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Tensile Properties of Al 6061 Alloy Surface Composite Via Friction Stir Processing

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Abstract:- In the current work, attempts were made to create friction stir processed Al-based nano composites (FSP). The microstructure of the nugget zone (NZ) was improved by the addition of Al2O3 and Tic nanoparticles, and the growth of granular material in the heat-affected zone was constrained (HAZ). The impacts of adding Al2O3 and Tic nanoparticles on the development of the grain structure and various mechanical properties of the friction stir-welded aluminium matrix were thoroughly investigated. The results showed that the addition of Al2O3 and TiB2 nanoparticles caused a remarkable refinement of grains in the nugget zone because of the pinning effect produced by nano-sized Al2O3 and TiB2 particles that prevent the grain growth followed by recrystallization during FSW, leading to a remarkable reduction in the amount of grain that was unable to be refined.

Keywords:- *Friction Stir Processing, Nugget Zone, Grain Growth.*

I. INTRODUCTION

Due to their low densities and excellent strength to weight ratios, aluminium and its alloys are extensively used in a variety of industries [1]. It is challenging to increase the dispersion of reinforcement particles on the metal surface using traditional surface modification techniques [2]. The properties of surface composites prepared using thermal spraying and laser beam procedures are reportedly deteriorated as a result of the formation of undesirable phases, according to earlier studies [3–4]. Therefore, the solid state method most suited for processing aluminium and its alloys is friction stir processing. Based on the fundamental ideas of FSW, it was created by Mishra et al. as a general tool for microstructural modification as well as to enhance surface modification [5]. Using traditional surface modification techniques, it is difficult to regulate the distribution of nano reinforcing particles on the surface of an aluminium alloy [6]. As surface-dependent degradations, wear and corrosion can be improved by making the appropriate changes to the surface microstructure and/or composition. A FSP technique can be employed to refine the microstructure and homogeneous dispersion of reinforcements on metallic surface [7]. Nevertheless, their poor resistance to wear and corrosion causes certain limitations for their application [8]. This exhibited better mechanical properties (hardness, tensile strength and percentage of elongation) than the base material [9]. These composites are a new type of material that exhibit good wear and corrosion resistance properties as compared to the matrix [10]. These Al Matrix Composites exhibit higher properties than that of parent alloy such as stiffness, improved tribological characteristics, weldability and high strength. Further these properties can be enhanced by using nano scale ceramic materials [11-12]. Sharma et al[13] have studied that was used to carry out the tribological tests. Das. et.al [14] have demonstrated dry sliding wear behavior, aluminum alloy reinforced with reinforced with Al_2O_3-TiB_2. A detailed analysis is carried out using SEM in order to find the influence of Al_2O_3 and TiB_2 particles on Al 6061.This investigation is helps to fabricate and study the influence of nano sized Al_2O and TiB_2 (average size is 35 nm) reinforcement particles with their volume percentages accordingly on microstructural and mechanical behavior of 6061-T6 Al alloy surface nano-composites by using FSP.

II. EXPERIMENTATION

A. Materials

The base material used in the present study is Al 6061 alloy plate with 6mm thickness. Aluminum 6061 alloy after artificial aging (temper T6) it exhibits full strength, good mechanical properties and weldability along with excellent corrosion resistance, 6061 alloy has a density of 2.70 g/cm^3 and its composition is shown in Table 1.

Al6061 is used as the base material and Al_2O_3 and TiB_2 particulates in powder form fabricated through powder metallurgy process method of an average particle size of 35 nm at a required volume percentage (such as 1.5%, 3% and 4.5%) was chosen as the reinforcement materials. Aluminum Oxide is one of the most commonly used non-metallic reinforcements, combined with Aluminum, Magnesium etc., to obtain composites. It provides unique combination of properties such as high strength-to-weight ratio, stiffness, hardness, wear resistance.

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Table 1: The Chemical Composition of Al 6061 alloy

CHEMICAL ELEMENT	Manganese (Mn)	Iron (Fe)	Copper (Cu)	Magnesium (Mg)	Silicon (Si)	Zinc (Zn)	Chromium (Cr)	Titanium (Ti)	Aluminium (Al)
AA 6061 wt %	0.15 Max	0.70 Max	0.15 – 0.40	0.80 – 1.20	0.40 – 0.80	0.25 Max	0.04 – 0.35	0.15Max	BALANCE

B. Fabrication of Composites

Friction stir processing is effective for improving the mechanical properties and eliminates casting defects and refines microstructures, thereby improving strength and ductility. Earlier researches [15] reported that thermal spraying and laser beam techniques were utilized to prepare surface composites, in which it degrades the properties due to creation of unfavorable phases so in order to avoid the problems FSP technique is used as best solid state technique for processing Al 6061 plates.

These plates held in position with the help of a clamp. The entire setup was kept in the vice of the converted milling machine and accordingly as shown in Figure:1. A non-consumable tool made from JIS-SKH 57 was used as the tool material, EN31 tool was used for the process. A concave shaped tool with a shoulder diameter of 20 mm was selected , pin dia. and pin length of 5 mm and 3.2 mm, respectively. [16**].**

The plates were shear cut to avoid any misalignment. The aluminium plate AA6061 - 100mm x 70mm x 6mm of required dimensions shown in Figure:2 are taken and grooves of different breadth and depth (1.5*1.5, 2*2, 2.5*2.5mm) are cut. The grooves are filled with nano sized Al_2O_3 and TiB_2 (The average size is 35 nm) reinforcement particles at a required volume percentage (such as 1.5%, 3% and 4.5%) and the region is processed with three different tools according to their requirement. Here the emphasis is laid on various combinations of the parameters like the plunge depth, cooling rate and backing plates. Tool RPM – 1120 rpm; Tool traverse speed – 80 mm/min.

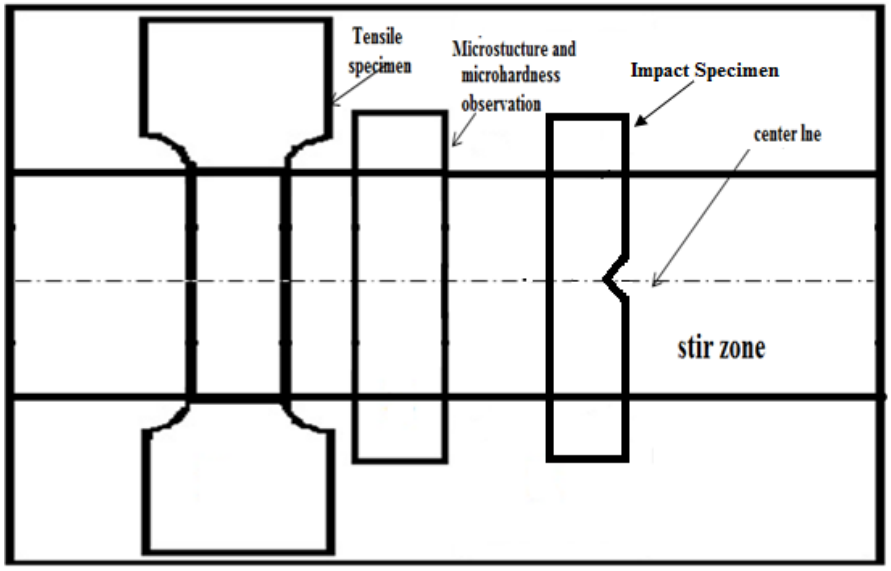

Fig. 1: Schematic sketch of samples for testing

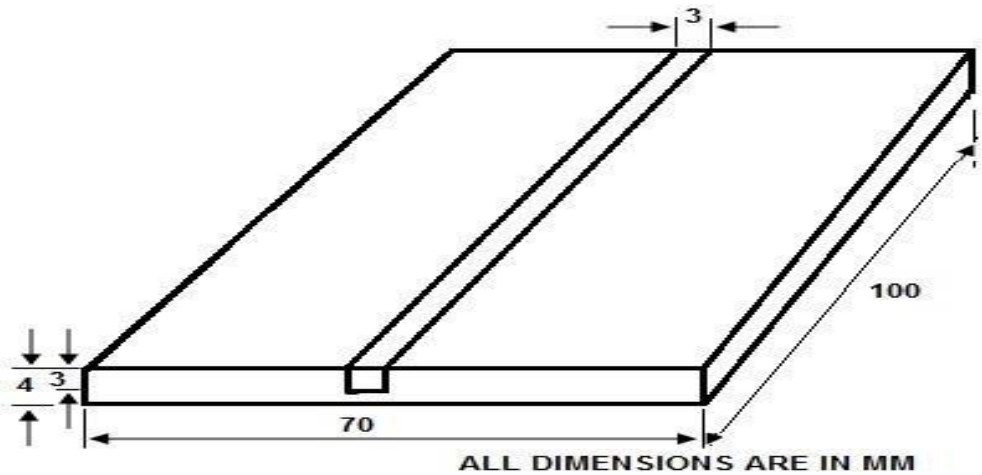

Fig. 2: Schematic diagram of Aluminum alloy plate for FSP

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Table 2: Friction Stir Processing Parameters

Specimen No.	Speed(RPM)	Tool Profile	Volume Percentage
1	900	Threaded	1.5
2	900	Square	3
3	900	Tapered	4.5
4	1120	Threaded	3
5	1120	Square	4.5
6	1120	Tapered	1.5
7	1400	Threaded	4.5
8	1400	Square	1.5
9	1400	Tapered	3

III. RESULTS AND DISCUSSIONS

A. Macro and Microscopic Visual Examination of a Al 6061 Material at Different Magnifications Range

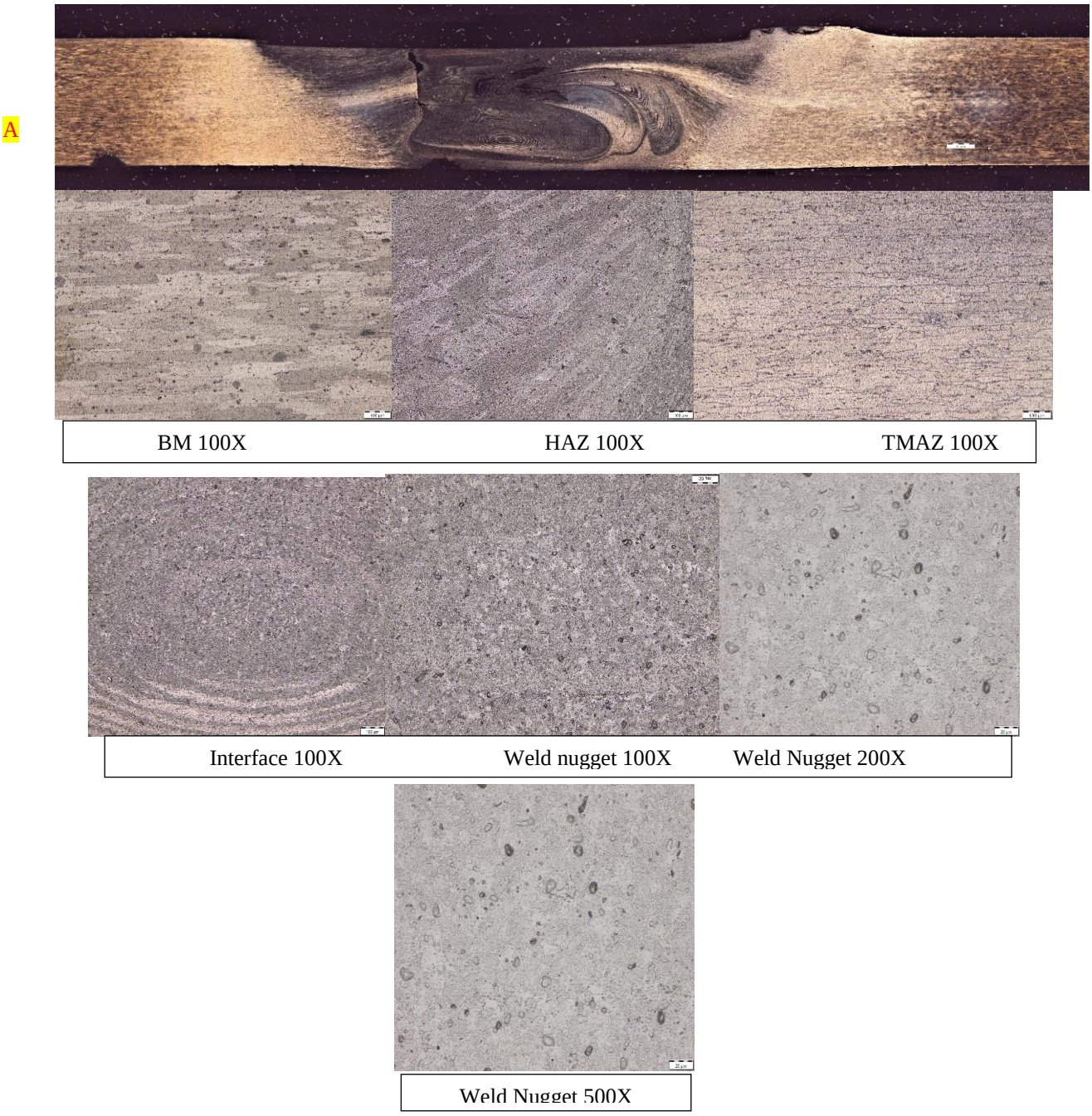

Fig. 3: Microstructures of different zones for all the 9 samples at Different magnification

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B. Hardness values of Al 6061 Composite Material reinforcing with Al_2O_3 and TiB_2 Nano Particles

Vickers firmness HV1 was measured over the entire range of the weld at the weld's centre (2 mm listed below the surface). All of the examples demonstrate the firmness. Weld face, midway through the weld nugget, and close to the origin of the FSP joint are all places where firmness value can be recovered. The typical value was described in relation to the welding center's price range. It was shown that the element's hardness increases as turning rate increases by more than 1120 rpm. The results also show that when traverse rate increases from 31.5 mm/min, there is an 80–90% drop in stiffness compared to base steel.

Table 3: Hardness Values

S.No	Sample ID	Charpy Impact Value
1	Sample 1	28
2	Sample 2	26
3	Sample 3	36
4	Sample 4	26
5	Sample 5	26
6	Sample 6	24
7	Sample 7	38
8	Sample 8	24
9	Sample 9	38

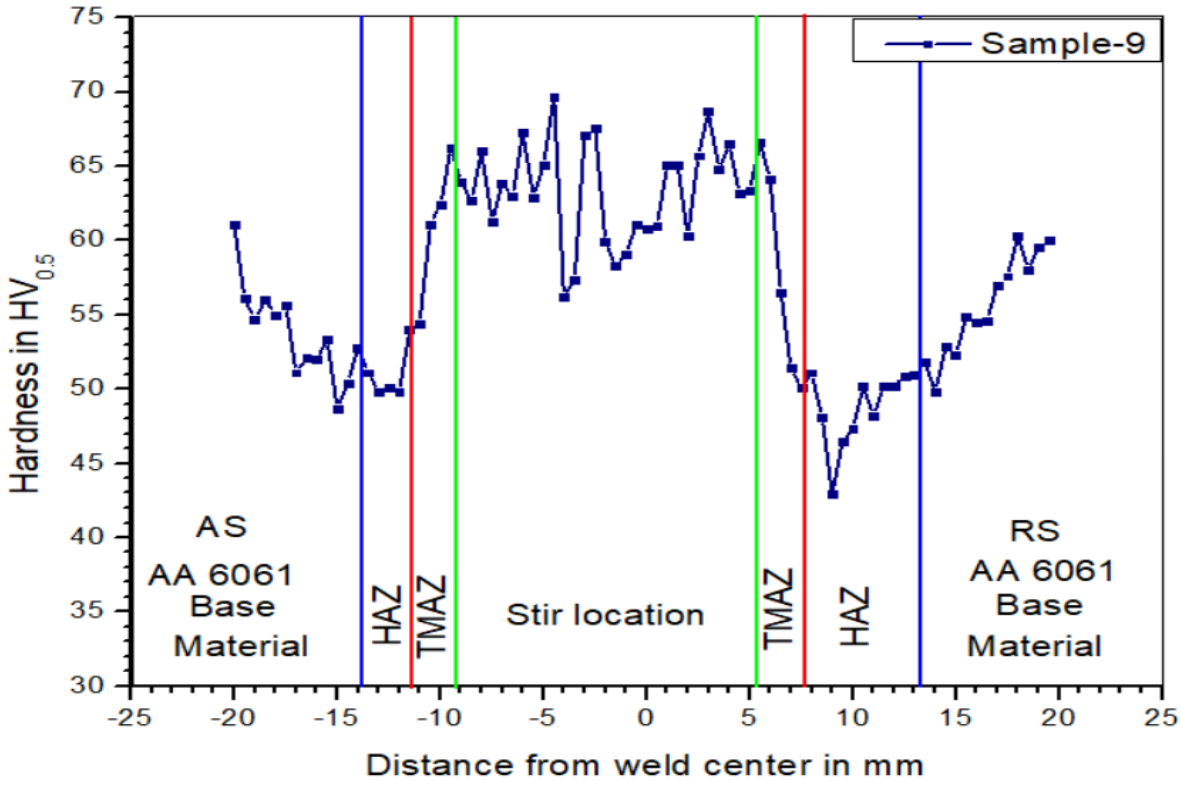

Fig. 4: Micro hardness survey of Al/Al_2O_3 and Tib_2 surface nano composites and as-received Al alloy

Table 4: Tensile Test Results of all Samples of Al6061 Material

Sample Description	Maximum stress in MPa	Yield Strength in MPa	% Elongation
1	72	163	10.7
2	39	171	13.5
3	100	173	11.6
4	70	147	8.6
5	66	166	12.5
6	81	173	15
7	80	150	9.12
8	86	154	8.18
9	74	92	4.4

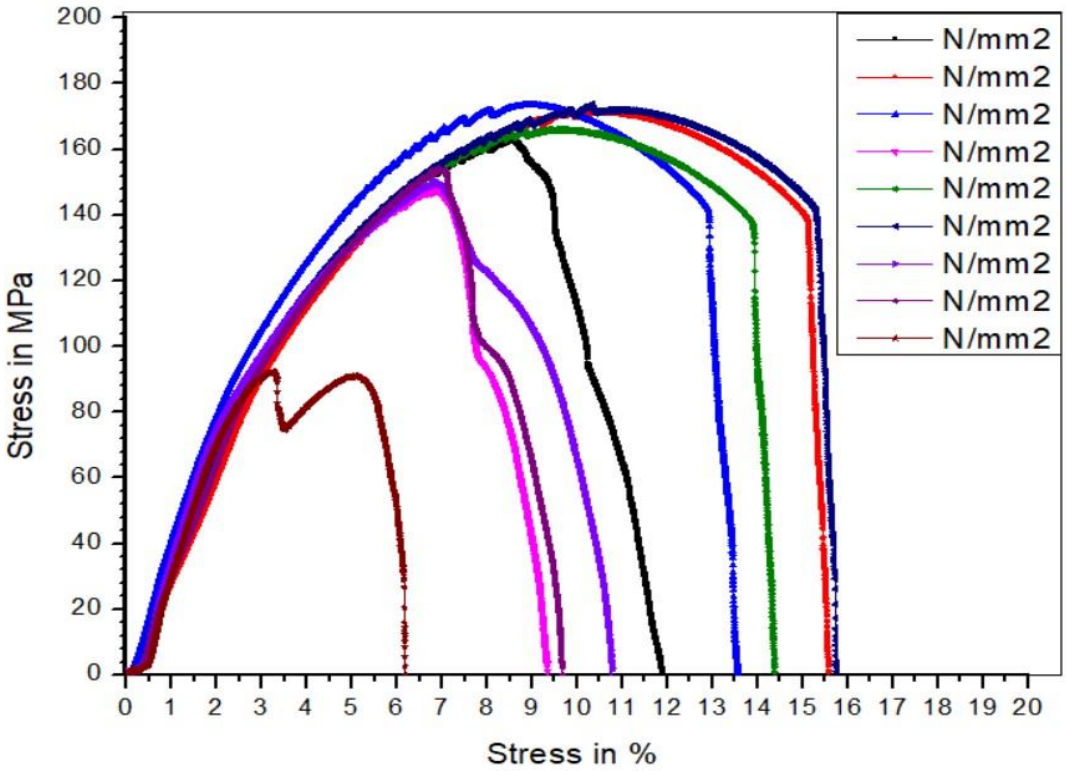

Fig. 5: Stress Strain Curve of Al/Al_2O_3 and Tib_2 nano composites and as-received Al alloy

IV. CONCLUSION

A. Al_2O_3 Nano Particles:

- By effectively using FSP to reinforce SiC particles on 6061-T6 Aluminum Alloy, the nanosurface composite surface layer was created. The following results were reached after examining the impact of nanosized reinforcement particles, such as Al2O3 (average size is 35 nm), on the microstructure and mechanical characteristics of 6061-T6 Aluminum alloy based surface nano composites produced by FSP.
- Al2O3 micro hardness is seen to decrease as volume percentage of the material increases.When compared to the Al alloy in its as-received state, all of the tensile characteristics of Al surface nano composites had been lowered.
- It can be noticed that the tensile characteristics showed greater values at 4.5 volume percentage than they did at 1.5 and 3 volume percentage.
- The SEM and optical micrograph images.

B. TiB_2Nano Particles:

- Metallurgical advantages: much less distortion, high security, great microstructure
- Because of high plastic contortion and also heat in the mixed area throughout FSP recrystallization and also microstructure development happens in mixed area as well as speed up dissolution and also coarsening within and also around the mixed area.
- The micro structural variants in various areas have substantial impact on various other residential properties.

REFERENCES

[1.] Bakes, H.; Benjamin, D. Metals Handbook; ASM international: Metal Park, OH, USA, 1979.
[2.] Budinski, K.G. Surface Engineering for Wear Resistance; Prentice Hall: Upper Saddle River, NJ,USA, 1988.
[3.] Gupta M, Mohamed F A, Lavernia E J. Solidification behaviour of Al-Li-SiCp MMCs processed using variable co-deposition of multi- phase materials. Materials and Manufacturing Processes, 5: 2: 165-196, 1990.
[4.] Mabhali L A B, Pityana S L, Sacks N. Laser Surface Alloying of Aluminum (AA1200) with Ni and SiC Powders. Materials and Manufacturing Processes, 25:12: 1397-1403, 2010.
[5.] R.S. Mishra, M.W. Mahoney, S.X. McFadden, N.A. Mara, A.K. Mukherjee, High Strain Rate Superplasticity In A Friction Star Processed 7075 Al Alloy, 42 (2000).
[6.] Rabinowicz E. Friction and wear of materials. New York: JohnWiley and Sons 1965.
[7.] Shafiei-Zarghani, A.; Kashani-Bozorg, S.F.; Zarei-Hanzaki, A. Microstructures and mechanicalproperties of Al/Al2O3 surface nano-composite layer produced by friction stir processing.Mater. Sci. Eng. *A* 2009, *500*, 84–91.
[8.] Ravi, N.; Sastikumar, D.; Subramanian, N.; Nath, A.K.; Masilamani, V. Microhardness and,Microstructure Studies on Laser Surface Alloyed Aluminum Alloy with Ni-Cr. Mater. Manuf. Process. 2000, *15*, 395–404.
[9.] Mechanical and tribological properties of AA7075–TiC metal matrix composites under heat treated (T6)

and cast conditions- Veeravalli Ramakoteswara Rao, Nallu Ramanaiah [b],Mohammed Moulana Mohiuddin Sarcar [c]-2 0 1 6 ; 5 (4) : 377–383.

[10.] Miracle, D.B. Metal matrix composites–From science to technological significance. Compos. Sci.Technol. 2005, *65*, 2526–2540.

[11.] Ravi N, Sastikumar D, Subramanian N, Nath A K, Masilamani V. Microhardness and microstructure studies on laser surface alloyed aluminium alloy with Ni-Cr. Materials and Manufacturing Processes, 15: 395–404, 2000.

[12.] Clyne T W, Withers P J. An Introduction to Metal Matrix Composites. Cambridge University Press: Cambridge, 1993.Rabinowicz E. Friction and Wear of Materials. JohnWiley and Sons: New York, 1965.

[13.] S.C. Sharma "The Sliding Wear Behaviorof Al6061–Garnet Particulate Composites": Wear 249 (2001) 1036–1045.

[14.] S.Das, "Development Of Aluminium Of Alloy Compositefor Engineering Application"; Trans. Indian Inst. Met. Vol.57, No. 4, August 2004, Pp. 325-334.

[15.] Gupta M, Mohamed FA, Lavernia EJ. Solidification behaviour of Al-Li-SiCp MMCs processed using variable co-deposition of multi- phase materials. Mater Manuf Process 1990;5(2):165e96.