Mechanical Behavior of Al7075-TiO2 metal Matrix Composites through Powder Metallurgy Process

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Abstract - *Composites with an aluminium metal matrix have become a significant material in the field of composite materials and particulate reinforced aluminium MMCs has received importance due to their superior technical properties. The research of the influence of processing parameters on better mechanical characteristics is vital because it has a substantial impact on the performance of the product, even though powder metallurgically manufactured aluminium MMCs found applications where superior mechanical properties are required. In this experiment, TiO2 particles with mean diameters of 23, 37, and 67 m and varied weight fractions of 2, 4, and 6% were added to a TiO2/Al 7075 metal matrix composite via powder metallurgy. For each composite, a thorough analysis was conducted to determine how the sintering temperature affected the material's density, porosity, and mechanical, or tensile, and hardness, qualities. The impact of the size and amount of reinforcement, the sintering temperature, and other process parameters on the microstructural and mechanical characteristics of the composites was thoroughly investigated. The experimental examination revealed that excellent sintering could be accomplished up to 500°C. Structure property interactions can only be related in terms of density, porosity, microstructure, compressive strength, and hardness with smaller-sized TiO2 reinforcement. Sintered density/porosity do not supplement with corresponding attributes on hardness with increased TIO2 size, especially with higher temperature. This is due to possible matrix TIO2 achieved, heat partition and its impact on matrix flow stress, as well as potential pooling or agglomeration while dealing with coarse- and medium-sized reinforcing.*

Key Words: **Powder metallurgy, Scanning Electron Microscope, Porosity, density, compressive strength and hardness**

1.INTRODUCTION

1.1 ALUMINIUM (AL)

Aluminum and its alloys are lightweight silvery White metal belonging to the periodic table's primary Group 13 (IIIa, or boron group). The most common nonferrous metal and most plentiful metallic element in the crust of Earth is aluminium. Aluminium never occurs in nature in its metallic form due to its chemical activity, but practically all rocks, plants, and animals contain some amount of aluminium compounds. Aluminium makes up around 8% of the total weight of the outer 16 km (10 miles) of the Earth's crust, with oxygen and silicon coming in second and third, respectively. Potash alum, or aluminium potassium sulphate, KAl(SO4)2√12H2O, is known by its Latin name, aluminium, which comes from this term.

1.1.1 Superior properties / Advantages

- Light weight
- Processing capability & formability
- Strength
- Corrosion resistance
- Recyclability
- Cost effectiveness
- Conducts electricity even better than copper
- Easily colored by anodization, and holds paint extremely well
- It acts as a good thermal conductor
- It is hygienic and magnetically neutral

1.1.2 Inherent properties /Disadvantages

- It is abrasive to tooling
- It is more expensive than steel
- It is not quite as strong as steel
- It is more difficult to weld than steel
- Faster deceleration in crash
- It can be easily dent
- Aluminium would expand about twice than that of steel

1.1.3 Applications

The excellent characteristics of aluminum alloys, including their low density, high strength, resistance to corrosion, and good formability, make them useful across multiple industries. A few of the most popular aluminum alloys are used in transportation, electrical applications, consumer goods, medical equipment and construction.

1.2 ALUMINIUM MATRIX COMPOSITES

Aluminium matrix composites (AMCs) are a class of lightweight, highly functional materials systems that centre around aluminium. volume percentages between a few percent and seventy percent. AMCs' properties can be adjusted to meet the needs of various industrial applications by selecting the right matrix, reinforcement, and processing route combinations.

2. EXPERIMENTAL INVESTIGATION

3.1 INTRODUCTION

To find out more about the Al 7075-TiO2 composite's mechanical properties and microstructure, experimental studies were conducted. This Chapter presents the experimental setup and experimental techniques utilized for characterization of the composite in this investigation. A brief explanation of the composite's preparation and characterization for its micro structural and mechanical properties is included in an overview of the setup. The final section of this chapter highlights the approach used for the current investigation. Two stages of the experimental inquiry have been completed. The processing of the composite is the initial stage. The composite is examined for its mechanical and micro-structural characteristics in the second stage.

3.2 METHODOLOGY

The methodology flow chart, which is described below, in order to meet the project's goals.

- Combining the desired content (Al7075 & TiO_2) by using planetary type ball milling in order to get homogenous mixture.
- As reinforcements for the composite, titanium oxide particles with average particle sizes of 23, 37, and 67 µm are used.
- The finished composite specimens are then placed in a muffle furnace under air circumstances for four hours at each of three different sintering temperatures, namely 400, 450, and 500°C.
- Then, all the cooled specimens are artificially aged in the same muffle furnace for 8 hours at 200°C.
- Conducting physical, micro-structural, mechanical testing, studying the hardness, density, porosity & compressive strength.

3.3 OBJECTIVES

- Mixing of powder
- Fabrication of die and punch
- Cold Compaction process
- Sintering temperature
- Description of the specimen

3.4 FABRICATION OF THE COMPOSITE

3.4.1 Work piece Materials

As the composite's matrix material, Al 7075 powder with an average particle size of 60-120µm is used. As reinforcements for the composite, titanium oxide particles with average particle sizes of 23, 37, and 67 µm are used. Tables 3.1 to 3.3, respectively, list the parameters of the matrix and reinforcement material as well as the chemical makeup of the matrix aluminium alloy.

Table 3.4.1 a) Composition of Al7075

S. No.	Element	Composition by weight(%)
1	Silicon	0.40
2	Copper	1.60
3	Manganese	0.30
4	Zinc	5.50
5	Titanium	0.20
6	Magnesium	2.50
7	Iron	0.50
8	Chromium	0.15
9	Aluminium	Balance

Table 3.4.1 b) Properties of TiO_2

S. No.	Mechanical	Values
1	Density	4.23 gm/cc
2	Porosity	0 %
3	Color	White
4	Flexural Strength	270 MPa
5	Elastic Modulus	230 GPa
6	Poisson's Ratio	0.27
7	Compressive Strength	3675 MPa
8	Hardness	102900 MPa
9	Maximum Use Temperature (no load)	1910

3.4.2 BLENDING AND CONSOLIDATION OF POWDERS

- **POWDER METALLURGY METHOD**

Powder metallurgy is defined as mixing different metal powders to create semi-finished and finished goods components by compressing it after compressing subsequent heating at elevated temperature in a furnace with a gradually increasing environment in order to achieve the necessary strength and density without losing shape. The method of powder metallurgy usually comprises these four fundamental steps: powder manufacture, powder blending, compacting, and sintering.

- **COMPACTION OF POWDER**

The process of compacting metal powder in a die by applying high pressure is known as powder compaction. The punch tool forms the bottom of the cavity when the tools are held in a vertical configuration. After being compressed into a shape, the powder is released from the die cavity. The parts may require very little extra work for their intended use in a number of these applications, which would result in very cost-effective manufacture. The amount of pressure applied has a direct relationship with the density of the compressed powder. For metal powder compaction, pressures ranging from 10,000 kg/mm^3 to 50,000 kg/mm^3 are frequently used.

3.4.3 SINTERING

The technique of taking metal powder and putting it into a mould or die is called solid state sintering. The material is compressed into the mould and then exposed to high heat for an extended amount of time. The porous aggregate particles bond when heated, and when the powder cools, the bonds solidify into a single piece.

Three phases can be thought of as the process of sintering. In the first, powder particles stay distinct but neck development happens quickly. Particles diffuse into one another and the structure recrystallizes during the second phase of densification, which is the most intense.

In the third phase, densification proceeds at a significantly slower rate and isolated pores typically take on a spheroidal shape. In Solid State, the terms "solid state" Sintering is just the term describing the solid state in which the material is in during the bonding process; in other words, it indicates that the material was not melted in order to produce an alloy.

A recently developed method for high-speed sintering includes heating the asperities preferentially in a powder by running a strong electrical current through it. Where migration is desired, the majority of the energy is used to melt that area of the compact.

3.4.4 DIE PRESSING OF METALLIC POWDERS
Die pressing (molding):

It is a method of compacting powder that uses uniaxial pressure to compress powder held between two stiff punches in a die.

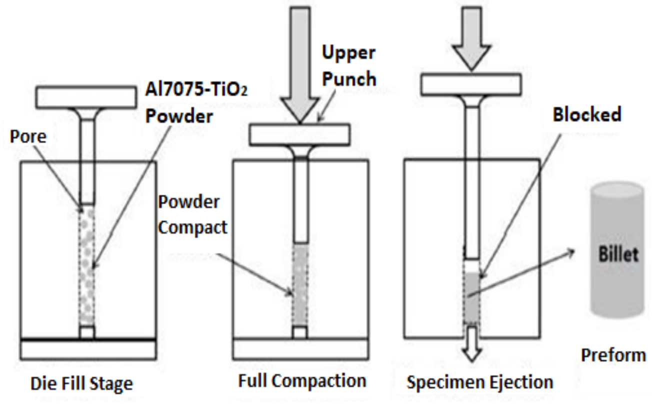

Figure.3.4.4 a) Die fill stage

- **Die pressing (uniaxial):**

It works well for producing simple parts in large quantities (isostatic pressing is an alternate way). The die pressing method's plan is shown in the figure.

Figure.3.4.4 b) Die set preparation

The following steps make up the pressing process:

i) Die filling: A precise quantity of powder is injected into the die cavity at this point.
ii) Compaction: An upper punch presses down on the powder at a set pressure. The range of pressure is 69 MPa to 1000 MPa.
Depending on the type of press, the characteristics of the powder filling, the size and geometry of the item, and other factors, the pressing cycle repeats 400–5000 times per hour. Powder dies pressing is done using hydraulic and mechanical presses that can hold loads of up to 750 tons.

Cold pressing is the process of die pressing that is done at room temperature. Hot pressing is the term for pressing that takes place at a higher temperature. Hot pressing makes it possible to get greater compact density and improved compaction.

3.4.5 HEAT TREATMENT FURNACE

Thermal processing the furnace can be used for melting copper and gold, sintering ceramic parts and components, and general-purpose laboratory heat treating applications. It is a double-layered piece of equipment with an energy-efficient heating element and air conditioning system that consistently provides amazing performance. Excellent temperature homogeneity is ensured by the unique ceramic fibre insulation found in this crucible furnace. The working temperature of the unit is 1100°C, with a maximum operating temperature of 1200°C.

We furthermore provide custom manufacturing facilities to our clients in order to satisfy their unique needs and project specifications. We can also manufacture our crucible furnace with the necessary heating element type, temperature range, and other settings. This equipment is given with great warranty and after-sales support throughout India and internationally at a very affordable price.

The mechanical alloying method involves mixing the matrix and reinforcement particles with the help of planetary type ball milling. The image of the device is displayed in Figure 3.4.5 b. by sintering. In a compression moulding machine, the cold compaction procedure is completed. The powders are shaped into 25 mm long and 8 mm diameter cylindrical specimens. Figure 3.4.5 c, show images compression moulding equipment and Figure 3.4.5 d, show images of the muffle furnace used for ageing as well as the compression moulding equipment. In Figure 3.4.5 e, samples of the manufactured composite specimens are also displayed. At room temperature, the consolidation is done under 1.5 N/mm2 of pressure. The finished composite specimens are then placed in a muffle furnace under air circumstances for four hours at each of three distinct temperatures 400, 450, and 500°C for the sintering process. After that, all of the cooled specimens are artificially aged for eight hours at 200°C in the same muffle furnace. After that, chill down with regular water.

In a ball mill, the mechanical alloying process introduces hard dispersion particles into a comparatively soft metal matrix.

The resulting composite powders are next cold compacted and cemented, followed.

Figure 3.4.5 e) Photographs of fabricated composite samples

3.5 TESTING THE COMPOSITE FOR MICROSTRUCTURE, PHYSICAL AND MECHANICAL PROPERTIES

3.5.1 Microstructure

Scanning electron microscope (SEM) micrographs demonstrate how well distributed the dispersion reinforcement particles are throughout the matrix.

3.5.2 Density

The equation below is used to get the mass density of the composite sample. After heat treatment, the specimens' densities are measured.

$$\rho = (\text{Mass}/\ \text{volume})\ (kg/m^3)$$

3.5.3 Porosity

Based on the theoretical and experimental values of the composites' density, the porosity of the sample is ascertained. Porosity is determined using the formula in Equation (3.3).

Porosity = (Theoretical Density – Calculated Density/Theoretical Density) *100(%) (3.3)

The mixing of two different materials, one of which is a very soft matrix material and the other of which is very hard reinforcing particles, may have been compacted, leading to the porosity of the composite specimens. Equation 3.1 is used to calculate the calculated density and the theoretical density by applying the mixes rule.

3.5.4 Hardness

The mechanical properties of composite materials reinforced with ceramic particles depend on the matrix properties, mutual wettability at the interphase, volume of the reinforcing phase, and the size of the reinforcement particles (Kaczmar et al 2000). Vickers hardness testers are used to determine the hardness of heat-treated composites (sintering followed by ageing) under a 1000 g load. Ten seconds pass while the load is applied. A minimum of three hardness readings are recorded for each specimen at various sites on the test samples in order to exclude any potential segregation impact.

3.5.5 Compressive Strength

A universal testing equipment with a 50 KN capacity is used to Determine the composites' compressive strength. A traversal speed of 0.125 meters per minute the compressive load is given to the composite specimens. A room-temperature environment is used for the compression test.

4. RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

The quality of sintering of the AMC is normally evaluated in terms of hardness, compressive strength, porosity, and density. The processing may be through liquid state (casting) or through particulate state (Sintering). The driving force for casting is the heat extracted and consequent nucleation and interface formation, while sustaining to heat to promote/facilitated grain boundary meeting/grain boundary sintering (in the case of powder metallurgy/compaction). Hence temperature is a critical factor influencing the sintering quality of composites with varying melting point and heat transfer coefficient of the ingredients making it material specific for achieving desired results. Al-TiO_2 metal matrix composites with different size of TiO_2 particle (23-67 μm) weight fractions (2-6 %) was sintered (compacted through powder metallurgy route).

Table 4.1

OBSERVED PHYSICAL AND MECHANICAL PROPERTIES OF COMPOSITES

S.No.	Size of TiO2 (μm)	Weight fraction of TiO2 (%)	Sintering temperature (°C)	Experimental density (kg/m³)	Porosity (%)	Compressive strength (MPa)
1	23	2	400	2417	6.50	52
2	23	2	450	2439	5.10	115
3	23	2	500	2576	3.10	153
4	23	4	400	2525	5.50	78
5	23	4	450	2526	5.10	135
6	23	4	500	2629	2.20	173
7	23	6	400	2635	5.20	113
8	23	6	450	2649	3.10	156
9	23	6	500	2681	0.20	178
10	37	2	400	2493	6.50	219.6
11	37	2	450	2524	6.43	290.5
12	37	2	500	2647	0.36	213
13	37	4	400	2520	5.95	241.3
14	37	4	450	2538	5.94	328.7
15	37	4	500	2710	0.59	272
16	37	6	400	2536	5.78	251.3
17	37	6	450	2636	2.94	350.5
18	37	6	500	2724	0.40	302
19	67	2	400	2414	9.26	254
20	67	2	450	2575	4.67	303.3
21	67	2	500	2497	6.33	296.5
22	67	4	400	2604	2.66	273
23	67	4	450	2629	2.76	316
24	67	4	500	2519	5.22	309.3
25	67	6	400	2705	1.13	298.5
26	67	6	450	2632	2.99	324.2
27	67	6	500	2555	2.49	320.2

4.2 MICROGRAPHS OF COMPOSITE POWDERS

Figures 4.1 a-h display the SEM micrographs of pure aluminium alloy powder, composite powders of aluminium alloy and TiO2 particulates with varying weight fractions (2, 4, and 6%), and average particle sizes (23, 37, and 67 μm). The homogeneous distribution of the reinforcement TiO2 particles within the aluminium alloy matrix is confirmed by the SEM micrographs. Aluminium powder appears in spherical form and silicon carbide particles in irregular crystalline form. Higher weight fraction and higher particle size composite powder appears to be more crystalline whereas at lower weight fraction and lower particle size composite powder, the structure appears to be soft and more isotropic.

Smaller sized TiO_2 with medium weight fraction and higher order sintering temperature results in reduced order of porosity. Smaller sized TiO_2 with medium weight fraction and sintering temperature of 500°C facilitating better sinterability. Increased weight fraction of TiO2 and minimum sintering temperature results in increased porosity in 37 µm with all weight fractions (2, 4 and 6 %) and at higher sintering temperature of 500°C results in good sinterability. Coarser TiO2 (67 µm) with 2 % weight fraction and 500 ºC associated with grain flow of matrix material 67 µm TiO2 is with 4 wt.% at 500°C with formation of compound (contrasted aluminium grain) 67 µm TiO2 with 6 wt.% at 500°C absence of compound formation and good sinterability. The above figure shows that the SEM micrograph of aluminium alloy image captured at 37 µm with 6% weight fraction,

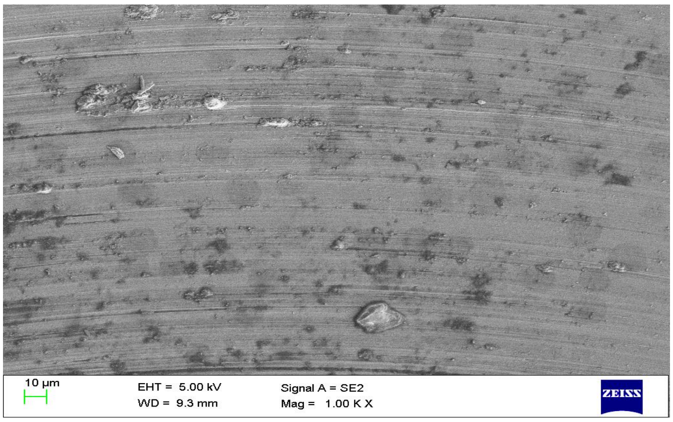

Figure. 4.a Scanning Electron Microscope 37 µm size with TiO_2 6% WF

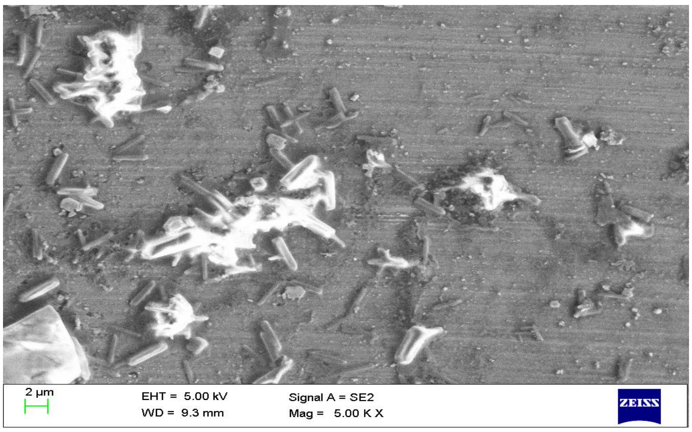

Figure. 4.b Scanning Electron Microscope - 37 µm size with TiO_2 6% WF

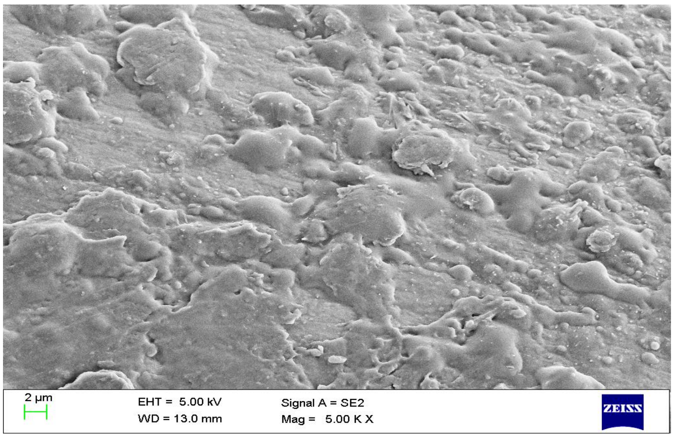

Figure. 4.c Scanning Electron Microscope - 37 µm size with TiO_2 6% WF

Figure. 4.d Scanning Electron Microscope - 37 µm size with TiO_2 6% WF

Figures 4.b and 4.c illustrate the establishment of bonding between Al7075 and TiO2 using SEM micrographs at 2 µm and 1 µm.

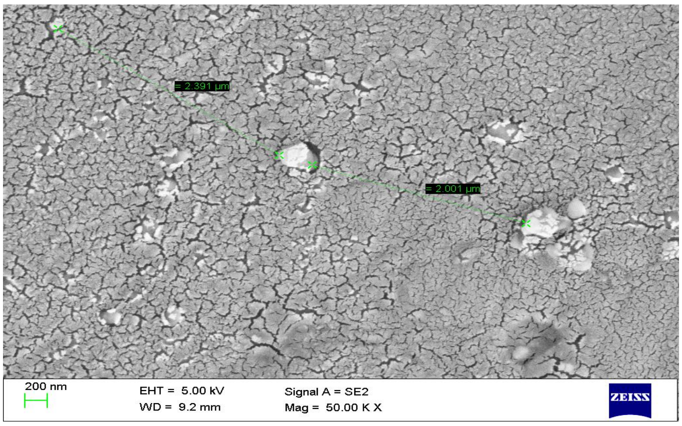

Figure. 4.e Scanning Electron Microscope micrograph at 37 µm size with 6% wf

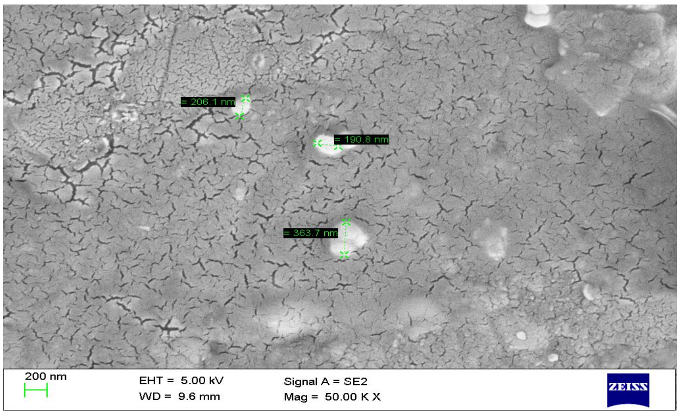

Figure.4.f Scanning Electron Microscope micrograph at 23 µm size with 6% WF

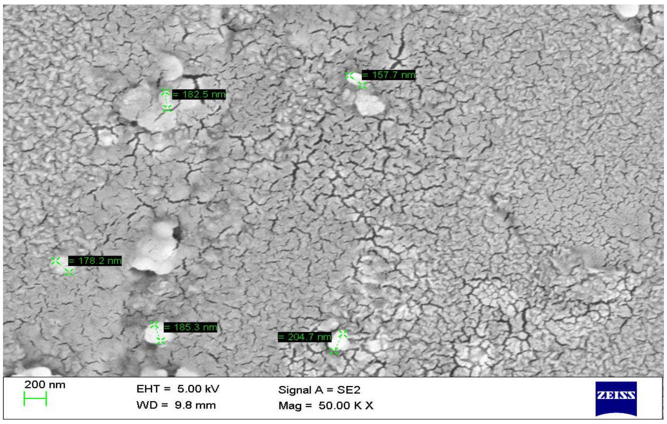

Figure. 4.g Scanning Electron Microscope micrograph at 67 µm size with Wf 6%

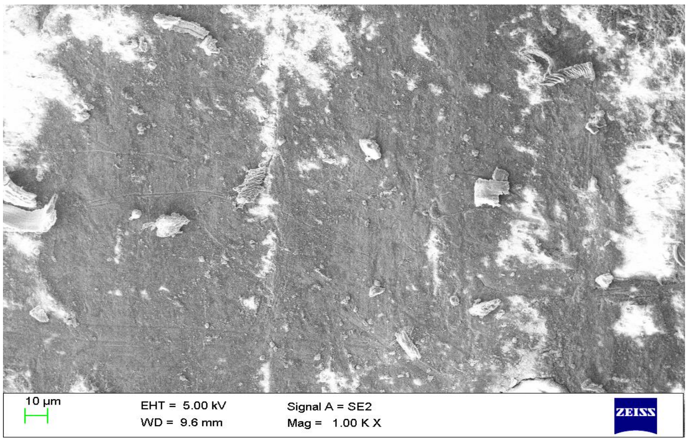

Figure. 4.h
Scanning Electron Microscope Micrograph 37 µm with TiO_2 6% WF

from the figures 4.e, 4.f, g we can observe that the SEM micrograph at 67 **µm with WF= 6%** are shown the pores formed in different sizes. The pores reduced in due to the TiO_2 with increased weight fraction and sintering temperature 500⁰C results in increased porosity in 37 µm.

4.3 DENSITY

Table 4.1 lists the common physical characteristics that are noticed, such as density and porosity, as well as the structural mechanical characteristics, including hardness and compressive strength. Table 4.3 and Figure 4.3 show the typical observed effects of sintering temperature on density for various composites.

Sample of Specimen at 500ºC	23 µm	37 µm	67 µm
Al 7075 + 2 % TiO_2	2567	2623	2681
Al 7075 + 4 % TiO_2	2647	2710	2724
Al 7075 + 6 % TiO_2	2497	2519	2555

Table 4.3: Density

With TiO2 that is smaller in size (23 µm), the density remains relatively constant up to 500ºC, after which a discernible increase is observed. Therefore, the flow stress of aluminium decreases with smaller sized TiO2 reinforcement just at 500°C, permitting simpler matrix flow and improved grain boundary meeting/sintering. Sintering density also rises as weight fraction does. More weight percentage of reinforcement leads to a narrower matrix space, which facilitates better grain boundary sintering and greater densities.

With medium sized TiO2 (37 µm), the trend of influence on density is quite different. While with 6% wt. fraction, Density increases gradually with temperature; for low-medium weight fractions, density increases only to a point over 500°C. With 2% and 4% wt. fractions, only a marginal difference in density between 23 and 37µm size can be seen up to 500 ºC. However, with sintering temperature of 500°C, a distinct rise in density can be seen with 37 µm sized TiO2. With coarse TiO2 particle, barring low weight fraction, mostly the sintered density drops down with temperature. Relatively higher density seen with lower temperature can be attributed to the size effect, while significance of heat conducted and consequent heat partition between matrix and reinforcement particle is seen with the reduction of density with increasing temperature.

For all weight percentages of reinforcement in 67 µm TiO2 composites, the density decreases as the sintering temperature rises. This may be due in adequate compaction with higher particle size or formation of compound affecting wettability of the matrix material also.

4.4 POROSITY

The variation of porosity with sintering temperature is shown in Figure 4.4. Reduction in porosity with increasing wt. % can be seen. However, unlike the case of density, the porosity is seen to progressively drop with increase in temperature. The reduction in porosity above 500°C is supplemented with the observed rise in density. Possibly swelling of matrix particles up to a certain temperature and possible oxidation in the surficial region can contribute to this phenomenon.

With 37 m, the porosity tends to down with increasing temperature, especially above 500°C. This is mostly in order with the observation on density. With 67μm TiO2, porosity mostly drops down with weight fraction. However, a mixed mode of relationship with temperature can be seen. With smaller weight fraction, the porosity tends to drop down up to 500°C, above which a rise can be seen. This is supplemented with the observation on density. With 4% wt. fraction, porosity is stable up to 500°C, rising with increasing temperature, which supports the density measurement. With higher weight fraction, porosity increases up to 500°C and get set with higher temperature.

Sample of Specimen at 500°C	**23** μm	**37** μm	**67** μm
Al 7075 + 2 % TiO_2	3.10	0.36	6.33
Al 7075 + 4 % TiO_2	2.20	0.59	5.22
Al 7075 + 6 % TiO_2	0.20	0.40	2.49

Table 4.4: Porosity % values

Figure.4.4: Comparison of Porosity %

MMC containing 23 μm and 37 μm TiO2 reinforced exhibits around 6 % porosity with lower temperature and around 6-10% at higher temperature. However, MMC containing 67 μm TiO2 exhibits a wide variation in porosity.

4.5 COMPRESSIVE STRENGTH

Structural properties of sintered composite, such as density and porosity, can influence the relative properties such as hardness and compressive strength. Figure 4.5.1 depicts the typical monitored fluctuation in AMC's compressive strength that is impacted by the size of the reinforcement TiO2 particle and the sintering temperature - With smaller size (23 μm) TiO2 reinforced composite, compressive strength rises progressively with sintering temperature also high wt.% enhances the compressive strength. With increasing sintering temperature, better compaction and strength are made possible by the metal's (matrix) decreased flow stress. The driving force for sintering is grain growth and interface (boundary) formation. As such, higher wt. % and temperature facilitates better compaction. It is seen that with increasing size of the TiO2, the MMC exhibits relatively higher order compressive strength. Also, despite increased porosity, higher compressive strength can be seen. This can be attributed to effective dispersion strengthening of the composite structure with size of the TiO2. It is seen that with 23 μm TiO2 the compressive strength of sintered specimen increases with sintering temperature, while it drops with higher temperature. A mixed mode of relationship between porosity and compressive strength of MMC can be seen with coarser TiO2 reinforcement.

Figure 5.3 illustrates the sintering performance of aluminium matrix composite with 37 μm TiO2. Up to 500°C, a rise in compressive strength is observed, followed by a drop with higher temperatures. Referring to density/porosity it is seen that a rise in density is associated with reduction in porosity could have resulted in matrix crazing and consequent reduction in compressive strength.

The matrix material's response to compressive loading greatly influences how the MMC responds to it. The composite material's particle strengthening and the matrix material's flow stress both affect the matrix material's response.

Figure 4.5.1 Compressive Strength Specimen

Sample of Specimen at 450°C	**23** μm	**37** μm	**67** μm
Al 7075 + 2 % TiO_2	115	290.5	303.3
Al 7075 + 4 % TiO_2	135	328.7	316
Al 7075 + 6 % TiO_2	156	350.5	324.2

Table 4.5.2 Compressive Strength test values

4.6 HARDNESS

With smaller sized TiO2 (23 µm), the MMC exhibits a slight rise in hardness with sintering temperature. Figure 4.6.2 shows the typical observed fluctuation of hardness of the MMC as impacted by sintering temperature and reinforcement. The hardness also increases with wt.% of the reinforcement. The hardness characteristic is almost supplemented by the observation on porosity. There is a noticeable overall increase in MMC's hardness with 37 µm TiO2 over MMC with 23 µm TiO2. Up to 500°C, the hardness increases proportionately with the sintering temperature; beyond that, a decline is evident.

With smaller sized (23 µm) TiO2, a rise in sintered density, reduced porosity with sintering temperature is associated with increased hardness. However, with 37 µm TiO2, a rise in density and reduction in porosity with sintering temperature is associated with a mild reduction in hardness. The observation unequivocally shows that there is a threshold sintering temperature of 500°C, above which no discernible structure-property link could be seen.

Figure shows the typical measured fluctuation in MMC's hardness with TiO2 particles of 67 µm in size. Hardness is observed to decrease up to 500°C, after which it increases. In MMC, particulate reinforcement can improve compressive strength by limiting matrix displacement or flow. The hardness can be enhanced above a specific temperature by a potential interaction between TiO2 and aluminium. A coarser grain size of 67 µm would result in a heat partition between TiO2 and aluminium that would affect both compressive strength and hardness, potentially due to insufficient matrix flow. TiO2's tiny size (23 µm) is fully indicative of density through sinterability. Hardness, compressive strength, and porosity all complement one another.

Reduced hardness and compressive strength are linked to an increase in density with sintering temperature when the size is 37 µm, particularly at higher sintering temperatures.

Reduced porosity/increased density can constraint the matrix material during compression, resulting in matrix crazing and observed reduction in compressive strength. Apart from % weight fraction, an increase in size of reinforcement TiO2 results in increased hardness. However, sintering temperature is highly sensitive to size of the reinforcement. With medium sized TiO2, sintered hardness increases up to 500°C, while it is invariant up to 500°C with 67 µm TiO2. Hardness increases with 67 µm TiO2 and decreases with 37 µm TiO2 at higher order sintering temperatures.

Sample of Specimen at 500°C	**23 µm**	**37 µm**	**67 µm**
Al 7075 + 2 % TiO_2	50	65	112
Al 7075 + 4 % TiO_2	61	66.5	126
Al 7075 + 6 % TiO_2	78	72	134

Table 4.6.1 Hardness test values

4. CONCLUSIONS

The purpose of this investigation was to examine the Al 7075-TiO_2 analysis was conducted to determine how the sintering temperature affected the material's density, porosity, compressive strength, hardness, micro structural properties of the composites. The following conclusions were made:

- Al 7075-TiO_2 composites with different weight fractions (2-6 %) and different size of TiO_2 particle (23-67 µm) was sintered (compacted through powder metallurgy route) by mechanical alloying process with the help of planetary type ball milling.

- The homogeneous dispersion of the reinforcement TiO2 particles throughout the matrix of the aluminium alloy is confirmed by the SEM micrographs. Smaller sized TiO_2 with medium weight fraction and sintering temperature of 500°C facilitating better sinterability, increased porosity in 37 µm with all weight fractions (2, 4 and 6%) and at higher sintering temperature of 500°C results in good sinterability. With medium sized TiO2 (37 µm), sintering temperature of 500°C and 6% weight fraction, a distinct rise in density can be seen with 37 µm sized TiO2.

- The case of density, the porosity is seen to progressively drop with increase in temperature. With 37 µm, the porosity tends to down with increasing temperature, especially at 500°C. This is mostly in order with the observation on density.

- The sintering performance of aluminium matrix composite with 37 µm TiO2. Up to 500°C, a rise in compressive strength is observed, followed by a drop with higher temperatures.

- The hardness is relatively increasing with sintering temperature up to 500°C with 37 µm TiO2. The hardness characteristic is almost supplemented by the observation on porosity a rise in sintered density, reduced porosity with sintering temperature is associated with increased hardness.

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