E3S Web of Conferences
Volume 130 (2019)

The 1st International Conference on Automotive, Manufacturing, and Mechanical Engineering
(IC-AMME 2018)

Kuta, Bali, Indonesia, September 26-28, 2018
R.H. Setyobudi, F.D. Suprianto, M. Mel, O. Anne, P. Soni, T. Turkadze, Y. Jani and Z. Vincēviča-Gaile (Eds.)

Export the citation of the selected articles Export
Select all

About the conference
Published online: 15 November 2019

- PDF (1.92 MB)

Statement of Peer review
Published online: 15 November 2019

- PDF (232 KB)

Simulation-based Prediction of Structural Design Failure in Fishing Deck Machinery a Hydraulic Type with Finite Element Method 01001
Agri Suwandi, Dede Lia Zariatin, Bambang Sulaksono, Estu Prayogi and I Made Widana

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001001

- PDF (599.7 KB)
- References
- NASA ADS Abstract Service

[Effect of Frequency on Droplet Characteristics in Ultrasonic Atomization Process](#) 01002

Amelia Sugondo, Sutrisno, Willyanto Anggono and Olga Anne

Published online: 15 November 2019

- [PDF (413.2 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

Open Access

[Sound Absorption Performance of Sugar Palm Trunk Fibers](#) 01003

Anditya Endar Prabowo, Kuncoro Diharjo, Ubaidillah and Iwan Prasetiyo

Published online: 15 November 2019

- [PDF (645.0 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

Open Access

[Characteristics Of Aluminium ADC 12/SiC Composite with the Addition of TiB and Sr Modifier](#) 01004

Astari Indarsari, Anne Zulfia Syahrial and Budi Wahyu Utomo

Published online: 15 November 2019

- [PDF (677.3 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

Open Access

[Optimizing The Addition of TiB to Improve Mechanical Properties of the ADC 12/SiC Composite Through Stir Casting Process](#) 01005

Cindy Retno Putri, Anne Zulfia Syahrial, Salahuddin Yunus and Budi Wahyu Utomo

- [PDF (585.7 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

Open Access

[Drivers and Barriers of Mobile Phone Remanufacturing Business in Indonesia: Perspectives of Retailers](#) 01006

Didik Wahjudi, Shu-san Gan, Yopi Yusuf Tanoto, Jerry Winata and Benny Tjahjono

- [PDF (379.7 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

Open Access

[Experimental Analysis on Solid Desiccant Used in An Air Conditioning](#) 01007

Ekadewi Anggraini Handoyo, Andriono Slamet and Muhammad Danang Birowosuto

- [PDF (605.5 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

Open Access

[Influences of Groove Angles and Filler Metals on 304L Stainless Steel to AISI 1040 Carbon Steel Dissimilar Joint by Gas Tungsten Arc Welding](#) 01008

Eriek Wahyu Restu Widodo, Vuri Ayu Setyowati, Suheni and Ahmad Rilo Hardianto

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001008

- [PDF (839.3 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[The Effect of Biodiesel Blends Made from Carica papaya L. Seeds on the Performance of Diesel Engine](#) 01009

Fandi Dwiputra Suprianto, Willyanto Anggono, Teng Sutrisno, Daniel William Gunawan and Gabriel Jeremy Gotama

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001009

- [PDF (990.1 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[Container Ship Accident Analysis due to Container Stacked on Deck as an Attempt to Improve Maritime Logistic System](#) 01010

Gafero Priapalla Rahim and Sunaryo

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001010

- [PDF (474.4 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[Automatic Petrol and Diesel Engine Sound Identification Based on Machine Learning Approaches](#) 01011

Halim Frederick, Astuti Winda and Mahmud Iwan Solihin

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001011

- [PDF (588.2 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[Optimization of Soft Body Armor with Laminates of Carbon–aramid Fiber and Polyester Fiber Using the Taguchi Method](#) 01012

Hari Purnomo, Wahyu Ismail Kurnia, Farham Haji Muhammad Saleh and Alex Kisanjani

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001012

- [PDF (565.2 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[Hybrid Turbulence Models: Recent Progresses and Further Researches](#) 01013

Hariyo Priambudi Setyo Pratomo, Fandi Dwiputra Suprianto and Teng Sutrisno

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001013

- [PDF (537.1 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

Preliminary Study on Mesh Stiffness Models for Fluid-structure Interaction Problems 01014

Hariyo Priambudi Setyo Pratomo, Fandi Dwiputra Suprianto and Teng Sutrisno

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001014

- PDF (828.8 KB)
- References
- NASA ADS Abstract Service

Development of Real Time Machine Tools Component Utilization Data Acquisition for developing Dynamic Model of Maintenance Scheduling 01015

Herman Budi Harja, Tri Prakosa, Yatna Yuwana Martawirya, Indra Nurhadi and Andrian Sagisky Januartha

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001015

- PDF (456.7 KB)
- References
- NASA ADS Abstract Service

Probabilistic Evaluation of Fatigue Crack Growth Rate for Longitudinal Tungsten Inert Gas Welded Al 6013-T4 Under Various PostWeld Heat Treatment Conditions 01016

I Made Wicaksana Ekaputra, Gunawan Dwi Haryadi, Stefan Mardikus and Rando Tungga Dewa

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001016

- PDF (515.6 KB)

[Experimental Performance Analysis of Shallow Spiral-tube Ground Heat Exchangers in Series and Parallel Configurations](#) 01017

Jalaluddin, Akio Miyara, Rustan Tarakka and Muhammad Anis Ilahi Ramadhani

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001017

[Structural Evaluation on Sugarcane Bagasse Treated Using Sodium and Calcium Hydroxide](#) 01018

Juliana Anggono, Hariyati
Purwaningsih, Suwandi Sugondo, Steven Henrico, Sanjaya Sewucipto and Jay Patel

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001018

[The Influence of Room and Ambient Temperatures of Exergy Loss in Air Conditioning Using Ejector as an Expansion Device with R290 as Working Fluid](#) 01019

Kasni Sumeru, Pratikto Pratikto, Andriyanto Setyawan and Adenkule Moshood Abioye

Published online: 15 November 2019

- PDF (440.2 KB)
- References
- NASA ADS Abstract Service

Automotive Start-Stop Engine Based on Face Recognition System 01020

Lim William, Astuti Winda, Dewanto Satrio, Tan Sofyan and Mahmud Iwan Solihin

Published online: 15 November 2019

- PDF (1003 KB)
- References
- NASA ADS Abstract Service

The Effect of Coconut Shell Powder as Functional Filler in Polypropylene during Compounding and Subsequent Molding 01021

Matt Kirby, Benjamin Lewis, Benjamin Peterson, Juliana Anggono and Walter Bradley

Published online: 15 November 2019

- PDF (623.2 KB)
- References
- NASA ADS Abstract Service

Automotive Start–Stop Engine Based on Fingerprint Recognition System 01022

Pranoko Rivandi, Astuti Winda, Dewanto Satrio and Mahmud Iwan Solihin

Published online: 15 November 2019

- PDF (459.6 KB)
- References
- NASA ADS Abstract Service

Effect of T6 on Mechanical Properties of TiB and Sr Modified ADC12/SiC Composite Produced by Stir Casting 01023

Pritamara Wahyuningtyas, Anne Zulfia Syahrial, Wahyuaji Narottama Putra and Budi Wahyu Utomo

Published online: 15 November 2019

- PDF (869.7 KB)
- References
- NASA ADS Abstract Service

Regression Equations to Determine the Stages of Electric Current in Electrical Discharge Machining (EDM) According to the Level of Desired Surface Roughness with Shortest Processing Time 01024

Roche Alimin, Didik Wahjudi, Hariyanto Gunawan and Prayogo Putra Poernomo

Published online: 15 November 2019

- PDF (597.2 KB)
- References
- NASA ADS Abstract Service

[Increasing Port Performance through Port Navigation Safety Assessment using the Formal Safety Assessment Method (Case Study Port of Tanjung Priok - Indonesia)](#) 01025

Sahlan Ridwan and Sunaryo

- [PDF (354.3 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[A Feasibility Study of Mobile Phone Casings Remanufacturing](#) 01026

Shu–San Gan, Juliana Anggono, Didik Wahjudi, Yopi Tanoto, Randy and Novana Hutasoit

- [PDF (540.7 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[3D Simulative Investigation of Heat Transfer Enhancement Using Three Vortex Generator Types Surrounding Tube in Plate Fin Heat Exchanger](#) 01027

Stefan Mardikus, Petrus Setyo Prabowo, Vinsensius Tiara Putra, Made Wicaksana Ekaputra and Juris Burlakovs

- [PDF (770.6 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[Investigation on the Sandwich System Hull Materials for Solar Powered Electrical Sport Boat](#) 01028

Sunaryo and Aldy Syahrihaddin Hanifa

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001028

- [PDF (589.6 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[Electrical System Design of Solar-Powered Electrical Water Recreational and Sport Vessel](#) 01029

Sunaryo and Pradhana Shadu Imfianto

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001029

- [PDF (674.8 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[Experimental Investigation of Avocado Seed Oil Utilization in Diesel Engine Performance](#) 01030

Sutrisno, Willyanto Anggono, Fandi Dwiputra Suprianto, Cokro Daniel Santosa, Michael Suryajaya and Gabriel Jeremy Gotama

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001030

- [PDF (517.8 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[Optimization of Boring Process Parameters in Manufacturing of Polyacetal Bushing using High Speed Steel](#) 01031

The Jaya Suteja, Yon Haryono, Andri Harianto and Esti Rinawiyanti

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001031

- [PDF (379.0 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[Development of Total Hip Joint Replacement Prostheses Made by Local Material: An Introduction](#) 01032

Tresna Priyana Soemardi, Agri Suwandi, Cholid Badri, Anwar Soefi Ibrahim, Sastra Kusuma Wijaya and Januar Parlaungan Siregar

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001032

- [PDF (549.9 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[Strategy to Improve Recycling Yield of Aluminium Cans](#) 01033

Victor Yuardi Risonarta, Juliana Anggono, Yosias Michael Suhendra, Setyo Nugrowibowo and Yahya Jani

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001033

- [PDF (317.9 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[Using Agricultural Waste to Create More Environmentally Friendly and Affordable Products and Help Poor Coconut Farmers](#) 01034

Walter L. Bradley and Sean Conroy

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001034

- [PDF (783.3 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[Intelligent Automatic V6 and V8 Engine Sound Detection Based on Artificial Neural Network](#) 01035

Wenny Vincent, Astuti Winda and Mahmud Iwan Solihin

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001035

- [PDF (585.9 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[Effect of Various Supercharger Boost Pressure to in-Cylinder Pressure and Heat Release Rate Characteristics of Direct Injection Diesel Engine at Various Engine Rotation](#) 01036

Willyanto Anggono, Wataru Ikoma, Haoyu Chen, Zhiyuan Liu, Mitsuhisa Ichiyanagi and Takashi Suzuki

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001036

- [PDF (791.3 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[Experimental and Numerical Investigation of Laminar Burning Velocities of Artificial Biogas Under Various Pressure and CO₂ Concentration](#) 01037

Willyanto Anggono, Akihiro Hayakawa, Ekenechukwu C. Okafor and Gabriel Jeremy Gotama

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001037

- [PDF (560.1 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[Kinematic Analysis of Triple Ball Tie-rod in Ackermann Steering and Tilting Mechanism for Tricycle Application](#) 01038

Wimba Pramudita Wid, Aufar Syehan and Danardono Agus Sumarsono

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001038

- [PDF (704.2 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[Process Planning Review for Mobile Phone Remanufacturing in Indonesia](#) 01039

Yopi Yusuf Tanoto, Shu-San Gan, Didik Wahjudi, Niko Adrisenna Pontjonoto and Michael Suryajaya

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001039

- [PDF (326.7 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[Studies on Water Sorption Behaviour of Laminated Bamboo Polymer Composite](#) 01040

Yuniar Ratna Pratiwi, Indah Widiastuti and Budi Harjanto

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001040

- [PDF (408.3 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[The Impact of Enterprise Resources Planning Implementation in Cross-Functional for Sharing Knowledge and Quality Information in Preparing the Financial Statements](#) 01041

Zeplin Jiwa Husada Tarigan, Sautma Ronni Basana and Widjojo Suprapto

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001041

- [PDF (333.3 KB)](#)
- [References](#)
- [NASA ADS Abstract Service](#)

[Effect of Key User Empowerment, Purchasing Strategy, Process Integration,Production System to Operational Performance](#) 01042

Zeplin Jiwa Husada Tarigan, Hotlan Siagian, Sautma Ronni Basana and Ferry Jie

Published online: 15 November 2019

DOI: https://doi.org/10.1051/e3sconf/201913001042

- [PDF (426.6 KB)](#)
- [References](#)

- [NASA ADS Abstract Service](#)

Scopus Preview

Author Search   Sources   Create account   Sign in

Source details

Feedback >   Compare sources >

E3S Web of Conferences

Open Access

Scopus coverage years: from 2013 to 2021

Publisher: EDP Sciences

E-ISSN: 2267-1242

Subject area: (Earth and Planetary Sciences: General Earth and Planetary Sciences) (Energy: General Energy) (Environmental Science: General Environmental Science)

Source type: Conference Proceeding

View all documents >   Set document alert   Save to source list   Source Homepage

CiteScore 2021	
0.8	ⓘ

SJR 2021	
0.237	ⓘ

SNIP 2021	
0.364	ⓘ

CiteScore   CiteScore rank & trend   Scopus content coverage

ℹ️ Improved CiteScore methodology

CiteScore 2021 counts the citations received in 2018-2021 to articles, reviews, conference papers, book chapters and data papers published in 2018-2021, and divides this by the number of publications published in 2018-2021. Learn more >

CiteScore 2021 ▾

$$0.8 = \frac{19,869 \text{ Citations } 2018 - 2021}{25,181 \text{ Documents } 2018 - 2021}$$

Calculated on 05 May, 2022

CiteScoreTracker 2022 ⓘ

$$0.8 = \frac{17,582 \text{ Citations to date}}{21,482 \text{ Documents to date}}$$

Last updated on 06 June, 2022 • Updated monthly

CiteScore rank 2021 ⓘ

Category	Rank	Percentile
Earth and Planetary Sciences		
└ General Earth and Planetary Sciences	#142/191	25th
Energy		
└ General Energy	#54/68	21st
Environmental Science		
└ General Environmental Science	#183/228	19th

View CiteScore methodology >   CiteScore FAQ >   Add CiteScore to your site 🔗

Would you help us improve Scopus?

It will take just a few minutes.

Maybe later   Share your thoughts

IC-AMME
INTERNATIONAL CONFERENCE
ON AUTOMOTIVE, MANUFACTURING,
AND MECHANICAL ENGINEERING

CONTINUING
EDUCATION
CENTRE

Certificate

awarded to

Juliana Anggono

for participation as

Presenter & Participant

at 1st annual IC-AMME 2018
International Conference on Automotive,
Manufacturing, and Mechanical Engineering

September 26 - 28, 2018
Holiday Inn Resort Baruna Bali
Bali - Indonesia

Dr. Didik Wahjudi, M.Sc., M.Eng.

Strategy to Improve Recycling Yield of Aluminium Cans

Victor Yuardi Risonarta[1], *Julian*a Anggono[2*], *Yosias* Michael Suhendra[2],
Setyo Nugrowibowo[3] and *Yahya* Jani[4]

[1]Department of Industrial Engineering, Darma Cendika Catholic University, Jl. Ir. Soekarno No. 201, Surabaya 60117, Indonesia
[2]Department of Mechanical Engineering, Petra Christian University, Jl. Siwalankerto No. 121–131, Surabaya 60236, Indonesia
[3]Walisongo Gempol School of Technology, Jl. Raya Timur Pasar No. 09, Gempol, Pasuruan 67155, Indonesia
[4]Department of Biology and Environmental Science, Linnaeus University, Stuvaregatan 4 SE-392 31 Kalmar, Sweden

Abstract. Millions of canned drinks are consumed everyday globally and their wastes create an enviromental issue. Fortunately, the cans are made from aluminium (Al) so that it can be recycled. There are two main keypoints existing during the recycling process of Al cans, i.e. the aluminium loss or low Al-yield and low recycling yield. This work outlines the strategies to improve the recycling perfomance for Al beverage cans, i.e. by adding drossing flux, applying improved melting strategy, and cans decoating prior to melting. Drossing flux was added to assist the detachment of Al from the slag. Another improved melting strategy was worked out by decreasing exposure time cans to the furnace atmosphere during melting. All those above strategies result in an increase of recycle yield in a range of 4 % to 5 %.

Keywords: Aluminium alloy**,** beverage packaging, drossing flux, melting strategy

.

1 Introduction

Aluminium is the 3rd common used metal in the world and it is important metal for construction, automotive, airplane, and packaging industries. The construction of doors, windows, and facades, followed by walls and roofs is the main uses of aluminium in building. In automotive, aluminium is used as engine blocks, wheels, cylinder heads, gearboxes and many other automotive and engineering components. Aluminium also fits to be used as packaging of food and beverages due to its unique barrier and physical properties. Aluminium can effectively protects food and drink against the quality-reducing effects of oxygen, light, moisture, micro-organisms and unwanted aromas even in its thinnest form.

* Corresponding author: julianaa@petra.ac.id

Consumption of soda and beer in aluminium cans reaches 2×10^{11} cans every year [1]. If a can weighs 30×10^{-3} kg, thus 2×10^{11} cans provide 6×10^9 kg waste every year. This leads to growing environmental concerns of which is for the aluminium industry to be in a position to continue its growth while optimising its environmental performance. Recycling activity has to be boosted in order to conserve resources and to avoid littering.

From the enviromental point of view, aluminium recycling is not only beneficial due to reduction of aluminium waste but also due to its less energy consumption and greenhouse gas emission. Moreover, primary production of aluminium from bauxite is very energy intensive with the estimated energy consumption. Secondary aluminium production through recycling consumes much less energy, i.e. only 6 % of the energy consumption of primary aluminium production [2]. At present, around 1 % of the man made greenhouse comes from the aluminium industry. Recycling is an essential activity of sustained aluminium use, as more than a third of all the aluminium currently produced globally originates from old, traded and new scrap [3]. The use of old scrap, i.e. scrap from end of life products, is approximately 50 % of the scrap. If scrap is pre treated and/or sorted appropriately, the recycled aluminium can be utilised for almost all aluminium applications, thereby preserving raw materials and making considerable energy savings.

However, aluminium recycling experiences some challanges, i.e. aluminium oxidation which leads to aluminium loss as well as problem with purity of recycled aluminium. Carbon, silicon, and magnesium in steelmaking can be removed from liquid steel through oxygen blowing since oxidation of silicon and magnesium has more negative energy than ferrous oxidation. As a result, carbon goes to off-gas as CO or CO_2, silicon and magnesium go to slag as SiO_2 and MgO, respectively. In contrary, alloying elements in aluminium alloy, e.g. silicon and magnesium, are difficult to be removed from aluminium alloy. If oxygen is injected into liquid aluminium alloy, aluminium oxidizes prior to oxidation of silicon and magnesium since aluminium oxidation has more negative Gibbs free energy. Aluminium loss thus occurs. Due to this circumstance, recycled aluminium tends to be used as similar products in the process. For example, recycled aluminium cans will be reused as aluminium cans as well.

To avoid oxidation of aluminium, fluxing is one of the solutions. There are several flux types are commonly used in aluminium recycling, i.e. covering flux, drossing flux, and cleaning flux [4, 5]. Type of flux:
  (i)   Cover flux is used to protect surface of liquid aluminium from oxidation and hydrogen absorption.
 (ii)   Drossing flux is to separate trapped aluminium from oxides layer
(iii)   Cleaning flux is used to clean oxides from liquid aluminium.
(iv)   Furnace wall-cleaning flux prevents excessively formation of alumina on furnace wall.

In this study, drossing flux was used and its function to increase the recycling performance was evaluated.

2. Recycling procedure

2.1 Chemical composition

The beverage cans used in this study were from Sprite drink cans. The chemical composition of the can body and lid is different (Table 1). The body is made from alloy series 3 104 and the lid is from 5 052 [2, 6]. The magnesium content in the body is higher than in recycled cans lid can be reused as cans lid material while cans body can be reused as cans body material.

Table 1. Chemical composition of cans body and lid.

Part	Al	Mg	Mn	Fe
	[wt. %]			
Studied sample				
Body	93.75	4.82	0.27	0.26
Lid	96.46	2.53	0.33	0.32
From reference [2, 6]				
Body	95.20	0.80 to 1.30	0.80 to 1.40	0.80
Lid	97.80	2.20 to2.80	0.10	0.40

2.2 Melting preparation

Prior to melting, cans are decoated since decoated can since preliminary research work shows that decoated cans were predicted to deliver higher recycling yield higher compared to coated cans [7]. After decoating, the cans body and lid are separated. The cans body were prepared into two different forms; first one was by squashing them into thin products (approximately 0.03 m high) and second form was sectioning them into small pieces of 0.02 m × 0.02 m. Those forms were chosen to accelerate the melting process by shortening the contact duration between cans body and furnace atmosphere which results in less aluminum oxidation.

2.3 Crucible coating

To prevent iron diffusion to the aluminium melt, the inner wall of the steel crucible used in this work was coated prior to melting process (Figure 1). Iron diffusion to the aluminium should be prevented since iron deteriorates mechanical properties of aluminium alloys [3].

Fig. 1. Steel crucible coating.

2.4 Melting process

Melting of aluminium cans was worked out in an electric resistance furnace. The furnace temperature was set at 1 033.15 K. In this work, melting strategy used was creating hot heel of aluminium by melting the squashed body at first step. After that, the 0.02 m × 0.02 m aluminium sheets can be directly immersed in the hot heel when the molten aluminium (hot heel) is already available. This strategy was conducted to decrease contact duration between the cans and furnace atmosphere in order to prevent the aluminium oxidation in solid-state at temperature between 902.15 K and 923.15 K [8]. The formation of Al_2O_3 at temperature below melting temperature delivers difficulty since melting point of Al_2O_3 is 2 303.15 K which consumes very high energy to melt. For each experimental condition (Table 2), total aluminium cans used were 0.44 kg. Body or lid was charged into the furnace as three consecutive charges.

Table 2. Experiment condition in this work.

Experiment	Cans part	Decoating	Flux
1	Lid	Yes	No
2	Lid	Yes	Yes
3	Body	Yes	No
4	Body	Yes	Yes
5	Body	No	Yes

Meanwhile, the use of flux followed a particular procedure: 1×10^{-3} kg of flux containing NaCl and KCl was charged into the molten aluminium in three consecutive stages. The first flux was charged soon after the batch completely melted. The second charge was given after the last aluminum batch melted. Finally, the last one was charged afterward and the molten aluminium was put in hold for 6×10^2 s.

3 Result and discussion

3.1 Influence of drossing flux

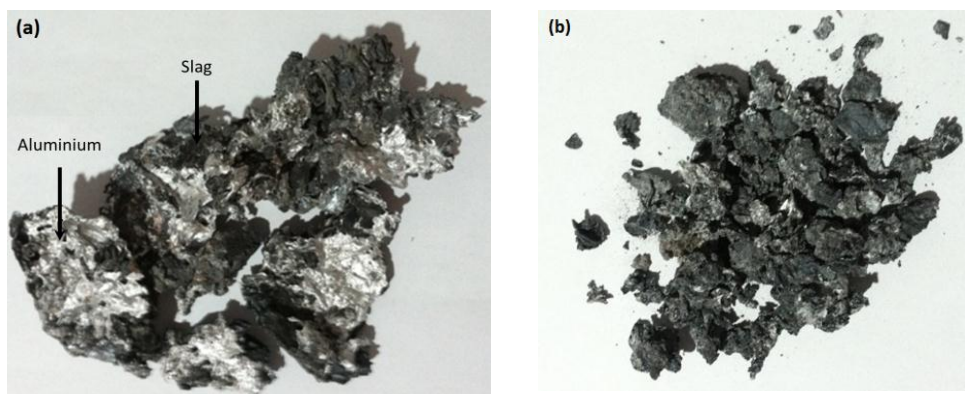**Fig. 2.** Slag without drossing flux (a) and with drossing flux (b).

From the experiment 1 and experiment 3, it was observed from the slag without drossing flux that some aluminium were adhered to the slag (Figure 2). The presence of this aluminium in slag leads to reduction of aluminium content in the melt. It can be seen on the photograph of the slag that the metallic (shiny) parts on the slag surface representing quite

significant amount the free aluminium in the slag. On the other hand, slag formation in experiment 2, exp. 4, and exp. 5 (with flux addition) shows almost no free aluminium sticking on the slag. Additionally, pouring of molten aluminium to cast the samples was easier when drossing flux was used. This leads to shorten tap to tap time which improves recycling productivity.

3.2 Recycling yield

Recycling yield ($Yield_{Recycle}$) in this work is defined as the ratio of total metal mass after melting (m_{tap}) compared with the input mass of aluminium cans ($m_{Cans,total}$) (Eq. 1).

$$Yield_{Recyxle} = \frac{m_{tap}}{m_{Cans,total}} \tag{1}$$

Cans recycling with drossing flux shows higher recycling yield (55.2 % to 59.1 %) than recycling without flux use (52.5 % to 54.7 %) (Table 3). Drossing flux increases the recycling yield of cans body 5 % higher than the yield obtained without drossing flux. The recycling yield of lid using drossing flux was also improved by 4.4 % higher compared with the process without drossing flux. Pirker et al. [9] also reported that NaCl and KCl increase recycle yield.

Table 3. Cans mass before and after recycling.

Experiment	$m_{Cans,total}$ [kg]	m_{tap}	Yield [%]
1	0.44	0.231	52.5
2	0.44	0.251	57.5
3	0.44	0.241	54.7
4	0.44	0.26	59.1
5	0.44	0.243	55.2

Meanwhile, decoating process performed on cans body was beneficial for improving the recycling yield. This strategy increased recycling yield by approximately 4 % higher than coated cans body. The coating used was made of inorganic pigment [10]. Exemplary pigments used in coating are titanium oxide (TiO_2), chromium oxide (Cr_2O_3), $ZnCrO_4$ or iron oxides (FeO, Fe_2O_3, Fe_3O_4) (Table 4). Gibbs free energy of these oxides formation is more positive than the formation of aluminium oxide (Al_2O_3). The Ellingham Diagram informs that oxides of other elements with less negative Gibbs energy, e.g. TiO_2, FeO, Cr_2O_3, transfer its oxygen to pure aluminium and creates Al_2O_3. This causes aluminium loss. Exemplary reactions causing aluminum loss are presented in Eq. 2 to Eq. 6.
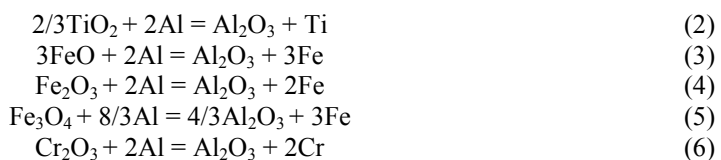
$$2/3TiO_2 + 2Al = Al_2O_3 + Ti \tag{2}$$
$$3FeO + 2Al = Al_2O_3 + 3Fe \tag{3}$$
$$Fe_2O_3 + 2Al = Al_2O_3 + 2Fe \tag{4}$$
$$Fe_3O_4 + 8/3Al = 4/3Al_2O_3 + 3Fe \tag{5}$$
$$Cr_2O_3 + 2Al = Al_2O_3 + 2Cr \tag{6}$$

Table 4. Inorganic substance used as coating pigment [10].

Substance	Chemical formula	Colour
Titanium dioxide	TiO_2	White
Ferrous oxides	FeO, Fe_2O_3, Fe_3O_4	yellow, red, brown, black
Chromium oxides	Cr_2O_3	green, blue
Zinc chromates	$ZnCrO_4$	Yellow
Carbon black	C	Black
Azurite	$Cu_3(CO_3)_2(OH)_2$	Blue

3.3 Chemical composition after recycling

Meanwhile, aluminium yield ($Yield_{Al}$) is defined as the ratio of aluminium mass after melting ($m_{Al,tap}$) compared to the input mass of aluminium ($m_{Al,i}$) (Eq. 7). The input mass of aluminium depends on each aluminium weight percent ($x_{Al,i}$) in cans body and lid (Eq. 8 and Eq. 9)

$$Yield_{Al,i} = \frac{m_{Al,tap}}{m_{Al,i}} \qquad (7)$$

$$m_{Al,body} = x_{Al,i}\, m_i \qquad (8)$$
$$m_{Al,lid} = x_{Al,i}\, m_i \qquad (9)$$

Where i = cans body or cans lid

Aluminium concentration after recycling of cans lid is higher than initial aluminium of cans lid (Table 5). Similar finding was identified with the aluminium content of recycling the cans body (Table 6). On the other hand, magnesium concentration after recycling of cans lid is slightly lower than the initial magnesium concentration. This condition occurs also on the recycling of cans body. In the Ellingham Diagram, magnesium oxidation shows more negative Gibbs free energy than aluminium oxidation. Thus, magnesium is more easily oxidized by the furnace atmosphere and also by oxides of other elements including Al_2O_3. Thus, the oxidized aluminium, both by furnace atmosphere and other oxides, may transfer its oxygen to magnesium resulting in magnesium loss. Exemplary reactions resulting magnesium loss are presented in Eq. 10 to Eq. 13.

$$TiO_2 + 2Mg = 2MgO + Ti \qquad (10)$$
$$FeO + Mg = MgO + Fe \qquad (11)$$
$$Cr_2O_3 + 3Mg = 3MgO + 2Cr \qquad (12)$$
$$Al_2O_3 + 3Mg = 3MgO + 2Al \qquad (13)$$

Tabel 5. Chemical composition of cans lid before and after recycling

Experiment	Al	Mg	Mn	Fe
	[wt. %]			
Initial	93.75	4.82	0.27	0.26
1	96.46	2.53	0.33	0.32
2	96.27	2.78	0.39	0.31

Tabel 6. Chemical composition of cans body before and after recycling

Experiment	Al	Mg	Mn	Fe
		[wt. %]		
Initial	96.61	1.21	0.73	0.69
3	97.19	0.95	0.63	0.58
4	97.28	0.83	0.66	0.57

4. Conclusion

Recycling is a key element for sustainable aluminium consumption. Besides reducing the amount of aluminum waste, aluminium recycling also delivers environmental benefit since aluminum recycling requires only 5 % of energy consumption of primary aluminum production. Strategies to improved aluminium recycling have been outlined in this work. Using of drossing flux increases recycling yield by 5 %. Due to thermal energy provided by exothermic reaction between drossing flux and aluminium metal sticking to slag, the slag temperature increases. This circumstance enables the sticking aluminium to detach from the slag. Additionally, de-coating of cans body can increase yield of aluminium recycling by 4 %. The coating contains inorganic pigments, such as Cr_2O_3 and TiO_2. They oxidize aluminium to form slag and this circumstance causes aluminium loss.

Reference

1. The World Counts. *We use a lot of aluminium*. [Online] from http://www.theworldcounts.com/counters/world_food_consumption_statistics/aluminium_cans_facts. (2014) [Accessed on 24 June 2018].
2. OECD global forum on environment focusing on sustainable materials management .p. 36-37 [Online] from http://www.oecd.org/environment/waste/46194971.pdf [Accessed on 1 June 2019].
3. R. Lumley. *Fundamentals of aluminium metallurgy*: *Production, processing and applications.* Sawston: Woodhead Publishing (2010). p. 71−73. https://www.elsevier.com/books/fundamentals-of-aluminium-metallurgy/lumley/978-1-84569-654-2
4. K.J. Friesen, T.A. Utigard. Coalescence behaviour of aluminum droplets under a molten salt flux cover, Light Metals (1997). p. 857−864. [Online] from https://www.researchgate.net/publication/289257624_Coalescence_behaviour_of_aluminum_droplets_under_a_molten_salt_flux_cover [Accessed on 1 June 2019].
5. R. Gallo, D. Neff. *Aluminum fluxes and fluxing practice. In ASM handbook volume 15 - casting*. Ohio: ASM International (2008). p. 230–239. https://app.knovel.com/web/toc.v/cid:kpASMHVC04/viewerType:toc/
6. United aluminum. *Chemical composition and properties of aluminum alloys.* [Online] from https://www.unitedaluminum.com/chemical-composition-and-properties-of-aluminum-alloys/. (2013) [Accessed on 24 June 2018].
7. P.A. Soetjipto, J.Anggono, V.Y. Risonarta. *Studi pengaruh cat serta pemisahan tutup dan badan kaleng minuman dalam proses peleburan pada kadar aluminium*. [The effect of paint and the separation of lids and beverage can bodies during melting process on the aluminium content], Mechanova Vol. 6. p. 1−4 (2017) [Online] from http://publication.petra.ac.id/index.php/teknik-mesin/article/viewFile/6879/6238 [Accessed on 1 June 2019] [in Bahasa Indonesia].
8. J. Anggono. *The influence of the morphology and size of aluminium powders on their oxidation behaviour.* In I. G. Antara, N. M. Dwidiani, A. Ghurri, & I. G. Karohika

(Eds.). Prosiding Seminar Nasional Tahunan Teknik Mesin IV, (Bali, Indonesia, 2005). Prosiding SNTTM **4**:135–139(2005).
https://www.researchgate.net/publication/43800802_The_Influence_of_the_Morphology_and_Size_of_Alumnium_Powders_on_Their_Oxidation_Behaviour

9. A. Pirker, H. Antrekowitsch, W. Fragner, H. Suppan, and M. Kettner. BHM Berg- und Hüttenmännische Monatshefte, **160**, 7:320–327(2015).
https://www.researchgate.net/publication/282540054_Optimization_of_the_Al-recycling_Process_for_Low_Grade_Scraps

10. J. Lakind. Can coatings for foods and beverages: Issues and options. International Journal of Technology Policy and Management. 13. 80. 10.1504/IJTPM.2013.050999. [Online] from
https://www.researchgate.net/publication/258109975_Can_coatings_for_foods_and_beverages_Issues_and_options. (2013). [Accessed on 1 June 2019].