EFFECT OF HEAT TREATMENT AND EQUAL CHANNEL ANGULAR PRESSING ON THE MICROSTRUCTURES, HARDNESS AND WEAR RESISTANCE OF A356 ALUMINIUM ALLOY WITH TiB_2

by

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LIST OF ABBREVIATIONS

Abbreviation	Description
AA	Aluminum Association
Ag	Argentum (Silver)
B	Boron
Al-B	Aluminum-Boron
Al-Si alloy	Aluminum-Silicon alloy
Al-Si-Mg alloy	Aluminum-Silicon-Magnesium alloy
Al-Sr	Aluminum- Strontium
Al-Ti	Aluminum-Titanium
Al-Ti-B	Aluminum-Titanium-Boron
Al-5Ti-1B	5 wt.% Ti, 1 wt.% B, Balance Aluminum
ARB	Accumulative Roll Bonding
ASTM	American Standard Testing and Material
CCC	Cylinder Covered Compression
CCDF	Cyclic Close Die Forging
CEC	Cyclic Extrusion-Compression
CGP	Constrained Groove Pressing
COF	Coefficient of Friction
Cu	Cuprum (Copper)
DDW	Dense Dislocation Walls
DIN	Deutsches Institut fur Normung (German Institute for Standardization)
EBSD	Electron Backscatter Diffraction

ECAE	Equal Channel Angular Extrusion
ECAP	Equal Channel Angular Pressing
EDS	Energy Dispersive X-Ray Spectroscopy
FCC	Face-Centered Cubic
Fe	Ferrum
FESEM	Field Emission Scanning Electron Microscopy
FSP	Friction Stir Processing
Ge	Germanium
GNBs	Geometrically Necessary Boundaries
GPa	Giga Pascal
HAGB	High-Angle Grain Boundary
HAGBs	High-Angle Grain Boundaries
HPT	High Pressure Torsion
HRc	Hardness Rockwell
HV	Hardness Vickers
IDBs	Incidental Dislocation Boundaries
IQ	Index Quality
IPF	Inverse Pole Figure
ISO	International Organization for Standardization
LBs	Lamellar Boundaries
LAGBs	Low-Angle Grain Boundaries
Li	Lithium
LPG	Liquefied Petroleum Gas
Mg	Magnesium
MML	Mechanically Mixed Layer

Mn	Manganese
Na	Natrium
nc	nanocrystalline
nm	nano meter
OIM Analysis	Orientation Imaging Microscopy Analysis
R	Radii
RPM	Rotation Per Minute
RCS	Repetitive Corrugation and Straightening
S/L interface	Solid/Liquid interface
SEM	Scanning Electron Microscopy
SFE	Stacking Fault Energy
SFSP	Submerged Friction Stir Processing
Si	Silicon
SiC	Silicon Carbide
SPD	Severe Plastic Deformation
ST	Solution Treatment
ST-Aging	Solution treatment, Quenching then Aging treatment
T6	Heat treatment process of Solution treatment, Quenching and Artificial aging
T	Temperature
T_m	Melting temperature
$TiAl_3$	Titanium Aluminide
TiB_2	Titanium Diboride
UFG	Ultrafine Grain
UTM	Universal Testing Machine

Zr	Zirconium
XRD	X-Ray Diffraction
XRF	X-Ray Fluorescence
Zn	Zinc

LIST OF SYMBOLS

Symbol	Description
Φ	Channel angle
Ψ	outer arc curvature
λ	Wave length
γ	Shear strain
ε	Strain
ε_{eq}	Equivalent strain
ε_N	Shear strain after N-pass of ECAP
$\Delta\sigma_0$	Net interfacial energy
σ_{ps}	Interfacial energy between particle and solid
σ_{pl}	Interfacial energy between particle and liquid
σ_{UTS}	Ultimate Tensile Strength
τ_{CRSS}	Critical resolved shear stress
E	Young's Modulus
n*	constant
N	Rotational speed (RPM)
r	radius of sliding (m)
t	time (s)
V	Translational/sliding speed (m/s)
ω	Rotational speed (rad/s)

KESAN RAWATAN HABA DAN PENEKANAN SUDUT SALUR SAMA KE ATAS MIKROSTRUKTUR, KEKERASAN DAN RINTANGAN HAUS ALOI ALUMINIUM A356 DENGAN TiB_2

ABSTRAK

Penekanan sudut salur sama (ECAP) adalah satu prosedur yang relatif mudah untuk menghasilkan ira ultra-halus dan mempunyai potensi untuk digunakan dalam pemprosesan logam komersial. Namun kesukaran pemprosesan mungkin timbul semasa ECAP kerana berlakunya keretakan. Dalam kajian ini, aloi aluminium A356 dan aloi aluminium A356 dengan pelbagai kandungan penghalus ira TiB_2 (0.75, 1.5, 2.63 wt.%) disediakan melalui tuangan acuan graviti. Spesimen aloi aluminium A356 tuang ditambah TiB_2 mengandungi fasa keras Si eutektik, zarah keras TiB_2 dan $TiAl_3$ yang berpotensi menyebabkan keretakan semasa pemprosesan ECAP oleh kerana itu rawatan haba dijalankan sebelum ECAP. Rawatan haba sepuh lindap pada suhu 540°C selama 8 jam diikuti dengan penyejukan dalam relau, rawatan larutan pada suhu 540°C selama 4 jam diikuti dengan lindap kejut dalam air, dan rawatan penuaan pada suhu 110°C, 155°C, 200°C, 245°C dan 290°C selama 3 jam. Spesimen yang telah melalui proses rawatan haba kemudian diproses 4-turutan ECAP mengikut laluan B_A (putaran 90°). Gabungan antara rawatan haba dan ECAP dilakukan untuk menganalisis kesan kedua-dua proses pada mikrostruktur, kekerasan dan rintangan haus spesimen. Spesimen dicirikan dengan mikroskop optik, SEM, EBSD, TEM, kekerasan dan ujian haus. Pemprosesan 4-turutan ECAP meningkatkan kekerasan dengan ketara spesimen yang mempunyai matriks relatif lembut. Matriks yang relatif lembut dalam gabungan dengan zarah TiB_2 dan Si memberi manfaat dalam mempercepatkan peningkatan ketumpatan kehelan membawa kepada penghalusan ira

semasa pemprosesan ECAP. Dari keseluruhan pertimbangan kekerasan, saiz ira purata dan kadar haus, spesimen rawatan larutan pra-ECAP mempunyai nilai terbaik secara umum, kemudian diikuti spesimen penuaan pada 155°C selepas ECAP pada kedudukan kedua.