# Effects of multi-pass friction stir processing on Microstructure Evolution and Tensile Analysis for AZ91D Magnesium Alloy

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**Abstract**

**In this paper, AZ91D magnesium composites fabricated by multi-pass Frictions stir processing (MFSP) method to enhance the grain size. The multi-pass frictions stir processing is characterized by fine grains and fine particles distributed at the grain boundaries as received AZ91D. The processing parameters, particularly rotational tool speed and pass number in FSP, have a major effect on strength properties and surface hardness. The maximum length and elongation achieved during multi-pass MFSP and product of ultimate tensile strength of the stir zone was significantly enhanced compared with that of the base metal for various tilting angles.**

**Keywords: AZ91D, magnesium, multipass, MESP, microstructure**

## 1. INTRODUCTION

During the most recent two decades, severe plastic deformation (SPD) has been exhibited as a compelling way to deal with produce ultrafine grain (UFG) materials. Broad research has been completed to create SPD methods and to build up handling parameters to deliver UFG metals and amalgams; particularly Aluminum Alloys (AA), with progressively alluring properties as summed up by Mishra and Ma (2005). Among various SPD strategies, friction stirs processing (FSP) and equal channel angular pressing (ECAP) have possessed the main focus of researchers. Contrasted with FSP, multi-pass ECAP is described by low strain rates and requires in any event 6–8 goes to accomplish smaller scale or UFG as summed up by Liu and Ma (2008). They likewise included that this method produces restricted shapes and furthermore moderately little amounts of material and is hard proportional up. FSP then again, is basically a nearby thermo-mechanical metal working procedure that changes the neighborhood properties without impacting the properties of the mass material. Nakata et al. (2006) have accomplished an improvement in the mechanical properties due to the microstructural change of an aluminum bite the dust throwing compound by multi-pass contact mix handling (MP-FSP), which is a strong state microstructural adjustment procedure utilizing a frictional warmth and mixing activity.

The paper conveys examination of assessing of macro,microstructure of multipass in various tilting point of contact mix prepared AZ91D magnesium compound. To assessing the elastic properties of grating mix prepared AZ91D magnesium composite in multipass at various tilting edge.

## 2 EXPERIMENT PROCEDURES

A progression of FSP was led opposite to the moving course at steady apparatus rotational speed. The exploratory work has been arranged in the accompanying succession:

Step-1: Evaluation of mechanical properties of base metal yield quality, extreme rigidity, level of extension and miniaturized scale hardness

Step-2: Friction mix handling of AZ91D magnesium composite to get deformity free altered surface and cross segment.
Step-3: Evaluation of elastic properties and miniaturized scale hardness at cross area of grinding mix prepared AZ91D magnesium composite.
Step-4: Micro auxiliary investigation of by optical metallography

The detailed experimental procedures associated with each phase of the test work are informed in the accompanying areas.

**2.1 Evaluation of Base Metal Properties**

The base metal utilized in this examination is a cast combination of AZ91D magnesium compound of 13 mm thickness. The synthetic organization of the base metal was acquired utilizing a vitality dispersive spectrometry (EDS). The concoction creation of the base metal in weight percent is yielded

Table 1 chemical composition (wt%) of base metal

| AL | MN | ZN | SI | FE | CU | NI | MG |
|---|---|---|---|---|---|---|---|
| 9.1 | 0.15 | 0.84 | 0.10 | 0.005 | 0.03 | 0.002 | Bal |

**2.2 Mechanical Testing:**

Tensile specimens were prepared to obtain the base metal tensile properties. ASTM E8M-2015a (ASTM, 2015a) guidelines were followed for preparing the test specimens. Tensile tests were carried out in 100 kN, MTS INSIGHT Universal Testing Machine.

The example was stacked at the pace of 7mm/min according to ASTM determinations, with the goal that elastic example experiences distortion. The example at long last bombs subsequent to necking and the heap versus uprooting was recorded.

Figure 2 Friction Stir processing setup

Figure 3 Friction Stir processing setup AZ91D alloy

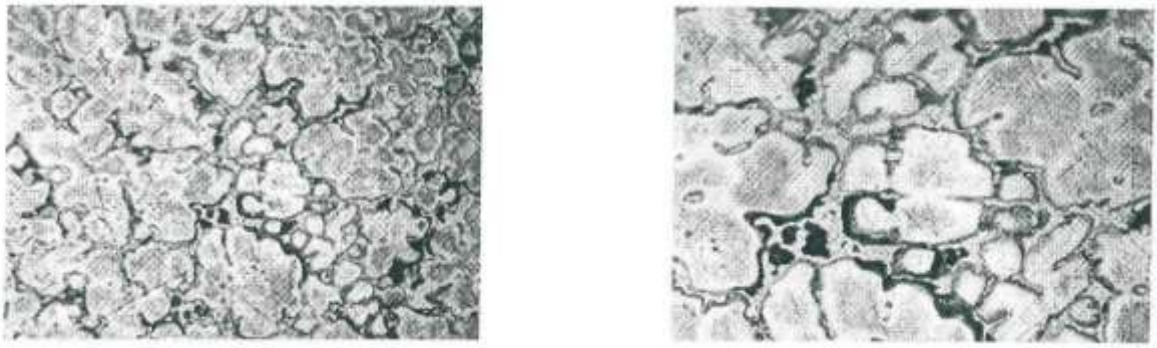
The base metal utilized in this examination was 13 mm thick cast plate of AZ91D magnesium compound. The top surface of cast composite was rubbing mix prepared to 6 mm profound on a retrofitted processing machine. The FSP exploratory arrangement is appeared in Fig. An arrangement tighten tube shaped erosion mix instrument (pin length 8 mm, pin measurement 6 mm, shoulder breadth 18 mm) made of high carbon steel was utilized in the current examination. An apparatus rotational speed of 1000 rpm and travel speed of 10 mm/min, were utilized.

## 3 RESULTS AND DISCUSSION

The optical and micrographs of friction stir processed in multipass AZ91D cast magnesium alloy. The microstructure of BM is mainly composed of □-Mg dendrites and coarse eutectic □-Mg17A12 phase. Most of the □-Mg17A12 phase exists as network structure, While some particles are distributed inside a grains.

The nugget zone of the FSP AZ91D is characterized by fine grains (4 □m) and fine particles distributed at the grain boundaries in the asreceived AZ91D disappeared after FSP. Friction stir processing resulted in significant breakup and dissolution of the network like eutectic □-Mg17A12 phase due to the stirring effect of the threaded pin and thermal exposure.

The observed structures suggest the mechanisms that lead to the strong reduction in the size and fraction of □ phase in the nugget are more complex than mechanical attrition/solid state dissolution as commonly supposed.



The Mg-A1 AZ91D die cast alloy consists of semisolid grains of Mg A1 eutectic (β phase)
In a matrix of α Mg phase.

### *3.1 Tensile Test*

After FSP, the tensile specimen was prepared along the weld direction (in the processed alone) and loaded at the rate of 7mm/min as per ASTM specifications, so that tensile specimen undergoes deformation. The specimen finally fails after necking and the oad versus displacement was recorded. The specimen loaded at the rate of 7mm/min as per ASTM specifications, so that tensile specimen undergoes deformation. The specimen finally fails after necking and the load versus displacement was recorded.

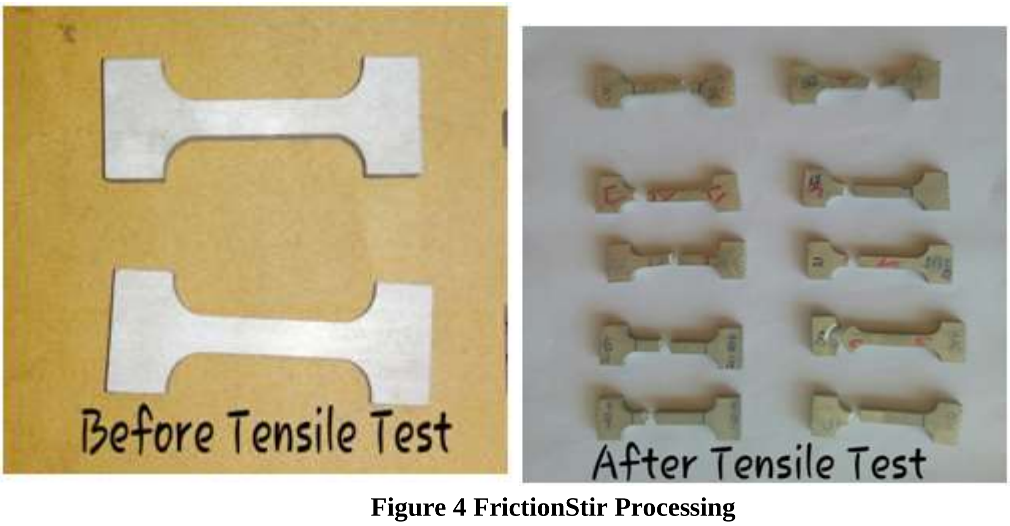



**Figure 4 FrictionStir Processing**

| Test | Base metal | | 1° | | 2° | | 3° | | 4° | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| Tensile Strength Mpa | 62.53 | 57.5 | 165.3 | 97.4 | 123.6 | 141.7 | 155.2 | - | 73.1 | 83.8 |
| Yield strength Mpa | 60.24 | 56.9 | 164.48 | 96.70 | 122.23 | 136.12 | 148.52 | - | 69.94 | 77.47 |
| Elongation | 2.4 | 1.2 | 2.0 | 4.0 | 2.80 | 4.0 | 4.4 | - | 4.4 | 4.4 |
| Hardness value | 71.33 | -- | 84 | -- | 102 | -- | 77.33 | - | -- | 97.33 |

**Table 2.Tensil test of different angles**

**4. Metallurgical Analysis using Optical Metallography**

Microstructural examinations have been carried out using a light optical microscope (VERSAMET-3) incorporated with an image analyzing software (Clemex-Vision). The friction stir processed material was subjected to metallurgical characterization employing optical and scanning electron microscopy. Section cut from unprocessed and friction stir processed zones were prepared for microstructural examination following standard metallographic practices. Polished surfaces were etched with standard reagent picral.

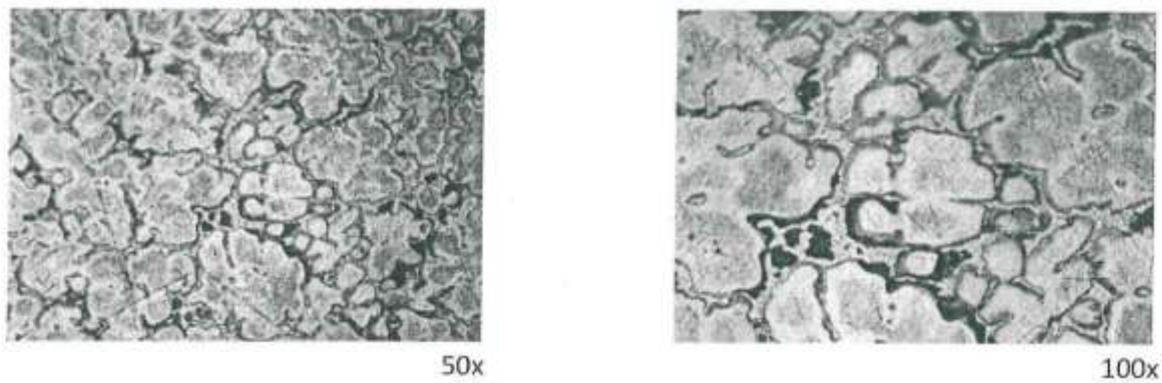



**Figure 5: microstructure analysis for a) $1^0$titling angle:**The Mg Aluminum AZ91D die cast alloy consists of Al enriched eutectic (13 phase) in a wider primary matrix of (1 Mg phase

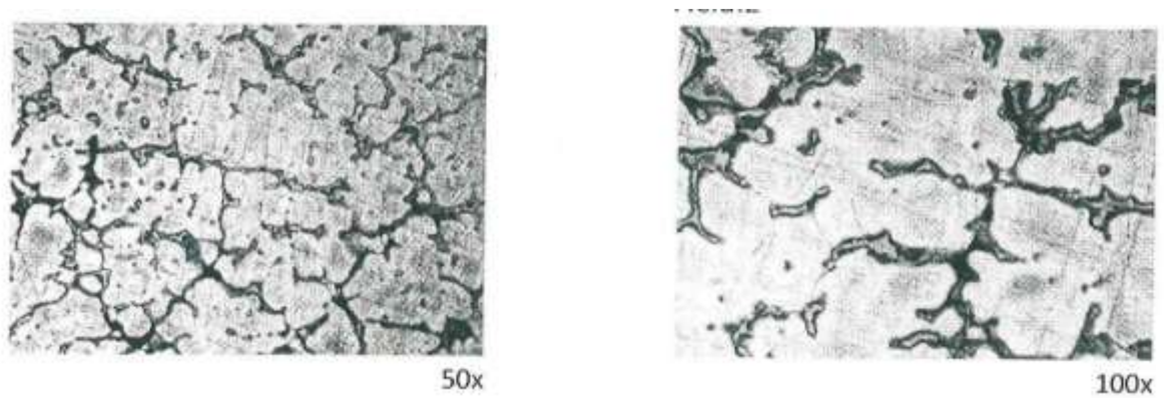



**Figure 5: microstructure analysis for b) 2º titling angle:**The Mg Aluminum AZ91D die cast alloy consists of Mg Al eutectic (f) phase) is clearly seen as a network.

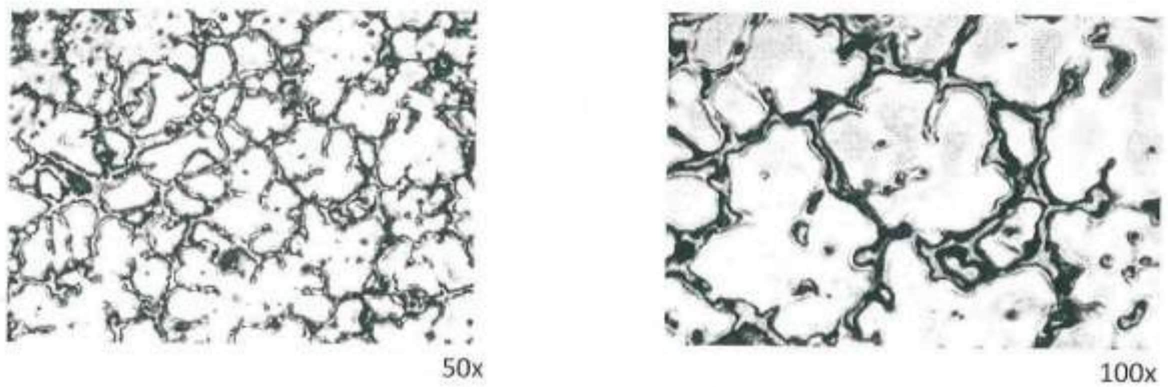



**Figure 6: microstructure analysis for a) $3^0$titling angle:**The Mg Aluminum AZ91D die cast alloy consists of semisolid structure of Mg Al eutectic (13 phase) in a primary matrix of (1 Mg phase.

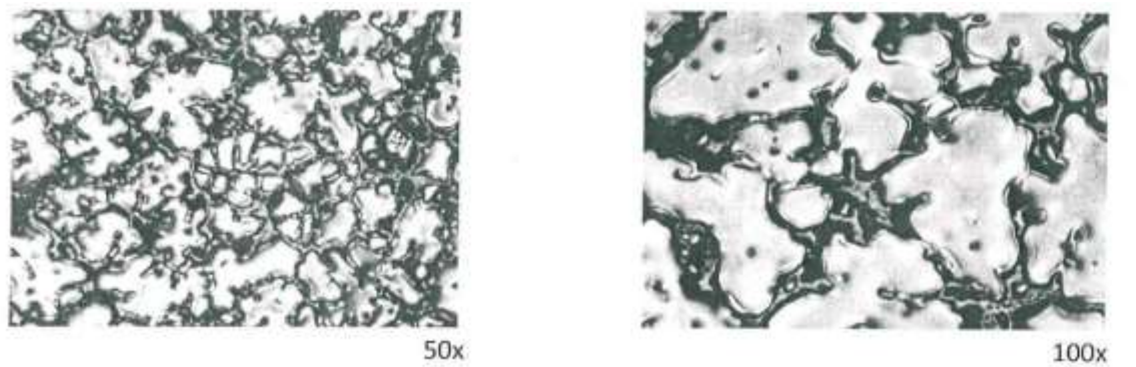



**Figure 6: microstructure analysis for b) 4º titling angle :**The Mg Aluminum AZ91D die cast alloy consists more of [3 eutectic of Mg-Al spread widely in a matrix of Mg phase.

## 4. CONCLUSION

In this paper the mechanical and miniaturized scale auxiliary properties of the multi-pass grinding mix handled AZ91D example have been resolved for different titling edges. The outcomes got are summed up as follows:

- It has been affirmed that the first base metal grain structure become totally wiped out and supplanted by exceptionally fine and equi-hacked out grains in the mix zone.
- The microstructural advancement during grating mix preparing FSP of AZ91D brought about a decrease of grain size, breakage and disintegration of second stage particles.

- A critical disintegration of reinforcing encourages accomplished during erosion mix preparing brought about a pinnacle 0.2% yield quality auxiliary properties of the multi-pass grating mix handled AZ91D example have been resolved.
- Tensile,macro,micro,micro hardness and obstruction test are directed on the multi-go in AZ91D cast magnesium amalgam.

## REFERENCES


1. Chai, F., Zhang, D., Zhang, W., Qiu, C. Effect of processing speed on microstructures and mechanical properties of submerged friction stir processed AZ91 alloy 2013 Materials Science Forum 747-748 , pp. 276-281
2. Friction stir processing for enhancement of wear resistance of ZM21 magnesium alloy Madhusudhan Reddy, G., SambasivaRao, A., SrinivasaRao, K. 2013 Transactions of the Indian Institute of Metals 66 (1) , pp. 13-24
3. Study of B-precipitates and their effect on the directional yield asymmetry of friction stir processed and aged AZ91C alloy, Jain, V., Mishra, R.S., Gupta, A.K., Gouthama 2013 Materials Science and Engineering A 560 , pp. 500-509
4. Effect of distance between passes in friction stir processing of magnesium alloy Govindaraju, M., Prasad Rao, K., Chakkingal, U., Balasubramanian, 2012 Advanced Materials Research 585 , pp. 397-401
5. Arora, H.S.,Singh, H., Dhindaw, B.K., Grewal, H.S. Improving the tribological properties of mg based AZ31 alloy using friction stir processing 2012 Advanced Materials Research 585, pp. 579-583
6. Microstructure and tensile behavior of a friction stir processed magnesiumalloyMansoor, B., Ghosh, A.K. 2012 ActaMaterialia 60 (13-14), pp. 5079-5088.
7. Achieving ultra-fine grains in AZ61 Mg alloy by friction stir processing Du, X., Zhang, E., Wu, B. 2008 International Journal of Materials Research 99 (12) , pp. 1375-1378.
8. Microstructure and properties of friction stir-processed AZ91 magnesium alloy Lu, Q.-Y., Sha, G.-Y., Wang, H.-S. 2008 HangkongCailiaoXuebao/Journal of Aeronautical Materials 28 (4) , pp. 27-30.
9. A.H. FENG, B.L. XIAO, Z.Y. MA, and R.S. CHEN Effect of Friction Stir Processing Procedures on Microstructure and Mechanical Properties of MgAl-Zn Casting.
10. A.H. Feng and Z.Y. Ma Enhanced mechanical properties of Mg–Al–Zn castalloy via friction stir processing.
11. Incipient melting during friction stir processing of AZ91 magnesium castings J.D. Robsona, S. Cuib, Z.W. Chen.
12. Producing nano grained microstructure in Mg–Al–Zn alloy by two-step friction stir processing C.I. Chang, X.H. Du, and J.C. Huang.
13. T. Morishige, M. Tsujikawa, M. Hino, T. Hirata, S. Oki and K. Higashi Micro structural modification of cast Mg alloys by friction stir processing, International Journal of Cast Metals Research 2008 VOL 21 NO 1–4 109