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Improvement of Mechanical and Fatigue Properties for Aluminum Alloy 7049 By Using Nano Composites Technique

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Abstract

The aim of present work is to improve mechanical and fatigue properties for Aluminum alloy7049 by using Nano composites technique. The ZrO_2 with an average grain diameter of 30-40 nm, was selected as Nano particles, to reinforce Aluminum alloy7049 with different percentage as, 2, 4, 6 and 7 wt%. The Stir casting method was used to fabricate the Nano composites materials due to economical route for improvement and processing of metal matrix composites. The experimental results were shown that the adding of zirconium oxide (ZrO_2) as reinforced material leads to improve mechanical properties. The best percentage of improvement of mechanical properties of 7049 AA was with 4% wt. of ZrO_2 about (7.76% σ_u) for ultimate tensile stress UTS, (9.62% σ_y) for yield stress YS and (9.92%) for hardness HB than other of adding of 2, 6 and 7% of ZrO_2. Also the results shown that the fatigue strength of 7049 AA with 4 wt% ZrO_2 nanoparticles is higher than that of 7049 AA under constant loading 9.86% at 10^8 cycles as well as the fatigue life factor (IFLF %) at different amplitude stress 400, 350, 300 and 250 MPa was improvement in range 66, 115, 63 and 107% respectively.

***Keywords**: Nanomaterial, 7049 AA, ZrO_2, Stir casting.*

1. Introduction

Only few machine parts are subjected to static loading and the majority of machine parts are subjected to variable loads. Experimentally, when a material is subjected to dynamic loads, it fails at a stress below the yield stress, such type of failure is known as fatigue. Fatigue may occur under constant or variable loads. Constant fatigue loading is defined as fatigue under cyclic loading with constant amplitude and a constant mean stress or load. But in service, the structures or components are subjected to variable amplitude loading, which can be a rather complex load time history [1].

Many Techniques were used to improve mechanical and fatigue properties for metal materials such as Surface cold work, shot penning and laser shock penning……etc. [2, 3 and 4]. The aim of present work is Improved mechanical and fatigue properties for Aluminum alloy7049 by Nano composites Technique. The Nano composites material was fabricated by stir casting method using Aluminum alloy7049 as a metal matrix and Nano particles of ZrO_2 as a reinforced material with different weight percentage, 2,4,6 and 7wt%. Metal matrix composites were studied which are widely used in an industry for many applications in aerospace, automotive and others so it is request to improve mechanical and fatigue properties of metal matrix composites for use in high-performance applications.

M. Dinesh and R. Ravindran [5] Studied hardness and tensile behavior of 7075 aluminum alloy with different reinforcement by Cr nanoparticles weight as 2,3,4,5 and 6 wt% and zinc nanoparticle of 1 wt% by air casting technique. They found the tensile stress and hardness values of the composite higher than the unreinforced alloy. The stir casting was suitable technique for manufacture of this type of composite material.

C. Kannan and R. Ramanujam [6], Studied Nano composite Al-7075 alloy for two conditions, single and hybrid for 2 wt% and 4 wt.% of SiC produced through stir casting. They observed that the addition of nanoparticles with 30-50 nm grain size, improved the ultimate stress and hardness by 63.7% and 81.1% for single and hybrid respectively.

Divagar, and M. Vigneshwar [7] "Fabricate 7075-T651 Al- alloy with various weight percentages of SiC nanoparticles 5,10 & 15 wt % of $A1_20_3$ nanoparticles as reinforcements by stir casting process. The metal matrix Nanocomposite comprising of AA7075-T651+SiC-10%+Al2O3-5% exhibits 12.13% higher fatigue strength than the base metal and other composites.

S.E.Shin and D. H. Bae [8] Studied fatigue behavior of aluminum alloy 2024 matrix composites reinforced with multi-walled carbon nanotubes under the tension-compression fatigue test. Tensile and fatigue strength of the Al2024 composites increases with increasing multi-walled carbon nanotubes content. Al 2024 with 4vol.% multi-walled carbon nanotubes composite shows the remarkably enhanced fatigue strength of 600 MPa at the 2.5×10^6 cycles and the ratio of tensile strength to fatigue strength of 0.78. When the composite is cyclically loaded, the developed incompatibility between the matrix and the fiber induces the fiber pull-out and it acts as a bridge when the cracks propagate. Thus, as the content of multi-walled carbon nanotubes increases in the composite, the prevailing bridging behavior of multi-walled carbon nanotubes enhances the number of fatigue cycle.

Al-Alkawi H. J. M. and Ibtihal A. [9] Studied the behavior of 2024 aluminum alloy with $A1_2O_3$ Nano composite which was fabricated by stir casting at 450 r.p.m and casting temperature of 850°C. The experimental tests showed an improvement in the fatigue strength and life compared to the metal matrix 2024 aluminum alloy. The S-N curves were obtained and the equations of the Nano composite which described the constant S-N curves were established based on Basquin power law equation for 0.2, 0.4, 0.6, 0.8 and 1.0wt% $A1_2O_3$. The experimental results analysis revealed that the fatigue strength is improved by 5.3% and the fatigue life is increased by 16.02% for 2024 aluminum alloy with 0.4wt% $A1_2O_3$ Nano composite compared to that for metal matrix.

A.P. Utkarsh Prajapati et al [10] They studied the effect of Nano Al_2O_3 on the mechanical properties of the aluminum based alloy, they concluded that the mechanical properties of aluminum based alloy can be increase by adding Al_2O_3 Nano particles into it. Also the stirring speed significantly affects the mechanical properties of the Nano-scattered castings. The speed more than 1500 rpm causes decrease in the elasticity. The distribution of Nano alumina particles in the aluminum from 1.0 to 3.0, the immunization particles are consistently scattered in Al, with alumina content under 4.0 wt.%.

AL Alkawi H. J. M. et al [11] Investigated 7075 Al-alloy metal matrix composites with different wt %, 0.2, 0.4, 0.6, 0.8, and 1.0 of $A1_20_3$ reinforced particles of 10 nm in grain size, were fabricated using stir casting technique. Discuss the influence of adding $A1_20_3$ particles content on the mechanical properties of the metal material composites. They concluded the nanomaterial reinforcement lead to improve the BHN hardness, ultimate strength σ_u and yield stress σ_y.The maximum improvement in BHN hardness, $\boldsymbol{\sigma_u}$and$\boldsymbol{\sigma_y}$was observed with 0.2 wt%. $A1_20_3$.While the minimum value of ductility was obtained with 0.2 wt% $A1_20_3$.

R. Senthilkumar et al[12] Studied the mechanical and fatigue properties for two different composite material, 90wt% of 2014 aluminum alloy with 10wt% micron size of Al_2O_3 and 90wt% of 2014 aluminum alloy with 8wt% micron size of Al_2O_3 and 2wt% Nano size of Al_2O_3. The results show the mechanical and fatigue properties for composite 90wt% 2014 aluminum alloy with 8wt% micron size of Al_2O_3 and 2wt% nano size of Al_2O_3 was higher than that of composite 90wt% 2014 aluminum alloy with 10wt% micron size of Al_2O_3 due to Nano size of Al_2O_3 reinforcement which more effectively.

Al-Alkawi et al [13] Studied 7075 Al-alloy with nanomaterial reinforced AI_20_3 of 10 nm in grain size which is used different wt% as, 0.2 , 0.4 , 0.6 , 0.8 and 1.0. It was observed that the best enhancement in fatigue strength and life occurred with 0.2wt% of AI_2O_3.The fatigue strength increased by 2.86% compared to the base metal alloy. The improvement may be coming from uniform distribution of Al_2O_3 and minimal porosity.

Hajizamani and Baharvandi [14] Used hybrid Nano composites with A356 aluminum alloy base metal taking four weight percentages 0.5, 1, 1.5 and 2wt% of Al_2O_3 and 10% volume of ZrO_2. The Stir casting technique was used for manufacturing the Nano composites. They observed experimentally that the mechanical and hardness increased for all the above Nano composites in an pproximately linear manner.

Ali Mazahery and Mohsen Ostadshabani [15] Study the vol.% of alumina nanoparticles were incorporated into the A356 aluminum alloy by a mechanical stirrer. Characterization of mechanical properties revealed that the presence of nanoparticles significantly increased compressive and tensile flow stress. The presence of Nano particle Al_2O_3 reinforcement leads to significant improvement in yield strength and ultimate tensile stress while the ductility of the aluminum matrix is retained.

2. Material and Properties

The material that used in this work was a 7049AA supplied from round bar of 12 mm in diameter. The experimental of chemical and mechanical properties of 7049AA was done at State Company for Inspection and Engineering Rehabilitation in Iraq SIER, which is reported in Table-1 and Table-2 respectively.

Table 1,
Experimental and standard chemical composition of 7049 AA in w t%

Material	Zn	Ti	Si	Cu	Fe	Cr	Mg	Mn	Al
Standard	0.25 max.	0.2 max.	0.8 max.	3.5-4.5	0.7 max.	0.1 max.	0.4-1	0.4-0.8	Balance
experimental	0.22	0.08	0.15	3.8	0.25	0.06	0.72	0.57	Balance

Table 2,
Mechanical properties of 7049AA

Property	σ_u MPa	σ_y MPa	E GPa	µ	EI%	HB
experimental	515	312	73	0.32	19	131
Standard	520	317	74	0.32	20	132

3. Experimental Technique of Fabricating the Nano Composites

Stir casting method was chosen as Technique of Fabricating the Nano composites due to economical route for improvement and processing of metal matrix composites materials. The 7049 AA was selected as the matrix and ZrO_2 as nano particles, as a reinforced material with different weight percentage, 2,4,6 and 7wt% with an average grain diameter of 30-40 nm. In stir casting process, the 7049 AA was first heated above its melting temperature (750°C), then keep it in the semisolid condition, at the same time the ZrO_2 particles was heated at the same temperature and dropped into semisolid and mixed with 450 r.p.m stirring speed for 4 minutes. The melt was then superheated above liquid temperature and poured into the mold for fabricating the specimens. The test rig which used to prepare the Nano composite material can be seen in Figure-1.

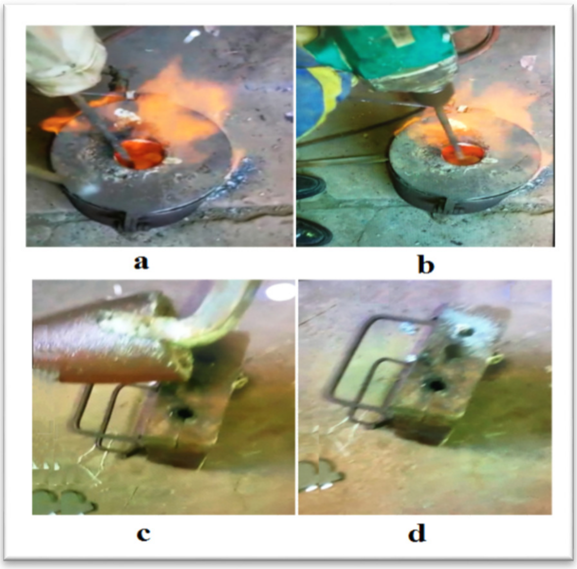


Fig. 1. Stir casting process; a: furnace Ignition and metal melting; b: move the nanoparticles with molten metal; c: the melt poured into the mold; d: composites product into mold.

The size of the composites product is 150 mm length and 12 mm in diameter. The composite product was fabricated in the rule of mixtures which can be seen in Table-3.

Table 3,
Nanocomposites mixture rule

Aluminum alloy 7049 (gm)	ZrO_2nanoparticles ($wt\%$)	ZrO_2 (gm)	Total weight (gm)
980	2	20	1000
960	4	40	1000
940	6	60	1000
930	7	70	1000

4. Fatigue Specimens preparation and machine Test

Fatigue specimens were prepared according to DIN 50113, 12 specimens for 7049 AA and 24 specimens for 7049 AA with 4% wt. of ZrO_2. The specimen dimensions' configuration of fatigue test was shown as in Figure-2. The silicon carbide papers were using for smooth surface of the specimen.

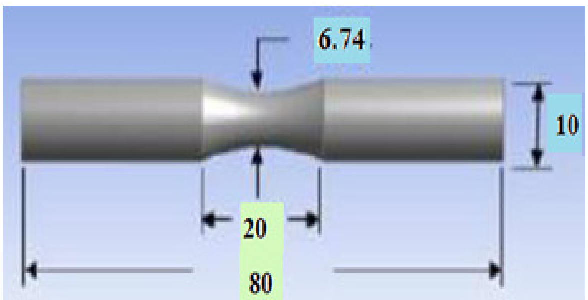


Fig. 2. The specimen dimensions in mm according to (DIN 50113) standard values

A rotating bending machine fatigue–testing Schenck product type as shown in figure-3 was used to implement all fatigue tests, with constant and variable amplitude stress. The fatigue specimen which is shown above has a round cross-section and is subjected to an applied load from the right side of the perpendicular to the axis of the specimen, developing a bending moment. Therefore, the surface of the specimen is under bending stress, tension and compression when it rotates.

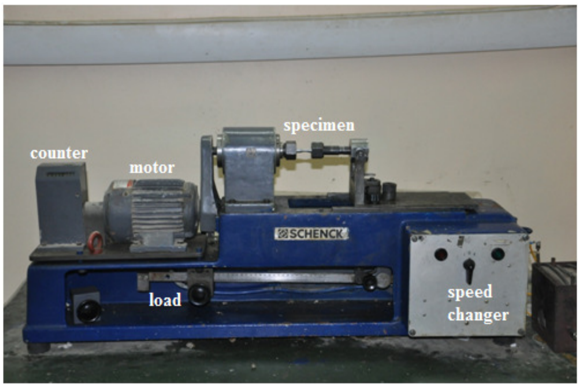


Fig. 3. Fatigue bending machine test Schenck.

5. Results and Discussions

5.1 Mechanical Properties of Composites

The experimental of mechanical properties of 7049 AA specimens with using zirconium oxide (ZrO_2) as a reinforced material with different $wt\%$ was done at State Company for inspection and engineering rehabilitation in Iraq SIER, which is reported in Table-4. The results show the adding of zirconium oxide ZrO_2 as reinforced material lead to improve mechanical properties and hardness. The results show the best improvements for mechanical properties and hardness was for composite with 4$wt\%$ of ZrO_2 compared with that the others $wt\%$ of ZrO_2 as shown in Table-4 and Figure-4. The tensile stress-strain diagram up to ultimate stress for 7049AA and Nano composite with 4$wt\%$ of ZrO_2 was shown in Figure-5.

Table 4,
Mechanical properties result for composite 7049AA with different $wt\%$ of ZrO_2.

property	σ_u MPa	Improve. %	σ_y MPa	Improve. %	HB	Improve. %
0%	515	-----	312	-----	131	-----
2%	534	3.689	320	2.564	136	3.816
4%	555	7.766	342	9.615	144	9.923
6%	540	4.854	332	6.410	138	5.343
7%	532	3.330	328	5.128	132	0.769

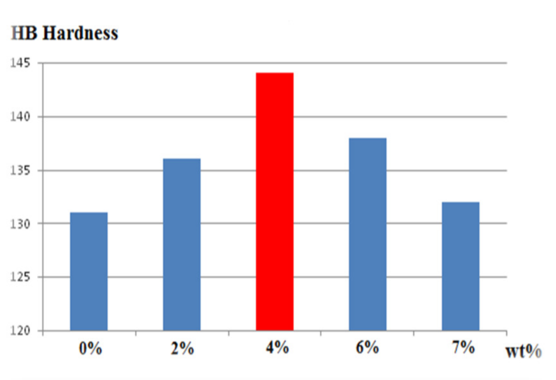


Fig. 4. Hardness (HB) result with different w*t*% of ZrO_2.

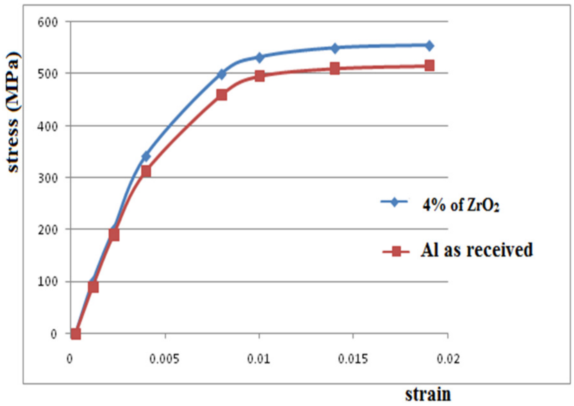


Fig. 5. Tensile test for 7049AA and Nano composite with 4w*t*% of ZrO_2 .

5.2 Fatigue Test Results Under Constant Loading

All fatigue specimens were tested under constant loading using the rotating bending machine fatigue. The fatigue Test under constant amplitude stress was for 7049AA without and with 4w*t*% ZrO_2 only to find the improvement for fatigue properties. The S-N curves results illustrated in Table-5 at four different levels stress or amplitude stress. The average of number of cycles to failures of three specimens at each level stress is recorded. It can be observed that the effect of the addition of 4w*t*% ZrO_2 nanoparticles on fatigue behavior by seen the improvement in fatigue life through estimating the improvement fatigue life factor (IFLF %) at different level stress by using equation-1[16].

$$FLIF\ \% = \frac{N_{f_c} - N_{f_D}}{N_{f_c}} \times 100 \quad \ldots(1)$$

where (N_{fD}) and (N_{fc}) is number of cycle to failure for base metal or with 0w*t*%ZrO_2 and for the composite with 4w*t*% ZrO_2specimens respectively. The (FLIF %) at different amplitude stress was shown in Table-5

Table 5,
Improvement fatigue life factor (IFLF) at different amplitude stress.

Amplitude stress MPa	**Average N_{fD} of 7049AA without ZrO_2**	**Average N_{fc} of 70499AA with 4wt% ZrO_2**	**IFLF%**
400	12600	21000	66.66
350	44800	96600	115.6
300	190600	310800	63
250	610800	1268600	107.7

The empirical fatigue power law regression given by: $\sigma = aN_f^{\ b}$ … (2)
where, (σ) is the applied stress, N_f is the number of cycles to failure and (**a**),(**b**) are the fitting parameters. The regression constants represent the fatigue trends from the model and the fatigue strength at 10^8 cycles can be observed as shown in Table-6. The results show the Improvement of Fatigue strength was 9.86%.

Table 6,
Fatigue Parameters and Fatigue Strength of AA 7049 with and without 4wt% ZrO_2.

Description	**a**	**b**	**Fatigue strength at 10^8 Cycles (MPa)**	**Improvement of Fatigue Strength (%)**
7049AA	1240	-0.1187	139.370	-----
7049AA with 4wt% ZrO_2	1283	-0.1154	153.118	9.86

The S-N curve under constant amplitude stress test for specimens 7049AA without ZrO_2 or with 0w$t\%$ ZrO_2 and for the composite 7049AA with 4w$t\%$ ZrO_2, and the empirical power law equation it can be shown in Figure-6.

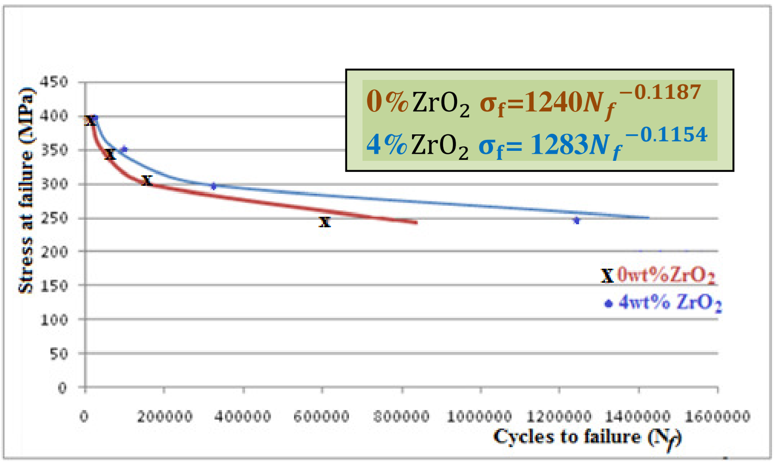


Fig. 6. S-N curves of the Nano composite with 4 w$t\%$ ZrO_2 compared with the base metal 7049AA with 0% ZrO_2 under constant amplitude stress .

The results show the introducing 4% of ZrO_2 to the7049AA lead to the higher mechanical properties, improve the fatigue life and fatigue strength. The higher mechanical properties of the 4wt% ZrO_2 composite could be attributed to the fact that ZrO_2 particles acts as obstacles to the motion of dislocation, the increasing in mechanical properties can be attributed to reduce grain size, leading to rise up the fatigue strength and fatigue life of composites and this results agreement with finding by Abdizadeh H., Baghchesara M.A. [17].

5.3 Fatigue Test Results Under Variable Loading

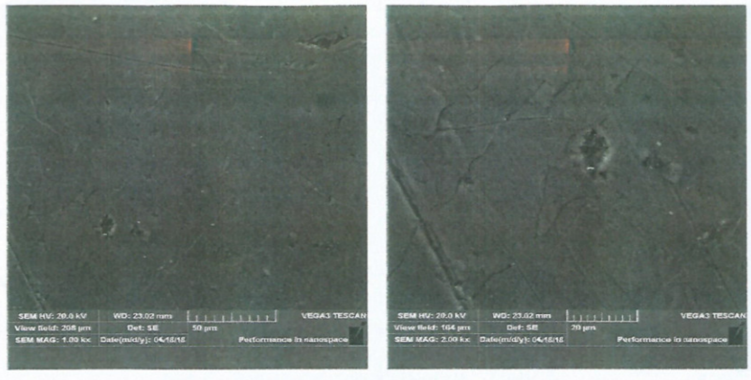
Fatigue test under variable loading was done by testing specimens under variable loading for two different conditions at low to high sequences loading and high to low sequences loading by using fatigue test machine type rotary, the machine run 10000 cycles for each stress level and so on to the failure of specimen, 6 specimen for each case. Experimental fatigue test under variable loading for base metal with 0wt% ZrO_2 and Nano composite 4w$t\%$$ZrO_2$ was recorded in Table-7. The results show improvement in fatigue life factor 33.7% and 15.8% of Nano composite with 4wt% ZrO_2 for both cases respectively through estimating the improvement fatigue life factor (IFLF %) for two cases by using equation-1.

Table 7,
Experimental fatigue test under variable loading for base metal with 0wt% ZrO_2 and Nano composite 4w$t\%$$ZrO_2$

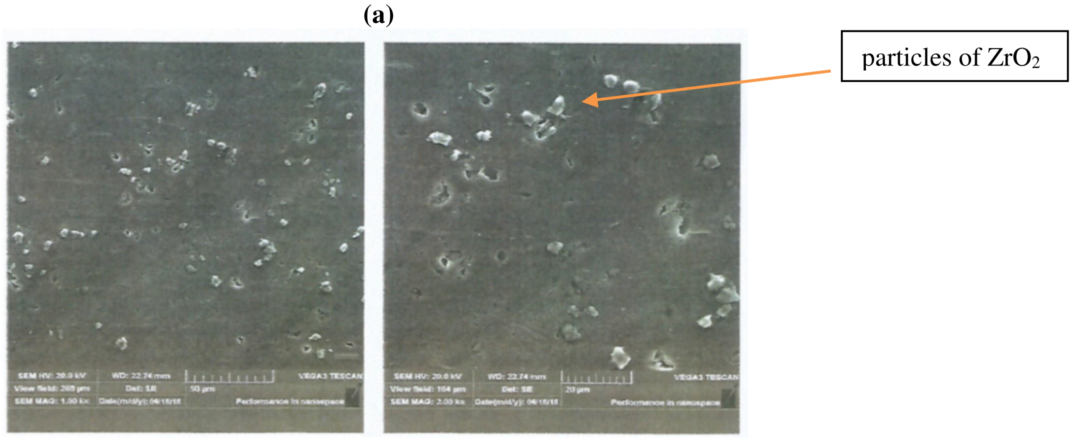
Loading Sequence MPa	$Average\ N_f$ 0wt% ZrO_2	$average\ N_f$ 4wt% ZrO_2	Loading program
350-250	37644	56800	350 10000 | 250 10000
250-350	72600	86233	350 250 10000 10000

5.3 Microstructure Analyses

Microstructures of 7049 AA as received and composites with the content of 4 wt.% ZrO_2, are shown in Figures-7, Dark regain represent AL matrix and bright particles represent particles of ZrO_2. It can be mentioned that Nano-particle ZrO_2 represents appropriate wettability with molten metal and good stability as well. It certainly should be noted that not only the wettability has an important role in the distribution of reinforcement particles in the matrix, but also, other factors such as pouring condition, stirring rate, solidification rate, etc. have profound influences on the even distribution of ZrO_2 in the metal matrix, fabricated by stir casting.



(a)



(b)

Fig. 7. (a) SEM micrograph of 7049AA as received at different magnification 50 and 20µm respectively (b)SEM micrograph of composites fabricated of 7049AA with 4wt% ZrO_2 at different magnification 50 and 20µm.

6. Conclusions

The results show the improvement of using different w*t*% of zirconium oxide ZrO_2 Nano particles reinforced Aluminum alloy7049 as Nano composites material on mechanical and fatigue properties. The significant findings of this investigation are as follows:

1. The mechanical properties of 7049AA specimens with zirconium oxide (ZrO_2) reinforced material lead to improving mechanical properties and hardness in different percentage according to different w*t*%of ZrO_2 reinforced 7049AA.The best improvement of mechanical properties and hardness was occurred with 4w*t*% of ZrO_2 in the rate of (7.76σ_u%) UTS, (9.615σ_y%) YS and (9.92%) HB.
2. Fatigue properties of 7049AA with 4w*t*% ZrO2 are higher than that of the non-reinforced 7049AA under constant loading. Also the Fatigue life of Nano composite with 4wt% ZrO2 was higher than that for base metal or with 0wt% ZrO2 under variable loading sequence for both high to low and low to high sequence.
3. The higher mechanical properties of 7049AA with 4w*t*% ZrO2 composite could be attributed to the fact that ZrO2 particles acts as obstacles to the motion of dislocation and

to reduce grain size, leading to rise up the constant and cumulative fatigue life of composites.

4. The results of Fatigue test under variable loading for two different conditions at low to high sequences loading and high to low sequences loading show improvement in fatigue life factor 33.7% and 15.8% of Nano composite with 4wt% ZrO2 for both cases respectively.

7. Reference

[1] N. E. Frost, K. J. Marsh and L. P. Pook “Metal Fatigue” Clarendon Press, Oxford (1974).

[2] Koji Takahashi, Hiroko Osedo, Takaya Suzuki, Shinsaku Fukuda, "Fatigue strength improvement of an aluminum alloy with a crack-like surface defect using shot peening and cavitation peening" Engineering fracture Mechanics, vol. 193, pp. 151-161, April 2018.

[3] Abdul-Jabar H. Ali, "Improvement of Fatigue Life of AA 7075 Using Laser Shock Peening (LSP) Surface Treatment Technique", Al-TAQANI Refereed Scientific Journal, vol. 29, pp. 47-57 (2016).

[4] Dorman, M., Toparli, M. B., Smyth, N., Cini, A., Fitzpatrick, M. E. and Irving, “Effect of laser shock peening on residual stress and fatigue life of clad 2024 aluminum sheet containing scribe defects”, Materials Science and Engineering: A, 548, pp. 142–151, (2012).

[5] M. Dinesh, R.Ravindran "Tensile and hardness behavior of aluminum 7075 and Zinc and Chromium metal matrix composite by Stir-Casting Route" International Archive of applied Sciences and Technology , vol. 7 , pp. 39- 46 (2016).

[6] C. Kannan, R. Ramanujam," Comparative study on the mechanical and microstructural characterisation of AA 7075 nano and hybrid nanocomposites produced by stir and squeeze casting" Contents lists available at Science Direct Journal of Advanced Research 309–319 8 (2017).

[7] S. Divagar, M. Vigneshwar, S.T. Selvamani " Impacts of Nano Particles on Fatigue Strength of Aluminum Based Metal Matrix Composites for Aerospace" Materials Today: Proceedings, vol. 3, pp. 3734-3739, (2016).

[8] S.E.Shin, D.H.Bae," Fatigue behavior of Al2024 alloy-matrix nanocomposites reinforced with multi-walled carbon nanotubes" Science Direct, Composites Part B: Engineering Volume 134, , Pages 61-68, (1 February 2018).

[9] Al-Alkawi H.J. M., Ibtihal A. M., Mamoon A. A. Al- Jaafari," An Estimation Study on Fatigue Transition Life of Nanocomposites Reinforced by Al203"Arab universities union general secretary of Arab engineering colleges society, (2017).

[10] A.P. Utkarsh Prajapati, A.P. Jay H Patel, Ketul V Patel, Parthkumar P Patel, Pujan P Bhatt, Sandipkumar O Varma," Effect ofAl2O3Nano-ParticleonMechanical Properties of Aluminum Based Alloy: A Review", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 13, Issue 2 Ver. II, PP 72-75, (Mar. - Apr. 2016)

[11] Al-Alkawi H.J.M., Abthal A. M., Mamoon A. A. Al- Jaafari," Mechanical Properties of 7075 Aluminum Alloy Matrix/Al_2O_3, Particles Reinforced Composites" Engineering and Technology journal, (2017).

[12] R. Senthilkumar, N. Arunkumar, M. Manzoor Hussian,"Comparative Study on Low Cycle Fatigue Behaviour of Nano and Micro A1203 Reinforced AA2oI4 Particulate" Hybrid Composites Results in Physics, vol. 5, pp. 273-280 (2015).

[13] Al-Alkawi H.J.M., Ibtihal A. M., Mamoon A. A. Al- Jaafari," Fatigue life Study on 7075 Aluminum Alloy matrix / nanoparticles Al_2O_3 reinforced composite" The Iraqi Journal for mechanical and materials Engineering (2017).

[14] Hajizamani, Hamidreza Baharvandi" Fabrication and studying the mechanical properties of A356 alloy reinforced with Al_2O_3-10% Vol. ZrO_2 nanoparticles through stir casting" Advances in Materials Physics and Chemistry, vol. 1, pp. 26-30 (2011).

[15] Ali Mazahery1 and Mohsen Ostadshabani, "Investigation on mechanical properties of nano-Al_2O_3-reinforced aluminum matrix composites "Journal of Composite Materials 45(24) 2579–2586, (2011).

[16] Sharp P. K., Barter S. A. and Clark G., "Localized life extension specification for the F/A-18. Y470x19 pocket", Melbourne: DSTO-TN-0279, (2000).

[17] Abdizadeh H., Baghchesara M.A., "Investigation into mechanical properties and fracture behavior of A356 aluminum alloy-based ZrO_2 particle reinforced metal matrix composites" Mechanics of composite materials, Vol.49, No.5 (2013).

تحسين الخصائص الميكانيكية و الكلال لسبيكة المنيوم ٧٠٤٩ باستخدام تقنية المركبات النانوية

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الخلاصة

الهدف من العمل الحالي هو تحسين الخصائص الميكانيكية والكلال لسبائك الألومنيوم ٧٠٤٩ باستخدام تقنية المركبات النانوية. تم اختيار ZrO_2 بمتوسط قطر الحبوب ٣٠-٤٠ نانومتر ، كجسيمات نانوية ، لتدعيم سبائك الألومنيوم ٧٠٤٩ بنسب وزنية مئوية مختلفة ٢ ، ٤ ، ٦ و ٧٪. تم استخدام طريقة الصب (Stir casting method) لتصنيع المركبات النانوية بسبب العامل الاقتصادي لتحسين مركبات المصفوفة المعدنية وتصنيعها. أظهرت النتائج العملية أن إضافة أوكسيد الزركونيوم (ZrO_2) مادة نانوية مدعمة تؤدي إلى تحسين الخواص الميكانيكية وان أفضل نسبة تحسين في الخواص الميكانيكية لـ AA ٧٠٤٩ كانت باستخدام نسبة وزنية ٤٪ فكانت نسبة التحسين تساوي (σu ٧,٧٦ ٪) و ($9.615\sigma y$ ٪) و (٩,٩٢ ٪) للإجهاد الشد الاقصى UTS و للإجهاد الخضوع YS و للصلابة HB على التوالي من غيرها عند استخدام ٢ ، ٦ و ٧ ٪ من ZrO_2. كما أظهرت النتائج أن متانة الكلال لسبيكة AA ٧٠٤٩ عند استخدام ٤ ٪ من الجسيمات النانوية ZrO_2 أعلى بنسبة ٩,٨٦ ٪ من متانة الكلال لسبيكة الالمنيوم AA ٧٠٤٩ بدون اضافة اي نسبة من اوكسيد الزركونيوم عند اختبار حمل ثابت عند ١٠⁸ دورة ، فضلا عن معامل عمر الكلال (IFLF ٪) عند اختبار بإجهادات مختلفة كانت ٤٠٠ و ٣٥٠ و ٣٠٠ و ٢٥٠ ميكا باسكال تحسنًا بحدود ٦٦ و ١١٥ و ٦٣ و ١٠٧٪ على التوالي.