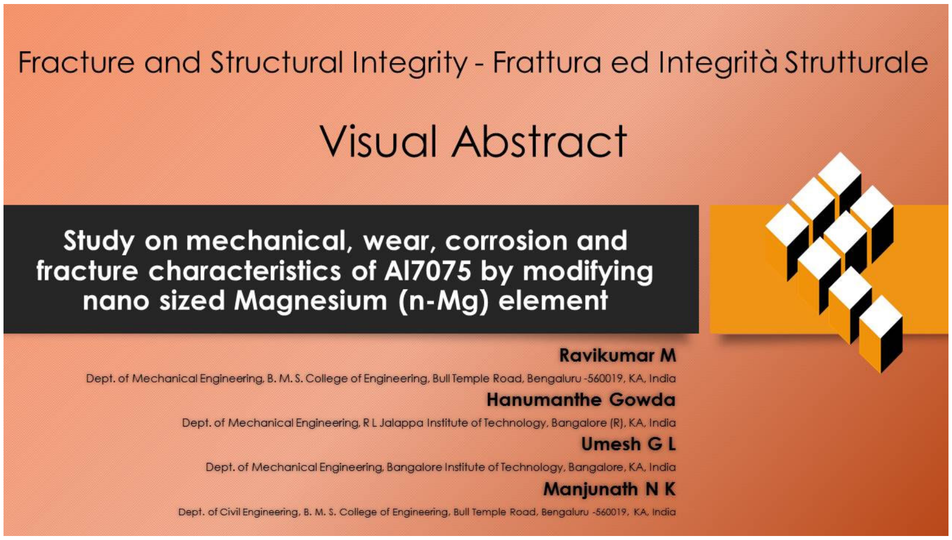
Study on mechanical, wear, corrosion and fracture characteristics of Al7075 by modifying nano sized Magnesium (n-Mg) element

M. Ravikumar
Dept. of Mechanical Engineering, B. M. S. College of Engineering, Bull Temple Road, Bengaluru -560019, KA, India
ravikumarm.mech@bmsce.ac.in, https://orcid.org/0000-0002-4958-839X

Hanumanthe Gowda
Dept. of Mechanical Engineering, R L Jalappa Institute of Technology, Bangalore (R), KA, India
hanumanthegowda@rljit.in

G. L. Umesh
Dept. of Mechanical Engineering, Bangalore Institute of Technology, Bangalore, KA, India
glumesh1238@gmail.com

N. K. Manjunath
Dept. of Civil Engineering, B. M. S. College of Engineering, Bull Temple Road, Bengaluru -560019, KA, India
manjunathnk.civ@bmsce.ac.in



Fracture and Structural Integrity - Frattura ed Integrità Strutturale

Visual Abstract

Study on mechanical, wear, corrosion and fracture characteristics of Al7075 by modifying nano sized Magnesium (n-Mg) element

Ravikumar M
Dept. of Mechanical Engineering, B. M. S. College of Engineering, Bull Temple Road, Bengaluru -560019, KA, India
Hanumanthe Gowda
Dept. of Mechanical Engineering, R L Jalappa Institute of Technology, Bangalore (R), KA, India
Umesh G L
Dept. of Mechanical Engineering, Bangalore Institute of Technology, Bangalore, KA, India
Manjunath N K
Dept. of Civil Engineering, B. M. S. College of Engineering, Bull Temple Road, Bengaluru -560019, KA, India

Citation: Ravikumar, M., Gowda, H., Umesh, G. L., Manjunath, N. K. Study on mechanical, wear, corrosion and fracture characteristics of al7075 by modifying nano sized Magnesium (n-Mg) element, Fracture and Structural Integrity, 75 (2026) 326-338.

Received: 06.08.2025
Accepted: 29.10.2025
Published: 13.11.2025
Issue: 01.2026

KEYWORDS. Al7075, n-Mg, Stircasting, Microstructure, Hardness, Tensile, Wear, Corrosion behavior, Fracture surface.

INTRODUCTION

Aluminum alloys' high strength-to-weight ratio, superior corrosion resistance, and workability make them widely used in a various sectors. These materials usually consist of an aluminum matrix with alloying elements. The size, shape, and distribution of the secondary phases have a major impact on their overall characteristics. Enhancements in hardness and strength are mostly attributed to fine and consistent particle dispersion. Casting, rolling, forging, and extrusion are some of the manufacturing processes that are essential in establishing the final qualities of the alloy. Specific heat treatment and surface modification techniques can be used to make further improvements. Natural aging is frequently used to maximize the strength properties of aluminum alloys in demanding applications like automotive and aerospace. The right mix of heat treatments can give aluminum alloys their maximum strength. By adding elements such as pure aluminum, manganese, silicon, and magnesium, solid solution strengthening is typically used to increase the strength of non-heat-treatable aluminum alloys [1, 2]. With an atomic number of 12 and a density of 1.7 g/cm^3, magnesium (Mg) is a silvery-gray metal that is commonly found in the sea. It is the lightest of the often used structural metals, which is frequently used. However, because there are fewer slip systems in its hexagonal close-packed (HCP) crystal structure, plastic deformation at room temperature is limited. However, it is appropriate for effective melting and casting processes due to its comparatively low melting point [3]. To increase its strength at high temperatures, magnesium can also be alloyed with rare earth elements. Due to the fact that magnesium is 33% lighter than aluminum it is a great choice for lightweight structural applications with better mechanical strength, wear and corrosion resistance [4]. In the extraction of metals like titanium, zirconium, and hafnium, it also functions as a potent reducing agent. Magnesium and its alloys are used extensively in many different engineering applications because of its light density, advantageous strength, ductility, resistance to creep, simplicity of recycling, and economical processing. Magnesium is especially well-suited for aeronautical components since it is both robust and lightweight. Magnesium is also utilized in a variety of products, such as electronic devices (such as camcorders, laptops, cell phones, and televisions), automotive components (such as seat frames, crankcases, steering wheels, steering columns, gearbox casings, transmission housings, and camshaft sprockets), and handheld tools (such as hedge trimmers, chainsaws, and power tools). Magnesium alloys have a number of advantages when used as castings: (i) they can produce castings with thinner walls than aluminum (1-1.5 mm vs. 2-2.5 mm); (ii) they cool faster because magnesium has a lower latent heat of fusion per unit volume; (iii) higher gate pressures can be obtained with relatively low applied pressures because of their low density; and (iv) die soldering in casting dies is less likely because of the limited solubility of iron in magnesium alloys. The rising demand for magnesium-containing alloys is reflected in the increased use of magnesium (Mg). By making it possible to directly fabricate near-net-shaped components, additive manufacturing (AM) has opened up new possibilities for magnesium-based materials. The combination of magnesium's characteristics and the design freedom of 3D printing give interesting potential for designing next-generation Mg alloys [5]. For weight-sensitive applications in industries including consumer electronics, automotive, and aerospace, its high specific strength makes it extremely desirable. Magnesium alloys also have an elastic modulus (45 GPa) that is similar to that of human bone, and because they are biodegradable, they promote natural tissue regeneration and lessen stress shielding. Because of these characteristics, materials based on magnesium are especially well-suited for biomedical applications, including joint replacements, orthopedic implants, fracture fixation devices, cardiovascular applications, as well as maxillofacial procedures. Currently, casting techniques, especially precision die casting, are used to manufacture more than 95% of magnesium alloy parts. However, because they are difficult to form and treat at room temperature, wrought magnesium alloys are not used very often [6, 7]. By strengthening the strain hardening effect, alloying magnesium into aluminum increases the metal's strength. By dissolving magnesium atoms into the aluminum matrix, a process known as solid solution hardening, the structure is strengthened without the need for heat treatment. The aluminum-magnesium alloy that is produced has high strength. This alloy series is more frequently produced into sheets and plates since extrusion is expensive and challenging for manufacturers. Storage tanks, railcars, trucks, buildings, and ships are among the structural applications for which these forms are appropriate. As a result, choosing materials that balance high strength and toughness is essential. In order to determine the best composition for improved performance, this study focuses on assessing the mechanical behavior as well as corrosion resistance of aluminum alloys with varying magnesium contents. Because of their exceptional corrosion resistance and outstanding formability, aluminum-magnesium alloys are particularly valued in the automotive and transportation industries [8-10]. Furthermore, these alloys' thermal characteristics are particularly remarkable. Intergranular corrosion and stress corrosion cracking are possible in certain aluminum-magnesium alloys, however they usually only happen when the magnesium concentration rises above 3.5 wt. % [9]. Ti foams containing both macropores and micropores were fabricated through powder metallurgy by removing Mg spacers composed of a mixture of fine powders and coarse particles. The results revealed that magnesium powders significantly influenced the deformation and densification of the green compact during pressing, more so than magnesium particles. After sintering, the pore structure of the Ti foams was governed by the size and quantity of the magnesium spacers. Larger Mg particles result in smaller macropores, and the final pore size is generally slightly larger than the original Mg particle size due to evaporation, which breaks mechanical bonds with the matrix and forms enlarged voids. Overall, magnesium particles control the macropores size and overall porosity of the sintered foams, while magnesium powders primarily influence the content and interconnectivity of open pores [11, 12]. An ideal manganese (Mn) content in aluminum alloys might help passivating the needle-shaped β-AlFeSi phase and promote its transition into a more spherical α-Al(Fe, Mn)Si phase, according to studies [13, 14]. MgSi strengthening phase is more evenly distributed as a result of this morphological change, which enhances the alloy's mechanical qualities. However, ductility may be diminished by the production of massive, brittle Al_6Mn phases brought about by an excessive Mn content. Therefore, improving the performance of Al-Mg-Si alloys requires rigorous alloy composition adjustment. According to [15], adding magnesium to aluminum alloys often increases their strength and hardness by forming Mg2Si precipitates and strengthening the solid solution. However, too much magnesium can weaken toughness and ductility, resulting in problems like hot cracking and decreased weldability. Mechanical characteristics and magnesium content have a complicated relationship that changes depending on the alloy's composition and processing techniques. Therefore, while creating Al-Mg alloys, it is crucial to carefully balance the desired features and trade-offs. The importance of different elements for improving alloy characteristics has been studied in the past, but there aren't many systematic investigations on the impact of the main alloying elements. The impact of magnesium alteration at the nanoscale on the mechanical, wear, corrosion, and microstructure behavior of aluminum 7075 alloys is examined in this work.

MATERIALS AND METHODS

Alloy fabrication

Using Al7075 as the basis alloy, customized cast components were fabricated by employing magnesium (Mg) as a unique modifying element. The Mg-modified alloy used in this investigation was made using the stir casting method. In increments of 0.5%, wt. % of magnesium in the modified cast pieces was gradually varied from 0% to 2.5%. In order to add nano sized magnesium granules (30-50 nm) at a stable temperature of 750°C, Al7075 was melted in a coke-fired furnace while being constantly agitated. To guarantee even dispersion throughout the molten alloy, stirring was maintained for about a minute after the addition of the micro magnesium particles. To enable the full dissolution of the micro magnesium particles into the melt, the temperature was raised and maintained at 800°C for 15 minutes. To fabricate the cast components, the prepared melt which included four modified samples (Al7075+n-Mg) and one unmodified sample (pure Al7075) was placed into a mold box that had been preheated.

Sample preparation

After solidifying, the castings were taken out of the mold and CNC-machined into standard test specimens in accordance with ASTM G99 standards for wear samples, ASTM E8 for tensile test samples, ASTM B647 for hardness test samples, ASTM E23 for impact test samples and ASTM G85 for corrosion test sample. The cast specimens of the modified alloy are shown in Fig. 1.

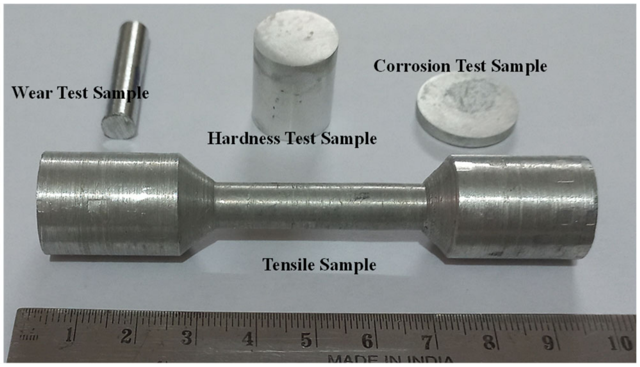


Figure 1: Test samples of n-Mg modified Al7075 alloy

CHARACTERIZATION TECHNIQUES

Microstructure (optical microscopy)

To achieve a smooth surface, the microstructure samples were first polished with 800 and 1200 grit emery papers, and then they were finally polished with a velvet cloth. After applying Keller's reagent a solution including glacial or anhydrous acetic acid to the samples for microstructural examination, they were carefully cleaned with sterile cloth. The analysis was carried out in compliance with the standard specifications of ASTM B483. The as-cast and nano sized magnesium particulates-modified alloy specimens were etched, let to air dry, and then inspected under a metallurgical microscope. A Nikon optical metallurgical microscope (Model: Epiphot 200) was used for the microscopic examination.

Density (Archimedes)

To ascertain the degree of porosity, critical characteristics which impact the integrity of the casting process, densities of the ascast and modified samples were measured. The impact of nano sized magnesium particulates on the modified alloy overall density is shown in Eqn. (1). Using the water displacement technique and Archimedes' principle, the experimental density was determined.

$$\varrho_{\text{exp}} = \frac{m}{V} \ (\text{g/cm}^3) \tag{1}$$

where, m denotes mass (g) and V denotes volume of the test trails samples (cm^3).

Hardness (ASTM E92)

In compliance with the E92-ASTM standard, Vickers microhardness testing apparatus was used to assess the microhardness of the created modified alloy. A diamond-shaped indenter was used to apply a 5 kg load for 30 seconds. Measurements were made at three different places of the wear test specimens at room temperature (27°C) in order to calculate the average hardness value.

Tensile test (ASTM E8)

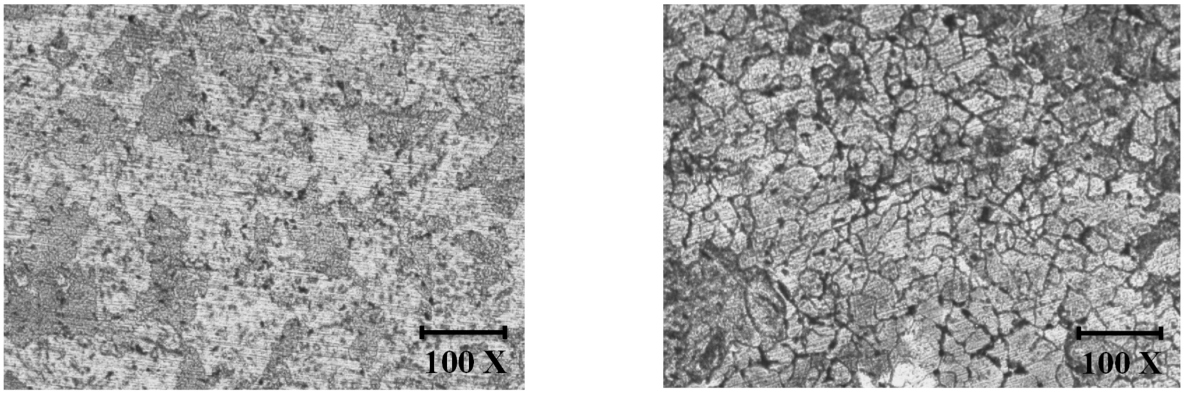
Tensile testing was performed in accordance with ASTM E8 standards. The specimens were subjected to a regulated extension rate and a uniaxial tensile force until they fractured. A Universal Testing Machine (UTM) having a maximum load carrying capacity of 450 kN was used for the testing.

Wear test (ASTM G99)

Wear tests were carried out according to ASTM guidelines. In these tests, the samples were slid against an EN-32 grade steel disc with predetermined parameters: a 10 N load, a sliding speed of 500 rpm, and a 1000-meter total sliding distance. The test specimens were manufactured with a dimension of 6 mm in diameter and 30 mm in length, in accordance with ASTM G99-05. The weight loss method was used to evaluate the wear behavior of the changed alloy and as-cast samples. During testing, each specimen was firmly held against the revolving disk of hardened steel. The specimens were weighed again after each test, and the difference between the initial and final weights was used to determine the wear rate.

Corrosion test (weight loss in seawater)

The weight loss technique was used in this investigation to measure the corrosion rate at room temperature (27°C). Both as-cast and modified alloys were used in the test samples, which were shaped to the standard specifications of 20 mm in diameter and 5 mm in thickness. For 30 days, these specimens were completely submerged in seawater, and the moisture content was continuously monitored. The seawater used as the corrosive environment came from the Tamil Nadu coast of Pondicherry, which is close to Thiruvannamalai. To calculate the weight loss following exposure, each sample was precisely weighed before being submerged. The specimens were taken out, cleaned, and weighed again after being submerged for 30 days. The corrosion rate, measured in grams, was determined by comparing the initial and final weights.



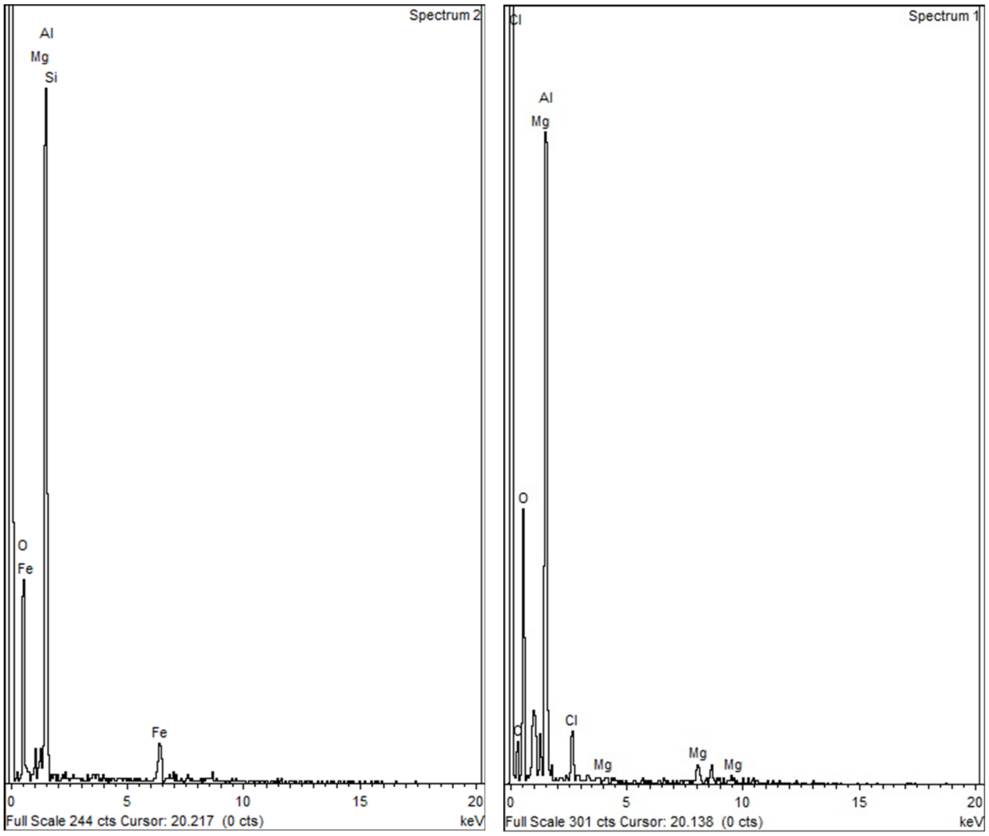
(a) (b)

Figure 2: Optical Micro-structure of (a) Al7075 alloy and (b) n-Mg modified Al7075 alloy

RESULTS AND DISCUSSIONS

Microstructural study

The eutectic microstructures of the Al alloy and the nano sized magnesium -modified Al alloy are shown in Fig. 2. The intermetallic phases of the unmodified alloy and the particular alloying elements present have the biggest effects on its overall microstructure. The Al alloys utilized in this investigation had different concentrations of Mg, Fe, and Mn, as was previously mentioned. Grain refinement as well as an increase in dislocation density is caused by the particles in the alloy acting as nucleation sites and growth-restraining agents. As a result, the Mg modified alloy becomes stronger because it has more grain boundaries and a larger dislocation density, which prevents dislocation motion and deformation [16]. The microstructural investigation showed that the darker portions corresponded to eutectic phases, whereas the gray areas represented the α-Al matrix. There were discernible variations in the α-Al grain structure among the five alloy samples, with the amount of dark eutectic phases within the α-Al grains increasing as the magnesium content rose. The interaction between magnesium and silicon results in the formation of additional Mg_2Si phases at increasing Mg levels. Since, the Mg_2Si particles can dissolve in the aluminum matrix, the concentration gradient along the solid–liquid interface is lessened. Coarser dendritic arm structures form as a result of this impact, which slows the solidification front's movement and prevents grain formation. Microstructural observations indicated that higher Mg addition (2.5 wt. %) led to a noticeable increase in grain size compared to the 2 wt. % sample. This grain coarsening can be attributed to the formation of Mg-rich intermetallic phases that reduce the availability of solute atoms for nucleation and promote grain growth during solidification. Fig. 3 represents the EDS spectrum of Al7075 alloy and n-Mg modified Al7075 alloy. By EDS analysis it is observed that distinct peaks for aluminum and magnesium, along with other alloying elements, show potential impurities. Tab. 1 shows the composition of Al7075/n-Mg with sample IDs.



(a) (b)

Figure 3: EDS spectrum of (a) Al7075 alloy and (b) n-Mg modified Al7075 alloy

Sample IDs	Al7075	Wt. % n-Mg
Sample 1	100	0
Sample 2	99	1
Sample 3	98.5	1.5
Sample 4	98	2
Sample 5	97.5	2.5

Table 1: Composition of Al7075/n-Mg with sample IDs

Hardness

Fig. 4 displays the hardness data for the nano sized magnesium -modified alloys as well as the parent Al7075 alloy. When comparing the hardness value of Mg-modified alloys with that of unmodified alloy, it is clear that the former have greater hardness. The hard, brittle Mg phases are the cause of this hardness development, and the distributed nano sized magnesium particles provide more to the alloy's hardness than they did in the original sample [18]. A similar result was reported in a study [19], which found that the hardness of the alloy improved as the magnesium level increased. In contrast to the 2 wt. % addition, the study found that increasing the nano sized magnesium content to 2.5 wt. % did not result in notable improvement in hardness. This was attributed to grain coarsening at higher Mg levels, which limits the alloy's ability to hinder dislocation movement, thereby reducing the potential for hardness enhancement [9].

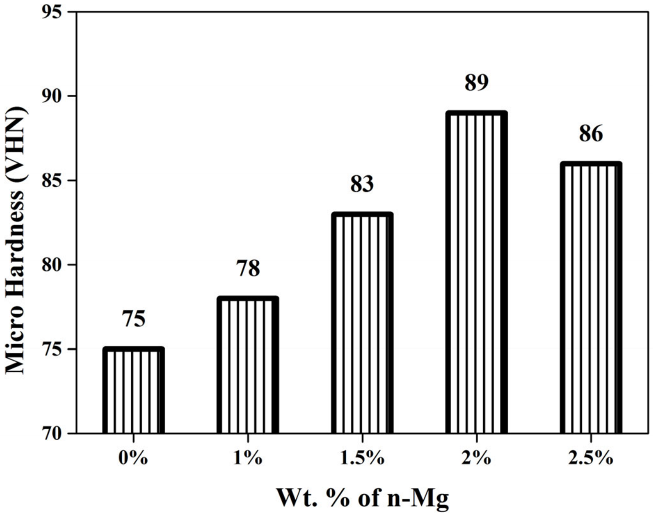


Figure 4: Hardness of n-Mg modified alloy.

Tensile properties

Tensile strength readings for the unaltered Al7075 alloy and the versions improved with nano sized magnesium are shown in Fig. 5. The results show that the addition of magnesium has significantly increased the tensile strength. Grain boundary refinement, solid solution strengthening, and the development of the brittle Al_3Mg_2 intermetallic compound are the main causes of this improvement [17]. The alloy experienced several dislocations when subjected to tensile loading. Deformation took place and dislocations began to shift as the applied force increased. Addition of magnesium caused an Al_3Mg_2 intermetallic that was evenly dispersed throughout the alloy and served as a barrier to dislocation motion. Because of this constraint, it required more energy for the dislocations to migrate, increasing the material's strength.

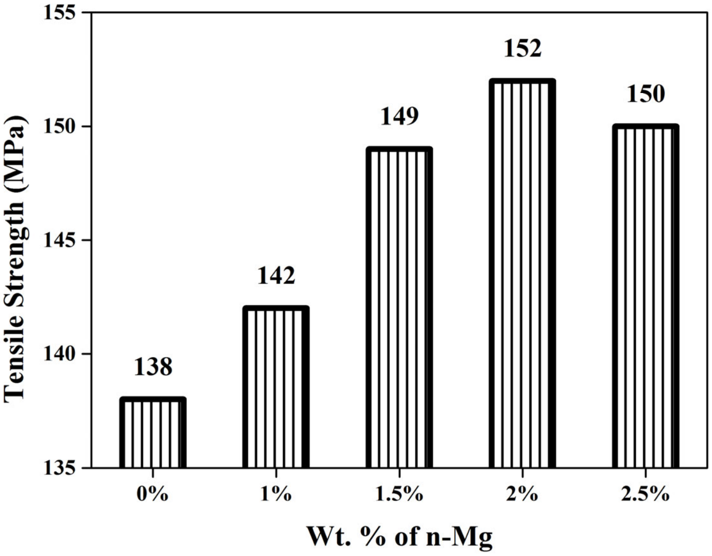
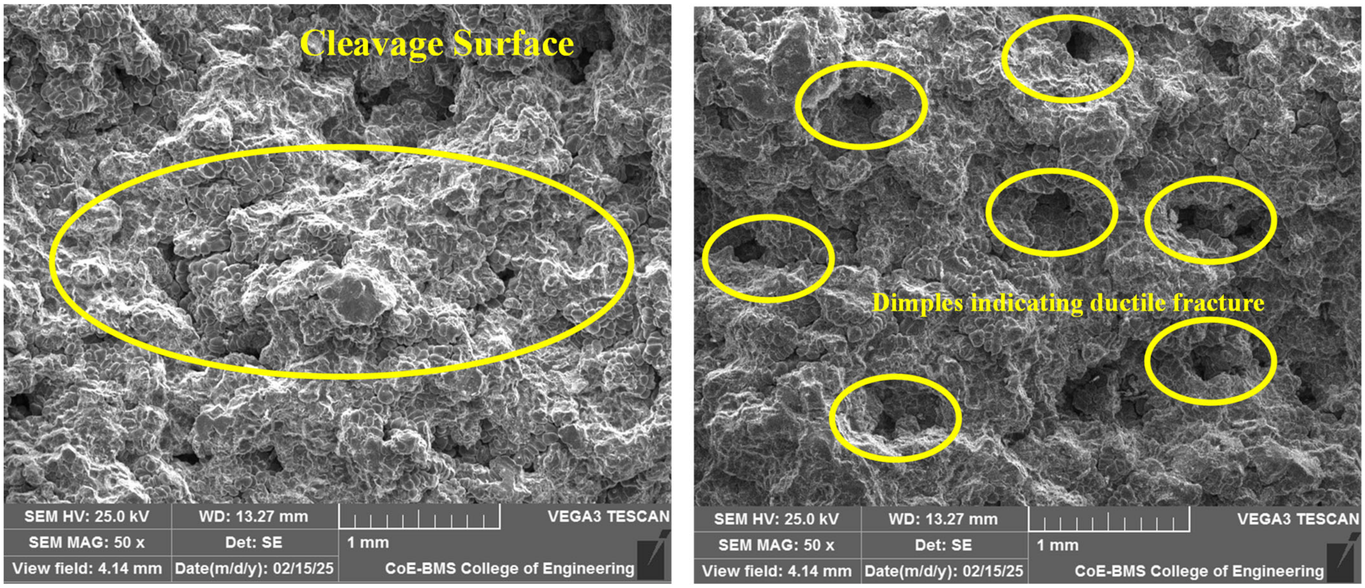


Figure 5: Tensile strength of n-Mg modified alloy.

With a maximum tensile strength of 152 MPa, the strengthening effect was most noticeable when up to 2 wt. % of nano sized magnesium was added. The observed drop in tensile strength at 2.5 wt. % Mg can be verified experimentally by measuring the size, distribution, and density of the Al_3Mg_2 intermetallic phase. Using SEM analysis, the mean particle size and interparticle spacing can be quantified and statistically compared across compositions. A measurable coarsening of Al_3Mg_2 would indicate fewer, larger particles with increased spacing, which reduces the material's ability to hinder dislocation motion. Correlating these microstructural parameters with the tensile data using Orowan or precipitation-strengthening models would confirm that the strength reduction results from the coarsening of the Al_3Mg_2 phase [18]. Scanning Electron Microscopy (SEM) was used to analyze the fracture surface in order to gain a better understanding of how different magnesium contents affect the tensile strength for both unmodified and nano sized magnesium modified alloys, as illustrated in Fig. 6. Multiple cleavage facets were visible on the base alloy's fracture surface, indicating a primarily brittle fracture characteristic. Tearing ridges and dimples becomes more noticeable as the amount of nano sized magnesium increases, indicating an increase in the alloy's hardness. Excess magnesium promotes grain coarsening by forming Al_3Mg_2 at grain boundaries, reducing boundary pinning and encouraging grain growth. The resulting coarse grains and brittle boundary phases decrease toughness by facilitating crack initiation and propagation, as the researcher [20] pointed out.



(a) (b)

Figure 6: Tensile fractured surface of (a) Al7075 and (b) n-Mg modified Al7075 alloy

Impact Strength

Fig. 7 shows a clear relationship between the impact energy and the amount of nano sized magnesium particles added to the aluminum alloy. A decrease in impact energy is the result of the alloy becoming more brittle as the magnesium percentage increases. The development of rigid, brittle intermetallic compounds brought about by magnesium addition is thought to be the cause of this brittleness. The alloy was more prone to fracture and required less energy to shatter the specimens as its brittleness rose. As a result, the magnesium-added alloys showed decreased toughness and impact energy [9]. In particular, the impact energy decreased from 28 J to 18 J, a 35% decrease.

Wear Behavior

Wear volume and material hardness are inversely correlated, according to Archard's law. With a higher hardness than its unmodified counterpart, the nano sized magnesium modified alloy showed improved wear resistance, as shown in Fig. 8. The increased concentration of hard particles in the n-Mg modified alloy causes this improvement. Usually, when subjected to high loads, these hard particles might either rupture or embed in the matrix. As a result, the n-Mg modified alloys showed a somewhat lower wear loss than the untreated alloy. It is clear that both the hardness and the microstructure of the alloy affect wear loss under the same loading circumstances. In comparison to the unmodified alloy, the n-Mg modified alloy showed noticeably finer grain size and higher hardness, this aids in avoiding adhesive wear.

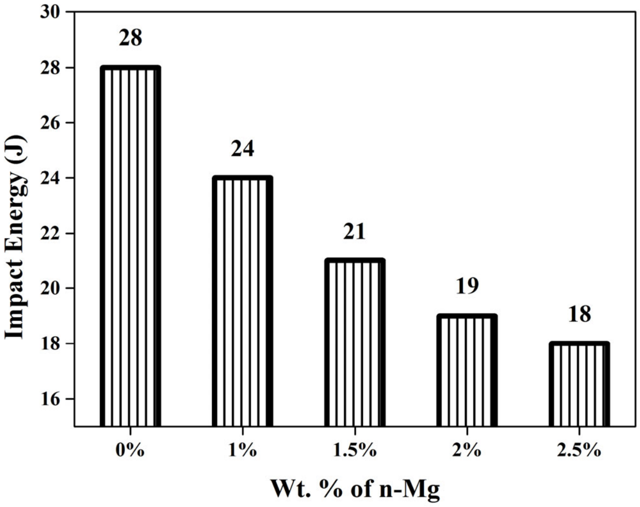


Figure 7: Impact strength of n-Mg modified alloy.

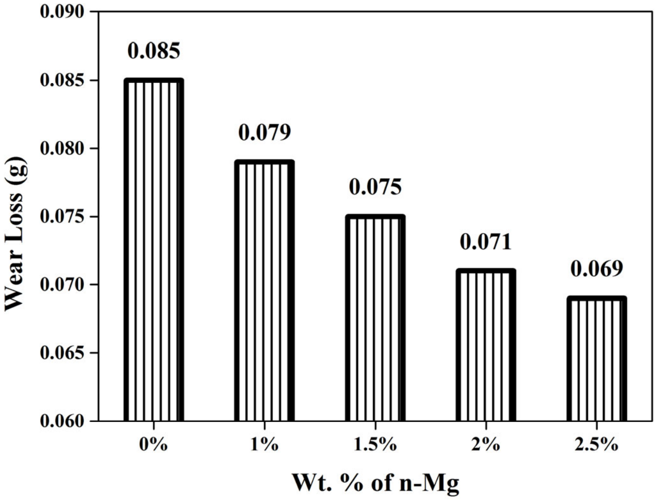
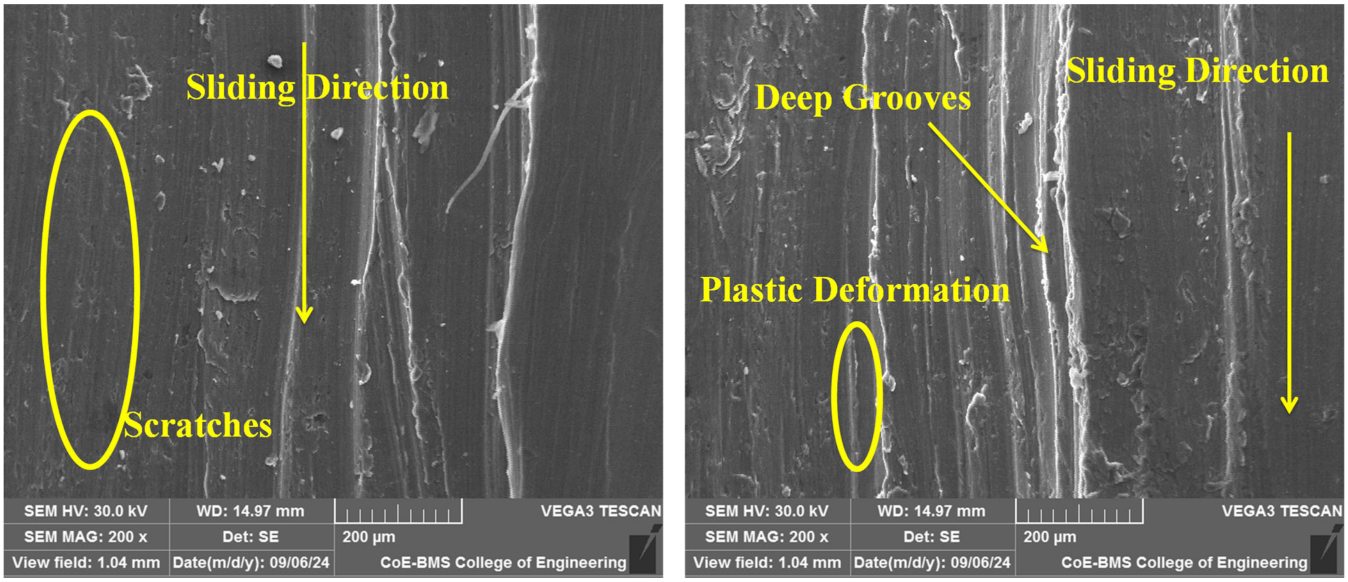


Figure 8: Wear loss (g) of n-Mg modified alloy.

Furthermore, the alloy's resistance to debris particles plowing on the contact surface is improved by the increased hardness, which reduces abrasive wear [19]. The addition of hard particles also increases the alloy's load-bearing capacity and reduces the possibility of adhesive wear, which can happen when low-melting-point microstructural regions melt or soften. Furthermore, the β phase serves as a solid lubricant, preventing cracks from spreading at secondary phase boundaries and reducing overall wear loss [21]. Both the as-cast as well as nano sized magnesium modified alloys' wornout surfaces, as seen in Fig. 9, exhibit scratch marks oriented across the sliding direction, which is indicative of abrasive wear, according to the SEM analysis. The hard particles that were removed from the alloy surface during testing are primarily responsible for this wear behavior. The coefficient of friction rises when there are loose particles from the test specimen and the disc, especially in the early phases of testing. When the loaded surface comes into contact, micro-cutting takes place, and friction-induced plastic flow causes plastic deformation to form on the sample surface. As the sliding distance grows, particles build up at the sample/disc interface, intensifying this deformation even further. Consequently, the worn surfaces exhibit both abrasive and adhesive wear mechanisms [22]. Moreover, plastic deformation on the specimen's surface is encouraged by the hard, nano sized magnesium particles that separate from the oxide layer during sliding.



(a) (b)

Figure 9: Wornout surfaces SEM image of (a) Al 7075 alloy and (b) n-Mg modified Al 7075

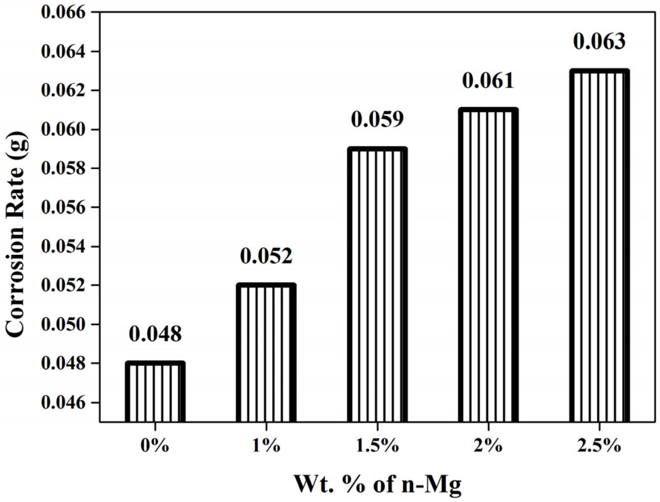
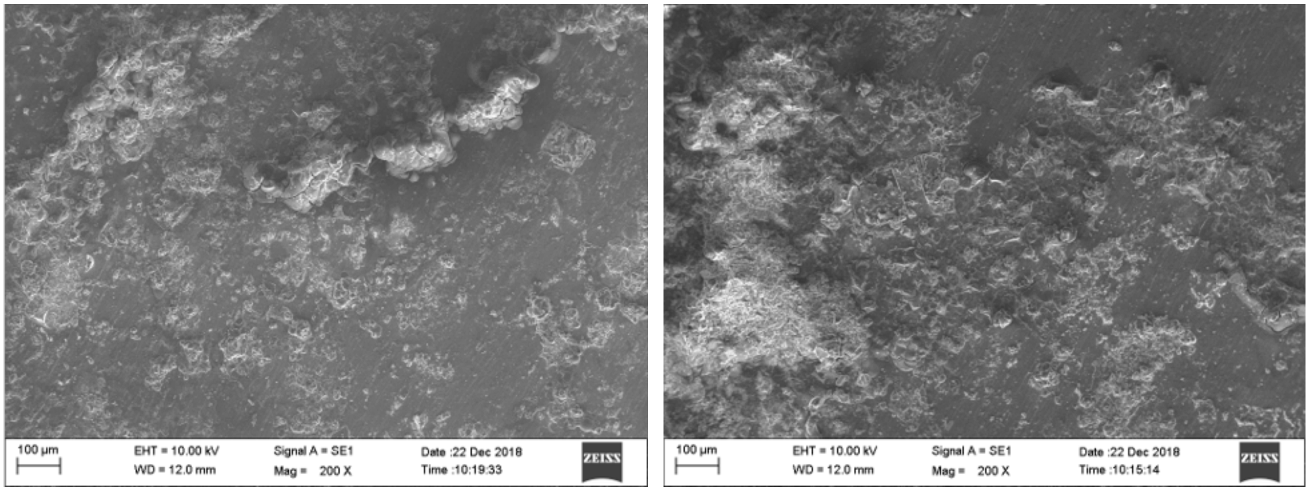


Figure 10: Corrosion rate of n-Mg modified alloy.

Corrosion rate

Fig. 10 displays the developed modified alloy's corrosion rate. According to experimental findings, pure aluminum had the lowest rate of corrosion and weight loss. Weight loss increased noticeably when the quantity of nano sized magnesium particulates increased. Given that magnesium behaves anodically in comparison to the aluminum alloy, this is explained by its strong reactivity. According to [9], the durability of the protective oxide layer is often affected by magnesium's increased reactivity, which speeds up corrosion at greater Mg concentrations. The corrosion properties of the Al7075 alloy as well as the nano sized magnesium modified Al7075 alloy following 30 days of submersion in saltwater is depicted in the SEM study in Fig. 11. Localized corrosion is indicated by the corroded samples' uneven, concave convex surface characteristics. The existence of internal tensions or dehydration of hydroxides, which may be linked to stress corrosion cracking caused by magnesium, is indicated by the emergence of cracks and pits inside the corrosion products. The alloy surface first develops a protective Al_2O_3 layer that provides significant corrosion resistance. Significant localized corrosion, however, starts to form beneath the surface after extended exposure. The development of nano-pores that weaken the protective layer's integrity is thought to be the cause of this degradation. Long-term exposure weakens the oxide layer and promotes localized corrosion in those particular regions due to the leaching of magnesium and aluminum surrounding exposed secondary phases and the accumulation of porous corrosion products. Micro-galvanic interactions between the aluminum matrix and Al_2Mg_3 phases are likely the reason for the passive coating's collapse and the development of pits and crevices, which is why the corrosion resistance was demonstrated to be decreased [23]. Similar trends were noted by the author in [9], where SEM analysis of corroded samples revealed pits and apparent cracks caused by alloy breakdown, as well as degradation of the Al_2O_3 coating. Elevated oxygen levels on the surface provided additional evidence of corrosion activity by elemental mapping. It was discovered that the alloy's magnesium content increased the overall susceptibility to corrosion by hastening the breakdown of the Al_2O_3 layer.



(a) (b)

Figure 11: SEM image of the corroded surface of (a) Al7075 alloy and (b) n-Mg modified Al7075 alloy

CONCLUSIONS

Stir casting was used to modify the Al7075 alloy by adding 1, 1.5, 2, and 2.5 wt. % of nano sized magnesium. The purpose of this experimental investigation was to assess how the mechanical, wear, as well as corrosion behavior of the Al7075 alloy would be affected by the addition of nano sized magnesium. The following are the main conclusions drawn from the results:

- Magnesium's reinforcing function in the aluminum alloy was highlighted by the optical microstructure study, which showed uniform distribution of nano sized magnesium particulates in the alloy.
- Addition of n-Mg to modify the Al7075 properties resulted in reduction in density of the alloy.
- Tensile strength, hardness, wear resistance, and corrosion resistance improved by roughly 9.21%, 15.73%, 18.82%, and 23.80%, respectively, in the n-Mg modified Al7075 alloy.
- The coarsening of intermetallic phases reduced their effectiveness in hindering dislocation motion; therefore, addition of 2.5 wt. % Mg adversely affected the strength improvement compared to the alloy containing 2 wt. % Mg which was observed using fractured surface SEM analysis.

REFERENCES

[1] Suchendra., Sreenivasa Reddy. and RaviKumar, M. (2023). Influence of quenching agents on mechanical, wear, and fracture characteristics of Al_2O_3 / MoS_2 reinforced Al-6061 hybrid Metal Matrix Composite (MMCs), Frattura ed Integrità Strutturale, 63, pp. 122-133.

[2] Chang Rong Song., Bai Xin Dong., Si-Yu Zhang., Hong-Yu Yang., Lin Liu., Jie Kang., Jia Meng., Chang Jie Luo., Cheng Gang Wang., Kuang Cao., Jian Qiao., Shi-Li Shu., Ming Zhu., Feng Qiu. and Qi-Chuan Jiang.

(2024). Recent progress of Al-Mg alloys: Forming and preparation process, microstructure manipulation and application, Journal of Materials Research and Technology, 31, pp. 3255-3286.

[3] Prakash., Ganghadharappa., Santhosh Somashekar. and Ravikumar, M. (2024). The Impact of nanoparticles (B_4C-Al_2O_3) on mechanical, wear, fracture behavior and machining properties of formwork grade Al7075 composites, Frattura ed Integrità Strutturale, 18 (69), pp. 210-226.

[4] Parvin. and Kazeminezhad. (2024). Modeling the effect of Mg addition on microstructure and strength of aluminum during severe plastic deformation. Journal of Materials Research and Technology, 28, pp. 3013-3024

[5] Modassher Nomani., Azmery Akter. and Mohammad Salman Haque. (2024). Effect of Mg Addition on the Improvement of the Mechanical Properties of Aluminum, Proceedings of the 14th International Conference on Mechanical Engineering, pp. 211-216.

[6] Dania Bani Hani., Raed Al Athamneh., Zaid Albataineh., Mustafa Rawashdeh. and Issam Makableh. (2022). Modeling the Effect of Magnesium Content on the Electrical Conductivity and Hardness of Technical Aluminum (1050) Alloy, Crystals, 12, https://doi.org/10.3390/cryst12040457.

[7] Ravikumar, M. (2025). Investigation on the tensile strength, hardness and wear properties in n-B_4C reinforced Al7075 composites, Frattura ed Integrità Strutturale, 73, pp. 219-235.

[8] Guan Cheng Chen., Till Felix Reufsteck., Yitian Chi. and Xiaochun Li. (2024). Nanotechnology enabled casting of aluminum alloy 7075 turbines, npj Advanced Manufacturing, 1 (6), pp. 1-10, https://doi.org/10.1038/s44334-024-00004-x.

[9] Mohammad Salman Haque., Modassher Nomani., Azmery Akter. and Istiak Ahmed Ovi. (2024). Synergistic effect of Mg addition on the enhancement of the mechanical properties and evaluation of corrosion behaviors in 3.5 wt % NaCl of aluminum alloys, Heliyon, 10, 1-13.

[10] Haque, Khan and Kaiser. (2022). Effect of Sc and Zr on precipitation behaviour of wrought Al- bronze, IOP Conf. Series: Mater. Sci. Eng., 1248, doi:10.1088/1757-899X/1248/1/012037.

[11] Hongjie Luo., Jiahao Zhao., Hao Du., Wei Yin. and Yang Qu. (2022). Effect of Mg Powder's Particle Size on Structure and Mechanical Properties of Ti Foam Synthesized by Space Holder Technique, Materials, 15, 1-34, https://doi.org/10.3390/ ma15248863.

[12] Chia Ming Yang., Yen Hsi Chen., Meng Hsiu Tsai., Ben Bang Yu Hsu., Wen Ta Tsai., Chiu-Feng Lin., Chun Chieh Tseng. and In Gann Chen. (2022). Observation of morphology and compositional changes of magnesium alloy using liquid cell TEM, Journal of Material Research and Technology, 21, pp. 4548-4557.

[13] Haonan Chen., Jiangbo Lu ., Yi Kong., Kai Li., Tong Yang., Arno Meingast., Mingjun Yang., Qiang Lu . and Yong Du. (2020). Atomic scale investigation of the crystal structure and interfaces of the B' precipitate in Al-Mg-Si alloys, Acta Materialia, 185, pp. 193-203. https://doi.org/10.1016/j.actamat.2019.11.059.

[14] Sung Hwan Hong., Sang Chul Mun., Gyeol Chan Kang., Hae Jin Park., Yeon Beom Jeong, Gian Song. and Ki Buem Kim. (2022). Recent development of coloring alloys, Progress in Materials Science, 123, https://doi.org/10.1016/j.pmatsci.2021.100811.

[15] Xuanjie Yan., Yudong Sui., Hao Zhou., Wenwen Sun., Yehua Jiang. and Qudong Wang. (2022), Influence of the Mg content on the microstructure and mechanical properties of Al-xMg-2.0Si-0.6Mn alloy. Journal of Materials Research and Technology, 23, 3880-3891. https://doi.org/10.1016/j.jmrt.2023.02.046.

[16] Ravikumar, M. and Rudranaik. (2022). Impact of nano sized SiC and Gr on mechanical properties of aerospace grade Al7075 composites, Frattura ed Integrità Strutturale, 62, pp. 439-447.

[17] Xu., Xin., Zhang. and Li. (2022). Stress corrosion cracking resistant nanostructured Al-Mg alloy with low angle grain boundaries, Acta Materialia, 225, https://doi.org/10.1016/j.actamat.2021.117607.

[18] Sreenivasa Iyengar., Sethuramu. and RaviKumar, M. (2023). Mechanical, Wear, and Fracture Behavior of Titanium Diboride (TiB_2) - Cerium Oxide (CeO_2) Reinforced Al-6061 Hot-rolled Hybrid Composites, Frattura ed Integrità Strutturale, 63, pp. 289-300.

[19] Dongmei Wang., Xiaolan Wu., Kunyuan Gao., Shengping Wen., Hong Wu., Jingwen Qiu., Wu Wei., Hui Huang., Dejing Zhou. and Zuoren Nie. (2022). Study on the microstructure and wear behavior of Mg-containing Ale12Sne4Si alloys, Journal of Materials Research and Technology, 18, pp. 338-351. https://doi.org/10.1016/j.jmrt.2022.02.087

[20] Chao Li., Zhi Fan., Hai-Long Jia., Cheng Wang., Pin-Kui Ma., Ming-Wen Ren. and Hui Yuan Wang. (2021).Synergetic modification effects on primary Mg2Si in Al-20Mg2Si alloy induced by the co-addition of beryllium and antimony, Journal of Alloys and Compounds, 888, https://doi.org/10.1016/j.jallcom.2021.161477.

[21] Joyce., Reed. and Syngellakis. (2003). Numerical modelling of crack shielding and deflection in a multi-layered material system, Materials Science and Engineering: A, 342 (1-2), pp. 11-22. https://doi.org/10.1016/S0921-5093(02)00279-4.

[22] Ibrahim Saglam., Dursun Ozyurek. and Kerim Çetinkaya. (2011). Effect of ageing treatment on wear properties and electrical conductivity of Cu-Cr-Zr alloy, Bulletin of Materials Science, 34, 1465-1470. https://doi.org/10.1007/s12034-011-0344-5.

[23] Yuyao Li., Shun Meng., Qianming Gong., Yilun Huang., Jianning Gan., Ming Zhao., Bin Liu., Lei Liu., Guisheng Zou. and Daming Zhuang. (2019). Experimental and theoretical investigation of laser pretreatment on strengthening the heterojunction between carbon fiber-reinforced plastic and aluminum alloy, ACS applied materials & interfaces, 11(24), pp. 22005-22014.