International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 4 April 2023, pp: 661-667 www.ijaem.net ISSN: 2395-5252

Friction Stir Processing OFAZ91 Magnesium Alloy and Effect of Process Parameters.

M.Sudhakar[1], A.Issac Stanley[2], K.Sai Venkata Suri[3], B.SatyaSai[4], D.Anil[5], Y.Venkateswara Rao[6], Sk.Basha[7], Ch.Vikas[8], K.Surya Charan[9].

Department of Mechanical engineering
Andhra Loyola institute of engineering and technology, Vijayawada, India

---

Date of Submission: 05-04-2023 Date of Acceptance: 15-04-2023

ABSTRACT
Friction Stir Processing (FSP), a solid – state surface modification technique, derived from friction stir welding (FSW), FSP was performed on MAGNESIUM AZ91 alloy using shoulder with probe cutting tool. In the present work the friction stir processing of AZ91 magnesium alloy and the effect of process parameters like traverse, rotational speed and force by friction stir processing on AZ91 magnesium alloy were studied at different combination of rotational and traverse speeds were used to perform on the metal surface.Tests like hardnessand microstructure examination were carried out and compared with as received material.
Key words:friction stir processing, microstructure, magnesium alloy, grain refinement, hardness.

I. INTRODUCTION:

Friction Stir Welding (FSW) is the process of joining of two metals by using a tool having the shoulder with probe. From the FSW the Friction Stir Process (FSP) is developed, FSP is used to change the surface structure of the metal surface at the room temperature. Friction stir process is a solid-state process. The metal is plastically deformed then the properties of the metal surfacewill change.

FSW has been proven to be an effective process for welding aluminum, brass, copper, and other low-melting-temperature materials. The latest phase in FSW research has been aimed at expanding the usefulness of this procedure in high-melting-temperature materials, such as carbon and stainless steels and nickel-based alloys, by developing tools that can withstand the high temperatures and pressures needed to effectively join these materials.

In friction stir processing (FSP), a rotating tool is used with a pin and a shoulder to a single piece of material to make specific property enhancement, such as improving the material's toughness or flexibility, in a specific area in the micro-structure of the material via fine grain of a second material with properties that improve the first. Friction between the tool and workpieces results in localized heating that softens and plasticizes the workpiece. A volume of processed material is produced by movement of materials from the front of the pin to the back of the pin.

II. LITERATURE SURVEY:

JozefIwasko et al [1] stated that the FSP generates heat in process that deforms the material into plastic to decrease grain size to get required or to approximate properties, if the FSP successfully on AZ91 alloy the main properties are changed by significantly varying FSP parameters. This FSP done by the conventional tooling process to form plastic deformation. This results to change the microstructure and to reduce the boundary of the microstructure. Samir Rathod et al [2]quoted that This treatment enhancing to change the sheet metal properties by effective tooling to modification of microstructure and grain refinement by single pass of tool, it to improve formability, especially by elevated temperature, in this work essential examination using FSP to modify microstructure and properties of mg alloy AZ31B -H24 mg alloy sheets. speeds are between 1200-2000rpm rotational speed and 20-30mm/min travel speed.B.M.Darras et al [3] investigated the mechanical properties by the effect of tool shoulder on the AZ31B mg alloy. the concave tool shoulder is used. Strain hardening effect was played a major role in determining the properties and step shoulder tool also used here to compare. The test was conducted by 3 levels, 2 factors means, 3 speeds and 2 parameters with concave and shoulder tool when the rotational speed is increasedit increase tensile strength, lower rotational speed results strain hardening effect the step shoulder increased tensile strength when low rpm and high feed and minimum wear occur when high tensile strength concave tool.K.GanesaBalamurugan et al [4]found outthe corrosion resistance of thick AZ31B magnesium alloy examined here by using stationary shoulder FSP(SSFSP) process by the use of the low temperature and low heat is produced on the stir zone. The corrosion resistance increased this SSFSPed and uniform grain microstructure is present. Vivek Patel et al [5]stated that by using of stainless powder on the AZ61 mg alloy by FSP and this is the fabrication of surface matrix composites (MMC's) and one of most emerging technique used to produce good and efficient mechanical properties are increased up to 12.1% and corrosion resistance also increased. Sithole et al [6] indicating that 9 combination and 4 essential processes are involved, they are rotational speed, travel speed, depth, tilt angle were chosen 1600rpm, 63mm/min, 0.1 and 2° on the pure mg alloy and changes occurred. D.Ahmad khaniha et al [7]quoted that the addition of metal matrix composites on the pure magnesium on the top surface is used to increase the particles and grain refinement result by FSP and the aim of this process is to fabricate the MMC's magnesium-based composites. Some of the limitations occur by MMC's composites and it is better in some of the applications.B.RatnaSunil et al [8] used Multi Walled Carbon Nano Tubes (as MWCNT) reinforced magnesium matrix was fabricated by using FSP with the aim of mechanical and electro chemical behavior. After FSP the range of microstructural particles 2500µm and hardness is significantly increased.N.SaiKrishna et al [9] Multi Walled Carbon Nano Tubes (as MWCNT) reinforced magnesium matrix was fabricated by using FSP with the aim of mechanical and electro chemical behaviour. After FSP the range of microstructural particles 2500µm and hardness is significantly increased.

III. EXPERIMENTAL PROCEDURE:

The received material of AZ91 mg alloy having the dimensions of 30cm ×24cm×10cm. The metal has processed into the 10×3×1 cm piece for FSP with the help of hand saw and hand cutter into some plates.The chemical composition of the AZ91 Magnesium alloy is 90% of mg ,9% of Al,1% of zinc,0.04 to 0.5% of Mn. The processed metal plate is fixed on the base with clamps on a universal vertical milling machine and the specially designed cylindrical pin tool is fixed to the tool holder of Vertical milling machine. The plates were subjected to the FSP with different combinations of rotational and traverse speed. They are 760 rpm, 1130 rpm,2000 rpm rotational speed and travel speeds are 11, 22, 48 mm/min respectively. With the 10mm shoulder and 3 mm pin diameter thickness is used to machine. The friction stir processing is carried out at 9 combinations with 3 feeds.

IV. TESTS PERFORMED

Microstructure Analysis:

The microstructure analysis is done on Scanning Electron Microscope test. The SEM test is conducted on the specimen in stir zone. The 10×8× 1cm is cutted into 1×1×8 mm piece for this SEM is used for imaging the microstructure of the specimen using by electron beam and effectively very used microscopy.Microstructure test was conducted on three pieces they are 760,1130rpm with 11mm/min and on received material the microstructure of three pieces have been observed at 100x,200x,500x,1.0kx,2.50kx and 5.00kx magnification and the plate with 1130rpm at 11mm/min have good microstructure and grain size was decreased as compared to another two pieces.

Hardness test:

The hardness test was performed on vickers hardness testing machine on three pieces, those are at 760,1130rpm and as received material. When hardness value was compared in between those three pieces, the metal with 1130rpm at 11mm/min gives the high hardness value. The hardness value of those three materials were 382VHN,547VHN and 326VHN respectively.

V. RESULT:

As per the tests performed on the friction stir processed metal at different process parameters, was obtained different images at different magnification the following figures gives the information about the microstructure of the metal at different magnifications and also the hardness of the metal at different rotational and traverse speeds.

Microstructure Analysis:

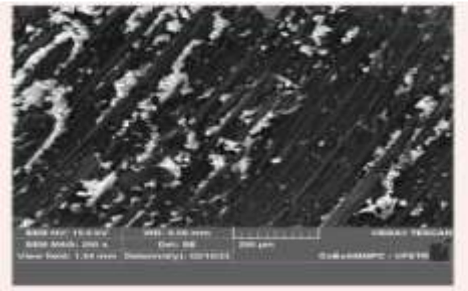


Fig 5.1.1 At 760rpm with 11mm/min with200x magnification

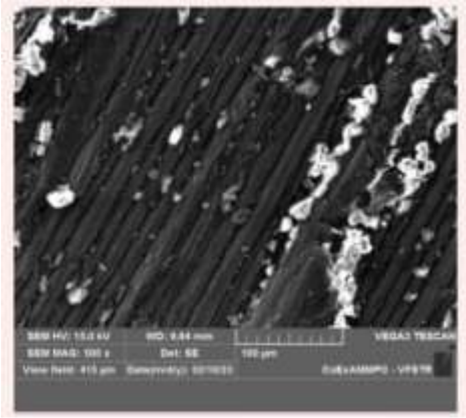


Fig 5.1.2 At 760rpm with 11mm/min with500x magnification

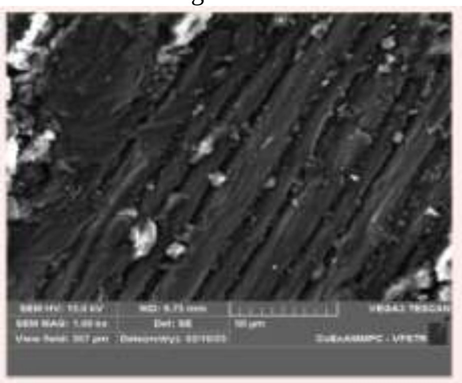


Fig 5.1.3 At 760rpm with 11mm/min with1.00kx magnification

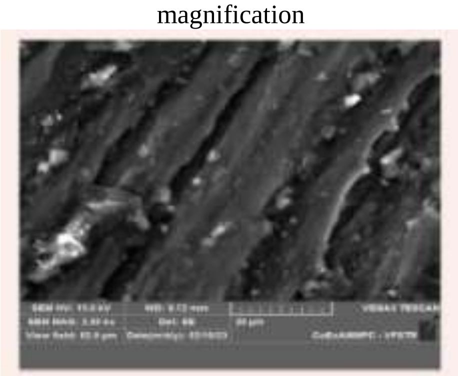


Fig 5.1.4 At 760rpm with 11mm/min with 2.50kx magnification

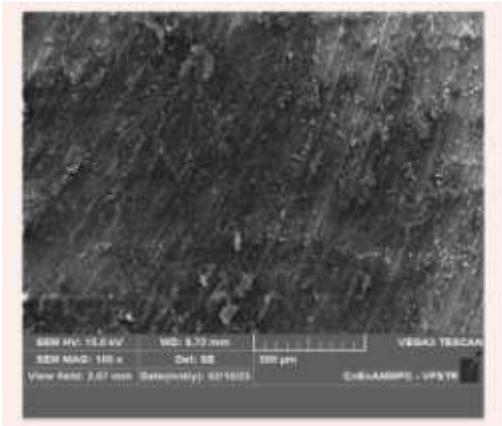


Fig 5.1.5 At 760rpm with 11mm/min with100x magnification.

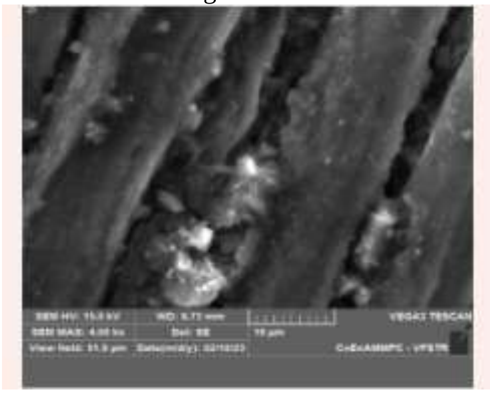


Fig 5.1.6 At 760rpm with 11mm/min with4.00kx magnification

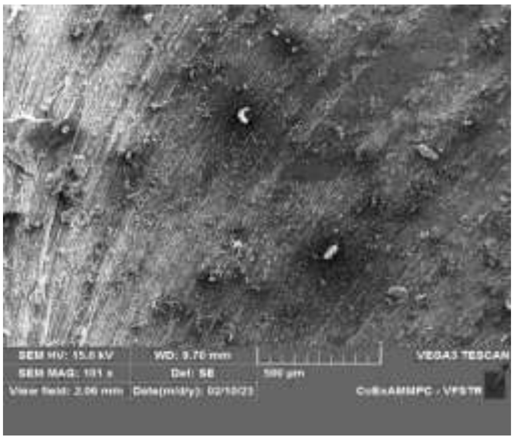


Fig 5.2.1 At 1130rpm with 11mm/min with 101x magnification

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 4 April 2023, pp: 661-667 www.ijaem.net ISSN: 2395-5252

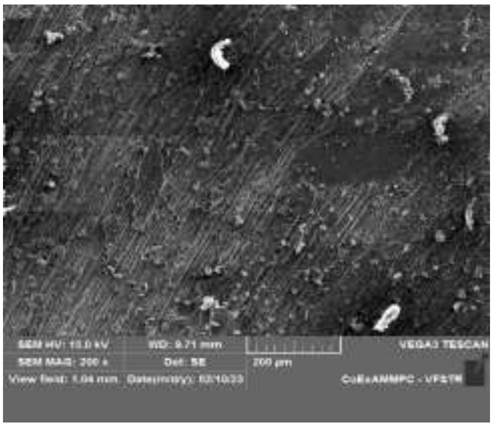


Fig 5.2.2 At 1130rpm with 11mm/min with 200x magnification

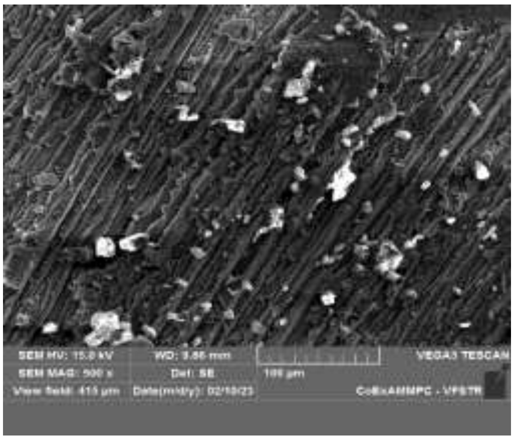


Fig 5.2.3 At 1130rpm with 11mm/min with500x magnification

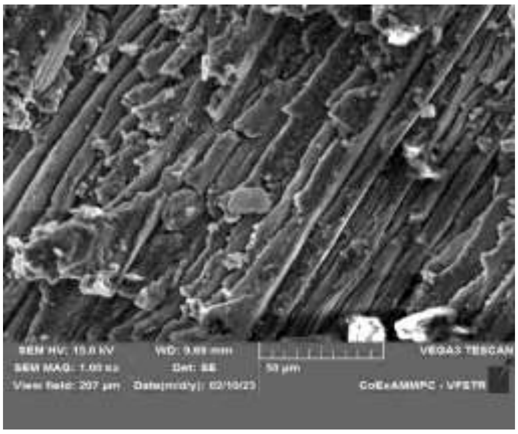


Fig 5.2.4 At 1130rpm with 11mm/min with 1.00kx magnification

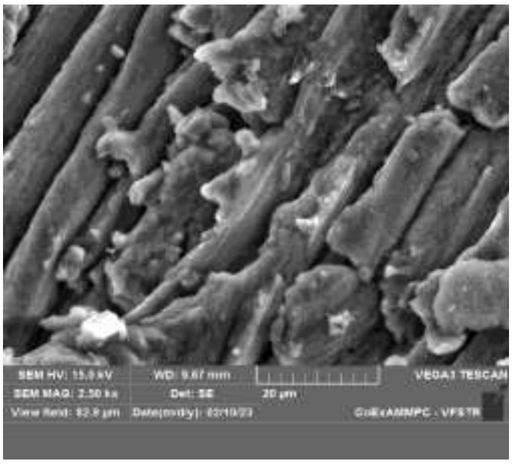


Fig 5.2.5 At 1130rpm with 11mm/min with 2.50kx magnification

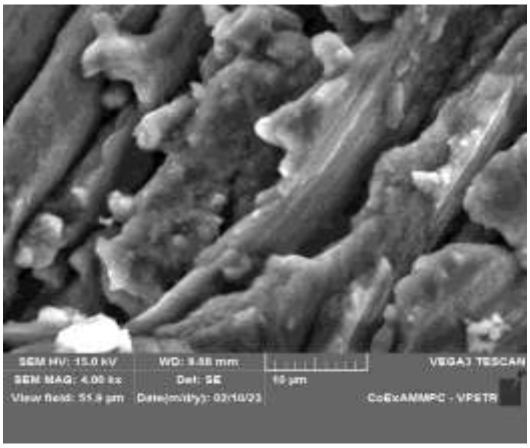


Fig 5.2.6 At 1130rpm with 11mm/min with4.00kx magnification

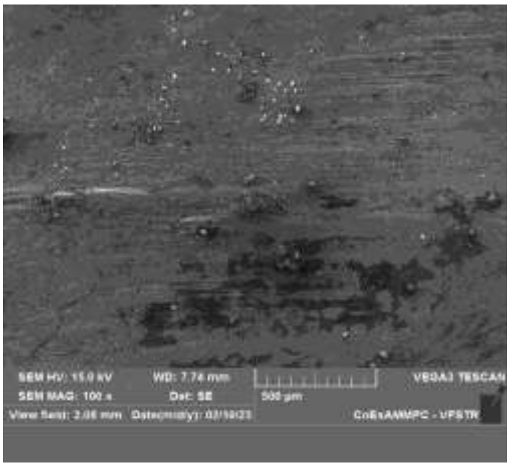


Fig 5.3.1 Non FSP plate with 100x magnification

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 4 April 2023, pp: 661-667 www.ijaem.net ISSN: 2395-5252

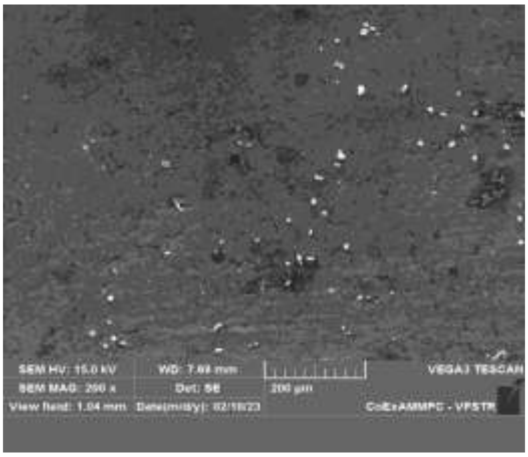


Fig 5.3.2 Non FSP plate with 200x magnification

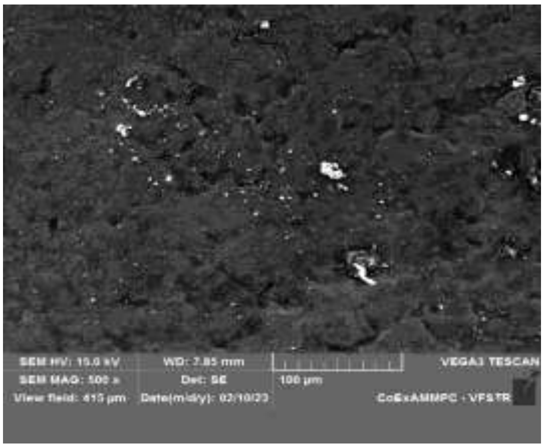


Fig 5.3.3 Non FSP plate with 500x magnification

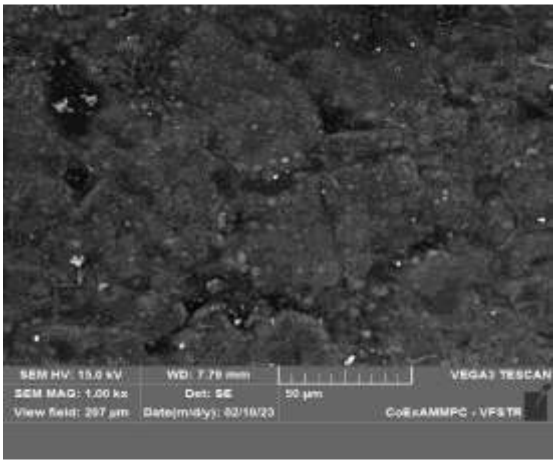


Fig 5.3.4 Non FSP plate with 1.00kx magnification

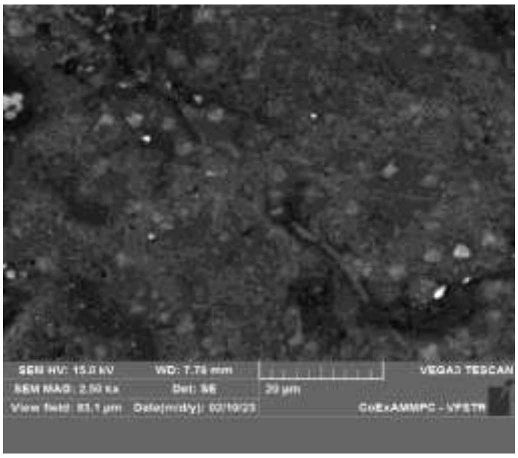


Fig 5.3.5 Non FSP plate with 2.50kx magnification

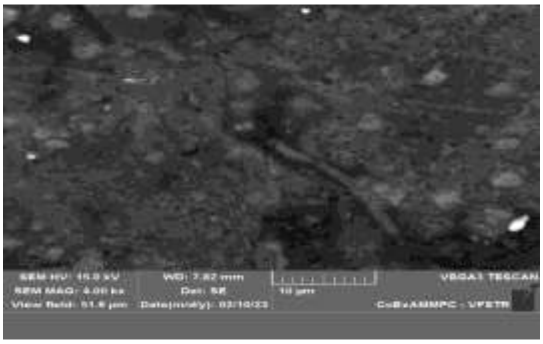
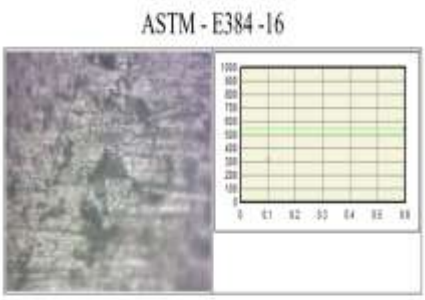


Fig 5.3.6 Non FSP plate with 4.00kx magnification

Hardness:

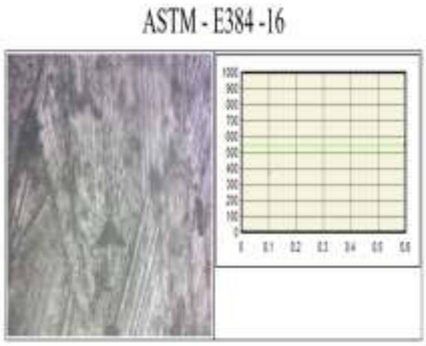
Hardness test is performed on the Vickers hardness testing machine on the Friction stir processed material and the following figure will give the information about the hardness valuerefinement was good, Which improves the properties like hardness and tensile strength.



S.No.	D1	D2	Force(Kgf)	Distan ce	VHN	VHN(M Pa)	VHN(G Pa)	HRB	HRC	Tensile Strength	Case Depth
1	35.106	32.345	0.2	0.1	326	3197.12 1	3.197		33	1030	

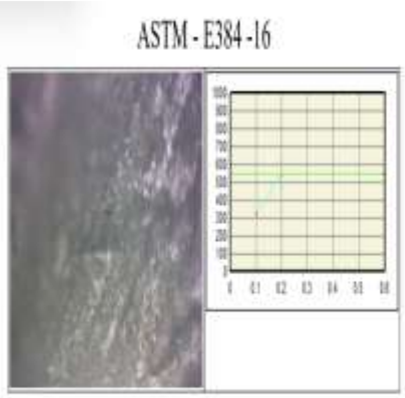
Fig 5.4.1 Hardness test on received plate

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 4 April 2023, pp: 661-667 www.ijaem.net ISSN: 2395-5252



S.No.	D1	D2	Force(Kgf)	Distan ce	VHN	VHN(M Pa)	VHN(G Pa)	HRB	HRC	Tensile Strength	Case Depth
1	30.175	32.148	0.2	0.1	382	3744.89 2	3.745		39	1220	

Fig 5.4.2 Hardness test on 760rpm with feed rate of 11mm/min FSP plate



S.No.	D1	D2	Force(Kgf)	Distan ce	VHN	VHN(M Pa)	VHN(G Pa)	HRB	HRC	Tensile Strength	Case Depth
1	35.106	32.345	0.2	0.1	326	3197.12 1	3.197		33	1030	
2	26.428	25.639	0.2	0.1	547	5365.50 8	5.366		53	1950	

Fig 5.4.3 Hardness test on 1130rpm with feed rate of 11mm/min FSP plate

VI. CONCLUSION:

Friction Stir Processing was carried out on AZ91 magnesium alloy with combination of 760, 1130rpm tool rotational speeds and 11,22,48mm/mintraverse speeds respectively. It was observed that at tool speed 1130rpm the microstructure appearance was good when compared with as received material. The hardness at 1130 rpm was found to be 547 and 326 for as received material. Hence by friction stir processing hardness of AZ91 magnesium alloy can be improved.

REFERENCE:

[1]. JozefIwaszko& Krzysztof Kudla, “Microstructure, hardness, and wear resistance of AZ91 magnesium alloy produced by friction stir processing with air-cooling”, The International Journal of Advanced Manufacturing Technology, Vol 116 Pg. no 1309–1323.

[2]. Samir Rathod, Daulat Kumar Sharma, Minal Dani, Paras Rank & Nikunj Savaliya, “Effect of Friction Stir Processing on AZ91 Mg-alloy: A Review”, Journal Kejuruteraan Vol 33(4) pg no.793-80.

[3]. B.M. Darras, M.K. Khraisheh, F.K. Abu-Farha, M.A. Omar, “Friction stir processing of commercial AZ31 magnesium alloy”, Center for Manufacturing and Department of Mechanical Engineering, University of Kentucky, USA vol pg. no. 77–81.

[4]. K. Ganesa Balamurugan, K. Mahadevan,” Investigation on the changes effected by tool profile on mechanical and tribological properties of friction stir processed AZ31B magnesium alloy”, vol pg. no. 659–665.

[5]. Vivek Patel, Wenya Li b, Joel Andersson a,” Enhancing grain refinement and corrosion behavior in AZ31B magnesium alloy via stationary shoulder friction stir processing” vol pg. no. 3150-3156.

[6]. Lorraine M. Sithole, and Nkosinathi Madushele, “Surface treatment of magnesium AZ61 alloy with stainless steel powder by friction stir processing”, vol pg. no. 1047–1053.

[7]. D. Ahmadkhaniha, M. HeydarzadehSohi, A. ZareiHanzaki, S.M. Bayazid, M. Saba,” Taguchi optimization of process parameters in friction stir process of pure mg alloy”, vol pg. no. 1155-4563.

[8]. B.Ratna Sunil, G.PradeepKumar Reddy, H emendra Patle, Ravikumar Dumpale,”mag nesium based surface metal matrix composite by friction stir process”, vol 4 pg. no.52-61.

[9]. N. Saikrishna, G.PradeepKumar Reddy, B alakrishnan Munirathinam, Ravikumar Du mpal, M. Jagannatham, B. Ratna Sunil,” an investigation on the hardness and corrosion behaviour of MMCNT/Mg

composites grain refined mg” vol 6 pg. no. 83-89.

[10]. Wen Wang, Peng Hana, Pai Peng, Hongju Guo, Liying Huang, KeQiao, Minna Hai, Qi Yang, Hongduo Wang, Kuaishe Wang, Liqiang Wang,” Superplastic deformation behavior of fine-grained AZ80 magnesium alloy prepared by friction stir processing”, vol pg. no. 9(3):5252–5263.

[11]. Fang Chai, Datong Zhang, Yuanyuan Li” Microstructures and tensile properties of submerged friction stir processed AZ91 magnesium alloy”, vol pg. no. 203-209.

[12]. Ravi Butola, Ranganath M S and Qasim Murtaza.” Fabrication and optimization of AA7075 matrix surface composites using Taguchi technique via friction stir processing (FSP)”, vol 025015.

[13]. Zhanyongzhon, rongxiazhon, peikang bai, wenbo du, renguo guan, zhanhuguo, “AZ91 alloy nanocomposites reinforced with mg-coated graphene: phase distribution interfacial microstructure, and property analysis”, vol 902 pg.no. 163484.

[14]. W.Liu, The Influence of Friction Stir Processing on Microstructure and Mechanical Properties of AZ91 Magnesium Alloy", Journal of Materials Research and Technology, September–October 2022, Pages 1940-1975.

[15]. J Suresh kumar, Effect of Friction Stir Processing on Microstructure and Mechanical Properties of AZ91 Magnesium Alloy. September 2012Rare Metal Materials and Engineering. issue 41(9):1522–1526, DOI:10.1016/S1875-5372(13)60004-1.

[16]. M. Raja and R. Umanath. A comprehensive review of recent progress in fabrication of magnesium base composites by friction stir processing technique state of research on FSP of magnesium alloys, AIMS Materials Science, 2020, Volume 7, Issue 5: 684-704. doi: 10.3934/matersci.2020.5.684.

[17]. Sushanta Kumar panigrah and RS Mishra Sunil, G.R.K.Reddy, H.Patle, R.Dumpala, Magnesium based surface metal matrix composites by friction stir processing , Material science, Published 1 March 2016.

[18]. Hariom Tripathi and Kuldeep K. Saxenab, Improvement in mechanical properties of structural AZ91 magnesium alloy processed by friction stir processing, Pages 1543-1556 | Accepted 26 Jun 2021, Published online: 10 Aug 2021.