ANALYSIS OF SHOCK WAVES TREATED ALUMINIUM 2024 REINFORCED WITH GRAPHITE

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Abstract - *Composite materials are rapidly replacing conventional engineering materials, because of their benefits over monolithic structures. The creation of a composite metal matrix has been one of the main developments in materials in recent years. The Metal Matrix Composite is a composite composed of a metal alloy combined with continuous fibers, whiskers, or ceramic particles. Metal-ceramic composite particles, aluminum-graphite, aluminum-aluminum, and aluminum-silicon carbide particles could have enhanced wear resistance, high-temperature hardness and strength, Al 2024 with 0%, 0.25%, 0.5%, 0.75%, 1% graphite MMC material were fabricated using the stir casting method. For the treatment of shockwaves, the cast composites were machined and prepare the flat square plate specimens. From the tests conducted for the characterization of mechanical properties, composite material specimens have been found to possess enhanced hardness. Also, from the Surface hardness (BHN) test performed it is found that hardness of the composite with 1% graphite as reinforcement more surface hardness compared with 0%, 0.25%, 0.5%, and 0.75% of reinforcement. Also, the surface hardness of composite with 0%, 0.25%, 0.5%, 0.75%, 1% of reinforcement increased with an increase in the number of shockwaves.*

***Key Words*: Aluminium 2024, Graphite, Shock Wave, Stir Casting, Surface Hardness, Shock Tube.**

1. INTRODUCTION

A composite is a two-phase or multiphase substance whose mechanical properties are greater than the individual working materials. Each of the phases is typically discontinuous, stiffer and heavier, and is called reinforcing, while the less steep and softer phase is constant, and is called matrix. Often a further step called interface occurs between the reinforcement and the matrix due to the chemical reactions or other manufacturing effects. The continued interest in designing manufacturing materials that could comply with the higher performance requirements led to the development of a new material class called Metal Matrix Composites (MMC's). We are a family of interchangeable products with flexible associations to essential properties. These materials are known for their extremely high modulus, rigidity, wear resistance, fatigue life, strength-to-weight ratios, flexible thermal expansion coefficient, etc. For these property upgrades, they present for good candidacy to replace traditional structural materials. But what makes them stand out is their ability to modify their assets to suit the requirements of the operation. This category of materials has made these advantages a good choice for use in weight-sensitive and stiffness-critical components in transport systems.

1.1 Shock Wave

The speed at which this disturbance (sound) moves is an important parameter in the gas dynamics. A quick draining of mechanical energy into a medium contained in limited space may cause shock waves. During Earthquakes and when lighting happens, shock waves are created in nature. Cell information-Bypassing shock waves of appropriate strength, DNA can be pushed inside a cell, in such a way that the function of DNA will not be affected by the impact of shock waves. Needle-less drug delivery- Without using needles and by using shock waves drugs can be injected into the body. In pencil manufacturing industries, shock waves are used. They are also used to extract oil in sandalwood. Needle-less drug delivery- Without using needles and by using shock waves drugs can be injected into the body.

1.2 Literature Review

N.Subramani et.al, [1] studies involved in designing aluminum-based metal matrix composite by combining the different percentages of particulates in the combination. This study is concentrated on the fabrication of 2024 aluminum-based metal matrix composites reinforced with boron carbide (chemical formula B4C) is an extremely hard ceramic material, graphite by stir casting technique to determine Tensile strength, hardness, and microstructure of the metal matrix was performed on the samples obtained by stir casting technique The results of the composite material which is manufactured by using stir casting technique to determine Hardness, Tensile strength, and microstructure of the metal matrix was performed on the samples obtained by a stir casting technique and also to find out the distribution of the reinforcement particles like boron carbide and silicon carbide, SEM analysis test is conducted. This will increase the strength of the aluminium 2024. Harry J. Davis et.al, [2] in this research, the shock tube techniques were observed and instrumentation is presented. Ideal shock tube theory is outlined as are various phenomena that affect the actual performance. For distinct purposes, shock tubes were designed and that are described in this work. And also, in terms of the variable to be measured, shock tube instrumentation was discussed. Zakrajsek et.al, [3] study reveals that the water sheets breakup time decreased with a rise in the strength of the incident shockwave. In this research water sheet of 0.3cm was used. Experimental data is substantiated and using CTH a numerical prototype is evolved. In the water sheet, the water sheet breakup time was found to be a function of the perturbation. Besides, from numerical and experimental results the water-sheet breakup time reduced with an increase in the strength of the incident shock wave. KPJ Reddy et.al, [4] publication outlines the invention of conventional shock tube and hypersonic shock tunnel in a miniaturized version that is small enough to be mounted on a tabletop. By using the effect of human force, the shock tube (named as Reddy tube) will work and by the manual action, the driver gas is pressurized using a plunger rod. Their ease of operation and low cost make them useful in research work into a large number of applications involving shocks. Pardeep Sharma et.al, [5] made a research work on mechanical and tribological behavior of aluminum alloy 6101-graphite composites in dry sliding conditions were studied. To manufacture the composite materials, the orthodox liquid casting technique had been used and imperiled to T6 heat treatment. The flexural strength also reduces with a rise in graphite content and at 4 wt.% of graphite, it reached its maximum value the amount of wear reduces with an increase in graphite content and was observed to be at least 4 wt. percent of the graphite reinforcement, which displays better wear properties than the Al6101 cast metal matrix and other composites. Ajith kumar.R et.al, [6] studied the mechanical properties of aluminum alloys that were studied and analyzed. In this research, we have prepared aluminium metal matrix composites in which aluminium is the base metal and graphite powder and titanium dioxide powder are the reinforcement materials. The aluminum metal matrix composites were manufactured by using the stir casting method. The tests carried out are the tensile test, hardness test, and optical microscopy. The hardness value of aluminium 6061 was obtained as 36.5 BHN while testing. Its hardness value was increased when 2% of graphite was reinforced with it. Its hardness value was further increased when 3% TiO_2 was added with Al 6061+2% graphite. With 8% TiO_2, its hardness value was increased by 50.96% that is 55.1 BHN and with 13% TiO_2, its hardness value was increased by 51.51% that is 55.3 BHN.

2. STIR CASTING

This involves incorporating ceramic particulate matter into the melting of molten aluminum and causing the mixture to solidify. The main thing here is to create strong wetting between the binding of particles and the melting of liquid aluminum alloy. The simplest and most commonly used method is known as the method of a vortex or stir-casting. Distribution of reinforcement depends on the geometry of the stirrer, melt temperature, and the position of the stirrer in the melt. Major factors to be considered during stir casting is that the difficulty of achieving uniform distribution of the reinforcement materials, Porosity in cast metal matrix composites, and the chemical reaction between the reinforcement material, and matrix alloy.

2.1 Processing Details

The casting unit consists of a crucible, which is heated by heating coils of type electrical resistance. The heating unit's temperature level is controlled by a thermocouple control device which is enabled. The period of the heating is

Fig -1: Pouring of Molten metal

determined according to the volume of material to be cooled. The furnace used in the present work is of the form of bottom pouring, which is controlled using a valve worked from below. To combine the particulate reinforcement with the molten metal, a motor-operated stirrer is given at the rim. When manufacturing by metal casting, pouring is a process by which the molten metal is put or sends into the mold. By using the gating system flows through them and into the main cavity.

2.2 Machining

Machining is a manufacturing concept that encompasses a wide range of technologies and techniques. This may be a tremendous opportunity to improve as a means of separating content from a workpiece utilizing power-driven machine tools to turn it into a design planned to be used.

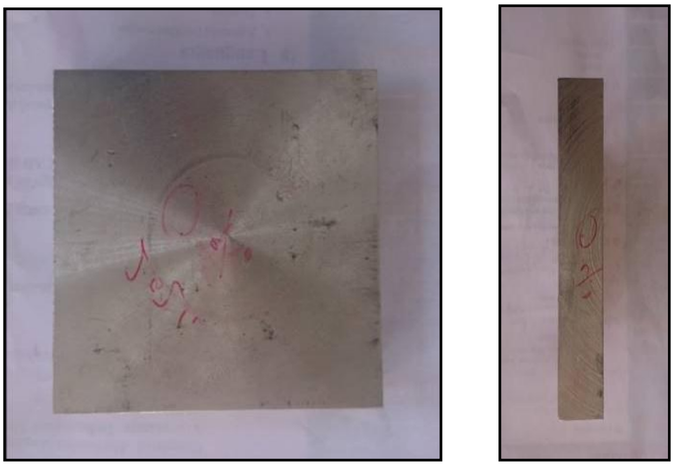

Fig-2: Square plate specimen

Many metal components and parts require some kind of machining during production. The square plates of 100×100mm having thickness 18 mm for different reinforcements of graphite are machined.

2.3 Wire Electrical Discharge Machining

The experiments were carried on the Concord Wire EDM DK7732 machine. It is also known as wire-cut EDM and wire cutting, a thin metal wire is used to cut materials, submerged in a tank of dielectric fluid, typically deionized water. This machine is 4 axes and controlled by CNC. The gap between wire and workpiece is 0.02 mm and is constantly maintained by a computer-controlled positioning system. Molybdenum wire having a diameter of 0.18 mm was used as an electrode This machine allows the operator to select the input parameters according to the material and height of the workpiece. Plates of thickness 300m can easily cut by using EDM and to make punches, tools, and dies from hard metals that are difficult to machine with other methods.

Fig-3: Square plate specimen

The wire, which is constantly fed from a spool, is held between upper and lower diamond guides which are centered in a water nozzle head. By using this technique square plates of different reinforcement was sliced into 3 pieces of 6mm each.

3. EXPERIMENTATION

3.1 Construction of Reddy Tube

Dr. K.P.J. Reddy and his colleagues created a very basic, miniaturized, hand-operated, pressure-driven shock tube called 'Reddy tube.' The main objective of this comfort capability is to run a simple, mini shock tube which is more flexible than the conventional compression-driven and blast-driven shock tube

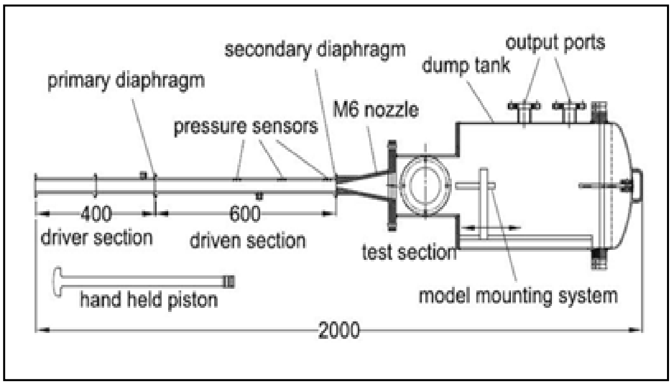

Fig-4: Square plate specimen

A Reddy tube operates on the principle of a conventional piston-driven shock tube. A Reddy shock tube is made of the simple medical syringe with the following dimensions. A

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Reddy tube is a hand-operated shock tube used to produce shock waves by using manual energy.

A Reddy tube is a hand-operated shock tube used to produce shock waves by using human energy. This contains a cylindrical stainless steel tube with a diameter of about 30 mm and a length of around 1m. It also contains two sections of length about 40cm and 60cm called the driver section and the driven section. The two sections are separated by 0.1 mm thick aluminum or Mylar or paper diaphragm. The far end of the driver section is fitted with a piston whereas the end of the driven section is locked with a door by a screw mechanism. The driver compartment is filled with a gas called a driver fuel, which is kept at reasonably high pressure due to the compression action of the piston. A fixture is a type of holder or support device for the specimen. A fixture is used to mount the specimen in the correct position. It gives support during the operation and also there is an increase in accuracy, precision, reliability, and interchangeability in the finished parts.

3.2 Working of Reddy Tube

The paper diaphragm is placed inside the Reddy tube. The end of the driven tube is closed with a blanking plate. By connecting it to a vacuum pump the pressure is reduced inside the driven section of the shock tube, and then the valve is closed. The atmospheric gas is then compressed by pushing the piston horizontally towards the diaphragm until it ruptures. The pressure reading from the pressure gauge in the driver tube is observed. Due to the rupture of diaphragm, the driver gas quickly rushes inside the driven chamber and pushes the driven gas towards the far downstream end of the shock tube.

Fig-5: Reddy tube

This generates a moving shock wave that travels along the length of the driven section. As the shock passes through it, the shock wave immediately increases the temperature and pressure of the powered (test air) air. The primary shock wave that propagates is transmitted from the downstream end. The test gas undergoes more compression after the reflection which raises temperature and pressure to higher values still. This state of high pressure and temperature values is retained at the downstream end until an expansion wave mirrored from the driver tube's upstream end arrives there, and partly neutralizes the compression.

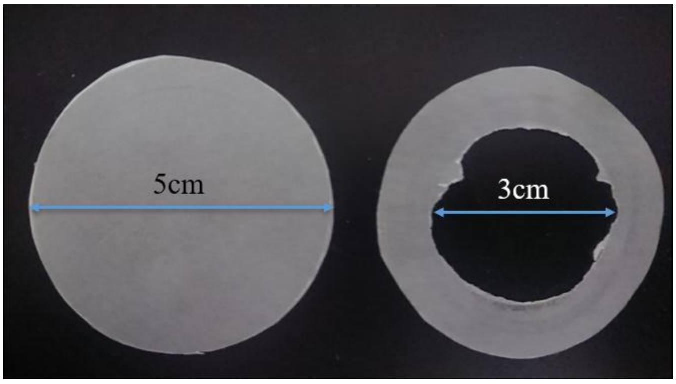

Fig-6: Diaphragm before and after it ruptures

At the time the diaphragm is ruptured, expansion waves are produced and they migrate in a direction opposite to that of the shock wave.

Fig-7: Plates subjected to multiple shocks

The procedure repeats for all specimens of different percentages of reinforcement of graphite. For 0% there are three specimens so for all three specimens the shockwave treatment is different. For a specimen, we treat 20 number of shocks and 40 shocks, 60 shocks respectively.

4. RESULTS AND DISCUSSIONS

Al-Gr composite of different composition was prepared by the stir casting process. The cast specimens were treated to shockwaves than subjected to mechanical characterization (Hardness). The result of the characterization tests is discussed in the following section.

It can be observed that the hardness values of the composites are increasingly trendy. The improvement in hardness in the Aluminum 2024 matrix can be due to the uniform distribution of graphite particulate reinforcement, forming a tight interfacial bond between the matrix and the reinforcement. By taking random points on the shockwave treated aluminum 2024 reinforced with graphite, Brinell Hardness Number is calculated. The test method is IS-1500-

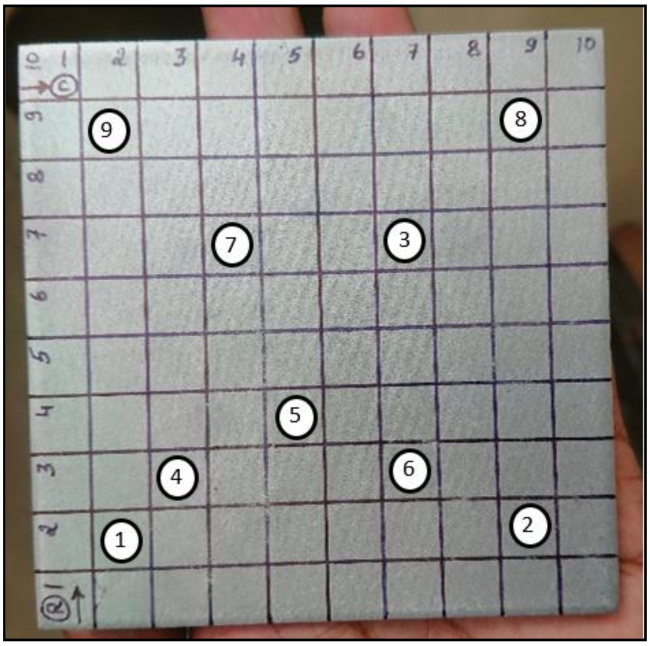

Fig-8: Random places where Hardness is measured

2010, a ball indenter of diameter 5mm, and the load 500kg are applied for all test specimens. Test results and graphs are shown below and dwell time is 10 seconds.

4.1 The Experiment Is Conducted For Variation Of Hardness For Varying % Of Reinforcement

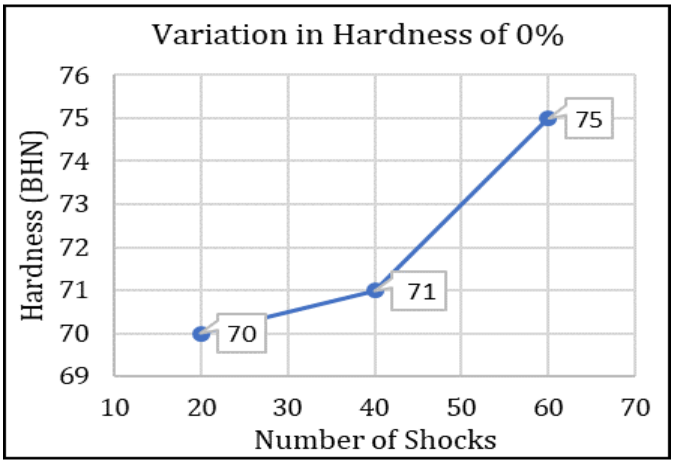

Chart -1: Variation in surface hardness of 0%

In chart -1, After 20 shocks for 0%, BHN is 70 and as shocks increase to 40. The BHN also increased to 71 and for 60 shocks the BHN is further increases to 75. And also, for 0.25% the surface hardness increases from 72 to 92 as the number of shocks increases from 20 to 6, shown in chart –2.

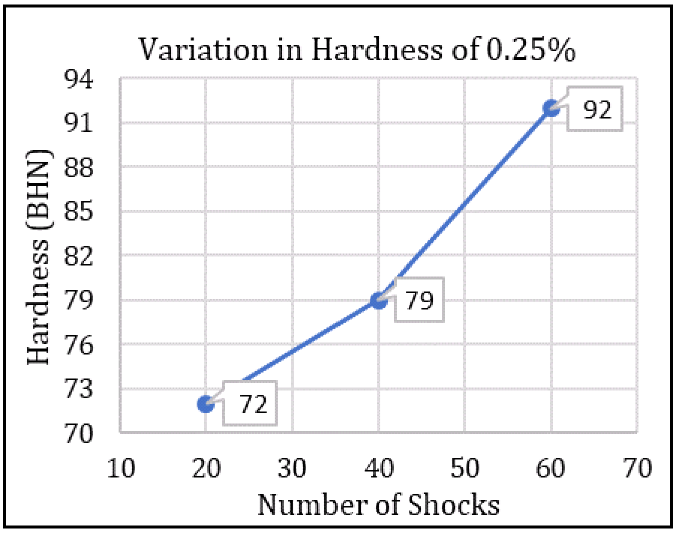

Chart-2: variation in surface hardness of 0.25%

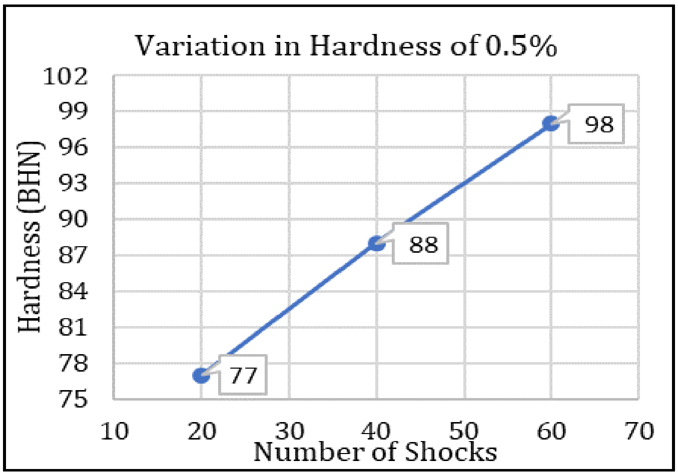

Chart-3: variation in surface hardness of 0.5%

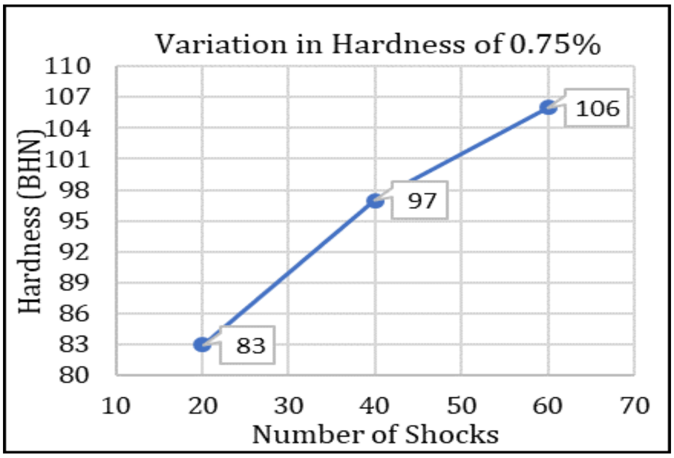

Chart-4: variation in surface hardness of 0.75%

In chart 3, for 0.5% treated with 20 shocks, the surface hardness (BHN) is more when compared to 0% and 0.25%

respectively. And for this plate also the surface hardness will increase from 77 to 98 as the number of shocks increases.

In chart 4, for 0.75% reinforcement of graphite treated with shocks the surface hardness is further increases and reaches the maximum surface hardness(BHN) of 106, which is high when compared to 0%, 0.25%, and 0.5% respectively.

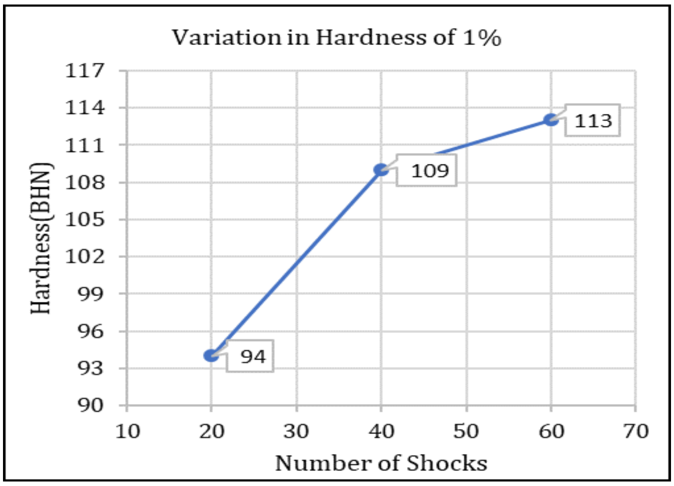

Chart-5: variation in surface hardness of 1%

For 1% reinforcement of graphite, the surface hardness (BHN) of the plate is 94 for 20 shocks, 109 for 40 shocks and 113 for 60 number of shocks.

4.2 Percentage Of Increase In Surface Hardness For 0%, 0.25%, 0.5%, 0.75%, 1% Reinforcement Of Graphite

$$\% \text{ of Increase in hardness} = \frac{\text{Maximum} - \text{Minimum}}{\text{Maximum}} \times 100$$

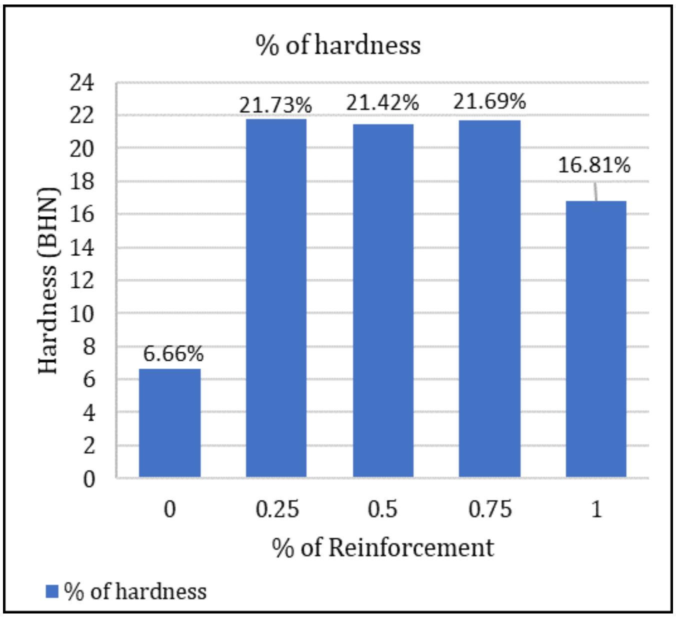

Chart-6: variation in surface hardness of 0.5%

Chart-6 shows that the increase in the percentage of surface hardness as the percentage of reinforcement increases and for the treatment of the different number of shocks. For 0% (as cast), 0.25%, 0.5%, 0.75%, and 1%, the percentage of increase in surface hardness (BHN) is 6.66%, 21.73%, 21.42%, 21.69% and 16.81% respectively.

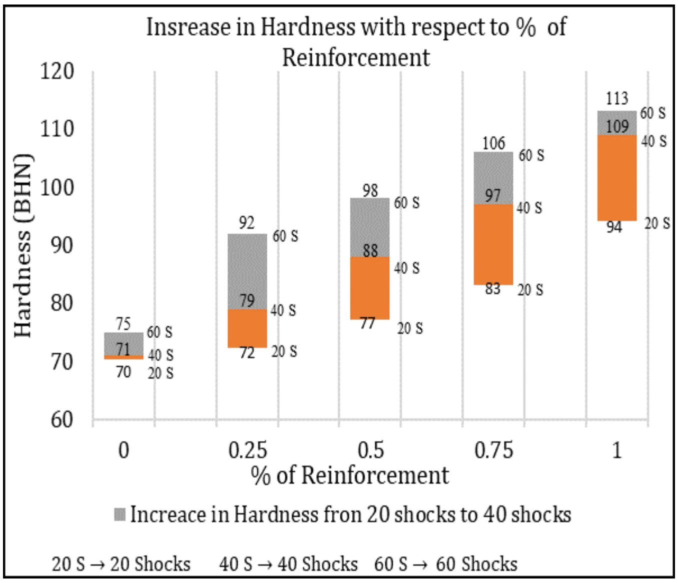

Chart-7: Increase in Hardness for % of Reinforcement.

Chart-7 clearly shows that how much increment in surface hardness for the different number of shocks. For 0% (as cast) the surface hardness(BHN) is 70 for 20 shocks, which is minimum. And for 1% The surface hardness is 113 for 60 shocks which are maximum when compared to all other reinforced materials with a different number of shocks.

5. CONCLUSION

Research conducted in the present work to study the influence of percentage composition of Graphite particulates in Aluminium matrix alloy on the mechanical characteristic has provided the following conclusions, The Reddy tube and Reddy hypersonic shock tunnels have the potential to become revolutionary devices with the capability of bringing shock waves and high speed flows to the fingertips of aspiring engineers in the field. Increasing the percentage of reinforcement of graphite found enhances the shock absorption capacity of the material. More surface hardness results in the center portion compare to the surrounding area. Surface hardness enhancement was noticed with increased multiple shockwaves.

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REFERENCES

[1] N.Subramani et.al, Analysis and Investigation on A2024 Metal Matrix Composites with B4C and Graphite (International Journal of Innovative Research in Science, Engineering and Technology) ISSN: 2319-8753 Vol. 2, Issue 9, September 2013.
[2] Harry J. Davis et.al, Shock tube Techniques, and Instrumentation, March 1969 pp 10-16.
[3] Andrew James Zakrajsek et.al, Experiments and analysis of water-sheet breakup and mitigating potential under blast loading (An International journal on shock waves, detonations and explosions) 2012.
[4] KPJ Reddy et.al, Hand-operated shock tube and hypersonic shock tunnel (Fluid Mechanics Research International Journal) July 06, 2018, pp 144-146.
[5] Pardeep Sharma et.al, A study on wear behavior of Al/6101/graphite composites (Journal of Asian Ceramic Societies) 5 (2017) pp 42–48.
[6] Ajith kumar.R et.al, Enhancement of Mechanical Properties of Aluminium 6061 Metal Matrix Composite
[7] (International Journal of Pure and Applied Mathematics) ISSN: 1314-3395, Volume 119, No. 15 2018, pp 2063-2078.
[8] Nachiketa Ray et.al, Response of shock wave deformation in AA5086 aluminum alloy. Materials Science & Engineering (Materials Science & Engineering 622) 23 October 2014 pp.219-222
[9] S R Nagaraja et.al, Theoretical–experimental study of shock wave-assisted metal forming process using a diaphragms shock tube (Journal of Aerospace Engineering) 7 September 2011 pp.1535-1543
[10] F Biennier L et.al, Shock-wave processing of C_{60} in hydrogen (Astronomy & Astrophysics) March 2017, Volume 599, id.A42, 14 pp.
[11] K. P. J. Reddy et.al, Investigation of strong shock wave interactions with CeO2 ceramic (Journal of Advanced Ceramics) ISSN 2226-4108 2014, 3(4): pp 297–305.
[12] G Jagadeesh et.al, Fascinating World of Shock Waves General Article August 2008 pp 752-767

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