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Tribotechnics and tribomechanics – wear resistance

EFFECTS OF SILICON (Si) AND ZINC (Zn) ADDITION ON MACHINABILITY AND WEAR RESISTANCE BEHAVIOURS OF AZ21 AND AS21 MAGNESIUM ALLOYS

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ABSTRACT

This study investigates the effect of zinc (Zn) and silicon (Si) in AZ91 (2% Al, 1% Zn) and AS21 (2% Al, 1% Si) magnesium alloys on wear resistance and machinability. In magnesium alloys, the effect of hardness, wear resistance and machinability was investigated by establishing the impact of 1% zinc (in AZ21) and 1% silicon (in AS21) within the microstructure in AZ21 and AS21 alloys with aluminum amount less than 3%. It was found that the intermetallic phases found in the microstructure within the alloy had an effect on hardness, wear resistance and machinability.

Keywords: machinability, cutting force, weir, magnesium alloys, AZ21, A21.

AIMS AND BACKGROUND

Magnesium and alloys have many areas of use thanks to their mechanical, physical and chemical properties. Especially due to the fact that being among the lightest structure metals in addition to their low density and high resistance characteristics, magnesium alloys find many areas of use predominantly in logistics, automotive, and aviation sectors[1–3]. For this reason, magnesium alloys with various alloy properties are prepared and studies are being carried out on improving such characteristics of these alloys as mechanical properties, hardness, and wear[4,5].

Another significant property of magnesium alloys is that it is among construction metals with ease of machinability[6–8]. However, the most important risk in machining magnesium alloys is the presence of combustion and burning potential at higher cutting speeds. It may be noted that such possibility may increase especially in finishing operation and high cutting speeds. Risk of combustion rises in the event of magnesium alloys reaching 600°C which is the melting point of fine chips[6]. Especially in certain magnesium alloys, Flank Build-up (FBU) formation on the cutting surface during machining with cemented carbide tools was reported at higher cutting speeds, under dry machining conditions[6,8,9]. FBU formation was also reported to facilitate the occurrence of combustion/burning[6,10]. The reason why FBU is formed in certain alloys has not yet been completely clarified with systematic investigations. FBU formation is believed to correlate with components of alloys. However, a systematic study is not present on the issue. Our study on the machinability of AZ series magnesium alloys might be a resource[11].

Studies conducted on alloy properties affecting the improvement of wear characteristics of magnesium alloys and their correlation with machinability are quite low in number and insufficient. The use of magnesium alloys in engine, piston, and cylinders especially in automotive sector is in the process of development depending on investigating such characteristics as hardness, wear resistance, and machinability. It is known that wear resistance is closely related with tensile properties of the material. Wear can be defined as resistance of metal against friction in its most basic sense. Today, the most commonly used Mg–Al (magnesium–aluminum) alloys are AZ21 and AS21 alloys. The most significant properties of these alloys are their well castability and improved tensile properties.

This study investigates the effect of Zn (zinc) and Si (silicon) in AZ21 and AS21 magnesium alloys on wear resistance and machinability, and also the effects on hardness, wear resistance, and machinability depending on microstructure in AZ21 and AS21 containing 1% Zn and 1% Si. The effects of alloy components in magnesium alloys on microstructure and FBU formation and the resulting effect of all this on machinability were also investigated.

EXPERIMENTAL

Mechanical (hardness, wear) and microstructural properties. The most common magnesium alloys AZ21 and AS21 were used in this study. These alloys were obtained by melting in specially designed atmosphere-controlled melting furnace (750°C) by method of casting into metal moulds (preheated to 250°C). As a protective gas, protective SF6 was used during casting. Samples was 26 mm in diameter and 200 mm in length. The chemical compositions of the alloys were determined by a Spectrolab M8 Optical Emission Spectrometry (OES). Detailed information on casting methods of magnesium alloys was provided in a study by Unal[12]. Components of alloys used in the study are given in Table 1. Lateron, microstructure examination, hardness, and wear tests were carried out on samples obtained by casting method.

Surfaces of samples prepared in 15 mm diameter and 12 mm thickness and used in microstructure examinations of alloys were cleaned by sanding (emery

Table. 1. Chemical composition of the studied AZ21 and AS21 alloys (wt.%, 'A' refers to Al content, 'Z' refers to Zn and 'S' refers to Si content of the alloy)

Alloys	Al (%)	Mn (%)	Zn (%)	Si (%)	Fe (%)	Mg (%)
AZ21	2.0	0.13	1.3	0.08	0.02	rest
AS21	2.1	0.2	0.2	1.2	0.02	rest

papers from 200 up to 1200 grits were used). Then, the surfaces of samples were polished by diamond paste of 6, 3 and 1 µm, respectively. Following polishing process, the surfaces of samples were etched in a specially prepared solution (contents: 100 ml ethanol, 5 ml acetic acid, 6 g picric acid, and 10 ml water) and thus, microstructure images were obtained (Nikon Eclipse LV150). X-ray diffraction (XRD) analyses (Panalytical–Empyrean) were carried out under Cu Kα radiation with an incidence beam angle of 2°.

Test data on mean hardness values of alloys used in the study were obtained (Shimadzu HMV-2). Wear tests of experimental samples (15 mm in diameter and 12 mm in thickness) were carried out on a pin-on disk test device (Tribotester TM, Clichy) (Fig. 1). At the end of wear experiment, sizes of marks left on sample surfaces were measured and thus wear resistances of samples were estimated. Wear tests were performed on a reciprocating wear tester under a load of 4 N. Al_2O_3 balls having a 6 mm diameter rubbed on the surfaces of the samples with a sliding speed of 5 mm/s. The stroke of the Al_2O_3 balls was 5 mm for a total sliding distance of 25 m. Wear test samples were 15 mm in diameter and 10 mm in length. The coefficient of friction and frictional force were continuously recorded throughout the wear tests. Contact surfaces of the samples were examined using a surface profilometer (Dektak TM 6 M). Wear test experiment is given in Fig. 1.

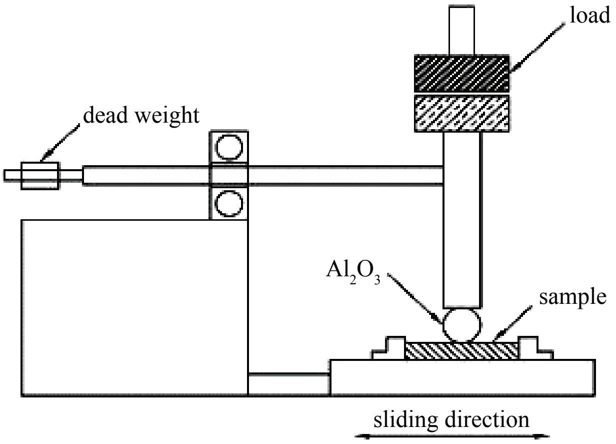
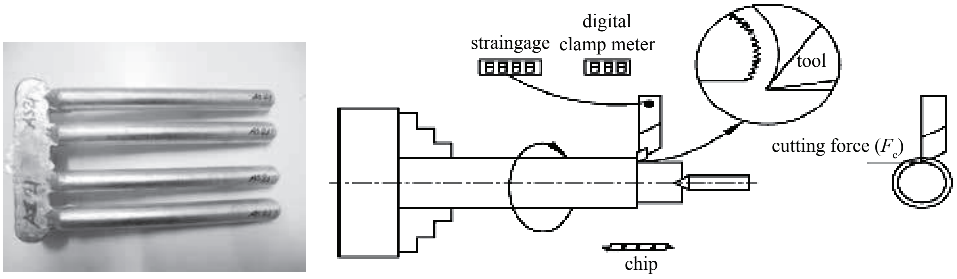


Fig. 1. Schematic view of the reciprocating wear tester utilised in this study

Machining properties. This study investigated the machinability of alloys by obtaining data on cutting forces by keeping the chip section fixed at various cutting forces on AZ21 and AS21 magnesium alloys acquired through casting method (Fig. 2*a*). Data on cutting forces were obtained under dry machining conditions and vertical processing method. Machining tests were carried out by turning process in a DMG CTX Alpha 300 CNC lathe machine. Polycrystalline Diamond (PCD) (CCGT 120408 FL K10) was used as the cutting edge. Data on cutting forces were obtained from specially-designed strain gauge (Fig. 2*b*). Surface roughness values of sample surfaces were measured with a Time-TR200 device. Machining parameters used in the study are given in Table 2.



a *b*

Fig. 2. Samples obtained by casting method in the study (*a*) and schematic representation of experimental set-up with strain (*b*)

Table. 2. Machining parameters and conditions used during the test

<table>
<tr><th colspan="2">Parameters and conditions</th></tr>
<tr><td>Operations</td><td>: Turning</td></tr>
<tr><td>Feedrate (f, mm/rev.)</td><td>: 0.10 (constantly)</td></tr>
<tr><td>Depth of cut (DoC, mm)</td><td>: 1.0</td></tr>
<tr><td>Cutting speed (V_c, m/min)</td><td>: 56, 112, 168</td></tr>
<tr><td>Cutting conditions and lubricant-coolant</td><td>: orthogonal and dry cutting</td></tr>
<tr><td>Workpiece materials</td><td>: AZ21 and AS21</td></tr>
<tr><td>Cutting tool properties</td><td>: CCGT 120408 FL K10
<table>
<tr><td>α</td><td>γ</td><td>λ</td><td>ε</td><td>κ</td><td>r_ε</td></tr>
<tr><td>7°</td><td>5°</td><td>0°</td><td>80°</td><td>50°</td><td>0.8 mm</td></tr>
</table></td></tr>
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RESULTS AND DISCUSSION

Microstructural, XRD and mechanical (hardness and wear) properties. Microstructure photographs and XRD patterns of AZ21 and AS21 magnesium alloys used in the study are given in Figs 3 and 4. Microstructure of magnesium alloys analysed in the study was generally observed to be made up of α-Mg matrix and $Mg_{17}Al_{12}$ and Mg_2Si intermetallic phases. In AZ series magnesium alloys, the fact that β intermetallic phase within the microstructure ($Mg_{17}Al_{12}$) occurred in the form of network within the scope of α-Mg matrix was reported in some studies[11,13,14]. In AS series magnesium alloys, the fact that Mg_2Si intermetallic phase was observed in the form of Chinese characters within the microstructure was already known through literature[14]. It was reported in literature that the forma-

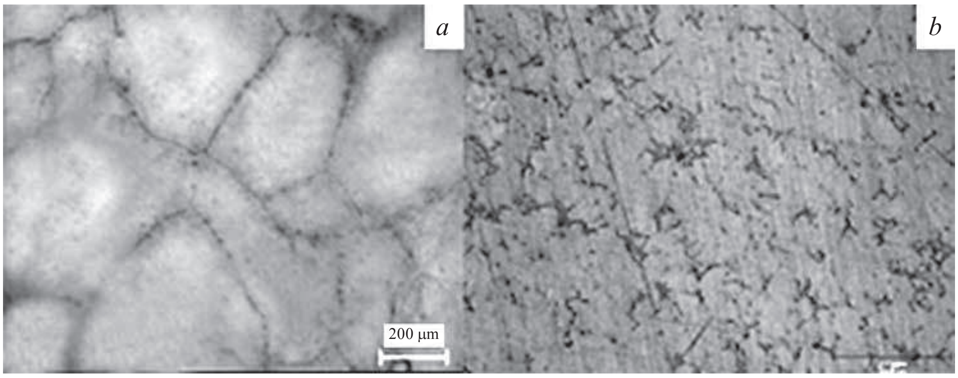


Fig. 3. Optical micrographs of AZ21 (*a*) and AS21 series magnesium alloys (*b*)

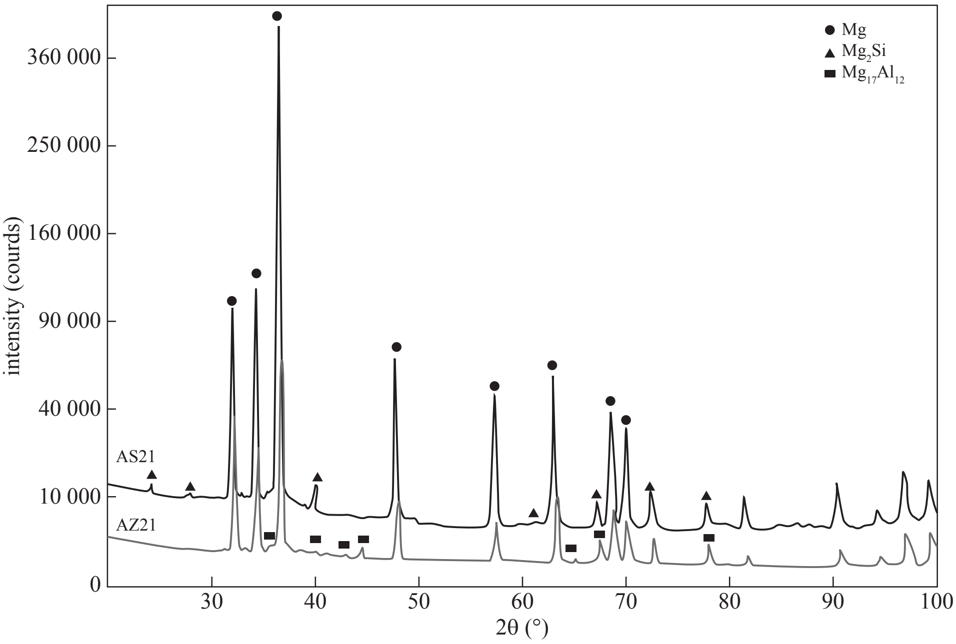


Fig. 4. XRD patterns of AZ21 and AS21 magnesium alloys

tion of β intermetallic phases within the microstructure ($Mg_{17}Al_{12}$ and Mg_2Si) was correlated with the Al% amount in the alloy. β intermetallic phases were reported to become clear along with the increase in Al amount to above 3% in alloy[6,11]. It was reported in previous studies that the formation, appearance and shape of intermetallic phases in magnesium alloys shifted depending on changes in the alloy components and in the solidification behaviour[5,14–17]. It is seen in Fig. 3 that β intermetallic phases in microstructure of AZ21 and AS21 alloys were not observed and did not occur in a completely apparent manner. Microstructure images and XRD pattern data obtained in this study are in concordance with literature.

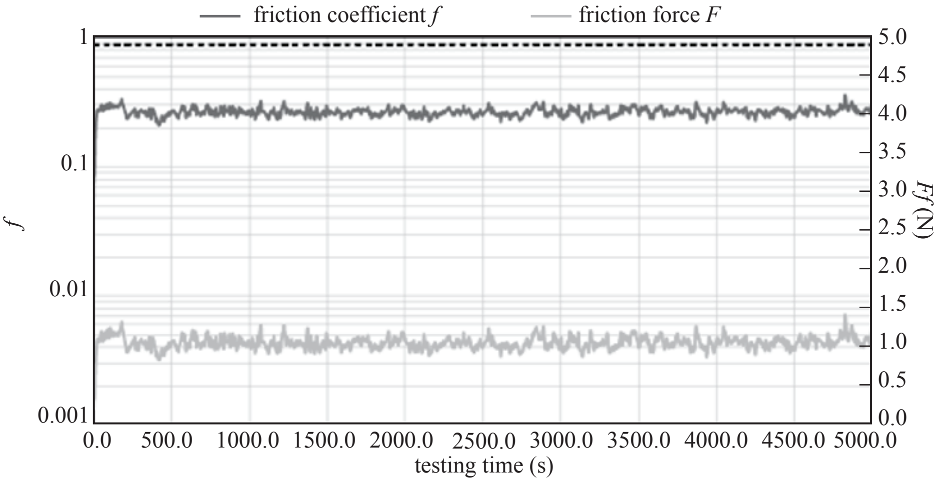
Hardness and wear values of the analysed AZ21 and AS21 alloys are given in Table 3. When checked the mean hardness values of alloys, these were estimated to be 47 HV10 in AZ21 alloy and 49 HV10 in AS91 alloy. It was observed from the hardness tests that AS21 alloy demonstrated a higher hardness property compared to AZ21 alloy. The fact that AS91 demonstrated a higher hardness property resulted from the Mg_2Si phase found in the microstructure.

Table. 3. AZ21 and AS21 hardness and relative wear resistance

	AZ21	AS21
Hardness test results		
Hardness (HV_{10})	47	49
Wear test results		
Relative wear resistance (RWR)	1.00	1.48
Friction coefficient (mean)	0.26	0.26

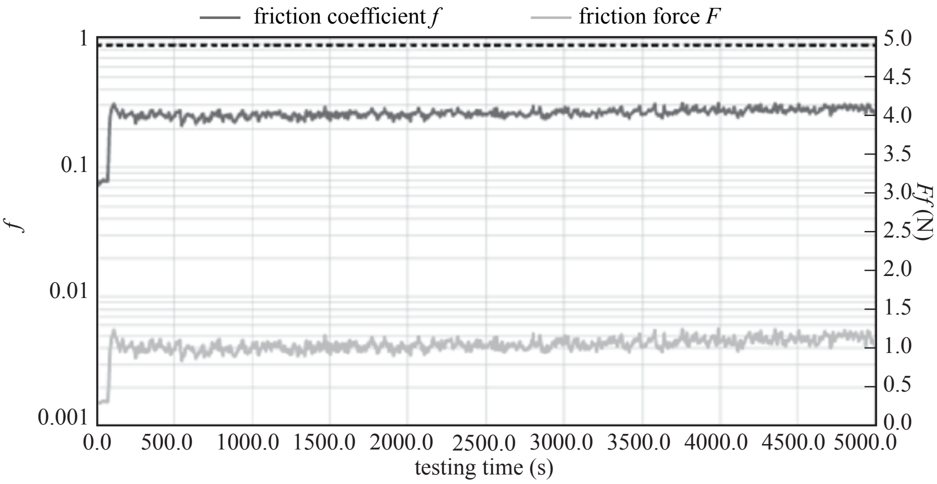
Based on the data obtained from wear tests, the presence of Mg_2Si intermetallic phase in AS21 alloy microstructure provided the demonstration of a higher wear resistance at a rate of 48% compared to AS21 alloy. According to this, it was observed that the Mg_2Si intermetallic phase that occurred due to the effect/presence of Si in AS21 alloy increased wear resistance compared to $Mg_{17}Al_{12}$ intermetallic phase formed due to the effect/presence of Zn in AZ21 alloy. A significant difference was not found between the alloy friction coefficients of these two alloys (AZ21, AS21) (Fig. 5). The reason for AS21 alloy to demonstrate a higher hardness and wear resistance compared to AZ21 alloy was due to Mg_2Si intermetallic phase found in the microstructure. When analysed the correlation between wear resistance and hardness in the experimental study, wear resistance was observed to increase depending on hardness (Table 3). From this point of view, Mg_2Si intermetallic phase found in AS21 alloy was observed to have an impact on hardness and wear properties.

It was reported in previous studies that hardness and strength of alloy increased parallel to the rise in Al% amount in magnesium alloy. Microstructure images of intermetallic phases causing the increase in hardness and strength of



Friction coefficient: at start of test: *t* = 0.074; average: *t* = 0.265; minimum: *t* = 0.074; maximum: *t* = 0.355

a



Friction coefficient: at start of test: *t* = 0.079; average: *t* = 0.260; minimum: *t* = 0.072; maximum: *t* = 0.315

b

Fig. 5. AZ21 (*a*) and AS21 (*b*) friction coefficient and friction force testing time

alloys and XRD patterns of alloys are given in Figs 3 and 4. Massive β intermetallic phases were reported in previous studies to appear along with the increase in Al amount to above 3% in alloy[11]. It was observed that these intermetallic phases within microstructure affected the mechanical properties of the alloy.

Machining properties. In the turning processes of AZ21 and AS21 experimental samples used in the experimental study, data obtained as a result of applications conducted by keeping chip sections fixed are given in Fig. 6. The highest cutting

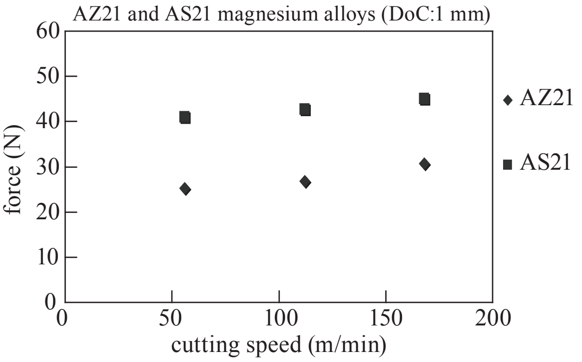


Fig. 6. Relationship between cutting forces and alloy compositions of AZ21 and AS21 series magnesium alloys (DoC: 1 mm, *f*: 0.10 mm/rev.)

force in AS21 alloy was obtained as 45.2 N at a cutting speed of V_c:168 m/min, and as 30.6 N in AZ21 alloy; the lowest cutting force value was 40.9 N in AS21 and 25.5 N in AZ21 at a cutting speed of 56 m/min. It was observed at 3 different cutting speeds selected in the experiment that cutting forces occurred during machining of AS21 alloy was higher compared to cutting forces occurred during machining of AZ21 alloy. An increase was observed in cutting forces (with chip section fixed) due to a rise in cutting speed in machining both alloys (AS21 and AZ21 alloys (Fig. 6). When compared the cutting forces formed during the machining of the two alloys, the highest cutting force value was obtained from AS21 alloy (Fig. 6). From this point of view, it may be noted that the increase in cutting forces depending on cutting speed could occur due to dislocation build-up with chips in cutting edge. It was observed that that the Mg_2Si intermetallic phase found in the microstructure of AS21 alloy compared to $Mg_{17}Al_{12}$ intermetallic phase in AZ21 alloy was more effective, and that it caused cutting forces to increase during machining along with rising the hardness and wear resistance of the alloy. This, as a result, reduces the machinability of alloy.

Values of surface roughness that occur by machining AZ21 and AS21 magnesium alloys (at fixed chip section) are given in Fig. 7. Both alloys were observed to have an increase in surface roughness as the cutting speed rises. It was ob-

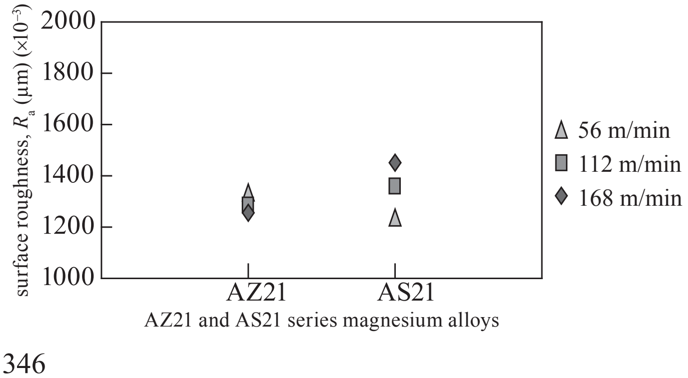


Fig. 7. Relationship between surface roughness and cutting speeds of AZ21 and AS21 series magnesium alloys (DoC:1 mm)

served that the surface roughness values obtained from AS21 alloy were higher compared to surface roughness values from AZ21 alloy. It may be noted that intermetallic phases that occurred due to Zn and Si effect/presence (Mg_2Si and $Mg_{17}Al_{12}$) in the alloy had an impact on the formation of surface roughness values. It was observed that the surface roughness especially of AS21 alloy increased depending on the rise in cutting speed.

Flank Build-up (FBU) formation increases depending on the rise in Al amount and cutting speed. The formation of $Mg_{17}Al_{12}$ β intermetallic phase in AZ91 alloy and its effect on FBU formation were reported[11]. It is known that β intermetallic phase within the structure is correlated with Al amount and that β intermetallic phase increases along with the rise in Al% amount. Also it is known that this increased FBU formation has an impact on the rise in surface roughness and tool wear.

Images on cutting edge surfaces with AZ21 and AS21 magnesium alloys are given in Fig. 8, and chip images obtained from the alloys are shown in Fig. 9. Regarding such wear occurring on cutting edge surfaces; it was observed that cutting edges were worn due to dry friction formed between work piece and cutting surface during the machining of the alloy. It was found that wear spread on a wider surface on cutting edge surface with which AS21 alloy was machined, and that more wear was established in the cutting edge. It was reported in previous studies that friction and temperature occurring here affected Flank Build-up (FBU) formation[3,6–9]. This wear was observed to be deeper in the cutting edge from AS21 and that chips advanced along chip angle on a narrower surface on cutting surface with which AZ21 alloys were machined (Fig. 8).

Images of chips (with fixed chip section) obtained from machining AZ21 and AS21 series magnesium alloys are given in Fig. 9. When analysed the chip images, it was observed that chips formed from AZ21 alloy were longer compared to chips from AS21. Chips from AS21 were found to be firmer and in an overlapping helical form[6,18]. It may be noted that chips from AS91 alloy were smaller in length and occurred as a result of brittle breaks due to the effect of Mg_2Si intermetallic phase, and in AZ21 alloy, chips were longer and formed as a result of ductile breaks due to

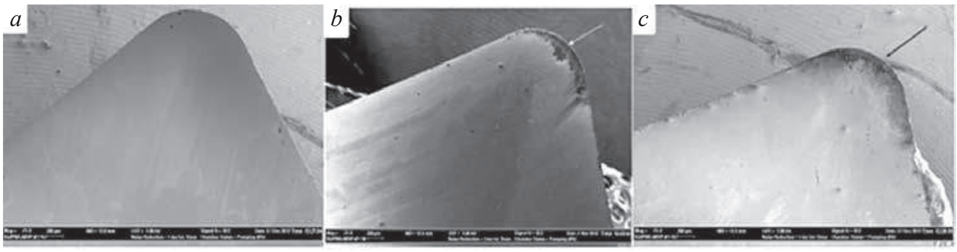


Fig. 8. SEM image of cutting tool tip used for machining of unused (*a*), AZ21 (*b*) and AS21 series magnesium alloys (*c*) (V_c: 168 m/min, DoC : 1 mm, f: 0.10 mm/rev.)

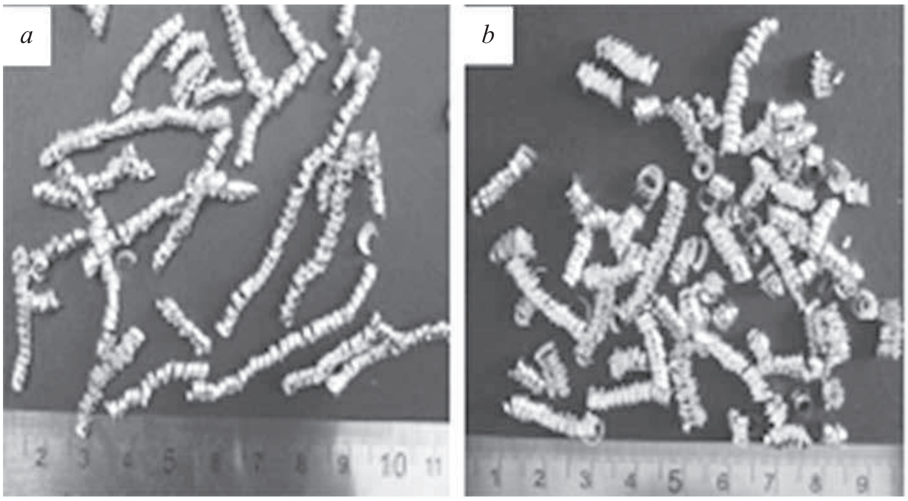


Fig. 9. Chip formation of AZ21 (*a*) and AS21 (*b*) series magnesium alloys (V_c : 168 m/min, DoC : 1 mm, f : 0.10 mm/rev.)

the effect of Mg_2Si intermetallic phase (Fig. 9). In both alloys, chip formations were observed to occur due to intermetallic phases thanks to Zn and Si effect/presence (Mg_2Si and $Mg_{17}Al_{12}$) found in the alloy[6]. It may be mentioned that chips obtained from AS21 alloy were harder and more fragile compared to AZ21.

Moving from the experimental study, $Mg_{17}Al_{12}$ and Mg_2Si intermetallic phases occurred/found in the microstructure of AZ21 and AS21 alloys were observed to have an effect on cutting forces. Since the Mg_2Si intermetallic phase formed due to the effect/presence of Si in AS21 demonstrated a higher increasing effect on hardness and wear resistance of alloys compared to $Mg_{17}Al_{12}$ intermetallic phase formed due to the effect/presence of Zn in AZ21, it may be noted that this increased cutting forces and caused wear in cutting surfaces[7,18]. Flank Build-up (FBU) increase in the cutting surface between the cutting edge and sample surface due to intermetallic phases also causes a rise in cutting forces (Fig. 6). Flank Build-up (FBU) formation increases with friction and temperature rise occurring on the cutter surface due to an increase in cutting speed, and this may be noted to raise cutting forces[7,18]. Increase in cutting forces reduces the machinability of materials.

CONCLUSIONS

- Zn and Si found in the AZ21 and AS21 alloys that were investigated in this study were effective on hardness, wear resistance, and machinability of alloy in addition to having an impact on formation and type of intermetallic phases ($Mg_{17}Al_{12}$ and Mg_2Si) formed in the microstructure. It was observed that intermetallic phases had an increasing effect on hardness and wear resistance of magnesium alloys.

- It was found that the Mg_2Si intermetallic phase that occurred thanks to the effect/presence of Si in AS21 alloy increased wear resistance and hardness compared to $Mg_{17}Al_{12}$ intermetallic phase formed due to the effect/presence of Zn in AZ21 alloy. A significant difference was not found between the alloy friction coefficients of these two alloys (AZ21, AS21). The reason for AS21 alloy to demonstrate a higher hardness and wear resistance compared to AZ21 alloy was due to Mg_2Si intermetallic phase found in the microstructure.
- It was observed that that the Mg_2Si intermetallic phase found in the microstructure of AS21 alloy compared to $Mg_{17}Al_{12}$ intermetallic phase in AZ21 alloy was more effective, and that it caused cutting forces to increase during machining along with rising the hardness and wear resistance of the alloy. This, as a result, reduces the machinability of alloy.
- Both alloys were observed to have an increase in surface roughness as the cutting speed rises. It was observed that the surface roughness values obtained from AS21 alloy were higher compared to surface roughness values from AZ21 alloy.
- Despite the hardness and wear resistance of AS21 alloy were higher compared to AZ91 alloy, its machinability was lower compared to AZ21. The reason for this is that the Mg_2Si intermetallic phase found in the microstructure of AS21 alloy had an effect so as to increase wear resistance and hardness of the alloy. Intermetallic phase that increased hardness and wear resistance reduces the machinability of AS21 alloy.
- It was observed that chips formed from AZ21 alloy were longer compared to chips from AS21. Chips obtained from AS21 alloy were established as harder and more fragile compared to AZ21. Intermetallic phases ($Mg_{17}Al_{12}$ and Mg_2Si) were found to have an effect on chip formation.
- Intermetallic phases within the microstructure have an impact on cutting forces, FBU formation, and machinability. Cutting speed influences cutting forces reaching the cutting tool, surface roughness, and chip form.
- Hardness and wear resistance of AS21 alloy were found to be higher compared to AZ21 alloy. However, machinability of AZ21 was higher compared to AS21.

REFERENCES

1. H. E. FRIEDRICH, B. L. MORDIKE: Magnesium Technology. Springer-Verlag, Berlin–Heidelberg, 2006.
2. D. S. MEHTA, S. H. MASOOD, W. Q. SONG: Investigation of Wear Properties of Magnesium and Aluminum Alloys for Automotive Applications. J Mater Process Tech, **155–156**, 1526 (2004).

3. H. K. TONSHOFF, B. DENKENA, R. J. WİNKLER, C. PODOLSKY: Machining, Magnesium Technology, Metallurgy, Design Data, Applications (Eds H. E. Friedrich, B. L. Mordike). Springer-Verlag, Berlin–Heidelberg, 2006, p. 398.
4. A. SRINIVASAN, K. K. AJITHKUMAR, J. SWAMINATHAN, U. T. S. PILLAI, B. C. PAI: Creep Behavior of AZ91 Magnesium Alloy. Procedia Engineering, **55**, 109 (2013).
5. C. LI-JIE, M. GUO-RUI, T. CHUN-CHONG: Effects of Isothermal Process Parameters on Semisolid Microstructure of Mg 8%Al 1%Si Alloy. Trans Nonferrous Met Soc China, **22**, 2364 (2012).
6. N. TOMAC, K. TONNESEN, T. MIKAC: Study of Influence of Aluminum Content on Machinability of Magnesium Alloys. Strojarstvo, **50** (6), 363 (2008).
7. X. L. ZHAO, Y. TANG, W. J. DENG, F. Y. ZHANG: Effect of Tool Flank Wear on the Orthogonal Cutting Process. Key Eng Mater, **329**, 705 (2007).
8. H. K. TONSHOFF, T. FRIEMUTH, J. WINKLER, C. PODOLSKY: Improving the Characteristics of Magnesium Workpieces by Burnishing Operations, Magnesium Alloys and their Applications (Ed. K. U. Kainer). WILEY-VCH Verlag GmbH, Weinheim, 2006, p. 405.
9. H. K. TONSHOFF, J. WINKLER: The Influence of Tool Cutting in Machining of Magnesium. Surf Coat Technol, **94–95**, 610 (1997).
10. J. HOU, W. ZHOU, N. ZHAO: Methods for Prevention of Ignition during Machining of Magnesium Alloys. Key Eng Mater, **447–448**, 150 (2010).
11. B. AKYUZ: Influence of Al Content on the Machinability of AZ Series Cast Mg Alloys. Trans Nonferrous Met Soc China, **23**, 2243 (2013).
12. M. UNAL: An Investigation of Casting Properties of Magnesium Alloys. Gazi University, Institute of Science and Technology, Ph.D. Thesis, 2008.
13. S. CANDAN, M. UNAL, E. KOC, Y. TUREN, E. CANDAN: Effects of Titanium Addition on Mechanical and Corrosion Behaviours of AZ91 Magnesium Alloy. J Alloy Compd, **509**, 1958 (2011).
14. A. SRINIVASAN, J. SWAMINATHAN, M. K. GUNJAN, U. T. S. PILLAI, B. C. PAI: Effect of Intermetallic Phases on the Creep Behavior of AZ91 Magnesium Alloy. Mater Sci Eng A, **527**, 1395 (2010).
15. G. R. MA, X. L. LI, L. XIAO, Q. F. LI: Effect of Holding Temperature on Microstructure of an AS91 Alloy During Semisolid Isothermal Heat Treatment. J Alloy Compd, **496**, 577 (2010).
16. L. XIN-LIN, C. YAN-BIN, W. XIANG, M. A. GUO-RUI: Effect of Cooling Rates on AS-cast Microstructures of Mg-9Al-x Si ($x=1$, 3) Alloys. Trans Nonferrous Met Soc China, **20**, 393 (2010).
17. M. S. DARGUSCH, A. L. BOWLES, K. PETTERSEN, P. BAKKE, G. L. DUNLOP: The Effect of Silicon Content on the Microstructure and Creep Behavior in Die-Cast Magnesium AS Alloys. Metall Mater Trans A, **35A**, 1905 (2004).
18. K. LIU, X. P. LI, S. Y. LIANG: The Mechanism of Ductile Chip Formation in Cutting of Brittle Materials. Int J Adv Manuf Technol, **33**, 875 (2007).

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Journal of the Balkan Tribological Association is an International Journal edited by the Balkan Tribo-logical Association for rapid scientific and other information, covering all aspects of the processes included in overall tribology, tribomechanics, tribochemistry and tribology.

Aims and Scope

The decision for editing and printing of the current journal was taken on Balkantrib'93, Sofia, October, 1993 during the Round Table discussion of the representatives of the Balkan countries: Bulgaria. Greece, Former Yugoslavian Republic of Macedonia, Romania, Turkey and Yugoslavia. The Journal of the Balkan Tribological Assosiation is dedicated to the fundamental and technological research of the third principle in nature - the contacts.

The j ournal will act as international focus for contacts between the specialists working in fundamental and practical areas of tribology. The main topics and examples of the scientific areas of interest to the Journal are:

a) overall tribology;

b) tribotechnics and tribomechanics; friction, lubrication, abrasive wear, boundary lubrication, adhesion, cavitation, corrosion, computer simulation, vibration phenomena, mechanical contacts in gaseous, liquid and solid phase, technological tribological processes, coatings, etc.;

c) tribochemistry - defects in solid bodies, tribochemical emissions, triboluminescence, tribochemiluminescence, technological tribochemistry; composite materials, polymeric materials in mechanics and tribology; special materials in military and space technologies, etc.;

d) kinetics, thermodynamics and mechanism of tribochemical processes;

e) biotribology - biological tribology, tribophysiotherapy, tribological wear, biological tribotechnology, etc.;

f) lubrication - solid, semi-liquid lubricants, additives for oils and lubricants, surface phenomena. wear in the presence of lubricants; lubricity of fuels;

g) ecological tribology; the role of tribology in the sustainable development of technology: h) management and organisation of the production; machinery breakdown; oil monitoring; j) European legislation in the field of tribotechnics and lubricating oils;

k) educational problems in tribology, lubricating oils and fuels.

The Impact factor for 2013 is 0,321 and the Impact factor for the last 5 years - 0,266.

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