

PERFORMANCE EVALUATION OF UNCOATED AND COATED
CARBIDE TOOLS WHEN DRILLING TITANIUM ALLOY

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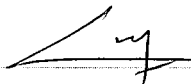
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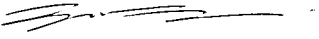
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ABSTRACT

Titanium alloys are widely used in the aerospace industry especially in airframes and engine components due to their high strength-weight ratio that is maintained at elevated temperature and their exceptional corrosion resistance. Nevertheless, titanium and its alloys are thought to be difficult-to-machine material due to their poor thermal properties and highly chemical reactivity. In this study, Ti-6Al-4V has been drilled using single-layer PVD-HIS-TiAlN coated carbide, Type A (T12-A) and Type C (T12-C and T13-C), multi-layer PVD-HIS-Supernitride coated carbide, Type A (S13-A) and Type C (S12-C and S13-C) and uncoated carbide Type B (U12-B and U13-B) and Type C (U12-C and U13-C) drills with different drill point geometry under various cutting speeds and constant feed rate. The tool performance, tool failure modes and tool wear mechanisms were analyzed under various cutting speeds. On the other hand, the cutting forces and the surface roughness were measured. In this study, Type C drills outperformed Type A and B drills in terms of tool life for almost all the cutting conditions tested. At low cutting speed of 25 m/min, the uncoated carbide tool of U12-C drills demonstrated the longest tool life, which resulted in low tool wear rate. The excellent improvement of both coated drills were mainly due to their ability of maintaining oxidation resistance and high hardness especially at elevated temperatures. On the other hand, poor performance of Type B drills was mainly due to premature tool failure caused by severe chipping and breakage. Non-uniform flank wear, chipping, cracking and catastrophic failure were the dominant failure modes of all tools under most cutting conditions tested. These failure modes were mainly associated with adhesion, diffusion and plastic deformation wear mechanisms. Based from the results obtained, it can be suggested that Type C drill was recommended and the lower cutting speed of 25 m/min should be employed in order to achieve high performance in drilling Ti-64.

ABSTRAK

Aloi titanium telah digunakan dengan meluas di dalam industri aero-angkasa untuk membuat kerangka pesawat dan komponen enjin disebabkan oleh nisbah diantara kekuatan-berat yang tinggi serta mampu bertahan pada suhu yang melampau dan tahan karat. Tambahan lagi, aloi titanium adalah sukar untuk dimesin kerana sifat termalnya yang lemah dan mempunyai tahap tindak balas kimia yang tinggi. Di dalam kajian ini, Ti-6Al-4V telah digerudi menggunakan gerudi disalut selapis TiAlN pada karbida, Jenis A (T12-A) dan Jenis C (T12-C dan T13-C), disalut berlapis-lapis Supernitride pada karbida, Jenis A (S13-A) dan Jenis C (S12-C dan S13-C) dan karbida tanpa disalut, Jenis B (U12-B dan U13-B) dan Jenis C (U12-C dan U13-C) pada pelbagai halaju pemotongan dan kadar suapan malar. Prestasi mata gerudi, mod kegagalan mata alat, dan mekanisma kehausan mata alat telah dianalisa pada keadaan penggerudian yang basah. Daya pemotongan dan kekasaran permukaan pada dinding lubang juga telah diukur. Di dalam kajian ini, gerudi Jenis C adalah lebih baik jika dibandingkan dengan Jenis A dan B dari aspek jangka hayat gerudi tersebut bagi hampir kesemua keadaan pemotongan. Pada halaju pemotongan 25 m/min, gerudi karbida tanpa disalut, U12-C mempamerkan jangka hayat yang lama dan kadar kehausan mata gerudi yang rendah. Peningkatan prestasi bagi gerudi karbida yang disalut adalah disebabkan oleh keupayaan gerudi tersebut untuk menangani pengoksidaan dan mempunyai kekerasan yang tinggi pada suhu yang melampau. Prestasi yang buruk ditunjukkan oleh gerudi Jenis B adalah kerana kegagalan pra-matang disebabkan oleh sumbing yang ketara dan mata alat patah. Keausan rusuk yang tidak seragam, sumbing, retakan dan kegagalan bencana merupakan mod kegagalan yang utama bagi semua mata alat pada hampir kesemua keadaan penggerudian. Mod-mod kegagalan ini boleh jadi berkaitan dengan rekatan, resapan dan perubahan bentuk plastik. Berdasarkan kepada keputusan yang diceraap, gerudi Jenis C telah disyorkan dengan halaju pemotongan pada 25 m/min bagi mencapai prestasi penggerudian yang optimum untuk menggerudi Ti-6Al-4V.

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LIST OF SYMBOLS

α	-	Tool rake angle
b	-	Width of cut
β	-	Friction angle
C_T	-	Chisel edge wear (depth)
C_M	-	Chisel edge wear (width)
$2d$	-	Drill diameter
F_f	-	Component of parallel frictional force
F_p	-	Component of horizontal force
F_s	-	Component of horizontal shear force
F_t	-	Component of vertical force
i	-	Inclination angle
K_M	-	Crater wear
L	-	Lead length of the helix
M_w	-	Margin wear
N_f	-	Component of normal frictional force
N_s	-	Component of normal shear force
P_M	-	Chipping (width)
P_T	-	Chipping (depth)
$2p$	-	Drill point angle
R_a	-	Arithmetical mean deviation
R_{\max}	-	Maximum height of the profile
R_z	-	Height of the profile irregularities in ten points
r	-	Drill radius
t_c	-	Undeformed chip thickness
V_b	-	Flank wear