Key Improvements In Machining Of Ti6al4v Alloy: A Review

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Abstract : Now a days the use of ti-6al-4v alloy is high in demand in many industries like aero space ,bio medical automobile, space, military etc. the production rates in the industries are not sufficient because the machiniability of ti-6al-4v is the main problem , there are several cutting tools available for metal cutting operations still there is a gap in finding the proper cutting tool material for machining of ti-6al-4v .because the properties of titanium like high heat resistant ,low thermal conductivity ,low weight ratio ,less corrosiveness , and more many properties attracting the industrialists to use titanium as their material for their products ,many researchers done the research on machininbility of ti-6al-4v by using different tool materials .but as for my literature survey there is still lot of scope is available ,to find better cutting tool with techniques for machining ti-6al-4v .in this paper iam discussing the work done by various researchers on ti-6al-4v alloy with different techniques .

Key words : TI-6AL-4V, machining, cutting tools, techniques, cooling techniques,.

Introduction : The applications of titanium alloys have been widely used in aerospace Industry, biomedical and chemical industry owing to the strength-to-weight ratio and excellent corrosion resistance at high temperature.[1.] the study of on machine ability of titanium alloy has been increasing over the years high speed machining is gaining more significant as it can produce stress free and high quality surface. [2.] The machining technique of titanium alloy is impeded basically due to their chemical reactivity and low thermal conductivity.[3.] The low thermal conductivity of these materials does not allow the heat generated during machining to dissipate quickly from the tool edge. many engineers are of the opinion that an effective method for lengthening the life of a tool used to machine a titanium alloy is the maintenance of a sufficient low cutting temperature, Recently various cooling-lubrication techniques have been developed to improve the machine ability of titanium alloys, the HPS increases tool life by almost three times in comparison to conditional cooling. [7.] In the recent years lot of research has been carried out to avoid the use of cutting fluids in machining. [10.] In recent year's high speed machining has got special attention due to the fact of higher material removal rate (MRR) better part quality and relatively low manufacturing costs. Achieving higher MRR in machining of titanium (Ti) alloys there are several cutting tool used.[12.] In machining of titanium alloy with HSS and cemented carbide tools were identified as excessive cratering and deformation at the more. They change to diffusion-dissolution with the use of composite tool WBN-CBN. which has high fraction toughness and hardness.[16.] Titanium alloy machining performance can be raised by PVD&CVD coated and uncoated carbide inserts low cost coated carbide tools are seen as a possible replacement to uncoated carbide inserts for machining titanium alloy.[24.] PCBN and PCD tools have been used in recent years for farming titanium alloy and PCD tools are reported to perform better.[25.] PVD-Ti A/N-coated carbide tools are used frequently in metal cutting process due to their high hardness, wear resistance and chemical stability they offer higher benefits in terms of tool life and machining performance compared to other coated cutting tools variants.[26.] Evaluation of recently developed cutting tools material PCD inserts, CBN inserts when machining titanium bars -Ti bal 4v at high speed machining conditions.

Literature Reviews

Titanium Alloy :- Titanium alloys divided into four main group's according to their basic matellergical charaterstics α alloy's , near α alloy's , α-β alloy's and β alloy's but in all four different titanium Alloy's Now a day's α-β alloy's are mostly used for commercial purpose . TI-6AL-4V is the α-β alloy's it is have applications in aerospace , biomedical space , automobile industry etc.

Material Properties Of The TI-6AL-4V Alloy

Hardness (HRC)	36
Density (g/cm^3)	4.42
Yield tensile strength (MPA)	870
Ultimate tensile Strength (MPA)	923
Fatigue strength (MPA)	510
Modulus of elasticity (GPA)	113.8
Elongation (%)	14%
Poission ratio	0.342
Thermal Conductivity (w/mk)	6.7
Specific Heat (J/kg k)	560
Electrical Resistivity (μΩm)	1.7

Composition Of TI-6AL-4V

C	Fe	N2	O2	AL	V	H2	Ti
<0.08	<0.2	<0.05	<0.2	6.0	4.0	<0.01	Balance

Property	Description
Thermal conductivity	Low thermal conductivity causes concentration of heat on the tool cutting edge and face , influencing negativity the tool life
Chemical reactivity	Reactivity with common gases such as oxygen hydrogen and nitrogen leads to formation of oxides, hydrides and nitrides, respectively. These causes embrittlement and decrease of the fatigue strength of the alloy.
Elastic modulus	Low elastic modulus allows deflection of slender work piece under tool pressure, inducing chatter and tolerance problems.
Hardness and strength	The high temperature strength and hardness of titanium alloys require high cutting forces which results in cutting process.
Work hardening	The peculiar work hardening of titanium alloys causes absence of builtup edge in front of the cutting tool and increase of the shearing angle which in turn inducess a thin chip to contact a relatively small area in the cutting face, resulting in high bearing loads per unit area how ever the formation of built-up edge is refered to be determental for tool coating.

Titanium Properties On Its Machinability

"In optimization studies in high speed turning of TI-6AL-4V " To achive this optical machining parameters (cutting , feed , depth of cut) have been obtained using different optimization algorithm" [2] An Experemental study of wire EDM on TI-6AL-4V Alloy by A.V.S.RAM PRASAD kanmaram, JiG.L.Datta proposed Based on the nvestigation's performed the most significant parameter's on both MRR and Rawm found to be peak current and pluss on time[3] Riviews on machinability of titanium Alloy's . "The process porspective , C.Vigal, J.P>Davim and A.J.R Loureriro, there is a lack of Research on qualifications of chemical reactivity between titanium and tool materials , [5] wear mechanism of PVD - coated cutting tools during continous turning of TI-6AL-4V alloy" The wear of the aminted carbide resulted from the falling off of WC-CO par iculus due to the softening of the co phase at elected temperature by cutting heat[6]. S.R Chavhama Kali Dass et al. Concluded that the surface roughness increases with in the cutting speed and the fad rate and decreases with decreases in approach angle and depth of cut [9]. Experimental investigastion on machining of titanium alloy under different machining environments by M.Venkata Ramana Gt al concluded that the optimal and best combination vlues for minimizing Surface Roughness are palm oil, cutting speed at 79m/min feed rate at 0.206 mm/rev ,depth of cut at 1.0 mm and CVD coated tool [10] Energy Efficient machining of titanium Alloys by controlling cutting Temperature and vibtat "zhingang wang et al. The results show that the numerica models used in this study can predict cutting forces and cutting forces and cutting temperatures with good accuracy [11] . The properties provided in especially the tensile strength (TS) and hardness (H), one can infer that the Ti-6Al-4V alloy in the annealed condition requires less machining power than the same alloy in the solution and aged condition. But with regard to thermal conductivity the last seems to be easier to machine because higher thermal conductivity generally results in lower cutting temperature. Besides, the referred table provides information on the -tarsus temperatures, Titanium and its alloys present low machinability due to their low thermal conductivity, high reactivity, low elastic modulus, high hardness and strength at elevated temperature, and peculiar work hardening .

The Main Techniques For Cutting Process Improvement

Technique	Description
Dry cutting	Dry cutting minimizes environmental pollution, health risk for machine operator and thermal shock in interrupted cutting
Flood cooling	This method the coolant is delivered with a low pressure pump and flooded in general cutting area, which is effective when machining at low cutting speed
MQL	A little amount of water and soluble oil to the cutting edge which allows reducing the temperature, surface roughness and cost
HPS	The cutting fluids is supplied under high pressure and very close to the critical point. lower cutting force better tool life and acceptable surface finish
Cryogenic cooling	Cooling is based on directing a cutting fluid, usually liquid nitrogen under pressure and at low temperature into cutting zone that can significantly improve tool life
Solid lubricants	Performance of solid lubricants is better at higher cutting speed , Elimination of environmental pollution and capacity to lower the cutting temperature are encouraging the use of these lubricants
Hot machining	This technique consists in pre-heating the work piece in order to minimize the required cutting force improve surface finish
Chip breaker	In this case, chips are broken into smaller pieces by using inserts with chip breaker geometrics

As stated by Sharma et al.,, all types of cooling techniques give good results with majority of tool materials, The majority of them use special cooling lubrication methods in order to reduce temperature and friction at the tool tip interface , while dropping cost and increasing productivity by saving cutting fluids improve material removal rate , tool life and surface integrity and reducing environmental pollution.

MATERIAL	TOOL MATERIAL	TECHNIQUE	LUBRICATION
TI-6AL-4V	PCBN (cBN and TiAlN	SEM	coconut oil vegetable oil
TI-6AL-4V	PVD-coated cutting tools Cemented carbide	(SEM) (EPMA)	A diluted water-soluble cutting oil
TI-6AL-4V	N+TiN-coated carbide cutting tool	Taguchi	water soluble oil (Swisslube BlaserBCool 650)
TI-6AL-AV	whilst CVD coated carbides and ceramics	Ezugwu and Machado	Chlorine
TI-6AL-4V	Carbide tools (CVDcoated TM 4000), (PVD coated TS 2000)	Taguchi	palm oil and boric acid
TI-6AL-4V	PCD	Surface integrity analysis	alkanolamine salts of fatty acids and dicyclohexylamine
TI-6AL-4V	coated (PVD & CVD) and uncoated carbide insert.	Taguchi	palm oil and palm oil with boric acid.
Ti-6Al-4V	Silicon carbide (SiCw)	PCD	Coolant
Ti-6Al-4V	HPC	Turning	Coolant
Ti-6Al-4V	PVD-coated cutting tools	SEM EPMA/WDS/BSI	Wet
Ti-6Al-4V	Coro Mill® 690 cutter ,A cemented carbide insert with a PVD coating, Multus B300	RSM	oil-water emulsion coolant, Chip Blaster JV10

Khalid H.Hashmi et al. concluded that the HSM of TI-6AL-4V for measuring ra value relealed that better surface quality with Improved MRR can be achived by using HSM [12] "Optimal machining conditions for turning TI-6AL-4V using responss surface methodology " in this research increases in d @ f causes the maximum chip thickness to increses , there by formation of larger uncut ridge results in the formation of poor surface finish.[13] Neelishku Sahu et al. in his Research . A news advanced optimization algorithm TLBO was used silva et al. find that machining TI-6AL-4V alloy with silicon carbide (sicw) whisker rainferud alumina ceramic cutting tools did not demonstrate satisfactory performance in terms of tool wear and tool life in all the conditions investigated , due to super abrasive wear and chipping of the cutting edge (15) Pravin Pawar et al. concluded that machining α+β alloy shows adherence of material on the cutting edge . Thus built up edges formed encourage abrasion and diffusion durng machining operations . slow and unform coating de-lamination underlines the effectiveness of tool coating in machining of α+β titanium alloy's (16) V.G Sargadea et al. Research Feed rates is the most significant factor in fluencing the surface of wrought TI-6AL-4V cylinder , where as the surface Roughtness was not significantly influenced Munish Kumar Gupta et al. sajusted that the machining performance of titanium (grand-2) alloy under NFMQL Conditions was assesed during turning at different conditions (30). A Borbin , sartori et al. The paper proved the feasibility of replacing emulsion cutting fluids with more sutaimable alternatives when machining the TI-6AL-4V alloy(21) Arvind sridharam et al. Concluded that There has been extensive research done in the field of machinability of titanium alloy and of high preasure collant in machining . S.K.Bhavmik et.al .The machining of titanium alloy is difficult basically due to its high chemical affinity and high local Temperature generated because of its poor thermal conductivity (35) Narasimhely Andrigen et al. proposed that the effect of cutting speed feed depth of cut and effective rake angle on the fed forces (fx) trust forces (fy) cutting (fz) and surface roughness Ra in machining of TI-6Al-4V

Conclusions

- Several Techiques for improve the machinability have been studied by different Researchers the report shoe that majority of them present considerable Improvement in cutting process.
- There is a lack of work that compare these techniques and determine the conditions under which each of them is most advantageous.
- There is a trend to use environment friendly fluids , including water vapour , air and other gases in order to improve the mahinability and ensure green cutting .
- The machining force with cutting variables and environment seems not to agree in same casus , probably due to difference in the cutting conditions , thus more studies need to be camadout .
- The effect of the type of chip on surface finish of machined pieces no agreement was reached yet .
- The increases in the cutting temperature may occur during the machining of titanium alloys if no cooling techniques is used , but at the start of cutting fluids may have negligible influence .
- There is a lack of studies on the relationship between the cutting conditions, rate of heat generations and extraction and evolution of cutting temperature .
- There is a lack of research an quanbication of chemical reactivity between titanium and tool material and on the relationship between cutting parameters with work piece hardness

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