Indian Science Technology and Engineering facilities Map (I-STEM)

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Format for requesting support for accessing and using facilities through the I-STEM web portal.

(i) Details of the Personal Information

a. Name of the Researcher/Faculty Member: Mr. KORE MAHESH
b. Name of the Institution/Start-up: National Institute of Technology Mizoram
c. Name of the Department: Department of Mechanical Engineering
d. Degree registered for/Product being developed (for start-up): PhD
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(ii) **Project/Research topic Details**:

a. Project Title/Research Title: Investigations to improve the machinability and surface integrity of Inconel 718 with various textured tools under green machining environments
b. Sub area: Machining of Difficult to cut material with sustainable techniques
c. Area Description:

During machining of Inconel 718, tremendous heat is generated by the shear deformation at the tool-work interface and the friction between the tool-chip interfaces. Itcauses to generation of high cutting temperatures at the interface regions, leads to rapid progression of tool wear and reduction in the tool life, lower the surface finish of the machined surface. In order to overcome the above difficulties,generally, cutting fluids are employed for lubrication and cooling purposes, but some of the problems associated with the usage of cutting fluids in machining such as;

- Financial (i.e., Purchase of the cutting fluids)
- Health issues to the workers (i.e., By addition of chemical additives to the cutting fluids for improve the lubrication)
- Environmental obligations (i.e., Due to disposal of cutting fluids)

In order to eliminate the use of cutting fluids, manufacturing industries are moving towards the sustainable machining environments. The special characteristics of Sustainable Machining (SM) as mentioned below;

- Eco-friendly or green machining
- Cost effective,
- Energy efficient
- Waste free
- Non-lethal

Limitation of SM

- In some techniques special and additional equipment to be provided for carry out the cutting operations.

Sustainable methods are very much suitable for machining of high temperature-resistant alloy such as Inconel 718.

d. Aims &Objective :
   - To investigate the influence of the various textured patterns on the tribological, machining and surface integrity characterstics while machining of the Inconel 718 at dry, compressed and cold compressed air machining conditions.
   - To examine the affect of variation of the cutting speed (m/min) on the performance of textured tools during machining of Inconel 718 at sustainable machining conditions, especially at the cold compressed air condition.
   - To assess the performance of various cutting tools with chosen groove and dimple textured geometry and to recommended the best textured tool for the selected operation.

e. Duration (MM/YYYY): 09/2022 to 03/2023 within 6 months

f. Project Summary :

With the continuous development of technology, excessive usage and demand for the heat resistant alloy such as Inconel 718 (Nickel based super alloy) is increasing tremendously in the aviation industries for reduce the operating cost and energy saving of the aircraft. For instance, in some Pratt and Whitney engines, among all the super alloys, the components of IN-718 account for 50% is used [1]. Because, it's exhibits high corrosion resistant, superior fatigue, oxidation and wear resistance at service temperatures up to 900 ºC [2]. Furthermore, Inconel 718 is strengthened by γ'' (body-centered tetragonal lattice, i.e., Ni_3Nb) and γ' precipitation (face-centered cubic i.e., Ni_3 (Al, Ti)), which has exhibit high tensile strength at room temperature such as at about 1375 N/mm^2 , decreases by 20% of its value to about 1100 N/mm at 650 ºC (Refer.figure.1) [3]. As a result, most of the aircraft structures and critical hot sections of aircraft engine parts such as power developing devices inclusive of turbines and its parts (blades, disks, fasteners and shafts) are manufactured using this super alloy [3].

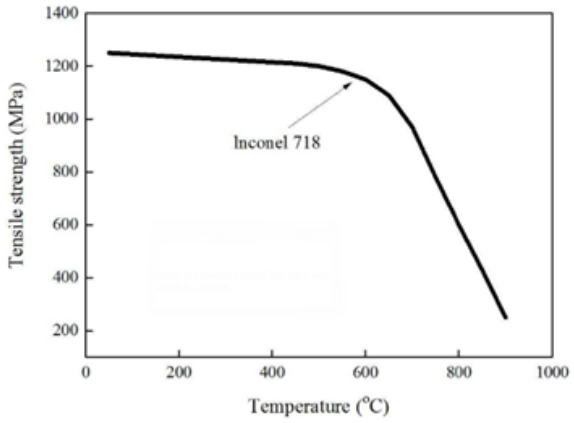


Fig.1 Variation of the tensile strength of IN-718 with respect to temperature [4]

Highly compact Ni based super alloy (Inconel 718) have been developed by incorporating a number of high melting point metallic elements, such as Fe, Ti, Cr, Ni, V, W, and Mo. Moreover, various non-metallic elements, such as C, B, and N, are also introduced to ensure high hardness. However, these factors generally make the machinability of Inconel 718 is very poor [5]. Machinability index is usually determined by considering four factors which include tool life, surface finish, power consumption, and cutting forces. The machinability index of Inconel 718 is 12. This is much lower than the machinability index of low carbon steel (AISI 1018), which is 100. As shown in figure. 2(a, b), the machinability rating and relative machinability of Inconel 718 stand very low as compared to other conventional engineering materials.

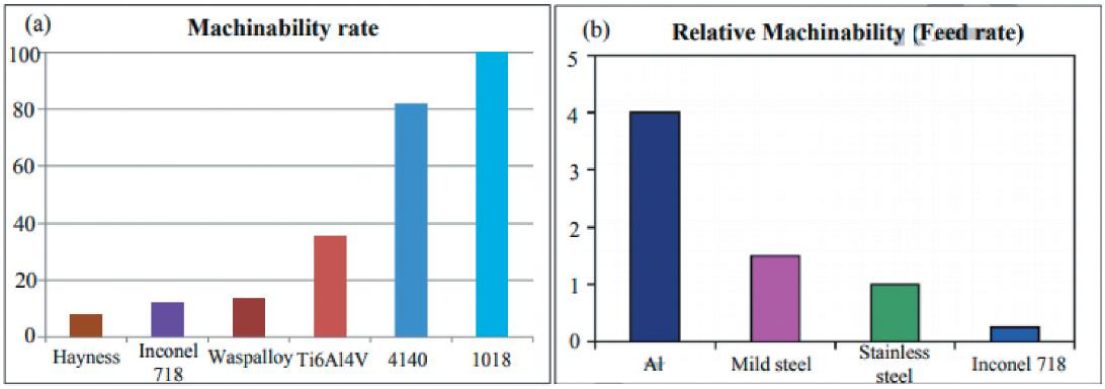


Fig.2 (a) Machinability rating of engineering materials, and (b) Relative machinability with respect to feed rate [6]

It is resulted due to some peculiar characteristics of Inconel- 718 responsible for classify this special alloy group into difficult to cut material as mentioned below;

- During machining of Inconel 718 tremendous heat is generated at the primary shear deformation zone and most of the heat is accumulated at the cutting zone, due to its consists of low thermal conductivity (about 11 W/m ºC), resulted to severe generation of cutting temperatures at the cutting zone, leads to welding, and adhesion of chips to the tool results in high tool wear and also high chemical affinity with many tool materials at elevated temperature , cause to the diffusion wear, shorten the tool life.
- During machining, cracking of carbides (NbC,TiC, etc.,) are presents in the microstructure of the Inconel 718 cause to severe generation of friction due to rubbing between the tool and chip at the secondary shear deformation zone (SSDZ) resulted to severe heat is generation at the SSDZ and also the high surface roughness of Inconel 718 could be due to the cracking of these carbide particles as shown in figure.4 [6].
- The existence of Ni_3Nb (body-centered tetragonal) in Ni_3 (Al,Ti) (face-centered cubic) precipitates of Inconel 718 can strengthen the material, leading to a continuous increment in hardness characteristics up to a temperature rise of 650°C. This peculiar characteristic of Inconel 718 lowers its machinability [7].

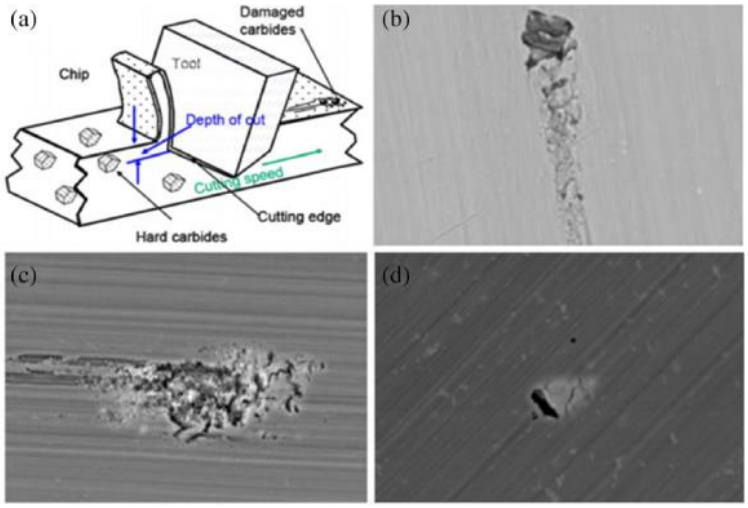


Fig.3 Influence of Hard carbides on surface roughness, a) Cracking of carbide; b) dragging; c) smearing; and d) marks on the machined surface [6]

By considering the above problems, it is concluded that the cutting temperature plays an important role in determining the tool life and surface integrity. In order to overcome the cutting temperature rise, cutting fluids are employed as a coolant during machining of Inconel 718. But, during machining with cutting fluids which contains sulfur, chlorine, and phosphorous-based chemical additives during machining of Inconel 718, they can assist the formation of thick solid lubricating film at the tool-chip interface which potentially lowers the friction and cutting temperatures. Nonetheless, the work material (Inconel 718) may chemically react with sulfur and chlorine constitutes present in the cutting fluids. These constituents are highly poisonous and can exhibit a damaging impact on human health and the surroundings [7]. Various diseases caused due to use of cutting fluids in machining as shown in figure.4. At higher pressure and temperature attained during machining, chlorinated paraffin changes its physical and chemical characteristics, and thereby disposal cost can further increase (8% (approx.)) due to stringent environmental policies.

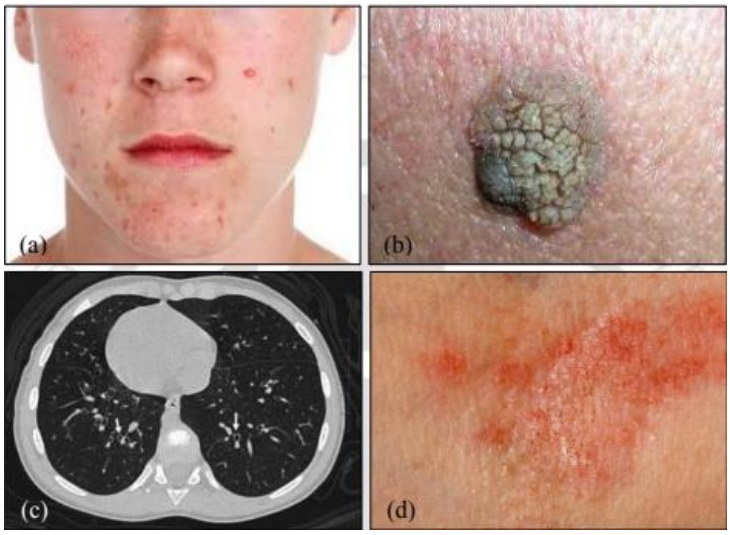


Fig.4 various diseases caused due to prolonged exposure of the cutting fluids: (a) oil acne [8], (b) skin cancer [9], (c) mild bronchiectasis [10] and (d) dermatitis [11]

In order to overcome the problems associated with the cutting fluids, in recent years, manufacturing premises are moving towards the sustainable machining due to health issues to the workers, financial and severe environmental policies. Some of the sustainable machining techniques as shown in the figure.5. In order to maintain the sustainability in the metal cutting domain, from few years researchers are mostly concentrated on the surface modification method such as surface textures are provided on the faces of cutting tools in the form of micro or nano levels for improve the tribological and machining performance of difficult to cut material Inconel 718. The three basic mechanisms are responsible for enhancing the textured tools performance, namely; (i) decrement of contact length, leads to frictional force decreases (Refer.6 (a)); (ii) wear debris entrapment, cause to decrease the adhesion and abrasion wear (Refer.6 (b)); and (iii) acts as cutting fluid reservoir (Refer.6 (c)), leads to drastic decrement of cutting temperature by provide the fluid inaccessible regions. But, still these method i.e., surface texturing of cutting tools alone is not exhibited the good performance, because it is employed to reduce the generation of the frictional heating at the secondary shear deformation zone (SSDZ), but during machining, tremendous heat is generated at the primary shear deformation zone (PSDZ) than SSDZ and also there is no such method for reduce the heat generation at the PSDZ and only heat dissipation is the choice. So, for improve the heat dissipation from the cutting zone, another sustainable technique is need to be combined with surface modification process for effective cooling. Hence, compressed air is used as a cutting fluid, because, **compressed air is freely available in the every shop floors and industrials so, no disposal problems, no chemicals are added, hence, there is no health problems to machinists.** Many researchers have been used oxygen, CO_2, argon, water vapors, compressed air and nitrogen for the lubrication and cooling purpose [16, 17]. So, in the present work combined methods such as air cooling and surface texturing is employed for promote the economical, eco-friendly or green machining during machining of nickel-based alloy, Inconel 718.

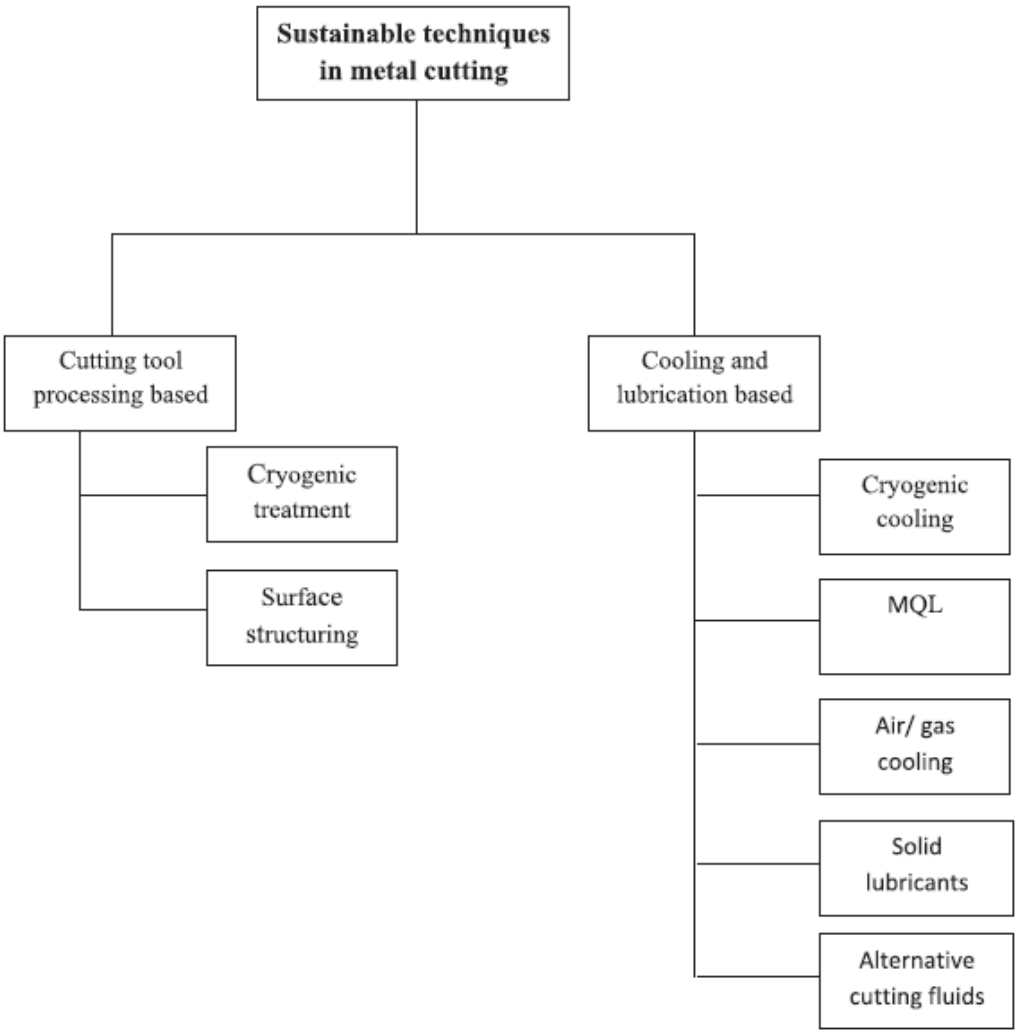
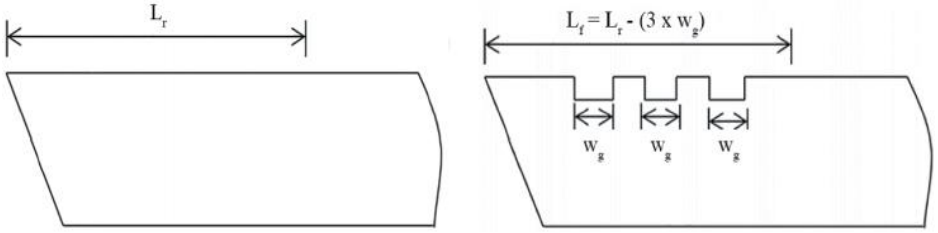
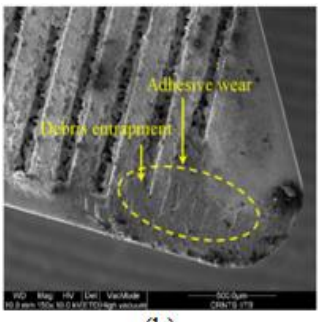


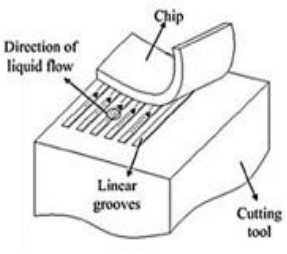
Fig.5 sustainable methods applied for cleaner production [12]

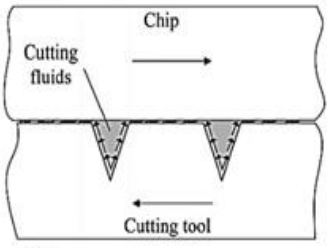


(a)



(b)





(c)

Fig.6 Mechanisms involved with textured tools are; (a) Decrement of contact length [13], (b) Wear debris entrapment [14], and (c) Reservoir for cutting fluid [15]

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g. **Technical Details**

a. TRL: 6th level

b. Methodology:

The general methodology for the proposed project is to be executed in three stages. In the whole project total 54 textured tools and 18 non-texturedd tools (i.e., total 72 tests) need to be evaluated for successful completion of the project. In each stage total 18 textured inserts and 6 non-textured inserts need to be tested. The generation of textures with 40^0 to the cutting edge on the rake and perpendicular to the flank face of the tool, namely Groove textured (GT), Dimple textured (DT) and Hybrid Textured (HT) (i.e., textured pattern is combination of groove and dimple) in the Preliminary experimentation. In all the 3 stages, variable cutting speed, 50, 70 and 90 (m/min), constant depth of cut, 0.2 mm and feed rate, 0.1 mm has been taken as machining parameters. The various stages of the proposed work have been explained in detailed as below;

STAGE I(Ongoing):In this stage, the turning experiments is to be performed with the absence of any type of cutting fluid on the Inconel 718. During machining with non-textured tools, due to absence of cutting fluids cause to generation of severe cutting temperatures between the tool and chip interfaces. Due to which work material elements (i.e., Ni, Cr etc.,) is adhered on to the tool surface and leads to formation of severe crater wear on the rake face is depicted by EDS analysis in contrast to textured tools. From the SEM images the dominant wear mechanisms are may be evaluated on various textured tools in dry environment. Shaw [1] reported a frictional force equation for dry sliding condition as shown in Equation.1

$$F_f = \tau b l_f \text{---------- (1)}$$

Where F_f, τ, b and $l_f$are the frictional force, shear strength of the tool-chip interface, width of the chip and actual contact length between the tool-chip interfaces, respectively. According to the above equation.1, the frictional force and its associated cutting temperatures can be decreased through a reduction in the actual area of contact by fabricating the textures on the cutting tool faces. Also, Wu et al[2], developed an analytical model to predict the temperature generated at the tip of the cutting edge (θ_t) as shown in Equation.2

$$\theta_O + \frac{R_1 \vartheta_s \tau_s}{C_1 \rho_1 \vartheta} \sin\phi + 0.752\, R_2 \tau_C \sqrt{\frac{\frac{\alpha_2 l_f \vartheta}{\xi}}{\lambda_2}} \text{---------- (2)}$$

Based on Equation (2), the contact length and machining velocity have a direct influence on the temperature generated. Due to alternation of the tool surface by textures may decreases the contact length of the chip on the tool during machining of Inconel 718 may cause to decrement of cutting temperatures, resulted to flank wear showed is less for textured tools in contrasted to non-textured tools, hence, the

main cutting force also showed less in textured inserts while comparing with the non-textured tools by increasing the cutting speed. The long serrated type chips are supposed to be generated owing to the unstable plastic deformation with adiabatic shear band (low thermal conductivityof Inconel-718) for non-textured tools. During machining with textured tools the short spring types are produced while using textured tools

STAGE II: During machining, achieving effective chip evacuation is a significant concern during machining of difficult-to-machine materials such as Inconel 718 at the dry condition. If not adequately addressed, it can lead to the generation of high cutting temperatures, resulted to severe adhesion of the work material on the tool surfaces, formation of BUE. It is not only effect on the productivity (shorten the tool life) but also affect on the surface roughness of the work component. Hence, the green cutting fluid such as compressed air has been supplied to the cutting region. The compressed air is supplied at the rake and flank face of the cutting tool for effective cooling. According to the design of textures when the coolant is supplied to the rake face and supplied coolant is move towards the cutting region so that entire cutting edge including nose radius may be effectively cooled. Due to supply of compressed air, convective heat transfer may highly increases, causes to improvement of heat transfer rate accordingto the equation.3 (Newton's law of cooling) [3] as follows;

$$Q = hA(T_{\alpha} - T_{o}) \text{ ---------- } (3)$$

Based on Equation (3), the convective heat transfer coefficient, surface area, surface temperature and fluid temperature have a influence on the heat transfer rate. Hence, due to supply of compressed air, heat transfer coefficient may be increases and rate of heat dissipation by the cutting fluid may increases from the cutting region. It is causes to decrease of the cutting temperatures, enhance the wear resistance and tool life and surface integrity characteristics.

STAGE III: In Final stage, **the adjustable spot cooler method** which uses vortex tube technology is to be applied during machining of Inconel 718 for effective cooling. Employing compressed cold air for cooling in machining operations is a relatively new technique. Air that rotates around an axisis called a vortex. The principal of operation of vortex tube as shown in figure.1. The vortex tube is a mechanical device that creates cold and hot air by forcing compressed air through a generation chamber, which spins the air at a high rate of speed (1,000,000 rpm) into the vortex. Cold gas stream leavesfrom the cold tube which is supplied to the machining region. The control valve located in the hot exhaust end can be used to adjust the temperature drop and rise. **Based on Equation (3), due to decreases of the fluid temperature** may be drastic increase of the heat exchange rate (heat transfer rate) from the cutting zone to cutting fluid, so that drastic decrease of the cutting temperatures. By applying the adjustable spot cooler technique is may be perfect solution for one of the most peculiar characteristic of Inconel 718 such as

the existence of Ni_3Nb (body-centered tetragonal) in $Ni_3(Al,Ti)$ (face-centered cubic) precipitates of Inconel 718 can strengthen the material, leading to a continuous increment in hardness characteristics up to a temperature rise of 650°C. Due to effective cooling, may be drastic decreases of the cutting temperatures hence tendency of work hardening is lower so that cutting forces is decreases and improves cutting life (i.e., production cost may decreases).

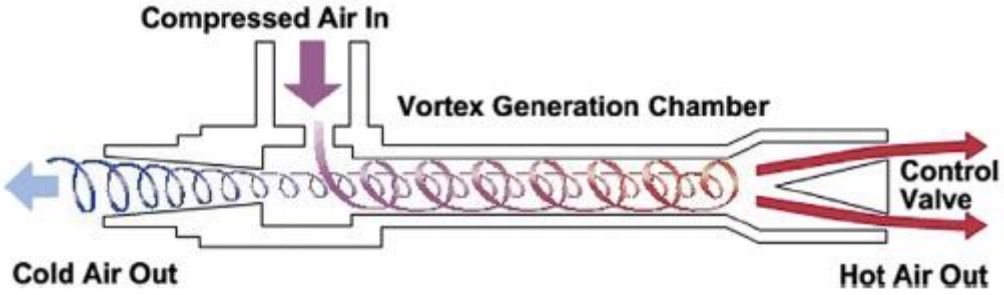

Fig.1 Schematic view of working principle of vortex tube [4]

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c. Design & Development

Despite the efforts of numerous researchers to develop the various textures on the rake or flank or rake and flank surfaces of the cutting tools in the different geometry and orientation, complete knowledge of the topic is necessary to unveil successful textures. The textured tools with the dimple diameter/groove width is 80µm, depth of dimple and groove is 50 µm and spacing or pitch between the grooves and dimples is 150 µm are considered for the proposed work. The various designed textured patterns such as GT, DT, HT and CT. The textured patterns should be exhibited the enhancement of the tribological performance such as improve the flank and crater resistance and exhibit less coefficient of friction by increasing with the cutting speed (m/min) in contrast to the conventional tools. During machining of Inconel 718, due to high work hardening tendency, cutting forces recorded as high, leads to decreases the tool life (min). But, while machining with the textured tools, cutting forces also should be in the decrement and these values are to be recorded in the reasonable limits so that tool life (min) of the textured tools improved in contrast to non-textued tools (NT).

d. Facilities and Instrumentation required

The successful completion of the project depends on the availability of testing and characterization facilities. The following facilities are required to the proposed project

i. Scanning Electron Microscope (SEM) :for identify the type of wear mechanisms and to measure the crater and flank wear and also used for the study of chip morphology

ii. Scanning Electron Microscope with EDS: used for identify the various work piece elements on the tool faces, which are mainly displaced by rise of cutting temperature.

iii. X-RAY Diffraction (XRD) : it is used for characterize the oxides and carbides formation on the tool surfaces

iv. Electron Backscatter Diffraction (EBSD) :used for find the grain orientation and grain size of machined component

v. Optical microscope : To measure the flank wear values instantaneously for identify the tool failure criteria (< 0.3 mm)

vi. Micro – Hardness tester :used to measure the variation of the micro-hardeness values from the top surface to beneath surface of the machined component

vii. 3D- profile meter : to measure the dimple diameter, groove width and spacing or pitch between the two adjacent textures and also it is used for measure the surface roughness values.

viii. IR Camara: Used for measure the cutting temperatures at the cutting region

ix. Dynamometer: used for measure the cutting forces developed while machining of Inconel 718.

e. Consumables (Scientific materials)

The consumables required for the sample preparation includes polishing papers of different grades ranging from 120 to 2000 grade. The polishing papers compatible with the available polishing machine can be purchased from local market, Ranijunj, Hyderabad. The rake face and flank face of these tools were finished by grinding and polishing to the roughness R_a of less than 0.018 μm and then were cleaned with a 20-min ultrasonic bath in acetone, respectively for remove the dirt, grease, etc,.

h. **Expected output and outcome**

The proposed work is expected to develop a textured parameters and textured geometry during machining of Inconel 718 with sustainable techniques. Such sustainable techniques will benefit to the workers or mechanists and to the manufacturing premises by eliminating the cutting fluids, including the cost associated with purchase of cutting fluids. Due to absence of cutting fluids, no need to follow the obligations from environmental policies for desposal of cutting fluids. Due to lot of benefits with the suggested work of surface texturing with compressed air cooling is mostly suitable for machining of difficult to cut material Inconel 718, so, it can be highly recommended to the manufacturing premises for promote the eco-

friendly and green machining while machining of Inconel 718. The novel work proposed in the project can be published in SCI-indexed journals.

i. **Industry/Institute Collaboration:**

(i) Name of the Collaborating Industry/Institute
National Institute of Technology Warangal

(ii) Collaboration Details
The turning operations to be carried out on the lathe Machine with dynamometer, which is not available in the home institute (NIT Mizoram) and the same set-up was available in the NIT Warangal. Hence, the machining experiments by using various cutting tools need to be conducted in NIT Warangal.

(iii) Additional Details if any: NO

j. **Funding required from I-STEM:**

1) **Characterization:**

The funding required is mostly for the purchase of the consumables for conducting the machining experiments, testing and characterization. There is no facilities such as SEM, SEM with EDS, XRD, EBSD etc., are available in the NIT Mizoram.Testing and characterization for all the samples will be carried out at the reputed institutions such asIISc/IITs/NITs/other testing centers and also whicheverinstitution offers lowest charges for the testing and characterization are preferred. The SEM analysis is to be used for the entire evaluation of tool wear mechanisms on tool rake and flank faces. Also,its effect on the tool surface and work piece surface is to be characterized by EDS analysis. During machining high cutting temperatures are developed thereby the chances for the formation of oxides and carbides on the tool surface are high. In order to understand the different phases abd composition present in these oxides and carbides, XRD analysis is very much esential. Electron Backscattered Microscope (EBSD) have been employed for measure the grain size variation and grain orientation of the machined component.After machining, chips need to be analysed with SEM to analysis its variation in the morphology and to understand the influence of cutting temperatures, cutting forces and textured patterns during formation of chip. After generation of the textured patterns on the rake and flank face, it is mandatory to measure the dimple diameter, groove, depth of groove and dimple and spacing between the textured has been analysed by the 3D surface profile meter and also it is used for measurement of surface roughness of the work material. Due to development of cutting temperatures, hardness of the work material may be altered, thefore the measurement of micro-hardness is important. Thefore, the following estimate of the fund requirement for the charectrization is calculated.

Table 1.Estimate for characterisation

Sl. No.	Facility/Instrument	Availability	Testing charges per sample (INR)	Remarks (Min. charges)	Total Charges (INR)
1.	SEM	IISc/IITs/NITs/other testing centers	1000.00	5 samples	5000.00

2.	SEM with EDS	IISc/IITs/NITs/other testing centers	500.00	5 samples	2500.00
3.	XRD	IISc/IITs/NITs/ other testing centers	500.00	5 samples	2500.00
4.	3D-Profile meter	IISc/IITs/NITs/other testing centers	300.00	3 samples	900.00
5.	Micro-hardness tester	IISc/IITs/NITs/other testing centers	500.00	4 samples	2000.00
6.	EBSD	IISc/IITs/NITs/other testing centers	1500.00	4 samples	6000.00
Total expected(INR)					**18900.00**

2) **Consumables**

(i) Chemicals and consumables for sample preparation

The consumables required for the sample preparation includes polishing papers of different grades ranging from 120 to 2000 grade. The polishing papers compatible with the available polishing machine model (Bainpol PMV019) can be purchased from MetkorpEquipments Pvt. Ltd, leading manufacturers of metallography equipment in Hyderabad. The rake face and flank face of these tools were finished by grinding and polishing to the roughness R_a of less than 0.018 μm and then were cleaned with a 20-min ultrasonic bath in acetone, respectively for remove the dirt, grease, etc,.

Table 2. Chemicals and consumables for sample preparation

Sl. No.	Chemicals/Consumables	Price (INR)	Quantity	Total price (INR)
1.	Polishing paper 120, 200, 400, 800, 1200, 1500 and 2000.	7 × 22.00	10 No.s of each	1,540.00
2.	Acetone	1000	1 ltr	1000.00
Total (INR)				**2540.00**

(ii) Consumables for conduct the machining experiment

i. **Work piece Material(Inconel 718)**

The turning experiments are conducted on the work piece of Inconel 718 cylindrical bar of length is 250 mm and diameter of 50 mm was chosen by following ISO 3685:1993 i.e., L/D ratio ≤ 10 used as a work material.

ii. Tool Material (Tungsten Carbide)

Uncoated tungsten carbide (WC) tool with ISO designation of CNMA 120408 – THM (WIDIA) was considered as a cutting tool for all the machining tests. WC inserts has been selected as there is no coating and chip brakers on the tool surfaces. This helps in an easy manufacturing of the texture patterns on rake and flank face of the tool.

iii. Tool Holder

The tool holder has designation of DCLNR 2525 M12 is used for fix the tool inserts rigidly.

iv. Fabrication of textures on the cutting inserts

For conducting the turning experiments cemented carbide (WC/Co) was selected as a tool material for this study. This insert has been selected as there are no coating and chip breakers in the insert surfaces. This helps in an easy manufacturing of the texture patterns. The rake face and flank face of these tools were finished by grinding and polishing to the roughness R_a of less than 0.018 μm and then were cleaned with a 20-min ultrasonic bath in acetone and alcohol, respectively. Nano-second Nd:YAG laser has been used for produce the three different kinds of textured tools by laser surface texturing (LST) process.

Table.3 Expenditure details for consumables for conduct the cutting tests

S. No	Consumables	Designation	Unit Price/Kg (INR)	QTY	Gross Price (INR)	Freight charges + Tax: 18% GST	Net Total (INR)
1	Inconel 718 Round Rod	250 mm length and 50 mm diameter	3500.00	4.6 Kgs	16100.00	600 + 3006	19706.00
2	Tungsten carbide inserts	CNMA 120408-THM (WIDIA)	235.00	30 No.s	7050.00	150.00 + 1681.00	11015.00
3	Tool Holder	DCLNR 2525 M12 (Turkey)	2134	1 No	2134.00		
4	Textures generation	GT DT HT	750.00	54 cutting edges	40,500.00	7290	47790.00
Total expected (INR)							**78511.00**

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Table 4. Total Expenditure for Consumables

Sl. No.	Chemicals/Consumables	Total price (INR)
1.	For sample preparation	2540.00
2.	For the experiments	78511.00
Total (INR)		**81051.00**

Details of Requirements & Mode of the Engagement: <u>(Attach the quotation for the consumables)</u>

(i) Short term Engagement:

(i) Usage of testing/characterization facilities across the country (Characterization Mode)

i. Testing Charges

Sl. No.	Facility/Instrument	Availability	Testing charges per sample (INR)	Remarks (Min. charges)	Total Charges (INR)
1.	SEM	IISc/IITs/NITs/other testing centers	1000.00	5 samples	5000.00
2.	SEM with EDS	IISc/IITs/NITs/other testing centers	500.00	5 samples	2500.00
3.	XRD	IISc/IITs/NITs/other testing centers	500.00	5 samples	2500.00
4.	3D-Profile meter	IISc/IITs/NITs/other testing centers	300.00	3 samples	900.00
5.	Micro-hardness tester	IISc/IITs/NITs/other testing centers	500.00	4 samples	2000.00
6.	EBSD	IISc/IITs/NITs/other testing centers	1500.00	4 samples	6000.00
Total expected (INR)					**18900.00**

ii. Consumable charges

Sl. No.	Chemicals/Consumables	Total price (INR)
1.	For sample preparation	2540.00
2.	For conduct the experiments	78511.00
Total (INR)		**81051.00**

The total expense is estimated to be:

Sl. No.	Category	Amount (INR)
1.	Testing charges	18900.00
2.	Consumables	81051.00
Total expenses (INR)		**99951.00**

In order to cover the remaining expenses of my project, I would approach my institution (NIT Mizoram) for the sponsorship. In case of any disappointment from my institution, I would like to assure that the cost for project completion will be borne by me.

Details of User's Bank Account

Beneficiary Name (User's name): NIT MIZORAM PAN: AAALN1036D

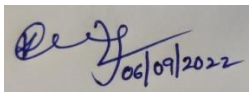
Bank Account No: 33755447886 Name of the Branch: State Bank of India

IFSC Code: SBIN0007059

Note: Proposed proposal must be executed within stipulated duration (max. 6 month) to avoid fund availability issues. Travel form will be provided by the I-STEM office. The users will submit the technical report, original invoice (duly signed by the Head of the Institution) raised by the Host Institution through I-STEM portal only along with a copy of the travel forms and original tickets through post to the Nodal Officer, I-STEM, Indian Institute of Science, Bangalore. A scan copy of all the documents may be sent in advance.

Declaration:

We have read the terms and conditions for the I-STEM scheme under *"Partial financial support for using R&D facilities through the I-STEM web portal to Users from Academic Institutions and Start-ups (Proposal Format-1)"*

a) Researcher/ PhD scholar: (Mr. Kore Mahesh) 

b) Faculty member/ Guide: (Dr. Basil Kuriachen)
06/09/2022

06-09-2022

NIT Mizoram

Bhagyashali Metal

No. 42/44, Shop No. 7, Matru Aashish Building, 5th Kumbharwada, Maruti Mandir Marg
Mumbai, Maharashtra
+91-9869310849
022-67496183, 66151443
bhagyashalimetal@gmail.com
GST NO: 27AOMPS2817P1Z4

Date: 10/08/2022
Quotation no: 152/22-23

TO,
Kore Mahesh
Research scholar,
Department of Mechanical Engineering,
National Institute of Technology Mizoram

Subject: Quotation for Inconel 718 Round bar.

Dear sir,

Thank you for showing interest in our products & contacting us. Please find our exclusive Quotation for your requirement of Inconel 718 Round bar.

SR.NO	PRODUCT DISCRIPTION	QUANTITY	RATE	UNIT	TOTAL AMOUNT
1	Nickel Alloy rod Inconel 718 rod – 50 mm dia x 250 mm length – 1 pec	4.6	3500	P/ kg	16100
	WE HOPE YOU WILL FIND OUR OFFER ACCEPTABLE & HENCE LOOK FORWORD TO RECIEVE YOUR VALUED ORDER AT THE EARLIEST.			GROSS TOTAL	16100
				P&F CHARGES	600
				GST 18%	3006
				NET TOTAL	**19706**

Terms and Conditions
Applicable tax: 18% GST.
Delivery period: 15 days
Payment Terms: 100% advance payment.
Remarks: Freight including
Validity:-7 days
Price basis:- Ex work Mumbai India

BANK DETAILS:
BHAGYASHALI METAL
BANK OF BARODA
GULAL WADI BRANCH
C A/C NO: 14390200002141
IFSC CODE: BARB0GULALW

Please contact us in case of any concerns.
Sincerely yours,
Mr. Champak Sanghvi
+91 9869310849
www.bhagyashalimetal.com

TAX INVOICE

Transporter's Copy

A-tec Corp. 301, Levata, 64, Nagdevi Street, Mumbai - 400003 Ph: 98196 30794 **GST: 27AAYFA5414A1ZK**	Invoice No. **A1610**	Dated **12-Aug-22**
	Mode/ Terms of Payment **CHEQUE/NEFT - 100% Advance**	
Buyer:Kore Mahesh (DT17ME008) Ph.D scholar Department of Mechanical Engineering National Institute of technology-Mizoram **Ph: 77026 77286** **GSTIN: 15SHLN01396D1DT**	Terms of Delivery Within 1 - 2 days after receipt of payment	

Description of Goods	Qty	Rate	Per	Amount
CNMA 120408 THM	30	235.00	nos	7050
DCLNR 2525 M12	1	2134.00	nos	2134
Freight				150
Sub Total	**31**			9334
	Tax: GST 18%			1681
	Total			**11015**

Amount Chargeable(in word)

Rupees Eleven Thousand Fifteen Only

Prices valid for 30 days only.

Bank Details: HDFC Bank (Mumbai Central) Current A/c No.: 50200002674912 IFSC Code: HDFC0000522	For **A-tec Corp.** Authorised Signatory

This is a Computer Generated Invoice

NANO MARKER'S
LASER
CUTTING
ENGRAVING
MARKING
9150053500
22, Sudarsan Nagar,
SRIRANGAM
Trichy - 620 006
INDIA
nanomarkers@gmail.com

QUOTATION

To:

Kore Mahesh (DT17ME008), Ph.D. Scholar,

Department of Mechanical Engineering

National Institute of Technology Date: 17.08.2022

MIZORAM

Sir,

We are offering affordable charges for LASER processing

S.NO	DESCRIPTION	QUOTATION RATE PER EDGE	NUMBER OF EDGES	TOTAL AMOUNT
01	**Laser texturing on TUGSTEN carbide INSERT tool CNMA 120408 THM 27 INSERTS**	**Rs. 750.00**	**54**	**Rs.40500.00**
	IGST 18%			**Rs. 7290.00**
	TOTAL			**Rs. 47790.00**

TERMS AND CONDITION

1. This quotation validity up to 30 days only.
2. TEXTURE DESIGNS are drive by nit MIZORAM
3. PAYMENT WITHIN 20 WORKING DAYS FROM THE GOODS DELIVERY DATE
4. INSERTS SUPPLIED BY NIT MIZORAM WITH SUPPLY ORDER

*NANOMARKERS GSTIN NO: 33AAFPP2107G1Z6 *SERVICE TAX GST REG.NO: AAFPP2107GSD001

Yours Faithfully,

For Nano Markers

NANO MARKER'S Sign Srirangam

NANO MARKER'S
22, Sudarsan Nagar
Srirangam. Trichy-620 006
Ph 9150053500