done dry or with a lubricant. A machine oil of high-flowing characteristic is suitable for rough grinding. Semi finish and finish grinding is done with a lubricant such as cottonseed oil. The addition of kerosene imparts a high-flowing characteristic to the oil.

Honing is done with aluminum oxide vitrified bond honing stones of medium-to-soft grade. The honing stone must have uniform breakdown characteristics. Ample coolant must be supplied; proprietary honing oils, either as-supplied or diluted by 2 to 3 parts kerosene, are recommended. A mixture of 50% oleic acid, 35% kerosene, and 15% turpentine is also suitable. Surface speeds for rotation of the hone are between 45 and 75 m/min. Reciprocation surface speeds are between 11 and 15 m/min.

The lower speeds are used for roughing, and the higher speeds are for finishing. Honing pressure should be about 450 psi. The manufacturers of honing stones should be consulted for detailed recommendations on specific problems.

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PART FOUR

Cutting Fluids

Almost any cutting fluid, or none, can be used in machining nickel alloys. In many applications, nickel alloys respond well to ordinary sulfur zed mineral oil; sulfur imparts improved lubricity and anti weld properties. If the temperature of the oil and work piece becomes high enough during machining to cause brown sulfur staining of the work, the stain can be readily removed with a cleaning solution of the sodium cyanide or chromic-sulfuric acid type. This should be done before any thermal treatment, including

Welding, because during further exposure to high temperature the staining may cause inter granular surface attack. To avoid inter granular corrosion; the parts should be immersed in cleaning solution only long enough to remove the stain. High-speed machining operations that create high temperatures might preclude the use of sulfur zed oil because of sulfur embitterment of carbide tools. (Many sintered carbides have a nickel or cobalt matrix that is sensitive to sulfur attack at high temperature.) However, flooding the cutting area with cutting fluid generally cools the tool enough to avoid breakdown of the carbide bond.

Water-base fluids are preferred in high-speed turning, milling, and grinding of nickel because of their greater cooling effect. These may be soluble oils or chemical solutions. Except for grinding, which depends almost entirely on cooling and flushing, some chemical activity is always desired and is generally provided by chlorine, amines, or other chemicals.

For slower operations, such as drilling, boring, tapping, and broaching, heavy lubricants and very rich mixtures of chemical solutions are needed. Oils should be used when drilling nickel 200 and in conel X-750. In the drilling and tapping of small-diameter holes and in other operations in which lubricant flow and chip flushing are restricted, solvents will improve performance. These less viscous fluids can be used alone or can be used for diluting mineral and lard oils. A cutting fluid of the spray-mist type is adequate for simple turning operations on all alloys.

PART FIVE

5 Special machining processes

In recent years the methodological site of the engineering industry has developed and introduced new metals such as nickel and titanium alloy some of this are harder, stronger and more temperature resistant than the older materials, only grain ding of the older and conversional metal removing processes, has had only application in the shaping of this new metals. This has lead to the development and applications of new metal removing processes. some of this special processes which have been improve malleability of Nickel and successfully applied in a wide field up on varieties of materials or removed by using

5.1 Electrical discharge machining process

The electrical machining process has one thing in common i.e. they employ on the electric current as a means of metal removing. This means that it is necessary to convert electrical energy to mechanical energy. In order to do the something, as is done in the conversional process such as single point tool machining or grinding. The advantage and in proving machining of nickel by electrical maligning are:

-Tool force do not increase as nickel is harder.

-Economic metal removal rate does not decrease as the work material (nickel) gets harder.

-Tool material does not have to be harder than the work material (nickel)

- There is no any defect on the surface of the work (the product).

-To produced quality products

The metal removal process of electrical machining process like EDM)

The electrical discharge machining (EDM) or spark erosion depends up on the eroding effect of on electrical spark up on two electrodes used to produce the spark , one electrode being the tool and the other electrode being the work if both electrodes are made of the same material, it has been found that the grater erosion takes place upon the positive electrode. There for the work is made positive and the tool negative, hence giving maximum metal removal rate to the work and minimum wear to the tool.

The spark is g generated by a heavy electrical discharge across a gap b/n the electrode w/h are immersed in a dielectric fluid, such as paraffin, whiter sprite or transformed oil the gap has electrical value 0.025mm to 0.075mm w/h must be maintained through out the operation as work and tool wear. This is done using a revisable servomotor.

Principle of the process the shaped tool negative electrodes is fed in to the work piece Causing Sparking to occur b/n the closed point of a approach b/n the tool and the work. As the tool fully enters the work, sparking occurs equally across the whole area of the tool front face causing the tool from to be reproduced up on the work. machining or metal removal is possible b/c repetitive spark of short duration (interval b/n successive sparks

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in approx 0.0001s) release their energy in the form of local heat (local temperature approx 12000oc) melting a small area of the work piece and forming a crater upon the work surface. The pumped dielectric fluid w/h acts as an insulating medium and provides the correct conditions for efficient spark discharge also carries away the eroded metal particles the time interval b/n the spark is so short that the heat is unable to conduct in to the work piece.

The servo control receives signals causing it to operate the servo motor and feed the tool forward until the gap reaches its central value again .so the sparking takes place again and the whole cycle is repeated.

5.1.1 Dielectric fluid

It provides on effective insulator after each discharge (metal removals) the dielectric fluid used must remain non-conducing until break down rapidly and then demonized rapidly after the condenser has discharged

Other unconventional (newer) machining process like ECM, ultrasonic machining (USM) plasma machining, Electro beam mashing are improve the machine ability of nickel and produced good quality products. These processes are not affected by the strength, hardness; toughness and brittleness of nickel and other materials' Fig3

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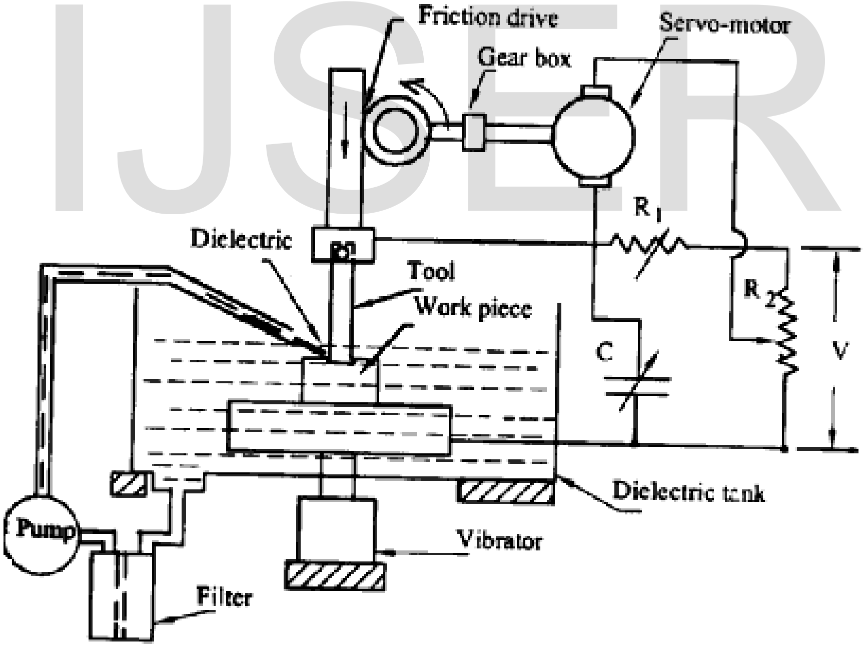

Fig 3 EDM machining process

5.2 precision optical machining of Nickel

Precision optical machining refers to the use of single-point diamond tools and specialized machine tools to produce high figure and finish accuracy on certain sub- states. standard machines, diamond tools and accessory- rise make it possible to precision machine optical components that in- tract with light waves in a useful and predictable manner to machine hard materials Like nickel any state-of-the-art technology, precision machining places a premium on good communication between the component designer and equipment engineer, and on thorough know- ledge of the special character is the technologic Capabilities

The development of electro-optics, particularly high-energy lasers and infrared technology, has created a need for metal and other non-glass optics. In many cases, these components must be aspheric or in other shapes difficult or impossible to pro- duce by conventional lapping and polishing. Diamond machining provides an economical approach to the fabrication of many unconventional shapes of hard materials like Nickel.

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5.2.1Tooling for precision machining of Nickel and its Alloy

The single crystal diamond tool has unique characteristics; the highest possible hardness, low friction, high stiffness, good thermal conductivity, and an edge that can be sharpened to atomic levels of sharpness .So it follows that the specialized machine tools used for precision machining of optics can be classed as fine instruments they require "accuracy levels normally associated with the finest metrology instruments. For instance, these machines must maintain the relationship between the cutting tool edge and work surface to within two micro inches {.05itm) or better under dynamic cut- ting conditions. To meet these requirements, machines must be stiff, have no lost motion or backlash, have no internal vibration, be isolated from external vibration.

5.3. Monitoring and improvement of cutting states of nickel and its Alloy

In modern machining systems, the monitoring of cutting states, including tool condition

monitoring, is regarded as a key technology for achieving reliable and improved machining processes, free from fatal damage and trouble Tool

wear, tool breakage and chatter vibration are the tool conditions of major concern, causes due to the machining of different materials like nickel .

Sources of signals used for monitoring the cutting forces, cutting torque, acoustic emission from the tool, work piece and the interface between the, tool and work piece displacements, cutting temperature, cutting speed, tool wear , etc. The monitoring of cutting states may be classified into direct and indirect methods.

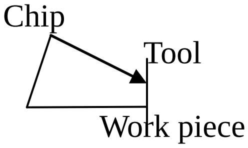
Indirect monitoring, the width of flank wear, crater depth, chipped edge shape, displacements of tool or work piece, etc, are measured in-process or out-of-process.

In-process monitoring that does not require the machining process to be stopped is preferable to out-of process monitoring, other things being equal. However, chips being produced and cutting fluid are obstacles to measurement; the space available for measurement is limited; and direct measurement sensors may disturb the process. The continuing development of ingenious measurement methods is indispensable for reliable monitoring, for example the in process and direct monitoring of worn or chipped end mill edges by laser-based tool image reconstruction, in the presence of cutting fluid. Indirect monitoring, which interprets signals related to a particular cutting state, can be free from the obstacles and space limitations of direct monitoring. , indirect monitoring which is closely related to process models and its application to the improvement of cutting nickel are described although the treatment is not comprehensive.

5.3.1 Monitoring procedures

There are three activities in monitoring cutting improvement, **sensing, processing and recognition**. Guidance on what signals to sense is obtained, if possible, from process models. tool and work piece geometry, etc are what need to be monitored for the indirect assessment of wear. If a physical model is incomplete or weak, so that there is uncertainty as to what should be measured, more reliable monitoring is achieved by selecting redundant signals. The monitoring of cutting states based on multiple signals with more than one sensor is called sensor fusion or sensor integration

Table 4 Monitoring and improvement of cutting states of nickel

Cutting system	Signals	Signal processing	Recognition of cutting states
	Force Torque Spindle current Acoustic emission Displacement Acceleration Temperature Heat flux Sound Image	Fourier transform Wavelet transform Statistics mean, variance skew, kurtosis Wave shape characteristics peak, slope envelope	-**Direct monitoring** cutting force chatter vibration tool wear tool chipping tool breakage -Indirect monitoring tool wear tool chipping tool breakage chatter vibration chip control actual depth of cut dimensional error

After signal processing, the cutting states can be characterized by two kinds of representation. One is a quantitative value, obtained from the cutting state process model: for example, the output of a wear monitoring system may be the

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width of flank wear. The other is a status, for example normal or abnormal, classified by pattern recognition using such tools as threshold or linear discriminate functions, artificial neural networks, or fuzzy logic. For an operator, pattern output with one bit of information is easy to deal with. What should be done, in response to normal or abnormal, is to continue or stop, respectively. However, to control a machining process by changing operation variables, the quantitative output of a numerical value is preferable.

5.4 using the Reference paper

The Reference paper performs an analysis on Nickel alloy. The purpose of the paper is to analyze the influence of the cutting velocity and the depth of cut on the cutting forces and chip segmentation, specifically the shear band morphology and spacing.

The paper concludes that the separation distance between shear bands is strongly dependant on the cutting velocity V, and can be modeled through Equation 1 below.

Equation 1: Chip Serration Frequency Model.

$f = V7 / 5$---------- (1)

Where:

f = Chip serration frequency (hertz)

V = Cutting Velocity (m/s)

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Experimental Setup:

Two experimental setups were utilized to examine the orthogonal cutting of Nickel.

The first utilized a universal high speed testing machine and was used to examine cutting velocities from 0.01 to 1 m/s. The high speed testing machine is essentially a tensile test machine that has a work piece attached to the actuator. The machine forces the work piece through two symmetrically mounted cutting tools to form a chip, during which the longitudinal cutting force is measured. The second test setup is for cutting velocities from 10 to 73 m/s and utilizes an air gun to produce the required cutting velocities. The work piece is mounted to the air gun's projectile and is fired at two symmetrically mounted cutting tools. The projectile is guided by a tube and eventually stopped by a shock absorber. The longitudinal cutting force is calculated through strain gage measurements taken at the holding fixture of the cutting tools10 of 27 and the tube immediately prior to the shock absorber. For both experimental setups chip

serration and segmentation is examined by examining the chips and comparing the number of serration and segmentations to cutting velocity.

The nomenclature utilized by the Reference 1 paper is described in Figure 4 below,

where w is the width of the work piece (10 mm), L is the length of cut (12 mm), and the

difference between hi and hc is the depth of cut. The initial height of the rectangular work piece was 44.4 mm. All cutting experiments were carried out using square shaped carbide cutting tools that have a rake angle of 0 degrees. Two depths of cut equal to 0.12 mm and 0.25 mm are utilized through out the experiments.

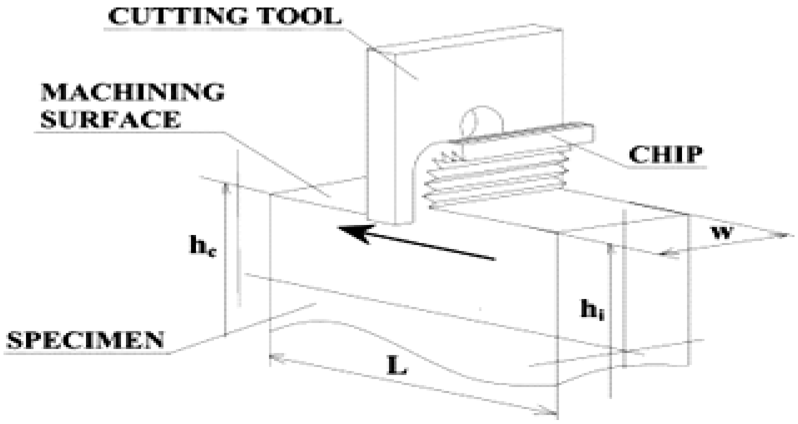

Figure 4 Cutting Process Nomenclature.

Experimental Results:

The results from the Reference cutting experiments are shown in Figure 5 and Figure 6 below. The cutting force as a function of cutting velocity is shown in Figure 5. The cutting speed is normalized by dividing the measured longitudinal force by the product of the cutting width w and depth of cut ti. The data was collected for a depth of cut equal to 0.12 mm. From the figure, the cutting force generated by the experiments rapidly decreases as the cutting speed increases, for cutting 11 of 27 ,speeds between 0 and 10 m/s. The cutting force continues to decrease with increasing velocity until about 30 m/s, where it becomes approximately constant. The data contained in the figure shows a clear trend of decreasing force with increasing cutting speed until a constant cutting Force is reached, but shows low precision in measured results between the experimental data.

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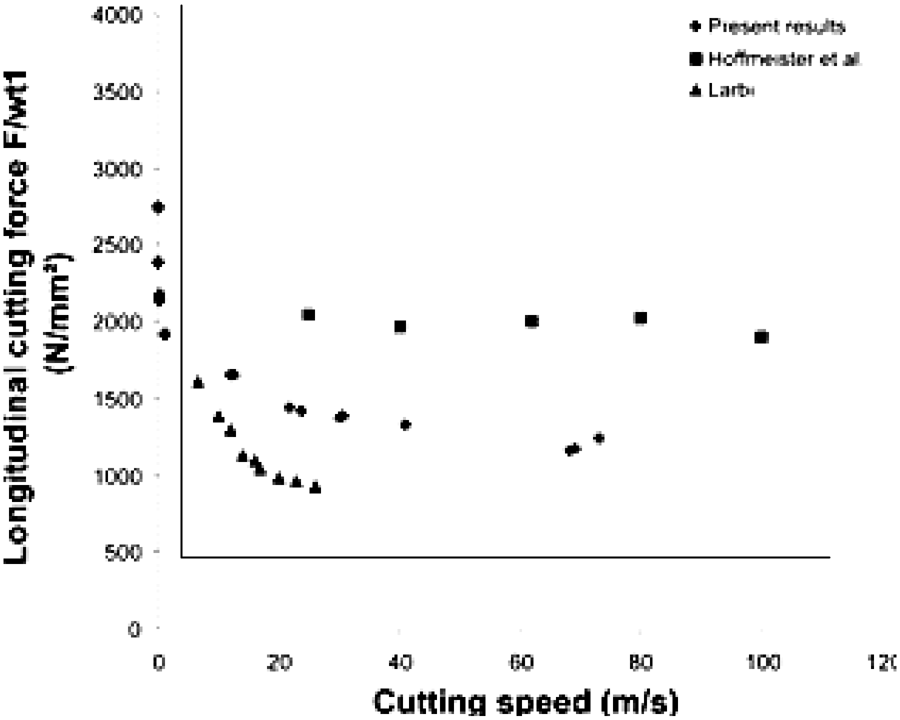

Figure 5: Cutting Force as a Function of Cutting Speed.

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The results for the experiments carried out to examine chip serration frequency as a function of cutting velocity is shown in Figure 6 below. For cutting velocities between 0.01 s and 21 m/s the chip was found to be serrated, but remained continuous. When the cutting velocity exceeded 21 m/s the chip became discontinuous and fragmented into small pieces. The serration frequency is defined as the ratio of the number of chip segments to the cutting time and is plotted on a log-log scale. When the date is linearly curve fit it is found to have a slope of 7/5. This corresponds to the power function shown in Equation above that relates serration frequency to the cutting speed..

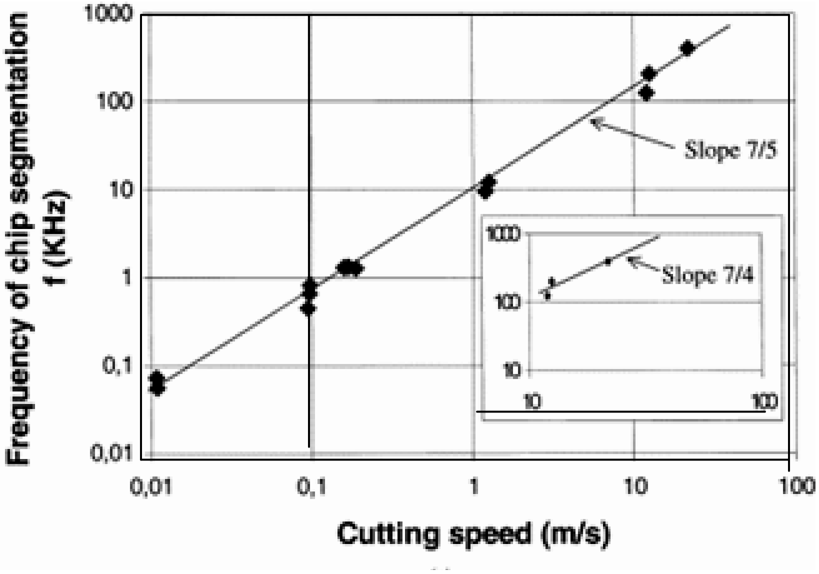

Figure 6: Chip Segmentation Frequency as a Function of Cutting Speed.

PART SIX

Conclusion

In this, paper the improvement is guideline for machining of nickel. The goal is to facilitate proper selections of the machining process parameters. Specifically, the axial depth of cut, the feed per tooth are critical in achieving performance objectives in terms of cutting forces, surface accuracy, tool life, etc.

Analytical model to provide an understanding of the machining with minimum chip thickness and edge radius effects, mechanistic time-domain simulation modeling to provide predictive capability in practical machining performance, such as cutting forces, tool vibrations, surface accuracy, and surface roughness are utilized.

The generalized improvement process planning strategy consists of two steps: roughing and finishing.

In roughing, the objective is to control the cutting force within a predefined threshold to prevent premature tool breakage and to maximize the material removal rate.

In finishing, the primary objective is to control the form error within the tolerance and to obtain satisfactory surface roughness.

I study the hard machining process that is a beneficial practice to increase quality and reduce cost and lead-time for machining nickel components. I develop methods of improving machining of nickel to predict field variables such as forces, temperatures, and stresses in the chip, the tool and the work piece. I have also developed tool wear rate based on predicted field variables.

The quality of the finish-machined surfaces is highly dependent upon the tool wear. I have to validate the tool wear with the experiments and conduct multi-objective optimization studies using special machining processes most desirable surface finishes with prolonged tool life and improved productivity in the hard machining processes.

Study is also an initiative to characterize work piece material and friction properties in dry machining of

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aerospace nickel alloys. Machining of difficult-to-cut aerospace alloys and materials is a challenging process and desired part quality (surface finish and tolerance) requirements are tough to achieve with conventional machinery due to process stability problems associated with rigidity, vibrations and wear behavior of cutting tools. Improvement of machining processes have the potential to reduce experimentation, optimize cutting parameters, and improve overall mach inability and part quality for aerospace machining applications of nickel.

PART SEVEN
REFERENCES:

1. Metal cutting 4th edition Edward .trent
2. http://www.espi-metals.com/tech/machiningnickel&alloys.pdf.
3. Machining Research Centre
4. T., D., Marusich, M., Ortiz, *“Modeling and simulation of high speed machining”*,
5. .Internationl Journal for numerical methods în engineering, Vol. 38, 3675-3694, 1995.
6. *** www.wildefea.co.uk
7. G.R. Nagapal, “Machine Tool Engineering”,. 8th ed, New Nirman Printing press, Chawri Bazar.Delihi-110006.
8. J.S.Senthilkumaar.2010,Selection Of Machining Parameters Based On The Analysis Of Surface Roughness And Flank Wear In Finish Turning And Facing Of Inconel 718 Using Taguchi Technique
9. K.Bonny, Influence of electro-discharge machining on tribiological behavior of hard metals.
10. L. Deshayes, Mechanical And Thermal Behavior For Machining Ti-6Al-4v With Almgb and Wc-Co Tools
11. Dongtao Jiang, Residual stresses in hard metals caused by grinding and EDM machining and their influence on the flexural strength.
12. S. A. Thompson, An overview of nickel–titanium alloys used in dentistry
13. T. H. Bass ford, Nickel And Its Alloys, Inco Alloys International, Inc. Huntington, West Virginia
14. Vedat TOPUZ,2011, Prediction of nickel-based super alloy surface roughness in CNC end milling operation using connectionist models
15. Mason Dane Morehead 2007, Machinability And Microstructure Stability During The Machining Of Pure Copper And Titanium Processed By Equal Channel Angular Pressing
16. K.Kadirgama, 2010, Effect of Dry Cutting on Force and Tool Life When Machining Aerospace Material.

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