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Effect of Ultrasonic Treatment on Ti/Al Composite using Squeeze Casting: Microstructural Analysis and Mechanical Properties

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Abstract: To segregate the Titanium (Ti) from the reinforcements of the molten scrap of Titanium/Aluminum (Ti/Al) composite, application of ultrasonic vibration is known to be one of the sound techniques. Various studies have been looked at the effect of ultrasonic vibration on the melting process, however not much have been investigated with respect to the solidification process. To fabricate Ti/Al composites in situ, ultrasonic vibration can be effectively used to compress the solidifying melt during the casting process. In this line, the present study focused to investigate the influence of ultrasonic vibration and squeeze pressure on solidification behavior of the α-Al matrix, characteristics of the matrix-reinforcements interface, and distribution of reinforcements. The experimental data indicated that when the amplitude was 60 µm, the Vickers hardness, yield strength, and tensile strength of composites increased by 8.6, 3.9, and 3.1 %, respectively, due to gravity casting. While the squeeze pressure was increased from 50 to 100 MPa, the mean grain size decreased from 90 to 60 µm during the ultrasonic aided squeeze casting (SC) process. However, as the squeeze pressure was raised, the microstructures became coarser and the mechanical characteristics weakened. Yield strength, and tensile strength were increased by 18.7% and 3.2%, respectively, when the squeeze pressure was 100 MPa.

Keywords: Ultrasonic Treatment, Squeeze Casting, Gravity Casting, Solidification, Mechanical Characteristics

1. Introduction

Recently, iron aluminides have a competitive advantage over various alternative materials due to the wide availability of both iron and aluminium as raw ingredients. Tests of these alloys' resistance to oxidation at temperatures between 800 and 1100 ^{o}C in air reveal that their behavior is comparable to that of alloys produced by traditional methods [1]. In investigations elsewhere, composites made from recycled copper and ceramic provide an alternate method for fixing electric motors [2]. Moreover, using Nano-iron oxide (Fe_3O_4) as a reinforcement, aluminium matrix composites (AMCs) with varying concentrations of titanium dioxide (TiO_2), 5%, 7.5%, and 10% were fabricated. The matrix and the reinforcements seemed to have a strong connection, and the components were spread out uniformly [3]. The effect of the modified addition on the flexibility of the A356.2 grade alloy has been linked to the magnitude of crystals holding the modifying elements in the base alloy structure [4]. It is vital to manage the secondary production of aluminium from auto-shred waste because aluminium alloys are predicted to be in high demand in the transportation, electronics, and packaging industries [5]. In doing so, the Taguchi method was utilized with evaluations of the cutting surface and cutting roughness which serves a optimization criteria [6]. In this sense, Aluminum (AA2014) chips from waste of manufacturing were employed as the matrix [7]. Semi-solid stirring and ultrasonic treatment were used to create the A356

aluminium matrix composites enhanced by titanium dioxide nanoparticles of varying sizes. However, it was proven that A356 composite prepared by adding 1% wt. of 40 nm titanium dioxide particles displays the best mechanical performance under the same mass percentage [8].

In recent time, the use of ultrasonic aided squeeze casting (USC) technique is employed where ultrasonic vibration is applied during the solidification process of a material, while the material is also subjected to external pressure. Herein, squeeze casting (SC) with ultrasonic treatment (UT) is extensively used to generate high-characteristics behavior Al-Cu-Li alloy casting billets. This alloy is free of Ag, Zn, Zr, RE, etc. [9]. In study elsewhere, a Ti48Al2Cr2Nb2.5C alloy was fabricated by arc melting, then subjected to ultrasound treatment across a spectrum of temperature gradients to investigate the correlation between melt superheat and ultrasonic action [10]. Results showed that the forming metals in a condition between liquid and solid called "thixoform", which is the basis of semi-solid processing technique known as thixo-forming. It was proven that the strengthening effect of the nanoparticles were greatly improved the tensile characteristics of the thixoformed nanocomposites compared to the thixo-formed A356 alloy without reinforcement [11]. Thus, the salt-melt reaction method was used to create an in-situ composite of Al/2TiB_2. After then, it was melted again and subjected to ultrasonic waves of varying intensities and durations. The hardness of Al/2TiB2 in-situ composite has been significantly improved with ultrasonic treatment [12]. In this context, ultrasonic-aided in-situ cast TiB_2/AA2195 composites were analyzed by different researchers for their phase composition, microstructure, and mechanical properties. Additionally, mechanical characteristics of composites and the additive impact of UT and TiB_2 were also addressed [13].

Generally, the nanocomposites are synthesized by re-melting, diluting, and ultrasonically treating in-situ AA 4043/10TiB_2 composites for 5 minutes. According to the results of the microstructural study, TiB_2 particles are better dispersed and refined after undergoing ultrasonic treatment [14]. The UT-treated alloy was found to be low-temperature superplastic [15]. Since as-cast Ti-Al composites have a difficulty with severe Al segregation and coarse Ti_2AlN particles, researchers opted to use UT to better control the macro/microstructure of the alloy and mechanical characteristics when reinforced with Ti_2AlN particles [16]. Mechanical characteristics and wrought processes can be enhanced by decreasing the as-cast grain size, but the same effect can be achieved by decreasing the recrystallized grain size and obtaining a fully recrystallized microstructure [17]. In yet another study, to create TiB_2/AA 2024 composites on the spot, Wang et al. have used ultrasonic vibration to solidify melt with squeezing casting [18].

In case of magnesium alloys, its strength and ductility seemed to be lowered due to stress concentration when coarse primary and eutectic Mg_2Si phases precipitate during fortification at a slow cooling rate [19]. Tensile characteristics of 367 MPa and elongation of 3.84 % in the as-cast state were found in Al-Zn-Mg-Cu alloys with an extra 0.2 wt. % of Al-5Ti-0.2C using the UT-SC process [20]. Ultrasonic treatment followed by squeeze casting successfully generated Al3Ti/AA2024 aluminium matrix composites with variable percentages of Al_3Ti. However, the yield strength did not improve in a linear fashion with increasing Al_3Ti phase mass percent. [21]. As cast AlMg alloy billets were examined for their grain refinement and mechanical qualities in respect to UST using a titanium (Ti) sonotrode in the molten state. Mechanical characteristics like elongation at break were greatly enhanced by the refining of grains, Al_3Fe particles, dendrites, and pores of UST [22].

So far, Aluminum, copper, manganese, and titanium composites reinforced with silicon carbide nanoparticles (SiCnp) have been successfully fabricated employing high-intensity ball milling, mechanical stirring, and ultrasonic treatment for composite slurry and squeeze casting [23]. Heat treatment of a squeeze-cast Al-Cu-Mn-Ti alloy resulted in enhanced strength and ductility. In addition, strength and elongation both were enhanced at the same time due to the precipitation reinforcement [24]. Latterly, the SiC/Al and HEA/Al interfaces of hybridized composites were extensively investigated in respect to solution time and precipitation characteristics [25]. Metal matrix composites (MMCs), like Al-B4C, have several desirable properties, including high hardness, high strength, high resistance to chemicals, high neutron absorption capacity, and so on [26]. T6 treatment enhances the mechanical characteristics of the squeeze cast component by localizing the eutectic Si, refining the eutectic Si, homogenizing the composition for the produced component, and precipitating the Mg_2Si phase in the α-Al matrix [27].

In view of evaluating the suggested microstructure-based strengthening model, compression stress measurements have taken at temperatures between 50 ^oC and 300 ^oC. It was determined that the strengthening term originating from the refined grain structure was observed to be most effective [28]. Squeeze casting was used by Mishra *et al.* [29] to create three samples of reinforced magnesium composites. It was found from the microstructure investigation; the reinforcements were evenly dispersed throughout the matrix. To investigate the influence of micron-sized Ni and Ti-based heterogeneous metal particles on the microstructure and mechanical characteristics of AA7075 hybrid composites, Liu et al. [30] included the particles into SiCp/AA7075 composites through squeeze casting. In such a way, squeeze casting was used to create a 5140 Steel matrix

composite with improved mechanical characteristics with the use of Ti powder addition into an alumina preform. incorporation of Ti powder in the preform helps the Al_2O_3p/steel interface wet and bind, which boosts the composite's mechanical characteristics [31]. Since the composite's reinforcements are short fibres which made from potassium hexatitanate, the resulting aluminium alloy can be machined and exhibit high strength, high stiffness, and a low thermal expansion rate. [32]. An yet another advantage, squeeze casting is utilized to make precision-sized parts for the hollow axle of the transmission shaft. Using squeeze casting infiltration technique, Ti-Al-C MAX/Al-Si MMC composites with a porous MAX phase were produced by Dmitruk *et al*. [33].

In the present study, squeeze casting was utilised to make in-situ Ti/Al composites aided by ultrasonic vibration and the solidification process was evaluated. In addition, during ultrasonic aided of gravity casting and squeeze casting, the effects on microstructure and mechanical properties of fabricated composite were analyzed. Furthermore, causes for solidification process for α-Al matrix and the behavior of matrix t with respect to ultrasonic vibration that might affect the distribution of reinforcement were also investigated.

2. Experimental

2.1. Materials

In the first phase, a resistance furnace (200 mm inner diameter and 320 mm height) was employed having capable of producing a maximum heating temperature of 1000 °C. The addition of fluorine salts to the molten aluminium alloy was supported by rapid mechanical stirring to ensure the continuity of the chemical reactions. The propeller-shaped graphite rotor in this device spins at a pace of 200-300 rpm was used in the furnace. It measures 15 mm in thickness and 50 mm in diameter. After the composite melt had been appropriately stirred mechanically, a maximum energy to ultrasonic probe was injected into it, cracking the formed Ti agglomeration. The apparatus for preparing a melt is depicted in a simplified form in Figure 1.

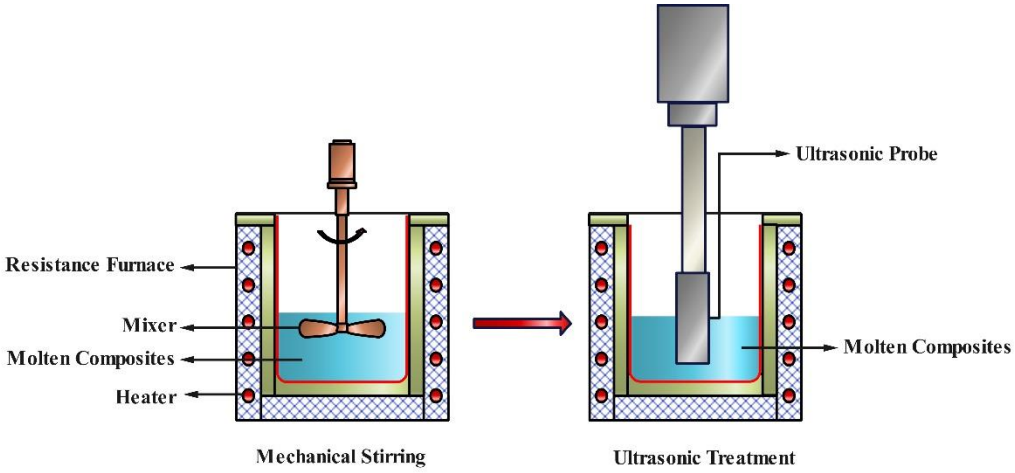


Figure 1. Illustration of the melt fabrication machine



Figure 2. Ultrasonic assisted squeeze casting set up

In general, USC is applied during the solidification process of a material, while the material is also subjected to external pressure. A high-energy ultrasonic unit with a heating system and a set of squeeze casting dies (inner chamber measuring 60 mm in diameter and 70 mm in altitude) were executed that made up for the USC equipment. Figure 2 presents an ultrasonic squeeze casting set up used for the experimentation.

The X-ray fluorescence spectrum was employed to determine the chemical composition of the initial aluminium sample. Aluminum scrap has a solidus temperature of 638 ^{o}C and a liquidus temperature of 502 ^{o}C. Casting aluminium alloys has a solidification rate of 10-20 $^{\circ}$C

2.2. Method

In the present study, 600 g of aluminium were melted in a well-type furnace with a graphite crucible. The amounts of KBF4 and K2TiF6 (representing 5 % by wt. Ti/Al) were determined to be 123.97 g and 119 g, respectively were considered. The melt was ultrasonically vibrated before being poured into a hollow die warmed to 300 °C. The punch was lowered at a pace of 5 mm/s, and the composites were dispensed into the cavities with a pressure holding duration of 30 seconds to ensure constant pressure during solidification. The process was started with a two-hour isothermal drying process at 200 ^{o}C with constant stirring of the accurately weighed fluorine salts. Following this, the fluorine salts were mixed, then wrapped in aluminium foil before being introduced to the melt repeatedly while being mechanically agitated at a rate of 500 rpm. The melt was refined and degassed by adding 3 g of C_2Cl_6 powder. Ultrasonic treatment was applied to the melt after it had been mechanically stirred for 30 minutes (to a depth of about 60 mm below the melt's surface).

In order to reduce thermal gradients, the produced 5 wt. % Ti/Al composite was chilled to a lower temperature (750 ^{o}C) before casting. The melt was ultrasonically vibrated (Figure 2) before being poured into a hollow die that had been warmed to 300 ^{o}C. The punch was then lowered to its lowest feasible position at a pace of 5 mm/s, and the composites was dispensed into the cavities. To guarantee that the applied pressure would be held throughout the whole solidification phase of the composite, a pressure holding duration was chosen for 30 s. In the present study, different ultrasonic amplitudes (30, 60, and 90 µm) and pressures (50, 75, and 100 MPa) were investigated to study their effects on the microstructures and mechanical characteristics of the composite. Gravity casting occurred at zero MPa of squeeze pressure.

2.3. Ascertaining Mechanical Properties

Central regions of the solidified composites were sampled for the microstructural analysis, and then processed using normal grinding and polishing metallographic techniques. The samples were etched for 15 seconds in Keller reagent. A TH701 single head Vickers hardness meter was employed to evaluate the samples hardness under 1.96 N of pressure for 10 seconds. The average of ten readings was used to obtain each hardness value. The mechanical characteristics of the material were analyzed at a rate of 1 mm/min using the Instron 5967 testing apparatus. The T6 thermal treatment was performed on the solidified composites, and the specimens were then cut from the ingots perpendicular to the axis for the mechanical property testing. The average of three individual measurements was utilized to determine each mechanical attribute value. Figure 3 shows mechanical characteristics testing sample.

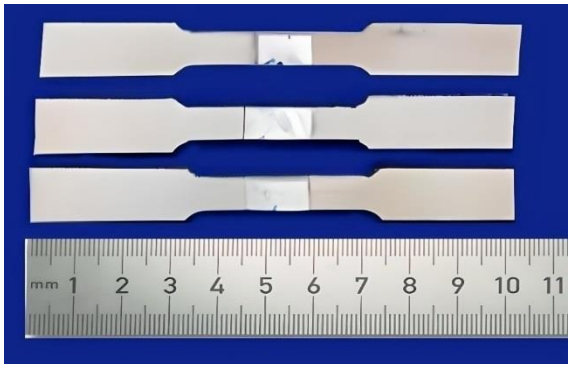


Figure 3. Specimens for mechanical properties

The mean grain sizes (d) of the α-Aluminium matrix were determined using the OLYMPUS-DSX image analysis system and the related equations as given below [34].

$$D_i = \frac{L_i}{M_i} \quad (1)$$

$$d = \frac{\sum_{i=1}^{n} D_i}{n} \quad (2)$$

Where, Li - Span of the measuring line, Mi - No of grains, n - The total number of lines used to take the measurement.

3. Results

3.1. Gravity casting using Ultrasonic

Microstructures of a gravity-cast 5 wt% Ti/Al composite is displayed in Figure 4. It was found that the mean grain size was observed to be 61 µm and that 7.3% of the grains were found as coarse having diameter more than 79 µm. Measurements included 82HV Vickers hardness, 281 MPa tensile strength, and 122 MPa yield strength.

The microstructures of Ti/Al composites cemented at 5 wt %, using different amplitudes of ultrasonic were examined. Results showed that while the ultrasonic amplitude was raised, the α-Al matrix was polished, and the resultant grains were equiaxed.

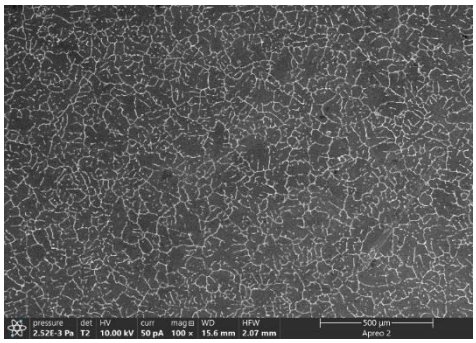


Figure 4. Microstructural image of 5 wt. % Ti/Al by gravity

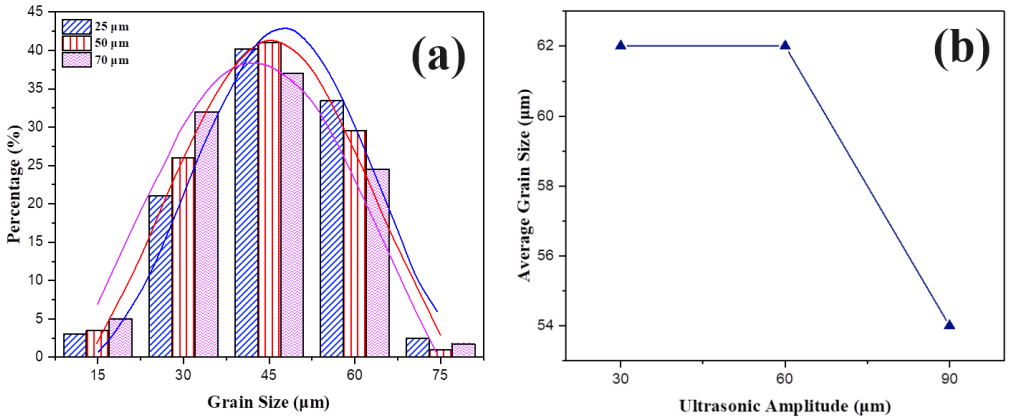


Figure 5. Effect of ultrasonic amplitude on (a) grain size distribution and (b) mean grain size of 5 wt. % Ti/Al composites during solidification (squeeze pressure 60 MPa) casting

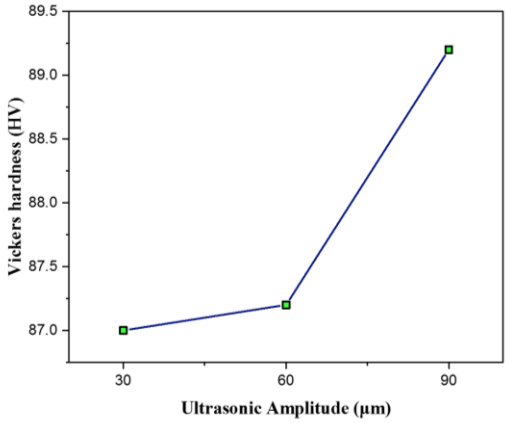


Figure 6. The hardness of solidified (5 wt %) Ti/Al composites (the squeeze pressures were 50 MPa) was studied at several ultrasonic amplitudes

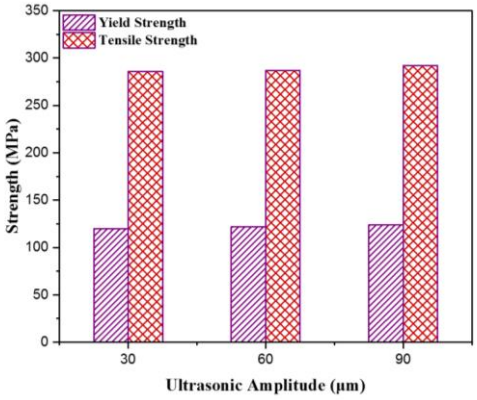


Figure 7. Effect of ultrasonic amplitudes on mechanical characteristics of solidified 5 wt. % Ti/Al composite (squeeze pressure 0 MPa)

The report documented by Nursyifaulkhair *et al.* is well-supports these results [35]. Figure 5 displays these computed values for common grain sizes. The mean grain size was calculated to be 62 µm while the ultrasonic amplitude was 30 µm. On other hand, 1.8 % decrease in mass was observed when compared with gravity casting. However, the average particle size did not change when increased the amplitudes from 30 µm to 60 µm. The mean grain size was reduced to around 60 µm (16.3 % due to gravity casting) when the amplitude of the ultrasonic waves was increased to 90 µm. Figure 6 displays the Vickers hardness of Ti/Al composites consolidated at 5% by weight at varying ultrasonic amplitudes (at constant squeeze pressure, 50 MPa). According to Lu et al., as the amplitude of the ultrasonic waves was increased, the Vickers hardness was inferred to increase proportionally [36]. A 60 µm ultrasonic amplitude was used to determine a Vickers hardness of 87.3 HV. The hardness was found to be 89.2 HV when it raised to 90 µm amplitude.

Figure 7 displays the mechanical characteristics of 5 wt. % Ti/Al composites reinforced with varying ultrasonic amplitudes. From the results, the yield strength was calculated to be 116 MPa, and the tensile properties were calculated to be 122 MPa, and 286 MPa, respectively (increased 1.8 %, and 1.4 % from the gravity casting) at 60 µm. Ultrasonic amplitude had a significant impact on elongation at fracture but had a minimal effect on strength. However, yield strength increased to 124 MPa and tensile strength to 292 MPa when the amplitude was elevated to 90 µm (by 4.9 % and 3.4 % increment compared to gravity casting).

3.2. Characteristics of ultrasonic assisted squeeze casting

When ultrasonic amplitude was 60 µm, and microstructures of 5 wt% Ti/Al composites solidified at varying pressures are depicted in Figure 8. It was apparent that the composite consisted of several equiaxed grains with a size of 62 µm and a pressure of 50 MPa. As can be seen in Figures 8(a) and (b), increasing the pressure to 50 MPa, reduced average grain size to 45 m was observed (28.3 % decrement compared to gravity casting).

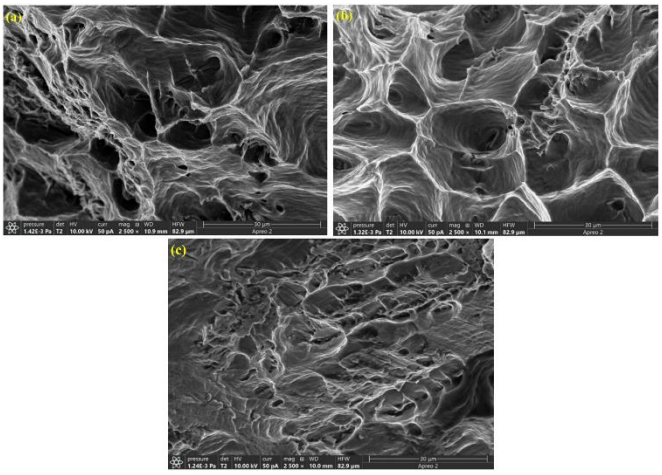


Figure 8. Microstructural images of 5 wt% Ti/Al composites that were solidified under variant specific pressures: (a) 50 MPa, (b) 75MPa, and (c) 100 MPa at the ultrasonic amplitudes of 60 µm

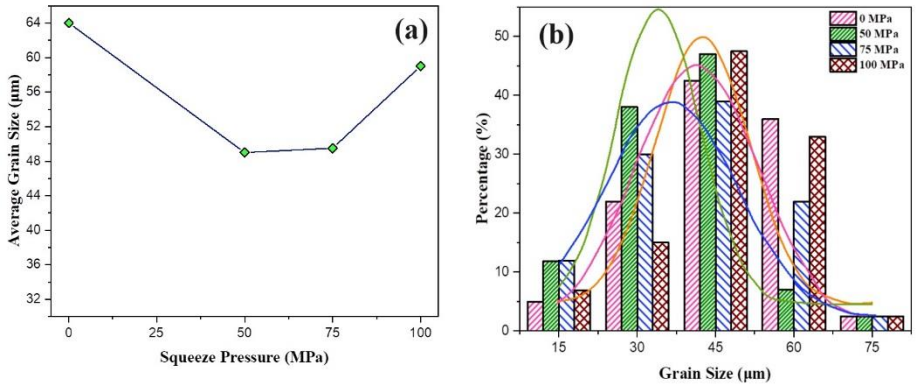


Figure 9. (a) Average grain size and (b) grain size distribution of 5 wt% Ti/Al composites that were solidified at ultrasonic amplitudes of 50 µm

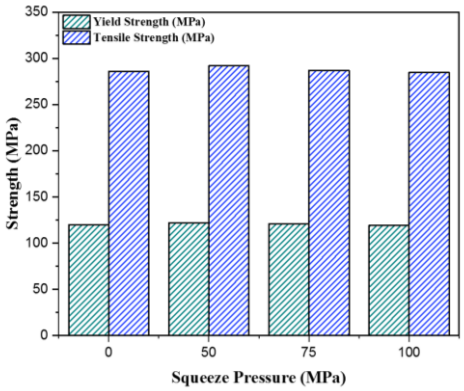


Figure 10. Solidified Ti/Al composites at 5 wt% that show mechanical characteristics at varying pressures (ultrasonic amplitude at 50 µm)

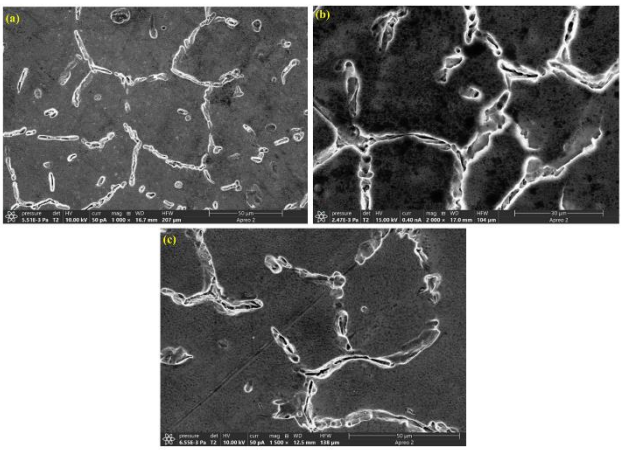


Figure 11. Different squeeze pressures and ultrasonic amplitudes resulted in distinct fracture morphologies in 5wt % Ti/Al composites: (a) 30 µm + 50 MPa, (b) 60 µm + 75 MPa, and (c) 90 µm + 100 MPa

Figures 8 (b)-(c) illustrate that grain coarsened when squeeze pressure was raised in phases. The grain size coarsened when the squeeze pressure was raised in phases. The mean grain size increased to roughly 59 µm when the squeeze pressure was raised to 100 MPa. The typical grain sizes are shown in Figure 9.

Figure 10 displays the effect of squeezing pressure on mechanical characteristics of resulted composites (5 wt. % Ti/Al) solidified using ultrasonic amplitudes of 60 µm. When tested at a squeezing pressure of 50 MPa, the material's yield strength climbed to 122 MPa, and its tensile strength increased to 292 MPa (by 18.7 %, 3.2 %, and 3.4 %, respectively, compared to gravity casting). There was a notable degradation in the mechanical properties as the squeeze pressure was raised further, especially the elongation to fracture. In this case, tensile strength was measured to be 122 MPa, while yield strength was recorded to be 286 MPa.

Figure 11 displays the fracture morphologies of Ti/Al composites cast by aided squeeze casting with a weight percent of 5%. Ti reinforcements were highly concentrated on the gravity-cast composite's fracture surface. Figures 11(a) and (b) show that the application of ultrasonic vibration (amplitude of 60 µm) reduced the amount of Ti reinforcements on the fracture surface. The application of ultrasonic vibration reduced the amount of Ti reinforcements on the fracture surface. Composites solidified using an ultrasonic amplitude of 60 µm and a squeezing pressure of 50 MPa exhibited a more uniform distribution of reinforcements and a larger number of dimples.

Cavitation bubbles in molten composites expand and proliferate under the influence of ultrasonic vibration, and their collapse causes intense localized bursts of heat and pressure, which can be considered adiabatic. Composites with a more uniform distribution of reinforcements and a larger number of dimples may be solidified using an ultrasonic amplitude of 60 µm and a squeezing pressure of 50 MPa, as illustrated in Figure 11(c).

4. Discussion

There was some loss of ultrasonic power since the heel block was employed to transmit the vibrations to the melt. The ultrasonic amplitudes utilized here were significant enough to generate cavitation in the composite melt, even after accounting for the ultrasonic power loss. Cavitation bubbles in molten composites expand and proliferate under the influence of ultrasonic

vibration. Since the collapse of a cavitation bubble causes intense localized bursts of heat and pressure, this process might be conceived of as adiabatic. Maximum temperatures T_{max} and particular pressures (P_{max}) can be calculated with the help of Equations (3) and (4) [37].

$$T_{\max} = T_0 \quad (3)$$

$$P_{\max} = A\rho cf \quad (4)$$

where

ρ - Density of molten composites

P_0 - 1.01 × 10^3 Pa, atmospheric pressure

f - 20 kHz frequency of ultrasound.

T_0 - 925 K, melting point of the composites

A - ultrasonic amplitude

c - 2.62 g/cm^3, velocity of propagation of ultrasound

γ - 1.42, gas constant

P_{max} - maximum pressure on the Ti particle

A can take on any value between 60 and 90 µm. As a result, it was determined that the maximum allowable temperatures and pressures are 12,234 K and 7,912 MPa (A = 90 µm), respectively. Dispersion of agglomerated reinforcements was aided by the high temperature and pressure, leading to greater distribution homogeneity. As was previously indicated, tensile loads can readily cause agglomerated Ti reinforcements at grain boundaries to shatter. As a result, ultrasonic vibration can aid increase elongation by dispersing reinforcements and dispersing agglomerations. Elongation is further aided by the degassing and contamination clearance that occurs during the ultrasonic vibration. At the same time, the distributed Ti reinforcements have the chance to become crystal nucleus which helps refine the matrix and boost plasticity. The exploding bubbles in a cavity instigate the formation of crystals and their dispersion, ensuring that the reinforcements are of the same quality, which improves microstructures and thereby enhances mechanical characteristics.

There are primarily three methods in which the Ti/ Al composite's tensile strength and yield strength are enhanced. The Hall-Petch connection suggests that strengthening can be achieved by matrix refinement. However, when the composite undergoes plastic deformation when subjected to external pressures, the distributed Ti particles act as pins for the motion of dislocations, hence promoting strengths. These dislocations contribute to strengthen the composite. As shown in Figures 6 and 7, the improvement in tensile strength and yield strength are proportional to the increase in ultrasonic amplitude, but only within a certain range. The matrix is polished to a minor degree, but the Ti are scattered more uniformly by raising the amplitudes from 60 µm to 90 µm.

Squeezing the melt harder raises its solidification temperature in accordance with Eqn (5) of the Clausius-Clapeyron equation. The equation (5) that describes the rising temperature is as follows:

$$\Delta T_m = \frac{T_m(V_L - V_S)}{\Delta H_m}\Delta P \quad (5)$$

where

V_S - Molar volume of the α -Al matrix $\left(\frac{\mathrm{m}^3}{\mathrm{mol}}\right)$

H_m - Latent heat of crystallisation (J/mol)

T_m. - Temperature at which solidification occurs at air pressure (K)

P - Squeeze pressure (MPa).

V_L - Molten composites molar volume, $(\mathrm{m}^3/\mathrm{mol})$

The values of, $V_L - V_S$ in this study are $391\mathrm{kJ}/\mathrm{Kg}, 923\ \mathrm{K}$ and $1.12 \times 10^5\ \mathrm{kg/m3}$. ΔP can take on a value between 50 and 100 MPa. ΔT_m is 3.8 ºC when P is 100 MPa. Undercooling at the liquid-solid interface during the solidification of pure aluminium is on the order of 10 ºC to 15 ºC, so an increase of 3.8 ºC can be significant. The critical radius of nucleation decreases and the free energy difference between the liquid and solid phases widens as undercooling increases. The transition from liquid to solid occurs faster, and the interface between the two phases shifts position more rapidly. Increasing the free energy variation among the liquid and solid phases and lowering the contact angular among the strengthening and the interface may improve the wettability of Ti reinforcement.

Some reinforcements become stuck at the liquid-solid boundary as the α-Al matrix expands, while others are rejected and carried along with the solidification front. The grain boundaries are the last places to solidify, and they are where clumped particles are finally separated [38]. Trapping particles requires a solid-liquid contact velocity over a certain threshold. A higher percentage of the strengthening is trapped in the α -Al matrix when undercooling increases the speed at which the solidification interface moves. Elongation is improved because agglomerations are suppressed. Gravity casting typically results in solidification faults like shrinkages and porosities unless special pressure is applied to reduce the amount of space among the die and the solidifying outer shell. Matrix refinement occurs as a natural byproduct of the increased nucleation rate. At a squeezing pressure of 50 MPa, the material's yield strength climbed to 122 MPa, and its tensile strength increased to 292 MPa, showing improvements of 18.7%, 3.2%, and 3.4% respectively compared to gravity casting. However, there was a notable degradation in mechanical properties, particularly in elongation to

fracture, as the squeeze pressure was increased further. The results were supported by Lu et al. [39].

The matrix was originally refined to promote an applied squeeze pressure of 50 to 100 MPa when the ultrasonic amplitude was 60 µm. Ultrasonic vibration has been shown to have a positive effect on grain refinement, to which the addition of a squeeze pressure of 50 MPa only adds to the advantages. Interestingly, though, the granules became much coarser as the squeeze pressure was increased from 50 to 100 MPa.

Because of the three-dimensional compressive pressure exerted by the squeeze pressure, the power density is reduced as the real vibration intensity of the melt is consumed. This limits the cavitation effect's strength, which is detrimental to the process of refining grains. Furthermore, the cavitation effect induced by ultrasonic vibration has a shorter practical duration the faster crystallization occurs at the given specific pressure. The lessened cavitation impact at a lower squeezing pressure (50 MPa) allows grain refining's benefits to outweigh the downsides. Though, this constraint strengthens with increased squeeze pressure, and the cavitation impact is diminished even further. Since Ti reinforcement agglomerations are resistant to breaking under such limited ultrasonic vibration, the α-Al matrix coarsens (strengths are reduced) and elongation at fracture worsens.

5. Conclusion

Microstructure and mechanical properties of Ti/Al composites with a weight percentage of 5 % were studied when ultrasonic vibration was applied during solidification. Formation of crystals and their dispersion of the maximum temperature and squeezing pressure were instigated by the exploding bubbles in a cavity can help ensure that the reinforcements are all of the same quality. Thereby, the microstructures may be improved, which in turn enhances the mechanical characteristics. Although there was minimal variation in mechanical strength was decreased from 60 µm to 90 µm amplitudes. Micro-shrinkage is prevented and mechanical qualities are enhanced due to the application of squeeze pressure. In addition, it raises the undercooling at the solidification interface, making it more likely that reinforcements will become entrapped in the α-Al matrix. However, the cavitation effect brought on by ultrasonic vibration can be limited by applying a certain pressure that is too high. Increasing the squeezing pressure results in less of a cavitation effect, which in turn causes the grains to coarsen and lose some of their mechanical characteristics. Microstructures and mechanical characteristics were achieved at a particular pressure of 50 MPa. Tensile strength was recorded at 286 MPa, and yield strength was measured at 122 MPa (increased 18.7% and 3.2%, compared to gravity casting).

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R. Srinivasan: Methodology, investigation, writing-original draft. S. Muthukumarasamy: Software, supervision, writing-review & editing. Pramod Kumar Singh: conceptualization, supervision. Kundan Meshram: Methodology, writing-review & editing, validation. S. Mayakannan: conceptualization, supervision, writing — review & editing. B. Sasikumar: Data validation. S. Venkatesa Prabhu: conceptualization, Methodology, supervision.

Competing Interests

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Data Availability

The data used to support the findings of this study are included in the article.

Has this article screened for similarity?

Yes

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