

Preparation, Characterization and Mechanical Properties of Al356.1 Aluminium Alloy Matrix Composites Reinforced With MgO Nanoparticles

Girisha K.B¹, Dr.H.C.Chittappa².

Research scholar, Department of mechanical engineering, UVCE, Bangalore, India¹

Associate professor, Department of mechanical engineering, UVCE, Bangalore, India²

ABSTRACT: In this research Aluminum alloy (Al 356.1) matrix composite reinforced with Magnesium Oxide Nano particle in the weight % of 0.5, 1.0, 1.5, and 2.0 %. Reinforcement process is carried out by stir casting method Microstructure and mechanical properties of Nano composites. The nanocomposites were characterized by scanning electron microscope (SEM) and X-ray diffraction (XRD). mechanical Test were carried out in order to identify the properties The results reveal that the composites containing 1.5 wt % reinforcement particle fabricated at 850° C have homogenous reinforcements of MgO in Al356.1 Tensile, wear properties and hardness strength also improved .

Keywords: Metal matrix composites, Nano structured materials, MgO /Al356.1 composites

I. INTRODUCTION

Nowadays, demands for developing metal matrix composites for use in high performance applications, have been significantly increased [1]. Among these composites, aluminium alloy matrix composites attract much attention due to their lightness, high thermal conductivity, moderate casting temperature, etc. [2,3]. Various kinds of ceramic materials, e.g. SiC, Al₂O₃, MgO and B₄C, are extensively used to reinforce aluminium alloy matrices. Superior properties of these materials such as refractoriness, high hardness, high compressive strength, wear resistance, etc. makes them suitable for use as reinforcement in matrix of composites [4–11]. Nevertheless, low wet ability with molten metal's and density differences increases their tendency toward agglomeration, which deteriorates mechanical properties. Numerous attempts have been made to overcome the mentioned weakness [12–14]. As aerospace technology continues to advance, there is a rapidly increasing demand for advanced materials with high mechanical and thermal capabilities for such ultra high applications [15]. Its application also stretched to automobile, electronic and computer industries to replace the existing materials including plastics [16].

The early 1990s are considered to be the renaissance for Al as structural material due to environmental concerns, increasing safety and comfort levels. A significant improvement in the properties of Al alloys, reduced fuel consumption because of Lightweight has made huge demand from automobile industry [17, 18]. This growing requirements of materials with high specific mechanical properties with weight savings has fuelled significant research activities in recent times targeted primarily for further development of Al based composites [19–21]. A recent industrial review revealed that there are hundreds of components from structural to engine in which aluminium alloy is being developed for variety of applications [22]. It is also predicted that for Al alloys demand increased globally at an average rate of 20% every year [23]. It is noticed that the limited mechanical properties (strength and hardness) of Al and its alloys adversely affect its applications in automobile and aerospace industries [24, 25]. This remains one of the major concerns in its fabrication to suit its application in recent days.

II. EXPERIMENTAL PROCEDURE

2.1 Synthesis of ZrO₂ nano material

The MgO Nano material was prepared by dissolving Magnesium oxide (MgO), Nitric acid (HNO₃) and Crystal sugar (C₆H₁₂O₆) as fuel in a minimum quantity of double distilled water is taken in a ceramic crucible. The crucible

**International Journal of Innovative Research in Science,
Engineering and Technology**

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 10, October 2013

containing the solution was introduced into a preheated muffle furnace maintained at $850 \pm 5^\circ \text{C}$. The solution initially boils and undergoes dehydration followed by decomposition with the evolution of large amount of gases. The solution boiled resulting in a transparent gel. The gel then formed white foam, which expanded to fill the vessel. Shortly thereafter, the reaction was initiated somewhere in the interior and a flame appeared on the surface of the foam and proceeded rapidly throughout the entire volume, leaving a white powder with an extremely porous structure. The entire combustion process for producing MgO powder takes place. The reaction for combustion synthesis in the present case can be written in equation (1)

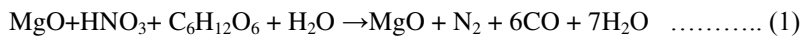
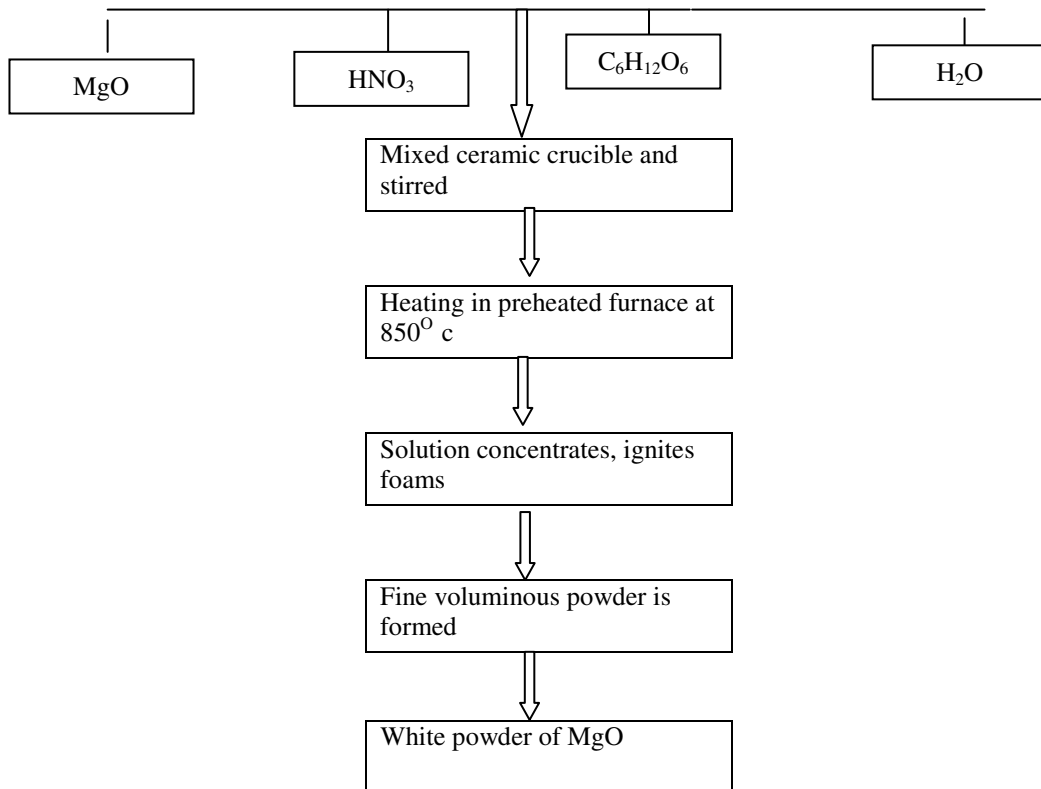


Fig.1. Flow chart for the combustion synthesis of MgO Nano powders



2.2 Preparation of Al- MgO nano composites:

Aluminium alloy (Al356.1) and Nano sized MgO were used to fabrication of composites. The composition of Al356.1 is shown in Table1 [1]

**International Journal of Innovative Research in Science,
Engineering and Technology**

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 10, October 2013

Table 1 Chemical composition of Al356.1

Elements	Al	Si	Fe	Cu	Mg	Mn	Zn	Ni
Mass %	91.73	7.23	0.32	0.18	0.38	0.02	0.05	0.05

The samples were prepared using a resistance furnace, equipped with a stirring system. After smelting of aluminum ingots, MgO Nano powder was added to the molten metal and stirring was carried out at constant rate of 150 rpm for 20 min. according to the results of literature and previous works [19, 20]. Nano-powder MgO (0.5, 1.0, 1.5, and 2.0wt %) added to the molten metal during stirring. The casting was performed at 850⁰C. Steel circular die was used for casting of specimens. Finally, specimens fabricated at five various conditions were prepared for subsequent Microstructural and mechanical analyses.

III.RESULTS AND DISCUSSION

3.1 X-ray Diffractometer (XRD) Studies

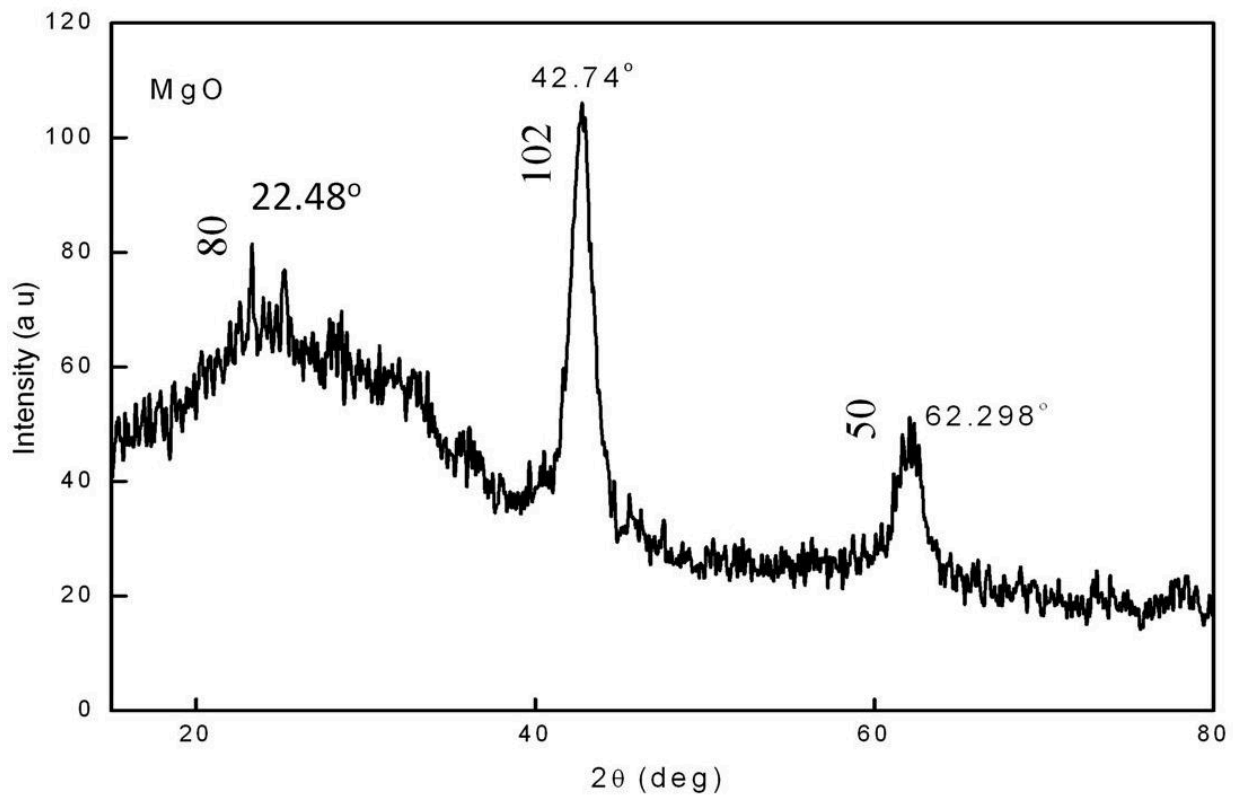


Fig.2. XRD pattern of Mgo Nano powder fabricated at 850⁰ C

**International Journal of Innovative Research in Science,
Engineering and Technology**

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 10, October 2013

The powder X-ray diffraction studies were carried out using Phillips X-ray diffractometer (model PW 3710) with Cu K λ radiation ($\lambda = 1.5405 \text{ \AA}$) The X-ray diffraction pattern of nano-MgO powder confirms the crystalline phase and mean crystal size determined was around 40 nm. In the XRD observations three Strongest peaks shown in Fig. 2 were detected with Miller indices (223), (054), (126), and (082) corresponding to Bragg angles 30°, 36°, 51° and 59° respectively. The characteristic peaks are higher in intensity which indicates that the products are of good crystalline nature. No peaks corresponding to impurities are detected, showing that the final product is purely ZrO₂ Nano powder. It is observed that intensity of the peaks increases with thermal treatment due to Agglomeration, which means that the crystalline has been improved. The full width at half maxima of major peaks decrease and confirms the grain size growth.

IV.TENSILE TEST

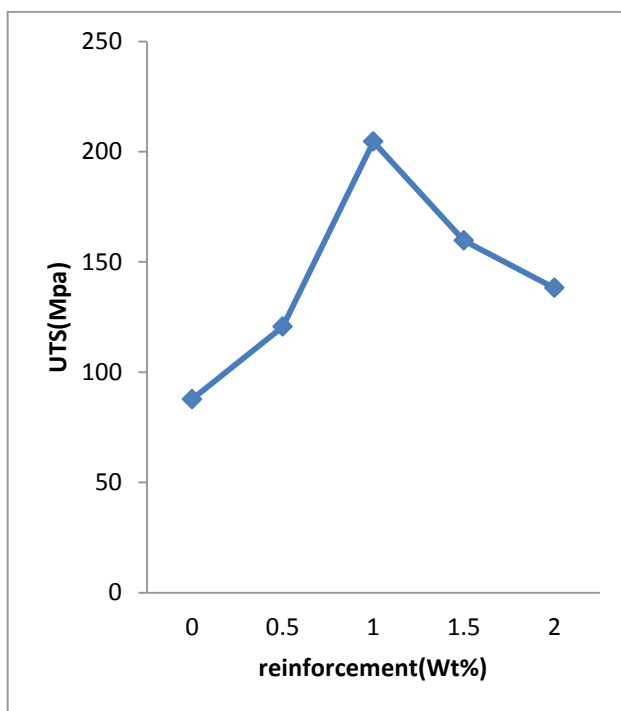


Fig 3: load v/s %variation of reinforcement

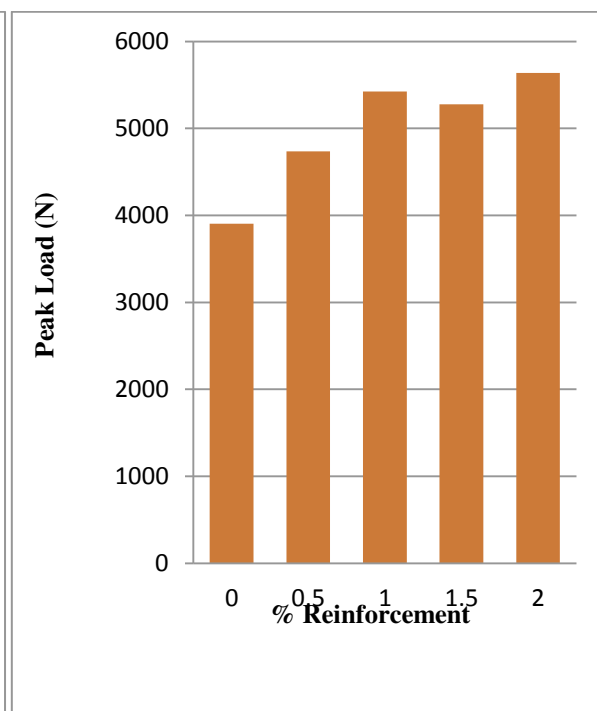


Fig 4: load v/s %variation of reinforcement

**International Journal of Innovative Research in Science,
Engineering and Technology**

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 10, October 2013

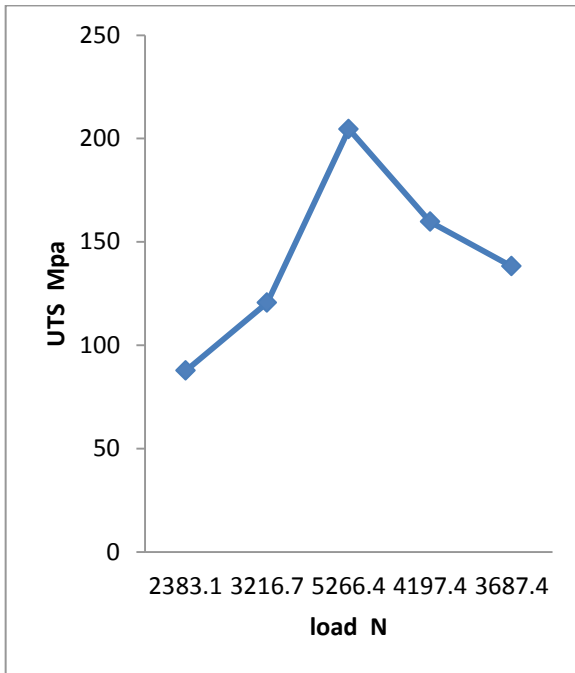


Fig 5: Ultimate tensile strength v/s load

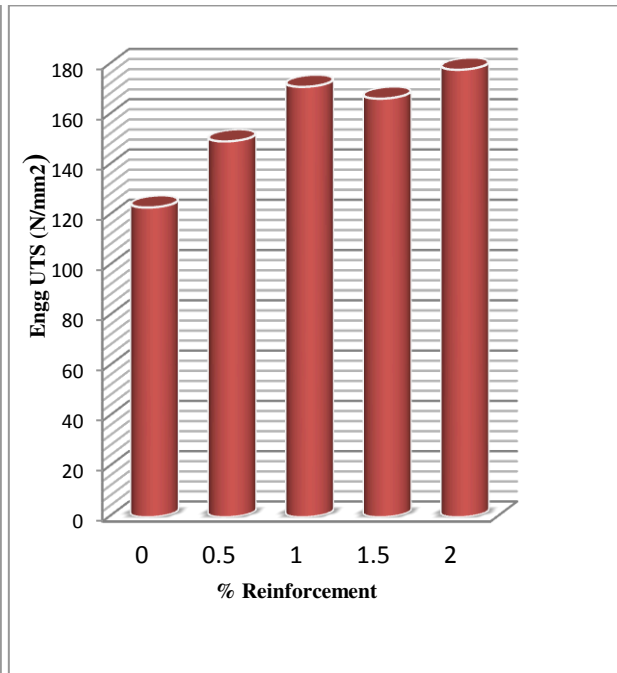


Fig 6: UTS V/s %of reinforcement

V. WEAR TEST :

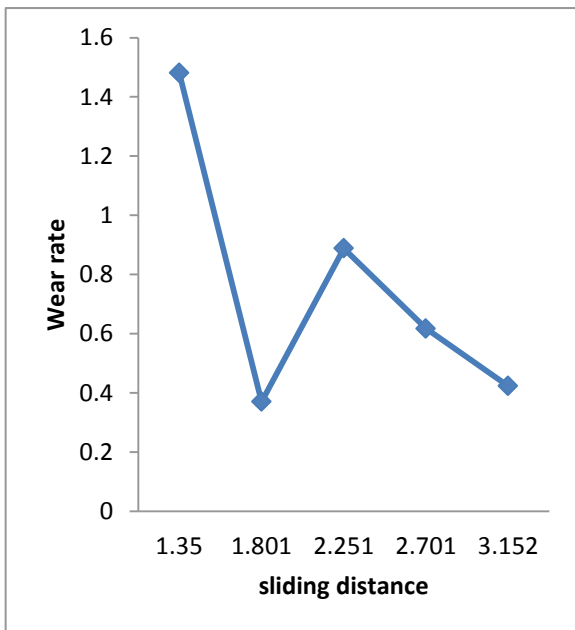


Fig 7: Wear rate v/s sliding distance

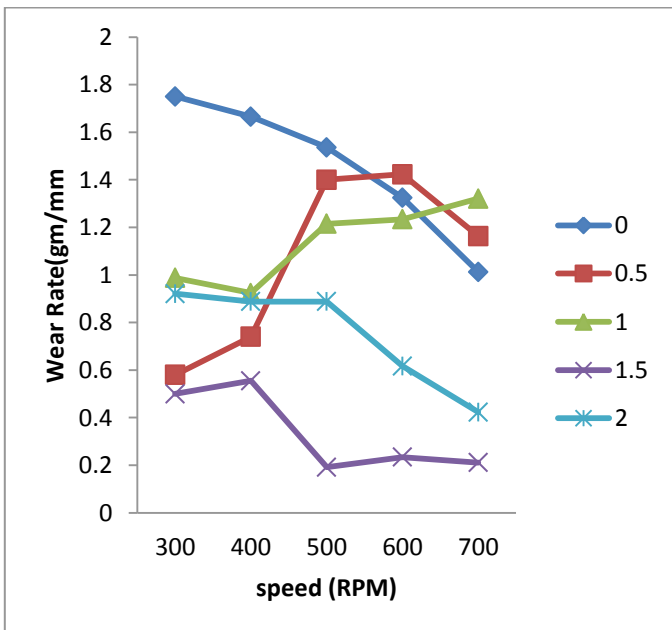


Fig 8: Wear rate v/s speed (RPM)

**International Journal of Innovative Research in Science,
Engineering and Technology**

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 10, October 2013

VI. HARDNESS TEST

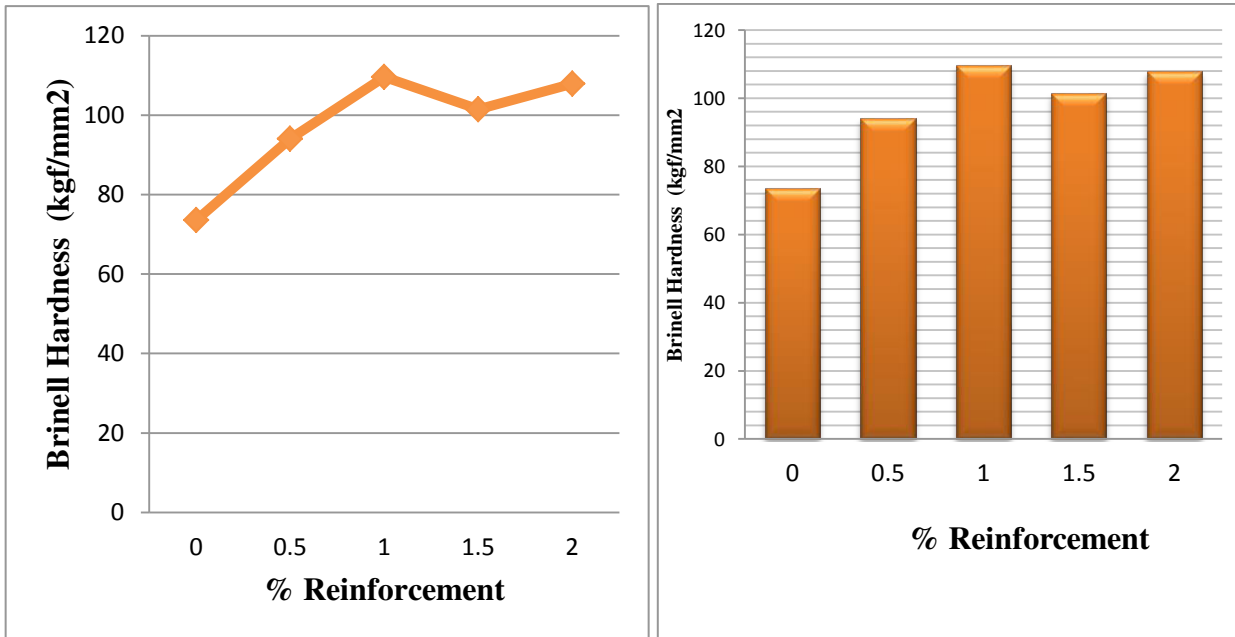
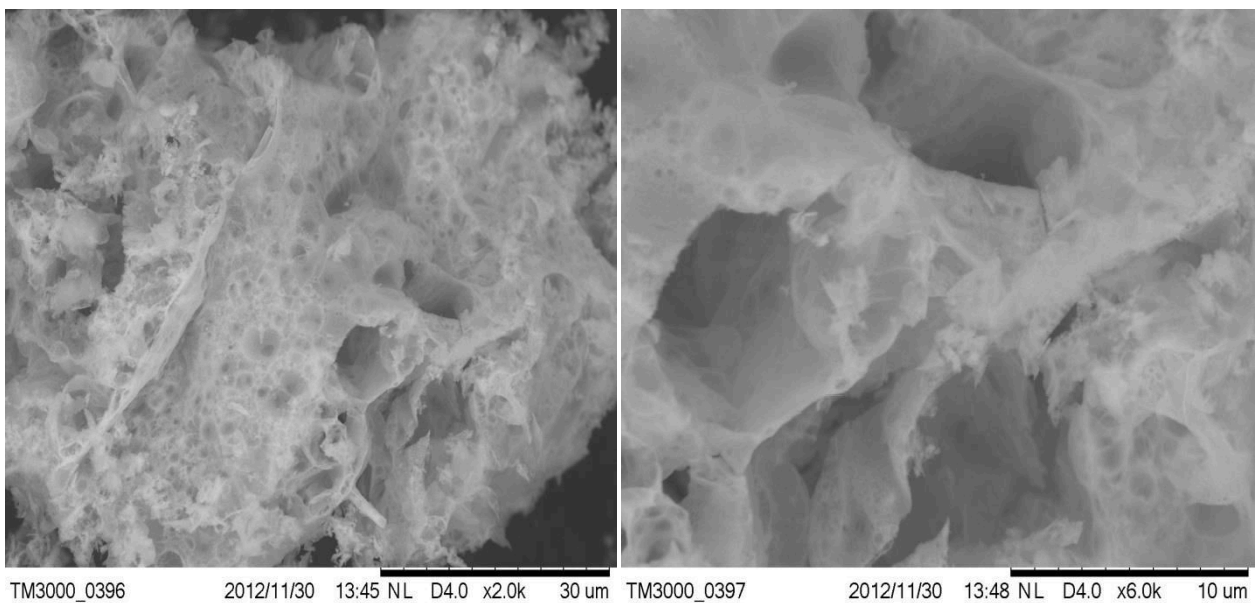


Fig 8: hardness V/s %of reinforcement

Fig 9:Bar chart of hardness V/s %of reinforcement

VII. SEM MICRO GRAPHS:



**International Journal of Innovative Research in Science,
Engineering and Technology**

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 10, October 2013

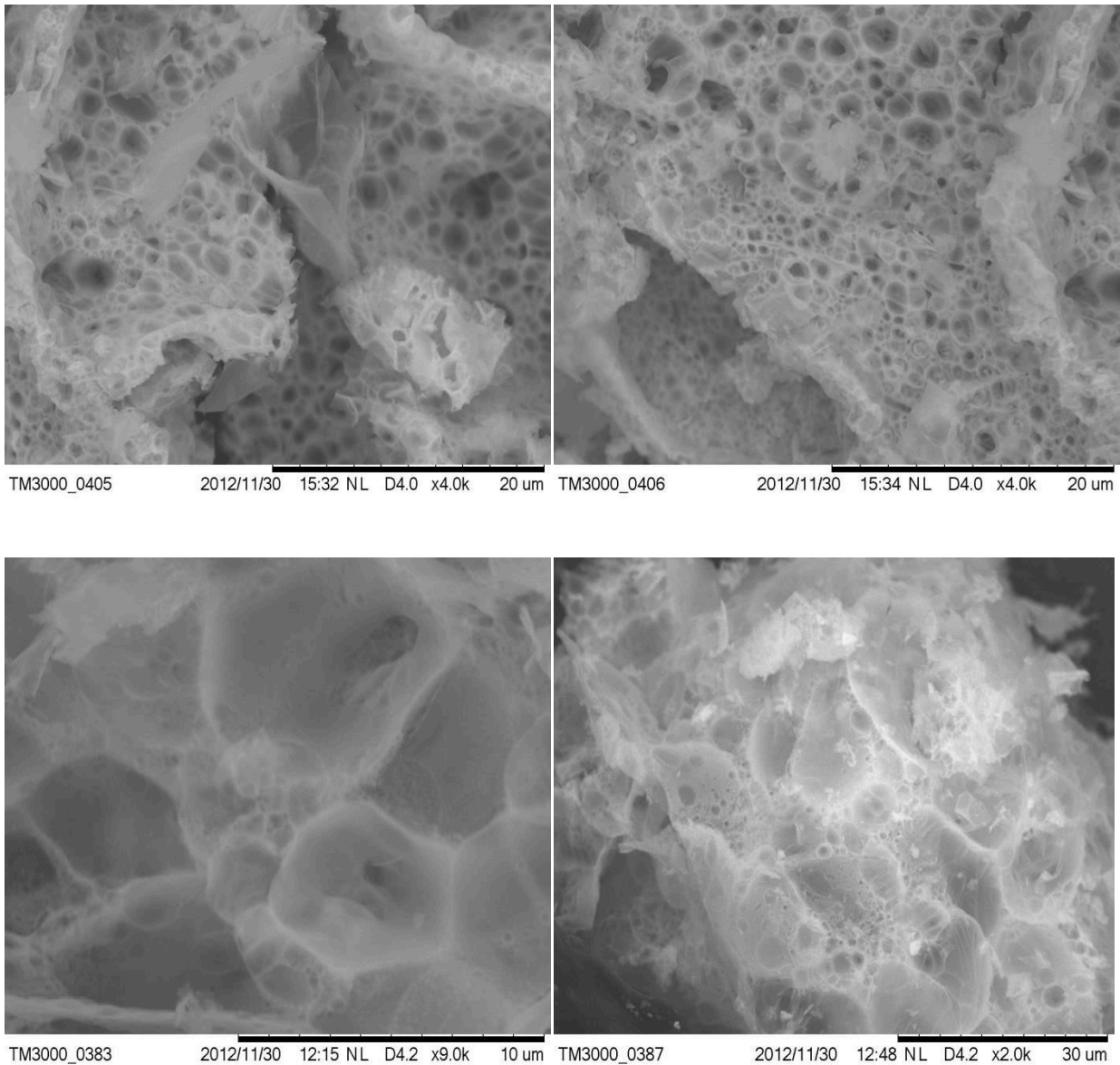


Fig 9. SEM Micro graphs of MgO nano

VII.CONCLUSION

After conducting the hardness test for various specimens having different percentages of the Magnesium nano material (0.5%, 1.0%, 1.5%, and 2.0 %) and after calculating the BHN. we have come to conclusion that the maximum BHN for the specimen having 1.% of Magnesium nano material

REFERENCES

- [1] G.E. Hatch, Aluminum, in: Properties and Physical Metallurgy, ASM International, Metals Park, OH, pp. 30–35, 1984,.
- [2] D. Hull, An Introduction to Composite Material, second ed., McGraw-Hill, New York, pp. 196–252 , 1981.
- [3] W.F. Smith, Principles of Materials&Engineering,McGraw-Hill,NewYork, 1996.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 10, October 2013

- [4] S.B. Hassan, O. Aponbiede, V.S. Aigbodion, J. Alloys Compd. 466 ,268–272 ,(2008).
- [5] S. Zhang, Y. Zhao, G. Chen, X. Cheng, J. Alloys Compd. 475,261–267 ,(2009).
- [6] W. Jianhua, Y. Danqing, S. Xuping, Y. Fucheng, L. Hongwu, Mater. Des. 30 ,78–81, ,(2009).
- [7] Y. Sahin, M. Kok, H. Celik, J. Mater. Process. Technol. 128, 280–291, (2002).
- [8] S. Chou, J. Huang, D. Lii, H. Lu, J. Alloys Compd. 419 , 98–102, (2006).
- [9] K.M. Shorowordi, T. Laoui, A.S.M.A. Haseeb, J.P. Celis, L. Froyen, J. Mater. Process. Technol. 142, 738–743, (2003).
- [10] E.L. Pen, D. Baptiste, G. Hug, Int. J. Fatigue 24 , 205–214, (2002).
- [11] M. Khakbiz, F. Akhlaghi, J. Alloys Compd. 479 ,334–341, (2009).
- [12] G.R. Li, Y.T. Zhao, H.M.Wang, G. Chen, Q.X. Dai, X.N. Cheng, J. Alloys Compd. 471,530–535, (2009)
- [13] J.K.M. Kwok, S.C. Lim, Compos. Sci. Technol. 59 , 55 63, (1999).
- [14] J. Hashmi, L. Looney, M.S.J. Hashmi, J. Mater. Process. Technol. 92/93 , 1–7, (1999).
- [15] M.M. Opeka, I.G. Talmy, J.A. Zaykoki, J. Mater. Sci. 32, 5887–5894, (2004).
- [16] A. Luo, Metall. Mater. Trans. 26 2445–2453,(1995).
- [17] R.A. Saravanan, M.K. Surappa, Mater. Sci. Eng. A 108 276–285, (2000).
- [18] S.F. Hassan, J. Gupta, J. Mater. Sci. 37 , 2467–2477, (2002)
- [19] A. Singh, A.P. Tsai, Scripta Mater. 49 , 417–426, (2003)
- [20] A.G. Guy, Elements of Physical Metallurgy, Addison-Wesley, USA, , 78–85, 1967
- [21] M.O. Lai, D. Saravanaranganathan, J. Mater. Sci. 35 2155–2164, (2000)
- [22] T. Yamamoto, Sasamoto, M. Inagaki, J. Mater. Sci. Lett. 19 1053–1064, (2000).
- [23] S. Awasthi, J.L.Wood, Adv. Ceram. Mater. 3449–3458, (1988).
- [24] M.O. Lai, J. Mater. Sci. 35, 2155–2169, (2000).
- [25] C.R.Wang, J.M. Yang, Mater. Chem. Phys. 74 , 272–286, (2002).