SUPERVISOR DECLARATION

I hereby declare that I have checked this thesis and in my opinion this thesis is adequate in terms of scope and quality for the award of Master of Science in Manufacturing.

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I hereby declare that the work in this thesis is based on my original work except for quotations and citation which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at University Malaysia Pahang any other institutions.

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DIRECT RECYCLING OF ALUMINIUM ALLOY 6061 AND 7075 EMPLOYING CYCLIC EXTRUSION COMPRESSION BACK PRESSURE TECHNIQUE

MOHAMAD SYAHMI BIN SHAHROM

Thesis submitted in fulfilment of the requirements
for the award of the degree of
Master of Science

Faculty of Manufacturing Engineering
UNIVERSITI MALAYSIA PAHANG

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TABLE OF CONTENTS

CHAPTER 6 CONCLUSION AND RECOMMENDATION

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

%	Percentage
ϕ	Porosity
^{o}C	Degree Celsius
dB	Decibel
GJ/t	Giga Joule per Ton
kN	Kilo Newton
ρ_{cyb}	Cyclic billets density, g/cm^3
ρ_{cys}	Cyclic specimens density, g/cm^3
ρ_{dcb}	Direct billets density, g/cm^3
H_{cys}	Cyclic specimens hardness, HV
µm	Micro meter
P	Pressure, MPa
P_b	Back Pressure,KPa
t_c	Cycle Time
t_h	Holding Time, s
s	Second
m_{cp}	Mass Chip, g
v_{dcb}	Volume direct billets, cm

LIST OF ABBREVIATIONS

AA	Aluminium Alloy
ANOVA	Analysis of Variance
CECBP	Cyclic Extrusion Compression Back Pressure
CB	Chip Boundaries
CL	Chip Length
CS	Chip Sizes
CYB	Cyclic billets
CYS	Cyclic specimens
DCB	Direct Billets
DOC	Depth of Cut
DOE	Design of Experiment
ECAP	Equal Chanel Angular Pressing
EDM	Electrical Discharge Machine
FR	Feed Rate
GD	Green Density
HV	Hardness Vickers
MAG	Magnification
MQL	Minimum Quantity Lubricant
SEM	Scanning Electron Microscopy
S/N	Signal Noise
SPD	Severe Plastic Deformation
SS	Spindle Speed
SCYB	Sample cyclic billets

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ABSTRACT

The direct recycling process is an alternative method of recycling waste of chip aluminium without melting the materials as compared to conventional recycling technique (secondary production). The cold compaction stage is the most crucial process of the direct recycling process. The billets density, ρ_b achieved through the cold compaction stage significantly influences the hardness (mechanical properties) and chip boundaries (microstructural properties). The problem of conventional compaction (direct compaction) presents low of ρ_b. The objective of this study is to develop the Cyclic Extrusion Compression Back Pressure (CECBP) technique to improve the ρ_b which influences the hardness and chip boundaries of aluminium alloy 6061 and 7075 chips in the direct recycling process. Taguchi Method was used as a tool to analyse and optimise the CECBP factors namely the pressure, P back pressure, P_b cycle time, t_c and holding time, t_h. Different lubricant strategy techniques (flood, dry and minimum quantity lubricant (MQL) were used to obtain different types of aluminium chips. Conventional compaction (direct compaction technique) was used to get ρ_b value. The MQL showed the highest ρ_b results compared to flood and dry technique. The experimental results suggested that the CECBP technique is able to improve cyclic billets density ρ_{cyb} to 12.11% (AA6061) and 5.45 % (AA7075) compared to direct compaction technique. It is also established that the cyclic specimen hardness, H_{cys} and chip boundaries for both aluminium alloys improved when ρ_{cyb} value increased by using regression analysis. Pressure is identified to be the most significant factor in influencing the properties of ρ_{cyb}, ρ_{cys} and H_{cys}. In conclusion, CECBP technique had successfully improved the cold compaction stage for a direct recycling process and can used as direct recycling process of aluminium in industry.

ABSTRAK

Proses kitar semula langsung adalah satu kaedah alternatif kitar semula sisa cip aluminium tanpa lebur bahan berbanding teknik kitar semula konvensional (pengeluaran menengah). Peringkat pemadatan sejuk adalah proses yang paling penting dalam proses kitar semula langsung. Ketumpatan bilet, ρ_b dicapai melalui peringkat pemadatan sejuk ketara mempengaruhi kekerasan (sifat mekanikal) dan sempadan cip (sifat mikrostruktur). Masalah pemadatan konvensional (pemadatan langsung) membentangkan rendah ρ_b. Objektif kajian ini adalah untuk membangunkan Cyclic penyemperitan Mampatan Kembali Tekanan (CECBP) teknik untuk meningkatkan ρb yang mempengaruhi kekerasan dan cip sempadan aloi aluminium 6061 dan 7075 cip dalam proses kitar semula langsung. Taguchi Kaedah digunakan sebagai alat untuk menganalisis dan mengoptimumkan faktor CECBP iaitu tekanan, tekanan P kembali, P_b masa kitaran, t_c dan memegang masa, t_h. Teknik strategi pelincir yang berbeza (banjir, kering dan minimum kuantiti pelincir (MQL)) telah digunakan untuk mendapatkan pelbagai jenis cip aluminium. Pemadatan konvensional (teknik pemadatan langsung) telah digunakan untuk mendapatkan nilai ρ_b. The MQL menunjukkan hasil ρ_b tertinggi berbanding dengan banjir dan teknik kering. Keputusan eksperimen menunjukkan bahawa teknik CECBP ini mampu meningkatkan kitaran ρcyb ketumpatan bilet kepada 12.11% (AA6061) dan 5.45% (AA7075) dan juga berbanding dengan teknik pemadatan langsung. Ia juga menetapkan bahawa kekerasan spesimen kitaran, H_{cys} dan cip sempadan untuk kedua-dua aloi aluminium meningkat apabila nilai ρ_{cyb} ditambah dengan menggunakan analisis regresi. Tekanan dikenal pasti sebagai faktor yang paling penting dalam mempengaruhi sifat-sifat ρ_{cyb}, ρ_{cys} dan H_{cys}. Kesimpulannya, teknik CECBP telah berjaya meningkatkan tahap pemadatan sejuk untuk proses kitar semula langsung.

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