JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

# Investigation of Tool Wear and Tool Life with Optimization of parameters on different Cutting tool alloys

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***Abstract:-****In this research work the Investigation of Tool Wear and Tool Life with Optimization of parameters on different tool alloys on S1(SS316),S2(SS304),S3(SS410),S4(SS440C),S5(HSS),S6Titanium alloy gradeS6 (Ti-6Al-4V) Tool material ,Workpiece material ,Max. Time elapsed(in min.)Flank wear(in mm),Wear rate m/min For mild steel workpiece material at low cutting speed the shear force of the SS440C(S4) material is high as compared to the HSS(S6) tool.For aluminium workpiece material, at lower cutting speed SS316(S1) has a greater Shear force than the Titanium alloy (Ti-6Al-4V) (S5), but at higher cutting speeds Titaniumalloy(Ti-6Al-4V)(S5 )was found to have higher Shearforce than SS316(S1).For mild steel workpiece material, at all cutting speeds tool life of HSS (S6) and SS440C(S4) was found to be relatively close.For aluminium workpiece material, at all speeds Titanium alloy (Ti-6Al-4V) (S5) was found to be having longer tool life than SS316(S1) and (Ti-6Al-4V) S5 tool cost is very high compare to other tools (S6) (S4)(S3) (S2)(S1). Finally the cutting tool Titanium alloy (Ti-6Al-4V) (S6) HSS (S5) is good compare to other alloy materials.*

*Keywords:- S1(SS316),S2(SS304),S3(SS410),S4(SS440C),S5(HSS),S6Titanium alloy gradeS6 (Ti-6Al-4V) Tool material, Optimization of parameters.*

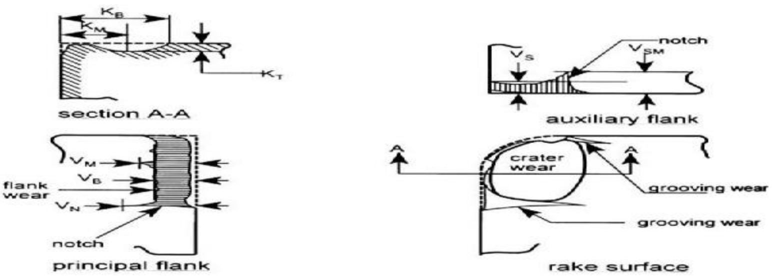
***1.Introduction:-*** 1.1.Cutting tool :-It is defined as eliminate or withdraw material from the component by using lathe machine.Removal of material on the workpiece is done by using single point cutting tool.

**Designation and Features of tools:-**The Designation and Features of tools are ASA system (American Standards Association), ORS or ISO Old System (Orthogonal Rake System), NRS or ISO New System (Normal Rake System), MRS (Maximum Rake System)

The resources for cutting tool are Ceramics; Cubic Boron Nitride(c-BN);High Speed Steel(HSS);Tungsten carbide and Diamond.

**Breakdownofcutting tools:-**Due to extreme forces and impacts.Due to exhaustive stress and thermal properties.Due to erosion of the cutting edges of the tool.The following are the methods of cutting tool wear,The following are the methods of cutting tool wear are: Mechanicalwear,Thermochemicalwear,Chemicalwear and ,Galvanicwear

Prevention of Tool wear:Suggestion from Machine Shop staff ;The following coating should be done



toimprove the tool life and reduces tool wear namely CVDand PVD technology (Chemical Vapour Deposition and Physical Vapour Deposition).

**Figure1.1:Shows Different flank and crater wear of turning tool[10-15].**

## 2.LITERATURESURVEY:-

**[1] Segun Isaac Talabi,1 et.al. [2013]** They investigated that the effects of heat treatment processes on the mechanical properties of as-cast Al-4% Ti alloy for structural applications. Heat treatment processes, namely, annealing, normalizing, quenching, and tempering, are carried out on the alloy samples. The mechanical tests of the heat treated samples are carried out and the results obtained are related to their optical microscopymorphologies.The results show that the heat treatment processes have no significant effect on the tensile strength of the as-cast Al-4% Ti alloy but produce significant effect on the rigidity and strain characteristic of the alloy.With respect to the strain characteristics, significant improvement in the ductility of the samples is recorded in the tempered sample. Thus, for application requiring strength and ductility such as in aerospace industries, this tempered heat treated alloy could be used. In addition, the quenched sample shows significant improvement in hardness.

In this study tensile elongation of aluminum-4% titanium alloy is found to improve significantly with respect to the heat treatment processes. The rigidity of the as-cast sample is affected by the heat treatment processes, with the tempered sample having the lowest Young modulus value. When strength, ductility, and hardness are important, the quenched sample possesses considerable strength (126MPa), elongation (42%), and hardness (60 HV) which make it a better candidate than the as-cast sample with high strength but low ductility. The microstructure shows that the heat treatment programmes affect both the size and distribution of the aluminium-titanium crystals as well as the volume fraction of the secondary phase TiB2 precipitates. However, the heat treatment processes do not significantly improve the alloy tensile strength.

**[2] Jakhale Prashant P et.al [2013]**They investigated that In most of the machining operations the main objective is within certain manufacturing purposes, or achieved through various equipment operations. Therefore, a general optimization of surface roughness is deemed to be necessary for the most of manufacturing industry. In this stage, an attempt has been made to investigate the effect of cutting parameters(cutting speed, feed rate, depth of cut) and insert geometry(CNMG and DNMG type insert) on surface roughness in the high turning of alloy steel. The experiments have been conducted using L9 orthogonal array in a TACCHI lathe CNC turning machine. Turning process carried out on the high alloy steel(280 BHN).The optimum cutting condition was determined by using the statistical methods of signal-to-noise (S/N) ratio and the effect of cutting parameters and insert type on surface roughness were evaluated by the analysis of variance (ANOVA).optimization of surface roughness. The higher value of surface roughness generates on the machining parts and due to rework or scrap results into increase in cost and loss of productivity. Surface roughness is a major factor in modern Computer Numerical Control (CNC) turning industry. Lots of optimization researches for CNC finish turning were either accomplished

**[3]. Shi shaojun et.al [2018].** have investigated that The high speed steels (HSS) have been widely adopted as the most basic material for cutting tools in mechanical processing since it was born. At present, HSS cutting tools still occupy the dominant position of the tool market. Although the development of tipped carbide cutting tools and grinding of cemented carbide cutting tools is very rapid, other varieties of the cutting tools still mainly adopt HSS material. In spite of the differences in the smelting mode of the HSS, the durability of tools is more directly with the chemical composition and reasonable heat processing. Therefore, the choice of the HSS cutting tool material and heat treatment process are very important to ensure the performance of HSS cutting tool.

**[4]. Jiatao Zhang et.al [2019]**They have investigated that High speed steels (HSSs) are widely used materials for tools production, which grab a third part of the global cutting tool market. Heat treatment is an indespensable process for the fabrication of HSS tools. Modifications of carbides and grain size of the matrix are two main aspects for the heat treatment of HSSs. In order to obtain better wear property, hardness or red hardness, modification of carbides attracts more researchers' attention, but grain refinement benefits to the toughness and tool life. Compared with the grain refinement methods used for other steels, such as controlled rolling, available method for grain refinement of HSSs seems deficient. Our previous study provided a new method to produce ultrafine grained M2 steel, but the effect of the starting structures on the grain refinement potential of electropulsing treatment (EPT) was not involved. Results in this work show that the grain size can both be refined or even ultra-refined by EPT, whatever the difference in the starting structures. But the austenite transformation of the matrix was completed at lower peak temperature when using starting tempered structure. And the pre-tempered M2 samples have higher hardness than that obtained after heat treatment or EPT when using the starting annealed structures.

**[5] Xuchao et.al [2020]** They have investigated that To achieve a better performance, a novel cutting tool has been developed with micro-grooves on its rake face. Such tools have great potential in manufacturing. However, micro-grooves of improper directions and shapes may adversely affect cutting tools. This paper investigates the performance of newly designed cemented carbide (WC/Co) cutting tools with micro-grooves on the rake face in the machining of titanium alloy Ti-6A1-4V using finite element (FEM) simulation. The objectives are to explore the influence of the directions and geometrical shapes of micro-grooves on the performance of cutting tools in dry turning of the titanium alloy and to compare it with conventional cutting tools. Specifically, the following aspects are compared: cutting temperature, cutting force, chip morphology, and stress distribution. It is found that these micro-grooved cutting tools generate lower cutting force and cutting temperature and increase chip curling. The maximum reduction of cutting force and cutting temperature occurs under different machining parameters. Compared with linear micro-grooves, the curvilinear micro-grooves diffuse the tool stress and weaken the stress concentration on cutting edges. In addition, the secondary cutting phenomenon of micro-grooved tools is analyzed, which can be effectively alleviated by reducing the width of micro-grooves and setting a reasonable radius of the secondary cutting edge.

**[6]. Chiara Soffritti et.al [2020].**have investigated that Towards the end of the last century, vacuum heat treatment of high speed steels was increasingly used in the fabrication of precision cutting tools. This study investigates the influence of vacuum heat treatments at different pressures of quenching gas on the microstructure and mechanical properties of taps made of M35 high speed steel. Taps were characterized by optical microscopy, scanning electron microscopy with energy dispersive spectroscopy, X-ray diffraction, apparent grain size and Vickers hardness measurements, and scratch tests. Failure analysis after tapping tests was also performed to determine the main fracture mechanisms. For all taps, the results showed that microstructures and the values of characteristics of secondary carbides, retained austenite, apparent grain size and Vickers hardness were comparable to previously reported ones for vacuum heat treated high speed steels. For taps vacuum heat treated at six bar, the highest plane strain fracture toughness was due to a higher content of finer small secondary carbides. In contrast, the lowest plane strain fracture toughness of taps vacuum heat treated at eight bar may be due to an excessive amount of finer small secondary carbides, which may provide a preferential path for crack propagation. Finally, the predominant fracture mechanism of taps was quasi-cleavage.

**[7] Daxun Yueet.al [2021]**They investigated that the process of metal cutting, the cutting performance of cutting tools varies with different parameter combinations, so the results of the performance indicators studied are also different. So in order to achieve the best performance indicator it is necessary to get the best parameter matching combination. In addition, in the process of metal cutting, the value of the performance index is different at each stage of the processing process. In order to consider the cutting process more comprehensively, it is necessary to use a comprehensive evaluation method that can evaluate the dynamic process of performance indicators. This paper uses a dynamic evaluation method that considers the dynamic change of performance indicators in each stage of the cutting process to comprehensively evaluate the tool parameters and cutting parameters at each level. For the purpose of high processing efficiency and long tool life, tool wear rate and material removal rate are used as performance indicators. In the case of specified rake angle, cutting speed and cutting width, titanium alloy is studied by end milling cutter side milling. The tool parameters and cutting parameters in milling process are optimized by using a dynamic comprehensive evaluation method based on gain horizontal excitation. Finally, the parameter matching combination that can make the performance indicator reach the best is obtained. The results show that when the rake angle is 8◦ , the cutting speed is 37.68 m/min, and the cutting width is 0.2 mm, the tool wear rate and material removal rate are the best when the clearance angle is 9◦ , the helix angle is 30◦ , the feed per tooth is 0.15 mm/z, and the cutting depth is 2.5 mm.

**[8] Nursel Altan O¨ zbek et.al[2021]** have investigated that Good surface roughness and topography are of great importance in plastic mold materials. This study investigated the effects of cutting parameters on cutting temperature, vibration (g), surface roughness (Ra), and noise (N) in the turning of AISI P20 die steel using coated tungsten carbide cutting tools. Experiments were carried out using the Taguchi L18 experimental design with cutting tools with two different types of coatings (CVD and PVD), three different cutting speeds (100, 150, and 200 m/min), three different feed rates (0.1, 0.15, and 0.2 mm/rev), and a constant cutting depth (1 mm). As a result of the study, the PVD-coated tools exhibited a higher performance for all outputs (cutting temperature, g, Ra, and N). It was observed that the vibration and surface roughness were proportional, vibration was mostly affected by feed rate, and increasing cutting speed and feed rate also increased the temperature and noise in the cutting zone. According to ANOVA results, the most effective parameter on surface roughness was feed rate (97.24%), the most effective parameter on vibration was cutting tool type (57.34%), and finally, the most effective parameter on noise was feed rate (50.37%)

**[9] N. J. Rathod et.al [2022]**They investigated that the study used the Taguchi technique to optimise the parameters for the AISI 304 stainless steel material in an effort to increase tool life, shorten production times, and lessen surface roughness. For the Taguchi process, ANOVA, Machining criteria are used that take tool life, surface roughness, and production time into account. These criteria include feed rate, cutting speed, and depth of cut (ANOVA). The statistical components of the experiment are prepared using Taguchi, GRA, and PCA. Tool life, Surface Roughness, and production time factors are maximised by the trials' findings, which were then used to determine S/N ratios. Then, surface roughness, minimal production time, and overall tool life are predicted using confirmation tests. The results show that cutting speed significantly affects tool life, cutting speed significantly affects production time, and cutting depth significantly affects surface roughness. For maximum tool life, it was discovered that a feed rate of 0.10 mm/rev, a depth of cut of 0.35 mm, and a cutting speed of 500 m/min were the ideal settings. The ideal circumstances for reducing production time include a cutting speed of 500 m/min, a feed rate of 0.20 mm/rev, and a depth of cut of 0.45 mm. The ideal circumstances for producing the lowest surface roughness are a cutting speed of 300 m/min, a feed rate of 0.15 mm/rev, and a depth of cut of 0.45 mm.

**3.Selection of materials and methodology:-**In this the SS316, SS304, SS410, SS440C, HSS and Ti-6Al-4V six different alloy materials are selected to conduct the Optimisation parameters with Tool Wear and Tool Life

Tool wear test results of Six different materials as indicated in the table 5.14 to 5.16 and consolidated values are shown in table.5.16.Optimization of parameters are considered in this research work.

The following are the Optimization of parameters has been used in this research work.

In machining, three process parameters are considered.

(i) **cutting speed or cutting velocity, (ii) feed rate and (iii) depth of cut**.

**Table.3.1.Metal cutting parameters on lathe**

| Sno | Machine Parameters | Job Parameters |
|---|---|---|
| 1 | Feed | Length of cut |
| 2 | Spindle speed | Job Complexity |
| 3 | Machine/Spindle power | Material of Job |
| 4 | Rigidity of Machine | Depth of cut |

**Table.3.2 Example of cutting tool parameters for HSS tool**

| Sno | **cutting tool parameters** | **Tool material:-HSS tool** |
|---|---|---|
| 1 | Tool Diameter | 08 mm |
| 2 | Rake angle($0^0$) | $12^0$ |
| 3 | Tool Helix Angle or flute angle | $30^0$ |
| 4 | Tool Clearence angle | 3° to 10° |
| 5 | No of Flutes | 04 |
| 6 | Nose radius | 0.5 mm. |

**cutting tool parameters for HSS tool :-Back rake angle = 0°, Side rake angle = 7°**, End relief angle = 7°, Side relief angle = 7°, End cutting edge angle = 15°, Side cutting edge angle = 15°, and Nose radius = 0.5 mm.

**Table.3.3.Example of Process parameters for HSS tool**

| Sno | Process Parameters | Material used:-Mild steel |
|---|---|---|
| 1 | Depth of Cut | 1 or 5 or 10 *mm* |
| 2 | Length of Cut | 0.4 or 0.5mm |
| 3 | Feed | 0.4 mm/rev |

| | | |
|---|---|---|
| 4 | Cutting Speed | 45 rpm |
| 5 | Coefficient of Friction | 0.3µ |

similarly the Optimization of parameters of the other tool materials are to be considered.

## **4.Experiment and methods:- Lathe Tool Dynamometer**

Most applications require assessing through one force may be inverse/dapper headings.IEICOS Electronic Dynamometer checks these forces. Different things have been considered in assembling these dynamometers like particular territories o f intensity,immovability required and minimization of effect of intensity from one route to the other.AbilitytowithstandaccidentalforceistherulefeatureoftheDynamometers.Overall,theDynamometerisastructurefitforassessingtheidealforcewhilesupportingcoincidental force comparatively present. IEICOS specific basic model agents uses latest forteof development in force assessment using significantly stable strain measure system. Thestrainmeasuresareusedtofreeaugmentationdistinguishesthenormallyinverse/dapperforces.The machine gadget dynamometer has been arranged with the objective, that it isclearlyfixedontothemechanicalassemblypostusingtheopeninggaveondynamometer. This hasbeen given yield connection for two/three powers inusuallycontrarydirections. i.e.,Horizontal/Vertical. The strain checks are used so the free expansion distinguishes the normally inverse/exactforces

### *4.1.MachineToolDynamometertoMeasureCuttingForce*

Machine Tool Dynamometer is a cutting force assessing instrument used to measure thecuttingforcesproceedingthegadgettipontheLatheMachine.Thesensorisarrangedsoit might be rigidly mounted on the gadget post, and the cutting gadget can be fixed to thesensor direct. This segment will help with assessing the forces absolutely without loss ofthe force. The sensor is made of single part with three one of a kind Wheatstone straincheck associate. Game plan is made to fix 1/2" size Tool bit at the front side of the sensor.The gadget tip of the device contact can be squash to any point required. Forces in X ,Y and Zheadingwillbeexhibitedonlyin threeDigitalIndicatorsSupplied.

**Figure4.1:LatheTool Dynamometer to Measure Cutting Force**

Specification:Forces:XYDirection.:Rangeofforces :0-99kgfBridgeResistance :350 ohms
typicalBridgeVoltage :12voltsmaximum:Linearity :±1%offullscale. Accuracy : ±1%
Tool post dia : Maximum 25 mm.

IEICOS digital multi component force indicator for two/three forces model Instrumentincludestwo/threefreeadvanced(3digit)showunitsadjustedtoshowpowersdirectlyutilizing two/three-part deviceDynamometer.

ThisInstrumentinvolvesIndependentDCexcitationsupplyfortakingcareofstraincheck scaffolds and sign preparing framework to measure and processes individual powersignalsfordirect independent presentation,instrumentsworks on20V, c/smains.

### 4.3FunctionalDetails

Refer the front panel of the Instrument. Function selector is provided to select various functions for adjustment like the one/two/three READ CAL be provided. The meter is calibrated for specified range of sensor transducers capacity and recorderoutputisprovidedforrecording purposes. The instruments comprises of highly stable integrated circuit powersuppliesforexcitationsensorandoperationoftheinstrument,DCAmplifierandindicatingmetersensorstraingaugeBridgeexcitationvoltageisobtainedfromastabilized DC power supply from AC mains.

The inherent unbalance in bridge balancingnet work, comprising of a potentiometer BAL across the bridge supply the variable armbeing connected to one end of the input amplifier through a resistor. The amplifier is anominal gain of 100 with frequency response up to 10 kHz. The amplifier output is fed toa calibrated rectangular panel meter or recorder terminals.The instruments has internalcalibrations facilities and meter sensitivity can be adjusted by CAL operates on +5-0-5volts DC power supply and digital meter works on 5 volt supply both load cell excitationsupplyand 12 amplifierpower supplyarederivedfrom 230 volts ACmains.

## 4.4DigitalPanelMeter

Computerized board meter is conservative 3.5 digit meter, which estimates pressure esteems. Theinstruments are thusly with the most recent pattern of advanced presentation of cycle boundarycomplexexactanddependable.Theinstrumentutilizesmostrecentinnovationandbroadutilization of LSI CMOS chips. Peruse out is brilliant READ LED type show frameworks whichis consider as quite possibly the most solid framework read out with long haul inconvenience freeactivity

.

**Figure4.2:Digital panel meter**

### Operation of Lathe Tool Dynamometer with Multi Component Force Indicator

1. Install the Lathe dynamometer on the tool post using the central hole provided onthe dynamometer. Insure that, the object being turned to smooth surface, the tooltipis exactly at control tight.

**Figure4.3:Tool post**

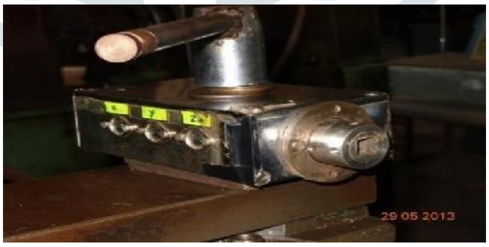


**Figure4.4:Inputcablesockets**

2. Plugthemain cord to the230 volt 50 Hzmain supply.3.Connect the input cable to respectiveX,Y,Zaxisoutputsocketofthedynamometerandconnectanotherendofthecabletofrontpanelofth einstrumentto respectiveinput terminals.
3. SetthefunctionREADCALLswitchatREAD 4.Switchon theinstruments bykeeping powerof switchat ON

4. Adjust the “BAL” potentiometer switch So that the meter reads zero.Allow theinstruments to warm up for 15 minute read and set Just the “BAL” potentiometer for zeroifit is change.

5. Turn the function switch to CAL.Adjust the “CAL” potentiometer until reads fullscale.This operation is to be conducted when the dynamometer does not have any applied load.

6. Repeattheoperation4, 5,6 forother axisalso.

8.Turn back the function switch to “READ” position in all axes, now the instrumentis calibrated to read force value up to calibrated capacity of dynamometer inrespective axis by manual axisselector. Oneafterthe other.

9.Ifrecordingoscillographoroscilloscopeistobeused,connectthemtothe“Recorder”output terminals.

Figure4.5:Tool Dynamometer set up with lathe machine

Figure4.6:Aluminumand mildsteel Specimens at lathework

Figure4.7:AluminumandmildsteelSpecimensafterlatheworkdone

**Figure4.8:Mildsteel Chips collected after tool wear test**

**Figure4.9:Aluminium Chips collected after tool wear test**

**5. Results and discussion :-Observations were found on** 5.1.Tool Wear Calculation and flank wear for S1(SS316) material Speed=71 rpm,Feed=0.4mm/rev,Depthofcut=1.0 mmWork piecematerial =Aluminium

**Table 5.1:flankwear for S1(SS316) material**

| Timeelapsed(in min.) | Flank wear(in mm) |
|---|---|
| 3 | 0.5 |
| 6 | 0.65 |
| 9 | 0.75 |
| 12 | 1.06 |
| 15 | 1.75 |
| 17.5 | 1.9 |
| Wearrate | $1.08\times10^{-4}$m/min |

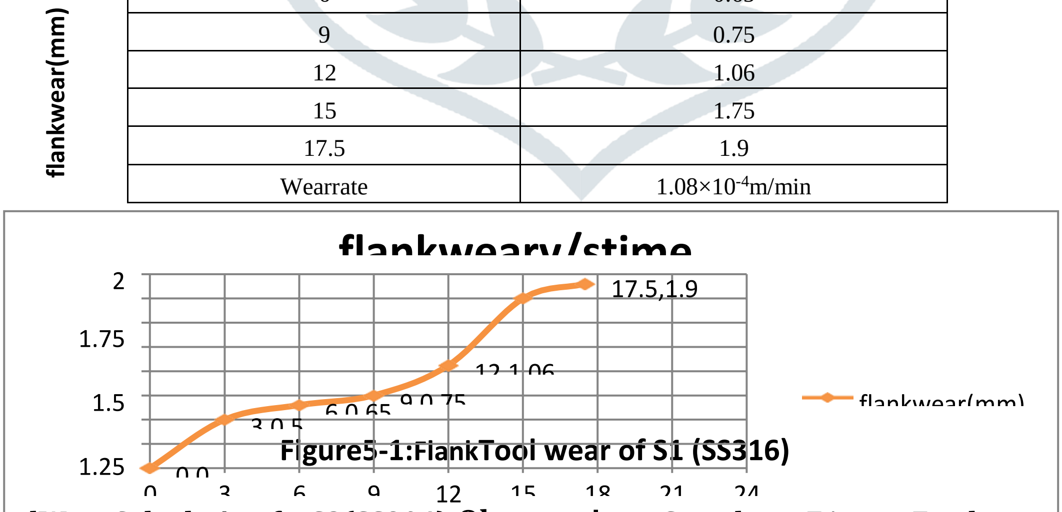


Figure5-1:FlankTool wear of S1 (SS316)

**5.2ToolWearCalculation forS2(SS304):Observations:Speed =71 rpm:Feed =0.4mm/rev:Depthofcut =1.0 mmWorkpiecematerial =Aluminium**

| Timeelapsed(in min.) | Flank wear(in mm) |
|---|---|
| 3 | 0.6 |
| 6 | 0.75 |
| 9 | 0.81 |
| 12 | 1.15 |

| | |
|---|---|
| 15 | 1.90 |
| 17.5 | 2.01 |
| Wear rate | $1.15\times10^{-4}$m/min |

**Table5.2:Toolwear for S2(SS304) material**

**5.3.ToolWearCalculation forS3 (SS410):<u>Observations:</u>Speed =71 rpm:Feed =0.4mm/rev:Depthofcut =1.0 mmWorkpiecematerial =Aluminium**

**Table5.3:Toolwear for S3(SS410) material**

| Time elapsed(in min.) | Flank wear(in mm) |
|---|---|
| 3 | 0.46 |
| 6 | 0.85 |
| 9 | 1.10 |
| 12 | 1.6 |
| 15 | 1.98 |
| 17.5 | 2.4 |
| Wearrate | $1.45\times10^{-4}$m/min |

**5.4ToolWear Calculation forS4(SS440C):<u>Observations:</u>Speed = 71 rpm:Feed= 0.4mm/rev:Depthofcut=1.0 mm Workpiece material=MildSteel Table5.4:Toolwear for S4(SS440C) material**

| Timeelapsed(Inmin.) | Flank wear(in mm) |
|---|---|
| 3 | 0.43 |
| 6 | 0.82 |
| 9 | 1.0 |
| 12 | 1.5 |
| 14 | 1.9 |
| Wearrate | $1.35\times10^{-4}$m/min |

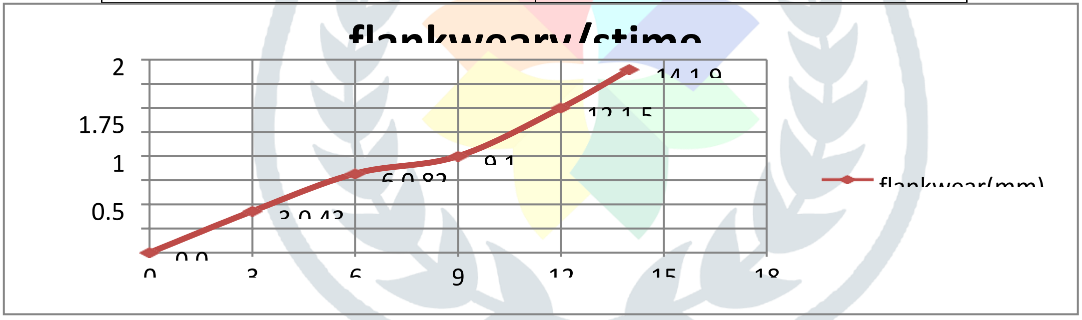


**Figure5.2:Flank ToolwearofSS440C(S4)**

**5.5ToolWearCalculationforS5 (HSS):-<u>Observations:</u>Speed =71 rpm:Feed =0.4mm/rev:Depthofcut =1.0 mmWorkpiecematerial =MildSteel:Table5.5:ToolwearforS5 (HSS)material**

| Timeelapsed(in min.) | Flank wear(in mm) |
|---|---|
| 3 | 0.6 |
| 6 | 0.8 |
| 9 | 0.88 |
| 12 | 1.3 |
| 15 | 1.9 |
| Wearrate | $1.26\times10^{-4}$m/min |

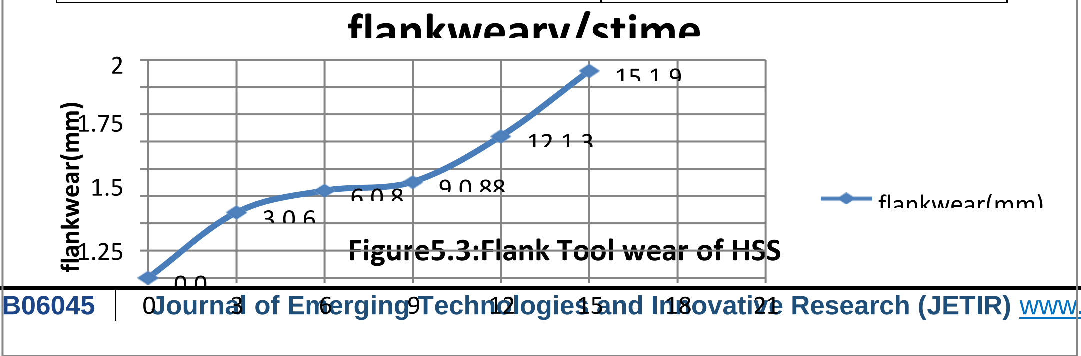


**Figure5.3:Flank Tool wear of HSS**

### 5.6ToolWearCalculation forTitaniumAlloyS6(TI-6AL-4V):<u>Observations:</u>Speed=71 rpm

Feed=0.4mm/rev:Depthofcut=1.0 mmWorkpiecematerial=Aluminium **Table5.6:Tool WearforS6 (Ti-6Al-4V)material**

| Timeelapsed(in min.) | Flank wear(in mm) |
|---|---|
| 3 | 0.3 |
| 6 | 0.55 |
| 9 | 0.66 |
| 12 | 0.7 |
| 15 | 0.79 |
| 18 | 1.0 |
| 21 | 1.4 |
| 24 | 1.6 |
| 27.33 | 1.9 |
| Wearrate | 1.35×$10^{-4}$m/min |

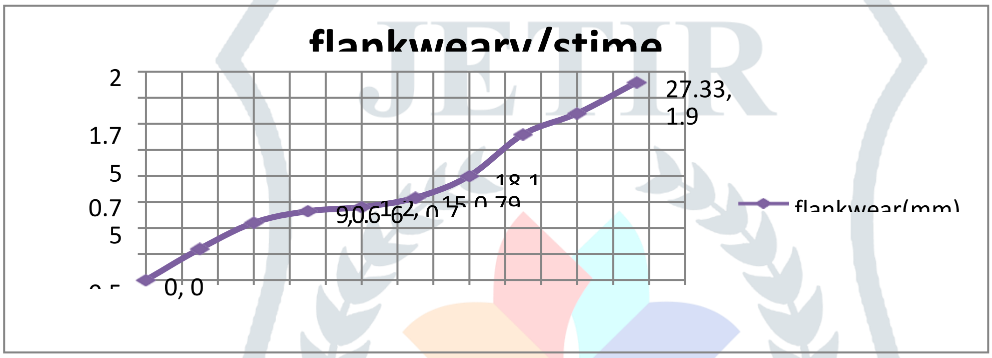


Figure5.4:Flank Tool wear of S6 (titanium alloy-grade5)

**Table 5.7: Table shows Consolidated Tool Wear value for specimens S1, S2, S3,S4,S5andS6 Material**

| Sl. No. | Naming ofSpecimens /CuttingTools /Composites/Alloys | Toolmaterial | Workpiecematerial | Max. Timeelapsed (in min.) | Flankwear(in mm) | Wearrate m/min |
|---|---|---|---|---|---|---|
| 1 | S1 | SS316 | Aluminium | 3 | 0.5 | $1.08\times10^{-4}$m/min |
| | | | | 6 | 0.65 | |
| | | | | 9 | 0.75 | |
| | | | | 12 | 1.06 | |
| | | | | 15 | 1.75 | |
| | | | | 17.5 | 1.9 | |
| 2 | S2 | SS304 | Aluminium | 3 | 0.6 | $1.15\times10^{-4}$m/min |
| | | | | 6 | 0.75 | |
| | | | | 9 | 0.81 | |
| | | | | 12 | 1.15 | |
| | | | | 15 | 1.90 | |
| | | | | 17.5 | 2.01 | |
| 3 | S3 | SS410 | Aluminium | 3 | 0.46 | $1.45\times10^{-4}$m/min |
| | | | | 6 | 0.85 | |
| | | | | 9 | 1.10 | |
| | | | | 12 | 1.6 | |
| | | | | 15 | 1.98 | |
| | | | | 17.5 | 2.4 | |
| 4 | S4 | SS440C | MildSteel | 3 | 0.43 | $1.35\times10^{-4}$m/min |
| | | | | 6 | 0.82 | |
| | | | | 9 | 1.0 | |
| | | | | 12 | 1.5 | |
| | | | | 14 | 1.9 | |
| 5 | S5 | HSS (Highspeedsteel) | MildSteel | 3 | 0.6 | $1.26\times10^{-4}$m/min |
| | | | | 6 | 0.8 | |
| | | | | 9 | 0.88 | |
| | | | | 12 | 1.3 | |
| | | | | 15 | 1.9 | |
| 6 | S6 | TitaniumAlloy( grade 5)<br>Ti-6Al-4V | Aluminium | 3 | 0.3 | $1.35\times10^{-4}$ m/min |
| | | | | 6 | 0.55 | |
| | | | | 9 | 0.66 | |
| | | | | 12 | 0.7 | |
| | | | | 15 | 0.79 | |
| | | | | 18 | 1.0 | |
| | | | | 21 | 1.4 | |
| | | | | 24 | 1.6 | |
| | | | | 27.33 | 1.9 | |

**5.2.ToolLife:-Tool life test results of Six different materials as indicated with in the table 5.8,5.9, 5.10,5.11,5.12,5.13 and consolidated values areshown in table 5.18**

**ToolLife Calculation:-Tool life of S1 (SS316):Workpiece=Aluminium**

**Table5.8:Tool life of S1 (SS316)tool**

| Speed(rpm) | Feed(mm/rev) | Depthofcut(mm) | Tool life (min) |
|---|---|---|---|
| 45 | 0.5 | 1.0 | 22 |
| 71 | 0.5 | 1.0 | 17.5 |
| 112 | 0.5 | 1.0 | 14 |

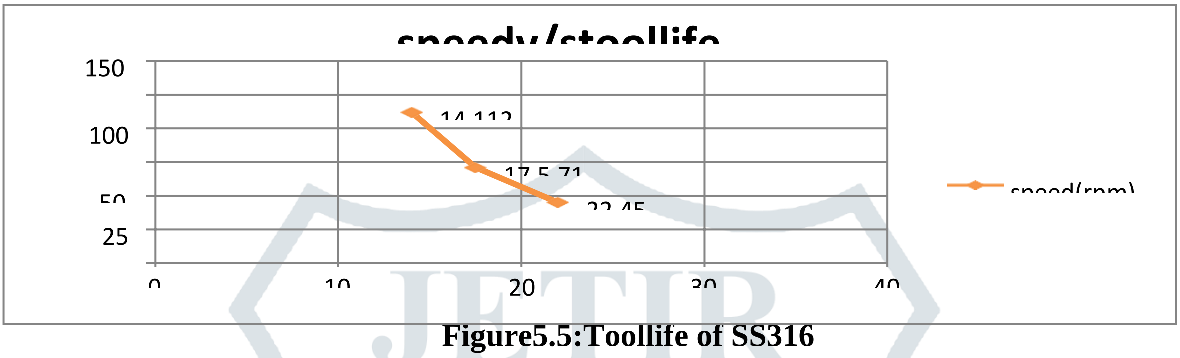


**Figure5.5:Toollife of SS316**

**5.2.1Tool lifeof S2 (SS304):Workpiece=Aluminium:Table5.9:Tool lifeof S2 (SS304)tool**

| Speed(rpm) | Feed(mm/rev) | Depthofcut(mm) | Tool life (min) |
|---|---|---|---|
| 45 | 0.5 | 1.0 | 23 |
| 71 | 0.5 | 1.0 | 18.5 |
| 112 | 0.5 | 1.0 | 15 |

**5.2.2Tool lifeof S3 (SS410):**Workpiece=Mildsteel:**Table5.10:Tool lifeof S3 (SS410)tool**

| Speed(rpm) | Feed(mm/rev) | Depthofcut(mm) | Tool life (min) |
|---|---|---|---|
| 45 | 0.5 | 1.0 | 22 |
| 71 | 0.5 | 1.0 | 16 |
| 112 | 0.5 | 1.0 | 9.87 |

**5.2.3.Tool lifeof S4 (SS440C):**Workpiece=Mildsteel:**Table5.11:Tool lifeof S4 (SS440C)tool**

| Speed(rpm) | Feed(mm/rev) | Depthofcut(mm) | Toollife(min.) |
|---|---|---|---|
| 45 | 0.4 | 1.0 | 20 |
| 71 | 0.4 | 1.0 | 14 |
| 112 | 0.4 | 1.0 | 6.67 |

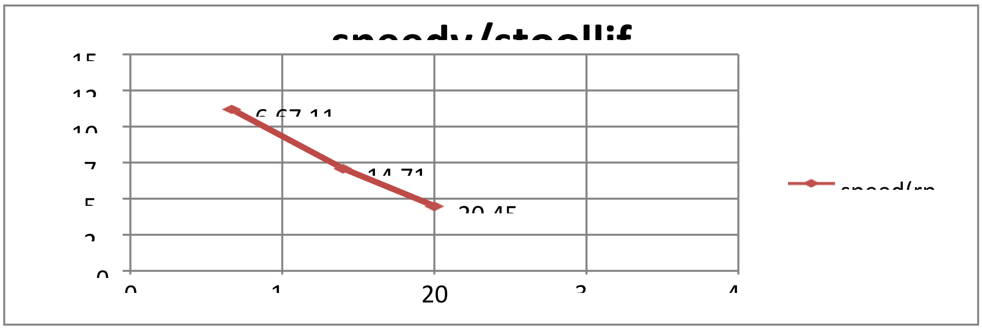


Figure5-6:Tool life of S4 (SS440C)

### 5.2.4.Toollifeof S5 HSS:Workpiece=Mild steel:Table5.12:Tool lifeof S5 (HSS tool)

| Speed(rpm) | Feed(mm/rev) | Depthofcut(mm) | Tool life (min) |
|---|---|---|---|
| 45 | 0.4 | 1.0 | 21 |
| 71 | 0.4 | 1.0 | 15 |
| 112 | 0.4 | 1.0 | 6 |

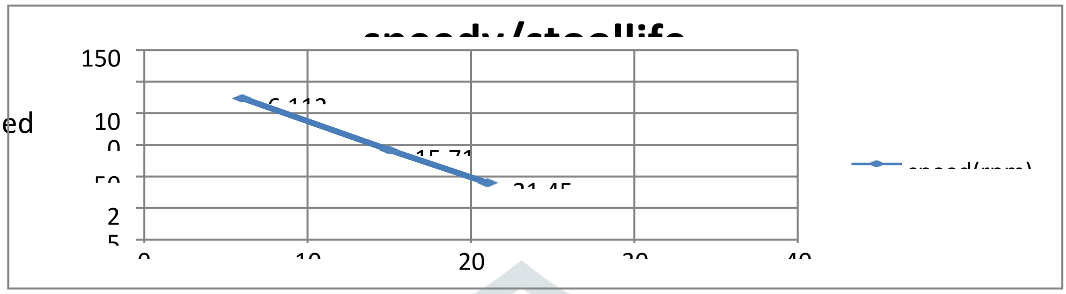


Figure5-7:Tool lifeofS5 (HSS)

### 5.2.5.Tool life of Titanium alloy gradeS6 (Ti-6Al-4V):Workpiece=Aluminium: Table 5.13:Tool life of S6 (Ti-6Al-4V) tool

| Speed(rpm) | Feed(mm/rev) | Depthofcut(mm) | Tool life (min) |
|---|---|---|---|
| 45 | 0.5 | 1.0 | 31.8 |
| 71 | 0.5 | 1.0 | 27 |
| 112 | 0.5 | 1.0 | 19 |

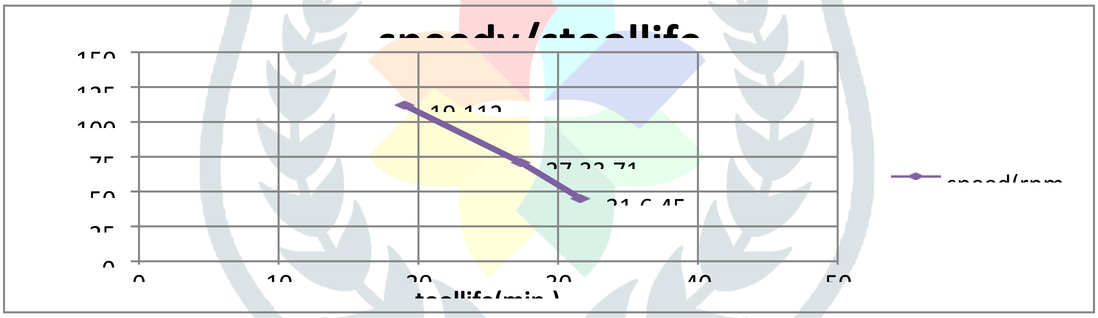


Figure5-8:Toollife of S6 (titanium alloy-grade5)

Table5.14:Consolidated Values of Tool life of S1,S2,S3,S4,S5 and S6specimens

| Sl.No. | Namingofcomposite | Workpiece | Speed(rpm) | Feed(mm/rev) | Depthofcut(mm) | Toollife (min) |
|---|---|---|---|---|---|---|
| 01 | S1(SS316) | Aluminium | 45 | 0.5 | 1.0 | 22 |
| | | | 71 | 0.5 | 1.0 | 17.5 |
| | | | 112 | 0.5 | 1.0 | 14 |
| 02 | S2(SS304) | Aluminium | 45 | 0.5 | 1.0 | 23 |
| | | | 71 | 0.5 | 1.0 | 18.5 |
| | | | 112 | 0.5 | 1.0 | 15 |
| 03 | S3(SS 410) | Mildsteel | 45 | 0.5 | 1.0 | 22 |
| | | | 71 | 0.5 | 1.0 | 16 |
| | | | 112 | 0.5 | 1.0 | 9.87 |
| 04 | S4(SS4 40C) | Mildsteel | 45 | 0.4 | 1.0 | 20 |
| | | | 71 | 0.4 | 1.0 | 14 |
| | | | 112 | 0.4 | 1.0 | 6.67 |
| | | | 45 | 0.4 | 1.0 | 21 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 05 | S5(HSS) | Mildsteel | 71 | 0.4 | 1.0 | 15 |
| | | | 112 | 0.4 | 1.0 | 6 |
| 06 | S6 (titanium alloy - grade5) | Aluminium | 45 | 0.5 | 1.0 | 31.8 |
| | | | 71 | 0.5 | 1.0 | 27 |
| | | | 112 | 0.5 | 1.0 | 19 |

**DISCUSSIONS:**The tool life of S1,S2,S3,S4,S4,S5 and S6 cutting tools decreases with increase in cutting speed as shown in the graphs. Good surface finish was obtained for aluminium and MS workpiece when machined with respective cutting tools at high cutting speeds which slightly reduces tool life. Due to hardening process carried out on respective tools, they can withstand mechanical vibrations at highspeeds. Heat generated between tool-workpiece interface results inchange in grainstructure of the tool tip zone. At high temperature the material removed gets fused to the tool tip and thus results in poor surface finish. In order to remove the heat generated at tool tip the cutting fluids are used. By providing proper coatings the heat generated can be reduced and thus the tool life canbe improved.

**Table5-15:Consolidated Values of Toollife when the Flankangle changes for theS1,S2, S3, S4,S5 and S6 specimens**

| Sl. No. | Naming ofcomposite | Workpiece | Speed(rpm) | Feed(mm/rev) | Depthofcut(mm) | Changein Flankangle(5°) | Toollife (min) |
|---|---|---|---|---|---|---|---|
| 01 | S1(SS316) | Aluminium | 45 | 0.5 | 1.0 | 5° | 22 |
| | | | 71 | 0.5 | 1.0 | 5° | 17.5 |
| | | | 112 | 0.5 | 1.0 | 5° | 14 |
| 02 | S2(SS304) | Aluminium | 45 | 0.5 | 1.0 | 5° | 23 |
| | | | 71 | 0.5 | 1.0 | 5° | 18.5 |
| | | | 112 | 0.5 | 1.0 | 5° | 15 |
| 03 | S3(SS 410) | Mildsteel | 45 | 0.5 | 1.0 | 5° | 22 |
| | | | 71 | 0.5 | 1.0 | 5° | 16 |
| | | | 112 | 0.5 | 1.0 | 5° | 9.87 |
| 04 | S4(SS440C) | Mildsteel | 45 | 0.4 | 1.0 | 5° | 20 |
| | | | 71 | 0.4 | 1.0 | 5° | 14 |
| | | | 112 | 0.4 | 1.0 | 5° | 6.67 |
| 05 | S5(HSS) | Mildsteel | 45 | 0.4 | 1.0 | 5° | 21 |
| | | | 71 | 0.4 | 1.0 | 5° | 15 |
| | | | 112 | 0.4 | 1.0 | 5° | 6 |
| 06 | S6 (titaniumalloy - grade5) | Aluminium | 45 | 0.5 | 1.0 | 5° | 31.8 |
| | | | 71 | 0.5 | 1.0 | 5° | 27 |
| | | | 112 | 0.5 | 1.0 | 5° | 19 |

**Table 5-16: Table shows Consolidated Tool Wear value when flank angle changed for specimens S1, S2, S3,S4, S5 andS6 Material**

| Sl. No. | Namingof Specimens | Toolmaterial | Workpiecematerial | Max.Timeelapsed(in min.) | FlankAnglechanged | Flankwear(inmm) | Wearratem/min |
|---|---|---|---|---|---|---|---|
| 1 | S1 | SS316 | Aluminium | 3 | $5^{o}$ | 0.5 | $1.08\times10^{-4}$m/min |
| | | | | 6 | $5^{o}$ | 0.65 | |
| | | | | 9 | $5^{o}$ | 0.75 | |
| | | | | 12 | $5^{o}$ | 1.06 | |
| | | | | 15 | $5^{o}$ | 1.75 | |
| | | | | 17.5 | $5^{o}$ | 1.9 | |
| 2 | S2 | SS304 | Aluminium | 3 | $5^{o}$ | 0.6 | $1.15\times10^{-4}$m/min |
| | | | | 6 | $5^{o}$ | 0.75 | |
| | | | | 9 | $5^{o}$ | 0.81 | |
| | | | | 12 | $5^{o}$ | 1.15 | |
| | | | | 15 | $5^{o}$ | 1.90 | |
| | | | | 17.5 | $5^{o}$ | 2.01 | |
| 3 | S3 | SS410 | Aluminium | 3 | $5^{o}$ | 0.46 | $1.45\times10^{-4}$m/min |
| | | | | 6 | $5^{o}$ | 0.85 | |
| | | | | 9 | $5^{o}$ | 1.10 | |
| | | | | 12 | $5^{o}$ | 1.6 | |
| | | | | 15 | $5^{o}$ | 1.98 | |
| | | | | 17.5 | $5^{o}$ | 2.4 | |
| 4 | S4 | SS440C | MildSteel | 3 | $5^{o}$ | 0.43 | $1.35\times10^{-4}$m/min |
| | | | | 6 | $5^{o}$ | 0.82 | |
| | | | | 9 | $5^{o}$ | 1.0 | |
| | | | | 12 | $5^{o}$ | 1.5 | |
| | | | | 14 | $5^{o}$ | 1.9 | |
| 5 | S5 | HSS (Highspeedsteel) | MildSteel | 3 | $5^{o}$ | 0.6 | $1.26\times10^{-4}$m/min |
| | | | | 6 | $5^{o}$ | 0.8 | |
| | | | | 9 | $5^{o}$ | 0.88 | |
| | | | | 12 | $5^{o}$ | 1.3 | |
| | | | | 15 | $5^{o}$ | 1.9 | |
| 6 | S6 | Titanium<br>Alloy(grade5) Ti-6Al-4V | Aluminium | 3 | $5^{o}$ | 0.3 | $1.35\times10^{-4}$m/min |
| | | | | 6 | $5^{o}$ | 0.55 | |
| | | | | 9 | $5^{o}$ | 0.66 | |
| | | | | 12 | $5^{o}$ | 0.7 | |
| | | | | 15 | $5^{o}$ | 0.79 | |
| | | | | 18 | $5^{o}$ | 1.0 | |
| | | | | 21 | $5^{o}$ | 1.4 | |
| | | | | 24 | $5^{o}$ | 1.6 | |
| | | | | 27.33 | $5^{o}$ | 1.9 | |

**Conclusion:-**Discussions of Tool life and wear rate by changing the rake angle or flank angle of the different specimens S1, S2, S3, S4, S4, S5 and S6.The tool life of the S1, S2, S3,S4, S4, S5 and S6 selected cutting tools when flank angle changed to $5^0$ is as shownintable5.15:Consolidated Values of Tool life when the Flank angle changes for the S1,S2, S3, S4, S5, and S6 Specimens table 5.15 and table 5.16. It is found that tool wear rate of HSS andS6 (Titaniumalloygrade5) is very less when compare to other specimens S1,S2, S3 and S4 tool life decreases with increase in speed.

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