Scientific Journal of Impact Factor(SJIF): 3.134
e-ISSN(O): 2348-4470
p-ISSN(P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 2,Issue 9, September -2015

EXPERIMENTAL INVESTIGATION OF TOOL WEAR IN TURNING OF INCONEL718 MATERIAL-REVIEW

Ramesh kannan.C[1], Prathap.J[2], Pamanabhan.P[3]

[1] *Faculty, Department of Mechanical Engineering, Anna University Regional centre, Madurai.*
[2] *P.G Scholar, Mechanical Engineering Department, Anna University, Madurai.*
[3] *Principal, V.V. Engineering college, Tisaiyanvilai.*

Abstract: *In this paper focus the experimental investigation of tool wearin turning of inconel718. This review paper is the optimization of input parameter like cutting speed, feed rate, and depth of cut. The different cuttingconditions tool geometry and tool treatment are used to reduce the tool wear. The output parameters arecutting force, cutting temperature, vibration,power consumption, surface roughness and material removal rate.To analysis the tool wear based on the literature review to continue the machining of inconal718work material using Computer Numerical Control (CNC)machine .To analysis the experimental and predicted values in selected optimization method to reduce the tool wear.*

Keywords: *Inconel718, turning, tool wear, tool treatment, vibration.*

I. INTRODUCTION

Turning processis the major role in manufacturing industry, in machining of inconel718 is a major issue on tool wear. The applications of inconel718 are aircraft engine parts, steam turbine power plants, space vehicle, pressure vessels, medical application, Marian application, pollution control equipment, automotive sectors, combustion chambers, shaft exhaust system, bolt, blade[1].Inconel718 work piece is a high resistance to corrosion, thermalfatigue,thermal shock,creep and erosion[2].The improper selection of machining parameters causes cutting tools wear,break quality,economical loss, damaged work piece and poor surface quality [3]. During machining tool wear plastic deformation of tool edge, severe notching and reduce the tool life [4].Turning as one of the most important machining process in which a single point cutting tool removes unwanted material from the surface of a rotating cylindrical work piece. The process parameters like cutting speed, feed rate, depth of cut, coolant condition and tool geometry affects the material removal rate in turning.[5] .The poor machinability of Inconel718 is due to its rapid work hardening ability during machining and also due to the presence of hard carbides in its microstructure. It possesses unusually high dynamic shear strength and poor thermal diffusivity which results in increase in temperature at machining zone [6]. Advances in cutting tool technology have led to the introduction of coated and uncoated carbide, ceramic, CBN/PCBN and PCD tools with adequate hot hardness and toughness to withstand elevated temperatures generated at high-speed conditions. Also, machining techniques, such as ramping (or taper turning), high-pressure coolant (HPC) delivery system, hot machining, cryogenic machining and the use of self-propelled rotary tooling (SPRT), have been developed in recent years. A good understanding of the behaviour and the relationship between the workpiece materials, cutting tool materials, cutting conditions and the process parameters is an essential requirement for the optimisation of the cutting process[7].This is the reason of select the inconel718 material, the machining of materials to experimentally investigate to produce the optimization parameters. The input parameters are Speed feed rate and depth of cut. The outputs are surface roughness, material removal rate, cutting force, and power combustion.

II. PROCESS PARAMETER

Theinput parameters are chosen based on the literature review and the effect on characteristics like surface roughness, material removal rate, tool wear, geometric tolerance, power consumption, vibration.The fish bone diagram help to identify which process affect the responding characteristics.

The main process parameters for turned parts are

- Cutting parameters: speed, feed rate, and depth of cut.
- Cutting tool parameters: Tool geometry, tool material and tool treatment.
- Work piece material: Hardness, Metallographic, and wear.
- Cutting environment: Wet and dry.

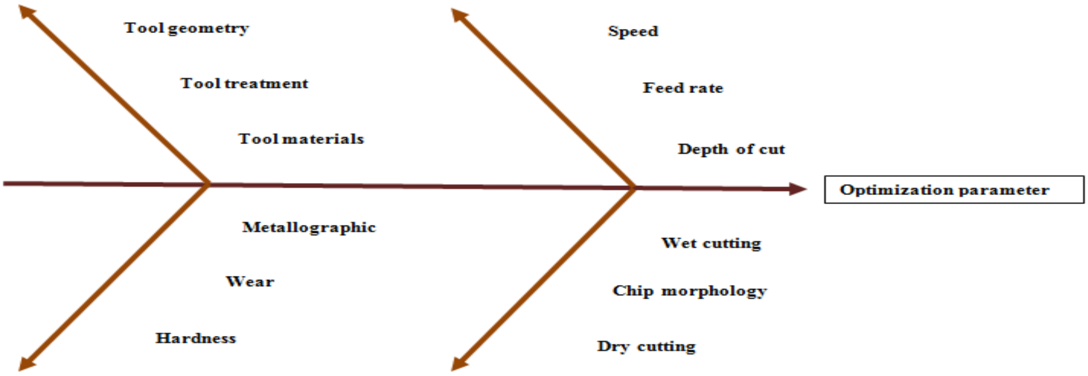

Fig .1Causes and effect diagram

III. WORK MATERIAL

Inconel718 material are the most widely used super alloys, accounting for about 50 wt. % of materials used in an aerospace engines, mainly in the gas turbine compartment (combustion part of the jet engine) [4].Inconel718 material is difficult to machining [5].Improper selection of machining parameters causes cutting tools to wear and break quickly as well as economical losses such as damaged work piece and rejected surface quality [6].chemical composition of Inconel718 material is given Table 2.

Table 2.Chemical composition of Inconel718 Material in percentage [2]

C	0.062	**Si**	0.12
S	0.004	**V**	0.027
Mn	0.0002	**Cr**	18.01
Mo	3.75	**Co**	0.17
Cu	0.11	**W**	0.12
Ti	0.97	**Ta**	5.34
Al	0.47	**B**	0.002
Nb	5.345	**Zr**	0.001
Mg	0.02	**Fe**	18.51
Sn	0.011	**Ni**	52.21
Ca	0.0003		
P	0.033		

Table.3 Physical properties of Inconel718 [6]

Tensile strength (MPa)	Yield strength (MPa)	Elastic modulus (GPa	Hardness (HRC)	Density (g/cm3)	Melting point (8C)	Thermal conductivity (W/m K)
1310	1110	206	38	8.19	1300	11.2

IV. TOOL MATERIAL

Uncoated cemented carbide cutting tool insert is used in turning process. (CNMG 120408-QM, grade H13A)[3].

V. MACHINING OF MATERIAL

The machining process is carried out in CNC lathe. The CNC lathe is performed the different process; I have selected the turning process. The main function of lathe is to remove metal from work piece and obtained required kind of shape and size. This is accomplished by holding the work piece securely and rigidly on the machine and then fed the tool against the work and obtained required work surface by removing metal in form of chip. The tool must be harder than the cutting work material.

The main function of lathe is turning. Turning is the removal excess material from the work piece to produce a cone shaped or a cylindrical surface [21]. The various types of turning operations are

- Straight turning
  - Tough turning
  - Finish turning
- Taper turning

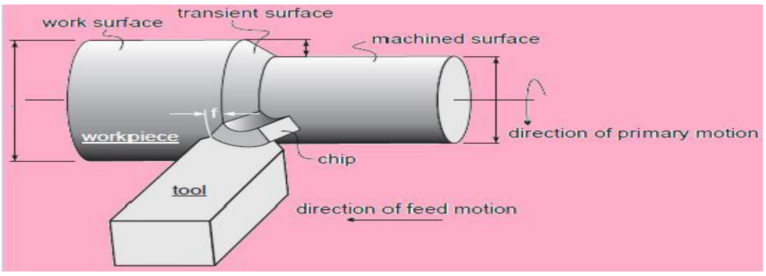

Fig.2 turning process (figure taken from reference [21])

VI. TOOL WEAR

The change of shape of the tool from its original shape, during cutting, resulting from the gradual loss of tool material is termed as tool wear. Cutting tools are subjected to an extremely severe rubbing process. They are in metal-to-metal contact between the chip and work piece, under conditions of very high stress at high temperature. The situation is further aggravated (worsened) due to the existence of extreme stress and temperature gradients near the surface of the tool. During machining, cutting tools remove material from the component to achieve the required shape, dimension and surface roughness (finish). However, wear occurs during the cutting action, and it will ultimately result in the failure of the cutting tool. When the tool wear reaches a certain extent, the tool or active edge has to be replaced to guarantee the desired cutting action. The important types of tool wear are flank wear, nose wear, crater wear and notch wear [22]. Currently, a major problem associated with conventional machining of Inconel718 is the accelerated tool wear, resulting from generated high temperature in the cutting zone. The use of high pressure jet-assisted cooling technology during the machining of Inconel718 provides temperature reduction at the cutting zone [4]. Increasing the cutting speed dominantly affects the tool-wear, which is the consequence of high temperatures in the cutting zone. Also, this observation is consistent with the machining theory [7].Tool wear can cause surface integrity deterioration and dimensional error greater than tolerance [4, 7].

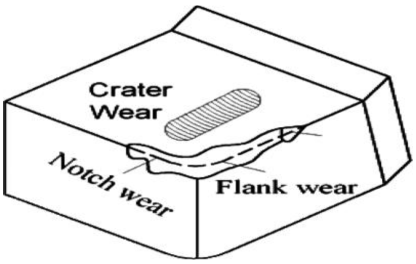

Fig.3 tool wear (figure taken from reference paper [22].)

7s. Literature review

Zemzemi.F and.Rech.J[1] In this paper analysis the sliding velocity and contact pressure in different tool like (carbide tool, c-BN tool) compare to give the result .The machining of Inconel718 work materials. The result is sliding velocity from 20 to 50 m/min for carbide tools and from 80 to 250 m/min for c-BN tools, and average contact pressure is 1.8 to 3.4.**GPa.Saravanakumar. K,** and**Pratheesh KumarM.R.**[2].In this paper reveals that material turning of CNC lathe with coated carbide tool inserts M30. In effect of optimization parameters such cutting speed, feed rate, depth of cut. To measure surface roughness and material removal rate by using empirical formulae. They optimum result is cutting speed(79.9 m/min),feed rate(0.15 mm/rev), depth of cut(0.1 mm) and surface roughness is (0.69um). **Thirumalai R** and**Senthilkumaar J.S**[3].In this paper investigated the influence of different machining parameters such as cutting speed ,feed ,depth of cut on different performance are measured like surface roughness, tool life, cutting force, power consumption and material removal rate on Inconel718. They used uncoated carbide tool under dry machining. They used multi attribute decision making method is used to optimization. The result is cutting speed 41.98m/min, feed 0.1 mm/rev and depth of cut 1.0 mm is the which gives surface quality(0.99 um) ,tool life is(22mm) ,cutting force (616 N) power consumption(0.85)and material removal rate(4221 mm3).**OguzColak**[4].This work deals with optimization parameter is cutting speed, feed rate, fluid pressure, and two level of depth of cut. The machining of Inconel718 material with coated carbide cutting tools, in different cooling condition like conventional and alternative high pressure cooling.To salve the ANOVA and Taguchi method. To measure the cutting force, tool flank wear. The result is high pressure cooling is used to reduces the cutting force, improve the quality of machining process, tool wear reduced, increase the tool life.**Bikash Chandra Beheral**and**Chetan**[5] .Objective of this paper is compare the three cooling condition to give better condition and optimization parameter, during turning of Inconel718 material in CNC lathe. The condition like wet, dry and MQL. The result is MQL condition better than the other two conditions**. Ezugwua E.O** and**Fadarea D.A.**[6]. Observed from this paper investigated the effect of machining parameters like spindle speed, feed, depth of cut, cutting time, and coolant pressure. To measure the parameter during machining of Inconel718 material like cutting force, axial force, power consumption surface roughness, average flank wear, nose wear, using artificial neural network methodology. They result is speed range (25-35 m/min), feed rate (0.27and 0.28 mm/rev). **FranciPusavec T and AshishDeshpande**[7]. In this paper experimental investigated of CNC turning of Inconel718 material, to compare the different fluid condition like dry, near-dry(MQL), cryogenic and cryo –lubrication using response surface methodology(RSM) and verified using ANOVA methodology. To measure the cutting force, surface roughness, and tool wear. They result is cooling/lubrication condition has on influence on machining performance.

Naik S.N. and. Sidhu J.S[8] The paper deals with the excremental results obtaining the maximum MRR, less surface roughness, and less power consumption on turning of CNC in SS316 material with different cutting tool (ceramic, carbide & CBN). They have result is surface roughness depends on feed rate in ceramic, carbide. CBN tool depends on speed. MRR dominates the all tools. Power consumption mainly depends up on the depth of cut in ceramic tool, then feed rate is carbide tool, then depth of cut is CBN tool. **Nikuj R Modh and Mistry G. D.**[9]. Objective of this paper optimized turning parameters is (cutting speed, feed, depth of cut)for calculate the surface roughness, cutting force, feed force. during machining the work material is heated in different temperature like 200,400,600.the result is analysed to ANOVA methodology, optimum result is cutting speed(965 rev/min),depth of cut (0.8mm), feed (0.265 mm/rev).then 600 o C. hot machining process is good surface finish, and low cutting force, feed force. **Yusuf Kaynak**[10]. In this paper reveals experimentally investigated the cryogenic machining of Inconel718 materials to compare the other two conditions like dry and MQL. To find the result is number of nozzles used to control the cutting forces and power consumption, and using cryogenic cooling at higher cutting speed, MQL machining at lower cutting speed is recommended to improve machining performance. **M.V.R.D. Prasad** and**YelamanchiliSravya**[11].In this paper reveals optimize the machining parameters in turning of Inconel718 using (CBN10) tool. The Taguchi's was used to analyze the result data. The result is optimal turning process parameters (speed, feed, depth of cut) to determination of surface roughness is up to 97.22% accurate.

Manohar. M and Joseph[12] objective of this paper to optimizing the process to yield higher metal removal , better surface quality , lower cutting force by method of RSM methodology and application of box Behnken .then the CNC turning of Inconel718 work material with coated carbide tools. The result is saving the amount of time and money.**Sujith Kumar Jha**and**Pramod K Shahabadkar**[13].Objective of this paper is optimization of process parameters (speed, feed, depth of cut) on material removal rate. During machining of aluminium alloys in CNC lathe. This used to ANOVA methodology is optimum parameters. The result is best parameter of material removal rate is cutting speed (1000 rpm), feed rate (0.20) mm/rev, depth of cut (1.5mm). **RohitGunerkar. S**and**Kuppan .P**[14]. In this paper deals optimization of turning parameter like speed, feed, depth of cut, cutting fluid and cutting velocity, with the machining of SS316L material in CNC lathe. then the cutting fluid is vegetable oil, To find the ANOVA methodology are used and calculate the surface finish, cutting force, and tool wear. **Umesh Gupta** and**AmitKohli**[15].Observed from the paper AISI 4340 material is turning of CNC lathe with two coated tools are used. Then the compare to produce the optimization parameters. Then the used of RSM method. To find the surface roughness, the result is dry condition in two coated tools is optimization machining.**Shaikh, J.B.** and**Sidhu J.S**.[16].The paper determination of best lubricant, then compare the three lubricant like servo cut oil, cotton oil, soya beam oil. To machining the AISI D2 steel in CNC lathe to determine the surface roughness and material removal rate. They concluded the servo cut oil is better than other oil.**Richard Geo** and **Jose SherilD'cotha**[17]. Find the machining parameter (cutting speed, feed, depth of cut) on power consumption of machining. They have machining the EN-24 work material, with comparison of different tools like, HSS and tungsten carbide tools. It is used to methodology of SPSS software to measure the power. They result is HSS more power than the carbide tool.

Thakur D.G.and**Ramamoorthy.B**[18].This paper analyzed the data of flank wear by turning Inconel718 work piece. And the use of abundant cutting fluid for machining of work piece, statically method of ANOVA was used in this work in order to analyzed results data. Finally concluded protects the operator's health and reduces the detrimental effects on the environment. **K Santa Rao**and**Dr.Ramana .S V**[19].This paper investigation of surface finish and materialremoval rate of work material is SAE40,with turning of CNC lathe. Then the comparison of three cooling condition like solid (boric aside), wet and dry. The result is composite lubricant; the particle size increased then surface roughness decreased, then boric aside better than the other two conditions.**Imran Ansari M.,D**and**Kotiveerachary**.

B[20].Optimization of parameter on tuning of Inconel800 in CNC lathe. Then the comparison of lubrication in different condition likes dry, MOL1, MQL2 and flood. To analyse the ANOVA method are used. The result is surface roughness is MQL1 (1.93 um), MQL2 and flood condition (2.07um).

Table.1 Summery of different review papers

Ref. No.	Years of publication	Author name	Input parameters	Output parameters	Tool used for analysed data
1	2015	Sujith Kumar Jha andPramod K Shahabadkar	Cutting speed, feed and DOC	MRR	ANOVA
2	2014	Richard Geo and Jose SherilD'cotha	Cutting speed, feed and DOC	Power Consumption	SPRR software
3	2014	J.B. Shaikh andJ.S.Sidhu	Cutting speed, feed and DOC	Surface roughness and MMR	Comparison
4	2014	T FranciPusavec and AshishDeshpande	Cutting speed, feed and DOC	Surface roughness, tool wear, MMR and cutting force.	ANOVA
5	2014	Umesh Gupta andAmitKohli	Cutting speed, feed and DOC	Surface roughness.	RSM
6	2014	S.N. Naik, and J.S. Sidhu	Cutting speed, feed and DOC	Surface roughness, MMR and power consumption	Comparison
7	2014	F.Zemzemi and J.Rech	Cutting speed, feed and DOC	Sliding velocity and contact pressure	Comparison
8	2014	Bikash Chandra Beheral andChetan	Cutting speed, feed and DOC	Surface roughness, MMR and cutting force.	Comparison
9	2013	M Manohar and Joseph	Cutting speed, feed and DOC	Surface roughness, MMR and cutting force.	RSM
10	2013	Md.Imran Ansari andB.Kotiveerachary	Cutting speed, feed and DOC	Surface roughness..	ANOVA
11	2013	RohitS.Gunerkar and P. Kuppan	Cutting speed, feed and DOC	Surface roughness, tool wear, MMR and cutting force.	ANOVA
12	2013	K Santa Rao and Dr.S V Ramana	Cutting speed, feed and DOC	Surface roughness and MMR	Comparison
13	2012	K. Saravanakumar, and M.R. Pratheesh Kumar	Cutting speed, feed and DOC.	Surface roughness and MMR	Empirical formula
14	2012	OguzColak	Cutting speed, feed and DOC	Surface quality, tool wear, tool life,MMR and cutting force.	ANOVA and Taguchi method
15	2012	K. Saravanakumar andM.R. Pratheesh Kumar	Cutting speed, feed and DOC.	Surface roughness and MMR	Empirical formula
16	2011	Thirumalai R and Senthilkumaar	Cutting speed, feed and DOC	Surface roughness, tool life, power consumption, MMR and cutting force.	malty attribute decision making method
17	2011	M.V.R.D. Prasad and YelamanchiliSravya	Cutting speed, feed and DOC	Surface roughness	Taguchi's
18	2009	D.G.Thakur and B.Ramamoorthy	Cutting speed, feed and DOC	Flank wear	ANOVA
19	2005	E.O. Ezugwua and D.A.Fadarea	Cutting speed, cutting time, coolant pressure, feed and DOC	Surface roughness ,flank wear, noise wear, power consumption ,axial force, And cutting force.	Artificial neural network methodology.
20	2000	Nikuj R Modh and G. D. Mistry	Cutting speed, feed and DOC	Feed force, MMR and cutting force	ANOVA

VII. RESULT AND DISCUSSION

The first review paper is give the optimum result is cutting speed(79.9 m/min),feed rate(0.15 mm/rev), depth of cut(0.1 mm) and surface roughness is (0.69um).The fifteenth review paper give the optimum cutting parameters is cutting speed 41.98m/min, feed 0.1 mm/rev and depth of cut 1.0 mm then find the output parameter is the surface quality(0.99 um) ,tool life is(22mm) ,cutting force (616 N) power consumption(0.85)and material removal rate(4221 mm3). The seventeenth paper analyses the sliding velocity and contact pressure in different tool like (carbide tool, CBN tool) compare to give the result .The machining of Inconel718 work materials. The result is sliding velocity from 20 to 50 m/min for carbide tools and from 80 to 250 m/min for CBN tools, and average contact pressure is 1.8 to 3.4 GPa [1,2,3]. The twentieth paper is during machining the work material is heated in different temperature like 200,400,600. optimum result is cutting speed(965 rev/min),depth of cut (0.8mm), feed (0.265 mm/rev).then 600 o C. hot machining process is good surface finish, and low cutting force, feed force. Nineteenth paper is Obtained results, using cryogenic cooling at higher cutting speed in machining of Inconel718 is highly recommended; however, using MQL machining at lower cutting speed is recommended to improve machining performance of this particular alloy [8,9].

All results were analyzed and the results is very high optimization parameters and good performance of Incone718 in turning process, in my project is developed the better result compare to these reference paper.

VIII. CONCLUSION:

The input parameters used in 20 research papers are as under

- The cutting speed has been used in 20 research papers.
- The feed has been used in 20 research papers.
- The depth of cut has been used in 19 research papers.
- The cutting time has been used in 1research paper.
- The fluid pressure has been used in 1research paper.

The performance parameter found in 20 research papers is as under

- The material removal rate has been found in 12 research papers.
- The power consumption has been found in 5 research papers.
- Cutting force has been found in 6 research papers.
- The surface roughness has been found in 14 research papers.
- Tool wear has been found in 4 research papers.

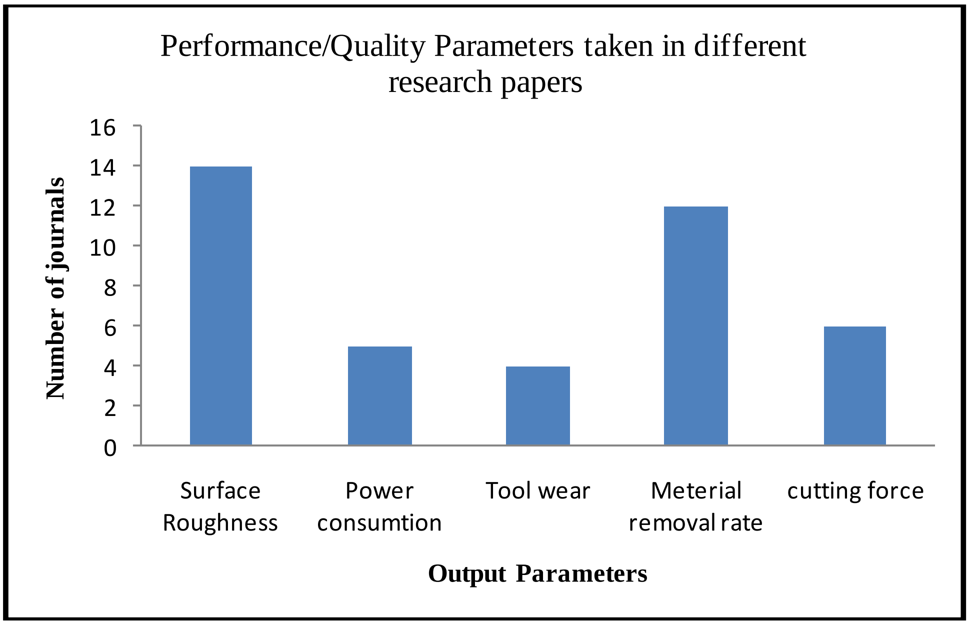

Fig.4 Performance/Quality Parameters taken in different research papers

From the above 20 research papers I come to the conclusion that is

Most of the research people have taken speed, feed and depth of cut as input parameters.These are very important factor, while studying the effect of process parameter on required output parameters are material removal rate, power consumption, cutting force, surface roughness, tool wear and tool life.Reduction of tool wear is based on the optimum input level and cutting condition. In order to reduce the tool wear to identify the levels and cutting process.

REFERENCE:

[1] F.Zemzemi andJ.Rech "identification of friction and heat partition model at the tool-chip-work piece interfaces in dry cutting of an inconel718 alloy with CNC and coated carbide tools" advances in manufacturing science and technology ,vol. 38, no. 1, 2014 DOI: 10.2478/amst-2014-0001.
[2]K. Saravanakumar, and M.R. Pratheesh Kumar "optimization of CNC turning process parameters on Inconel718 using genetic algorithm" IRACST – engineering science and technology: an international journal , ISSN: 2250-3498, vol.2, no. 4, august 2012.
[3] Thirumalai R andSenthilkumaar J.s "intelligent selection of optimum machining parameters in turning of inconel718" international journal of advanced engineering technology, e-ISSN 0976-3945, ijaet/vol.ii/ issue iv/october-december, 2011/167-173.
[4]Oguzcolak "investigation on machining performance of inconel718 under high pressure cooling conditions" journal of mechanical engineering 58(2012)11, 683-690 paper received: 2012-02-17, doi:10.5545/sv-jme.2012.730.
[5] Bikash Chandra Beheral, andChetan "effects on forces and surface roughness during machining inconel718 alloy using minimum quantity lubrication" 5th international & 26th all India manufacturing technology, design and research conference (AIMDTR 2014) December 12th–14th, 2014.
[6] E.O. Ezugwua and D.A.Fadarea "modelling the correlation between cutting and process parameters in high-speed machining of inconel718 alloy using an artificial neural network" international journal of machine tools & manufacture 45 (2005) 1375–1385.
[7] TFranciPusavec and AshishDeshpande "sustainable machining of high temperature nickel alloy e inconel718: part 1 e predictive performance models" journal of cleaner production (2014) 1e15.
[8] S.N. Naik, and J.S. Sidhu " optimization of cutting parameters of SS316 using different cutting tools on CNC lathe" international journal of scientific research and management studies , ISSN: 23493771 ,volume 1 issue 9, pg: 275-282.
[9]Nikuj R Modh and G. D. Mistry "an experimental investigation to optimize the process parameters of AISI 52100 steel in hot machining" international journal of engineering research and applications, ISSN: 2248-9622, vol. 1, issue 3, pp.483-489.
[10] Yusuf kaynak "evaluation of machining performance in cryogenic machining of Inconel718 and comparison with dry and MQL machining" international journals of manufacturing technology DOI:10.1007/s00170-014-5683-0 ,31 January 2014"
[11] M.V.R.D. Prasad, and YelamanchiliSravya "study of the influence of process parameters on surface roughness when Inconel718 is dry turned using CBN cutting tool by artificial neural network approach" international journal of materials, mechanics and manufacturing, vol. 2, no. 4, November 2014.
[12] M Manohar and Joseph " application of Box Behnken design to optimize the parameters for turning inconel 718 using coated carbide tools" international journal of scientific & engineering research, volume 4, issue 4, april-2013 620 ISSN 2229-5518.
[13] SujithkumarJha andPramod K Shahabadkar " experimental investigation of CNC turning of aluminium using Taguchi method" international research journal of engineering and technology , ISSN: 2395-0056 , volume: 02 issue: 03 | june-2015.
[14] RohitS.Gunerkar and P. Kuppan " experimental investigation of vegetable oil based cutting fluid during turning of ss316l" international journal on mechanical engineering and robotics, ISSN (print): 2321-5747, volume-1, issue-1, 2013.
[15] Umesh Gupta andAmitKohli "experimental investigation of surface roughness in dry turning of AISI 4340 alloy steel using PVD- and CVD- coated carbide inserts" international journal of innovations in engineering and technology , vol. 4 issue 1 august 2014 ,ISSN: 2319 – 1058.
[16] J.B. Shaikh, andJ.S.Sidhu "experimental investigation and optimization of process parameters in turning of AISI D2 steel using different lubricant" international journal of engineering and advanced technology ,ISSN: 2249 – 8958, volume-3, issue-5, June 2014.
[17] Richard Geo, and Jose SherilD'cotha " effect of turning parameters on power consumption in en 24 alloy steel using different cutting tools" international journal of engineering research and general science volume 2, issue 6, october-november, 2014 ISSN:2091-2730.
[18] D.G.Thakurand,B.Ramamoorthy "optimization of minimum quantity lubrication parameters in high speed turning of super alloy Inconel718 for sustainable, development" world academy of science, engineering and technology 54 2009.
[19] K Santa Rao andDr.S V Ramana "influence of solid lubricant emulsions on surface roughness of hardened steel when machining on shaper" international journals of mechanical engineering, volume 4, issue 5, September - October (2013).
[20] MD.Imran Ansari andB.Kotiveerachary "study of the effect of minimum quantity lubrication on the surface roughness of incoloy800 during turning operation" international journal of mechanical engineering and research, ISSN.

No. 2249-0019, volume 3, number 5 (2013), pp. 439-448.
[21] S.K. Bose, A .K. HajaraChaudhury and Nirjhar Roy, "Elements of Workshop Technology", Media promoters and publication pvt. Ltd., Vol - II, Eleventh edition.
[22]SanjeevSaini, Inderpreet Singh Ahuja,Residual Stresses "Surface Roughness, and Tool Wear in Hard Turning: A Comprehensive Review"Materials and Manufacturing Processes, 27:6, 583-598, DOI: 10.1080/10426914.2011.585505