# INVESTIGATION OF WIRE EDM PROCESS PARAMETERS OF ALUMINUM-CARBON NANOTUBE – GRAPHENE COMPOSITE

A Project Report Submitted

In partial fulfillment of the requirement for the award of degree of

**BACHELOR OF TECHNOLOGY**

**IN**

**MECHANICAL ENGINEERING**


Submitted by:

| | |
|---|---|
| R.V V S M PRABHAKAR | (18501A0384) |
| P.ABHISHEK | (18501A0378) |
| N.KARHIK SAI | (18501A0366) |
| T.JOSH DATTA | (18501A0399) |

Under the Esteemed Guidance of

**G.BALAKRISHNA**

Assistant Professor-ME Dept.

**DEPARTMENT OF MECHANICAL ENGINEERING**
**PRASAD V. POTLURI SIDDHARTHA INSTITUTE OF TECHNOLOGY**
**(AUTONOMOUS)**
Affiliated to JNTU Kakinada, Approved by AICTE, NEW DELHI
Accredited by NBA & NAAC A+, ISO 9001:2015 Certified Institution
KANURU, VIJAYAWADA – 520007


2021– 2022

**INVESTIGATION OF WIRE EDM PROCESS PARAMETERS OF ALUMINUM-CARBON NANOTUBE – GRAPHENE COMPOSITE**

A Project Report Submitted

In partial fulfillment of the requirement for the award of degree of

**BACHELOR OF TECHNOLOGY**

**IN**

**MECHANICAL ENGINEERING**

Submitted by:


| | |
|---|---|
| R.V V S M PRABHAKAR | (18501A0384) |
| P.ABHISHEK | (18501A0378) |
| N.KARTHIK SAI | (18501A0366) |
| T.JOSH DATTA | (18501A0399) |

Under the Esteemed Guidance of

**G.BALAKRISHNA**

Assistant Professor-ME Dept.

**DEPARTMENT OF MECHANICAL ENGINEERING**
**PRASAD V. POTLURI SIDDHARTHA INSTITUTE OF TECHNOLOGY**
**(AUTONOMOUS)**
**Affiliated to JNTU Kakinada, Approved by AICTE, NEW DELHI**
**Accredited by NBA & NAAC A+, ISO 9001:2015 Certified Institution**
**KANURU, VIJAYAWADA – 520007**


**2021– 2022**

**PRASAD V. POTLURI SIDDHARTHA INSTITUTE OF TECHNOLOGY**
**(Affiliated to JNTU, Kakinada, Approved by AICTE, New Delhi)**
**AUTONOMOUS, KANURU, VIJAYAWADA – 520007**
**DEPARTMENT OF MECHANICAL ENGINEERING**

# CERTIFICATE

This is to certify that the Project work entitled "**INVESTIGATION OF WIRE EDM PROCESS PARAMETERS OF ALUMINUM-CARBON NANOTUBE – GRAPHENE COMPOSITE**" being submitted by

| | |
|---|---|
| R.V V S M PRABHAKAR | (18501A0384) |
| P.ABHISHEK | (18501A0378) |
| N.KARTHIK SAI | (18501A0366) |
| T.JOSH DATTA | (18501A0399) |

In partial fulfillments of the requirements for the award **BACHELOR OF TECHNOLOGY** degree in **MECHANICAL ENGINEERING** at **PRASAD V. POTLURI SIDDHARTHA INSTITUTE OF TECHNOLOGY** is a record of bonafied work carried out by them under our supervision and guidance during academic year 2021-2022.

The results embodied in this report have not been submitted to any other university or institute for the award of any degree or diploma.

**G.BALAKRISHNA**
**ASSISTANT PROFESSOR**
**PROJECT GUIDE**

**Dr.B.RAGHU KUMAR, Ph.D**
**PROFESSOR**
**HEAD OF THE DEPARTMENT**

**EXTERNAL**

# DECLARATION

I declare that this thesis submission represents my ideas in my own words and where others ideas or words have been included, I have adequately cited and referenced the original sources I also declared that I have adhered to all the principles of academy honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission I understand that ant violation of the above will cause for disciplinary action by the institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

| | |
|---|---|
| R.V V S M PRABHAKAR | (18501A0384) |
| P.ABHISHEK | (18501A0378) |
| N.KARTHIK SAI | (18501A0366) |
| T.JOSH DATTA | (18501A0399) |

# ACKNOWLEDGEMENT

The satisfaction and euphoria on the successful completion of any task would be incomplete without the mention of the people who made it possible, whose constant guidance and encouragement crowned our effort with success.

We would like to express our profound appreciation to our Principal **Dr.K.SIVAJI BABU**, **Principal, PVP Siddhartha Institute of Technology** for extending his official support for the completion of our Project.

We express our thanks to **Dr.B.RAGHU KUMAR, Head of the Department**, **Mechanical Engineering Department** for all the facilities provided to successfully complete our Project work.

We are deeply indebted to our Project work Coordinator**, G.BALAKRISNHA, Assistant Professor, M.E,** for the motivation, guidance, tutelage and patience throughout this project work. We appreciate his broad range of expertise and attention to detail, as well as the constant encouragement he has given to us over the years.

In our association with all the above persons, we experienced not only their depth of knowledge but also affection towards us. Finally, we take this opportunity to thank one and all of our **Mechanical Engineering Teaching & Non-Teaching Staff** for their able cooperation both academic and non-academic all throughout our four years. We shall remember all our staff as long as our memory lives.

| | |
|---|---|
| R.V V S M PRABHAKAR | (18501A0384) |
| P.ABHISHEK | (18501A0378) |
| N.KARTHIK SAI | (18501A0366) |
| T.JOSH DATTA | (18501A0399) |

# ABSTRACT

Aluminum is cheaper and can be available everywhere so Aluminum based components are mainly used in engineering applications .The process of making these materials are easy but they require advanced machining techniques to cut them. In this project we have prepared the aluminum composite using stir casting method. The materials used for the composites are Graphene and Carbon nanotubes. After the preparation of the composite using Wire EDM machine by considering various process parameters such as Current(10A-12A),Pulse on time(90-100µs),Wire feed rate(1-3mm/min) the cutting is done. By changing the above mentioned parameters cutting is done and the output process parameters such as Kerf width, Cutting Speed , Material Removal Rate are calculated .We need to consider where the kerf width is minimum and where the value is obtained when we change the feed rate of the machine. Simultaneously we need to consider where the maximum speed has achieved.

## CONTENTS

## LIST OF FIGURES

# CHAPTER 1

# INTRODUCTION

# 1. INTRODUCTION

Aluminum composites have properties such as low density and higher strength so this makes it suitable for various industrial applications. Aluminum when reinforced with various ceramic composite materials gives high stiffness, low thermal coefficient, corrosive behaviour.
The metal matrix composites can be fabricated through many techniques such as

1. Stir casting
2. Squeeze casting
3. Powder metallurgy
4. Vapor deposition methods

Aluminum based composite materials reinforced with various ceramics have important industrial significance owing to best tribological and corrosion behavior, high stiffness and specific strength, low thermal coefficient and best mechanical properties even at high temperature. Hence, these composites are well suitable for the nuclear sector applications. Among all the fabrication techniques stir casting is best suitable method because it can give mass production and it is inexpensive too.

The machining can be done either by using conventional or non-traditional methods of machining. But composite materials are having improved mechanical properties such as high hardness; the conventional machining methods are not economical. Hence the unconventional machining process is well suitable for machining hard materials like metal matrix composites. WEDM is a recognized machining process for making a complexly shaped cutting on the materials such as difficult to machine.

## 1.1 TYPES OF CASTING METHODS

- **STIR CASTING:**
  Stir casting is a type of casting process in which a mechanical stirrer is introduced to form vortex to mix reinforcement in the matrix material. It is a suitable process for production of metal matrix composites due to its cost effectiveness, applicability to mass production, simplicity, almost net shaping and easier control of composite structure

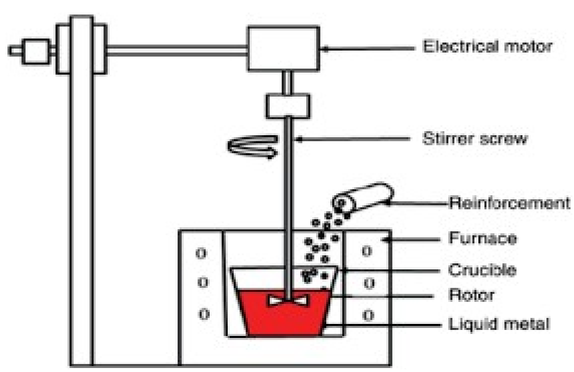



Figure 1.1 stir casting

In this process, the matrix material are kept in the bottom pouring furnace for melting. Simultaneously, reinforcements are preheated in a different furnace at certain temperature to remove moisture, impurities etc. After melting the matrix material at certain temperature the

mechanical stirring is started to form vortex for certain time period then reinforcements particles are poured by the feeder provided in the setup
at constant feed rate at the center of the vortex, the stirring process is continued for certain time period after complete feeding of reinforcements particles. The molten mixture is then poured in preheated mold and kept for natural cooling and solidification.

- **SQUEEZE CASTING:**

Squeeze casting is an important option for casting designs with thick-mass sections, mostly used for aluminum and magnesium alloys. There are two types of squeeze casting processes: direct and indirect squeeze casting. In both types of the processes, molten metal is introduced to casting cavities with minimum turbulence and solidifies under very high pressure (typically above 100 MPa) within closed dies.

***Direct squeeze casting***

Direct squeeze casting (DSC) is also termed liquid metal forging. The DSC process consists of metering liquid metal into a preheated, lubricated die and forging the metal while it solidifies. The pressure is applied shortly after the metal begins to freeze and is maintained until the entire casting has solidified. Casting ejection and handling are done in a similar way as in closed die forging.

***Indirect squeeze casting***

While direct squeeze casting is generally performed on a vertical machine (similar to a forging press), indirect squeeze casting (ISC) is more akin to conventional high pressure die casting, using both vertical or horizontal machines. During indirect squeeze casting, molten metal is transferred to the shot sleeve, and then injected into the die cavity through relatively large gates and at relatively low velocity (usually under 0.5 m/sec.). Melt in the die cavity is then solidified under high pressure "indirectly" applied by the plunger through the large gating system. Fig. 8 compares the metal flow in conventional die casting and indirect squeeze casting process . The reduced inject speed in the ISC process promotes the planar filling of the metal front within the die cavity, and thus eliminating entrapped gases in the castings.

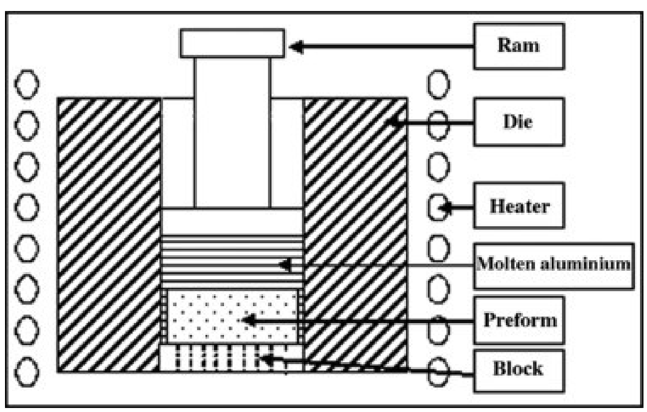



Figure 1.2 squeeze casting

- **VAPOR DEPOSITION METHOD**

Vapor deposition or evaporation involves the heating of precursor powders under a high vacuum until the vapor pressure is sufficient to coat a substrate suspended above the evaporation sources. Early reports document the use of the simultaneous evaporation (coevaporation) of both the organic halide compound and the lead halide precursors to form perovskite films without a solvent. Since then, considerable efforts have led to the development of sophisticated, vapor-based deposition methods, including solar cells that are fully processed under vacuum. Apart from the obvious advantage of being able to scale this deposition method easily, vapor deposition allows a much greater control of film thickness and more uniform film morphology. There are also inherently fewer impurities associated with evaporating materials in a high or moderate vacuum without solvents. A hybrid between vapor and solution processing known as vapor-assisted solution processing (VASP) has been reported, in which the inorganic metal halide is deposited via solution (or vapor) before the film is exposed to the organic halide vapor. In addition, alternative deposition methods that do not require such low vacuum levels such as chemical vapor deposition (CVD) have been reported, which could lower the inherent cost barrier to vacuum-based processing.

- **POWDER METALLURGY**

Powder metallurgy is a metal-forming process performed by heating compacted metal powders to just below their melting points. Although the process has existed for more than 100 years, over the past quarter century it has become widely recognized as a superior way of producing high-quality parts for a variety of important applications. This success is due to the advantages the process offers over other metal forming technologies such as forging and metal casting, advantages in material utilization, shape complexity, near-net-shape dimensional control, among others. These, in turn, contribute to sustainability, making powder metallurgy a recognized green technology

## 1.2 COMPOSITE MATERIAL CUTTING

Composite materials are more difficult to machine than metals mainly because they are anisotropic, non-homogeneous and their reinforcing fibres are very abrasive. During machining, defects are introduced into the workpiece, and tools wear rapidly. Traditional machining techniques such as drilling or sawing can be used with proper tool design and operating conditions. A review of traditional machining methods applied to organic and metal matrix composites is presented in this article. The use of non-traditional machining methods such as waterjet, laser and ultrasonic machining will be discussed in the second part.

A composite materials is very hard when compared with other metals so it is difficult to machine them. Machining of composite materials is difficult due to the heterogeneity and heat sensitivity of the material and the high abrasiveness of the reinforcing fibres. This results in damage being introduced into the workpiece and very high tool wear.. Here new methods are considered: laser, waterjet, electro-discharge, electro-chemical spark, and ultrasonic machining. These various techniques have been applied to organic matrix composites with aramid, glass, graphene fibre reinforcement but also to metal matrix and ceramic matrix composites.

**TRADITIONAL METHODS**

1. Diamond saw cutting
2. Wire saw cutting
3. Abrasive wheel cutting
4. Mechanical mounting

**NON TRADITIONAL METHODS**

1. laser machining
2. water jet machining
3. ultrasonic machining
4. wire electric discharge machine

5. laser beam machining
6. abrasive water jet machining

## 1.3PROCESS PARAMETERS OF WIRE EDM MACHINE

| PARAMETERS | RANGE |
|---|---|
| 1. Current | 10A-11A |
| 2. Pulse on time | 100µs-110µs |
| 3. Pulse off time | 50µs constant |
| 4. Wire feed rate | 1-3mm/min |

## 1.4OBJECTIVE

Thus our objective is to perform the experiments to minimize the kerf width and to increase the cutting speed during the machining process. The kerf width of the material can be calculated by using an optical microscope and the cutting speed can be determined directly on the display of the wire EDM machine. We need to find out the best piece among all of them which have the lowest kerf width value and which have the highest cutting speed.

There are many machining parameters affecting the wire EDM machine performance and the real mathematical models between machining performance and machining parameters are not easy to be derived because of the complex machining mechanism . The objectives are as follows:-

1. To achieve the shortest machining time whilst at the same time satisfying the requirements of accuracy and surface roughness.
2. To discuss the cause – effect relationship of machining parameters & machine performance in WEDM
3. To determine significant parameters affecting the machining performance. Finally the optimal machining parameters are obtained under the constraints & requirements.

# CHAPTER 2
# LITERATURE REVIEW

# 2.LITERATURE REVIEW

The literature review focused on relevant studies published in the last few years, and included both pre-reviewed and literature. Aluminum based composite materials related databases were searched with the help of key words such as ‘aluminum composite’, ‘wire EDM’ ‘stir casting’ ‘process parameters’ the review concentrated on varying the input parameters and finding out the resultant output parameters of the taken aluminium hybrid metal matrix composite

The data we collected is based on the papers published by S.Suresh Kumar,F.Erdemir, Temel Varol, S.tirumalai Kumaran, M.Uthayakumar, Aykut Canakci. They have prepared papers on aluminum based composites like aluminum with silicon carbide, with B4C, with titanium etc. based on the previous data by searching the keywords mentioned above we have prepared aluminum composites using graphene and carbon nanotubes

The aim of this project by Lee et al. was to study the effect of machining parameters in EDM of tungsten carbide on the machining characteristics. The characteristics of EDM refer essentially to the output machining parameters such as material removal rate (MRR). The machining parameters are the input parameters of the EDM process namely peak current, pulse duration, pulse interval.

By referring to the previous databases similar to this type of project we came to know that all composite materials combined with aluminum effects the physical and chemical properties such as hardness and stiffness etc. so we have referred to some of the projects based on the same theory below are some of the databases which we have referred to.

- Zhao et al. have applied WEDM process for cutting the crystal SiC and compared their performance with SKD11 material. It reveals that the material removal by WEDM process is higher for SiC and also it is a suitable alternative for cutting hard ceramic material.
- Ram Prasad et al. have investigated the machinability characteristics of Ti alloy through WEDM process. The significance of each parameter and their effect on metal removal and surface texture was measured.
- . Prashantha et al. have evaluated the performance of WEDM on Al 6061 alloy reinforced with SiC metal matrix composite at varying process parameters. The experimental study focused on the influence parameters of the material removal process with the change in machining conditions and reinforcement contents. The inclusion of SiC content in the Al composite significantly affects the material removal rate.
- . Karabulut et al. have done an experimental analysis of Al 6061 alloy based composite reinforced with varying contents of B4C particles. The results revealed that the surface finish of the composite materials, mostly affected by the peak current and voltage. An increase in the peak current decreases the surface finish and decrease in the voltage improves the surface characteristics.
- Shayan et al. have studied the effect of parameters on the performance of dry wire EDM on cemented tungsten carbide. They also formulated the modelling and predicted the experimental results and compared

Some of the keywords which we have used while referring to the databases

- Aluminum alloy
- Composite material
- Hybrid metal matrix
- Wire EDM
- Stir casting

**Aluminum:**

Aluminium is the world's most abundant metal and is the third most common element comprising 8% of the earth's crust. The versatility of aluminium makes it the most widely used metal after steel.

**Production of Aluminium:**

Aluminium is derived from the mineral bauxite. Bauxite is converted to aluminium oxide (alumina) via the Bayer Process. The alumina is then converted to aluminium metal using electrolytic cells and the Hall-Heroult Process.

**Annual Demand of Aluminium:**

Worldwide demand for aluminium is around 29 million tons per year. About 22 million tons is new aluminium and 7 million tons is recycled aluminium scrap. The use of recycled aluminium is economically and environmentally compelling. It takes 14,000 kWh to produce 1 tonne of new aluminium. Conversely it takes only 5% of this to remelt and recycle one tonne of aluminium. There is no difference in quality between virgin and recycled aluminium alloys.

**Applications of Aluminium:**

Pure aluminium is soft, ductile, corrosion resistant and has a high electrical conductivity. It is widely used for foil and conductor cables, but alloying with other elements is necessary to provide the higher strengths needed for other applications. Aluminium is one of the lightest engineering metals, having a strength to weight ratio superior to steel.

By utilising various combinations of its advantageous properties such as strength, lightness, corrosion resistance, recyclability and formability, aluminium is being employed in an ever-increasing number of applications. This array of products ranges from structural materials through to thin packaging foils.

**Mechanical Properties of Aluminium:**

Aluminium can be severely deformed without failure. This allows aluminium to be formed by rolling, extruding, drawing, machining and other mechanical processes. It can also be cast to a high tolerance.

**Aluminum Graphene Composites:**
Graphene has been reported to be a promising nanofiller in fabricating advanced metal matrix composites.

**Methods:**
Graphene nanosheets (GNSs) have been incorporated into an aluminium matrix composite using mechanical milling and hot pressing in the current study.

**Mechanical Properties:**
It is observed that graphene reinforced composite exhibit superior ultimate tensile strength compared to unreinforced pure aluminium. Nearly 46% improvement in the ultimate tensile strength is noticed compared to pure aluminum.

**Aluminum Carbon nanotube composite:**
Carbon nanotubes are nano materials, which are gaining popularity as good reinforcements due to their distinctive properties. CNTs are attractive reinforcement materials for metal matrix composites not only due to their high strength and elastic modulus, but also due to their exceptionally small diameters. This is because, when the same weight of CNTs is contained in composites, the number of CNTs in composite increases as the diameter of CNTs becomes smaller. And, when the CNTs are uniformly dispersed in the composites, the respective matrix domains enclosed by the CNTs become extremely small. It is expected that the Aluminum composites with carbon nanotubes reinforcement would possess better tensile and compressive properties compared to pure Aluminum. The hardness of the obtained composites is also expected to be greater than that of pure aluminum.

The Al-CNT composite is found to be affluent in improving the mechanical properties such that even for a small amount of CNT addition the response ineffective. The improvement in strength primarily depends on the dispersive phenomenon of CNTs and the bonding between the reinforcement (CNT) and matrix. The improvement in mechanical properties of Al-CNTs also depends upon nature of processing techniques, microstructure, grain size, amount and type of reinforcement. Powder metallurgy (PM) technique is the preferred route for most researchers due to most common and cheaper production route for composite fabrication and characterized by good dimensional and geometrical precision as well as good mechanical properties. Using PM process several properties of composite can be improved such as hardness, wear resistance, mechanical durability, thermal durability, and thermal conductivity with decreased density of the material. With this improvement in nanocomposite properties, the material exhibited better quality and can be used in many applications whereby demand of quality and less material are high especially in automotive and aerospace applications.

Powder metallurgy and ingot melting route can be subdivided into four different methods. A composite produced by powder metallurgy route has significant influence on strength enhancement owing to fine grain size obtained by powder metallurgy route when compared with liquid phase processing. The problem of defects persists since it is difficult to avoid agglomeration of CNTs, undesirable interfacial reactions and possible damages that may occur to CNTs while adopting conventional methods of fabrication. Powder metallurgy leads to the uniform dispersion of CNTs composites associated least defects. The produced composite will have combined properties of its constituting elements, and this is the main reason behind the development and success of MMC manufacturing since the type and amount of the constituents of the composite could easily be altered to obtain the desired properties of the new product.

# CHAPTER 3
# COMPOSITE MATERIAL PREPARATION

# 3.COMPOSITE MATERIAL PREPARATION

Aluminum with graphene and carbon nanotubes are fabricated and formed as a material.The process used here to fabricate is **stir casting route** because it is cheap and can produce more than any other method. First the aluminum is heated to a certain temperature until it melts and attains molten form the temperature required to melt is 1000°c-1200°c . Then the composites graphite and carbon are previously preheated to a certain temperature and then they are added to the aluminum alloy after adding the whole composite stirring must be done to mix all the composites perfectly and to attain dispersion of all the particles uniformly. Various materials are created based on the composition of graphite used we have considered here the composition of graphite as (0%,5%,10%).

## 3.1COMPOSITE MATERIAL:

**composite material**, also called **composite**, a solid material that results when two or more different substances, each with its own characteristics, are combined to create a new substance whose properties are superior to those of the original components in a specific application. The term composite more specifically refers to a structural material within which a fibrous material is embedded.

## 3.2 TYPES OF COMPOSITES

Some common composite materials include:

- **Ceramic matrix composite:** Ceramic spread out in a ceramic matrix. These are better than normal ceramics as they are thermal shock and fracture resistant
- **Metal matrix composite**: A metal spread throughout a matrix
- **Reinforced concrete**: Concrete strengthened by a material with high tensile strength such as steel reinforcing bars
- **Glass fibre reinforced concrete**: Concrete which is poured into a glass fibre structure with high zirconia content
- **Translucent concrete**: Concrete which encases optic fibres
- **Engineered wood**: Manufactured wood combined with other cheap materials. One example would be particle board. A speciality material like veneer can also be found in this composite
- **Plywood**: Engineered wood by gluing many thin layers of wood together at different angles
- **Engineered bamboo**: Strips of bamboo fibre glued together to make a board. This is a useful composite due to the fact it has higher compressive, tensile and flexural strength than wood
- **Parquetry**: A square of many wood pieces put together often out of hardwood. It is sold as a decorative piece
- **Wood-plastic composite**: Either wood fibre or flour cast in plastic
- **Cement-bonded wood fibre**: Mineralised wood pieces cast in cement. This composite has insulating and acoustic properties
- **Fibreglass**: Glass fibre combined with a plastic which is relatively inexpensive and flexible

- **Carbon Fibre reinforced polymer**: Carbon fibre set in plastic which has a high strength-to-weight ratio
- **Sandwich panel**: A variety of composites that are layered on top of each other
- **Composite honeycomb**: A selection of composites in many hexagons to form a honeycomb shape.
- **Papier-mache**: Paper bound with an adhesive. These are found in crafts
- **Plastic coated paper**: Paper coated with plastic to improve durability. An example of where this is used is in playing cards
- **Syntactic foams**: Light materials created by filling metals, ceramics or plastics with micro balloons. These balloons are made using either glass, carbon or plastic

## 3.3 USES OF COMPOSITE MATERIALS:

Composite materials have been introduced into almost every industry in some form or fashion. We shall look at some of the advantages of using composites and discuss some of the industries that have made used of these materials. The wide range of property values attained with composites and the ability to tailor the properties is an advantage. Composite materials also generally have higher strength- and modulus-to-weight ratios than traditional engineering materials. These features can reduce the weight of a system by as much as 20 to 30%. The weight savings translates into energy savings or increased performance. Advanced composites exhibit desirable dynamic properties and have high creep resistance and good dampening characteristics. In fact, the superior fatigue performance of composite materials enables them to be used to repair metallic airframes with fatigue damage.

Since composite materials can be manufactured into almost any shape, they allow great design flexibility and offer reduced parts count for articles. The opportunity to select the constituents, tailor them to obtain the required properties, and then through design make the optimum use of the properties is a situation that makes composites very attractive to many industries. The matrix polymer can impart great chemical and corrosion resistance to composites. The transportation industry has made extensive use of composite materials. The light weight and high strength and the ability to easily manufacture aerodynamic shapes have resulted in lower fuel costs. The lack of corrosion of the materials and the low maintenance cost have reduced the cost of ownership and extended the service life of many parts and products. Examples of products in this industry include auto and truck bodies and parts, trailers, tanks, special-purpose vehicles, and manufacturing equipment.

Composites have added new dimensions to the design and construction of buildings. Their ease of manufacture, light weight, high strength, low maintenance, decorativeness, and functionality have had a significant impact on the industry. New-construction time has been reduced and more flexibility has been added to the design of structures.

Composite materials affected the marine industry very early in their development, and their influence continues to grow. Lack of corrosion, low maintenance, and design flexibility have contributed to the acceptance of composites. The ease of fabricating very large and strong articles in one piece has been another. In addition to pleasure boats, large military and commercial boats and ship hulls have been fabricated. Large tanks for fuel, water, and cargo have been used aboard ships. Composites have made the greatest impact in the sporting goods industry, replacing traditional materials at a revolutionary pace. Applications such as golf club shafts, fishing poles, tennis rackets, skiing equipment, boating applications, and many other sports equipment products are now produced almost exclusively using advanced composites. In most cases, the change in material has translated into an improvement in performance or safety for participants.

The aerospace and military markets are the two areas that have accounted for the largest effort in the development and advancement in composite technology. The need for stronger, stiffer, and lighter structures was an opportunity for composite materials to demonstrate their superiority over more commonly used materials. Durability and low maintenance are additional assets. These increase the service life and reduce the cost of maintaining systems. The development of new and the improvement of existing fabrication processes have brought about a reduction in manufacturing cost. There have been reductions in the number of parts required to construct some components by using molding and composite materials. The unique features of composites have enabled designers to formulate advanced systems that could be made only of composite materials. New military aircraft almost exclusively utilize advanced composites for structure. Rocket motor cases, nozzles, and nose cones are missile applications. Radar domes, rotor blades, propellers, and many secondary structure components such as fairings, doors, and access panels are also fabricated from advanced composites. Numerous pressure vessels, armaments, and items of space hardware are made of selected composite materials.

The use of composite materials will continue to grow. As more engineers come to understand composites, more opportunities will be recognized for their use. As the use of composites increases, more developments will take place in the areas of constituent materials, analysis, design, and fabrication. Composite materials offer tremendous for tailorability, design flexibility, and low-cost processing with low environment impact. These attributes create a very bright future composite materials.

## 3.4 COMPOSITE PREPARATION USING STIR CASTING:

Stir casting is the best method for preparation of a composite materials because it can distribute the materials which we have taken uniformly. Here we are going to heat the aluminum alloy upto 1200C until it gets into molten form and then while the aluminum is heating we need to heat the other materials. Dimensions of the materials to be fabricated are 192x100x24mm. The materials considered here are

- Grapheme
- Carbon nano-tubes

Now we have to preheat graphene and carbon nano-tubes while aluminum is heating and add it to stir casting machine to mix all the three materials. By this the hardness of the formed material increases with the increase in the percentage of the composition adding. Therefore selection of stirring parameters plays major role in stir casting process. Stirring speed, stirring time, impeller blade angle, size of impeller and position of impeller are major parameters, affecting the distribution of the reinforcements in the matrix

We have considered here a total of 13 materials which are mentioned below

| S.NO | MATERIAL | COMPOSITION |
|---|---|---|
| 1 | PURE Aluminum | 100 |
| 2 | Cn1 | 10/50 |
| 3 | Cn2 | 20/100 |
| 4 | Cn3 | 30/150 |
| 5 | Cn4 | 40/200 |
| 6 | Gr1 | 10/50 |
| 7 | Gr2 | 20/100 |
| 8 | Gr3 | 30/150 |
| 9 | Gr4 | 40/200 |
| 10 | H1 | 10/50 |
| 11 | H2 | 20/100 |
| 12 | H3 | 30/150 |
| 13 | H4 | 40/200 |

NOTATIONS

- Cn- Carbon nanotube
- Gr- Graphene
- H- Hybrid

## ALUMINUM WITH CARBON NANOTUBES:

The material is prepared using composition as mentioned in above table. By considering it we'll fabricate four pieces naming them as Cn1, Cn2, Cn3, Cn4.
The weights composition of  the materials are as 10/50, 20/100, 30/150, 40/200


Figure3.1 aluminum with carbon nanotube composite material

## ALUMINUM WITH GRAPPHENE:

In here we have mixed aluminum with graphene by varying the compositons and fabricatd 4 materials by naming them as Gr1, Gr2, Gr3, Gr4  and the wight compostions of these materials are 10/50, 20/100, 30/150, 40/200. The obtained pieces afer stir cating process are shown below.


**Figure3.2  aluminum with graphene material**

## ALUMINUM WITH BOTH GRAPHENE AND CARBON NANOTUBES


Figure3.2  aluminum with hybrid material

The material is prepared by adding both the graphene and carbon nanotubes so it is known as hybrid metal matrix composite. The compositions of the hybrid materials are 10/50, 20/100, 30/150, 40/200. After preparing these materials using stir casting machining must be done so in this project we use wire EDM machine because it is accurate and can machine complex shapes with ease and very less time taking than other machines.

# CHAPTER 4
# MACHINING ON WIRE EDM

# 4.MACHINING ON WIRE EDM

The machine we are using to cut the material is wire EDM. This is a non-traditional process and can cut complex shapes easily. We fix the work piece inside the wire EDM machine and cut the work piece into desired shape by changing the parameters such as current , pulse on time , pulse off time , wire feed rate. We change the parameters for each 15mm distance on the work piece and note the cutting speed which is already present on the display of the machine. After cutting the piece using parameters we need to use optical microscope to calculate the kerf width in mm.

The machine we used to cut the hybrid metal matrix material is Wire EDM. The input process parameters involved in machining process are varied and the output parameters were founded. After the completion of the composite we have taken the material and fitted it in the machine and by varying different input parameters on the machine the cutting is done in a specimen shape.

## 4.1 WIRE EDM MACHINE

Electrical discharge machining (EDM) is a manufacturing process that implements electrical sparks to form a metal shape. Because of these sparks, EDM is also sometimes referred to as spark machining. In this process, the desired shape is cut from the metal when current discharges, or sparks, occur between two electrodes; where the sparking occurs, cuts are made into the metal, creating the desired shape and detaching it from the metal sheet.

The basic electrical discharge machining process is really quite simple. An electrical discharge (spark) is created between two electrodes (solid electric conductors). The tool electrode is typically referred to as the electrode, and the work piece electrode as the work piece. The spark is visible evidence of the flow of electricity. This electric spark produces intense heat with temperatures reaching 8000 to 12000 degrees Celsius, melting/vaporizing almost any conductive material. These rapid, repeated electrical current discharges take place in a very small gap between the two electrodes, which never come in contact with each other. The spark gap (aka discharge gap, electrode gap) is maintained by adaptive machine controls to ensure a constant, stable distance as the electric discharge occurs up to millions of times per second.

Wire electrical discharge machining (WEDM) uses a metallic wire to cut or shape a work piece, often a conductive material, with a thin electrode wire that follows a precisely programmed path. Typically the electrode diameters range from .004″ – .012″ (.10mm – .30mm), although smaller and larger diameters are available.

During the wire cutting process there is no direct contact between the wire and the work piece which allows for machining without causing any distortion in the path of the wire, or the shape of the material. To accomplish this, the wire is very rapidly charged to a desired voltage. The wire is also surrounded by de-ionized water. When the voltage reaches the correct level, a spark jumps the gap and melts a small portion of the work piece. The de-ionized water cools and flushes away the small particles from the gap.

EDM cutting is always through the entire work piece. To start wire machining it is first necessary to drill a hole in the work piece or start from the edge. On the machining area, each discharge creates a crater in the work piece and an impact on the tool. The wire can be inclined, thus making it possible to make parts with taper or with different profiles at the top and bottom. There is never any mechanical contact between the electrode and work piece . The wire is usually made of brass or stratified copper, and is between 0.1

and 0.3 mm diameter.

Depending on the accuracy and surface finish needed, a part will either be one cut or it will be roughed and skimmed. On a one cut the wire ideally passes through a solid part and drops a slug or scrap piece when it is done. This will give adequate accuracy for some jobs, but most of the time, skimming necessary.

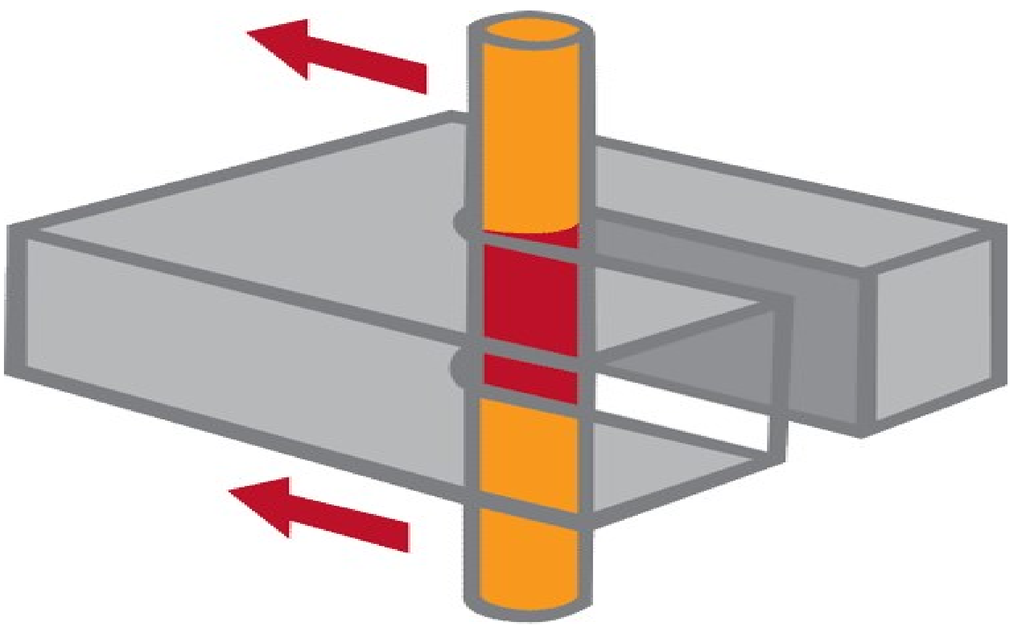


**Figure4.1 Wired EDM Cutting**

## 4.2 WIRED EDM MACHINE SPECIFICATIONS :

SPECIFICATIONS:

Model

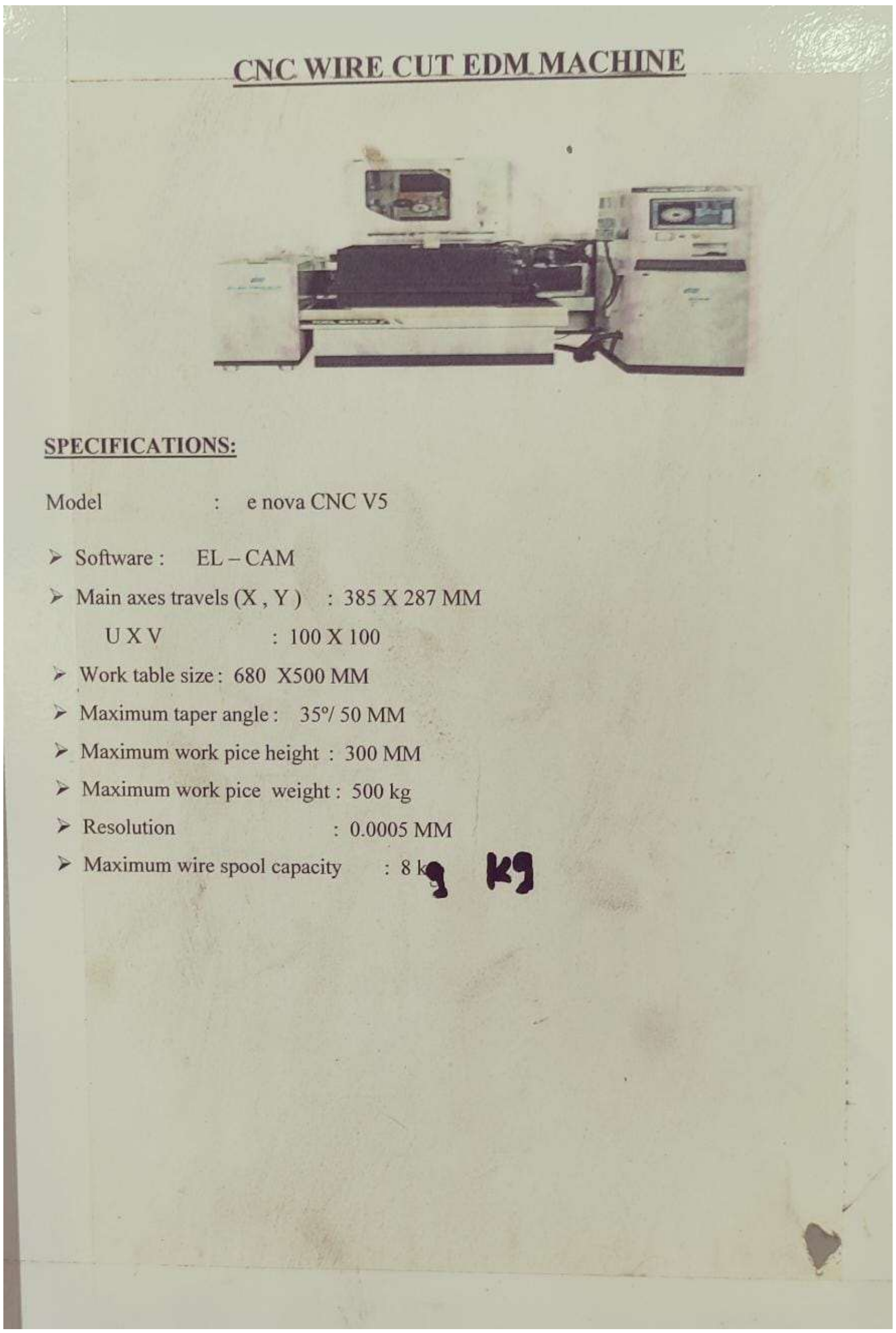
- Software: e nova CNC VS

EL-CAM Main axes travels (X, Y): 385 X 287 MM

UXV : 100 X 100

- Work table size: 680 X500 MM
- Maximum taper angle: 35°/ 50 MM

- Maximum work piece height: 300 MM
- Maximum work piece weight: 500 kg
- Resolution : 0.0005mm
- Maximum wire spool capacity : 8kg



CNC WIRE CUT EDM MACHINE

SPECIFICATIONS:

Model : e nova CNC V5

- Software : EL – CAM
- Main axes travels (X , Y ) : 385 X 287 MM
  U X V : 100 X 100
- Work table size : 680 X500 MM
- Maximum taper angle : 35°/ 50 MM
- Maximum work pice height : 300 MM
- Maximum work pice weight : 500 kg
- Resolution : 0.0005 MM
- Maximum wire spool capacity : 8 kg kg

Figure4.2 ENOVA CNC V5 machine

## 4.3 WIRE EDM CUTTING PROCESS

The composite produced were having the varying weight contents of reinforcements. The hybrid composites were prepared with Al, Gr , Cn into the composite. The produced composites were exposed to cutting using WEDM process with varying machining conditions such as current, pulse on time, wire feed rate and content of B4C particles. The machining characteristics considered for the evaluation study were cutting speed and kerf width. The schematic diagram shows the process of fabrication and the experimental procedures are shown. The experimental details of the machining process are shown. The experiments were carried out by varying the process parameters on each composite material. The kerf width after cutting at varying machining conditions can be measured by using an optical microscope read in a millimeter scale. The cutting speed can be easily measured during the machining process itself, which is displayed in the control panel of the EDM machine. On the other hand, it indicates the rate of metal removal during WEDM process.

The machine used for cutting the composite material is as shown in figure which is available at CIPET college.


Figure 4.3 wire EDM machine

- The 13 materials are fixed in the machine and using the various parameters mentioned above cutting must be done
- The process must be done for every piece varying the input parameters and while machining the Material we must note down cutting speed simultaneously
- The values obtained for each material are noted and compared each other for the best material with least kerf width and highest cutting speed
- The material with the above conditions is considered to be the best material among all the materials

The results of the material after cutting the material are shown below. The material is first machined into small pieces and then the specimen is machined on those small pieces by varying parameters at each 15mm.


Figure4.4 cutting of material

The machining of the  material is as shown in figure and the material is fixed as shown in the figures

After the cutting of material we need to cut into specimen shape and the figures of the resultant pictures after cutting while and after are shown below.

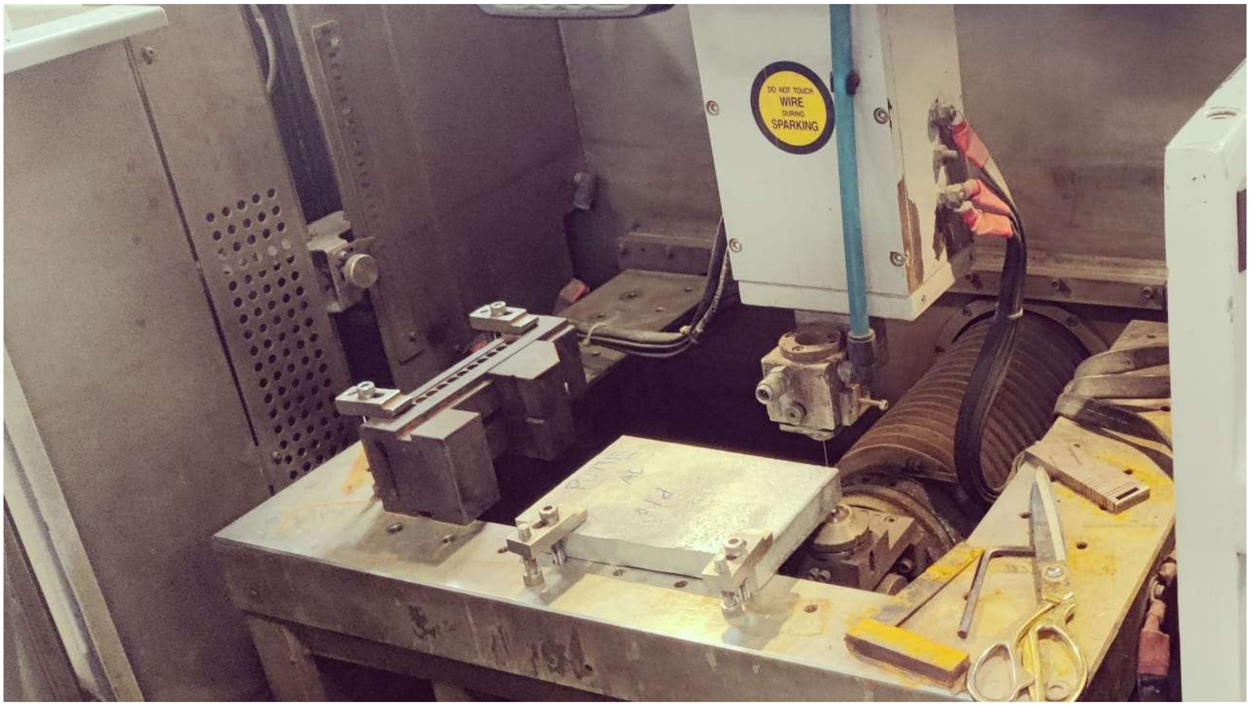



Figure4.5 fixing of material

## 4.4 WIRE EDM SPECIMEN CUTTING:

The specimen with desired shape and dimensions are machined and the length of the raw material is 192mm and the width is 100mm and thickness is 24mm. The specimen is to be of 100mm length, width of 10mm and thickness of 6mm are machined here in this step. The samples after the cutting is done are shown below.

- First we need to design the shape of the specimen in the software and load it into enova machine
- Then fix the material in the machine and machined using the machine until the end make sure to leave a distance of 1mm at the end
- It’s for making sure to fix the work piece together for measuring the kerf width and cutting speed

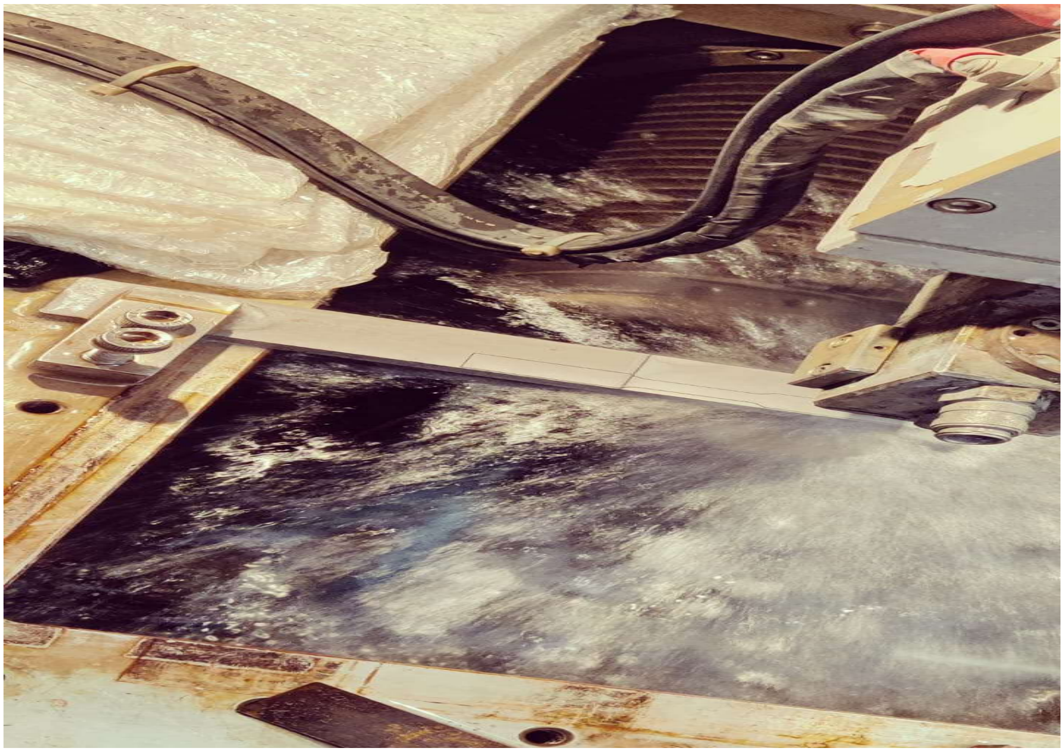
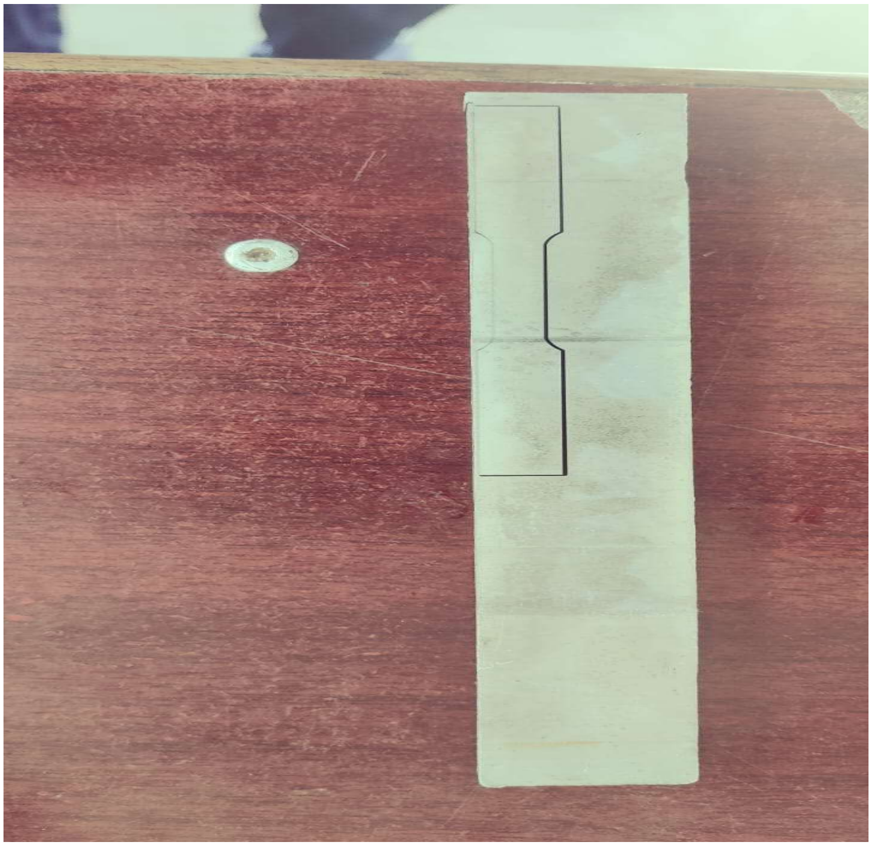
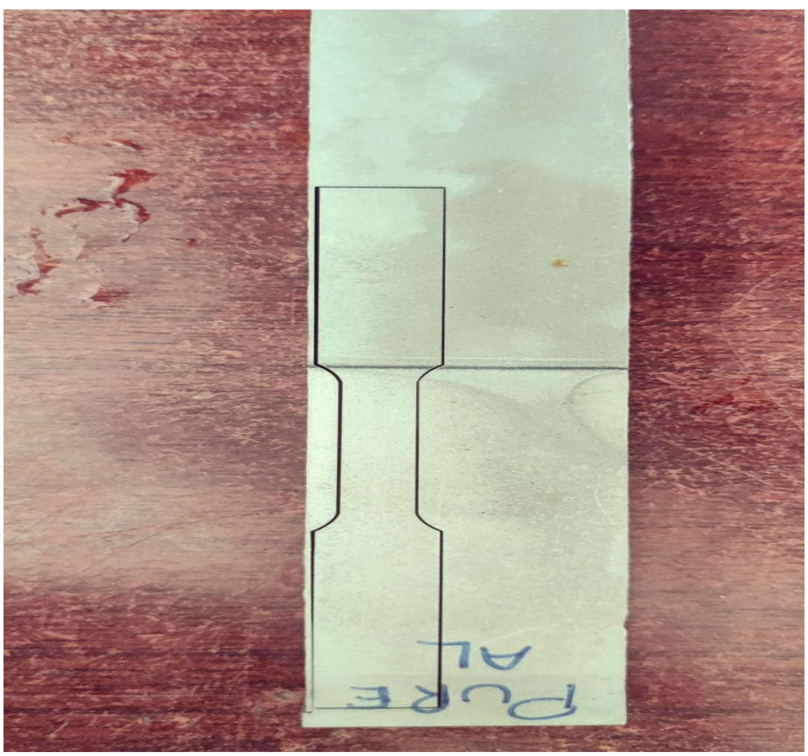


Figure4.6 while cutting specimen shape

Figure4.7 after cutting  raw material



Figur4.8e cutting specimen



## 4.5 WIRE EDM MACHINING COMBINATIONS:

Here we have kept the current as constant value and changed the values of pulse on time, pulse off time, wire feed rate. By changing these values at each level and cutting the material we have determined the output parameters. The combinations of varying input parameters are as shown below.

| SNO | PEAK CURRENT(A) | PULSE ON TIME(µs) | PULSE OFF TIME(µs) | WIRE FEED RATE(MM/MIN) |
|---|---|---|---|---|
| 1 | 10 | 100 | 50 | 1 |
| 2 | 10 | 105 | 50 | 2 |
| 3 | 10 | 110 | 50 | 3 |
| 4 | 11 | 100 | 50 | 1 |
| 5 | 11 | 105 | 50 | 2 |
| 6 | 11 | 110 | 50 | 3 |
| 7 | 12 | 100 | 50 | 1 |
| 8 | 12 | 105 | 50 | 2 |
| 9 | 12 | 110 | 50 | 3 |

# CHAPTER 5
# CONCLUSION

# 5.CONCLUSION

Aluminum is the cheapest and the best available metal which can be used in automobile application but aluminum is not strong enough to withstand some applications such as engine cylinders etc. to develop and increase the properties of aluminum we have to add some composite materials with aluminum. This project concludes that aluminum based metal matrix composites which are formed using graphene and nanotubes are stronger than normal aluminum alloy to find and prove it practically we have considered various input parameters as our references and found out the output parameters

The metal composite with the best output parameters such as less kerf width and high cutting speed are considered as the best material among all the materials we have taken aluminum with graphene and carbon nanotube of 5% has obtained least kerf width of 0.2967 and highest cutting speed of 4.97mm/min of the input parameter values at current 12A, pulse on time 110µs,wire feed rate of 3mm/min

- The enhanced mechanical and physical properties of the composite were obtained with an increase in the Carbon and Graphene content.
- The influence of each machining parameter of the WEDM process on the kerf width and cutting speed is determined.
- The mathematical model was determined and the statistically significance test was made and it was fit to the experimental results.

# CHAPTER 6
# REFERENCES

## 6.REFERENCES


1. D. Philip Selvaraj, P. Chandermohan, Optimization of surface roughness of AISI 6061 Austentic stainless steel in dry turning operation using Taguchi method, Journal Of Engineering Science And Technology, 2010, 5, 293-301

2. S. Prashantha, R.B. Veeresha, S.M. Shashidhara, U.S. Mallikarjun, A.G.S. Siddaramaiah, A study on machining characteristics of Al6061-Gr metal matrix composite through wire e cut electro discharge machining, Mater Today Proc. 4 (2017) 10779.

3. R.K. Fard, R.A. Afza, R. Teimouri, Experimental investigation, intelligent modeling and multi-characteristics optimization of dry WEDM process of Ale-Cn metal matrix composite, J. Manuf. Process. 15 (4) (2013 Oct 1) 483e494.

4. R.B. Azhiri, R. Teimouri, M.G. Baboly, Z. Leseman, Application of Taguchi, ANFIS and grey relational analysis for studying, modeling and optimization of wire EDM process while using gaseous media, Int. J. Adv. Manuf. Technol. 71 (1e4) (2014 Mar 1) 279e295.

5. A.V. Shayan, R.A. Afza, R. Teimouri, Parametric study along with selection of optimal solutions in dry wire cut machining of Hybrid Metal matrix, J. Manuf. Process. 15 (4) (2013 Oct 1) 644e658.

.

6. P. Shandilya, P.K. Jain, N.K. Jain, Parametric optimization during wire electrical discharge machining using response surface methodology, Process Eng. 38 (2012) 2371.

7. Kumar, V. Kumar, J. Kumar, Investigation of machining parameters & surface integrity in wire electric discharge machining of pure Aluminum, Proc. Inst. Mech. Eng. B J. Eng. Manuf. 227 (2013) 972.

8. J. Qu, A. Shih, R. Scattergood, Development of the cylindrical wire electrical discharge machining process. Part 1, Concept, design, and material removal rate, Trans. ASME 124, 2002, 702–707

9. Y. H. Huang, G. G. Zhao, Z. R. Zhang, C. Y. Yu, The identification and its means of servo feed adaptive control system in WEDM, CIRP Ann. Manuf. Technol. 35 (1), 1986, 121–123

10. J. K. Kozak, P. Rajurkar, S. Z. Wang, Material removal in WEDM of Carbon Nano Tubes, Trans. ASME, J. Eng. Ind. 116, 2002, 363– 369

11. Puertas, C. J. Luis, Modeling the manufacturing parameters in electrical discharge machining of Composite material, Proc. Inst. Mech., J. Eng. Manuf. 217 (Part B), 2003, 791–803