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Investigate the Mechanical properties of Al7075-MoS_2 Composite via Powder Metallurgy

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Abstract. Al7075 is a material that is both lightweight and has a high thermal conductivity. Aluminum is one of the best materials available, and it also happens to be one of the least expensive. This study examines the hardness, tensile strength, compressive strength, metallurgical characteristics, tribological behavior, impact of wear test parameters, and corrosion resistance of Al7075 hybrid composites reinforced with hard reinforcement MoS2. The powder metallurgy technique is used to create the Al7075 hybrid composites. Molybdenum disulfide served as a soft reinforcement to boost the corrosion resistance of the Al7075 hybrid composites and to give higher wear resistance with a reduced Coefficient of Friction. Al7075 hybrid composites contain 2%, 4%, 6%, and 8% weight of molybdenum disulfide. The scanning electron microscope is utilized to obtain SEM images in order to validate the homogeneous distribution of MoS2 within the aluminum 7075 matrix alloy. It is proof of a composite devoid of flaws and demonstrates the excellence of its fabrication.

1 Introduction

The creep and fatigue resistance, specific strength, hardness, stiffness, tensile strength, and tribological properties of metal matrix composites are superior to those of matrix materials. Metal matrix composites also have superior specific strength. Metals such as titanium, magnesium, and aluminium are the most common materials used to produce metal matrix composites. Compared to those ceramic materials reinforced with other matrix materials, those reinforced with an aluminum matrix material have superior properties. In addition, the cost of aluminium is significantly lower than that of other matrix materials. Components used in the electronic, aerospace, automotive, and sporting goods industries are common places to find aluminium-based composites being used. The density of this composite material is greater in comparison to pure Al material [1] due to the inclusion of 4% Mg and 6% MoS2. In contrast, MoS2 composites possess a compressive strength of 181.81 N/mm2, whereas Al

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composites exhibit a value of 167.52 N/mm2. MoS2-particle-containing composites remain devoid of buckle during compressive testing. Compared to unreinforced Al material, the attrition loss of composite materials is found to be negligible, and the coefficient of friction (COF) decreases as the MoS2 weight percent increases due to the solid lubricant property of MoS2 particles. MoS2-reinforced materials have excellent corrosion resistance because molybdenum works as a continuous layer barrier to prevent surface deterioration [2]. As compared to Al7075 (T6) base alloy, a hybrid composite with 3.5% SiC + 1.5% MoS2 enhances tensile strength and micro-hardness [3]. The mechanical behaviour of Al2O3-reinforced Al7075 matrix composites was studied. The particle size of the reinforcing has a significant impact on the increased qualities that can be achieved using composites. The performance of the composites was significantly improved by the nanoscale, submicron, and smaller particle size reinforcements. The hot pressing process creates the Al7075/Al2O3 composites in concentrations of 1, 3, and 5%, respectively. The mechanical characteristics of the composites experience an improvement together with a rise in the Nano size level of Al2O3 [4]. The wear behavior of hybrid composites made of Al7075/B4C/MoS2. Aluminium-based hybrid composites are frequently used in automotive applications due to their specific features. The stir casting method produces composites with the compositions Al7075/wt.%B4C (0, 4, 8, 12)/3wt.%MoS2. Because of the even distribution of hard reinforcement particles, the composites with the highest weight % of reinforcements get the best results regarding their enhanced mechanical properties. The matrix material's coefficient of friction increases when B4C is added to it. The abrasive wear mechanism has manifested itself due to the micro-reinforcing fracture in the produced composites. Hybrid composites made with Al7075 have superior qualities when it comes to wear resistance [5-6]. The ductility, strength, and corrosion resistance of aluminium 7075/2% micro and Nanocomposites. Compared to nanoparticle-size reinforced composites, the microparticle-size reinforced composite demonstrates significantly inferior mechanical characteristics [7]. Compared to macro-sized reinforced composites, micro-sized reinforced composites exhibit three times the wear resistance, tensile strength, and ductility of their larger counterparts [8]. The porosity has been significantly reduced because the Silicon Carbide particles are distributed evenly throughout the material. The corrosion resistance of the nanocomposite is significantly higher than that of the reinforced composites of macro size. The production of AMC reinforcing with MoS2 is not mostly known from earlier literature works utilizing Al7075 alloy as the matrix material with powder metallurgy, according to several research works conducted on the topic.

2 Experimental methodology

2.1 Materials Selection

Aluminium 7075 alloy has been chosen for structural applications because of its superior mechanical strength-to-weight ratio, exceptional ductility, high toughness, and fatigue resistance. Additionally, it possesses excellent corrosion resistance. Because of its poor tribological and corrosion behaviour is not used in aeroplane manufacturing, marine manufacturing, or vehicle manufacturing shown in fig 1. In light of the preceding, the underlying assumption directs us to select Al7075 as the matrix material for the ongoing investigation.

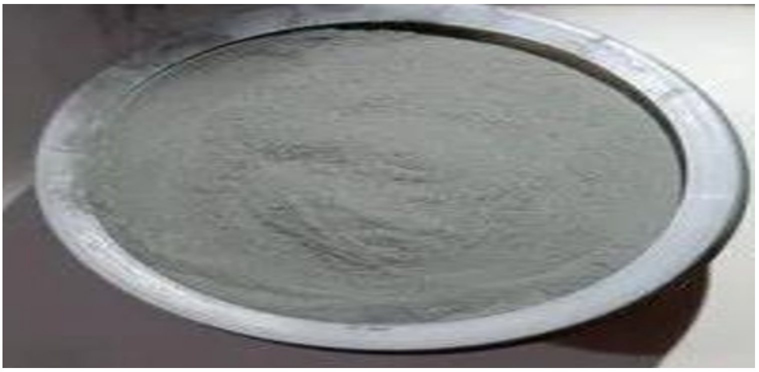

Fig.1. Al7075 Powder

Table 1. Chemical properties - Al7075

Material	Zn	Cu	Mn	Mg	Fe	Cr	Si	Ti	Al
Wt.%	5.55	1.46	0.07	2.5	0.23	0.21	0.09	0.071	Bal.

The only way to get molybdenum disulfide is through a chemical process because it does not occur naturally. In addition to this name, it is sometimes referred to as a solid lubricant substance and has a high dry lubricant property. The lubricating and corrosion-resistant characteristics of MoS2 are particularly impressive.

Fig. 2. MoS_2 powder

Molybdenum disulfide is utilized in various applications, some listed below: the metallurgy industry, thermally conductive polymers, the automobile industry, and tribology lubricants; the composition is listed in Table 2. The composites' wear resistance and thermal stability are improved by incorporating MoS_2 into the aluminium matrix components.

Table 2. Properties of MoS_2

Elements	Ti	B	Fe	O	C	N
Wt.%	68.40	31.12	0.08	0.5	0.3	0.3

Due to the poor performance in tribological and corrosive conditions, the material used for the matrix in this study is aluminium 7075. The reinforcement is made of molybdenum disulfide, which was chosen because of its mechanical, tribological, and corrosion capabilities. The average particle size of Al7075 and MoS_2 is 2 micrometres, while the average particle size of Al7075 is 10 micrometres. After compacting the matrix and reinforcement powders in a universal axial die at 800 MPa and sintering at 590oC for 90 minutes, the matrix and reinforcement powders were combined using a ball milling technique. In the following sections, we will delve into the production of Al7075-based MMCs and HMMCs, as shown in Table 3. Mechanical testing includes hardness, compressive strength, and tensile strength; metallurgical inspection; tribological and corrosion test techniques with ASTM standards; and more.

Table 3. Sample Preparation

Sample Number	Al7075	MoS2
1	100%	-
2	98%	2%
3	96%	4%
4	94%	6%
5	92%	8%

2.2 Microhardness test

The Vickers hardness of ten different locations on each ASTM E92 standard specimen was assessed using a diamond intender, with a load of 0.05 HV. A minimum dwell time of five seconds was established between each test in order to mitigate the occurrence of data repetition.

2.3 Tensile Test

A sequence of tensile tests was conducted on an ASTM E8M04 standard specimen by utilizing computerized universal testing equipment to regulate the material's tensile strength. The experiments were conducted under two conditions: 1mm/min strain rate and a maximal load of 50 kN.

2.4 Scanning Electron Microscopy

Scanning electron microscopy is applied to determine how evenly distributed the reinforcements are throughout the base alloy. To better understand the nature of the fracture and what caused it, the SEM fractography of tensile test specimens was analyzed.

3 Result and Discussion

3.1 Microhardness test

Using samples of Al7075 and Al7075-MoS2 composites, the microhardness test was carried out using a Vickers hardness tester with a load of 0.5 kilograms for 15 seconds. Each variety of the manufactured composites is subjected to three separate trials of testing, after which an average value is determined. The findings of the micro-hardness test are presented in Table 4.

Table 4. Microhardness results of MMCs

S.No	Al7075 (wt. %)	MoS2 (wt. %)	Microhardness value
1	100	0	92.4
2	98	2	94.5
3	96	4	97.2
4	94	6	100.4
5	92	8	103.5

3.2 Compressive test

In order to determine the compressive strength, a compressive test was carried out on both Al7075 and Al7075/MoS2 composites, the compressive strength of the matrix alloy is improved by the addition of TiB2 and MoS2 particles to Al7075, and the results of compression tests are displayed in figure 3 below.

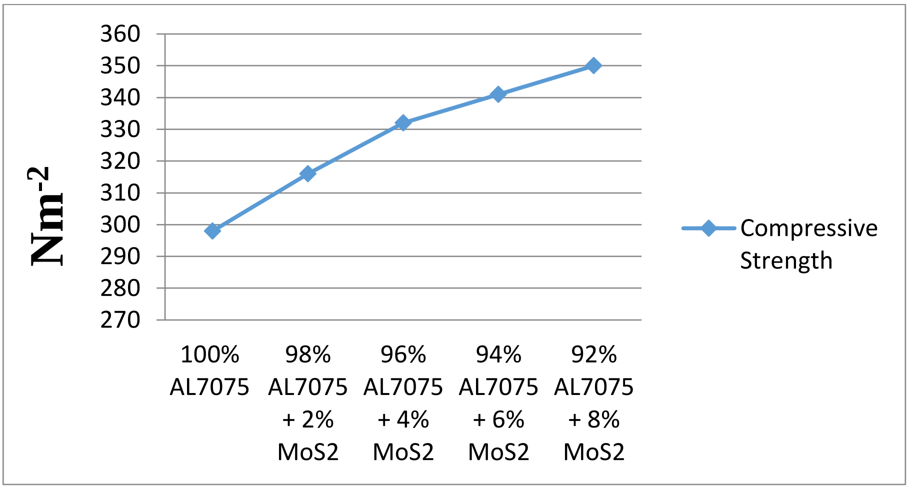

Fig. 3. Compressive test of Al7075 composite

3.3 Tensile Strength on Al7075-based Composites

To assess their tensile strength, a tensile test was performed on the Al7075 and Al7075/MoS2 specimens. In Figure 4, the tensile test results are depicted beside the specimens Al7075 and Al7075/MoS2. Compared to the blend of other Al7075 composites, the 92% Al7075/8 wt.%MoS2 composites have a more distinctive appearance.

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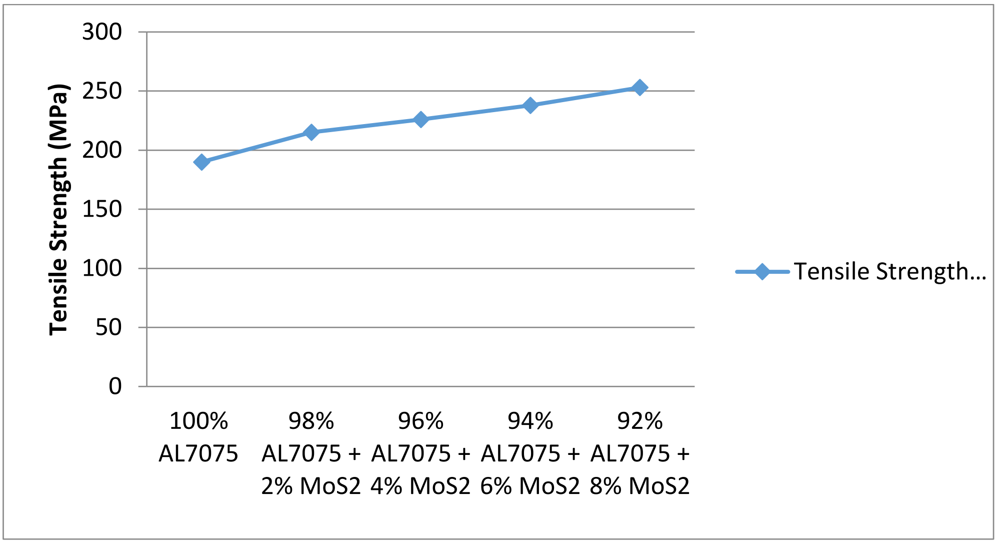

Fig. 4. Tensile test of Al7075 composite

3.4 SEM Analysis

Scanning electron microscopy examinations of the Al7075 and Al7075/MoS2 specimens are carried out. The scanning electron micrograph of the Al7075-fortified composites is shown in Figures 5 and 6. The scanning electron micrograph of each composite shows that the components that make up the aluminium matrix are held together by molybdenum disulfide. Molybdenum disulfide appears to be distributed consistently throughout the aluminium matrix, as the SEM photographs show. Sulfide gas is released from the created composites and escapes during the sintering process, which results in porosity.

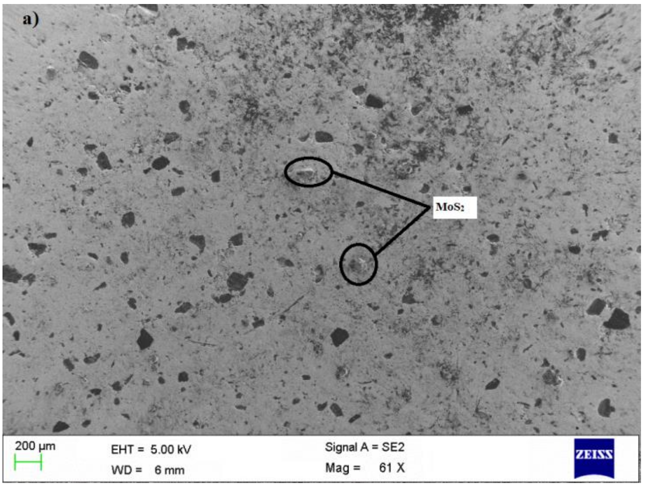

Fig. 5. SEM Analysis of 98% AL7075 + 2% MoS2

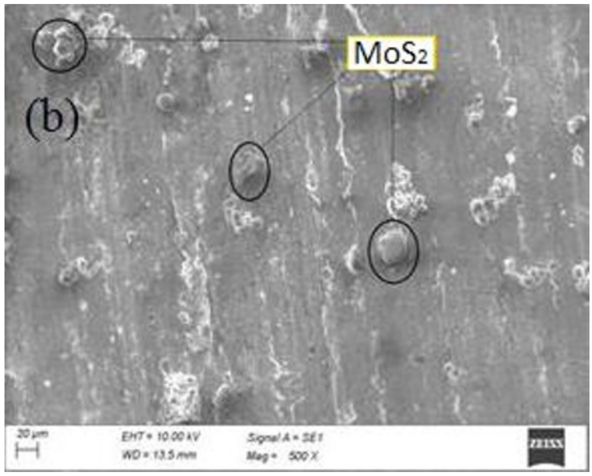

Fig. 6. SEM Analysis of 96% AL7075 + 4% MoS2

4 Conclusion

The aluminium metal matrix composite was made using the powder metallurgy process, and the following points were observed throughout preparation:

• The addition of molybdenum disulfide to al7075 composites results in increased tensile strength while also strengthening the materials interaction with al7075.

• The Composite compression strength was improved by using a high weight percentage of MoS2 in the Al7075 formulation.

• Due to the compaction pressure, some matrix and reinforcement particles have been fractured. This pressure was necessary to consolidate the matrix and reinforcement particles. Strong bonds are formed between the molybdenum disulfide and the substance of the Al7075 matrix.

References

1. K.M Varun, R.R. Goud, Mater. Today: Proc.**19** (2019)
2. N. Singh, R.M. Belokar, R.S. Walia, Mater. Today: Proc. **56** (2022)
3. V.K. Singh, B. Mukherjee, S.A. Aravindh, S. Das, Appl. Surf. Sci. **609** (2023)
4. Z.Y. Xu, C.J. Li, Y.Z. Peng, X. You, P. Gao, Y.C. Liu, J.M. Tao, R. Bao, Y.R. Wang, J.H. Yi, Mater. Charact. **194** (2022)
5. Y. Hou, H. Su, H. Zhang, X. Wang, C. Wang, Metals **11**, 6 (2021)
6. N.U. Salmaan, D.R. Smart, S.A. Raja, N. Gupta, S. Sehgal, M.M. Woldegiorgis, Int. J. Interact. Des. Manuf. (2022)
7. S. Devaganesh, P.D. Kumar, N. Venkatesh, R. Balaji, J. Mater. Res. Technol. **9**, 3 (2020)
8. N. Singh, R.M. Belokar, R.S. Walia, Mater. Today: Proc. **56** (2022)