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Study on Mechanical Properties of hBN Reinforced Al-7075 Metal Matrix Composite

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***Abstract:** Nickel-coated hBN particulate reinforced Al7075 matrix composites were developed using the stir casting technique. Al7075 – hBN composites were subjected to tensile test and heat treatment by solutionizing at a temperature of 550 °C for a span of 2 hr and then quenched in water at room temperature. Hardness was measured before starting the aging process and further, compacts were artificially aged in the furnace at temperatures of 100, 150, and 200 °C for intervals of 60 min. Results have revealed that nickel-coated hBN particles are uniformly distributed throughout the matrix alloy. Microhardness of Al6061- hBN composites increases with an increase in the percentage of reinforcement. Heat-treated Al-7075+4.5% nickel-coated hBN possesses higher hardness when compared with the Al-7075 alloy composites. Also, the hybrid reinforced composites exhibit excellent tensile properties; as compared with base metal (Al7075) and Al7075+4.5% nickel coated hBN show high Breaking Load and Ultimate Tensile Strength. The current studies focused on strength by varying aged harden treatment for Al7075+4.5% nickel coated hBN and their tensile strength.*
***Keywords:** Heat Treatment, Stir Casting, Interfacial Strength*

I. INTRODUCTION:

In the modern development of technology, lightweight materials have vital role industries applications, especially in the automotive fields and aerospace sectors. Aluminium is the most abundant non-ferrous metallic element extracted from the earth's crust due to its fabulous physical and mechanical properties such as high strength to weight ratio, ductility, malleability, high recycle potential, damping capacity, low co-efficient of friction corrosion resistivity, durability, good electrical and thermal conductivity. Aluminium and its alloys are used widely in fabricating metal matrix composites (MMCs) as matrix materials when compared with other PMCs and CMCs, MMCs exhibit excellent mechanical and physical properties such as high stiffness and strength, dimensional stability, wear resistance, high thermal resistance capacity, electrical conductivity. Adding reinforcement material into matrix composites enhances the desired characteristics of AMMCs. The mechanical properties of the composite materials are determined by considering different parameters which involve the characteristics of reinforcement materials and matrix, the bond characteristics between reinforcement material and matrix, orientation, the volume ratio of the matrix and reinforcement materials, structure and shape of the reinforcement material within the structure of composite.

The structure and characteristics of the matrix reinforcement interface significantly affect the composite material's physical and mechanical properties. As Aluminium metal matrix composites (AMMC) have a longer life and excellent performance compared with other conventional metals due to their excellent lightweight, low density, rigidity, specific strength, low thermal expansion coefficient and wear resistance. Thus, Aluminium and its composites had a wide range of applications in automobiles, aerospace, and other areas such as electrical fields, defence, marine, construction, sports, and recreation activities. While considering lightweight as major constitutes in automotive industries, replacement of cast iron and steel in IC engine applications, automotive braking system components such as calipers and disc brakes, in Toyota RAV4 EV and Volkswagen Lupo 3 L SiC reinforced Al brake rotors are used. The utilization of AMMC in aerospace and aircraft industries plays a vital role in the advancement of rocket technology and aircraft due to flexibility, lower fabricating costs, dampening, reduced weight, mechanical stability, and thermal management. And even in marine transportation-s, offshores applications mainly concentrated on corrosion resistance characteristic of AMMC thus it's important to use marine-grade aluminium alloys [1-5].

Among the Aluminium and its alloys, Al-7XXX series alloys contain Zinc and Magnesium as their principal alloying elements which improve its solid solubility, typically evolve high precipitation hardening along with refined metastable $MgZn_2$ η-phase precipitates exhibit ultra-high-strength, excellent processing and welding performance, high specific toughness, high specific stiffness and majorly used more than 70% constitutional materials in aircraft sectors such as fuselage stringers and frame, bumper components, and stringers in load-bearing components[6-8].

The main cons of these Aluminium alloys are their low wear resistance and low ability to high temperature, to conquer this enigma various ceramic particles are reinforced into the Aluminium Metal Matrix Composites (AMMC) such as B_4C, hBN, TiC, Al_2O_3, SiO_2, Fe_2O_3, ZrO_2, etc. Even when employing the stir casting technique to incorporate reinforced ceramic particles into composites made of an aluminium metal matrix, the interfacial bond between the reinforced ceramic particles and the composites results in a lack of most mechanical and physical qualities. For better interfacial bonding between the aluminium metal matrix composites and the ceramic particles, which is currently a problem, metal is coated on the ceramic particles (9-15).

II. METHODOLOGY

The AA7075 base material, which is 95.5 percent metal matrix and has 4.5 percent nickel-coated hBN particles, is the subject of the investigation. The literature review is used to determine the reinforcement's percentage composition. The stir casting technique is used to create MMC. The hybrid composite material plate was created at 540 °C and 80 rpm for stirring. The tensile and hardness of aged AA7075 reinforced with nickel-coated hBN particles are the main subjects of the investigation. Aluminium 7075 + nickel-coated hBN is the component in composite aluminium.

STEPS INVOLVED:

A. Selection Of Matrix And Reinforcement

Reinforcements give high strength, stiffness, and other improved mechanical properties to the composites. Also, their contribution to other properties such as the coefficient of thermal expansion, conductivity, etc is remarkable. Hexagonal Boron Nitride (hBN) also known as “White Graphite”, has a similar (hexagonal) crystal structure as Graphite. This crystal structure provides excellent lubricating properties. hBN powders are available in the following particle sizes: 70 nm, 150 nm, 0.5 microns, 1.5 microns, and 5 microns to 30 microns. hBN is much superior to Graphite due to its excellent lubricating properties (low Coefficient of Friction at 0.15 to 0.70), good chemical inertness, electrical insulator, thermal conductor, high-temperature stability (1000 ^{0}C in air and 1400 ^{0}C in vacuum), low thermal expansion, low dielectric constant, high load bearing properties. hBN is utilized in various aerospace, manufacturing (cosmetics, paints, dental cement, glass), and space applications due to its excellent range of qualities that make it useful as a lubricant additive. It also has strong thermal resistance, making it useful for high-temperature lubrication. Nickel is a hard, ductile, silvery-white transition metal. Nickel belongs to the ferromagnetic elements, and it is naturally present in the Earth's crust usually in combination with oxygen and sulphur as oxides and sulphides. It is resistant to very high temperatures, corrosion, and oxidation, its alloys readily, and is fully recyclable. Nickel compounds are majorly used in electroplating, electroforming, and production of nickel-cadmium batteries and electronic equipment.

B. Stir Casting

Stir casting is a type of casting process in which a mechanical stirrer is introduced to form a vortex to mix reinforcement in the matrix material. It is a suitable process for the production of metal matrix composites due to its cost-effectiveness, applicability to mass production, simplicity, almost net shaping, and easier control of the composite structure. Stir casting is a suitable processing technique to fabricate aluminium matrix composites and hybrid aluminium matrix composites as it is an economical process and is preferred for mass production. The first step of stir casting involves melting aluminium. During melting, aluminium melt reacts with the atmosphere and moisture and forms a layer of aluminium oxide. The stir casting process involves stirring of melt, in which the melt is stirred continuously which exposes the melt surface to the atmosphere which tends to continuous oxidation of aluminium melt. As a result of continuous oxidation, several process variables, including stirring speed, impeller blade angle, stirring time, impeller position, impeller blade size, and feed rate, must be taken into account when fabricating aluminium using stir casting procedures. e wettability of the aluminium reduces and the reinforcement particles remain unmixed.

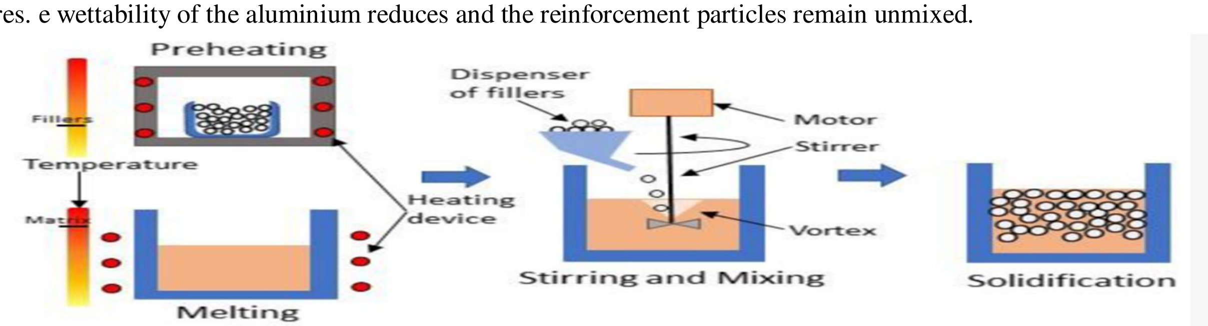

Fig.1. Stir Casting Process

C. Preparation of Composite Material

Table 1. Chemical composition of aluminium 7075 alloy

Properties		Al 7075
Compositions (% in mass)	Chromium	0.180 – 0.280
	Copper	1.20 – 20
	Iron	0.5
	Magnesium	2.10 – 2.90
	Manganese	0.3
	Silicon	0.4
	Zinc	5.10 – 6.10

The electroless bath employed for the present study consisted of Nickel methane sulphonate = 25 g/l; sodium hypophosphite = 22g/l; tri ammonium citrate =45g/l; acetylthiouria= 0.01 mg/l; proprietary surfactant = 0.01 g/l; pH =5.2; temperature =88ºC; mechanical agitation was provided at 240 rpm using Remi mechanical stirrer, India. The plating time was 30 minutes. Before plating, the reinforcement was subjected to pre-treatment such as degreasing with acetone, acid pickling in 10% HCl at room temperature, sensitization in $SnCl_2$ solution, and then activation of powders in palladium chloride solution. Subsequently washed with water and dried at 50^0C in the furnace for 30 minutes. Then the particles were introduced into an electroless plating bath. The reinforcement hexagonal boron nitride particles are coated with Nickel through an electroless coating process. Mixing the base metal Al7075 with reinforcement at the percentage of Al7075 95.5% and reinforcement (nickel coated hBN) 4.5% nickel coated hBN is fed into the furnace for melting at 540˚c at a stirring speed of 80 rpm. After melting the molten metal (Base and Reinforcement) pour it into a mould (die). And allows solidifying at some time.

Table 2: Electroless Nickel Coating Process

TYPE OF PRE-TREATMENT	CHEMICAL COMPOSITION	PARAMETERS	RESULTS
Acidic pre-treatment (AP)	Sodium hypophosphite (NaH_2PO_2-H_2O), 30g/l, and Lactic acid 98% ($CH_3CH(OH)COOH$), 20ml/l	T=85 ^{0}C T=35 min After flushing with distilled water or dryingat 105 ^{0}C for 15 min	Development of a thin hypophosphate layer
Surface Oxidation (SO)	Air atmosphere	T=1000 ^{0}C And 1100 ^{0}C, and t= 1,3,5 and 7 hours	Continuous, compact oxide SiO_2layer
Sensitization	Stannous chloride, $SnCl_2$ 15g/1 Hydro chloride acid HCL (cc.37 %), 55cm^3/1	T=298K (25 ^{o}C), t= 10 min	Sn^{2+} ions adsorb on the surface of silicon carbide particles
Activation	Palladium chloride, $PdCl_2$, 0.5 g/1 Hydrochloride acid HCL (cc. 37%), 2ml/l	T= 298K (25 ^{o}C), t =25 min	Palladium nuclei form on the surfaceof SiC particles

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D. Tensile Test For Composite Material

While selecting the materials for engineering applications, the tensile test plays a significant role. The tensile strength of the material indicates the quality of the material and its behavior with the application of different loading conditions.

Fig. 2. Universal Testing Machine

When the material is subjected to external loading, the atoms lose their cohesive strength and move apart. When the load is released, they regain their original position. This is called elastic deformation. If the atoms are unable to regain and move away from each other, they are said to be under plastic deformation. The fracture of the material takes place after undergoing plastic deformation. The ductile material will undergo more plastic deformation before the final fracture. The tensile test is carried out to assess the mechanical behavior of material when an axial pull is applied to it at room temperature. Specifically, these tests are aimed to evaluate tensile strength, yield strength, percentage elongation, reduction in area, and ultimate strength. In the present study, The Nickel coated hBN with Al7075 composite material obtained from the stir casting method is cut according to ASTM D638 standard with a dimension of 300 mm length, 115 mm of the Gauge length, and a diameter of 20mm. Then the specimen is given to check its tensile strength. The tensile strength of the composite was measured with a universal testing machine.

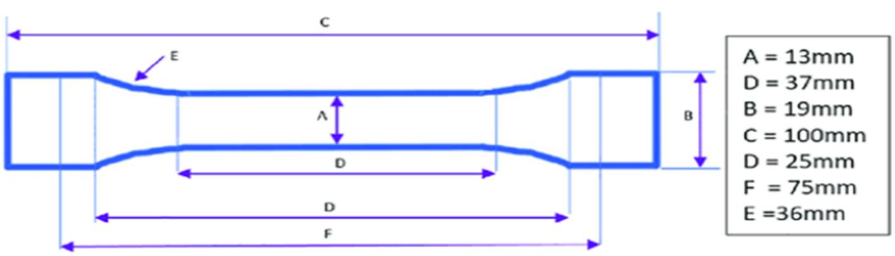

Fig.3. Standard Tensile Test Specimen (ASTM D638)

E. Hardness Test For Composite Material

Hardness is a characteristic of a material, not a fundamental property. It is defined as the resistance to indentation, and it is determined by measuring the permanent depth of the indentation. The Vickers hardness test is an optical testing method for samples with coarse or inhomogeneous grain structures. This is the best test method for achieving the bulk or macro hardness of a material, particularly those materials with heterogeneous structures. The surface of the test specimen must be either machined, grind, lapped, or polished apply a minor load of 10-kg-f during the initial stage and later apply a major load (remaining part of the test load) for the exactly specified dwell time (15 seconds).

Fig. 4. Vickers hardness testing equipment

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F. Aging Heat Treatment Process

The heat treatment process can be applied to ferrous metals such as cast iron, stainless steel, and other alloy steels, as well as non-ferrous metals such as aluminium, magnesium, titanium, copper, or brass. The sintered specimens were subjected to age-hardening heat treatment. The heat treatment was done in a controlled muffle furnace. The furnace temperature was initially made stable to the required temperature and then specimens were loaded to avoid surface oxidation. Compacts are soaked at 550 ^{O}C for a span of 2 hr and then quenched in water at room temperature. Hardness was measured before starting the aging process and further, compacts were artificially aged in the furnace at temperatures of 100, 150, and 200 ^{O}C for various intervals of time.

III. RESULT AND DISCUSSION

A. The hardness of Aged Specimens

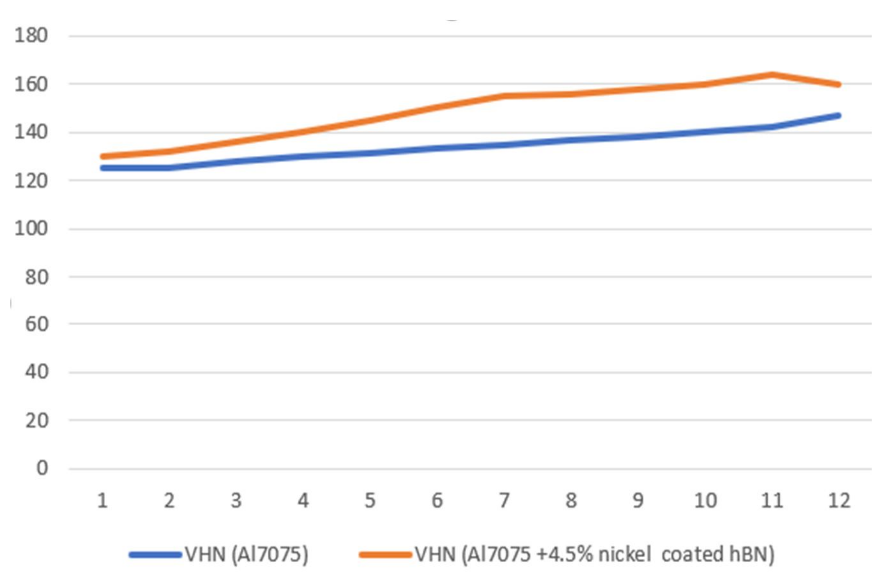
Hardness values are measured at the time interval of 60 minutes, to determine the peak aging time for that specific temperature. The hardness for each interval is tabulated for all the three types of compacts carried at 100, 150, and 200^{0}C are given in Tables. Comparison of peak hardness of specimens under different conditions as given in Table.

Table 3: Hardness Values of Al7075 Specimen Aged at 100 ^{0}C for Different Aging Times

Sample No	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Aging Time(h)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
VHN	125	125	128	130	131	133	135	137	138	140	142	147	150	156	152	148

Table 4: Hardness Values of Al7075+4.5% nickel coated hBN Composite Aged at 100 ^{0}C for Different Aging Times

Sample No	0	1	2	3	4	5	6	7	8	9	10	11
Aging Time(h)	0	1	2	3	4	5	6	7	8	9	10	11
VHN	130	132	136	140	145	150	155	156	158	160	164	160



Graph 1: Comparison of VHN (Al7075) and VHN (Al7075 +4.5% nickel coated hBN) at 100 ^{0}C

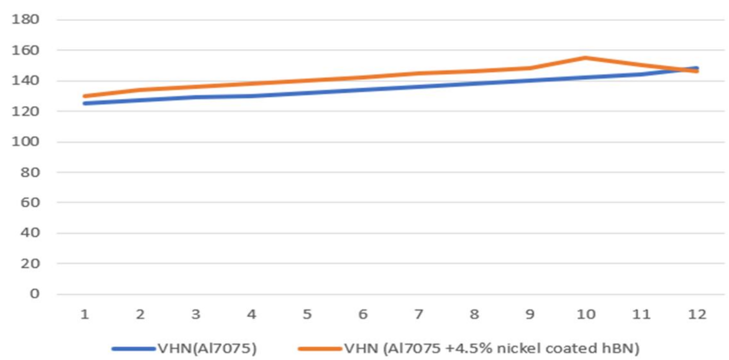
The hardness value of Al7075+4.5% nickel coated hBN Composite Aged at 100 ^{0}C for Different Aging Times exhibits excellent strength than Al7075 Specimen Aged at 100 ^{0}C for Different Aging Times due to uniform distribution of reinforced particles as shown in graph 1. The Vickers hardness number for Al7075 +4.5% nickel coated hBN is 160 at the temperature of 100 ^{0}C for 11 hours but Al7075 without reinforcement exhibits a lower Vickers hardness number (VHN) of 147.

Table 5: Hardness Values of Al7075 Specimen Aged at 150 ^{0}C for Different aging Times

Sample No	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Aging Time(h)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
VHN	125	127	129	130	132	134	136	138	140	142	144	148	149	145	143

Table 6: Hardness Values of Al075+4.5% nickel coated hBN Composite aged at 150^{0}C for Different aging Times

Sample No	0	1	2	3	4	5	6	7	8	9	10	11
Aging Time(h)	0	1	2	3	4	5	6	7	8	9	10	11
VHN	130	134	136	138	140	142	145	146	148	155	150	146



Graph 2: Comparison of VHN (Al7075) and VHN (Al7075 +4.5%nickel coated hBN) at 150 ^{0}C

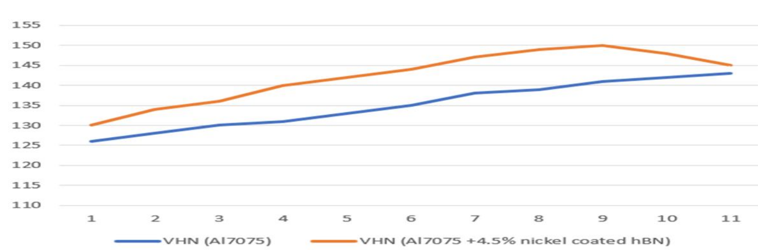
At 150 ^{0}C of age hardening, the Vickers hardness number of Al7075 increases as aging time increases after 12 hours of aging VHN decreases but even in Al7075 +4.5% nickel coated hBN specimen the VHN decreases after 10 hours of aging time but maximum VHN is 150 obtained at 10 hours of aging time.

Table 7: Hardness Values of Al7075 Specimen Aged at 200 ^{0}C for Different Aging Times

Sample No	0	1	2	3	4	5	6	7	8	9	10	11	12
Aging Time(h)	0	1	2	3	4	5	6	7	8	9	10	11	12
VHN	126	128	130	131	133	135	138	139	141	142	143	141	139

Table 8: Hardness Values of Al7075+4.5% nickel coated hBN Composite Aged at 200 ^{0}C for Different Aging Times

Sample No	0	1	2	3	4	5	6	7	8	9	10
Aging Time(h)	0	1	2	3	4	5	6	7	8	9	10
VHN	130	134	136	140	142	144	147	149	150	148	145

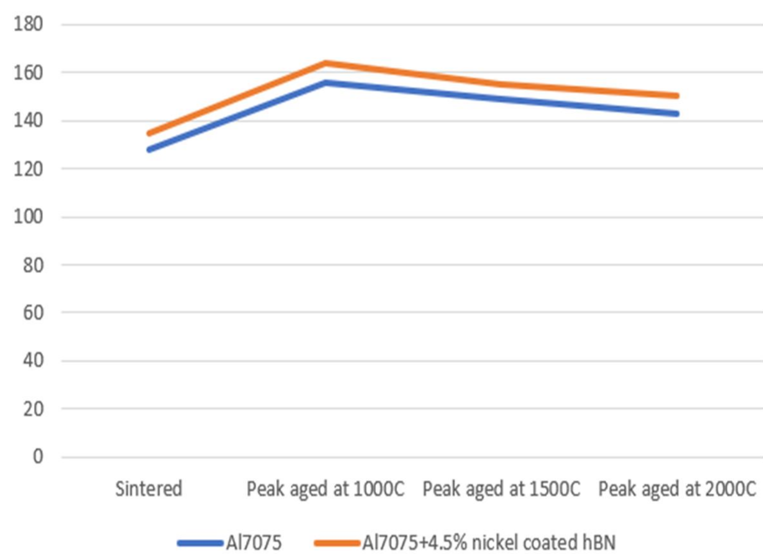


Graph 3: Comparison of VHN (Al7075) and VHN (Al7075 +4.5%nickel coated hBN) at 200 ^{0}C

As the temperature of Al7075+4.5% nickel coated hBN Composite increases, the VHN increases at minimum aging time. At 200 ^{0}C, hardness Values of Al7075+4.5% nickel coated hBN Composite of 8 hours aging time exhibits maximum of 150 when compared with Al7075 specimen.

Table 9: Comparative Tabulation of Peak Hardness of Specimens under Different Conditions

Condition	Al7075	Al7075+4.5% nickel coated hBN
Sintered	128	135
Peak aged at 100^{0}C	156	164
Peak aged at 150^{0}C	149	155
Peak aged at 200^{0}C	143	150



Graph 4: Comparative Peak Hardness of Specimens under Different Conditions

Peak hardness comparison for samples of Al7075 and Al7075+4.5 percent nickel-coated hBN Composite that have undergone various aging intervals during heat treatment. Among peaks aged at 100, 150, and 200 ^{0}C, the maximum Vickers hardness number is 164 of Al7075+4.5 percent nickel-coated hBN Composite when compared with another alloying specimen. During heat treatment, refining of grain microstructure led to change in physical and mechanical properties of specimen Al7075 along with reinforcement hBN. The crystal structure of hexagonal boron nitride is similar to graphite. A covalent bond exists in each boron and nitrogen atom and weak van der Waals is present in the adjacent layer of h-BN. Although the bond between the aluminium and the hBN has outstanding results, the mechanical properties of the hBN are still improved by coating the reinforcement with nickel and adding reinforcement to the aluminium 7075.

B. Specimen Preparation for Different Testing

Tensile Test Specimen

The specimen is prepared as per the ASTM Standard and Cut the specimen by using a power hacksaw machine with a diameter of 20 mm and length of 300 mm Gauge length of 115 mm and for gripping purposes, both sides give 75 mm. After Cutting the Knurling operation is done by using a lathe machine Knurling is because for gripping purpose

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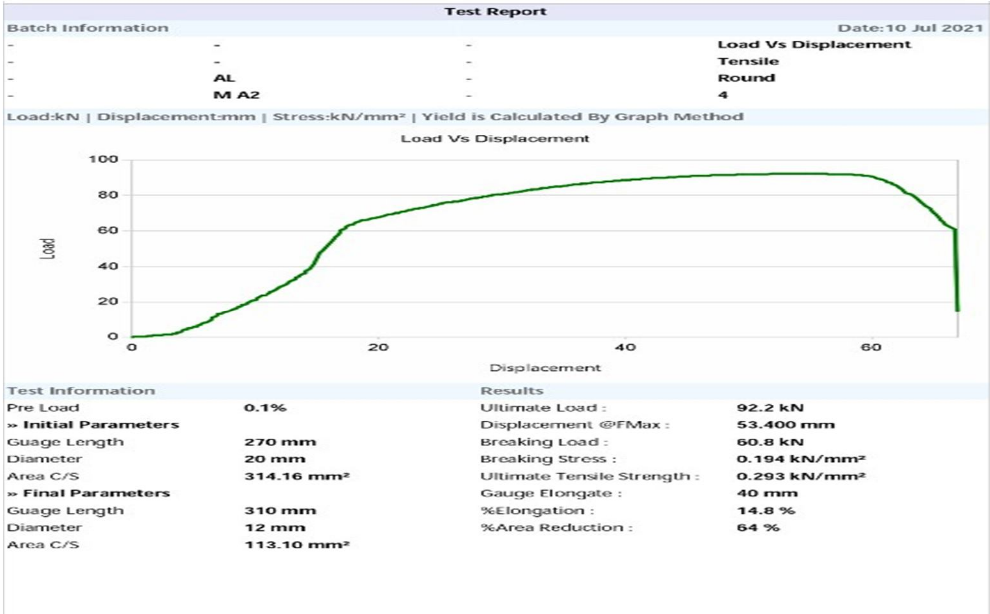


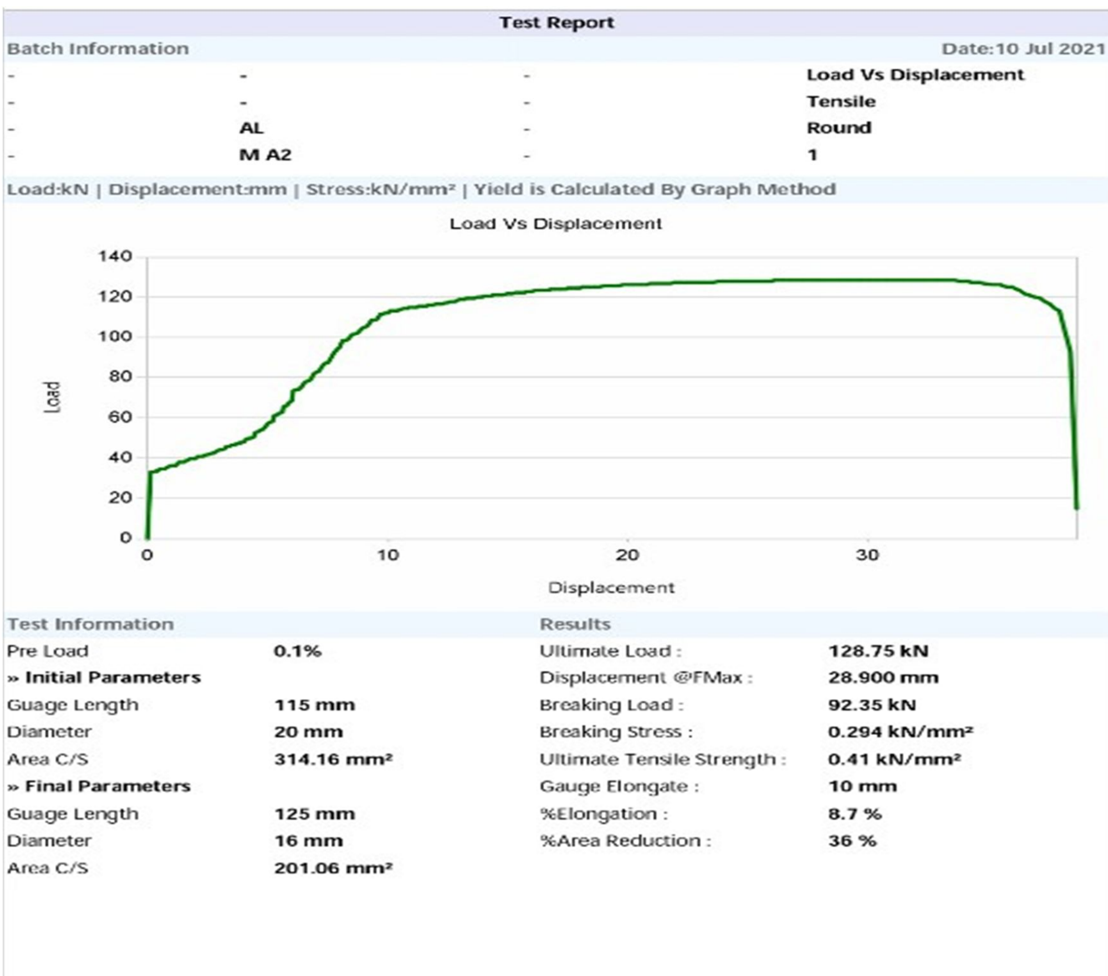
Test Report

Batch Information			Date:10 Jul 2021
-	-	-	Load Vs Displacement
-	-	-	Tensile
-	AL	-	Round
-	M A2	-	4

Load:kN | Displacement:mm | Stress:kN/mm² | Yield is Calculated By Graph Method

Test Information		Results	
Pre Load	0.1%	Ultimate Load :	92.2 kN
» Initial Parameters		Displacement @FMax :	53.400 mm
Guage Length	270 mm	Breaking Load :	60.8 kN
Diameter	20 mm	Breaking Stress :	0.194 kN/mm²
Area C/S	314.16 mm²	Ultimate Tensile Strength :	0.293 kN/mm²
» Final Parameters		Gauge Elongate :	40 mm
Guage Length	310 mm	%Elongation :	14.8 %
Diameter	12 mm	%Area Reduction :	64 %
Area C/S	113.10 mm²		

Graph 5: Tensile test graph for Al7075



Test Report

Batch Information			Date:10 Jul 2021
-	-	-	Load Vs Displacement
-	-	-	Tensile
-	AL	-	Round
-	M A2	-	1

Load:kN | Displacement:mm | Stress:kN/mm² | Yield is Calculated By Graph Method

Test Information		Results	
Pre Load	0.1%	Ultimate Load :	128.75 kN
» Initial Parameters		Displacement @FMax :	28.900 mm
Guage Length	115 mm	Breaking Load :	92.35 kN
Diameter	20 mm	Breaking Stress :	0.294 kN/mm²
Area C/S	314.16 mm²	Ultimate Tensile Strength :	0.41 kN/mm²
» Final Parameters		Gauge Elongate :	10 mm
Guage Length	125 mm	%Elongation :	8.7 %
Diameter	16 mm	%Area Reduction :	36 %
Area C/S	201.06 mm²		

Graph 6: Tensile test graph For Al7075 + 4.5% of Nickel coated hBN

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Table 10: Result table of the tensile test specimen

SL no	Test information	Al7075	Al7075 +4.5% nickel coated HBN
1	Pre Load	0.1%	0.1%
	»Initial Parameters		
2	Gauge Length	270mm	115mm
3	Diameter	20mm	20mm
4	C/S Area	314.16mm²	314.16mm²
	»Final Parameters		
5	Gauge Length	310mm	125mm
6	Diameter	12mm	16mm
7	C/S Area	113.10mm²	201.06mm²
8	Ultimate Load	92.2kN	128.75kN
9	Displacement @ FMax	53.4mm	28.900mm
10	Breaking Load	50.8kN	92.35kN
11	Breaking Stress	0.194kN/mm²	0.294kN/mm²
12	Ultimate Tensile Strength	0.293kN/mm²	0.41kN/mm²
13	Gauge Elongate	40mm	10mm
14	%Elongation	14.8%	8.7%
15	% of Area Reduction	64%	36%

The results were found superior for Al7075+4.5 percent nickel-coated hBN Composite while compared with Al7075 specimen due to interfacial bond strength and atomic strength increases.

IV. CONCLUSION

In the current study nickel coated hBN with Al7075 has a better property compared with Al7075 unreinforced material. The hybrid reinforced composite exhibits excellent hardness properties, due to the addition of nickel-coated hBN particles in the Aluminium 7075 matrix. Composite that have undergone various aging intervals during heat treatment. Among peaks aged at 100, 150, and 200 ^{0}C, the Vickers hardness number for Al7075 + 4.5% nickel coated hBN shows a high hardness value of 164 compared with the base metal. During heat treatment, refining of grain microstructure led to change in physical and mechanical properties of specimen Al7075 along with reinforcement hBN. The crystal structure of hexagonal boron nitride is similar to graphite. A covalent bond exists in each boron and nitrogen atom and weak van der Waals is present in the adjacent layer of h-BN. Although the bond between the aluminium and the hBN has outstanding results, the mechanical properties of the hBN are still improved by coating the reinforcement with nickel and adding reinforcement to the aluminium 7075. Also, the hybrid reinforced composites exhibit excellent tensile properties; as compared with base metal (Al7075) and Al7075+4.5% nickel coated hBN show high Breaking Load and Ultimate Tensile Strength.

REFERENCE

[1] Sharma, A. K., Bhandari, R., Aherwar, A., Rimašauskiene, R., & Pinca-Bretotean, C. (2020). A study of advancement in application opportunities of aluminum metal matrix composites. Materials Today: Proceedings, 26(xxxx), 2419–2424. https://doi.org/10.1016/j.matpr.2020.02.516

[2] Senthil, S., Raguraman, M., & Manalan, D. T. (2020). Manufacturing processes & recent applications of aluminium metal matrix composite materials: A review. MaterialsToday:Proceedings,45(xxxx),5934–5938. https://doi.org/10.1016/j.matpr.2020.08.792

[3] Nturanabo, F., Masu, L., & Baptist Kirabira, J. (2020). Novel Applications of Aluminium Metal Matrix Composites. Aluminium Alloys and Composites. https://doi.org/10.5772/intechopen.86225

[4] Prasad, S. V., & Asthana, R. (2004). Aluminum metal-matrix composites for automotive applications: Tribological considerations. Tribology Letters, 17(3), 445–453. https://doi.org/10.1023/B:TRIL.0000044492.91991.f3

[5] Zhou, B., Liu, B., & Zhang, S. (2021). The Advancement of 7XXX Series Aluminum Alloys for Aircraft Structures: A Review. Metals, 11(5), 718. doi:10.3390/met11050718

[6] Staley, J.T., & Lege, D.J. (1993). Advances in aluminium alloy products for structural applications in transportation. Journal de Physique 4, 3(7,pt1), 179-190.

[7] Warren, A.. (2004). Developments and Challenges for Aluminum - A Boeing Perspective. Materials Forum. 28.

[8] Vasanthakumar, P., Sekar, K., & Venkatesh, K. (2019). Recent developments in powder metallurgy based aluminium alloy composite for aerospace applications. Materials Today: Proceedings, 18, 5400–5409. doi:10.1016/j.matpr.2019.07.568

[9] Siddesh Kumar, N. M. (2022). Effect on wear property of aluminium metal matrix composite reinforced with different solid lubricants: a review. International Journal of System Assurance Engineering and Management. https://doi.org/10.1007/s13198-022-01654-w

[10] Siddesh Kumar, N. M., Kerur, M. R. H., Khan, N., & Shashank, T. N. (2022). Vibration analysis of healthy and faulty gear of parallel shaft drive system. AIP Conference Proceedings, 2463(May). https://doi.org/10.1063/5.0080184

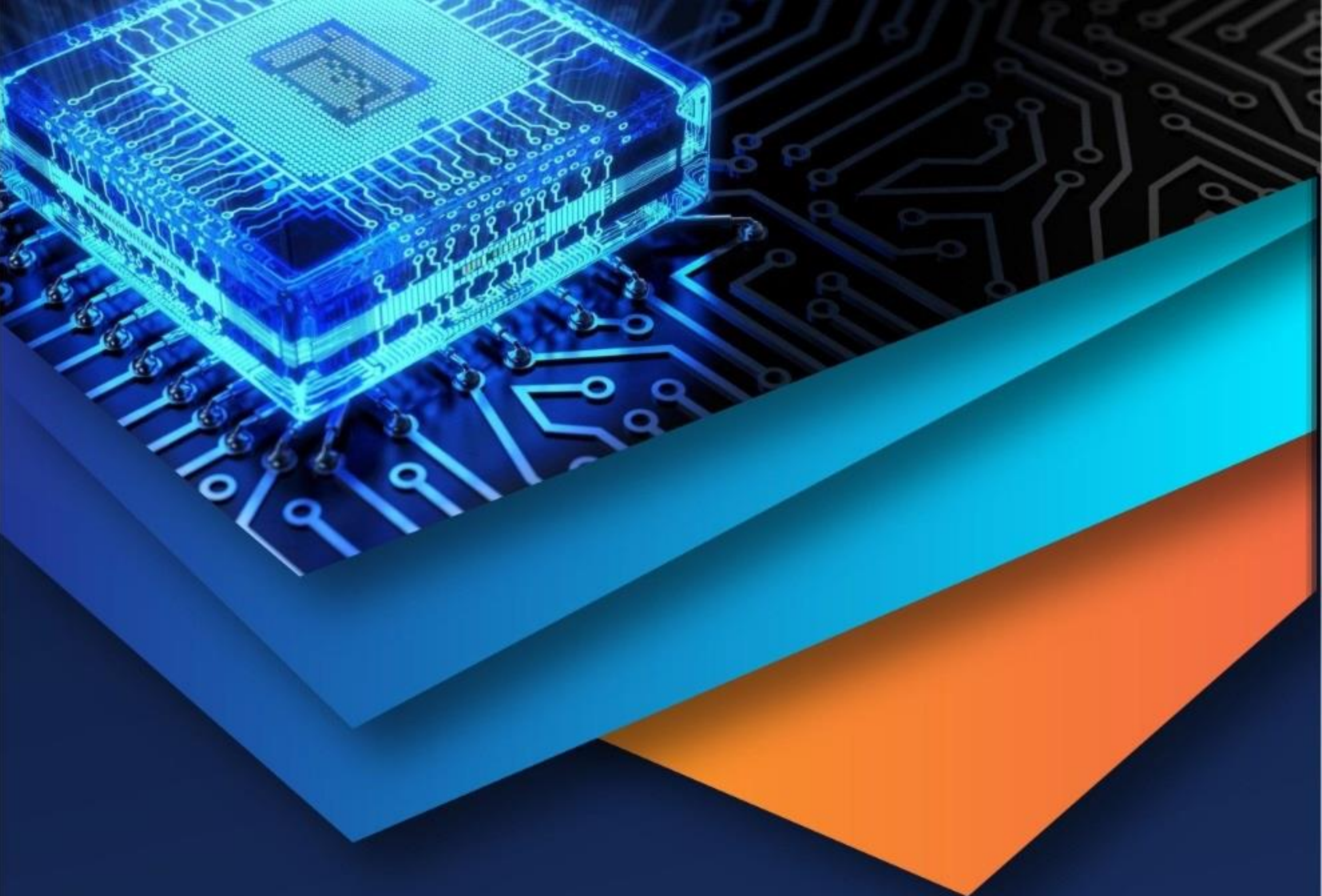
[11] M. Sadashiva, N.M. Siddesh kumar, J. Monica, M.R. Srinivasa, N. Santhosh and S. Praveen Kumar. 2021. The Effects of hardness and Impact strength Characteristics on Al Based Hybrid Composite FSW Joint, International Journal of Vehicle Structures & Systems (IJVSS). 2022, Vol.1 Issue1, p1317.5p. https://www.proquest.com/docview/2646985971?pqorigsite=gscholar&fromopenview=true

[12] N.M. Siddesh Kumar, Dhruthi, G.K. Pramod, P. Samrat, M. Sadashiva, A Critical Review on Heat Treatment of Aluminium Alloys, Materials Today: Proceedings,2022,ISSN 2214-7853, https://doi.org/10.1016/j.matpr.2021.12.586

[13] N.M. Siddesh Kumar, M. Sadashiva, J. Monica, S. Praveen Kumar,"Investigation on Corrosion Behaviour of Hybrid Aluminium Metal Matrix Composite Welded by Friction Stir Welding", Materials Today: Proceedings,2022, ISSN 2214-7853,https://doi.org/10.1016/j.matpr.2022.01.362.

[14] Siddesh Kumar N. M, T. N. Shashank, and Dhruthi, "Review—Different Ceramic Reinforcements In Aluminium Metal Matrix Composites," ECS J. Solid State Sci. Technol., vol. 10, no. 5, p. 053003, 2021, https://doi.org/10.1149/2162-8777/ac0114

[15] 11. Siddesh Kumar N. M, J. Monica, G. Karthikareddy, M. Sadashiva, and G. Bawge, "Comparitive Study on Methods used to Improve the Corrosion Resistance Property of Aluminium Alloys – A Review," 2021, ISSN NO. 0038-111X, Vol 62 Issue 2, pp. 3196 – 3213, http://solidstatetechnology.us/index.php/JSST/article/view/9935



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