A REVIEW ON EFFECT OF Sn ADDITION TO Al ALLOYS

[1]MOINODIN SHA, [1]KALYAN KUMAR, [1]PRASANNA S.Y, [1]SHREEDHAR BANKAPUR,

[1] Department of Mechanical Engineering

Alva's Institute of Engineering & Technology, Moodbidri-574225, Karnataka, India

Abstract

The mechanical properties as well as the microstructure of Al-Sn based alloys were characterized by using scanning electron microscopy, the Al-Sn alloys generally known as "soft tribological alloys" because these alloys have number of applications in engine bearing materials. The Al-Sn alloys posses excellent friction as well as wear properties. Sn added to Mg-6Zn-2Al alloy and the microstructure were characterized by SEM and the alloys composed of α-Mg, MgZn and Mg2Sn in the range of 0.5–3.0 mass% Sn, and no ternary phase was detected and also excessive Sn addition leads to the coarsening of Mg2Sn particles. Sn has a strong solid solution strengthening ability in the titanium alloy. Al based alloy used for disc material with composition (in wt%): 9.0-12..5%Sn, 0.8-1.25% Cu, Max 2.7-3.35% Si and remainder Al, At different loads i.e. 50,60,70 and 75N the friction and wear behavior of Alloy investigated against high carbon-high chromium steel was investigated at constant sliding speed of 1m/s. therefore the effect of Sn addition to different Al based alloys and its microstructure were characterized systematically.

KEY WORDS: *microstructure, mechanical properties, hardness.*

INTRODUCTION:

Al is the third most abundant metal and it has become an economic in all engineering applications since the end of eighteenth century. Al is versatile in nature. Aluminum tin alloys play an impotent role in transportation such as aerospace and automobile, structural applications and engine components [1].the Al-Sn based alloys are generally known as "soft tribological alloys", which are most commonly used in automotive industries such as sliding bearing components for supporting the reciprocating member such as crankshaft in IC engines and these Al-Sn alloys posses excellent friction as well as wear properties [2, 3, 4]. Al-Sn alloy based bearing components posses' high load and speed due to which the toxic Pb get eliminated effectively because of environment severely. The strength of Al-Sn alloy is low, which is about HV 30 with respect to hardness and these were fabricated by powder metallurgy and conventional casting method. The large Sn zone surrounds the Al grains and weak inter facial bonding. And the strength of Al based bearing alloy can be increased by adding Si, Cu, and Mg which leads to increase in transition load as well as wear resistance of the alloys[5]. Aluminum-tin-magnesium alloys posse's enhanced sinterability. The Al-Sn alloys are generally lead free can be used for advanced bearings in automotive and tribological applications. These alloys are well known for its antifriction and self lubricating properties so these alloys plays an important role in automotive industries as well as aerospace industries [6]. The Al-Sn alloys posse's good conformability, friction reduction, embeddability, seizure resistance and corrosion resistance so these alloys are selected in engine bearing materials. The Al-Sn composition should be in such a way that Sn in Al is below 0.09w% Sn(0.02at%Sn) therefore the Sn alloy forms films preventing a seizure of Al with steel on friction surface. It's very difficult to achieve homogeneous distribution of Sn in Al matrix [7]. This is because of high density difference between Al (2.7g/cm3) and Sn (7.2g/cm3) metals. The homogeneity of Sn phase in Al-Sn alloy can be improved by several techniques such as physical vapor deposition, powder metallurgy, rapid solidification, severe plastic deformation, electro deposition. The mechanical alloying is the noble technique to produce controllable refined and homogeneous microstructure, in addition to adding alloying elements in immiscible system. The nanostructure of Al-Sn and Al-Pb alloys has been manufactured by this method and which improves the wear properties, ductility and fracture toughness of MA alloy should be further improved to meet the higher application requirement [8].

Effect of Alloying Element Addition to Al-Sn alloys

Effect of Sn addition to Mg-6Zn-2Al Alloys

Chen Jihua and Chen Zhenhua investigated properties of - Sn added to Mg-6Zn-2Al alloy and the microstructure were characterized by XRD and the alloys composed of α-Mg, MgZn and Mg2Sn in the range of 0.5–3.0 mass% Sn, and no ternary phase was detected. The addition of Sn leads to suppression of the eutectic transformation and the refinement of divorced eutectics [1]. The addition of Sn resulted that the formation of the dispersed short rod-like Mg2Sn particles and the improvement in the ambient and elevated-temperature strength and excessive Sn addition leads to the coarsening of Mg2Sn particles, and thus resulted in the decline of strength and plasticity. Fractographic analysis demonstrated that quasi-cleavage fracture was the dominant mechanism of these alloys tested at ambient temperature and 150 ◦C. Cleavage fracture and quasi-cleavage fracture were preferential at ambient temperature 150 ◦C respectively, with the increment of Sn.

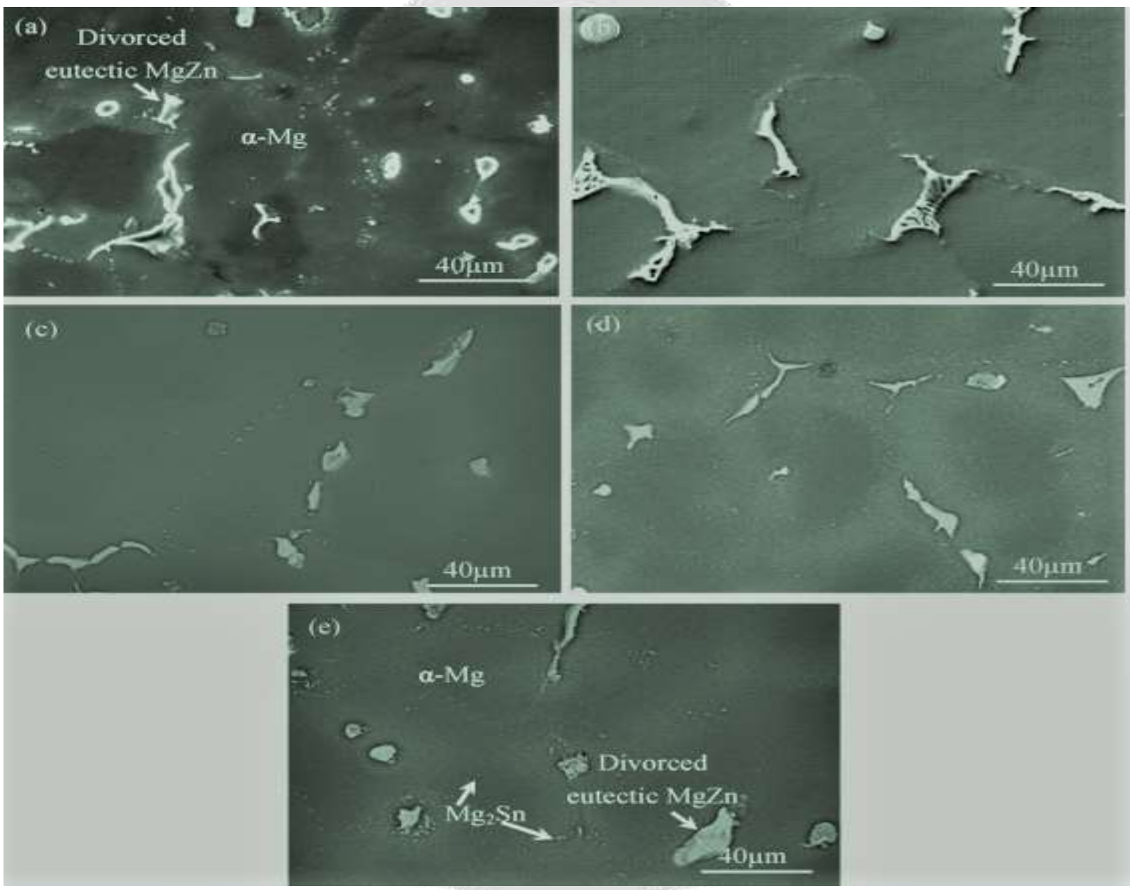

Fig1.Microstructures of the as-cast ZA62 alloys with different Sn additions: (a) ZA62; (b) ZASn6205; (c) ZASn6210; (d) ZASn6220; (e) ZASn6230.

Effect of Sn addition to Al-7Si-0.3Mg alloy

The effect of Sn addition on both the binary Al-Si equilibrium microstructure evaluation of an Al7Si0.3Mg alloy having solid by liquid ratio close to 0.5 were investigated and proposed by A.M Kliauga, M. Ferrante [4-8]. The application of THERMOCALC method showed in the range 0.2-10%, Sn decreases all the liquid to solid transformation temperature. The microstructure effect was studied by scanning electron microscopy (SEM), transmission electron microscopy (TEM) and by quantitative electron microscopy. Results showed that Sn additions decreased the rate of attainment of the equilibrium liquid fraction besides reducing the kinetics of particle spheroidisation and growth. This behavior was attributed to a decrease of solid/liquid surface energy brought about by the presence of Sn as small globules within the Si or Al phases and at the Al/Si interface.

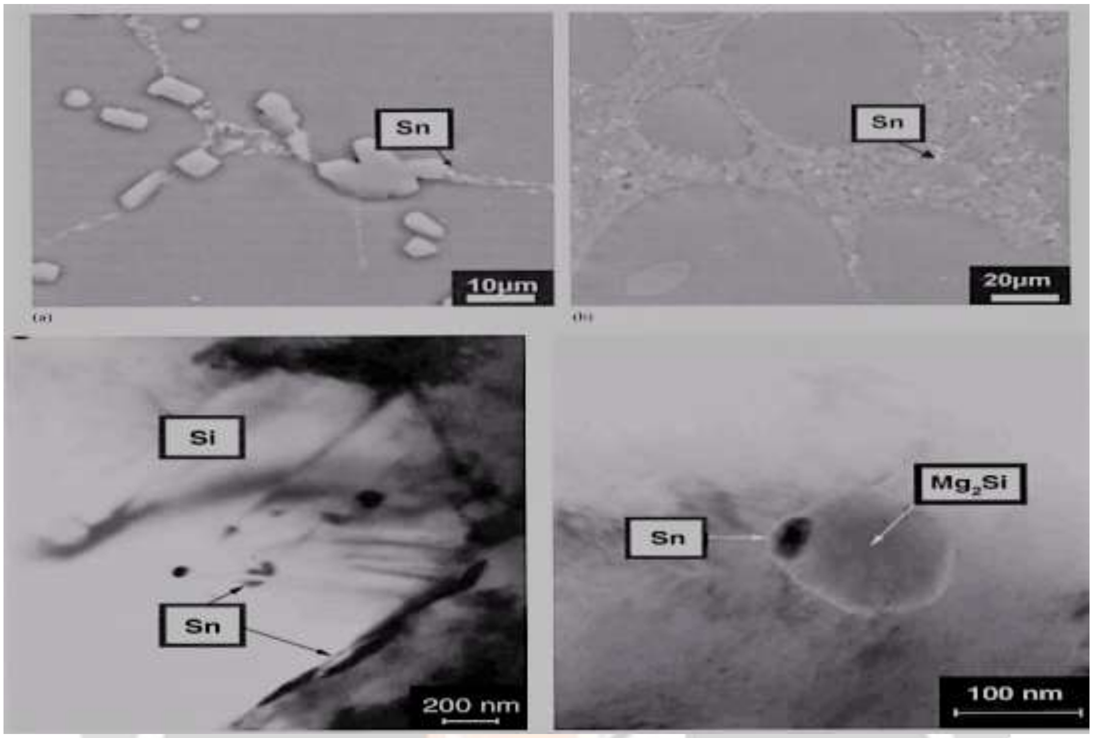

Fig 2-SEM image of Al-7Si-0.3Mg

The fig 2 SEM image of Al-7Si-0.3Mg showed Sn decreases both the eutectic and liquid temperature of A356 alloy. Sn additions equal to 0.2 and 0.5% decrease the quantity of liquid phase whilst the opposite was observed for the 2.0Sn sample and also interface Al-a/liquid and Si/liquid for both the 0.2 and 0.5Sn samples, were it decreases Al and Si dissolution rate. Tin does not change the shape factor but reduces both contiguity and coarsening rate of the solid Al-a particles. These effects were associated to a decrease of capillarity forces, in their turn caused by a reduction of surface energy brought about by the presence of Sn.

Effect of Si addition to Al-Sn alloys

The tribological and mechanical characteristics of of Al-Sn-Si alloy were reviewed by Satyanarayan and Jayaram Bhat using pin on disc tribometer. Al based alloy used for disc material with composition (in wt%): 9.0-12..5%Sn, 0.8-1.25% Cu, Max 2.7-3.35% Si and remainder Al, At different loads i.e. 50,60,70 and 75N the friction and wear behavior of Alloy investigated against high carbon-high chromium steel was investigated at constant sliding speed of 1m/s. the fig 3 shows the SEM image of Al-Sn-Si alloy in which Si particles surrounded by soft Sn phase in Al matrix augmented wear and ant frictional properties of alloy[9]. The hardness properties improved by adding the Si resulting in superior mechanical properties. The researchers investigated that hardness value increased with addition of Si (1.364 times more than pure Al and 1.224 times more than) Al-Sn alloy. These alloys exhibit little wear. The wear characteristic of newly developed alloy is better under lubrication characteristics.

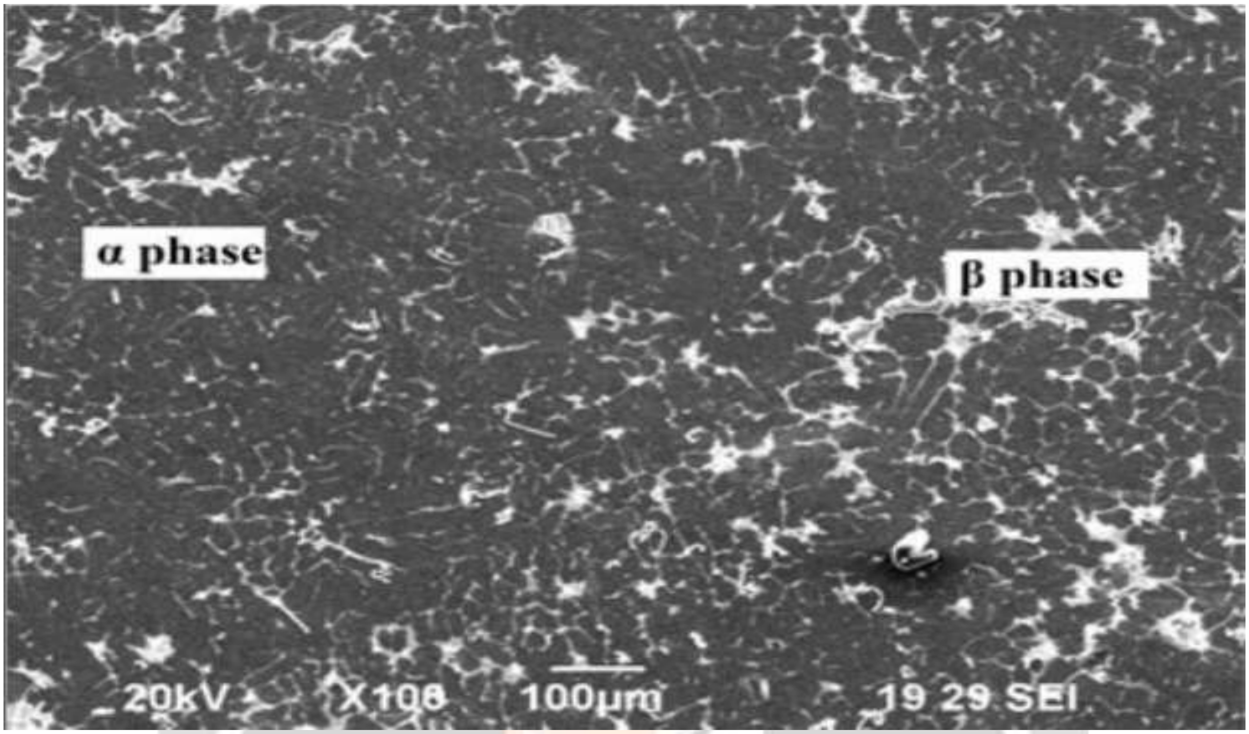

Fig 3. Microstructure of Al-Sn-Si alloys

Effect of Sn addition to titanium alloy (Ti6Al4V)

M. Rajadurai , A. Raja Annamalai were investigated and proposed the following properties as well as microstructure of titanium based alloys, the samples were sintered by spark plasma sintering[11]. The influence of Sn particles on microstructure characteristics of titanium alloy was investigated by the noble technique known as spark plasma sintering. It is investigated that Sn has a strong solid solution strengthening ability in the titanium alloy (Ti6Al4V). Moreover, the addition influences the microstructure and mechanical properties of titanium alloy. Figure 2shows As the percentage of Sn content increases the density of the samples decreases from 96.2 % to 86.8% and mechanical properties like yield strength, ultimate strength, percentage of elongation and harness decrease from 1523Mpa-1335MPa, 1691MPa-1364MPa,16.10% to 1.03% and hardness decreases from 33.2HRC to 26.9HRC respectively. Therefore the addition of Sn particles impacts on the characteristics of microstructure and mechanical properties of titanium alloys (Ti6Al4V) .

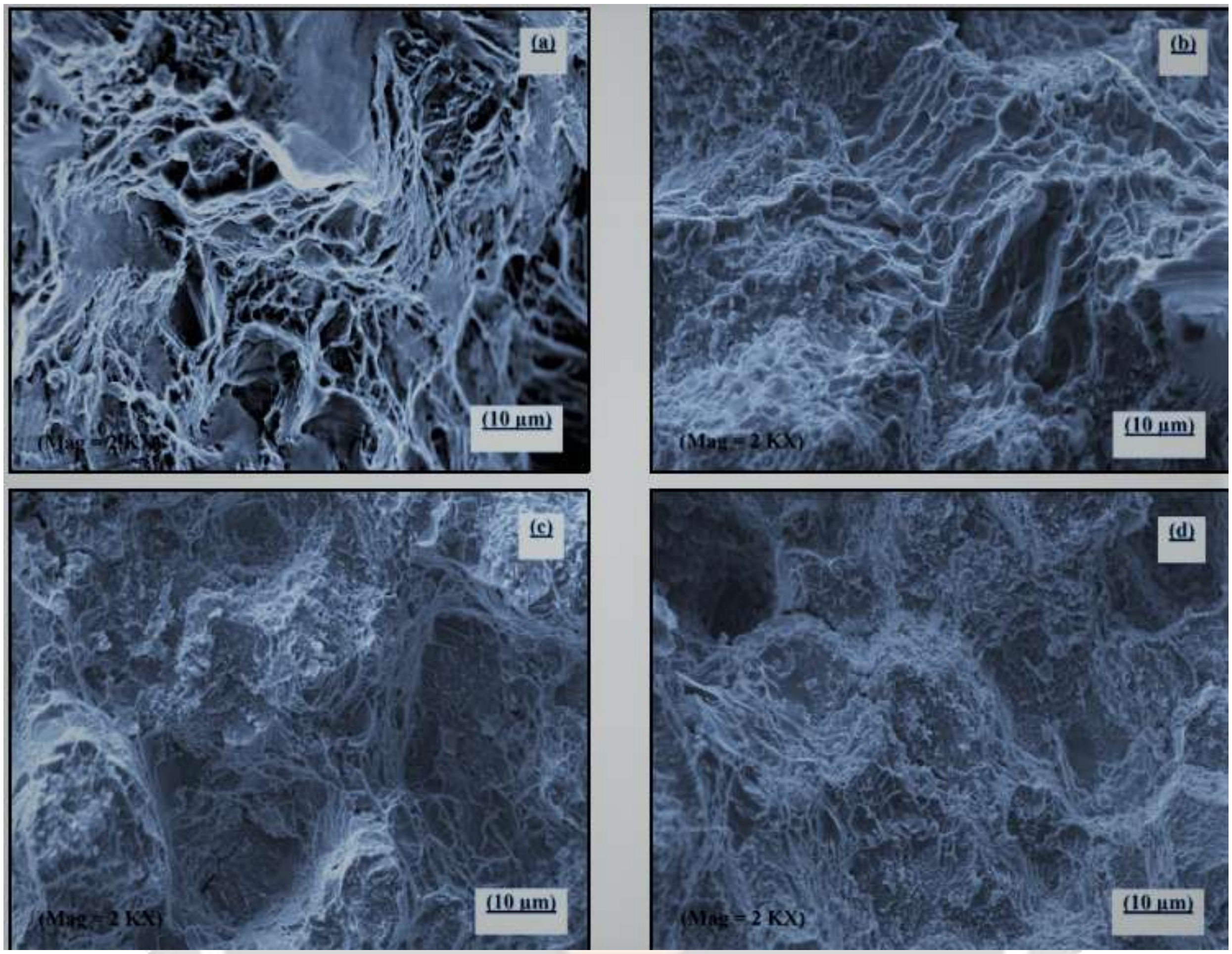

Fig.4 Fractography images of the titanium alloy: (a) Ti-6Al-4V, (b) Ti-6Al-4V-2Sn, (c) Ti-6Al-4V-4Sn, and (d) Ti-6Al4V-6Sn.

As the amount of Sn in the titanium alloy increases changes the microstructure which reveals pores in the sample increase due to sintered density reduces from 96.26 to 86.84%. The YS (1412 MPa), UTS (1502 MPa) and the percentage of elongation (15.29) with 2 % addition of Sn sample exhibit higher values than the 4 and 6 % addition of Sn in the titanium alloy and also the hardness of the sample increase from 23.8HRC to 26.9HRC with the addition of Titanium alloys[15], Al-6Cu,5Sn-3Ga,xln alloy was prepared by using casting and melting techniques and also the microstructure and properties of the alloys were discussed by X-ray diffraction and scanning electron microscopy and Vickers harness and the results showed that When the addition of In contents is 1 mass.%, the hardness of the Al-6Cu-6Mg-5Sn-3Ga-1In alloy reaches to 142HV, and the compressive strength up to 582 MPa. The Mg2Sn and the Al-In eutectic phases are the source of the degradation reaction, and the driving force to continue is the concentration of Al in the eutectic phase and alloys mainly consist of three phases: a-Al matrix, Al2MgCu and Mg2Sn. Ga exists in a solid solution, while In and Al form Al-In eutectic phase.

Conclusion

The current review provides an important factors for understanding the effect of Sn addition toAl based alloys such as Mg-6Zn-2Al, Ti6Al4V, Al-Sn-Si, Al-7Si-0.3Mg and the characteristic of microstrucre and mechanical properties of alloys.

Al-Sn alloy based bearing components posses' high load and speed due to which the toxic Pb get eliminated effectively because of environment severely.

Sn added to Mg-6Zn-2Al alloy and the microstructure were characterized by XRD and the alloys composed of α-Mg, MgZn and Mg2Sn in the range of 0.5–3.0 mass% Sn, and no ternary phase was detected. Excessive Sn addition leads to the coarsening of Mg2Sn particles.

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The researchers investigated that hardness value increased with addition of Si (1.364 times more than pure Al and 1.224 times more than) Al-Sn alloy.

REFRENCES

1) Chen Jihua, Chen Zhenhua ∗, Yan Hongge, Zhang Fuquan, Liao Kun (2008) Effects of Sn addition on microstructure and mechanical properties of Mg–Zn–Al alloys, Journal of Alloys and Compounds 461 (2008) 209–215
2) Yan Jiang , Yu'an Chen , Junjie Gao (2016),Comparative study regarding the effect of Al, Zn, and Gd on the microstructure and mechanical properties of Mg alloy Mg-Sn-Li , Materials and Design 105 (2016) 34–40
3) Philipp Okle, Jeffrey D, Lin ,Tianyu Zhu, David C, Dunand, David N, Seidman (2019), effect of micro-additions of Ge,In or Sn on precipitation in dilute Al-Sc-Zr Alloys, A Material science and Engineering 739(2019) 427-436
4) A.M. Kliauga, M. Ferrante (2002), The effect of Sn additions on the semi-solid microstructure of an Al/7Si/0.3Mg alloy, Materials Science and Engineering A337 (2002) 67-72
5) Z.C. Lu, Y. Gao, M.Q. Zeng, M. Zhu (2014), Improving wear performance of dual-scale Al–Sn alloys: The role of Mg addition in enhancing Sn distribution and tribolayer stability, 309 (2014) wear 216–225
6) J. Patel, K. Morsi (2012), Effect of mechanical alloying on the microstructure and properties of Al–Sn–Mg alloy, Journal of Alloys and Compounds 540 (2012) 100–106
7) Byeong-Chan Suh , Jae H. Kim , Jun Ho Bae , Ji Hyun Hwang , Myeong-Shik Shim , Nack J. Kim (2017), Effect of Sn addition on the microstructure and deformation behavior of Mg-3Al alloy, Acta Materialia 124 (2017) 268e279
8) Sheng-cheng ZHANG1 , Qing-lin PAN1,2, Jie YAN1 , Xing HUANG1(2015), Effects of sliding velocity and normal load on tribological behavior of aged Al−Sn−Cu alloy, Trans. Nonferrous Met. Soc. China 26(2016) 1809−1819
9) Satyanarayana and Jayaram Bhat(2018), recent advances on Al-Sn alloys with Ternary alloying elements, crimson publishers ISSN:2576-8840
10) Yunus Turen1 , Didem Guzel1 , Huseyin Zengin1, Yavuz Sun1 , Hayrettin Ahlatci (2017), Effect of Sn Addition on Corrosion Properties of As-Cast and Hot-Rolled AZ31 Magnesium Alloys, Key Engineering Materials, Vol.750,pp124-128 doi:10.4028/www.scientific.net/KEM.750.124
11) M. Rajadurai1 , A. Raja Annamalai2 * (2018), Effect of Sn addition on the microstructure characteristics and mechanical properties of the titanium alloy (Ti6Al4V), Kovove Mater. 56 2018 191–198 DOI: 10.4149/km 2018 3 191
12) Kovove Mater. 56 2018 191–198 DOI: 10.4149/km 2018 3 191 (2017), Effects of rapid solidification on the microstructure and surface analyses of laser-deposited Al-Sn coatings on AISI 1015 steel, Int J Adv Manuf Technol DOI 10.1007/s00170-017-0876-y
13) Z.C. Lu, Y. Gao, M.Q. Zeng, M. Zhu, Improving wear performance of dual-scale Al–Sn alloys: The role of Mg addition in enhancing Sn distribution and tribolayer stability, Wear 309 (2014) 216–225
14) M.F. Wang , D.H. Xiao , B.R. Sun , W.S. Liu, Microstructure, mechanical properties and corrosion behavior of AlCu-Mg-Sn-Ga-In alloy , Journal of Alloys and Compounds 776 (2019) 172e180
15) Shanghai Wei n , Tianping Zhu, Michael Hodgson, Wei Gao, Effects of Sn addition on the microstructure and mechanical properties of as-cast, rolled and annealed Mg–4Zn alloys, Materials Science & Engineering A 585 (2013) 139–148.