DEVELOPMENT AND CHARACTERIZATION OF AL-V METAL MATRIX COMPOSITE BY STIR CASTING

Report submitted to

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

For the Degree of

BACHELOR OF TECHNOLOGY
IN
MATERIAL SCIENCE WITH SPECIALIZATION IN NANOTECHNOLOGY

Submitted By: -

Aarti Munjal
(R240211001)
Shubham Shankar
(R240211033)

Kuldeep Jagrotiya
(R240211015)
Pooja Nethrika
(R240211043)

Under the supervision of

_____

Amneesh Singla

Asst. Professor

MECHANICAL DEPARTMENT

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES, DEHRADUN

CERTIFICATE

This is to certify that the project work entitled **"Synthesis and Characterization Al -V of Metal Matrix Composite by Stir Casting"** *is* carried out by **Aarti Munjal**, (R240211001), **Kuldeep Jagrotiya** (R240211015) **Shubham Shankar** (R240211033) **Pooja Nethrika** (R240211043) students of B.Tech in Material Science with specialization in Nanotechnology (2011-2015), University Of Petroleum And Energy Studies as **Major Project** at, University Of Petroleum And Energy Studies and Wadia Institute of Himalayan Geology, Dehradun.

Signature of the guide
Amneesh Singla
Assistant Professor
Mechanical Department
University of Petroleum and Energy Studies, Dehradun

DECLARATION

We hereby declare that the project entitled **"Development and Characterization AL -V of Metal Matrix Composite by Stir Casting"** is entirely new and original and has not been submitted to any other university or institution for the award of any Degree, Diploma, Fellowship or other similar titles.

Aarti Munjal (R240211001)
Kuldeep Jagrotiya (R240211015)
Shubham Shankar (R240211033)
Pooja Nethrika (R240211043)

Date:

Place: Dehradun

ACKNOWLEDGEMENT

Our heartfelt thanks to all those whose guidance, encouragement and help served as a beacon light and crowned our efforts with success.

We take this opportunity to express my sincere gratitude and deep sense of indebtedness to our respective Dean **Dr. Kamal Bansal (COES)**, who has kindly permitted us to carry out the project at University of Petroleum and Energy Studies, Dehradun.

We forward our sincere thanks to our respective mentor **Amneesh Singla (Assistant Professor, Mechanical Department)**, for guiding us throughout the work and for the suggestions he has provided us at every stage of our work with great interest and patience.

We express our sincere thanks to our activity coordinator **Dr. Subrahmanyam V. Garimella,** for his encouragement towards the completion of this project.

We also thank **Siddharth Jain** (Assistant Professor) for his assistance and valuable guidance throughout the entire project.

We would also acknowledge our parents whose unflagging support and co-operation was equally important for the completion of the project.

Finally, yet importantly thanking the Almighty for showing the path to keep moving forward.

ABSTRACT

Fabrication of Al-V composite using Vacuum Stir Casting with Al matrix (99.5% pure) and variation in concentration of V_2O_5, The experimental studies involves different concentration of V_2O_5: 3%, 5%, 7%, 9% (by weight) whereas other parameters as melt temperature 850°C, pre heating reinforcement temperature 250°C, stirring time 10 min, Stirring speed 700°C and addition of 5 gr of Mg to promote wettability. This project activity comprises the characterization of the fabricated Al-V metal matrix composite using metallurgical microscopy for metallurgical properties. Structural characterizations of the films were performed by grazing angle X-ray diffraction (XRD). Mechanical properties were analyzed using vicker's hardness and Brinell hardness. Vicker's hardness showed increase in the hardness with the increase in the concentration of V_2O_5. The XRD analysis depicted the 100% intensity at (111) peak with an angle of 2θ (38.65). The fabricated Al-V metal matrix composite is dependent on the process parameters. We studied the effect of variation of concentration of V_2O_5. It is found that the hardness, grain size, micro structure of the resultant Al-V metal matrix composite are influenced by concentration of V_2O_5.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1 INTRODUCTION AND LITERATURE REVIEW

1.1 INTRODUCTION

Composite materials are made up from two or more constituent materials with significantly different physical or chemical properties, that when combined produce a material with different characteristics from the individual components. The two materials i.e., matrix and reinforcement work together to give the composites unique properties. The matrix surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart their special mechanical and physical properties to enhance the matrix properties. The individual components remain separate and distinct within the finished structure. The new material is stronger and lighter when compared to traditional materials.

Composites are generally classified in the various ways. These are as follows-

1. Classification based on matrix
2. Classification based on reinforcement.

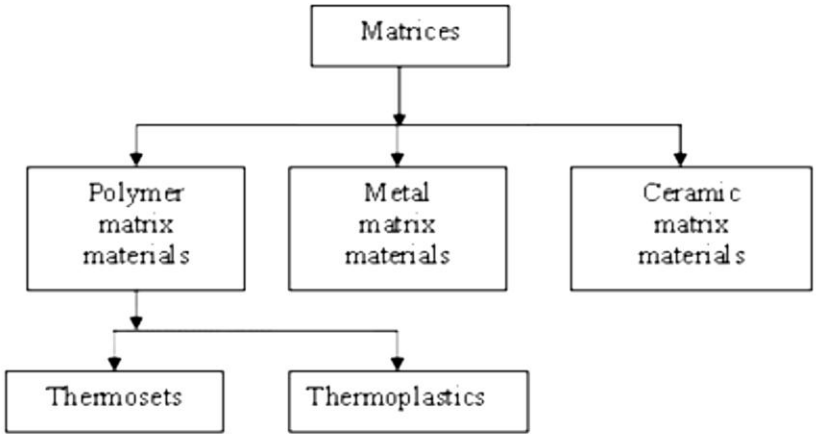


Fig 1: *Classification of Metal Matrix Composite*

Matrix - Metal Matrix Composite

Metal Matrix Composites is a composite material with at least two constituent parts, one being a metal. The other material may be different metal or another material, such as a ceramic or organic compound. MMCs are made by dispersing a reinforcing material into a metal matrix. The reinforcement surface can be coated to prevent chemical reaction with matrix. Most metals and alloys could be used as matrices and they require reinforcement materials which need to be stable over a range of temperature and non-reactive too. Most metals and alloys make good matrices.

For example, carbon fibers are commonly used in aluminium matrix to synthesize composites showing high strength. The carbon fibers are coated with nickel or titanium boride in order to prevent chemical reaction of carbon with aluminium matrix on the surface of fiber. Titanium, Aluminum and Magnesium are the popular matrix metals, which are particularly useful for aircraft applications.

Reinforced MMCs are produced by several processing routes such as powder metallurgy, spray deposition, mechanical alloying (MA) and various other casting techniques, i.e. squeeze casting, rheocasting and compo casting. These techniques are based on the addition of ceramic reinforcements to the matrix materials, which may be in molten or powder form. The scale of the reinforcing phase is limited by the starting powder size, which is typically of the order of microns to tens of microns and rarely below 1 mm. Main drawbacks that have to be overcome are the interfacial reactions between the reinforcements and the matrix, and poor wettability between the reinforcements and the matrix due to surface contamination of the reinforcements.

The properties of MMCs are controlled by the size and volume fraction of the reinforcements as well as the nature of the matrix ± reinforcement interfaces. An optimum set of mechanical properties can be achieved when fine and thermally stable ceramic particulates are dispersed uniformly in the metal matrix. Compared to the conventional MMCs produced by ex situ methods, the in situ MMCs exhibit the following advantages: (a) the in situ formed reinforcements are thermodynamically stable at the matrix, leading to less degradation in elevated-temperature services (b) the reinforcement ± matrix interfaces are clean, resulting in a strong interfacial bonding (c) the in situ formed reinforcing particles are finer in size and their distribution in the matrix is more uniform, yielding better mechanical properties.

Reinforcement

Another classification refers to the reinforcement form – **fiber reinforced composites**, **Laminar composites** and **particulate composites**. Fiber Reinforced composites (FRP) can be further divided into those containing discontinuous or continuous fibers.

- **Fiber Reinforced Composites** are composed of fibers embedded in matrix material. Such a composite is considered to be a discontinuous fiber or short fiber composite if its properties vary with fiber length. On the other hand, when the length of the fiber is such that any further increase in length does not further increase, the elastic modulus of the composite, the composite is considered to be continuous fiber reinforced. Fibers are small in diameter and when pushed axially, they bend easily although they have very good tensile properties. These fibers must be supported to keep individual fibers from bending and buckling.

- **Laminar Composites** are composed of layers of materials held together by matrix. Sandwich structures fall under this category.

- **Particulate Composites** are composed of particles distributed or embedded in a matrix body. The particles may be flakes or in powder form. Concrete and wood particle boards are examples of this category.

1.2 FABRICATION & PROPERTIES OF METAL MATRIX COMPOSITES

Metal matrix composites (MMCs) material in which rigid ceramic reinforcements are embedded in a ductile metal or alloy matrix. MMCs combine metallic properties (ductility and toughness) with ceramic characteristics (high strength and modulus), leading to greater strength in shear and compression and to higher service temperature capabilities. Various attractive physical and mechanical properties that can be obtained with MMCs are high specific modulus, strength, and thermal stability. These properties of MMCs are for use in the aerospace and automotive industries, and other structural applications.

The family of discontinuously reinforced MMCs includes both particulates and whiskers or short fibers. More recently, this class of MMCs has attracted considerable attention as a result of

(a) Availability of various types of reinforcement at competitive costs.

(b) Successful development of manufacturing processes to produce MMCs with reproducible structure and properties

(c) Availability of standard or near-standard metal working methods, can be utilized to fabricate these MMCs. The particulate-reinforced MMCs are of particular interest due to their ease of fabrication, lower costs, and isotropic properties.

Reinforced MMCs are produced by several processing routes such as powder metallurgy, spray deposition, mechanical alloying (MA) and various other casting techniques, i.e. squeeze casting, rheocasting and compo casting. These techniques are based on the addition of ceramic reinforcements to the matrix materials, which may be in molten or powder form. The scale of the reinforcing phase is limited by the starting powder size, which is typically of the order of microns to tens of microns and rarely below 1 mm. Main drawbacks that have to be overcome are the interfacial reactions between the reinforcements and the matrix, and poor wettability between the reinforcements and the matrix due to surface contamination of the reinforcements.

The properties of MMCs are controlled by the size and volume fraction of the reinforcements as well as the nature of the matrix ± reinforcement interfaces. An optimum set of mechanical properties can be achieved when fine and thermally stable ceramic particulates are dispersed uniformly in the metal matrix. Compared to the conventional MMCs produced by ex situ methods, the in situ MMCs exhibit the following advantages: (a) the in situ formed reinforcements are thermodynamically stable at the matrix, leading to less degradation in elevated-temperature services (b) the reinforcement ± matrix interfaces are clean, resulting in a strong interfacial bonding (c) the in situ formed reinforcing particles are finer in size and their distribution in the matrix is more uniform, yielding better mechanical properties.

Because of the great potential that in situ MMCs offer for widespread applications, a variety of processing techniques are developed. Using these routes, in situ MMCs with a wide range of matrix materials (including aluminum, titanium, copper, nickel and iron) and second-phase particles (including borides, carbides, nitrides, oxides and their mixtures) have been produced. Developments in fabrication, microstructure and mechanical properties of the composites reinforced with in situ ceramic phases.

1.3 BACKGROUND

With the modern development need of developments of advanced engineering materials for various engineering applications is enhanced. To meet such demands application of metal matrix composite is one of aspect of engineering. Composite material is one of the solutions for such requirement. In composites, materials are combined in such a way as to enable us to make better use of their parent material while minimizing to some extent the effects of their deficiencies. The simple term ‘composites’ is the combinations of two or more material in order to improve the properties. Materials development has shifted monolithic from to composite materials for adjusting to the global need for reduced weight, low cost, quality, and high performance in structural materials. Driving force for the utilization of Aluminium Metal matrix Composites in areas of aerospace and automotive industries include performance, economic and environmental benefits.

In Aluminum metal matrix composite, aluminum forms percolating network and is termed as matrix phase. The other constituent such as vanadium oxide added in this aluminum and serves as reinforcement. These advantages can be used to achieve better properties of the resultant composite material.

For example, elastic modulus of pure Aluminum can be enhanced from 70GPa to 240GPa by reinforcing with 60 vol. % continuous aluminum fibers. On the other hand incorporation of 60 vol% alumina fiber in pure aluminum leads to decrease in the coefficient of expansion from 24 ppm/°C to 7 ppm/°C. Similarly it is possible to process Al-9% Si-20 vol% SiCp composites having wear resistance equivalent or better than that of grey cast iron. All these examples illustrate that it is possible to alter several physical properties of aluminum/aluminum alloy by adding two or three appropriate reinforcement in suitable volume fraction.

1.4 OBJECTIVES

1) To fabricate the MMC material by taking Al Metal with addition of vanadium oxide through liquid metallurgy stir casting technique using in situ approach.
2) Development of composite under controlled variations in compositions of vanadium pantaoxide at 3%, 5%, 7%, and 9% (by wt).
3) To analyze the micro structural characteristics of the as cast material.

4) Investigations into the mechanical properties of developed composites like Micro hardness, Bulk Hardness etc.
5) Characterizations of the developed composite using XRD (X-ray diffraction).

1.5 METAL MATRIX Al

Aluminium alloy 2000, 6000 and 7000 series are used for fabrication of the automotive parts. An advantage of using aluminium as matrix material is casting technology is well established, and most important it is lightweight material. Aluminium alloy is associated with some disadvantages such as bonding is more challenging than steel, low strength than steel and price is 200% of that of steel. But with proper reinforcement and treatment the strength can be increased to required level.

1.6 REINFORCEMENT V_2O_5

Aluminum alloys with transition metals such as Vanadium are promising base for fabricating super high-temperature and light alloys that can be used as matrices for composite materials. Strong interatomic bonding and low diffusivity in the solid aluminum characterize these transition metals, and the limiting solubility of these metals in the solid solution is very low.

The effect of micro alloying aluminum and its alloys by different refractory metals and the effect of addition of some transition materials namely V and Zr on the mechanical behavior and machinability of commercially pure aluminum have been developed The grain efficiency is affected by many factors under three headings namely; parameters related to Al or Al alloy melt, parameters related to the grain refiner itself, and parameters related to the procedure followed in carrying out the grain refinement process. It has been also reported that the effectiveness of the grain refinement depends on the purity of the Al melt.

Prominent effects of 3%, 5%, 7% and 9% vanadium pantaoxide addition are on the microstructure, micro hardness, and mechanical properties of Al.

CHAPTER 2 SYSTHESIS AND TESTING METHODS

2.1 LIQUID METALLURGY STIR CASTING

In a liquid stir casting process, the reinforcing phases are distributed into molten matrix by mechanical stirring. Mechanical stirring in the furnace is a key element of this process. The resultant molten alloy/composite, with ceramic particles, can then be used for die casting, permanent mold casting, or sand casting. Stir casting is suitable for manufacturing composites with up to 30% volume fractions of reinforcement. The cast composites are sometimes further extruded to reduce porosity, refine the microstructure, and homogenize the distribution of the reinforcement. A major concern associated with the stir casting process is the segregation of reinforcing particles which is caused by the surfacing or settling of the reinforcement particles during the melting and casting processes. The final distribution of the particles in the solid depends on material properties and process parameters such as the wetting condition of the particles with the melt, strength of mixing, relative density, and rate of solidification. The distribution of the particles in the molten matrix depends on the geometry of the mechanical stirrer, stirring parameters, placement of the mechanical stirrer in the melt, melting temperature, and the characteristics of the particles added.

METHOD	Range of shape and size	Range of vol. fraction	Cost
Stir casting	Wide range of shapes; Larger size; up to 500 kg	Up to 30	Least expensive
Squeeze casting	Limited by pre form shape Up to 2cm height	Up to 0.5	Moderate expensive
Powder metallurgy	Wide range; restricted size		Expensive
Spray casting	Limited shape, large shape	0.3-0.7	Expensive

Table 1 Comparative Study of various fabrications Process

2.1.1Steps in Stir Casting

- Melting of Metal Matrix above melting temperature.
- Separate preheating of reinforcement to remove the moisture content.
- Mixing of matrix and reinforcement thoroughly
- Casting of the melt

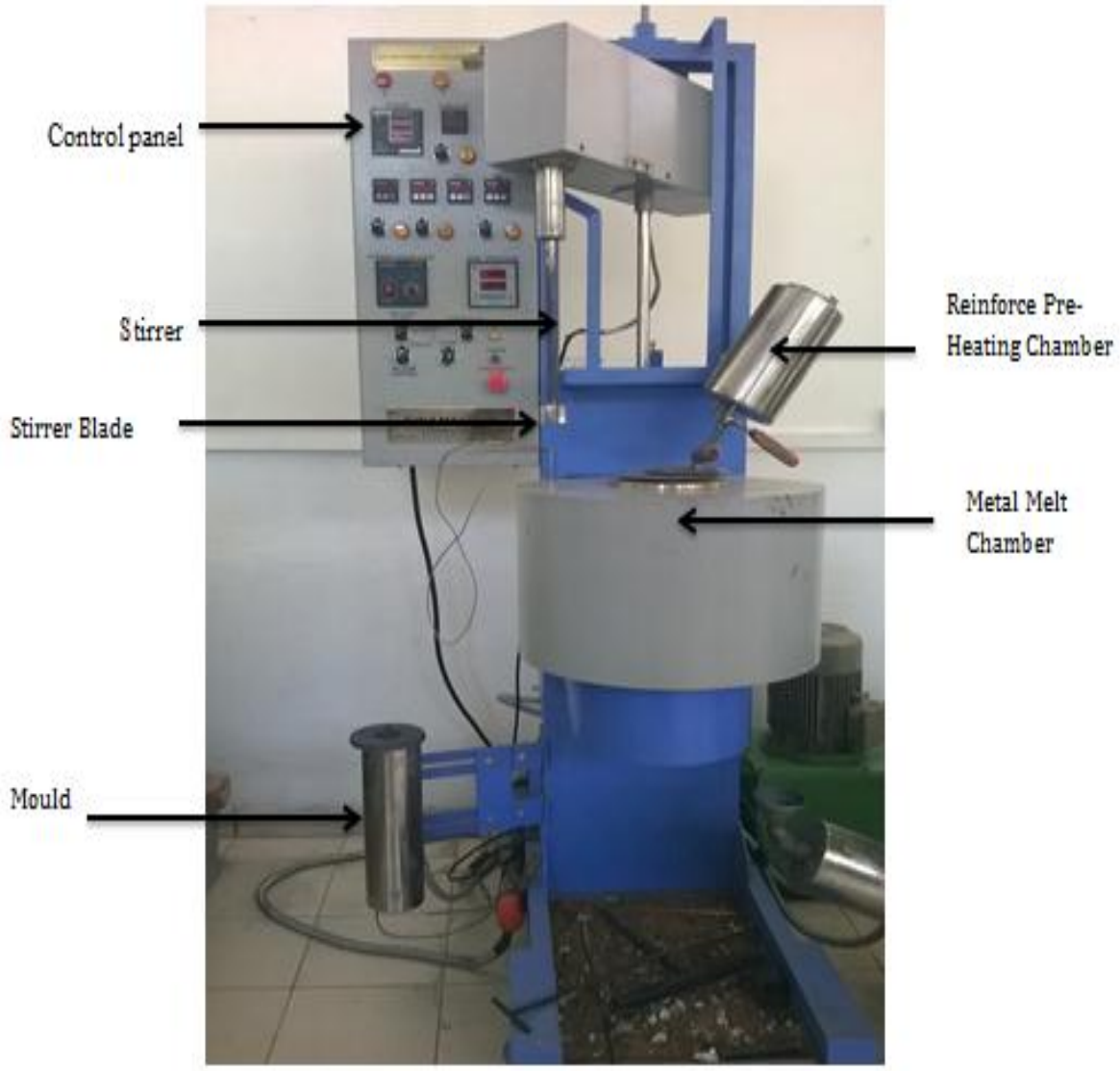


Fig 2: *Stir Casting Apparatus*

2.1.2 Process Parameters

Operating parameters are very essential for fabrication of composite material by stir casting. The process parameters are needs to be controlled properly in order to improve the properties of composite material. The various process parameters are as follows:

- **Stirring Speed:** It is an important process parameter as stirring helps in promoting wettability i.e. bonding between matrix & reinforcement. Stirring speed directly controls the flow pattern of the molten metal. Parallel flow will not promote good reinforcement mixing with the matrix. Hence flow pattern should be controlled turbulent.

- **Stirring temperature:** It is an important process parameter. It is related to the melting temperature of matrix i.e. aluminum. Aluminum generally melts at 660°C. The processing temperature is mainly influence the viscosity of Al matrix. The change of viscosity influences the particle distribution in the matrix. The viscosity of liquid is decreased when processing temperature is increased with increased holding time stirring time. It also accelerates the chemical reaction b/w matrix and reinforcement.

- **Reinforcement pre heat temperature:** Reinforcement is preheated at a temperature in order to remove moisture or any other gases present within reinforcement. The preheating of also promotes the wettability of reinforcement with matrix.

- **Addition of Mg:** Addition of Magnesium enhances the wettability. However increase in the content above 1wt. % increases viscosity of slurry and hence uniform particle distribution will be difficult.

- **Stirring time:** Stirring promotes uniform distribution of the particles in the liquid and to create perfect interface bond b/w reinforcement and matrix. The stirring time b/w matrix and reinforcement is considered as important factor in the processing of composite. For uniform distribution of reinforcement in matrix in metal flow pattern should from outward to inward.

2.2 TESTING METHOD

2.2.1 Analysis of Microstructure, Grain Size

Metallurgical microscope is used to determine the microstructure, grain size of the mounted specimen. In a typical metallurgical microscope, a horizontal beam of light from the light source is reflected by means of a plane glass reflector downwards through the microscope objective on the surface of the specimen. Some of these incidents light reflected from the specimen surface will be magnified and passing through the plane glass reflector and magnified again by upper lens system of the eye-piece.

Fig 3: *Metallurgical Microscope*

Component	Description
Source	Illuminating source
Stage	X-Y axis movement
Aperture diaphragm	Controls the amount of light
Field diaphragm	Area of specimen
Objective	Compound lenses
Eyepiece	Need to refocus
Filters	Improve contrast

Table 2: Components of metallurgical microscope

2.2.2 Micro Hardness

The **Vickers hardness test method**, also referred to as a micro hardness test method, is mostly used for small parts, thin sections, or case depth work. The Vickers method is based on an optical measurement system. The micro hardness test procedure specifies a range of light loads, using a diamond indenter to make an indentation, which is measured and converted to a hardness value. It is very useful for testing on a wide type of materials. A square base pyramid shaped diamond indenter is used for testing in the Vickers scale. The load ranges from a few grams to one or several kilograms. The micro hardness methods are used to test on metals, ceramics, and composites.

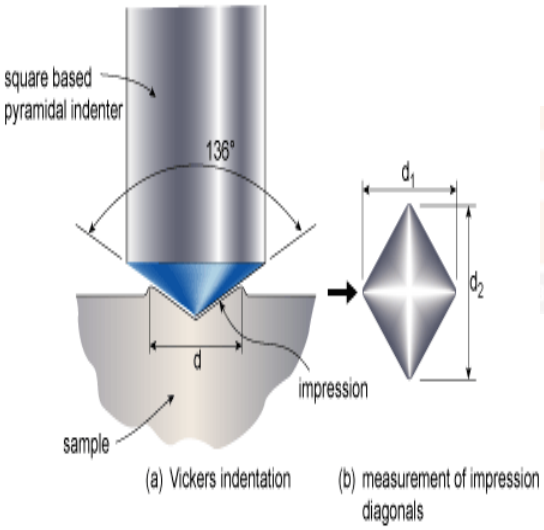


Fig 4: *Mechanism of Vickers's Indentation*

Fig 5: *Vickers's Hardness Tester*

2.2.3 Bulk Hardness (Brinell Hardness)

The **Brinell hardness test method** is used to determine Brinell hardness is defined in ASTM E10. Most commonly it is used to test materials that have a structure that is too coarse or that have a surface that is too rough to be tested using another test method, e.g., castings and forgings. Brinell testing often use a

very high-test load (3000 kgf) and a wide indenter so that the resulting indentation averages out most surface and sub-surface inconsistencies.

The Brinell method applies a predetermined test load (F) to a carbide ball of fixed diameter (D), which is held for a predetermined time period and then removed. The resulting impression is measured across at least two diameters. A Brinell hardness result measures the permanent width of indentation produced by indenter applied to a test specimen at a given load, for a given length of time.Most typically, a Brinell test will use 3000 kgf load with a 10mm ball. If the sample material is aluminum, the test is most frequently performed with a 500 kgf load and 10mm ball. Brinell test loads can range from 3000 kgf down to 1 kgf. The test standard specifies a time of 10 to 15 seconds.

Fig: 6 *Brinell Hardness Tester*

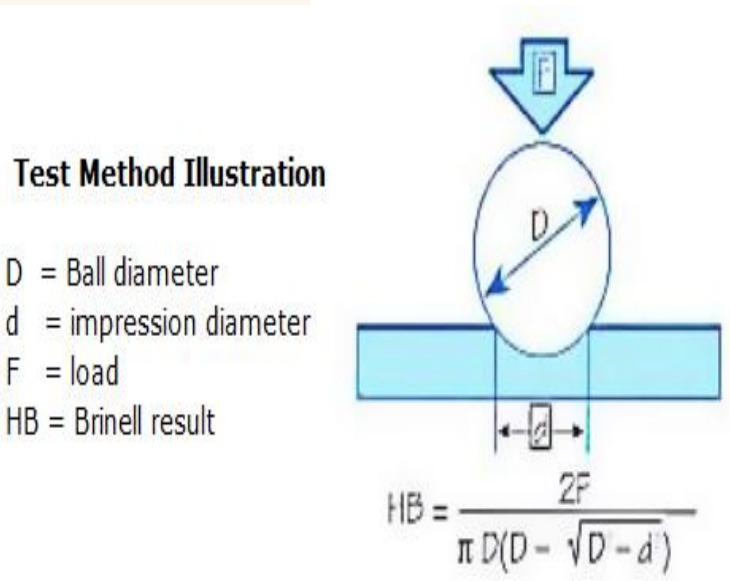


Fig: 7 *Mechanism of Brinell Indentation*

2.2.4 Optical Emission Spectroscopy

Optical Emission Spectrometer is used to determine the elemental composition in the sample**.** In this technique, atoms in a sample are excited by energy that comes from a spark formed between sample and electrode. The energy of the spark causes the electrons in the sample to emit light, which is converted into a spectral pattern. The intensity of the peaks in this spectrum is measured, and OES analyzers produce qualitative and quantitative metal analysis of the material composition. Optical emission spectrometry involves applying electrical energy in the form of spark generated between an electrode and a metal sample, whereby the vaporized atoms are brought to a high energy state within a so-called "discharge plasma". These excited atoms and ions in the discharge plasma create a unique emission spectrum specific to each element. Thus, a single element generates numerous characteristic emission spectral lines. The intensity of each emission spectrum depends on the concentration of the element in the sample. Detectors (photomultiplier tubes) measure the presence or absence or presence of the spectrum extracted for each element and the intensity of the spectrum to perform qualitative and quantitative analysis of the elements.

Fig: 8 *Optical Emission Spectrometer*

2.2.5 X-ray diffraction (XRD)

X-Ray Diffraction is used to study the structural properties, crystal structure and grain size of the sample. The samples tested by XRD are in the form of powders. X -rays are scattered by interaction with the electrons of the atoms in the sample material being investigated. It is used to study chemical analysis, stress and strain measurement, the study of phase equilibrium, measurement of particle size, as well as crystal structure.

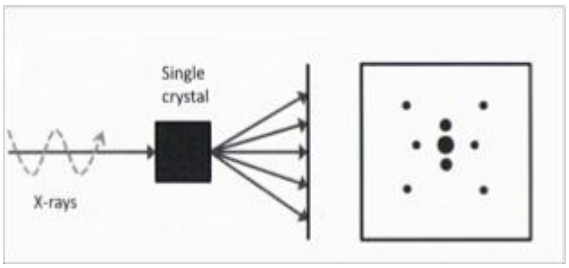


Fig: 9 *Series of spots produced by diffracted x-rays from a single crystal.*

When an X-ray beam hits the surface of crystalline sample where the layers of atoms or ions are separated by the inter atomic distance, the diffraction peak is formed when scattered X-rays produce by a constructive interference. The path difference is given by any integer number of wavelengths for construction interference as given by Bragg's law.

$$n\lambda = 2d \sin\theta$$

where λ is the wavelength of the incident X-ray beam, d is the spacing between diffracting planes, θ is the incident angle with lattice plane and n is the integer number, n = 1, 2, 3.The X-ray beam produced by the source scan the surface of the sample at different positions and angle 2θ is always maintained between incident beam and the detector position.

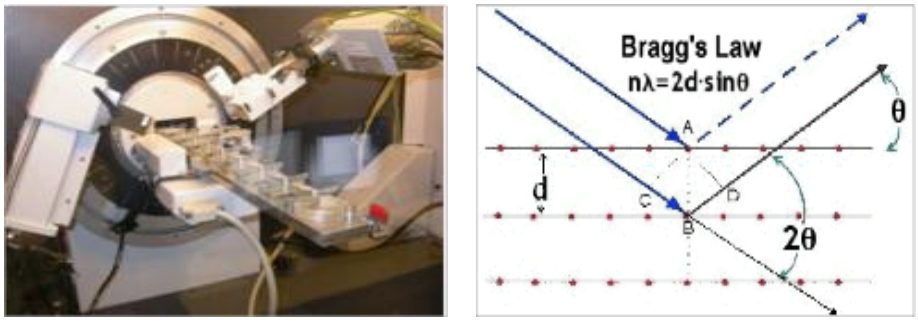


Fig: 10 *Mechanism of XRD*

CHAPTER 3 EXPERIMENT

3.1 FABRICATION OF Al-V MMC

3.1.1Compositional Analysis of procured Aluminium

The composition aluminium as received was analysed using OES.

The compositions are as follows:

Al	Mg	Sn	V	Pb	Si	Fe	Cu	**Mn**	**Ni**
99.5%	**0.014**	**0.008**	**0.016**	0.009	0.14%	0.18	**0.01**	**0.003**	**0.009**

Table 3: Composition of Procured Material

3.1.2 Material Weighing

S.No.	Sample	Weight of Aluminium (gm)	Weight of V_2O_5 (gm)
1	Al3% V_2O_5	1100	33
2	Al5% V_2O_5	1100	66
3	Al7% V_2O_5	1100	77
4	Al9% V_2O_5	1100	99

Table 4: Weight of Al and V

3.1.3 Experimental Procedure

- The melting chamber and the mould is properly cleaned and uniformly coated with graphite non-stick paste, so as to avoid adhesion of melt to the surface.
- The temperature is set to 850°C for melt chamber.
- When the set temperature is obtained, weighed aluminium is transferred to the melt chamber for melting.
- Once the added metal starts melting, the temperature of pre heating reinforced chamber is set to 250°C and weighed amount of V_2O_5 powder is added to it in order to remove moisture.

- When the al metal is completely melted, 5 gm Mg is added to promote wettability.
- The mix in the melting chamber is stirred for 3 minutes at 600rpm in order to promote uniformity.
- The knob of pre heating chamber is opened to release V_2O_5 into the melt chamber. After addition of V_2O_5 the melt is stirred for 10 minutes.
- The melt is transferred into the mould for casting.
- Once the mould is cooled to room temperature, the cast is removed from the mould.

3.2 CHARACTERISTIZATION

3.2.1 Metallurgical Microscope

To view the prepared cast under various magnification, and to analyse the resultant micro structure of the cast samples metallurgical microscope was used.

Sample Preparation: -

- **Cutting cast specimen**

  Small piece of the cast sample was cut using manual hacksaw.

- **Mounting**

  Mounting of specimens is usually necessary to allow them to be handled easily. It also minimizes the amount of damage likely to be caused to the specimen itself. Cast Specimens were hot mounted (at around 125 °C) using a mounting press, in thermosetting plastic Bakelite.

  A mounted specimen usually has a thickness of about half its diameter, to prevent rocking during grinding and polishing.

- **Grinding**

  Mounted Cast samples were made flat with proper geometry using belt grinder for making the surface flat.

  Then by using emery paper of following grades 220,400.600,800,1000,1500,2000 the surface was made exactly flat and severe scratches were removed.

- **Polishing:**

  During polishing the sample was rotated in exactly 90° after polishing of one side stroke, using diamond polishing, for polishing operation wet cloth was clamped over the wheel, 0.3 micron angular sided diamond paste solution was applied. Specimen was held firmly n hand against the rotating cloth. After which the specimen was washed with water and dried.

- **Etching:**

  Keller's reagent was used for etching. Etchant was applied on the polished surface with the swab cotton for the fraction of second to 5 seconds depending on the materials.

  Composition of Keller's Reagent

Distilled Water	95ml
Nitric Acid	2.5ml
Hydrochloric Acid	1.5ml
Hydrofluoric Acid	1.0ml

Table 5: Composition of Keller's Reagent

Examination:

The etched samples were viewed under the microscope at various magnifications such as 50X,100X, 200X,by adjusting the focus and brightness of the microscope.

Results:

Microstructure viewed under microscope for all the samples were analysized .

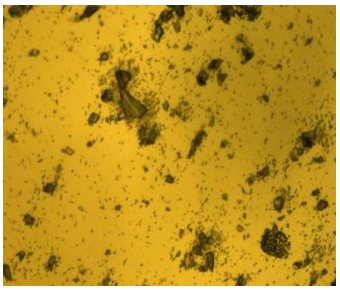
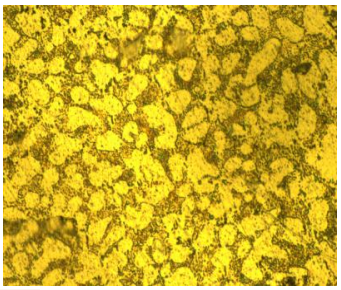
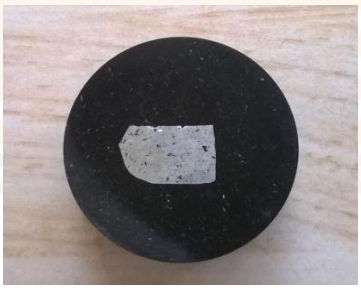
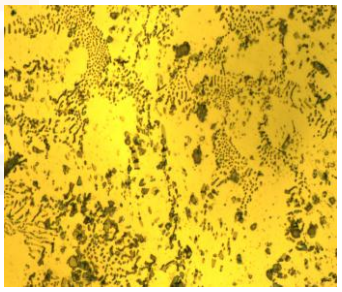
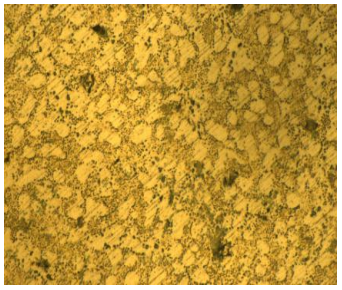
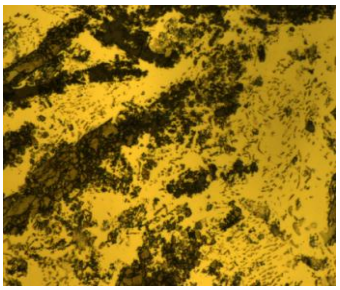
SAMPLES	MOUNTED SPECIMEN	MICROSTRUCTURE
PURE ALUMINIUM		
Al 3% V_2O_5		
Al 5% V_2O_5		
Al 7% V_2O_5		
Al 9% V_2O_5		

Table 6: Metallurgical Microstructure

3.2.2 Vickers Hardness

To determine the microhardness of the sample with addition of different of concentration of V2O5 brinell hardness was used.Load applied during the procedure was 250 kg,using diamond ball indentor with diameter of 5mm.

The microhardness of the samples is as follows:

Sample 1: Pure Aluminium

S.No.	D1	D2	HV(Vicker's Hardness)
1	122.71	119.86	25.21
2	122.71	119.22	25.21
3	135.36	131.27	20.87
Mean Reading			23.76

Sample 2: Aluminium 3% V_2O_5

S.No.	D1	D2	HV(Vicker's Hardness)
1	78.89	80.46	58.43
2	79.15	80.20	58.42
3	78.63	77.63	60.76
Mean Reading			59.20

Sample 3: Aluminium 5%V_2O_5

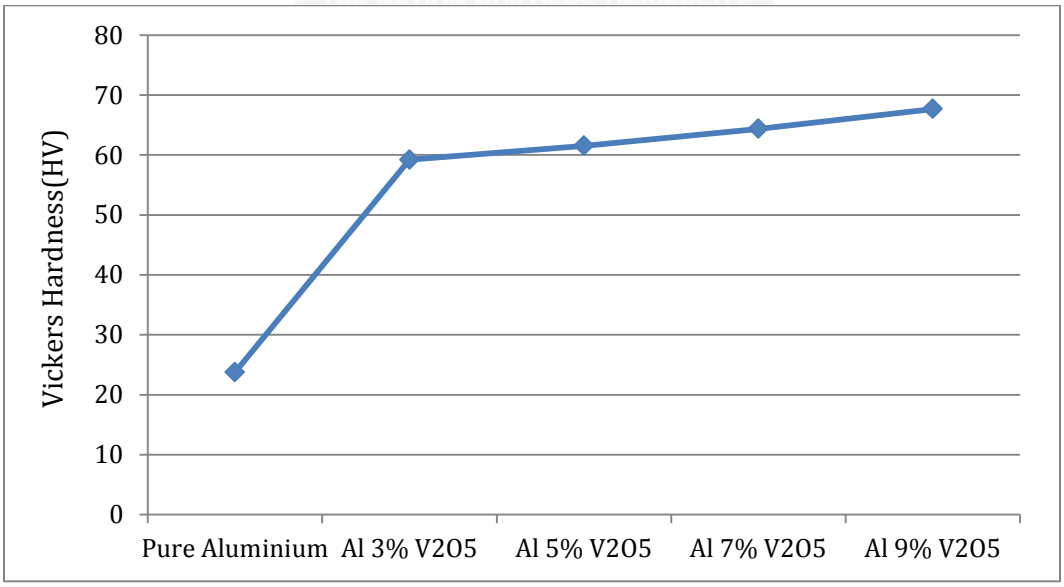
S.No.	D1	D2	HV(Vicker's Hardness)
1	79.90	70.98	60.43
2	81.46	72.89	62.42
3	78.63	70.98	61.76
Mean Reading			61.53

Sample 4: Aluminium 7%V2O5

S.No.	D1	D2	HV(Vicker's Hardness)
1	76.81	75.96	63.56
2	74.22	75.19	66.46
3	77.46	75.96	63.03
Mean Reading			64.35

Sample 5: Aluminium 9%V2O5

S.No.	D1	D2	HV(Vicker's Hardness)
1	70.84	74.42	70.31
2	72.92	76.35	66.58
3	75.42	74.40	66.10
Mean Reading			67.66



Graph 1: Variation of microhardness with concentration of V_2O_5

3.2.3 Bulk Hardness (Brinell Hardness)

To determine the Bulk hardness of the composite at different concentration of V_2O_5 brinell hardness was used. Load applied during the procedure was 250 kg, using diamond ball indentor with diameter of 5mm.

Formula used:

$$BHN = \frac{Load\ applied\ (in\ kg)}{Spherical\ surface\ area\ of\ indentation}$$

$$= \frac{2P}{\prod D\left(D-\sqrt{D^2-d^2}\right)}$$

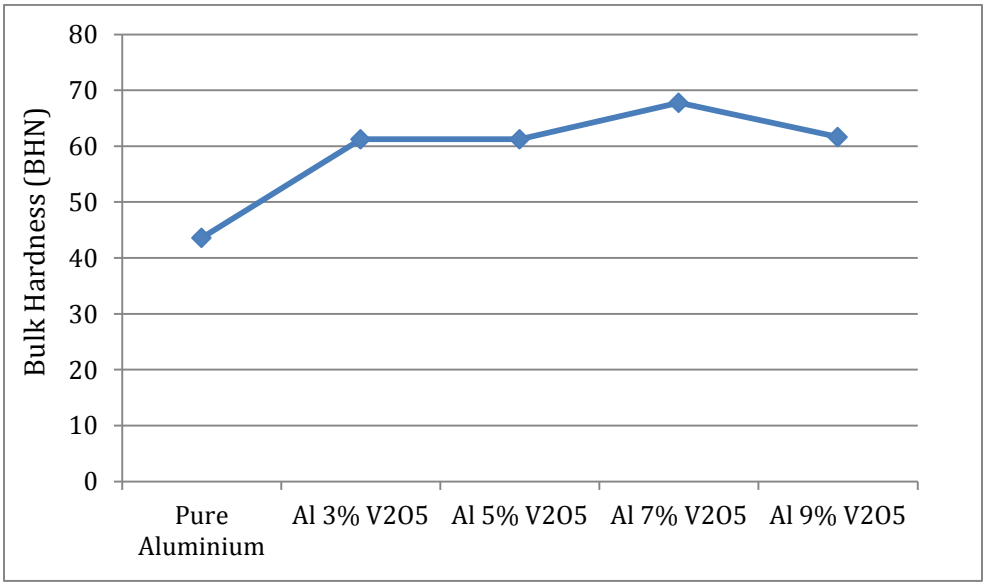
Procedure:

- Indentor was inserted into the machine.
- Cast surface was made clean by removing the dust, dirt, oil and grease.
- Load was selected to 250kg.
- Contact between the specimen surface and ball was made by rotating the jack adjusting wheel till needle touches the red mark.
- Load release lever was pulled and for minimum 30 seconds load was applied. The load was automatically applied gradually.
- Pulling the load lever back to normal position unloaded cast.
- Cast was removed from the support table, and the indentation so made was located.
- Indentation was viewed through optical microscope and diameter 'd' was measured by micrometer fitted on microscope.

Following observations were recorded from a test on cast using Diamond ball as indenter. An optical microscope viewed the diameter of indentation made.

S.no	Sample	Diameter of indentation (mm)'d'	BHN
1.	Pure Al	2.6mm	43.6
2.	Al-3%V2O5	2.2mm	61.23
3.	AL-5%V2O5	2.2mm	61.23
4.	AL-7%V2O5	2.1mm	67.75
5.	AL-9%V2O5	2.2mm	61.63

Table 7: BHN Results



Graph 2: Variation of bulk hardness with concentration of V_2O_5

3.2.4 X-Ray Diffraction (Structural Studies)

The XRD pattern as shown in Fig clearly shows the characteristics peaks of Al-V metal matrix composite with the variation in concentration of V_2O_5, fabricated using Stir Casting Method.

Calculations and Analysis

Grain size

$$D = \frac{K\lambda}{\cos\theta}$$

where, K= 0.94

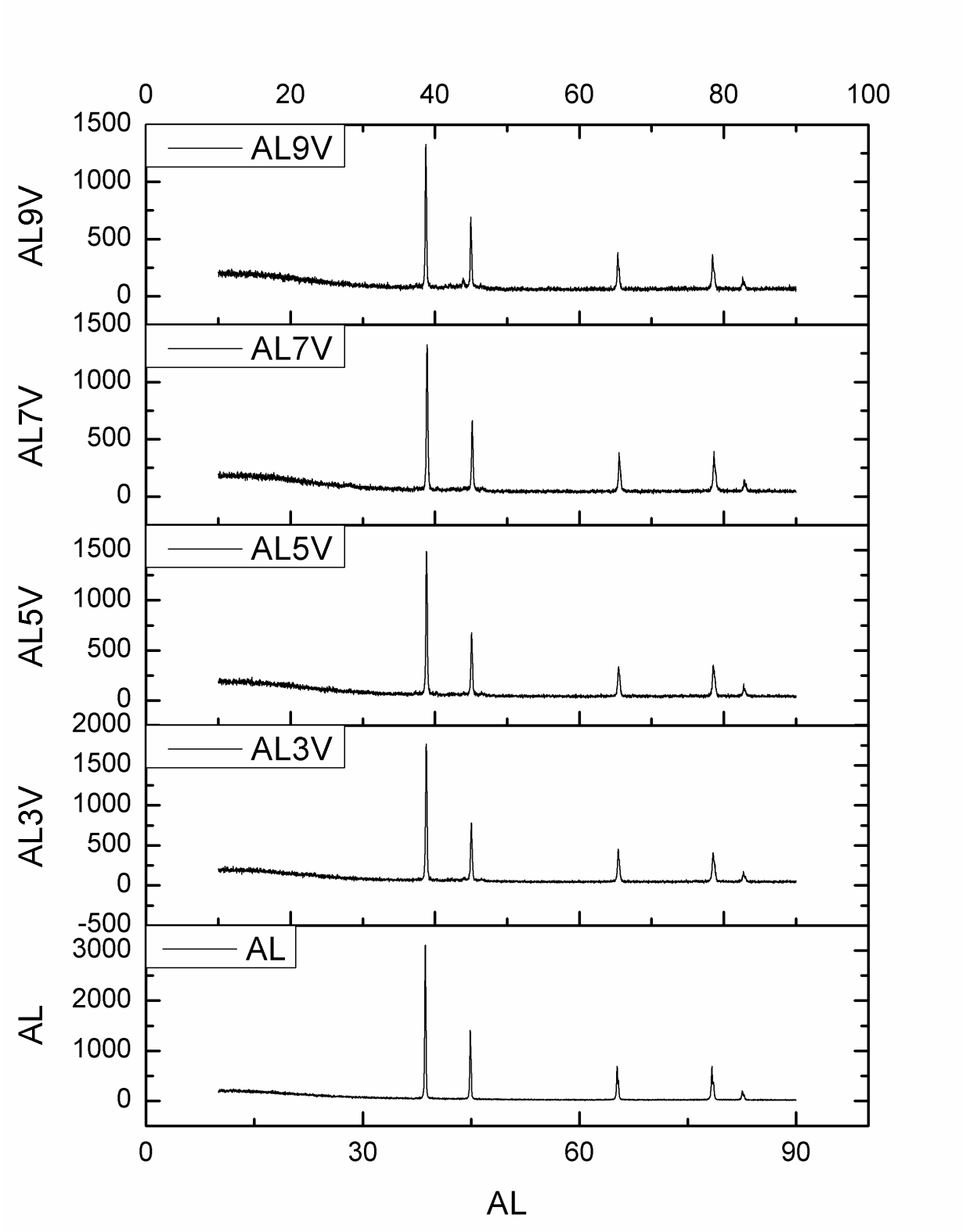
λ= wavelength of X-Ray (1.54A^o)

Dislocation Density

$\delta = 1/D^2$

Micro Strain

$\varepsilon = \beta\cos\theta/4$



Graph 3: XRD Peaks at various concentration of V_2O_5

AL-%V2O5	Peak Data						Grain size in nm	Micro Strain	
	2θ	θ	I	Cosθ	FWHM(β)	rad(β)		(e*10^-4)	Dislocation density (lines/vol)
PURE AL	38.6369	19.32	3048.64	0.9437	0.1224	0.00213	71.82	0.000504	193842874137061.00
3%V2O5	38.8006	19.40	1634.39	0.9432	0.1673	0.002920	52.57	0.000689	361778533940091.00
5%V2O5	38.7951	19.40	1365.31	0.9432	0.1338	0.002335	65.74	0.000551	231407709488361.00
7%V2O5	38.8943	19.45	1261.04	0.9429	0.1683	0.00293	52.28	0.000693	365905243920487.00
9%V2O5	38.7186	19.36	1237.96	0.9434	0.169	0.00294	52.03	0.000696	369354178510794.00

AL-%V2O5	Peak Data						Grain size in nm	Micro Strain	
	2θ	θ	I	Cosθ	FWHM(β)	rad(β)		(e*10^-4)	Dislocation density (lines/vol)
PURE AL	45.0066	22.50	707.41	0.9238	0.0978	0.001707	88.89	0.0003942	126555134256265.00
3%V2O5	45.0374	22.52	710.16	0.9237	0.1673	0.002920	51.97	0.0006744	370251784151918.00
5%V2O5	45.047	22.52	602.85	0.9237	0.1698	0.002963	51.21	0.0006844	381373461985538.00
7%V2O5	45.1487	22.57	600.29	0.9234	0.1767	0.003085	49.20	0.0007123	413067657242779.00
9%V2O5	44.9415	22.47	593.35	0.9241	0.1767	0.003085	49.16	0.0007129	413734531020213.00

AL-%V2O5	Peak Data						Grain size in nm	Micro Strain	
	2θ	θ	I	Cosθ	FWHM(β)	rad(β)		(e*10^-4)	Dislocation density (lines/vol)
PURE AL	65.2403	32.62	665.04	0.8422	0.1632	0.002848	58.43	0.0005998	292890303804302.00
3%V2O5	65.4103	32.71	374.75	0.8414	0.2007	0.003503	47.56	0.0007369	442112834330885.00

5%V2O5	65.3995	32.70	285.71	0.8415	0.1171	0.002044	81.51	0.0004300	150523650672839.00
7%V2O5	65.5076	32.75	322.78	0.8410	0.1687	0.002944	56.61	0.0006191	312028589414491.00
9%V2O5	65.2994	32.65	289.35	0.8419	0.1754	0.003061	54.39	0.0006444	338093565950102.00

AL-%V2O5	Peak Data						Grain size in nm	Micro Strain	Dislocation density (lines/vol)
	2θ	θ	I	Cosθ	FWHM(β)	rad(β)		(e*10^-4)	
PURE AL	78.3531	39.18	648.63	0.7751	0.1632	0.002848	63.49	0.0005520	248095547215520.00
3%V2O5	78.4979	39.25	349.78	0.7743	0.1673	0.002920	62.00	0.0005653	260180476811897.00
5%V2O5	78.49	39.25	292.97	0.7744	0.1224	0.002136	84.73	0.0004136	139281871505027.00
7%V2O5	78.6084	39.30	286.49	0.7737	0.1685	0.002941	61.60	0.0005689	263510208502826.00
9%V2O5	78.4268	39.21	292.35	0.7747	0.1745	0.003045	59.41	0.0005899	283343889185834.00

AL-%V2O5	Peak Data						Grain size in nm	Micro Strain	Dislocation density (lines/vol)
	2θ	θ	I	Cosθ	FWHM(β)	rad(β)		(e*10^-4)	
PURE AL	82.8287	41.41	87.39	0.7499	0.1224	0.002136	87.50	0.0004005	130605285362173.00
3%V2O5	82.7276	41.36	115.49	0.7505	0.2448	0.004273	43.72	0.0008017	523234419881489.00
5%V2O5	82.7575	41.38	82.49	0.7503	0.1265	0.002208	84.62	0.0004141	139654475935533.00
7%V2O5	82.8228	41.41	94.97	0.7499	0.2675	0.004669	40.04	0.0008754	623856848519550.00
9%V2O5	82.6216	41.31	83.33	0.7511	0.2798	0.004884	38.22	0.0009170	684661509639490.00

Table: 8 XRD Data Analysis

CHAPTER 4 CONCLUSION

Al-V metal matrix composite fabricated using Stir Casting by varying the concentration of V_2O_5 promising results. The Al-V MMC was analyzed for its mechanical and structural characteristics.

- The microstructure revealed the decrease in the size of the grain with the addition of concentration of V_2O_5. This is because V_2O_5 promotes the grain growth. Uniform distribution of the grain is observed at various magnification of the metallurgical microscope. Where as, magnification at 100X is taken into consideration for the comparison between various samples.

- Micro hardness is determined for Al-V MMC with variation in the concentration of V_2O_5. The results show the increase in the hardness with the increasing concentration of V_2O_5. Micro harness value of pure Al was 24.14 and increased to 58.04 for 3% V2O5, 61.02 for 5% V_2O_5, 64.66 for 7% and finally it reached to 67.44% with 9% V_2O_5. The result satisfies Hall Patch Equation i.e. with decrease in grain size hardness increases.

- Bulk Hardness is calculated for Al-V MMC with variation in the concentration of V_2O_5. The hardness increases with increasing the percentage of V_2O_5 up to 7%, whereas it decreases beyond 7%. This decrease in hardness may be due to non-uniform distribution of intermetallics.

- A structural characteristic of the Al-V MMC with variation in the concentration of V_2O_5 is investigated by XRD. The XRD plot for the films shows a single dominant peak (111) at 38.65deg (2-theta). This is Al Phase as agrees well with the literature. The intensity of the peak decreases with increasing concentration of V_2O_5. The grain size has been estimated by using the Scherrer equation. The grain size decreases with increase in concentration of V_2O_5.

CHAPTER 5 FUTURE WORK

To work on the future aspects,

- Fabricated Al-V metal matrix composite can be used for automotive and aerospace application.
- Tribological properties can be analyzed to determine the wear resistance and frictional coefficient.
- The morphology and microstructure of the resultant Al-V metal matrix composite samples can be examined by scanning electron microscopy (SEM), EDAX.
- Various other alloys matrix such as Al, Si and Al-Cu can be used to form metal matrix composite by the stir casting.

CHAPTER 6 REFERENCES

- ASM: "Properties and Selection: Nonferrous Alloys and Special-Pur- pose Materials," *ASM Handbook,* Vol. 2, ASM International, Materials Park, OH, 1990.
- T.B. Massalski, H. Okamoto, P.R. Subramanian, and L. Kacprzak: "Binary Alloy Phase Diagrams," ASM International, Materials Park, OH, 1990.
- W. Hume-Rothery and G.V. Raynor: *The Structure of Metals and Alloys,* Institute of Metals, 1962.
- 4. W.B. Pearson: *Handbook of Lattice Spacings and Structures of Metals and Alloys,* Vol. 2, Pergamon Press, 1967.
- L.F. Mondolfo: *Aluminum Alloys: Structure and Properties,* Butter- worths, 1976.
- G.B. Stroganov, V.A. Rotenberg, G.B. Gershman, Aluminum–Silicon Alloys, Metallurgiya, Moscow, 1977 (in Russian).
- M. Gupta, S. Ling, J. Alloys Compd. 287 (1999) 284–294.
- S.P. Nikanorov, V.V. Peller, in: G.E. Totten, D.S. Mackenzie (Eds.), Handbook of Aluminum, Physical Metallurgy and Processes, vol. 1, Marcel Decker, New York, 2003, pp. 81–211.
- M K SURAPPA, "*ALUMINIUM MATRIX COMPOSITES: CHALLENGES AND OPPORTUNITIES*," Sadhana Vol. 28, Parts 1 & 2, February/April 2003, pp. 319–334
- B.C. PAI, R.M.PILLAI AND K.G.SATYANARAYANA "*LIGHT METAL MATRIX COMPOSITES - PRESENT STATUS AND FUTURE STRATEGIES"*
- Muhammad Hayat Jokhio, Muhammad Ibrahim Panhwar, And Mukhtiar Ali Unar *"MANUFACTURING OF ALUMINUM COMPOSITE MATERIAL USING STIR CASTING PROCESS"* Mehran University Research Journal Of Engineering & Technology, Volume 30, No. 1, January, 2011 [Issn 0254-7821]
- M. N. Wahab, A. R. Daud and M. J. Ghazali " *PREPARATION AND CHARACTERIZATION OF STIR CAST-ALUMINUM NITRIDE REINFORCED ALUMINUM METAL MATRIX*

COMPOSITES" International Journal of Mechanical and Materials Engineering (IJMME), Vol. 4 (2009), No. 2, 115-117

- J Hashim, L Looney, M.S.J. Hashim *"THE ENCHANCEMENT OF WETABILITY SIC PARTICLE IN CAST ALUMINIUM MATRIX COMPOSITE*" Journal of material processing technology 119(2001) 329- 335

- Dunia Abdul Saheb "*ALUMINUM SILICON CARBIDE AND ALUMINUM GRAPHITE PARICULATE COMPOSITES*" ARPN Journal of Engineering and Applied Sciences VOL. 6, NO. 10, OCTOBER 2011 ISSN 1819-6608

- PradeepSharma, Gulshan Chauhan, Neeraj Sharma *"PRODUCTION OF AMC BY STIR CASTING- AN OVERVIEW"* International Journal of Contemporary Practises Vol.2 Issue1

- S. Naher, D. Brabazon, L. Looney "*SIMULATION OF THE STIR CASTING PROCESS"* Journal of Materials Processing Technology 143–144 (2003) 567–571

- G. G. Sozhamannan1*, S. Balasivanandha Prabu2, V. S. K Venkatagalapathy1 " *EFFECT OF PROCESSING PARAMTERS ON METAL MATRIX COMPOSITES: STIR CASTING PROCESS" Journal of Surface Engineered Materials and Advanced Technology,* 2012, 2, 11-15