4th Malaysia-Japan Tribology Symposium 2016 (MJTS 2016)

25th & 26th August 2016
Malaysia-Japan International Institute of Technology
Universiti Teknologi Malaysia
Kuala Lumpur, Malaysia

Organized by Tribology and Precision Machining i-Kohza (TriPreM)
In collaboration with Japanese Society of Tribologists (JAST) and Malaysian Tribology Society (MYTRIBOS)

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<table>
<tr><th>Day</th><th>Time</th><th colspan="2">Activities</th></tr>
<tr><td rowspan="14">Day 1 [25th Aug. 2016 (Thu.)]</td><td>09:00-09:30</td><td colspan="2">Registration</td></tr>
<tr><td>09:30-09:40</td><td colspan="2">Opening talk
Prof. Datin Dr. Rubiyah bt Yusof , Dean of Malaysia-Japan International Institute of Technology</td></tr>
<tr><td>09:40-10:00</td><td colspan="2">Introduction to Tribology
Dr. Nurin Wahidah binti Mohd Zulkifli, University of Malaya</td></tr>
<tr><td>10:00-11:00</td><td colspan="2">Keynote speech 1 (Different Facets of Tribology)
Prof. Dr. Salmiah Kasolang, Faculty of Mechanical Engineering, Universiti Teknologi MARA</td></tr>
<tr><td>11:00-12:00</td><td colspan="2">Keynote speech 2 (Sustainable Tribology)
Prof. Dr. Shinya Sasaki, Department of Mechanical Engineering, Tokyo University of Science</td></tr>
<tr><td>12:00-14:00</td><td colspan="2">Photo session and symposium lunch</td></tr>
<tr><td>14:00-14:45</td><td colspan="2">Invited speech 1 (Simulation Studies of Micro/Nano Tribology)
Prof. Dr. Hitoshi Washizu, Graduate school of simulation studies , University of Hyogo</td></tr>
<tr><td>14:45-15:30</td><td colspan="2">Invited speech 2 (Cutting Tool wear condition monitoring (TCM) and Dynamic Assisted Tooling for Turning process)
Prof. Dr. Jaharah A. Ghani, Department of Mechanical and Material Engineering, Universiti Kebangsaan Malaysia</td></tr>
<tr><td>15:30-16:00</td><td colspan="2">Coffee break</td></tr>
<tr><td colspan="3">General Session 1</td></tr>
<tr><td></td><td>Bio-Medical Tribology (Room A)
Session Chair: Assoc. Prof. Dr. Syahrullail bin Samion</td><td>Machining Technology (Room B)
Session Chair: Dr. Jun Ishimatsu</td></tr>
<tr><td>16:00-16:20</td><td>A - 1 - 1
Frictional Characteristics of Highly Hydrated Hydrogel Artificial Cartilage

Y. Sawae[1], R. Baba[2], Y. Hong[2], T. Yamaguchi[1], and T. Morita[1]

[1]Faculty of Engineering, Kyushu University, Japan
[1]Graduate School of Engineering, Kyushu University, Japan.</td><td>B - 1 - 1
Surface Roughness of Hyper-Eutectic Al-Si A390 In High Speed Milling

K. Othman[1], J. A. Ghani[2], C. H. C. Haron[2], and M. S. Kasim[3]

[1]Production Technology Department, German Malaysian Institute, Malaysia.
[2]Department of Mechanical and Material Engineering, Universiti Kebangsaan Malaysia, Malaysia.
[2]Department of Process,Universiti Teknikal Malaysia Melaka, Malaysia.</td></tr>
<tr><td>16:20-16:40</td><td>A - 1 - 2
Frictional Properties of Poly Vinyl Alcohol Hydrogel in Pseudo-Synovial Fluid Using A Pendulum-Type Friction Tester

C. Sawayama[1], T. Iwai[1], and Y. Syoukaku[1]

[1]Graduate School of Natural Science and Technology, Kanazawa University, Japan.</td><td>B - 1 - 2
Tribological Action and Cutting Performance of Lubricant Ester in MQL Machining

T. Wakabayashi[1]

[1]Kagawa University, Japan.</td></tr>
<tr><td>16:40-17:00</td><td>A - 1 - 3
Formation Process of Protein Film Adsorbed on Joint Prosthesis Material

K. Nakashima[1], S. Kudo[1], Y. Sawae[1], and T. Murakami[2]

[1]Kyushu University, Japan.
[2]Teikyo University, Japan.</td><td>B - 1 - 3
The Difference of Dimple Structures Fabricated using Turning and Milling Machines

M. N. A. B. Mohd Dali[1,2], J. A.Ghani[2], and C. H. C. Haron[2], and S. Hassan[1,2]

[1]Politeknik Ungku Omar, Malaysia.
[2]Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Malaysia.</td></tr>
</table>

Day	Time	Activities	
Day 2 [26th Aug. 2016 (Fri.)]		**General Session 2**	
		Composite Materials (Room A) Session Chair: Assoc. Prof. Dr. Tomoaki Iwai	**Fluid Lubrication (Room B)** Session Chair: Prof. Dr. Yoshinori Sawae
	09:00-09:20	**A - 2 -1** Effect of Stir Casting Process Parameters on Tribological Performance of Al6061-SiCp Composite A. A. Adebisi[1], M. A. Maleque[1], and K. A. Bello[1] *[1]Faculty of Engineering, Department of Manufacturing and Material Engineering, International Islamic University Malaysia, Malaysia.*	**B - 2 - 1** Tribological Performance Evaluation of Palm Trimethylolpropane (TMP) Ester as A Subsitute for Conventional Lubricant Base Oil R. Zahid[1,2], M. B. H. Hassan[1], M. Varman[1], R. A. Mufti[2], M. A. Kalam[1], N. W. B. M. Zulkifli[1], and M. Gulzar[1] *[1]Center for Energy Sciences, Department of Mechanical Engineering, University of Malaya, Malaysia.* *[2]School of Mechanical and Manufacturing Engineering, National University of Sciences and Technology, Pakistan.*
	09:20-09:40	**A - 2 - 2** The Influence of Friction Force on the Higher-Order Structure of Filled Rubber T. Iwai[1], K. Murata[1], and Y. Shoukaku[1] *[1]College of Science and Engineering, Kanazawa University, Japan.*	**B - 2 - 2** Performance Evaluation of Polyol Esters from Palm Oil as A Lubricant for Bentonite Suspension Drilling Fluid D. Kania[1], R. Yunus[1], R. Omar[1], S. A. Rashid[2], and B. M. Jan[3] *[1]Department of Chemical and Environmental Engineering, Universiti Putra Malaysia, Malaysia.* *[2]Institute of Advanced Technology, Universiti Putra Malaysia, Malaysia.* *[3]Department of Chemical Engineering, Faculty of Engineering, University of Malaya, Malaysia.*
	09:40-10:00	**A - 2 - 3** Bearing Load Capacity of A Palm Kernel Activated Carbon-Epoxy Composite D. N. F. Mahmud[1], , M. F. B. Abdollah[2], N. A. B. Masripan[2], F. F. Shuhimi[1], H. Amiruddina[2], and N. Tamaldina[2] *[1]Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka, Malaysia.* *[2]Centre for Advanced Research on Energy, Universiti Teknikal Malaysia Melaka, Malaysia.*	**B - 2 - 3** Vibration Characteristic on Ball Bearing Operated With Hexagonal Boron Nitride (HBN) Nanoparticle Mixed with Diesel Engine Oil N. S. R. Apandi[1], R. Ismail[1], M. F. B. Abdollah[1,2], and R. Ramlan[1] *[1]Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka, Malaysia.* *[2]Centre for Advanced Research on Energy, Universiti Teknikal Malaysia Melaka, Malaysia.*
	10:00-10:20	**A - 2 - 4** Lubricated Wear Behaviour of Sic Reinforcement on Ti-6Al-4V Alloy Based on Taguchi Approach M. A. Maleque[1], L. H. Paijan[1], K. A. Bello[1], and M. Azwan[1] *[1]Department of Manufacturing and Materials Engineering, International Islamic University Malaysia, Malaysia.*	**B - 2 -4** The Effect of Pure Aluminium Pin on Steel Disc with Varies Speed and Constant Load A. M. S. Zuan[1], S. Syahrullail[1], and S. M. Azhar[1] *[1]Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, Malaysia.*

Day	Time	Activities	
Day 2 [26th Aug. 2016 (Fri.)]	10:20-10:40	Coffee break	
		General Session 3	
		Coating Materials (Room A) Session Chair: Dr. Nurin Wahidah binti Mohd Zulkifli	**Fundamental (Room B)** Session Chair: Prof. Dr. Prof. Toshi Wakabayashi
	10:40-11:00	**A - 3 - 1** Tribological Behaviour of Surface Textured Hydrogenated Amorphous Carbon Coating in the Presence of PAO at Various Temperatures A. Arslan[1], H. H. Masjuki[1], M. A. Kalam[1], M. Varman[1], R. A. Mufti[2], M. H. Mosarof[1], and L. S. Khoung[1] *[1]Center of Energy Sciences, University of Malaya, Malaysia.* *[2]SMME, NUST, Islamabad, Pakistan.*	**B - 3 - 1** Tribological Properties of Plastic Materials Rubbed Against 6061-T6 Aluminum Alloy under High-Temperature Hydrogen Atmosphere T. Yasugi[1], T. Iwai[1], T. Ueda[1], and Y. Shoukaku[1] *[1-]Graduate School of Natural Science and Technology, Kanazawa University, Japan.*
	11:00-11:20	**A - 3 - 2** Friction Behavior of Polymer Overlays Containing Solid Lubricants Coated on the Micro-Textued Alminum Substrate T. Doi[1], K. Enomoto[2], and H. Usami[2] *[1]Division of materials science and engineering, Graduate school of Meijo University, Japan.* *[2]Department of materials science and engineering, Meijo University, Japan.*	**B- 3 - 2** Analysis on the Early Stage of Contact Adhesion in Different Relative Humidity Z. A. Subhi[1], and K. Fukuda1 *[1]Department of Mechanical Precision Engineering, Malaysia Japan International Instiute of Technology, Universiti Teknologi Malaysia, Malaysia.*
	11:20-11:40	**A - 3 - 3** Dry Sliding Wear Characterization of TIG Embedded Composite Coatings using Taguchi Based Grey Relational Analysis Approach K. A. Bello[1,2], M. A. Maleque[1,2], and A. Adebisi[1] *[1]Department of Manufacturing and Materials Engineering, International Islamic University Malaysia, Malaysia.* *[2]Department of Metallurgical and Materials Engineering, Ahmadu Bello University Zaria, Nigeria.*	**B - 3 - 3** Effects of Sliding Speed on Friction and Wear of Carbon Fiber Filled PTFE in Hydrogen T. Morita[1,2], Y. Abe[3], Y. Sawae[1,2], and J. Sugimura[1,2,4] *[1]Faculty of Engineering, Kyushu University, Japan.* *[2]International Institute for Carbon-Neutral Energy Research, Kyushu University, Japan.* *[3]Graduate School of Engineering, Kyushu University, Japan.* *[4]Research Center for Hydrogen Industrial Use and Strage, Kyushu University, Japan.*
	11:40-12:00		**B - 3 - 4** Time Dependent Change of Water Adsorption on Austenitic Stainless Steel N. D. A. Manaf[1], K. Fukuda[1], Z. A. Subhi[1], and M. F. M. Radzi[1] *[1]Department of Mechanical Precision Engineering, Malaysia Japan International Instiute of Technology,Universiti Teknologi Malaysia, Malaysia.*
	12:00-13:00	Lunch	

MJTS 2016 Proceedings Book

Table of Content

EFFECT OF STIR CASTING PROCESS PARAMETERS ON TRIBOLOGICAL PERFORMANCE OF Al6061-SiC$_p$ COMPOSITE

A. A. Adebisi [1], M. A. Maleque [1], and K. A. Bello [1]

[1]*International Islamic University Malaysia,*
Faculty of Engineering, Department of Manufacturing and Material Engineering,
53100 Kuala Lumpur, Selangor, Malaysia.

1. ABSTRACT

In this study, the tribological performance of Al6061-SiC$_p$ composite is investigated considering the influence of stir casting process parameters. The wear and frictional characteristics were studied using the dry reciprocating wear testing machine. Experimentation is generated through the central composite design (CCD) using a four factor five level design plan. The process parameters (reinforcement fraction *wt%*, stirring speed *rpm*, processing temperature *°C* and processing time *s*) are examined using ANOVA and multiple objective optimization (MOO) analysis. The result shows that stirring speed has the most significant contribution in controlling the wear and friction characteristics. Confirmation test is also conducted to verify and validate the process parameters in order to optimize the tribological output. Moreover, characterization of the composite wear scar mechanism is performed using scanning electron microscope. This study provides an effective method of minimizing the tribological properties of Al6061-SiC$_p$ composite by optimizing the stir casting process parameters.

2. INTRODUCTION

The demand for superior performance and light weight materials for tribological applications in the automotive and aerospace industries has led to the development of advanced materials. Due to these requirements, metal matrix composite (MMC) have become attractive and are increasingly preferred over monolithic materials due to their high strength to weight ratio, toughness and tribological characteristics [1]. As a result, aluminium based particulate reinforced MMC has attracted much attention by researchers owing to its low density, high thermal conductivity, low melting point and the ability to be reinforced by a wide variety of reinforcement phases [2]. Moreover, numerous processing technique such as powder metallurgy, squeeze casting, liquid infiltration and stir casting can be employed in developing MMC. However, studies [3] have shown that stir casting process possesses a simple and cost effective route to fabricate particulate reinforced composite. With this, achieving optimal AMC properties has been major challenge due to the influence of several processing factors considered.

As a result, it is of utmost necessity to consider the simultaneously interaction of these factors. This is because when two or more factors are investigated together, the effect of one factor on response depends on the level of the other factor. CCD has been a preferred method because it is a very efficient method to reduce the number of experiments with a large number of factors and levels. It provides high quality predictions in studying linear, quadratic and interaction effects of factors influencing the response [4]. It is also capable of achieving optimum conditions required to attain the best characteristic properties. Most studies conducted with experimental design are conducted using powder metallurgy route, however very limited report have been made on stir casting technique with CCD.Therefore, the aim of this study is to utilize the CCD to achieve optimal tribological performance of Al6061-SiC$_p$ composite. Crucial parameters considered for the stir casting process include the reinforcement fraction *wt%*, stirring speed *rpm*, processing temperature *°C* as well as the processing time *s*.

3. METHODOLOGY

The CCD of response surface methodology (RSM) accommodates five levels of each factors comprising of factorial, axial and center points as shown in Table 1

Table 1 Factors and levels in CCD plan

Factors	Levels				
	-2	-1	0	+1	+2
RF: Reinforcement fraction *(wt %)*	5	10	15	20	25
SS: Stirring speed *(rpm)*	200	300	400	500	600
PT_{emp}: Processing temperature *(°C)*	700	750	800	850	900
PT: Processing time *(secs)*	60	90	120	150	180

Wear test is conducted with a dry reciprocating wear and friction monitor according to ASTM D 6079-97/EN 590. The test utilized an applied load of 50 *N* at 600 *rpm* for 30 *mins* for each of the cast AMC from the design plan. The wear characteristics is calculated as expressed in the eq. (1):

$$w_r = \frac{\Delta m}{\rho t} \quad (1)$$

Δm = mass loss, ρ = density, t = time

4. RESULTS AND DISCUSSION

According to ANOVA, the response (wear rate w_r and friction coefficient μ) output indicates a quadratic relationship based on regression analysis with the processing factors. The tribological performance models suggested are dependent on the significant terms with p values < 0.05. To improve the model and also optimize the results insignificant terms are eliminated. The fitness and adequacy of the tribological output (w_r = 0.19, μ = 0.15) is confirmed by ensuring the R^2_{pred} and R^2_{adj} has a difference of < 0.2. The factor with the most influencing impact in order of importance on w_r are SS, PT_{emp} and RF. Fig. 1 shows the 3D surface plot of the process parameters interaction on w_r. Fig. 1(a) depicts the influence of SS and PT_{emp} which achieved a minimum w_r of 1.21 x 10^{-5} *mm³/min* at 530 *rpm* and 825 *°C*. Also, Fig 1(b) shows that SS and RF which attained minimum w_r of 1.22 x 10^{-5} *mm³/min* at 520 *rpm* and 16 *wt%*.

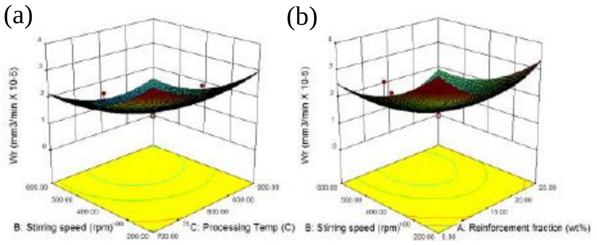


Fig. 1 3D surface plot of w_r performance considering (a) SS and PT_{emp} (b) SS and RF

For μ, SS and RF are the only factors which influences the ouput performance. Stable μ (0.39-0.41) is attained within the range of 500-540 *rpm* and 13-18 *wt%* respectively as shown in Fig. 2.

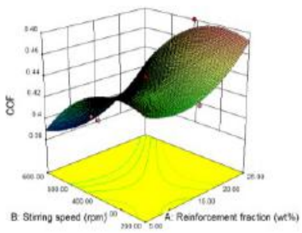


Fig. 2 3D surface plot of w_r performance for SS and RF.

In optimization analysis, the condition required is to minimize the w_r and μ properties. Therefore, the MOO is used to achieve a set of process factors which simultaneously optimizes the tribological performance. Table 2 shows the optimal generated desirability of the response with solution No. 1 selected as the predicted optimal by 84 % desirability.

Table 2: Optimal solution generated for response

RF	SS	PT_{emp}	PT	w_r	μ	Desir.	
14.283	*500.000*	*827.747*	*150.000*	*0.974*	*0.405*	*0.838*	*Selected*
14.300	499.999	828.556	150.000	0.974	0.405	0.838	
14.240	500.000	828.217	150.000	0.976	0.405	0.838	

Confirmation test were conducted three times to validate the predicted optimal process parameters in order to verify the MOO analysis. Fig. 3 shows that the percentage error of the response (w_r, μ) are within the range of 1.2 to 3.5%. The topography of the worn surface is characterized as relatively smooth mild wear without formation of cracks and craters. Also, the formation of oxide layer on the wear surface is represented as a brownish dark layer on AMC sample. However, it is viewed as the whitish scale profile as seen in Fig. 4 (a).

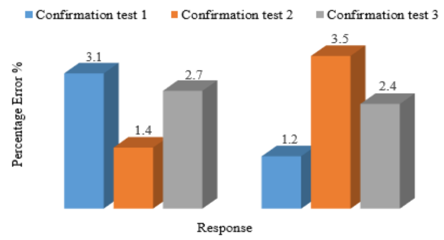
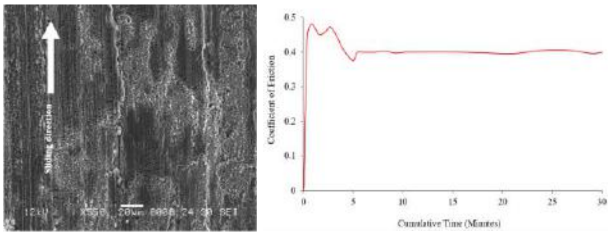


Fig. 3 Percentage error analysis between predicted and actual response



(a) (b)

Fig. 4 (a) Wear surface morphology and (b) frictional performance for optimized Al6061-SiC_p composite

This layer serves as a protective surface which improves the abrasion and adhesive resistance. Moreover, the layer acts as a coating shield protecting against excessive wear and also stabilizes frictional performance as shown in Fig. 4(b).

5. CONCLUSIONS

The optimum input process factor that achieved optimized tribological performance of Al6061-SiC_p composite are 14 *wt%* RF, 500 *rpm* SS, 828 *°C* PT_{emp} and 150 *s* PT. These conditions achieved a w_r of 0.974 x 10^{-5} *mm³/min* and μ of 0.41 with a desirability value of 84%.

6. REFERENCES

[1] A. A. Adebisi, M. A. Maleque and M. Y. Ali, “Wear characteristics of multiple particle size silicon carbide reinforced aluminium composite,” *Adv. Mater. Res.*, Vol. 1115, pp. 174-177, 2015.
[2] Hariprasad T, Varatharajan K, Ravi S., “Wear characteristics of B_4C and Al_2O_3 reinforced with Al-5083 metal matrix based hybrid composite,” *Procedia Eng*, Vol. 97, pp. 925-929, 2015.
[3] Sozhamannan G.G., Balasivanandha S.P, “Effect of processing parameters on metal matrix composites: stir casting process,” *J Surf Eng Mater Adv Technol*, Vol. 2, pp. 11-15, 2012.
[4] Suresh S., Moorthi N.S.V., Vettivel S., Selvakumar N., “Mechanical behavior and wear prediction of stir cast Al–TiB_2 composites using response surface methodology,” *Mater. and Des*, Vol. 59, pp. 383-396, 2014.