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Impact of Cutting Parameter and Cutting Environment on Surface Characteristics during Machining of Nimonic C-263

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Abstract- Especially in comparison with grinding, hard turning is profitable in many cases, with considerable potential benefits. Since machining is one of the most important process that gives a work piece the necessary shape as cutting tool in the form of chips. Workpiece material machining is done as a relative movement of the cutting edge of the tool with respect to workpiece in various Machining is critical process where tight dimensional and finish tolerances are required. The relative motion can be achieved either as work piece motion or as a tool and a mixture of materials. Feed movement, drive activism are motions which help to get the needed goal. Often, auxiliary motions are required to achieve their assigned function such as work piece clamping and de-clamping as scrap, dimensional inaccuracy etc. are the most common welding problems when selecting appropriate variables for cutting inputs variables for the respective work piece are the most prominent additives which reduce overall cost and time of production. To ensure prescribed point, exploring the contact results between tool and work piece is a primary start for economical and cutting equipment. Aero engine alloys are one of the crucial technical super alloy classification systems.

Keywords: Nimonic superalloy, XRD inspection, Surface characteristics, PVD multilayer coated

1. Introduction:

Super alloys are important in applications at high temperatures;s hence, they are also known as heat-resistant or high-temperature composite materials. Super casting alloys which maintain their mechanical strength and stability at temperatures where even the most other fail. They contain several elements for achieving its objective in a wide variety of methods.Superalloys consist of a two-phase crystalline structure comprised of precipitates of the type L12, known as gamma prime, embedded in a disordered FCC matrix, known as gamma. The high amounts of precipitates support Obstructing plastic movement and very stable quite stable upto high Temperatures. Main applications of ferrous alloys are in jet engines and gas turbines; other devices are in shared engines, rocket engines, metal hot-working tools and dies, particularly in the nuclear, petrochemical industry. Superalloys typically have strong resistance to corrosion, mechanical and thermal fatigue, mechanical and thermal shock, creeping and erosion at high temperatures. Superalloys build high temperature resistance by strengthening solid solution (SSS). SSS is a type of alloy which could be used to improve metal strength. The method works by adding atoms of one element (alloying element) to another element's crystalline lattice (the base metal).Age hardening is accomplished by preparing and quenching an alloy by solution. Term 'Age tightening' is used to explain the process, as force evolves over time. The condition for the hardening of extreme weather is that the second phase must be soluble at an elevated temperature but tends to cause on-rest and ageing at a temperature lower. This restricts the alloy structures which can be reinforced by hardening precipitation.

Such alloys are called superalloys of the iron-base, cobalt-base, or nickel-base. These include nickel, chromium, cobalt and molybdenum as a primary alloying element; aluminum, tungsten and titanium are other alloying elements. Superalloys are usually identified by trade names or special numeration systems, and are available in a variety of ways.The main objective of this research is a comparative study of different surface integrity characteristics , i.e. friction coefficient, elastic deformation, phase transfer, white layer formation, and work-hardening pattern, using PVD multilayer (TiN / TiAlN) coated and stainless steel cemented carbide inserts under different machining conditions.This also researched the effect of cutting parameters such as feed rate on various surface integrity characteristics.

2.Related work:

The main aim of this research is to study the impact of cutting parameters such as cutting speed, feed rate and type of coating on Nimonic C-263 surface integrity aspects under dry and wet situations. The goals set out during depth include.

- Formation of surface layers
- Trend to harden
- Microstructural changes
- Surface defects
- Residual tension

Workpiece fabric:-Nimonic C-263 was used as a reference in this experiment. The sample dimensions were 60 mm in diameter and 180 mm in length. The specimen has a chemical composition of 53.8 percent Ni, 18.1 percent Cr, 5.5 percent Nb, 2.9 percent Mo, 1 percent Ti, 0.55 percent Al, 0.25 percent C, 0.04 percent Si and the balance Fe (weight percent).

Table 1: Nimonic Chemical CompositionC-263

Element	Ni	Cr	Co	Mo	Ti	Fe	Mn	Al
Content	49-53 %	19-21 %	19-21 %	5.6-6.1 %	1.9-2.4 %	0.7 %	0.6 %	0.6 %

Cutting Instruments:-Commercially available uncoated carbide device and TiN / TiAlN (PVD multilayer) coated cemented carbide inserts were used. All instruments were supplied by SECO, India with SNMG 120408 ISO insert designation. On both uncoated and PVD coated materials, a tool holder with an ISO classification of PSBNR2020K12 (WIDIA, India) was used.

Cut parameters:-The machining was performed in dry and wet condition using the parameters listed in the table

Table 2: Cutting Parameters

Parameters	Range considered
Cutting Speeds (m/min)	51,84, 124
Feed rates (mm/rev)	0.1,0.14,0.2
Depth of cut (mm)	1
Cutting environment	Dry, wet, MQL

Using machining:-The turning operation was performed on NimonicC-263 using a heavy duty lathe (Make: Hindustan Machine Tools (HMT) Ltd., Bangalore, India; model: uncoated tool NH26, and PVD coated cutting tool. Nimonic C-263 turning was achieved with uncoated tool and PVD at variable cutting speed and feed rates with machining length progression. Each experimental run was performed in 30 s time.

A calculation of surface roughness:-Talysurf (Model: Taylor Hobson, Surtronic 3 +) with sample length parameters, Lc=0.8 mm, cut-off length, Ln=4 mm and filter=2CR ISO was used to calculate surface roughness for each run. Rughness tester (Make: Taylor Hobson, Model: Surtronic 3 +) was used to calculate surface roughness at four different locations for each run and then average value was taken.Preparation for Samples: Using Wireelectro-discharge machining (WEDM) parts of the machined workpiece were cut out of plate. Those samples were used for assessment of microstructural and microhardness. In order to test the other aspects of surface integrity, i.e. variance of microhardness and white layer, the samples (NimonicC-263) were first cut into a plane perpendicular to the longitudinal axis and then polished with decreasing degrees of polishing paper followed by diamond polishing. The polished surfaces were then coated with 2% (by volume) of diluted (40%) hydrofluoric acid, 40% concentrated hydrochloric acid, 50% de-ionized water and 8% hydrogen per oxide.

Analysis of Surface Deformation: After polishing the cross sectional plane the field emission scanning electron microscopy (SEM, model: NOVA NANO SEM-450) was analyzed to reveal the formation of white layers

Studying the morphology of machined surfaces:
A calculation of microhardness: Vickers microhardness tester (LECO, USA) was used to assess surface and subsurface microhardness. On cross sectional surfaces, indentation was taken in a straight line from the edge (corresponding to the diameter of the machined work piece) to the middle. Each indent separated by 0.5 mm from the next. All measurements were taken at 50 gmf load, and 10s dwell time.

Xrd analysis:- X-ray diffraction (XRD) can be used to calculate substance qualitative analysis, grain size and lattice distortion and crystallinity determination. To describe the surface and sub-surface phase composition, X-ray diffraction (XRD) (XPert PW3040/00, Make: PAN alytical) analyzed three samples turned with the same cutting condition. Accordingly, the samples were placed in the X-ray goniometric in the middle of the plate to ensure sufficient beam irradiation. The 2 scans between 30 ° and 90 ° 2 were performed. The increment of the scan was 0.05 °; the respective acquisition time was 2s / step.X–Ray diffraction for unmachined and machined surface of Nimonic C-263 using uncoated and coated tool at different cutting speeds was performed to determine any metallurgical changes occurring, such as phase transformation or any alteration of the lattice parameters that includes grain size and strain. In addition, the Scherrer method used XRD data to determine grain size.

Rough surface finish:-Surface roughness is important surface integrity indices, which is one of the factors influencing the efficiency of the system part. It greatly affects the wear resistance and fatigue life of the machined metal. Figure displays average Ra data obtained from each cutting condition during experiments. During dry machining at low feed rate uncoated tool under flood and MQL machining and PVD coated tool was observed with hardly any significant differences in surface roughness value.This may have ascribed TiN coating anti-friction properties and coolant tribological properties. Increased surface roughness arises as a result of an rise in feed volume, as can be seen from. It can be due to either increased feed marks or increased cutting load generation at the edge of the tool causing more plastic deformation resulting in higher surface roughness under dry cutting condition for PVD cutting tool. With the rise in the feed rate, an improvement in the surface roughness value of

2.6µm could be seen from this could also be attributed to the presence of several layers of coating for PVD multilayer coated device due to which cutting edge rounding took place[25]. The decrease in surface roughness was observed when feed rate for wet machining with uncoated tool increased from 0.14 to 0.2 mm / Rev. Nonetheless, application of MQL will increase surface finish as opposed to that obtained by dry machining due to better cooling and lubrication performance at the chip-tool interface and work-tool. In addition, decreased surface roughness with an increase in MQL flow rate can be associated with less wear of the instrument. Thanks to the successful penetration of the cutting fluid through the interface between the flank and the machined surface, frictional rubbing and therefore wear of the blade can be minimized.Carbides are especially useful in helping structural refinement during manufacturing and heat treatment, by helping to regulate grain size. When present intragranular, they reinforce the matrix and help with high temperature strength by inhibiting slip in the boundaries of grains. By comparison, carbides may also be a cause of dislocation and the initiation of fatigue cracks. However, carbides can have negative effects on the machining process, which can cause abrasive wear of the tool, shorten the life of the tool, and inflict damage on the machined area.

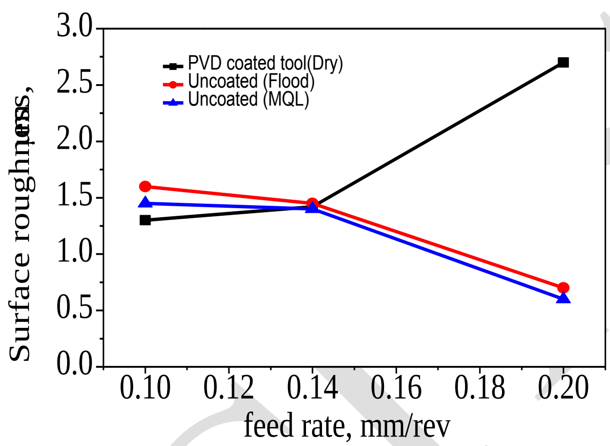


Fig. 1: Surface roughness variability using uncoated and PVD-coated inserts with feed rate.

It can be seen in Fig. 1 In NimonicC-263, somedefects such as primary particle borders, thermally induced porosity (TIP) and non-metallic inclusions appeared. Such defects are the sources of crack that decrease stress rupture and ductility of tensile and worsen the integrity ofthe machined surface. Fatigue life will then beshortened for the machinedNimonic C-263 portion. The coarse precipitates displayed irregular blocky forms with a size greater than 1µm and precipitated mostly at the boundaries of the grain; the fine precipitates were almost spherical; they are dispersedprecipitation in the grains.

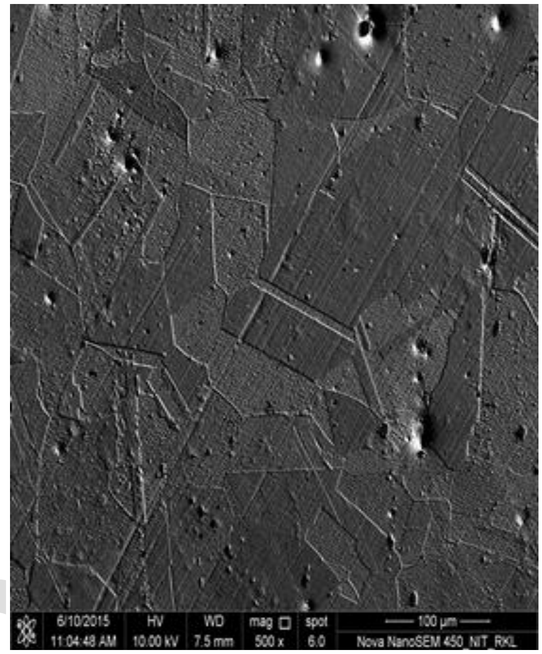
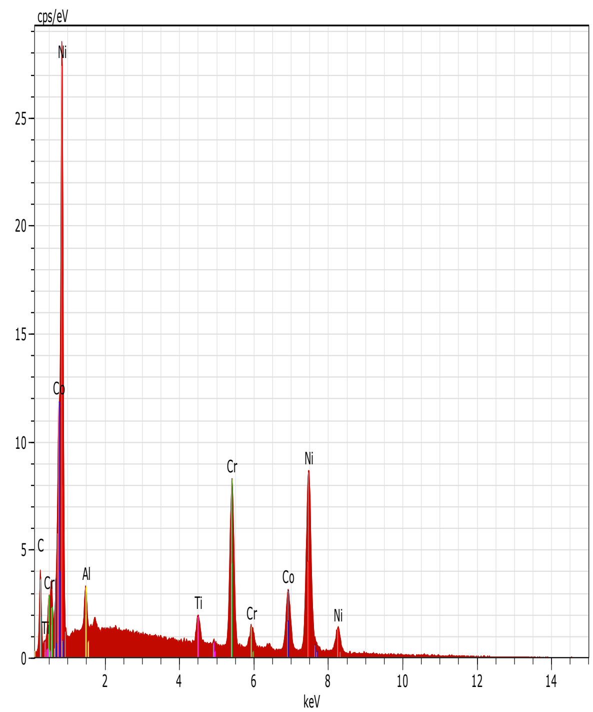
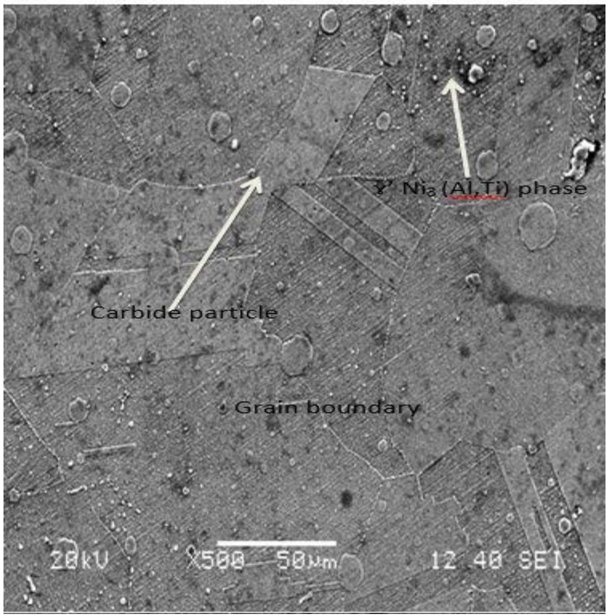


Fig. 2: NimonicC-263 microstructure (TIP) and primary particle limit (PPB) thermal induced porosity.





Hardness De Micro:

Machined surface hardness is greatly influenced by environmental cutting. In order to examine the effect of the atmosphere on the hardness of the machined surface, contrast between dry with wet as well as dry with MQL machining was performed. Dry machining resulted in greater toughness than both MQL and wet machining. MQL or wet machining decreases friction between the tooling. Regardless of the reduction in deformed layer thickness, the coated device also has the ability to interrupt the labor hardening tendency [67].Since the phenomenon is related to mechanical deformation caused by tool wear among other parameters, superior tool wear resistance of the coated tool compared to that of its uncoated counterpart is also important to remember.However, if the coated tool's thermal conductivity is lower, then prominent thermal effect can be anticipated again leading to the likelihood of more work-hardening than the uncoated tool. This may be the explanation why Zhou et al. [91] found, during Inconel 718 machining, a significantly higher value of microhardness with a coated cBN device than uncoated cBN.One of the stochastic processes is the chip formation mechanism which involves both elastic and plastic deformation.

3. Conclusion:

During the machining process, the layer being cut and the layer of the metal's main mass are subject to extreme plastic deformation, and therefore the hardness is increased.The most critical of these are the properties of the metal being machined, the cutting edge geometry, the degree of wear of the blade, cutting conditions and the use of the cutting fluid.

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