MECHANICAL PROPERTIES OF NEWLY DEVELOPED POLYMER MATRIX COMPOSITE – WIRE ELECTRIC DISCHARGE MACHINE(WEDM)

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BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY (PROCESS AND TECHNOLOGY)

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Faculty of Mechanical and Manufacturing Engineering Technology

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A thesis submitted
in fulfillment of the requirements for the degree of
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2021

DECLARATION

I declare that this thesis entitled "Mechanical Testing Of Newly Developed Metal Matrix Composite – Wire Electric Discharge Machine (WEDM) Waste" is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : --

Name : MOHAMMAD AIDIL AZREEM BIN IBRAHIM

Date : 20/1/2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Manufacturing Engineering Technology (Process and Technology).

Signature :

Supervisor Name : TS. DR. SYAHRUL AZWAN BIN SUNDI@SUANDI

Date : 20/1/2022

DEDICATION

Dedicated to

my beloved father, Ibrahim Bin Yaakub

my precious mother, Azizah Binti Ahmad

my supervisor En. Syahrul Azwan Bin Sundi@Suandi

Thank You So Much

ABSTRACT

The recycling of scrap metal chips has become more significant in recent years, owing to the rising prices of raw materials and energy. The goal of this study is to create laminar composites by mixing epoxy resin with wire electrodes from electro-deposition machines (EDM). The goal of this research is to create specimens that can be used to investigate the changes that occur in wire electrodes after they have been subjected to the discharge process. The findings of the research and the information gathered may be compared to the results of the new wire electrodes. The aim of this reserach is to anaylise mechanical properties of new and used electrode wire EDM electrode.

ABSTRAK

Sejak kebelakangan ini, kitar semula sisa serpihan logam menjadi sangat penting kerana masalah bahan mentah dan kos tenaga. Penyelidikan ini bertujuan untuk membuat komposit laminar dengan menggabungkan epoxy resin dan elektrod dawai dari mesin EDM. Ini bertujuan untuk menghasilkan spesimen untuk menkaji perubahan yang berlaku pada elektrode dawai yang telah menjalani proses pelepasan. Hasil kajian yang dilakukan dan data yang dikumpul boleh dijadikan perbandingan dengan elektrode dawai yang baru. Kajian ini bertujuan untuk medapatkan cara baharu dan terbaik dalam proses kitar semula elektrode dawai terutamanya elektrode dawai dari bahan iaitu tembaga.

ACKNOWLEDGEMENTS

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LIST OF SYMBOLS AND ABBREVIATIONS

EDM	-	ELECTRO DISCHARGE MACHINE
PMC	-	POLYMER MATRIX COMPOSITE
WEDM	-	WIRE ELECTRO DISHARGE MACHINE
	-	
	-	
	-	
	-	

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Manufacturing is an undoubtedly significant industry for a large number of industrially growing nations, since it is critical for employment and income generation. Manufacturing benefits the economy via synergies with other industries such as mining, trade, supply chain management, finance, and even services. It has the ability to significantly advance various economic and social goals, including job creation, poverty eradication, improved living standards, and more seamless access to nutrition, healthcare, and education. Any progress toward these goals will be fleeting unless industry leaders and politicians commit to ensuring sustainable economic growth and development via an ecologically sustainable strategy that takes into account green manufacturing and its drivers in that economy (Seth et al., 2018). The machining of wire electrical discharge (WEDM) today is one of the most commonly recognized and implemented non-traditional methods in the industry.

When it comes to EDM operations, wire is a crucial component. For the majority of applications, brass wire is used to create the wire. Through the use of electrical discharge, a small portion of the item is heated to thousands of degrees. The dielectric is made of ionized gas or plasma that ballonizes when subjected to extreme pressure. The wire erodes a bit at that precise time, removing a little amount of metal from the area around the wire and forming a cut in the wire. When the wire electrode has been subjected to the discharge procedure once, it is customary to discard the wire electrode. As a result, the wire electrode will be considered waste material. The aim of this research is to investigate the mechanical characteristics that influence the material characterization of WEDM electrodes, as well as to determine the most appropriate technique for recycling.

1.2 Problem Statement

Due to scarcity of resources and population growth, environmental quality conservation has become critical. Environmental issues have harmed regional and global collaboration in several ways and have sometimes sparked warfare. As a result, engaging in green activities has become a must for resolving these problems. Even manufacturing processes are not exempt. EDM is a non-traditional kind of machining that has been extensively employed in industries to make moulds and dies. It is a really wide discipline that encompasses several study topics. The many challenges that may be investigated in EDM research include materials, process parameter optimization, EDM variations, automation, green production, and electrode manufacture. Modern enterprises place a high premium on the possibility of transitioning to "green production" in order to limit their negative environmental consequences to the greatest degree feasible. In many types of EDM, the dielectric fluid degrades with time, impacting not just the environmental balance by mixing with the soil and reducing its fertility, but also the economic effect due to the dielectrics' short-term usage. This serves as a signal to EDM manufacturers to search for environmentally acceptable dielectric materials (Kuriachen et al., 2015).

1. Waste is a by-product of human action that is the same physically as the substance in the useful product.

2. EDM screening challenges include materials, optimization of the parameters, EDM fluctuations, acceptable manufacturing of green electrodes.

3. Modern businesses who priced the electrode wire at a high price to get premium production to minimize adverse environmental effects.

4. The wire electrode is again unusable after being discharged in the production environment. The wire electrode of the WEDM is also seriously wasted.

1.3 Research Objective

The main aim of the research is to conduct a study about properties changes that take place on wire EDM waste from the material characteristic distribution. The mechanical features of this research have been studied with the measurements regarded as flexural testing and tensile testing.

a) To fabricate composite using new WEDM electrode and waste WEDM electrode

b) To validate the mechanical properties of the new WEDM electrode and waste WEDM electrode.

c) To evaluate the comparison of new WEDM with WEDM waste characterization.

1.4 Scope of Research

The scope of this research are as follows:

- Prepare and fabricate a sample from the WEDM electrode before and after electro discharge using a composite bond specimen.
- Speciment preparation process polymer matrix composite.
- Analysis carried out mechanical properties from the tensile and flexural testing of the composite .

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The purpose of this study is to determine the feasibility of using wire electrode made from wire cut machine (WEDM) waste in the manufacturing business. The purpose of this research is to analyses the various qualities of wire electrode waste from WEDM and to briefly describe the various types and uses of cable. Round wire, bought on a spool or reel, is always used as the electrode for wire cut machines. There is no need to evaluate the electrode's interaction with the machine. Only about half of the electrode diameter is worn when the wire travels through the sparking region. At first glance, it may look as if the wire wear pattern would allow for a reduction in the electrode wire size. This may result in cost savings and recyclability benefits for the manufacturing sector, in addition to the eco-efficiency and renewability of WEDM wire electrode waste.

2.2 Industrial Waste

The majority of human actions produce waste. Despite this, waste generation continues to be a significant source of worry, as it has been since prehistoric times (Ab Rahim et al., 2015). In recent years, both the pace and volume of garbage creation have increased. As the number of trash rises, the diversity of wastes rises as we. Unlike in prehistoric times, when wastes were just an annoyance that needed to be disposed of, proper management was not a huge concern since the population was tiny and the populace had access to a wide quantity of land at the time. During that time period, the ecosystem efficiently absorbed the level of garbage created without degrading it (Xiao et al., 2016).

The majority of industrialized nations have gone through a phase of environmental development. However, the majority of these nations have successfully handled the majority of the health and environmental challenges related with garbage creation. By contrast, the growing pace of urbanization and growth in developing economies has resulted in a recurrence of the same issues that developed nations have faced in the past. A critical issue in contemporary waste management is this meaning of waste. Waste is a byproduct of human activity that is physically identical to the material found in the beneficial product. Additionally, wastes have been described as any product or substance that is rendered worthless by the maker. (Xiong et al., 2020) said that wastes are items that people would wish to dispose of regardless of whether payment is needed. While waste is a necessary by product of human activity, it is also the consequence of inefficient manufacturing processes, the constant development of which results in a loss of valuable resources.

Waste arises in many different forms and its characterization can be expressed in several forms. Some common characteristics used in the classification of waste includes the physical states, physical properties, reusable potentials, biodegradable potentials, source of production and the degree of environmental impact. White (Amasuomo & Baird 2016), stated that waste can be classified broadly into three main types according to their physical states; these are liquid, solid and gaseous waste. Although it is clear that several classifications exists in different countries. The most commonly used classifications are illustrated in table 2.1.

Table 2.1 illustrated classification of waste (Amasuomo & Baird, 2016).

Physical state	Source Household/Domestic waste	Environmental impact
Solid waste	Industrial waste	Hazardous waste
Liquid waste	Agricultural waste	Non-hazardous waste
Gaseous waste	Commercial waste	
	Demolition and Construction waste	

Solid waste is formed during the procurement of raw materials, the refining and manufacturing processes, and during the consumption of goods by customers. Significant amounts are produced as a byproduct of agricultural and mining activities, as well as as leftovers from wastewater treatment and electrical power production. Hazardous wastes, on the other hand, need particular management or treatment to avoid significant damage to individuals or ecosystems. Along with solid waste, human activities create liquid and gaseous byproducts that often surpass the natural environment's capacity for assimilation. Regardless of the sort of trash being evaluated. Individuals, companies, and governmental agencies all have a duty to reduce waste creation, regulate hazardous waste emissions, recover material and energy resources from waste streams, and dispose of garbage in a manner that preserves human health and the environment (Shamsudin et al., 2016). As shown in Table 2.2, the changes in the characteristics of municipal solid waste 147 reflect the influence 148 of urbanization and development. Compostable materials 150 (40%–60%) and inerts (30%–50%) make up the majority of municipal solid trash in metropolitan areas. Organic waste's proportional proportion 151 of municipal solid trash is normally 152 growing with decreasing socioeconomic class; hence, rural households create more organic waste than urban households create 154. Additionally, it has been noted that the proportion of recyclable materials (paper, glass, plastic, and metals) is quite low (Gupta et al., 2015).

Table 2.2 it is observed that the differences in the municipal solid waste characteristics indicate the effect of urbanization and development (Gupta et al., 2015)

S. no.	Name of city	Population (as per 2001 census)	Area (sq. km.)	Waste quantity (TPD)	Waste generation rate (kg/cap/day)
1.	Kavaratti	10119	4	3	0.30
2.	Gangtok	29354	15	13	0.44
3.	Itanagar	35022	22	12	0.34
4.	Daman	35770	7	15	0.42
5.	Silvassa	50463	17	16	0.32
6.	Panjim	59066	69	32	0.54
7.	Kohima	77030	30	13	0.17
8.	Port Blair	99984	18	76	0.76
9.	Shillong	132867	10	45	0.34
10.	Shimla	142555	20	39	0.27
11.	Agartala	18998	63	77	0.40
12.	Gandhinagar	195985	57	44	0.22
13.	Dhanbad	199258	24	77	0.39
14.	Pondicherry	220865	19	130	0.59
15.	Imphal	221492	34	43	0.19
16.	Aizwal	228280	117	57	0.25
17.	Jammu	369959	102	215	0.58
18.	Dehradun	424674	67	131	0.31
19.	Asansol	475439	127	207	0.44
20.	Kochi	595575	98	400	0.67
21.	Raipur	605747	56	184	0.30
22.	Bhubaneswar	648032	135	234	0.36
23.	Tiruvanantapuram	744983	142	171	0.23
24.	Chandigarh	808515	114	326	0.40
25.	Guwahati	809895	218	166	0.20
26.	Ranchi	847093	224	208	0.25
27.	Vijaywada	851282	58	374	0.44
28.	Srinagar	898440	341	428	0.48
29.	Madurai	928868	52	275	0.30
30.	Coimbatore	930882	107	530	0.57
31.	Jabalpur	932484	134	216	0.23
32.	Amritsar	966862	77	438	0.45
33.	Rajkot	967476	105	207	0.21
34.	Allahabad	975393	71	509	0.52
35.	Vishakhapatnam	982904	110	584	0.59
36.	Faridabad	1055938	216	448	0.42
37.	Meerut	1068772	142	490	0.46
38.	Nashik	1077236	269	200	0.19
39.	Varanasi	1091918	80	425	0.39
40.	Jamshedpur	1104713	64	338	0.31
41.	Agra	1275135	140	654	0.51
42.	Vadodara	1306227	240	357	0.27
43.	Patna	1366444	107	511	0.37
44.	Ludhiyana	1398467	159	735	0.53
45.	Mumbai	1437354	286	574	0.40
46.	Indore	1474968	130	557	0.38
47.	Nagpur	2052066	218	504	0.25
48.	Lucknow	2185927	310	475	0.22
49.	Jaipur	2322575	518	904	0.39
50.	Surat	2433835	112	1000	0.41
51.	Pune	2538473	244	1175	0.46
52.	Kanpur	2551337	267	1100	0.43
53.	Ahmedabad	3520085	191	1302	0.37
54.	Hyderabad	3843585	169	2187	0.57
55.	Bangalore	4301326	226	1669	0.39
56.	Chennai	4343645	174	3036	0.62
57.	Kolkata	4572876	187	2653	0.58
58.	Delhi	10306452	1483	5922	0.57
59.	Greater Mumbai	11978450	437	5320	0.45

Source: CPCB, 2005.

Machining is infamous for producing waste, generally in the form of enormous amounts of coolant and contaminated metal chips. New environmental regulations and expenses are driving businesses to limit their environmental effect, mandating the implementation of proper waste disposal solutions. A local manufacturer in Perth has been suffering liquid contamination of the work area ground as a result of liquid coolant leaking from the waste chip storage. The apparent solution to this groundwater pollution is to eliminate the contaminating source, which is the liquid coolant. Dry machining is unquestionably the most environmentally friendly method of metal cutting, since there are no environmental concerns with coolant usage or disposal. In reality, however, even removing the coolant may have an effect on the cutting parameters (Ginting et al., 2015).

2.2.1 Method Of Waste Management

Waste is defined as any substance or product that is generated as a raw material, matter, semi-finished product, or residue of another item or product during the manufacturing and/or consumption processes, as well as a product that has lost consumer qualities, despite the fact that it can be recycled at a cost. The phrase "reduce, reuse, recycle" relates to the importance of reducing our dependence on nonrenewable resources, repurposing things, and recycling. Figure 2.1 show the promotion of material cycle of proper waste disposal. Simultaneously, their normal existence has ended, only to be resurrected as new matter. Additional research in this area reveals that traditionally, waste management tried to protect human health and the natural environment from the consequences of littering and pollution spread. Additionally, and more pertinently, van Ewijk and Stegemann's resource cost of rubbish (2020).

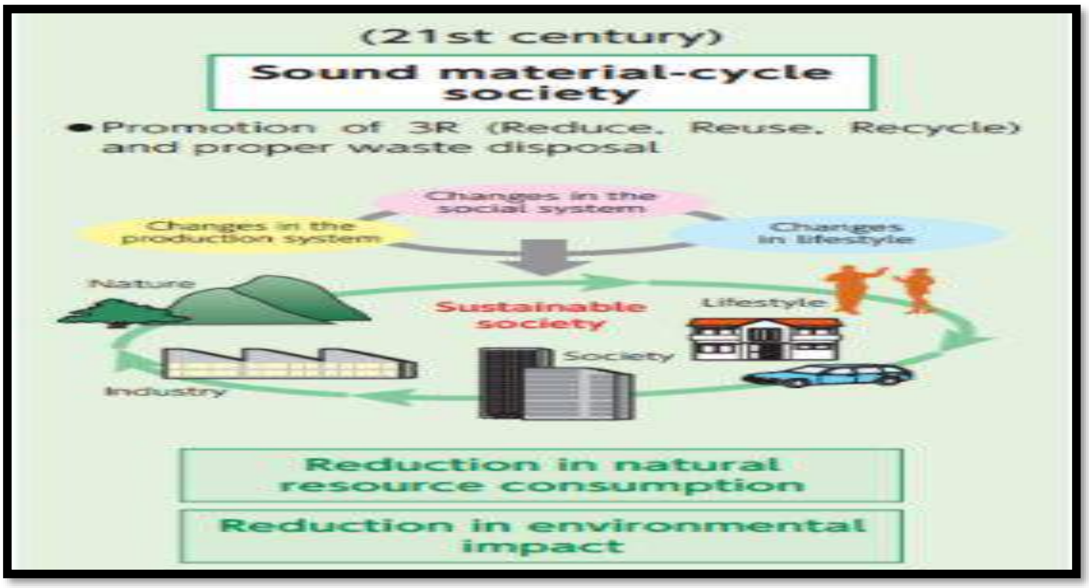

Figure 2.1 Promotion of 3R (Reduce, Reuse, Recycle) and proper waste disposal

Geyer et al. (2016) assert that such high levels of resource extraction result in an unparalleled number of environmental connections. Recycling is seen as a promising technique for minimizing the environmental consequences of growing industry and raw material use. Recycling has become ingrained in the supply chains of a broad range of items, including a range of metals. This is consistent with the findings of Uriarte-Miranda et al. (2018), who discovered two distinct kinds of recycling: reverse logistics and forward logistics (RL). Green Logistics include recycling, remanufacturing, and reusable packaging, all of which may contribute to more efficient and sustainable waste management.

Product diversity is defined as the number of distinct variants of a product that a business offers at any one moment. Variation within the product occurs as a result of modifying the values of qualities such as material, size, aesthetic, and performance. Because increasing product diversity has an effect on operational performance (production costs or outsourcing costs), there is a trade-off between product diversity and operational performance from a firm's standpoint. Additionally, it is critical to build a production system capable of producing the new sustainable version of the product. Figure 2.2 Demonstrates how, by including sustainability into the product and manufacturing system design phases, environmental impact throughout manufacture and at the end of a product's life may be minimized. This is critical given the increased emphasis placed on the link between production techniques and environmental performance. Increased public awareness of environmental issues, legislation resulting from environmental laws, and pressure from organized organizations all influence businesses to implement an Environmental Management System (EMS). These systems are designed to aid organizations in assessing their efficacy, operations, and services (Istrate et al., 2020).

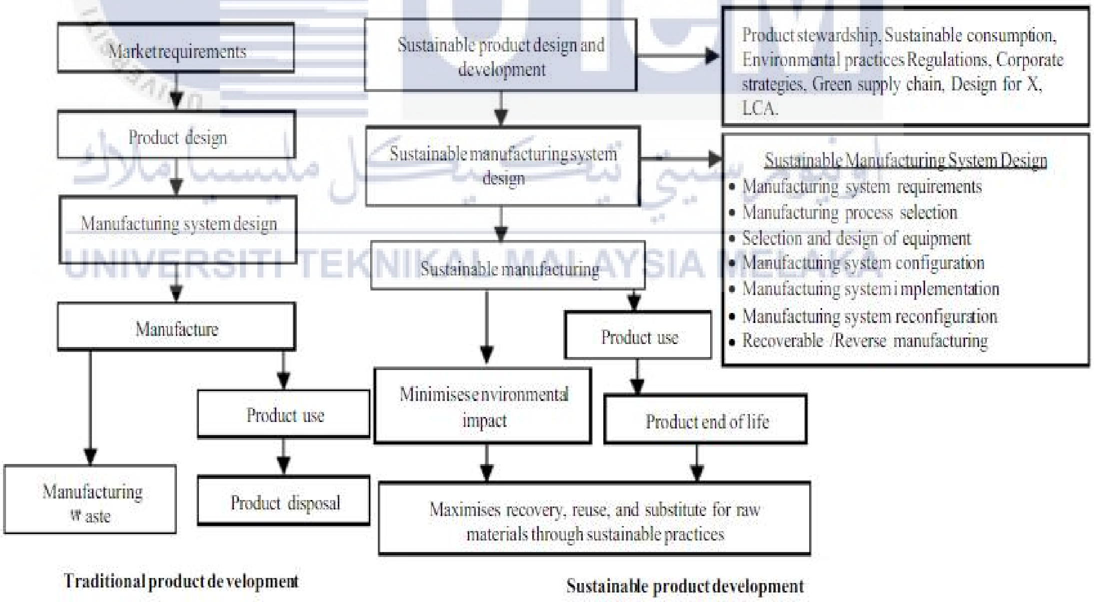

Figure 2.2 The imporatance of design product and manufacturing system for sustainablility (Istrate et al., 2020)

Human interactions with the environment have historically resulted in the generation of garbage. (Sharma et al., 2018) on the other hand, observed that garbage generation and management were not a significant concern until people started to live in communities. (Geyer et al. 2015) found that as the world's population and buying power expand, more items are created to fulfil rising demand, resulting in increased waste generation. (Sudibyo et al., 2017) noted that these continual fluxes of trash generated by human activities contributed to the environment's overburdening. According to good planning and management are necessary to avoid waste having a harmful influence on the environment. As a consequence, Ghiani et al. (2014) said that appropriate waste management organization has become a critical duty for environmental protection. Solid waste management system is today as critical as power, airports, and roadways. Residual trash must be prepared prior to biological treatment or sorting of materials. Initial trash preparation may include the simple removal of potentially hazardous things such as mattresses, rugs, or other bulky wastes that might clog downstream processing equipment. Additional mechanical waste preparation procedures may be utilized to prepare the materials for further stages of separation. Depending on the MBT procedure used, the purpose of these methods may be to break open trash bags and liberate the contents contained therein, or to shred and homogenize the trash into smaller particle sizes appropriate for a number of separation procedures or further biological treatment. Table 2.3 summarises the various waste preparation processes.

Table 2.3 various waste preparation processes

Technique	Principle	Key Concerns
Hammer Mill	Material significantly reduced in size by swinging steel hammers.	Wear on Hammers. Pulverising and 'loss' of glass / aggregates. Exclusion of pressurised containers.
Shredder	Rotating knives or hooks rotate at a slow speed with high torque. The shearing action tears or cuts most materials.	Large, strong objects can physically damage the shredder. Exclusion of pressurised containers.
Rotating Drum	Material is lifted up the sides of a rotating drum and then dropped back into the centre. Uses gravity to tumble, mix, and homogenize the wastes. Dense, abrasive items such as glass or metal will help break down the softer materials, resulting in considerable size reduction of paper and other biodegradable materials.	Gentle action – high moisture of feedstock can be a problem.
Ball Mill	Rotating drum using heavy balls to break up or pulverise the waste.	Wear on balls. Pulverising and 'loss' of glass / aggregates.
Wet Rotating Drum with Knives	Waste is wetted, forming heavy lumps which break against the knives when tumbled in the drum.	Relatively low size reduction. Potential for damage from large contraries.
Bag Splitter	A relatively gentle shredder used to split plastic bags whilst leaving the majority of the waste intact.	Not size reduction. May be damaged by large strong objects.

2.2.2 Green Manufacturing

Due to scarcity of resources and population growth, environmental quality conservation has become critical. Environmental issues have harmed regional and global collaboration in several ways and have sometimes sparked warfare. As a result, green activities have become a must for resolving these problems; even industrial processes cannot be excluded. Modern enterprises place a high premium on the possibility of transitioning to "green production" in order to limit their negative environmental consequences to the greatest degree feasible (Govindan et al., 2015) .

In many types of EDM, the dielectric fluid degrades with time, impacting not just the environmental balance by mixing with the soil and reducing its fertility, but also the economic effect due to the dielectrics' short-term usage. This serves as a signal to EDM system manufacturers to seek for environmentally friendly dielectrics. As a result, more attention is being paid to EDM with deionized water and dry EDM, which do not pose any disposal issues. The deionized water showed considerable promise for use as a dielectric. Additionally, it is inexpensive and non-polluting. (Xiong et al., 2020) shown that employing deionized water significantly improves the surface polish of micro-EDM holes. Dry EDM utilizes gas as the dielectric fluid, and it is possible to produce a high MRR while cutting high-strength engineering materials using oxygen.

In today's competitive environment, industrialization has spread like a virus. The businesses are fighting tooth and nail to stay afloat. In today's unparalleled global rivalry, they are more likely to provide superior goods and services and to enhance their production procedures. As a result, the industrial sector uses a significant amount of energy and other resources. It produces significant volumes of greenhouse gases, exacerbates environmental concerns such as climate change global warming, global dimming, and environmental degradation. Additionally, it discovered that a significant quantity of energy is squandered in a variety of ways. Green Manufacturing is one method for resolving these issues. Green Manufacturing is applicable to all manufacturing industries since it reduces waste and pollution, promotes economic growth, and conserves natural resources. There are numerous compelling reasons to actively explore metal recovery and recycling from mineral and metallurgical process industry waste effluents. These incentives include the following such as reducing the environmental effect of unregulated metals in water-soluble form entering aquifers and surface streams due to their poisonous nature optimizing strategic material conservation and limiting hazardous waste disposal costs. Around 18 metals are produced in the United States at a rate more than 1,000 tons per year, including 10 metals at a rate more than 50,000 tons per year (Seth et al., 2018).

The most popular way to dispose of Wire EDM filters is to throw them away. However, if your filters include metals such as chromium (from cutting tool steel or stainless steel) or cobalt (from cutting carbide), and are eventually disposed of in a landfill, groundwater contamination may occur. (Many of the most common type filters are now constructed entirely of metal components to allow incineration disposal.) Again, a qualified garbage collection firm can remove them and properly dispose of them (Xiong et al., 2020).

2.3 Electro Discharge Machine

Electrical discharge machining (EDM) is a well-established machining technique for fabricating geometrically complicated or difficult-to-machine objects. Electrical discharge machining (EDM) is one of the most widely utilized non-traditional methods for material removal. Its unique capability of machining electrically conductive parts independent of their hardness has been a significant benefit in the manufacture of mould, die, automotive, aerospace, and surgical components (Hadad et al., 2018).

Electrical Discharge Machining (EDM) is a procedure for machining electrically conductive materials by the use of precisely regulated sparks generated between an electrode and a workpiece in the presence of as shown in figure 2.3 . Thermal energy forms a plasma channel between the cathode and anode at temperatures ranging from 8000 to 12,000 °C or as high as 20,000 °C, initiating significant heating and melting of material at the pole surfaces. When the pulsing direct current source is turned off at a frequency of around 20,000–30,000 Hz, the plasma channel collapses. This results in a rapid decrease in temperature, which allows the flowing dielectric fluid to penetrate the plasma channel and flush the molten material from the pole surfaces in the form of minute debris. Melting and evaporating material off the workpiece surface is diametrically opposed to typical machining operations, since chips are not formed mechanically. The amount of material removed each discharge is normally between 10-6 and 10-4 mm3, and the material removal rate (MRR) is normally between 2×400 mm3 per minute, depending on the application. Due to the fact that the shaped electrode determines the region that will be eroded by the spark, the precision of the part generated by EDM is rather good. After all, EDM is a reproductive shaping technique in which the electrode's shape acts as a mirror for the shape of the workpiece (Kandpal et al., 2015).

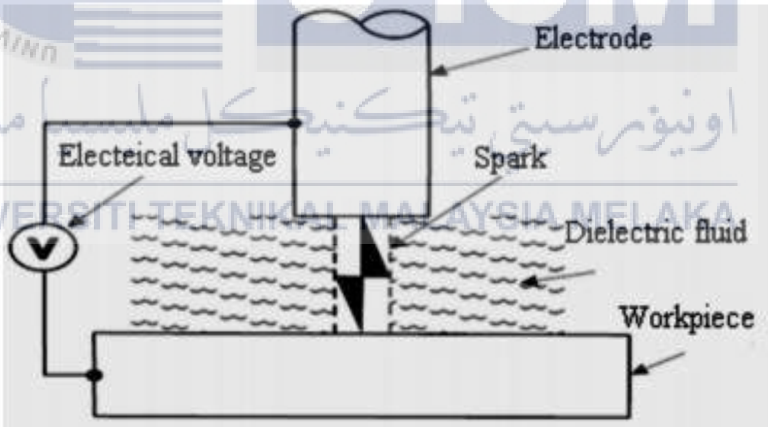

Figure 2.3 schematic diagram of EDM process

EDM is distinguished from most chip-making machining techniques by the absence of physical contact between the electrode and the workpiece during material removal. EDM produces no tool force since the electrode does not make contact with the workpiece. The electrode must always be positioned apart from the workpiece by the sparking gap. When the electrode makes contact with the workpiece, sparking stops and no material is removed. Certain EDM machines enable the electrode to make contact with the workpiece. These machines are generally used to remove damaged taps and drills; they are neither die-sinker or wire-cut EDM machines (Pant & Bharti, 2019)Distribution Feeders.

2.3.1 Type Of EDM Machine

The EDM process might well be expressed in a variety of methods that all subscribe to the same basic idea. As a result, several EDM versions have emerged. Die-sinking EDM and wire EDM are two of them. Die sinking EDM used a tool electrode with a profile that matched the desired form. Typically, the electrode has a more pronounced face. It is used to create a variety of different blind shapes and surface curves (Chakraborty et al., 2015).

Wire Cut EDM, on the other hand, uses a conducting wire as the tool electrode. This wire is moved constantly between two fixed pulleys, and the workpiece is fed against it. As a result, a spark is produced between the wire and the workpiece. It is ideal for cutting through profiles or sample preparation. It is not possible to create a blind feature because the wire must pass through several similarities and differences between die-sinking EDM and wire EDM (Koyano et al., 2018).

To maintain the sparking gap between the electrode and the workpiece, a dielectric substance is necessary. Typically, this dielectric substance is a fluid. Typically, die-sinker EDM machines run on hydrocarbon oil, while wire-cut EDM machines run on deionized water. Die-sinker EDM machines employ hydrocarbon oil to submerge the workpiece and spark, while wire-cut EDM machines typically utilize deionized water to submerge just the sparking region. Depending on the application, die-sinker EDM machines are often used to create three-dimensional forms. These forms are machined either cavity-type or through-hole, and through-hole machining is always performed on wire-cut EDM equipment. The electrode wire must pass through the machined workpiece (Srinivas Viswanth et al., 2018).

According to research that conduct by Prakash (2019), dielectric fluid used in EDM machines provides essential functions in the EDM process. These are controlling the sparking-gap spacing between the electrode and workpiece. Die-sinker machines produce sparks that occur between the electrode end and the workpiece. Figure 2.4 illustrates this sparking, and wire-cut machines produce sparks that occur between the electrode-side surface and the workpiece. Figure 2.5 illustrates this sparking.

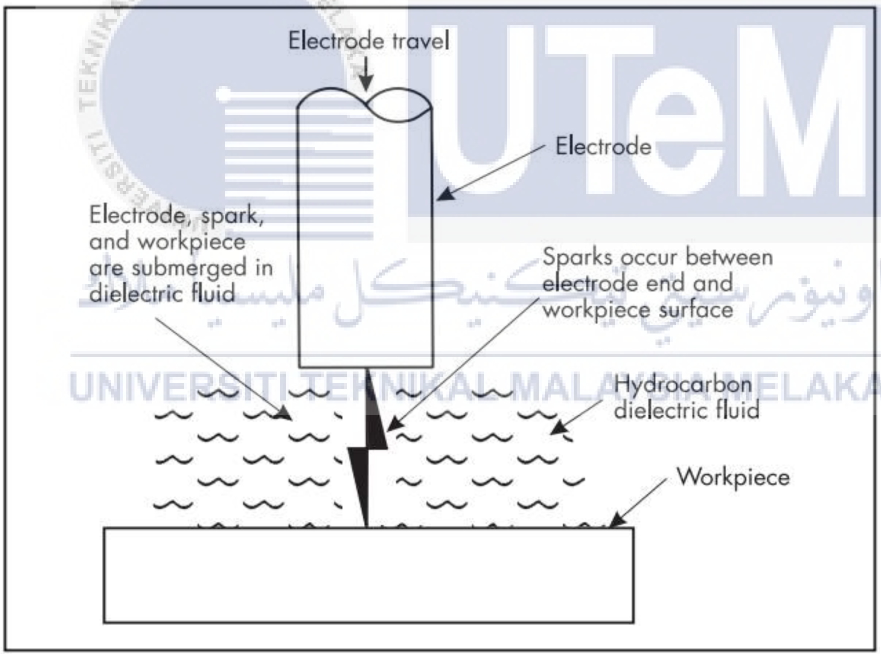

Figure 2.4 Basic die-sinker-EDM machine

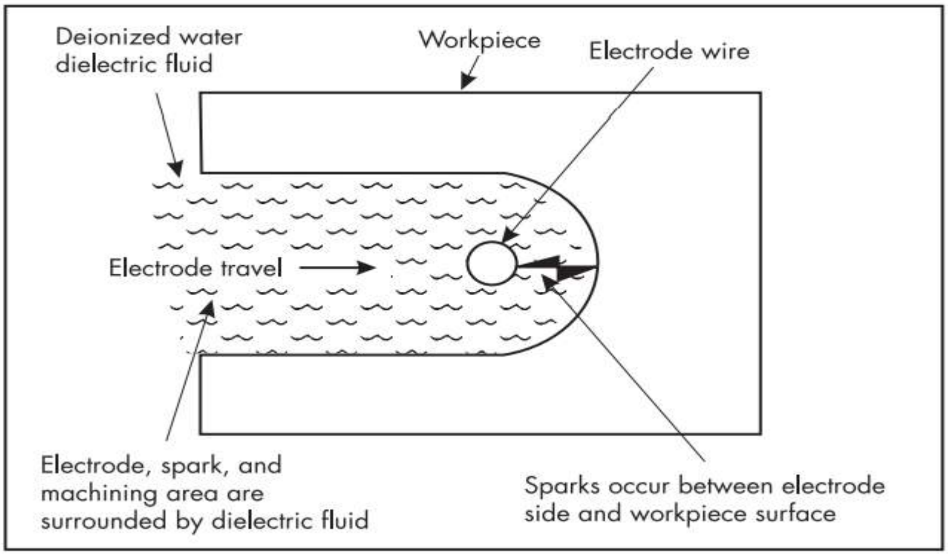

Figure 2.5 Wire-cut sparking from electrode side

2.3.2 Edm Application

This section addresses some of the most frequent EDM applications seen in industry. Additionally, it involves other experimental interests, allowing for a possible extension of EDM applications. Materials that have been heated in certain applications, such as milling heat-treated tool steels, EDM has overtaken conventional machining operations. With standard cutting tools, milled material must be within an acceptable hardness range of less than 30–35 HRC. However, EDM enables entire hardness treatment of tool steels before to machining, reducing the dimensional unpredictability associated with post-treatment. (Kumar Mohanty et al., 2017). Due to the absence of mechanical forces during machining, EDM offers an additional advantage in the fabrication of delicate goods. Additionally, numerous successful studies using a 50-m-diameter electrode and a multi-electrode for batch manufacturing of micro-parts were conducted (Shabgard et al., 2016).

The roughness of the surface is one of the factors that is measured after machining. By machining using this technology, precise surfaces with a roughness of up to 0.2 m may be achieved, but only in finishing mode. In industry, this is not always the case. Thus, in the industry, it is critical to understand the roughness of the surface in order to design the most cost-effective technique feasible. It was attaining the desired roughness that eliminates extra machining, which adds time and money. The authors conducted many trials in order to acquire data on machining and the quality of the treated surface. The major materials processed are the cardiac metals. By processing them using standard methods, the life of a work tool is significantly reduced (Li & Kara, 2015).

2.4 Wire Electrode Discharge Machine

WEDM is a spark erosion technology used to create complicated two and three dimensional forms utilizing electrically conductive work parts. WEDM is distinct from ordinary electrical discharge machining (EDM) in that the electrode is a fine (0.05-0.3 mm diameter) wire. The wire is fed into the workpiece as it unwinds from a spool. A power supply provides electrical pulses at a high frequency to the wire and workpiece. The space between the wire and the workpiece is inundated with a concentrated stream of deionized water that functions as a dielectric. The workpiece material is degraded by spark discharges similar to those used in traditional EDM. Each time a pulse of electricity is produced from the power source, the dielectric fluid's insulating characteristics are briefly compromised. This enables for the lowest possible distance between the wire and the workpiece for a little spark to jump. On the workpiece and the wire near the location of the spark, a tiny pool of molten metal forms. Around the spark and molten pools, a gas bubble develops. When the electrical pulse is interrupted, and the spark is extinguished, the gas bubble collapses. The surge of cold dielectric forces the molten metal away from the workpiece and the wire, creating tiny craters in their wake (Liang & Shih, 2015).

The components that comprise a wire cut machine are significantly distinct from those that comprise a die-sinker machine. Figure 2.6 depicts a wire-cut machine with a fixed-position worktable in one configuration. Additionally, the work piece may be supported on a moveable X-Y positioning table with the electrode wire maintained fixed. The wire-cut machine is moved by servomotors that are controlled by a computer numerical control (CNC). There must always be an aperture for the electrode wire to pass through. Precision cutting using a wire-cut machine necessitates extreme vigilance about the traveling-wire-feed mechanism. This comprises the wire guides on the top and bottom, the tensioning mechanism, and the condition of the wire on the supply spool. The electrode wire is only used once because the material removed from the surface of the wire during the sparking process weakens it. The spent wire is collected for disposal on a spool or chopped into small lengths and placed into a container after passing through the sparking area (Bisaria & Shandilya, 2019).

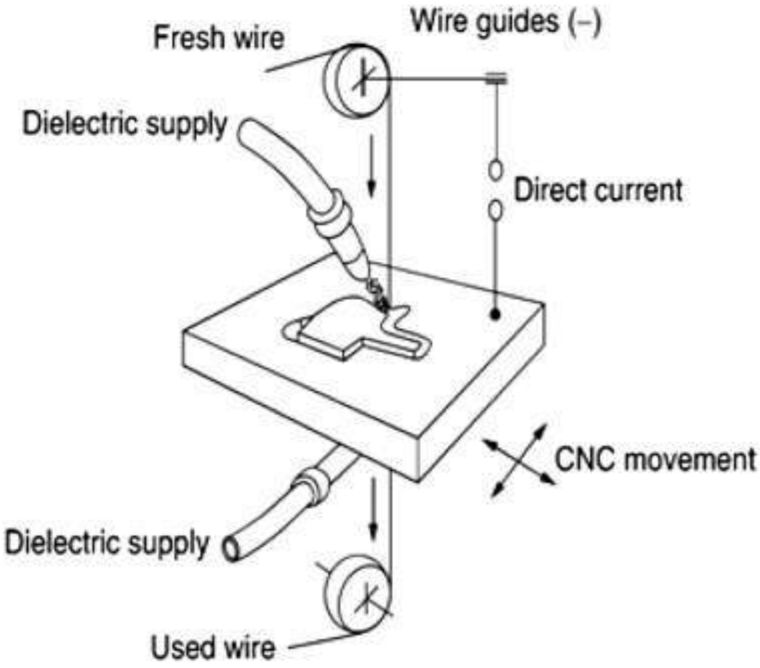

Figure 2.6 The components that comprise a wire cut machine

According research from (Ishfaq et al., 2018) Wire guides come in a variety of forms, patterns, and materials. The prospective machine user should examine the wire-guide design to guarantee that it will maintain the requisite machining precision over a prolonged period of time. These are the connections for the electrode wire's electrical sparking power and the elevating mechanism for altering the vertical distance between the wire guides to fit varying work piece heights. Electrical connections must be clean for successful wire-cut machining processes. A filthy contact will result in machining issues. Contacts should be conveniently accessible for cleaning, and what should be used to keep them to the specifications specified by the machine maker. The wire-guide elevating mechanism is configured to provide for correct work piece heights within the application range. Typically, the top wire guide is movable to accommodate the height of the work piece. The bottom wire guide is secured near to the work piece's bottom surface. We should evaluate wire guides for wear and cleanliness on a regular basis. Electrode guides that are worn or filthy might result in imprecise machining and irregular machine operation. The elevating mechanism's top guide must be positioned properly so that the mechanical structure does not come into touch with protruding surfaces from the work piece during operation (Das & Joshi, 2020).

2.4.1 Wire Electrode EDM Machine

As the wire-cut machine's name implies, electrodes are usually round wires bought on a spool or reel. There is no need to evaluate the electrode's manufacturing process. Only about one-half of the electrode diameter is worn when the wire travels through the sparking region. The wire-cut-wear pattern on the electrode wire is seen in Figure 2.7. The wire-wear pattern may seem to enable the electrode wire to be reused. However, reusing the electrode degrades its tensile strength and may result in breakage when the requisite force for the machining operation is applied during the reuse process. Usually, the electrode wire is discarded after passing over the sparking region once. Typically, providers of wire-cut wire offer the electrode material in sealed packaging to prevent the surface from deteriorating due to oxidation. When sparking energy is applied from the power source, surface oxidation lowers the wire's electrical conductivity. This harms the machining process. To avoid additional oxidation of the electrode surface, it is advised that any spool or reel taken from the machine for future usage be packed and sealed. The majority of wire-cut machines operate with electrode wire with a diameter of.004–.014 in (0.1–0.35 mm) (Habib, 2017).

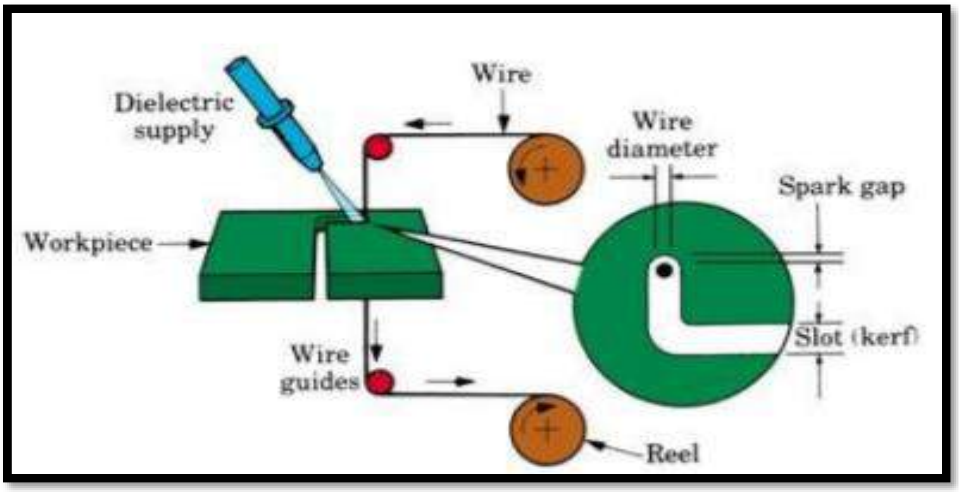

Figure 2.7 The wire-cut-wear pattern on the electrode wire

2.4.1.1 Cooper Wire

Copper wire was first chosen as the wire-cut electrode material because it was easily available in precision-drawn diameters and had a high electrical conductivity. However, the copper wire lacked the necessary strength to maintain its straightness when strain was applied. As a result, the mechanical and electrical properties of various materials are investigated (Kumar, n.d.2017).

2.4.1.2 Brass Wire

As wire-cut machines were created, brass became the preferred electrode material. Brass is composed of copper that has been alloyed with zinc. Copper and brass alloys may be produced to provide the requisite tensile strength while retaining excellent electrical conductivity. Brass is also available in a variety of hardnesses: soft, 1/2 hard, and complicated. The hardness of the material is determined by the machining operation that will be done. As the hardness of the wire rises, it becomes more resistant to direction change as it goes through the machine's wire guides. If the electrode wire must pass through the machine's wire guides to create an angled surface on the workpiece, soft brass is employed.

The material's softness enables the wire to easily change direction as it passes through the wire guides. This function is advantageous for machining angles larger than 7°. Angles less than 7° may be machined with strong brass alloys. When brass wire is defined as 1/2 hard and hard, it has a "memory." The wired memory resists any change in curvature when it is unreeled from the spool, which is not ideal when steep-angle machining is involved. Brass wire is particularly well suited to perpendicular wall cutting. Complex alloys feed more easily through the machine's automated re-threading systems than soft brass (Machining et al., n.d.2016).

2.4.1.3 Zinc Coated Wire

Zinc is used to coat electrode wire that has been wire-cut. Zinc offers excellent electrical conductivity when used in conjunction with a core-wire material that has a high tensile strength. Additionally, zinc acts as a protective heat shield. Discharge of Electrical Energy Machining takes place between the electrode core and the spark's heat (Farooq, 2018). The Figures 2.8 depict the application of the heat-shield barrier. Researcher (Gamage & Desilva, 2016) assert method is used to prepare food when the temperature of the meal cannot surpass that of boiling water—212° F (100° C). Water is boiled in the bottom pot using a flame. The 212° F (100° C) warmth of the boiling water is transferred to the higher vessel through steam. This prevents the food in the top vessel from being heated above the boiling water temperature. As the electrode wire is battered by the spark, the zinc coating on the wire core boils. When the coating boils, it vaporizes at a temperature lower than the wire-core material's melting point. If the zinc-vapour barrier is not there, heat from the spark is immediately transferred to the wire-core material. By absorbing this heat, the zinc-vapour barrier significantly lowers the amount of heat delivered to the electrode core and the degree of electrode wear.

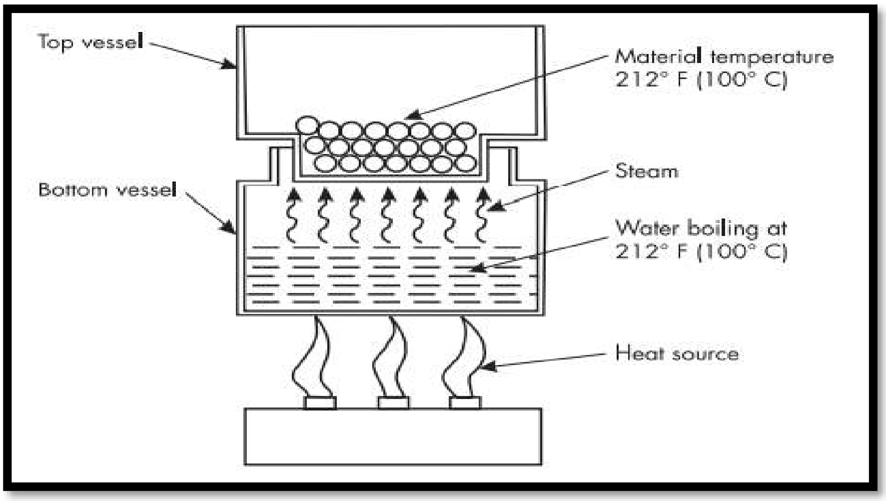

Figure 2.8 Double-boiler principle (Gamage & Desilva, 2016)

2.5 Properties Of Brass Wire Electrode EDM

Currently, brass wire electrodes are mostly used in unidirectional wire feeding WEDM. While cutting, the wire electrode is fed to the processing area through a wire reel. Additionally, when the wire electrode is discharged in the processing zone, it becomes useless. As a consequence, the wire electrode on the WEDM is wasted. Brass is a metal alloy largely composed of copper and zinc. Brass is mostly composed of copper; therefore, it is often categorized as a copper alloy. Brass is a dark reddish brown metal that ranges in color from dark reddish brown to a light silvery yellow, depending on the quantity of zinc present. This indicates that the higher the concentration of zinc, the lighter the hue. Brass is a substituted alloy (Xu et al., 2018).

Brass is mostly composed of copper, which may range from 55% to 95% by weight depending on the kind of brass and its intended application. Brasses with a high copper content are manufactured using electrically purified copper that is at least 99.3 percent pure to limit the presence of extraneous materials. Brasses with a lower copper content may also be manufactured using electrically refined copper, but are more often manufactured using less costly recovered copper alloy waste. When recycled scrap is utilized, the producer needs know the percentages of copper and other components in the scrap in order to modify the quantity of materials used to obtain the appropriate brass composition. Zinc is the second component of brass. Zinc content ranges between 5% and 40% by weight, depending on the kind of brass. Brasses with a greater zinc content are stronger and tougher, but they are also more difficult to manufacture and have a lower resistance to corrosion. Brass is made from commercial grade zinc, commonly referred to as spelter Base the research from Brass exhibits a wide range of mechanical properties; in fact, it is precisely because of this wide range of tensile strength, elongation, and hardness that brass is such an important alloy (Pavan et al., 2020).

2.5.1 Mechanical Properties

The mechanical properties of a material are defined by its response to stresses, temperature, and environment. The cumulative effects of these controlling features must be assessed in a variety of real-world situations. Prior to developing an understanding of the combined effects of load and temperature or load and environment, it is required to extensively research the separate effects of loads (elastic and plastic deformation). Additionally, the kind of loading may have an effect on the material response. When deformation is performed in a progressive manner (like in a tensile test), reversible (elastic) deformation may occur at low loads before irreversible/plastic deformation occurs at higher levels. Additionally, when reversed loading occurs, a phenomenon known as "fatigue" may develop. This occurs even at inadequate pressures for bulk plastic deformation (Erdem, 2015).

Mechanical characteristics of materials are determined via carefully planned laboratory experiments that imitate service circumstances as closely as feasible. Consider the kind and duration of the imposed stress, as well as the surrounding environment. The load may be tensile, compressive, or shear in nature, and its magnitude may be stable throughout time or change constantly. Application time may be as little as a fraction of a second or as long as many years. Temperature in the service area may be critical (Okayasu et al., 2017).

The properties of interest here are material properties; that is, the measured value is independent of the test method. Implicit is the understanding that the property is also independent of the size of the specimen, but that may not necessarily be the case for MEMS materials. The fabrication process for, say, thin-film silicon carbide is completely different from that of bulk silicon carbide, and it is reasonable to expect different mechanical behaviour. The question of specimen size effect needs to be considered at the appropriate length scale-in this case, whether a 200 × 200-µm cross-section tensile specimen behaves the same way as a 2 x 2-µm one. That question is not very easy to answer until test methods exist with sufficient sensitivity and reproducibility to differentiate the material behaviour (A. Heidarzadeh & Saeid, 2016).

Brass has a low melting point of around 900 to 940°C, depending on its composition and flow qualities, which makes it an easy material to cast. Brass properties may be varied by varying the copper and zinc content, resulting in hard and soft brasses. Brass has a density of roughly 8400–8730 kilos per cubic metre (equivalent to 8.4 to 8.73 grammes per cubic centimeter). Almost 90% of all brass alloys are recycled nowadays. Due to the fact that brass is not magnetic, it may be removed from ferrous debris by passing it near a strong magnet. Brass scrap is collected and brought to a foundry for melting and recasting into billets. Heat is applied to the billets, which are then extruded into the required shape and size. about 8400–8730 kg per cubic metre (equivalent to 8.4 to 8.73 grammes per cubic centimetre). Nowadays, about 90% of all brass alloys are recycled. Due to the non-magnetic nature of brass, it may be separated from ferrous detritus by passing it near a powerful magnet. Scrap brass is collected and sent to a foundry where it is melted and recast into billets. The billets are heated and then extruded into the desired form and size (Ma et al., 2016).

Conductivity is a critical attribute of the EDM wire because it dictates how the energy from the power supply is carried along the distance between the power supply source and the actual point of cutting. This distance may be rather significant, particularly if the operation requires cutting with open guides to clear a workpiece impediment. Due to the low conductivity of the wire, there will be a voltage drop and accompanying energy loss throughout the length of the wire from the power source to the cutting point. This is not trivial, given that the peak current of the majority of contemporary power sources often surpasses 100 amps. Conductivity is often represented as a percentage of IACS (International Annealed Copper Standard), a metric of electrical conductivity used to compare metals and alloys to standard annealed copper. Brass may be readily drawn into fine wire, rolled into very thin strips, or drawn into tubes and extruded into rods and sections. The single and double phase brass plates with dimensions of 100 mm×100 mm×2 mm were friction stir welded. After visual inspection, the microstructures of the joints were studied using optical microscope (OM) and scanning electron microscope (SEM) working with an accelerating voltage of 20 kV. The metallographic samples were cut from the joints, transverse to the welding direction, then polished and etched with a solution of 20 ml nitric acid and 10 ml acetic acid. The resulting microstructures are shown in Figure 2.9 and 2.10. X-ray diffraction was performed (Akbar Heidarzadeh & Saeid, 2015).

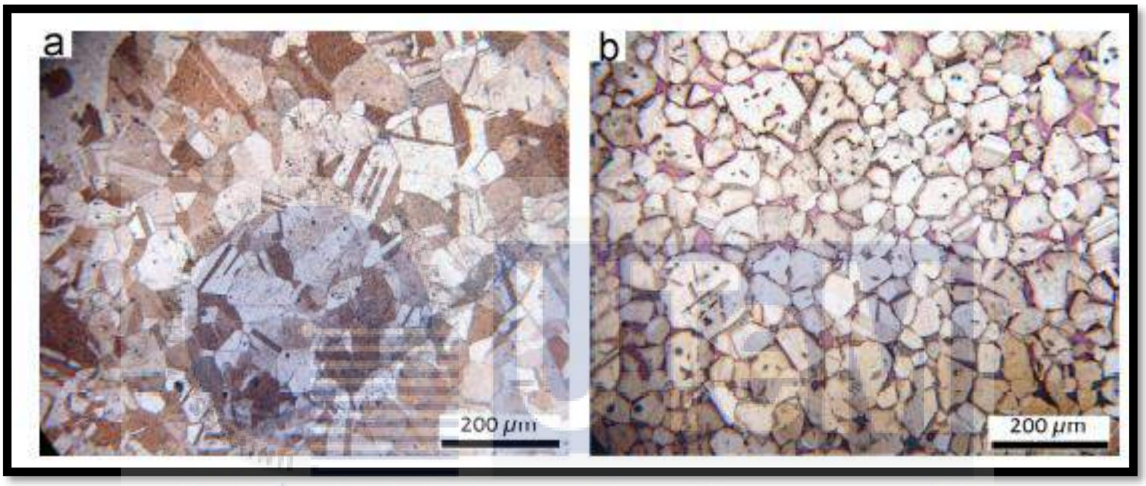

Figure 2.9 Microstructure of the base metal and two difference type of phase brass

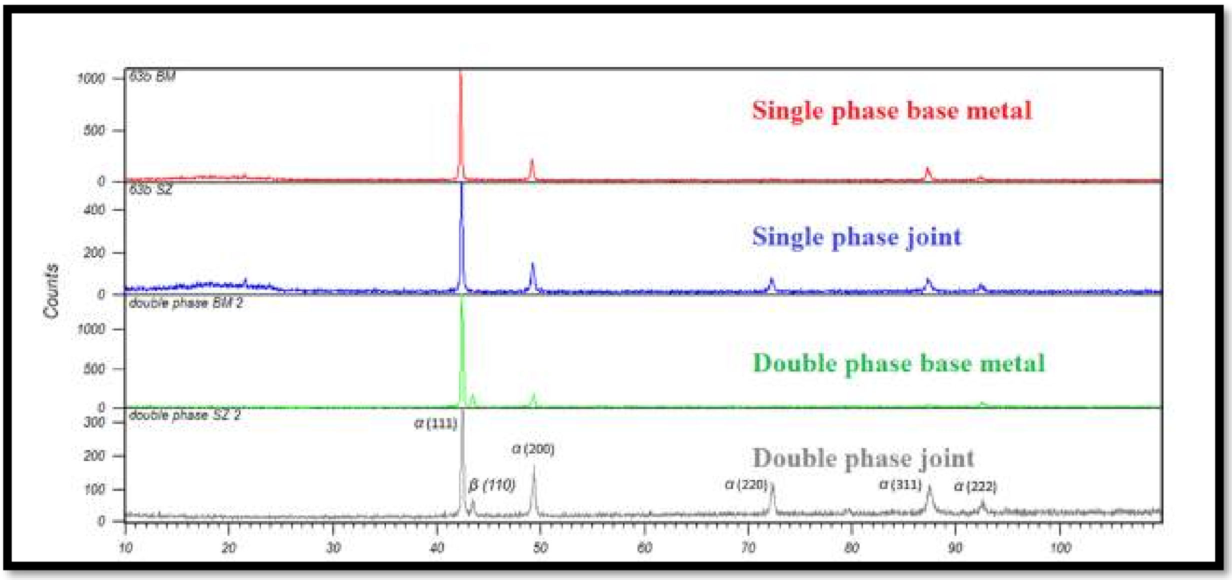

Figure 2.10 XDR pattern of the base material and joint

2.5.2 Tensile Strength

Tensile testing entails putting the specimen in a machine and applying tension to it. The testing procedure begins with the test specimen being placed in the testing machine and subjected to stress until it cracks. Tensile force is shown as a function of gauge length growth. During tension application, the gauge section's elongation is measured in relation to the applied force. Tensile strength and tensile modulus were used to determine the tensile characteristics of composites samples. The tensile strength of the composite is determined by the ease with which stress may be transmitted from the broken to the surviving fibres through shear in the resin at the interface, as well as the maximum amount of stress that a sample can sustain before failure. Tensile characteristics were determined using dumbbell-shaped specimens and different standards (Ciwen et al., 2018).

Tensile strength refers to a wire's capacity to withstand the tension applied during cutting in order to achieve a vertically straight cut. EDM wires are classified as "hard" when they have a tensile strength of 900 MPa or over, "half-hard" when they have a tensile strength of roughly 490 MPa, and "soft" when they have a tensile strength of less than 440 MPa. Hard wires are often utilized for the majority of work, whereas half-hard and soft wires are often used for taper cuts with a taper angle more than 5°, since a hard wire would resist bending at the guide pivot, resulting in inaccuracies in taper cutting. Unless the machine is especially intended to operate with wires that are half hard and half soft, they are often unsuitable for automated threading The dual tensile reels winded wire feeding system that has developed in this paper is apparently different from the normal WEDM wire feeding system, as shown in Figure 2.11. The normal WEDM wire feeding system only have one reel and do not need several servo motor to work together to complete the wire's feeding, as shown in Figure 2.12. (Ciwen et al., 2018).

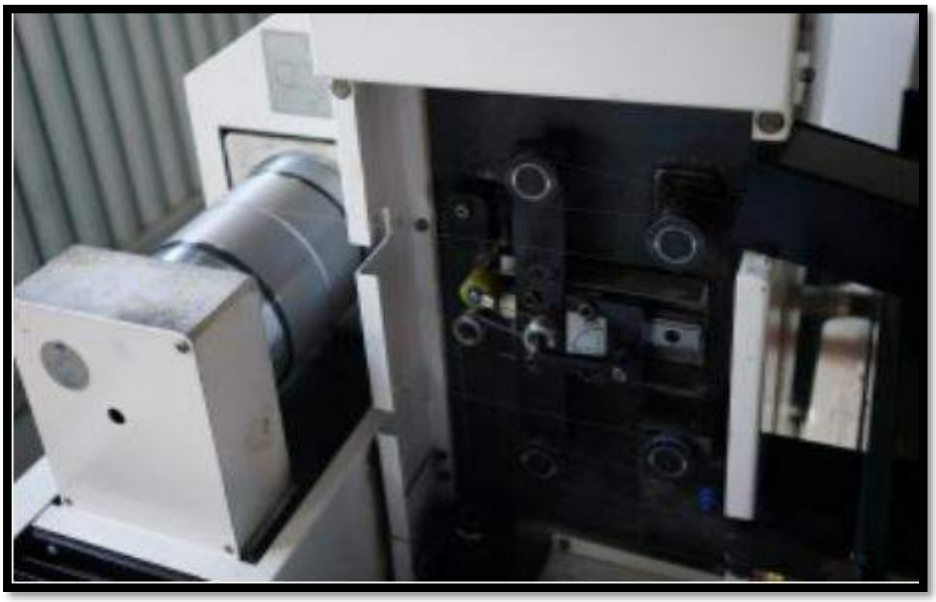

Figure 2.11 Single reel wire feeding system of WEDM

Figure 2.12 The wire reciprocate WEDM with dual tensile winded wire feeding system

2.6 Polymer-Matrix Composite (PMC)

The matrix connects the reinforcement of fibre to the composite element and determines its surface uniformity. Polymer, ceramic, metal or carbon can be used as a composite matrix. Shanmugaselvam (2020), examined Polymer composites are widely used in several different uses, such as sports equipment, aircraft parts, cars, etc. In the last 20 years, the growth of polymer Nano composites, where at least one of the measurements of the filler content is in the order of a nanometre, has been highly emphasised. The end result must not be in Nano scale, either micro- or macroscopic. A review of chapter 15 by Su (2018), in the research The introduction of scanning tunnelling microscopy and scanning probe microscopy in the early 80s significantly encouraged this growth in the area of nanotechnology. With these powerful tools, scientists can see with atomic resolution the nature of the surface structure. At the same time, the fast growth of computer technology has facilitated the characterization and prediction of Nano scale properties through modelling and simulation.

Including polymer matrix composites, polymer matrix composites, and ceramic matrix composites indicate by Lynch & Kershaw (2018), such as in Figure 2.14, composite materials may be classified in three categories. However, studied how fibre-reinforced composites can be graded like hooked, consisting of four groups, according to the matrix of their ceramic matrix composites (CMC) or composites of metal matrices (MMCs) as shown in Figure 2.15. The fact that MMC is being created and utilized in the aviation and aerospace sectors has proven convincingly to be instances of non-metallic composites routinely included in a metallic matrix like silicon carbide particles combined with aluminium alloy, as stated (Pärnänen et al., 2015).

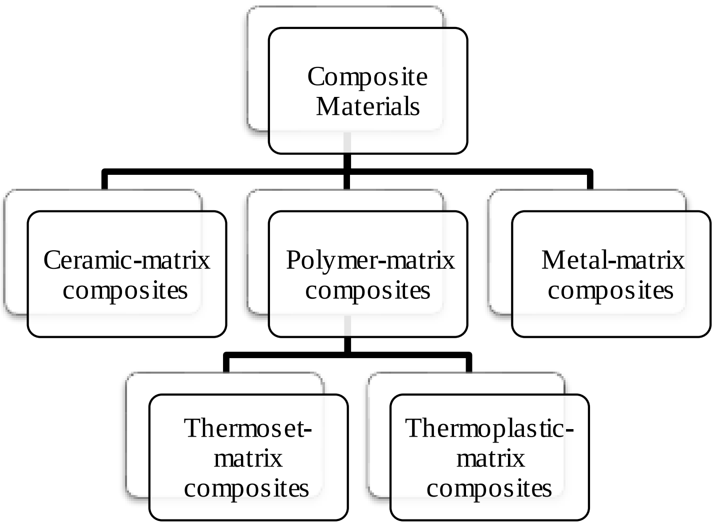

Figure 2.13 Three groups of matrices classification in composites (Lynch & Kershaw, 2018)

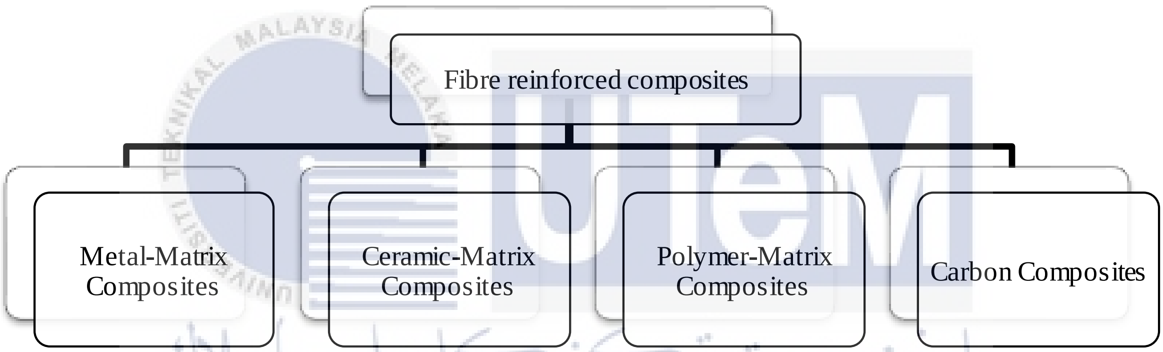

Figure 2.14 Four groups of matrices (Pärnänen et al., 2015)

Polymer matrix composites (PMCs) consist of a combination of short or continuous fibres attached to an organic matrix of polymers. In contrast to a composite ceramic matrix (CMC), of which the reinforcement is used mainly to increase the stability of the crack, the PMC reinforcement offers great strength and steadiness. The PMC is built to support the mechanical loads to which the structure is exposed in operation. The matrix's purpose is to bind the fibres together and to pass loads. Composites of polymer matrix are mostly classified into two categories: strengthened plastic and "advanced composites." stiffness), although there is no clear line between the two. Reinforced plastics are usually polyester resins with low rigidity fibres, and are reasonably cheap. Advanced composites, used only for about 15 years, mostly in the aerospace sector, are of high strength and rigidity and comparatively costly as (Sadighi et al., 2017). According to Abdullah (2015), Rapid development in the packaging industry has contributed to the need to increase the efficiency, rigidity, density and lower costs of the products for increased sustainability. Composite materials have been one of the materials with such improvements in properties that serve their potential in a number of applications. Composite products are an amalgamation of two or more components, one in the matrix process, and the other in particle or fibre shape. The use of natural or synthetic fibres to manufacture composite materials has been exposed in a number of areas, including architecture, mechanics, automobiles, aerospace, biomedicine and marine.

2.7 Mechanical Testing

Copper and brass are in high demand in industrial applications, the automotive sector, and the construction sector, which necessitates the enhancement of their mechanical qualities by the addition of appropriate alloying elements. The purpose of this research is to determine the impact of alloying copper and brass on their tensile strength, hardness, and microstructure. The tensile strength, impact strength, and Rockwell hardness of two copper alloys and two brass alloys have been determined. We examined the mechanical characteristics and microstructure of annealed copper and brass alloy specimens. The findings indicated that increasing the alloy content increased the tensile strength in both circumstances (Akbar Heidarzadeh & Saeid, 2015).

Mechanical tests are often performed to check that specified mechanical qualities have been met. Additionally, it is required to verify that the metal meets the stipulated minimum values. The mechanical attributes or material qualities that are most often analyzed include the following: The resistance of a material to fracture when subjected to an impact load. Apart from that, the material's capacity to palstically deform under stress, as well as its strength and ductility, are often evaluated using mechanical tests (Asgharzadeh et al., 2020).

A review of the literature revealed that many writers have utilized a variety of tensile specimens with varying dimensions depending on the availability of materials. Frequently, the specimen dimensions deviate from those specified by ASTM. They examined how specimen size and shape affect the tensile strength of pure ultra-fine-grained copper. The tensile qualities of two materials were studied, with the gauge length being varied to determine the effect on the mechanical characteristics. The yield strength, tensile strength, fracture strength, and ductility of the material were determined after the test, and the fracture surfaces were studied using an inverted microscope. Increased yield strength and decreased tensile elongation may be accomplished by reducing the thickness of the specimen (Bressan & Unfer, 2006).

The literature study and experimental observation by Pramanik & Basak (2019), revealed that the tensile characteristics of specimens are dependent on the annealing temperature and time, and that increasing either of these parameters results in a decrease in tensile strength and an increase in ductility. The experimental setup for tensile testing on each specimen is shown in Figure 1, as are the shattered specimens after the test. The stress-strain diagram, which depicts the relationship between stress and strain in a particular material, is a critical property of the material. To acquire a material's stress-strain diagram, a tensile test on a specimen of the material may be undertaken. The cross-sectional area of the specimen towards the centre is precisely determined. As seen in the Figure 2.17 below, two gauge markings are written at the central section at a distance of L0 from one another. The distance L0 is the specimen's gauge length.

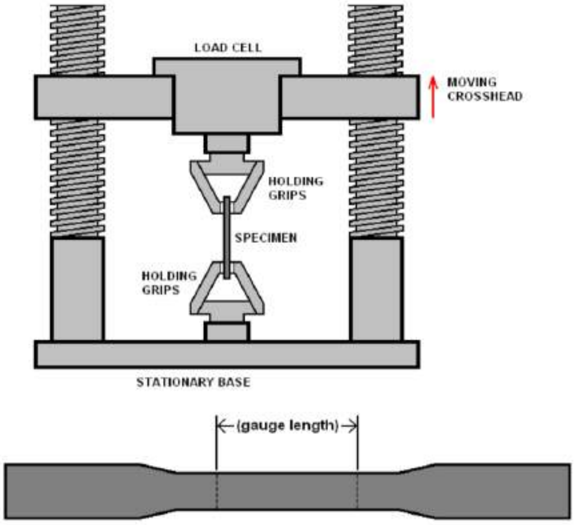

Figure 2.15 Shown The distance L0 is the specimen's gauge length

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describes the correct process flow and technique utilized in this study. The methodology will be explained as to how this study is carried out. This technique comprised preparation of materials, manufacturing and associated experimental testing. The American Society for Testing and Material will otherwise oversee the whole test. Finally, data from these experimental tests are gathered to study data.

In this chapter, four stages are included: sample preparation, following release, new EDM wire electrode and EDM wire waste electrode, manufacture of a mould of hand lay-up manufacture of specimens wire EDM electrode, mechanical tests of the specimen. The produced EDM wire electrode is subjected to several procedures before being utilized as a first stage EDM wire specimen. The mould for the must be developed for manufactured according to the necessary size and standard. The third stage involves the resin mixture. In the last stages, the test will be performed. The tensile,and flexural tests are included. The test results will be analyzed.

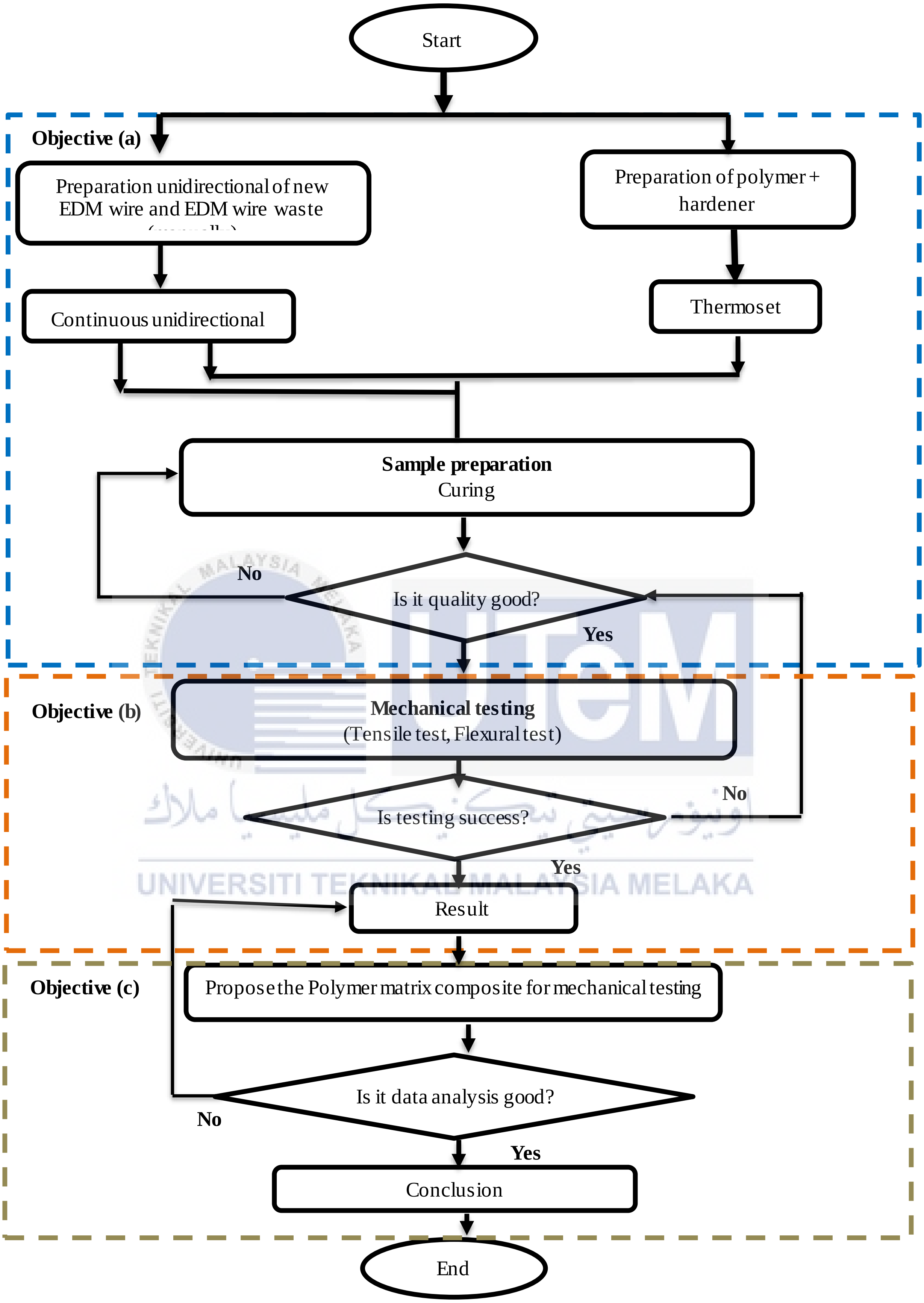

Figure 3.1 Flow chart of methodology

3.2 Data collection process

The data collection process will investigate the disposal process of the metal EDM wire classification category used for collecting data. This data information was collected from the manufacturing industry involving wire cutting discharge machines in the manufacturing process. The data was analyzed from three questionnaires. The first questionnaire is to know the quantities of EDM wire electrodes that have been discharged in a day of the manufacturing process. This data provides various information that runs the process using a wire cutting machine. The following questionnaire is to obtain the type material of wire electrode selection. From this information, the data statistically can be analyzed. The final questionnaire for collecting information from industry about a method that takes for disposal of metal wire EDM has undergone discharge.

3.3 Raw Material Preparation

This research started with the raw material, preparation. Raw material preparation is a significant and critical part of delivering better product quality. There were several steps to prepare the new EDM wire electrode specimen in this study. The specification and characteristics of each raw material will be explained in more detail, used in this research. Next, the fabrication of the specimen method used in this research is based on previous research and is suggested from this study.

3.3.1 EDM wire electrode

The most important material used in this research is Wire electrical discharge machining (EDM). Wire electrical discharge machining (EDM) is a kind of metal machining in which thousands of sparks are discharged onto a metal workpiece is the metal reinforcement used in this research. The new wire electrode used in this research is 0.2mm in diameter and has a tensile strength of 1000N/mm^2 supplied by EDM-TOOLS (M) SDN BHD. Thus, the EDM wire would be cut to two different lengths, which is 20mm in length and 20mm in length. The flow chart of the fibre preparation is shown in Figure 3.2. Table 3.4 showed the wire electrode material properties

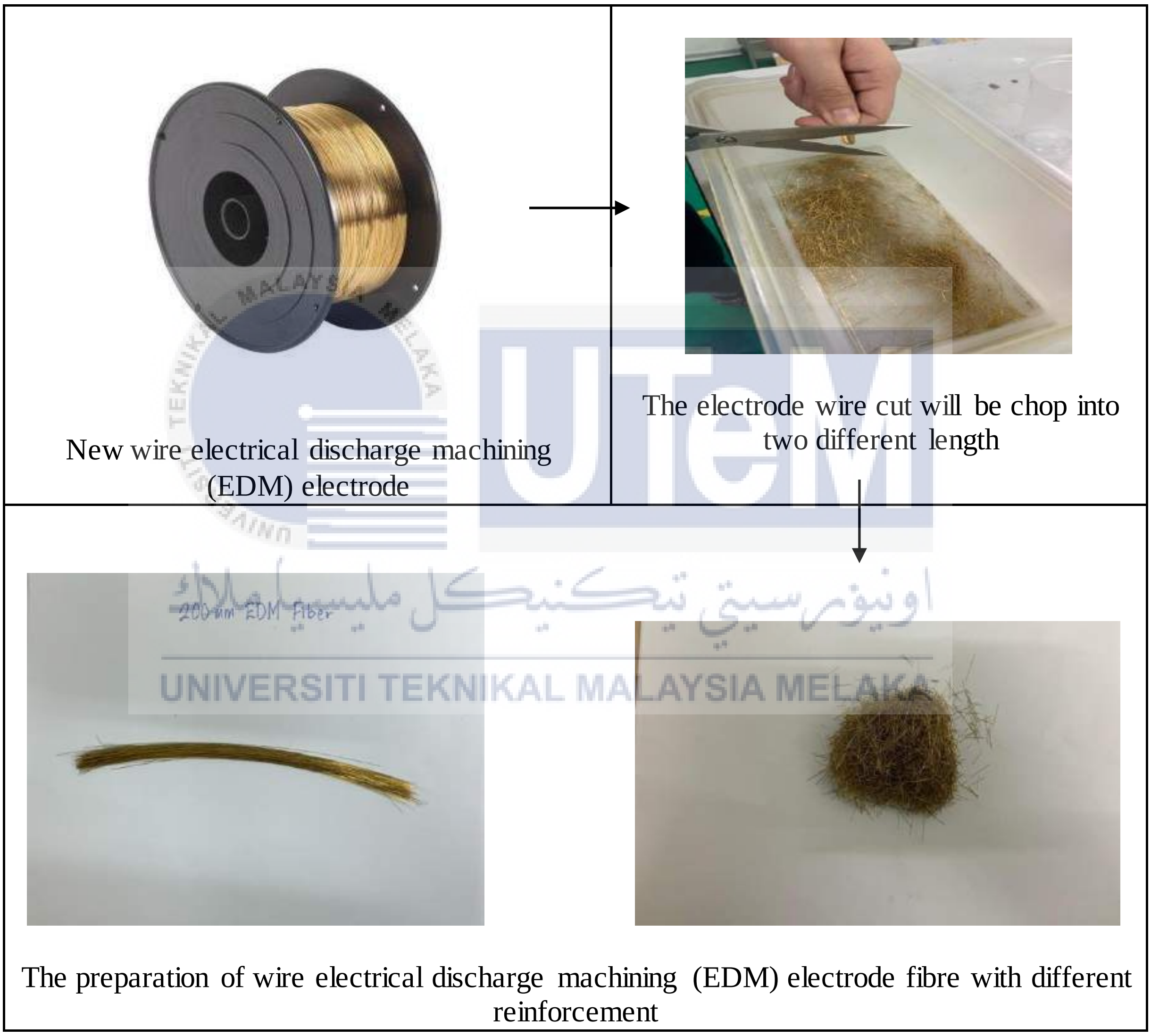

Figure 3.2 depicts the flow chart of the preparation of the fibre.

Table 3.1 Wire electrode mechanical properties

Wire Name	Material	Tensile Strength	Wire Diameter
Hard wire Non-paraffin	CuZnBrass, 63/37CoreComposition with Zinc Coating	1000N/mm²	0.2 mm

3.3.2 Vinyl ester

An epoxy device comprises two critical components: a resin and a cure. The curative initiates a chemical reaction that transforms the epoxy resin into a solid, cross-linked molecular network. This polymer is called a thermoset polymer because it is permanently stiff and retains its heat when cured. However, the word resin may also refer to the epoxy resins thermoplastic or curing state. ML Fiberglass. Sdn. Bhd provided the vinyl ester resin and Hardener for this study. The statistics for both materials are presented in Table 3.2. The digital scale indicates the amount of vinyl ester resin used in a 50:1 ratio of resin to Hardener. Each weaved type's weight will be utilized to apply the resin potion employed in this study. VE is priced at about RM150.00 per litre. As a result, 2.2 kg of resin will be utilized in this study. The resin was combined with the Hardener in the proportions mentioned before. The mixture is manually mixed for 4-6 minutes before applying to each fibre. Figure 3.7 illustrates epoxy.

Table 3.2 Specific data of epoxy resin and Hardener

Properties Of Liquid	Method	Margin value
Colour	Observation	Clear
Density	ISO 1657	1,004 g/cm3
Refraction Index	ISO 0489	1.5
Acid value	ISO 2114	Max. 7 mg KOH/g
Viscosity Brookfield	ISO 2555	220 cp
Thixotropy	-	Thixotropic
Gel Time	ISO 2535	30'
Monomer content	-	46%
Shelf life at 20°c	-	6 mths

Figure 3.3 Vinyl ester and Hardener

3.4 Preparation of sample

3.4.1 Fabrication EDM wire laminated

The form of material is essential when designing a composite laminated structure because it relates to the method of manufacturing, which has a specific constraint on the construction of that structure. The specimens with a metal in a matrix may be prepared to manufacture an epoxy matrix (Analdite D 80 wt% and 20 wt% hardeners) Hy 956. The Analdite D and the durder are combined at room temperature and vigorously agitated for one hour in a homogenous mixture. A hand lay-up and compression moulding technique were used to produce composite laminate based on EDM wire fibre volume and regulate the bonding between the composite layers in the mould cavity. Two types of specimens would be fabricated with different reinforcement. Many influential factors influencing the reinforcement's composite mechanical efficiency include fibre length, fibre orientation, fibre shape, and fibre density. To make the difference of regulating the bonding between composite. Thus, the EDM wire would be cut to two different lengths, which are 20mm in length and 20mm in size. Then modification of the EDM electrode fibre is carried out by merging various quantities of EDM electrode fibre (0,10,20,30,40, and 50 wt. %) into the polymer matrix, as shown in table 3.2. EDM electrode fibre is measured in ratio and added to the vinyl ester composite, then undergo process drying at room temperature.

The design hand lay-up process would mould, as shown in figure 3.4, to ensure that all specimens have similarity compacted in size pattern and polyethylene film has been inserted between the granulate and mild to prevent samples from sticking to the steel plate during the refrigeration phase. The composite would be left for 12 hours, after which the composite will become solid in the process of dring at room temperature. The specimen is separated carefully from the mould to avoid the sample from rupturing.

Figure 3.4 The hand lay-up prosess for EDM wire laminated composite

Table 3.2 EDM electrode fibre is measured in ratio and added to the vinyl ester composite

NO	Name	Capacity (g)	Capacity (%)
1	Vinyl ester	162	90%
2	Fiber	18	10%

NO	Name	Capacity (g)	Capacity (%)
1	Vinyl ester	144	80%
2	Fiber	36	20%

NO	Name	Capacity (g)	Capacity (%)
1	Vinyl ester	126	70%
2	Fiber	54	30%

NO	Name	Capacity (g)	Capacity (%)
1	Vinyl ester	108	60%
2	Fiber	72	40%

NO	Name	Capacity (g)	Capacity (%)
1	Vinyl ester	90	50%
2	Fiber	90	50%

3.5 Mechanical testing

As explained, there are four tensile and flexural tests carried out in this research. Tensile and flexural testing will be performed in this study research based on the standard required of ASTM. ASTM for mechanical testing is shown in Table 3.3.

Testing	Testing Standard
Tensile	ASTM D3039
Flexural	ASTM D7264

Table 3.3 Tensile standard for mechanical testing

3.5.1 Tensile testing

Tensile testing is used to determine the force of tensile that also known as tension testing. The testing is subjected to a sample or an object until the sample or object failure. It also can measure the mechanical properties directly, such as ultimate tensile test, elongation and reduction area. These measurements can also clarify Young's Modulus characteristics, yield strength, and strain-hardening. The dimension of samples for the testing was cut according to ASTM standards. Dimensions were cut into 100 mm x 25 mm in this research. Figure 3.5 shows the Instron 50 kN universal testing machine.

Figure 3.5 Instron 50 kN universal testing machine

Load of 50 kN are the maximum load with a standard speed of 2 mm/min were applied to carry out the testing process for every sample. There are two clamps were clamped at the end of the sample on the machine, and the force is applied until the sample break or fails. All the data was collected, analyzed, and evaluated. The maximum force, tensile stress, elongation of sample, reduction area, and modulus of elasticity were evaluated. Figure 3.6 shows the dimension of tha sample used for tensile test according to the standards of ASTM. Every design of the type of woven will have five specimens or readings that are required to study in this research. Stress-strain graph is obtained at the end of the testing session and will be analyzed on the discussion.

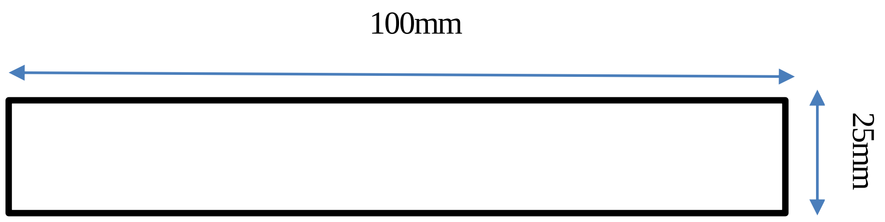

Figure 3.6 The dimension of tensile testing machine (ASTM D3039)

3.5.2 Flexural testing

The essence of flexural test is to determine the flexiblility of the composite by measuring the force require to bend under specified loading condition. Using the universal testing machine (INSTRON 5969) with a 5kN load cell, 3 sample could be cut to conduct this test and the crosshead speed is maintained at 2 mm/min. The dimension of the samples is 100mm length with 25mm wide. Figure 3.7 shows the Flexural test on Universal Testing Machine (INSTRON 5969).

Figure 3.7 Shows the Flexural test on Universal Testing Machine (INSTRON 5969).

3.6 Summary

This chapter presents the proposed methodology to develop a new, effective and integrated approach for developing on a new material followed by the good testing procedure and result collection. The aim of the proposed methodology is to obtain a simple, proper and efficient in such a way that the results of data analysis are the closest value to the real properties of the composite itself. The methods also aimed to exploit the network's widely accessible and restricted data on the testing method of new composite material.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results and analysis of experimental results after producing speciment and the conduct of different testing experiments. The discussion would be explained according to the objective. The first objective is to fabricate composite using new and waste EDM wire cut electrodes. The second objective to run experimental mechanical testing include tensile test and flexural test. To analyse mechanical properties of the developed PMC from WEDM electrode waste and new WEDM electrode.

4.2 Mechanical Properties of laminate Composite

This subtopic will address the mechanical properties of Polymer Matrix Composites. The test involved is the tensile test, the impact test and the flexural test. All the tests were followed by ASTM standards exposed in Table 4.3. Material performance is Material performance is often described in terms of its mechanical characteristics, such as tensile strength, maximum force and flexural strength. These characteristics are important for determining the ability of a material, especially under critical conditions that are directly linked to engineering efficiency.

4.3 Tensile properties

The reaction of the material to resist as a force are applied in stress consisting of tensile properties. It is important to determine the tensile properties since it provides data on the tensile strength, maximum force, maximum strain and other tensile properties. There is an exciting study by Dani et al., who have completed an experiment on the effect of fiber content on cassava starch green composite films with similar results (Dani et al., 2016). According to them, fibre and matrix power, fibre-to-matrix interfaces are the few main factors influencing composite performance. The result carried out by Dani et al. showed that the tensile strength is increased from 0% to 30% of fiber content in the composite (Dani et al., 2016).

The result of tensile testing, including tensile strength and elastic modulus, are shown in Figure 4.3 and Figure 4.4. The analysis of variance (ANOVA) of tensile properties is shown in table 4.1. Since the P-value is less than 0.05, it can be concluded as a statistically significant difference between the average value of the tensile strength and maximum force on the different percentages of the WEDM electrode composite. From the results shown in figure 4.3, the tensile strength of EDM electrode reinforced with EDM wire shows a substantial increase in EDM electrode fibre content from 0% to 40%.

4.3.1 Tensile performance of EDM long fibre composite

Tensile testing results, including tensile properties, are shown in Figures 4.1 and 4.2. Table 4.1 illustrates the analysis of variance (ANOVA) of tensile characteristics. Because the P-value is less than 0.05, it is possible to infer a statistically significant difference between the average values of tensile strength and maximum force for the various new and waste WEDM electrode composite percentages. According to the data given in Figure 4.1, the tensile strength of new EDM electrodes and waste EDM electrodes reinforced for long fibre 20mm orientation with EDM wire increases significantly from 0% to 40%. There is just a little change in the reinforcement's 0% and 10% ratios depending on the graft. This analysis shows that increasing the quantity of support does not produce an increase in composite tensile strength or maximum force. The reinforcement ratio of 20% to 30%

improves the tensile strength and maximum force values. Additionally, 40% has the highest tensile strength and can bear the most force when compared to the conventional of reinforcement. Table 4.1 illustrates the analysis of variance (ANOVA) of tensile characteristics. This is due to the strengthening effect of the EDM electrode fibre, which is caused by the interaction of the vinyl ester resin with very well fibres and the interfacial interaction between the fibers and the matrix. Apart from demonstrating a 50% ratio reinforcement reduction, these findings demonstrate that the matrix for vinyl ester resin is incapable of supporting 50% ratio EDM fibre reinforcement.

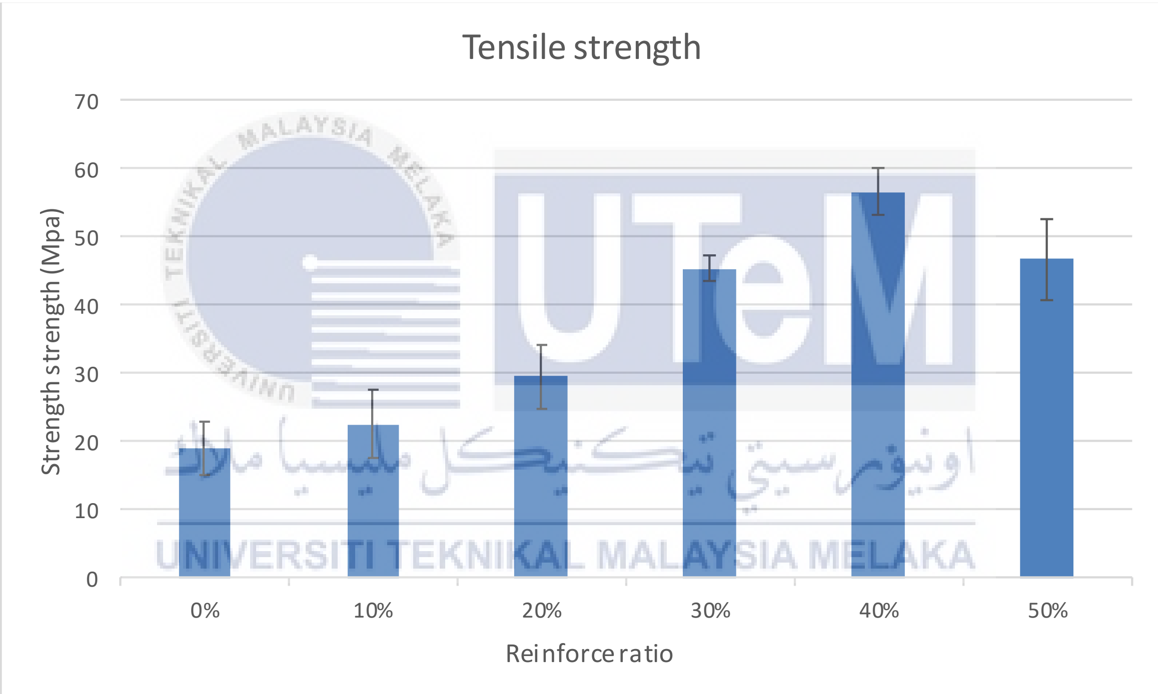

Figure 4.1 Tensile testing result for tensile strength for 200mm new WEDM electrode fiber

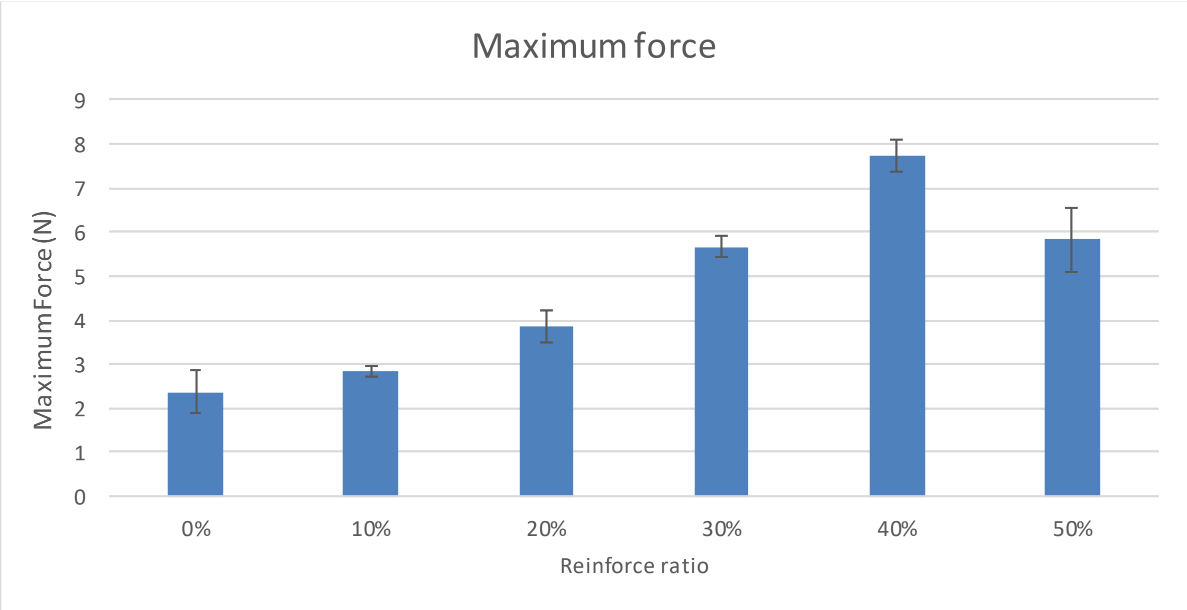

Figure 4.2 Tensile testing result for maximum force 200mm new WEDM electrode fiber

Table 4.1 The analysis of variance (ANOVA) of tensile properties for 200mm new WEDM electrode fiber

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	6000.421	3	2000.14	11.10491	0.000166	3.098391
Within Groups	3602.264	20	180.1132			
Total	9602.685	23				

EDM wire waste electrode was employed as a reinforcement in the composite. This data shows in Figures 4.3 and 4.2 the results of an examination of the EDM wire that had previously been discharged. Due to the nature of the wire changing throughout the discharge process, this research found that the tensile strength and maximum force generated decreases. The waste data EDM electrode reinforces a similar path to the new wire EDM. There is just a tiny variation between the composite values at 0% and 10% reinforcement. The reinforcing value of 20% to 40% results in a noticeable graft growth. When the amount of reinforcements applied in the composite is 50% lower in tensile strength, the maximum force allowed is dropped.

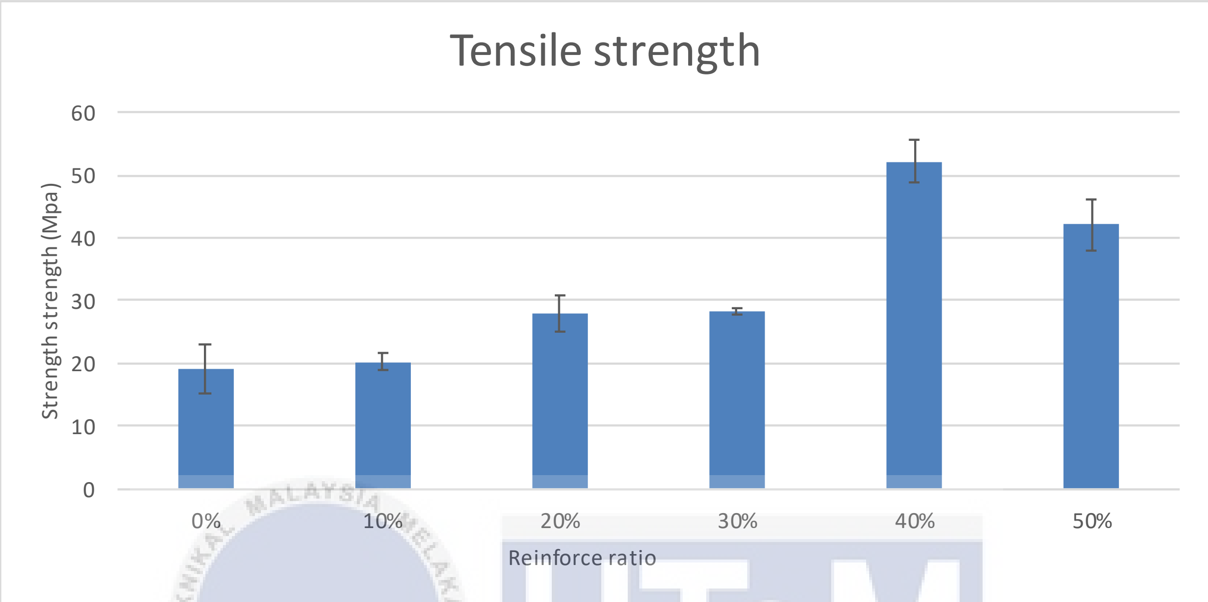

Figure 4.3 Tensile testing result for tensile strength for 200mm WEDM electrode fiber waste

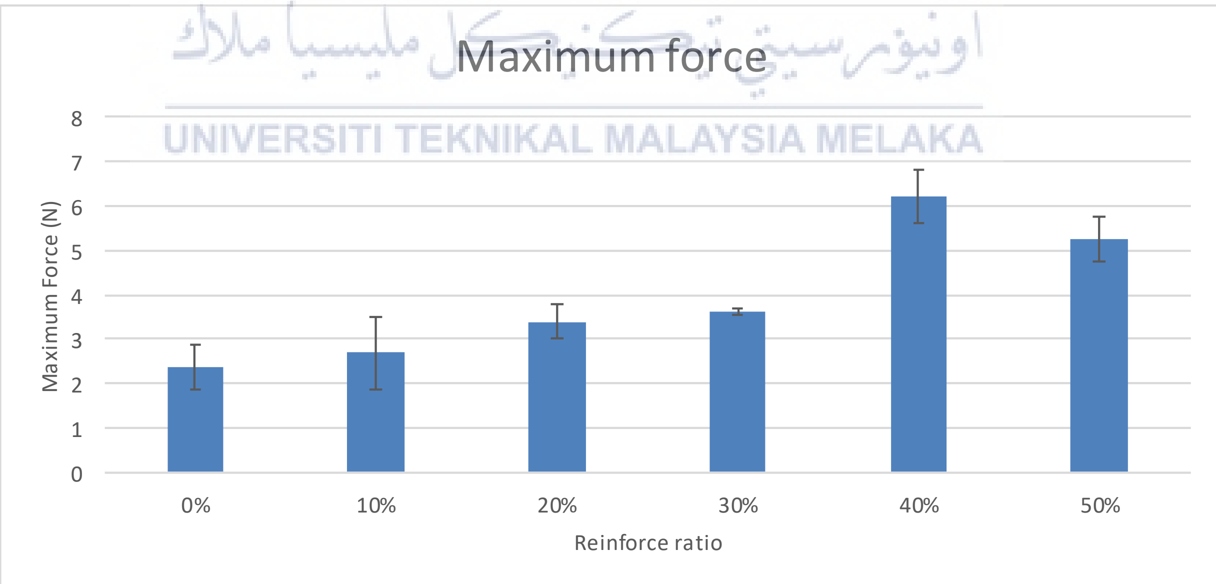

Figure 4.4 Tensile testing result for maximum force 200mm WEDM electrode waste fiber

Table 4.2 The analysis of variance (ANOVA) of tensile properties for 200mm WEDM electrode waste fiber

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4424.624	3	1474.875	11.22561	0.000155	3.098391
Within Groups	2627.695	20	131.3848			
Total	7052.319	23				

4.3.2 Tensile Performance of Short Fiber Composite

On three samples of EDM wire orientation cut 2mm lengths as reinforcement, tensile strength testing was carried out and poured vinyl ester was used as a matrix to keep the reinforcement in place in this composite. As indicated in figure 4.5, the value of the tensile strength test performed with the new reinforce shot fibre was determined, and figure 4.6 depicts the maximum force value of the reinforcing short fibre EDM wire waste electrode determined. Table 4.3 illustrates the analysis of variance (ANOVA) of tensile characteristics. Tensile strength test using new reinforce shot fibre based on the tests carried out, the analysis revealed that the values of tensile strength and maximum force increased by a factor of 0% to 30% from the starting point. The best tensile strength and maximum force value are obtained with a 30% quantity fibre. When the quantity ratio of fibre reaches 40% to 50%, however, there is a drop in fibre produced.

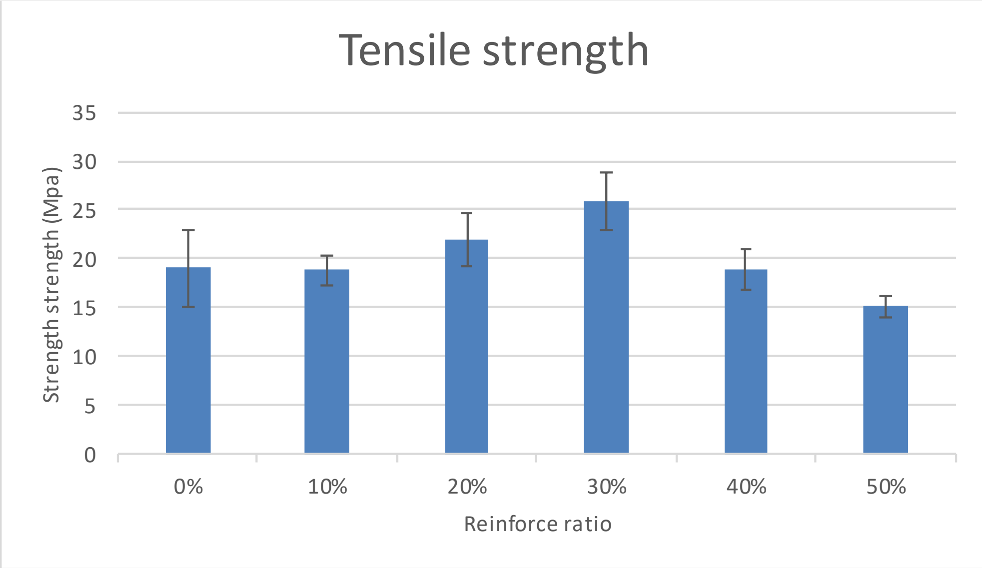

Figure 4.5 Tensile testing result for tensile strength for 20mm new WEDM electrode fiber

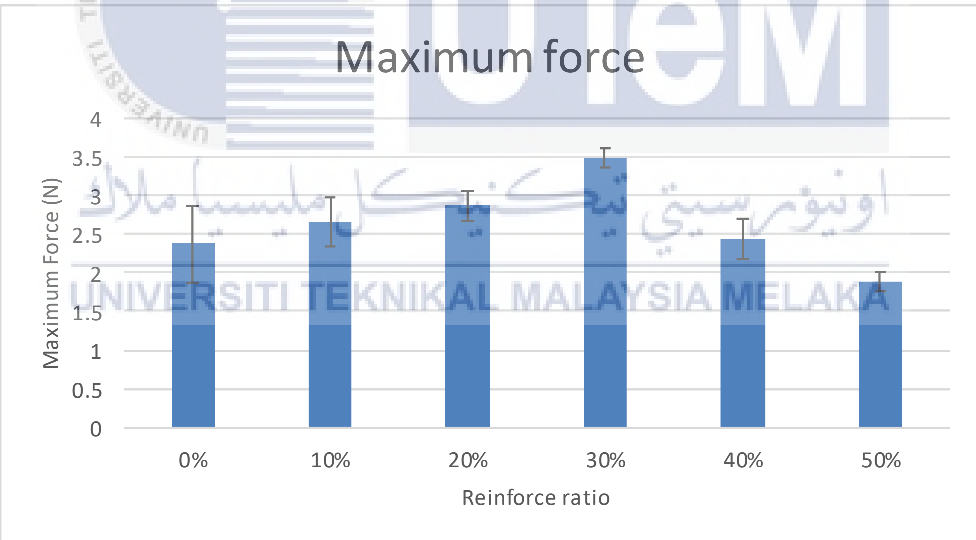

Figure 4.6 Tensile testing result for maximum force 20mm new WEDM electrode fiber

Table 4.3 The analysis of variance (ANOVA) of tensile properties for 20mm new WEDM electrode fiber

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1743.698	3	581.2326	41.92822	8.17E-09	3.098391
Within Groups	277.2512	20	13.86256			
Total	2020.949	23				

The waste electrode from an EDM wire was used as a reinforcement in the composite, and the results of an evaluation of the EDM wire that had previously been discharged are shown in this data. Because the nature of the wire changes during the discharge process, this study discovered that the tensile strength and maximum force produced both decrease due to the procedure. The waste data EDM electrode reinforces a similar route to the new wire EDM in structure and functionality. Tensile strength tests were performed using the new reinforce 20mm fibre. The tests conducted indicated that the values of tensile strength and maximum force rose by a factor of 0% to 30% from the beginning point, according to the analysis. It is found that 30% of the amount fibre produces the highest tensile strength and greatest force value. Nevertheless, as the quantity ratio of fibre exceeds 40% to 50%, there is a reduction in the amount of fibre generated. Figure 4.7 and 4.8 tensile testing results, including tensile strength and maximum force. Table 4.3 analysis of variance (ANOVA) of tensile properties for 20mm new WEDM electrode fiber.

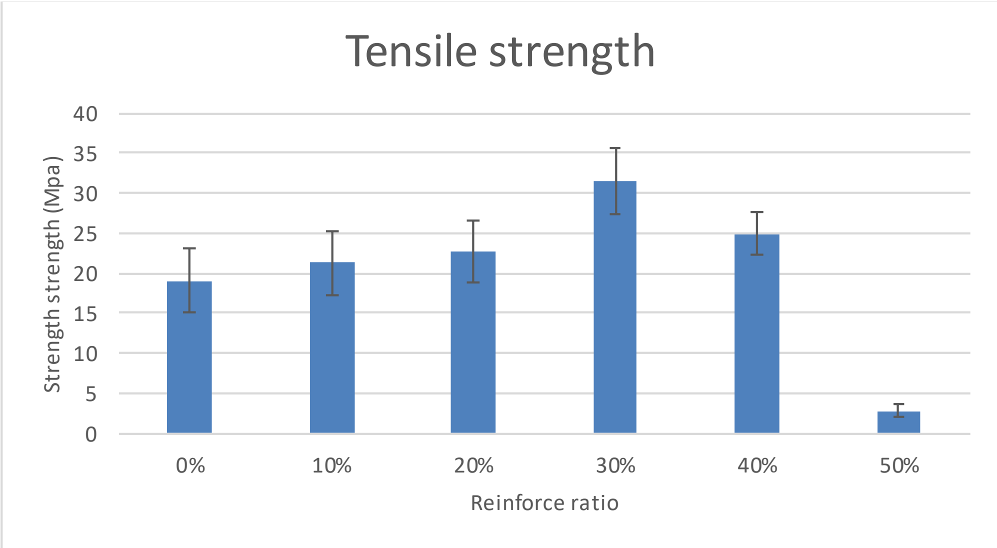

Figure 4.7 Tensile testing result for tensile strength for 20mm WEDM electrode wasre fiber

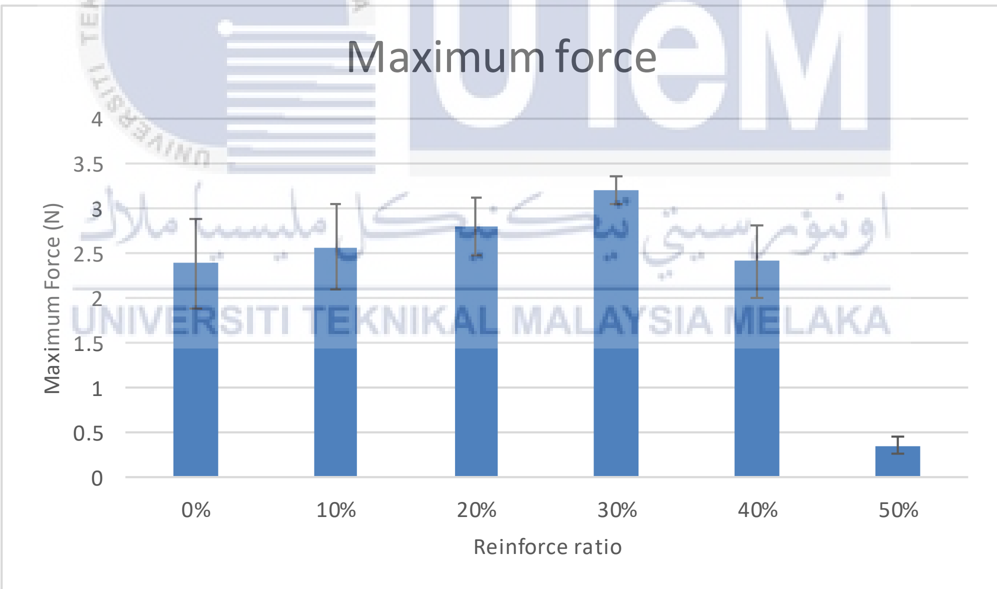

Figure 4.8 Tensile testing result for maximum force 20mm WEDM electrode waste fiber

Table 4.4 The analysis of variance (ANOVA) of tensile properties for 20mm new WEDM electrode fiber

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1886.224	3	628.7413	8.570288	0.000738	3.098391
Within Groups	1467.258	20	73.36291			
Total	3353.482	23				

4.3.3 comparison tensile test performance of 200mm new EDM wire reinforce with EDM wire waste

For each kind of specimen, as previously explained, there are differences in the length of the reinforce. This specimen testing involves a change in the reinforcement utilised, which is the kind of EDM wire used, which is a new EDM wire compare with EDM wire waste in this specimen testing. Furthermore, the length of the reinforcement differs between the two designs. The tensile test causes changes in the reinforcement; a compare between the maximum and lowest values of tensile strength on polymer matrix composites may be seen in terms of reinforcement and matrix ratio. Figure 4.9 depicts the difference between 200mm fresh EDM wire reinforce and 200mm EDM wire waste reinforce when compared to each other. The results of the investigation revealed that there were significant value disparities between the two kinds of wires. EDM wire waste is replaced with new wire EDM that has a greater tensile strength and maximum force value. This is owing to the characteristics of the new EDM wire, which are more significant than the properties of the EDM wire that has been subjected to the discharge process, resulting in the wire properties being more brittle as a result.

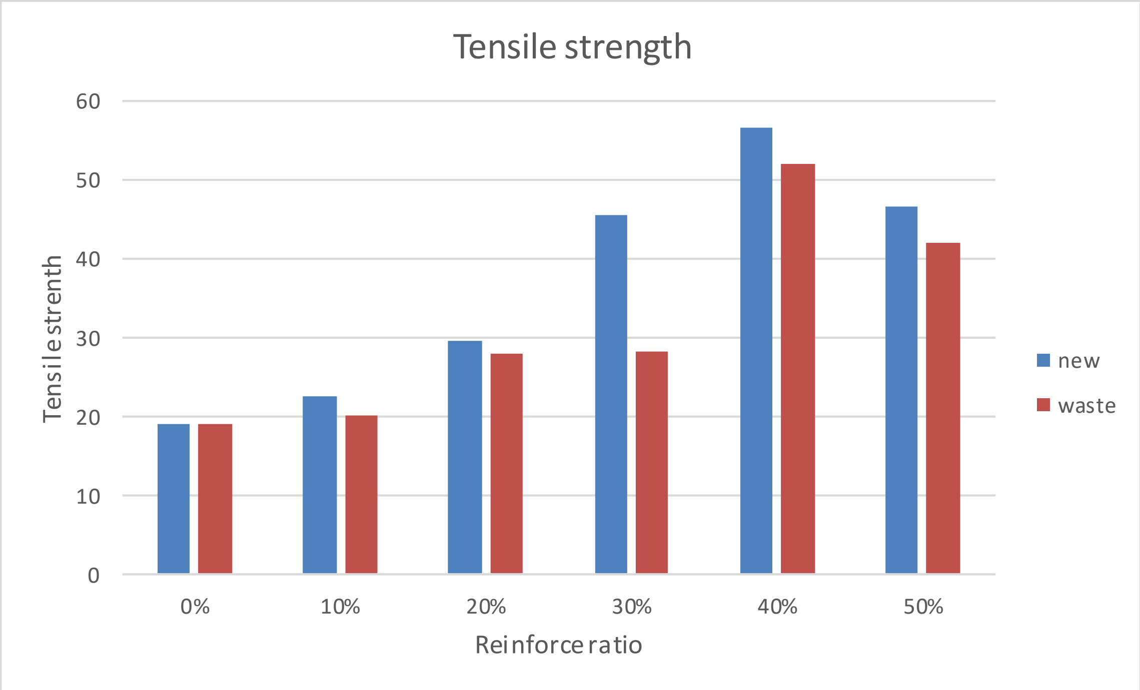

Figure 4.9 Comparison tensile test between 200mm new WEDM electrode fiber vs 200mm WEDM electrode waste fiber

The tensile test modifies the reinforcement; a comparison of the maximum and minimum tensile strengths on polymer matrix composites in terms of reinforcement and matrix ratio is possible. In comparison to each other, Figure 4.10 illustrates the difference between 20mm new EDM wire reinforce and 20mm EDM wire waste reinforce. The investigation's findings indicated that there were have differentials between the two types of wires. New EDM wire with a higher tensile strength compared with EDM wire waste. This is because the qualities of the new EDM wire are more important than the properties of the discharged EDM wire, resulting in the wire properties being more brittle because of the discharge process.

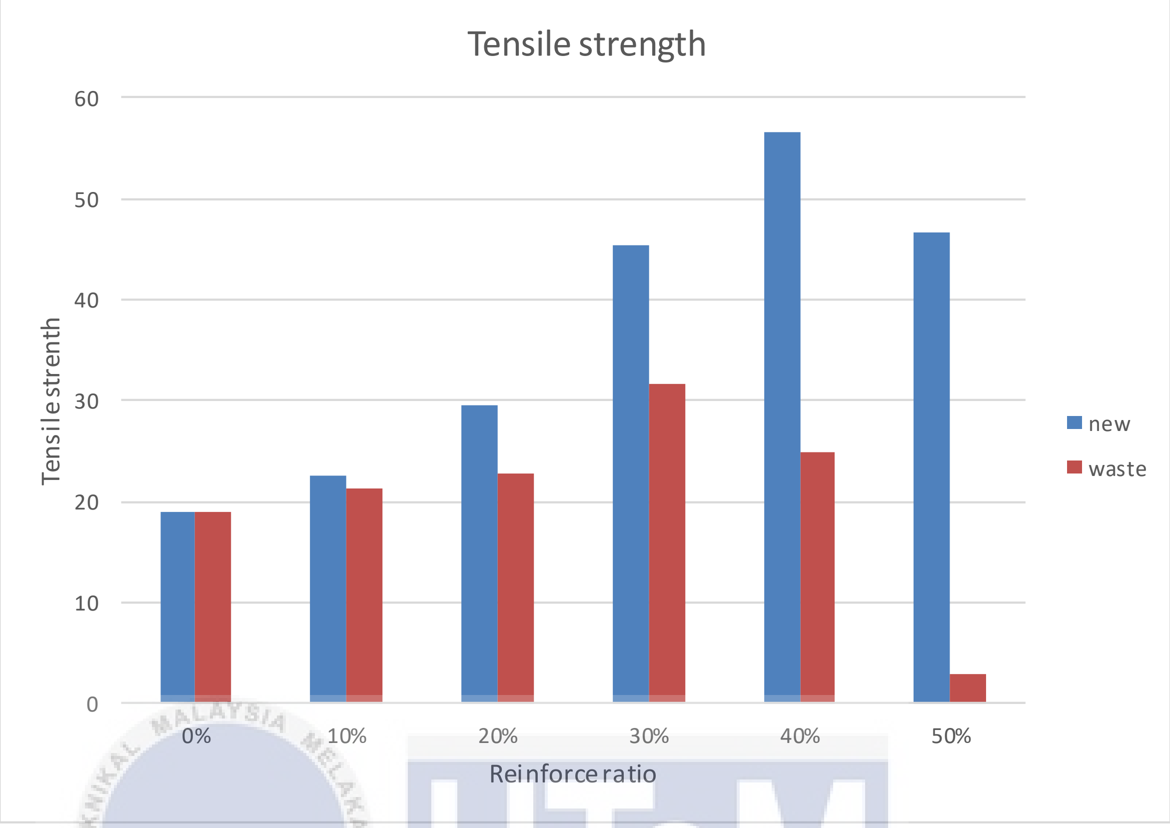

Figure 4.10 Comparison tensile test between 20mm new WEDM electrode fiber vs 20mm WEDM electrode waste fiber

4.4 Flexural properties

The material can sustain bending forces perpendicular to its longitudinal resistance measured in flexural resistance. The combination of flexural load that creates stress and compression strength is referred to as tensile strength (Ebinezar, 2014).

When the flexural test was conducted, the researchers recorded the flexural strength of the material. The results of the testing of the flexural characteristics are similar to those of the previous testing in that increasing the quantity of EDM electrode fibre in the component will result in an increase in flexural strength, but when the amount of fibre is surpassed, the flexural strength will decrease. The findings of this investigation are comparable to those of a prior study done by Kumar et al. Natural fibre reinforced hybrid polymer composites are the subject of this fascinating discovery. From the results, it can be concluded that the lowest flexural strength of the composite is 57.33 Mpa when there is no sisal fibre in it, and the maximum flexural strength is 62.044 Mpa when there is 100% fibre in it. The results revealed that the rising fibre content in the composite resulted in an increasing trend in flexural strength, which confirmed the hypothesis (Kumar et al., 2017).

4.4.1 flexural performance of 200mm fiber composite

The result of flexural properties, including maximum stress and maximum force, are shown in Figure 4.11 and Figure 4.12. The analysis of variance (ANOVA) of flexural properties is shown in table 4.5. Since the P-value is less than 0.05, it can be concluded as a statistically significant difference between the average value of the flexural strength on the different percentages of new wire EDM and EDM wire waste composite. Following the data obtained, there are a modest rise in the maximum stress and maximum force values on the graph when the new long wire EDM reinforcement ratio increases from 0% to 10% new 200mm wire EDM reinforcement. With an increase in the proportion of EDM wire reinforcement from 20% to 40%, the maximum stress and maximum force rise proportionally. At the same time, 40% is the proportion of long new wire reinforcement, which results in the most significant stress and maximum force value possible. However, a 50% reduction in the ratio is needed to strengthen the 200mm new wire EDM composite wire.

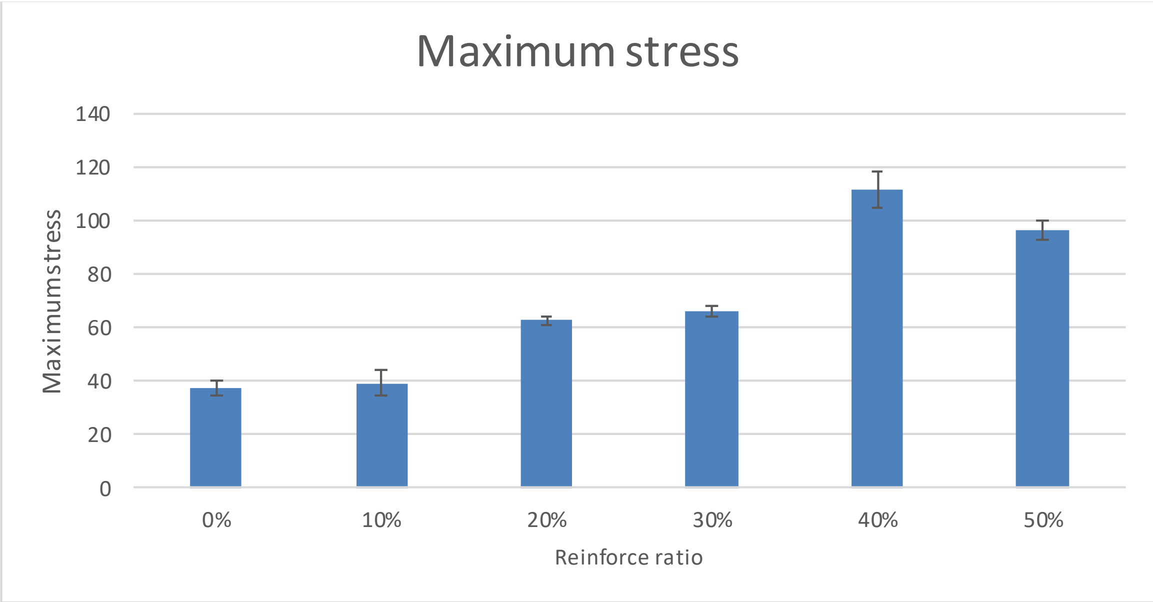

Figure 4.11 Flexural testing result for maximum stress for 200mm new WEDM electrode fiber

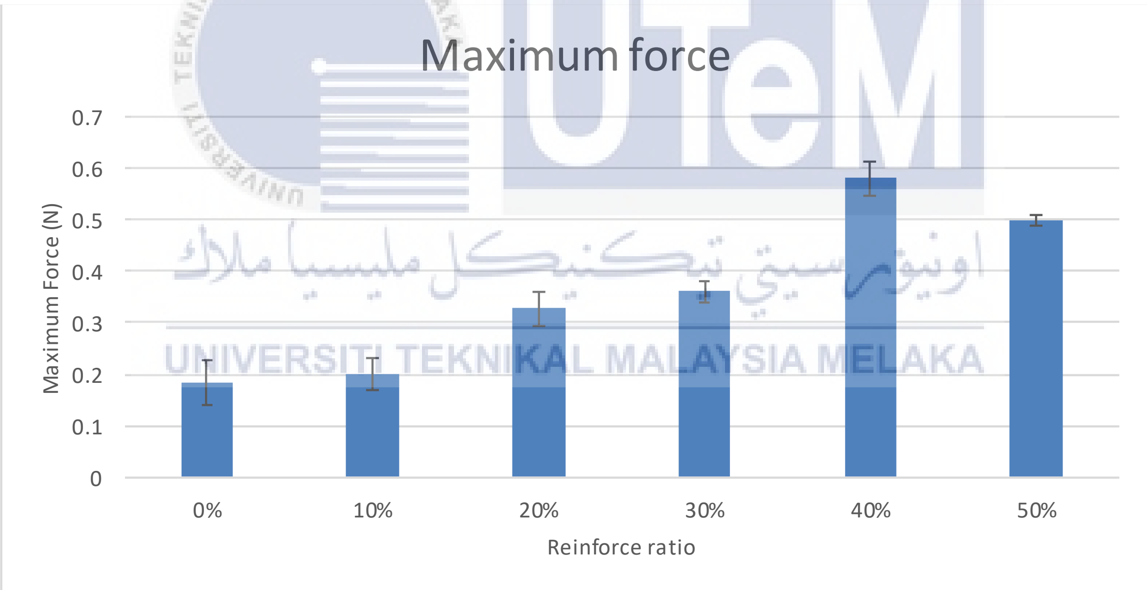

Figure 4.12 Flexural testing result for maximum force for 200mm new WEDM electrode fiber

Table 4.5 The analysis of variance (ANOVA) of flexural properties for 200mm new WEDM electrode fiber

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	21170.39	3	7056.798	10.36957	0.00025	3.098391
Within Groups	13610.59	20	680.5296			
Total	34780.99	23				

The waste electrode from a 200mm EDM wire was employed as reinforcement in the composite. The results of an examination of the EDM wire that had previously been discharged are displayed in this data. This investigation found that the maximum stress and maximum force generated both decreased due to the discharge process. According to the data acquired, there is a little increase in the maximum stress and force values on the graph when the new long wire EDM reinforcement ratio increases from 0% to 10%. Maximum stress and maximum force increase proportionately as EDM wire reinforcement increases from 20% to 40%. Simultaneously, 40% is the fraction of 200mm waste EDM wire reinforcement, which results in the highest feasible stress and force value. However, a ratio decrease of 50% is required to reinforce the 200mm wire EDM waste composite. The result of flexural properties including maximum stress and maximum force, are shown in Figure 4.13 and Figure 4.14. The analysis of variance (ANOVA) of flexural properties is shown in table 4.6.

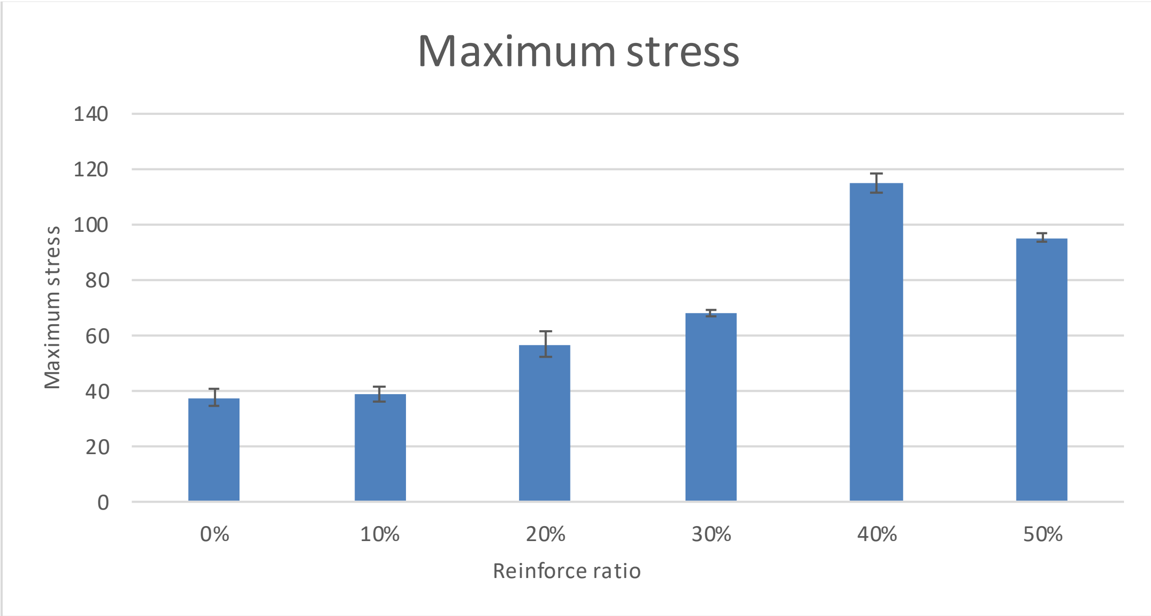

Figure 4.13 Flexural testing result for maximum stress for 200mm WEDM electrode waste fiber

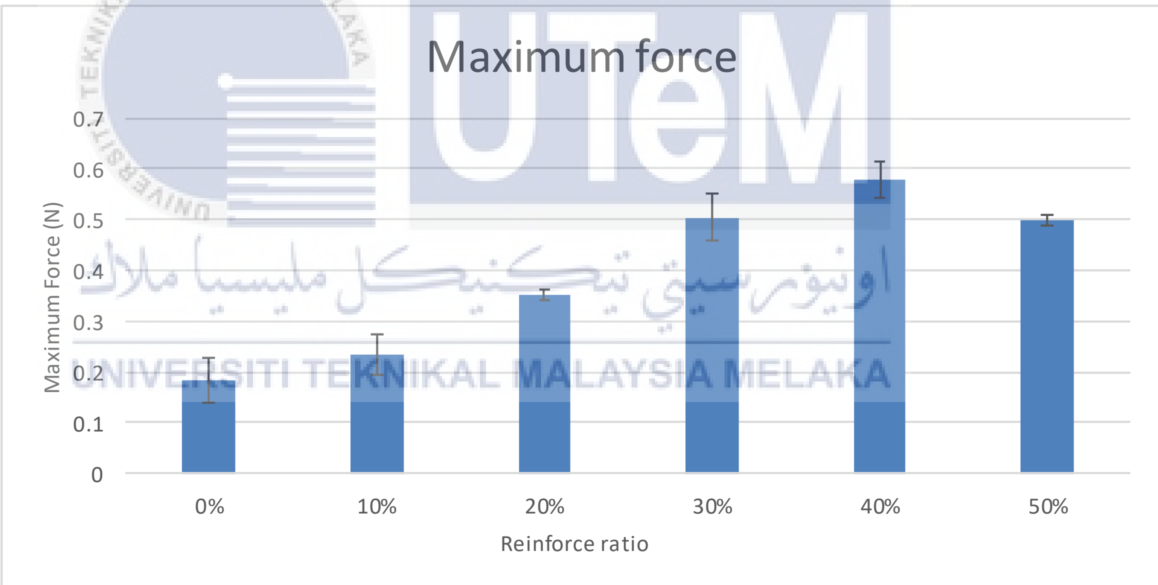

Figure 4.14 Flexural testing result for maximum force for 200mm WEDM electrode waste fiber

Table 4.6 The analysis of variance (ANOVA) of flexural properties for 200mm WEDM electrode waste fiber

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	20901.09	3	6967.03	9.561862	0.000401	3.098391
Within Groups	14572.54	20	728.6269			
Total	35473.63	23				

4.4.2 Flexural performance of 20mm fiber composite

Testing for tensile strength was conducted on three samples of EDM wire orientation cut 20mm lengths as reinforcement, which were then placed in an epoxy matrix to hold the reinforcement in place. Reinforcing 20mm fibre EDM wire electrode maximum stress value was calculated as shown in figure 4.15, and the maximum force results are shown in figure 4.16. The analysis of variance (ANOVA) of flexural properties is shown in table 4.6. employing a novel reinforced shot fibre for a toughness test Testing found that maximum stress and maximum force rose by a factor of 0% to 30% from the beginning point, based on the results of the tests conducted. A 30% amount fibre percentage provides the optimum tensile strength and maximum force. When fibre content is 40% to 50%, however, the amount of fibre generated decreases.

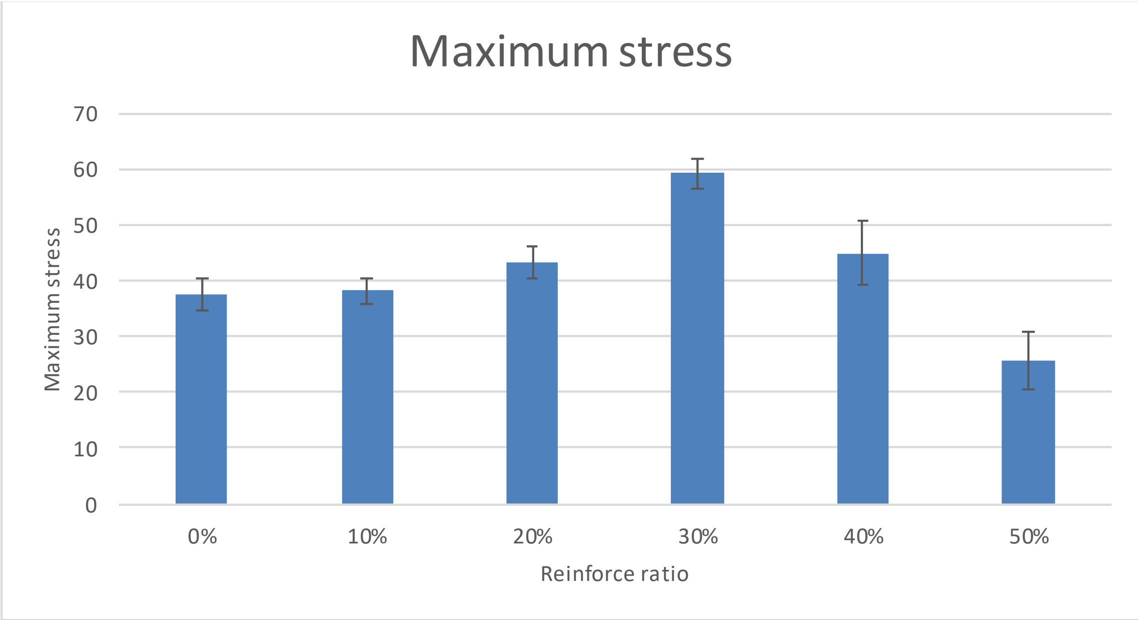

Figure 4.15 Flexural testing result for maximum stress for 20mm newWEDM electrode fiber

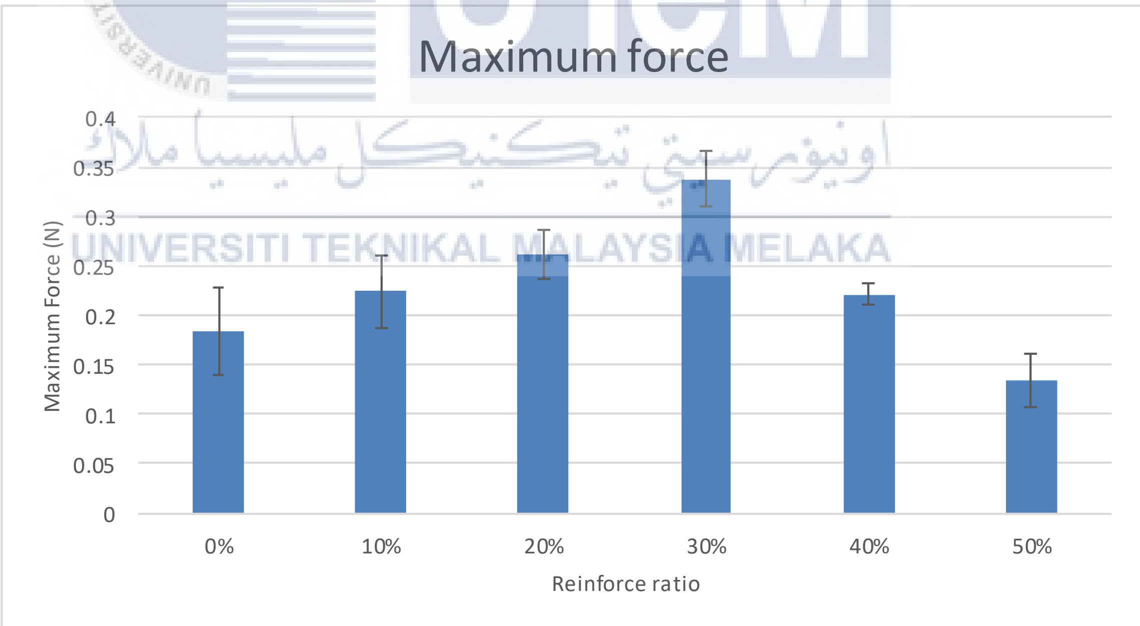

Figure 4.16 Flexural testing result for maximum force for 20mm new WEDM electrode fiber

Table 4.7 The analysis of variance (ANOVA) of flexural properties for 20mm new WEDM electrode fiber

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	7636.837	3	2545.612	25.44887	4.95E-07	3.098391
Within Groups	2000.57	20	100.0285			
Total	9637.407	23				

The waste electrode from an EDM wire was used as a reinforcement in the composite, and the results of an evaluation of the EDM wire that had previously been discharged are shown in this data. Because the nature of the wire changes during the discharge process, this study discovered that the tensile strength and maximum force produced both decrease as a result of the procedure. The waste data EDM electrode reinforce follows a similar route to the new wire EDM in terms of structure and functionality. Tensile strength tests were performed using the waste reinforce 20mm fibre. The results of the tests conducted indicated that the values of tensile strength and maximum force rose by a factor of 0 to 30 from the beginning point, according to the analysis. It is found that a 30 percent percentage of amount fibre produces the highest tensile strength and greatest force value. Nevertheless, as the quantity ratio of fibre exceeds 40% to 50%, there is a reduction in the amount of fibre generated. The result of flexural properties including maximum stress and maximum force are shown in Figure 4.17 and Figure 4.16. The analysis of variance (ANOVA) of flexural properties is shown in table 4.8.

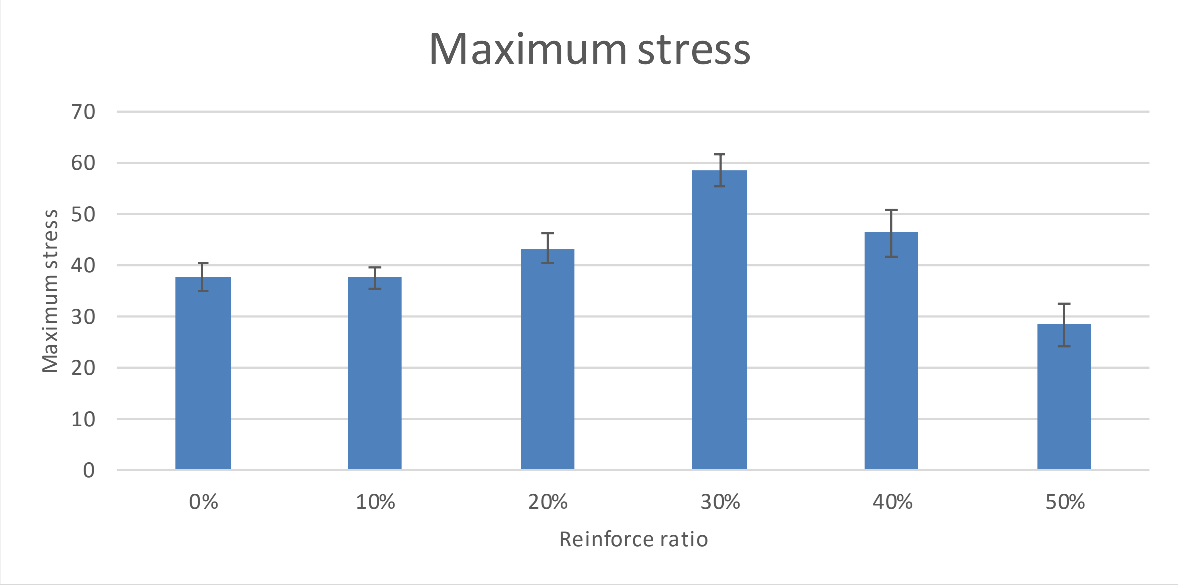

Figure 4.17 Flexural testing result for maximum stress for 20mm WEDM electrode waste fiber

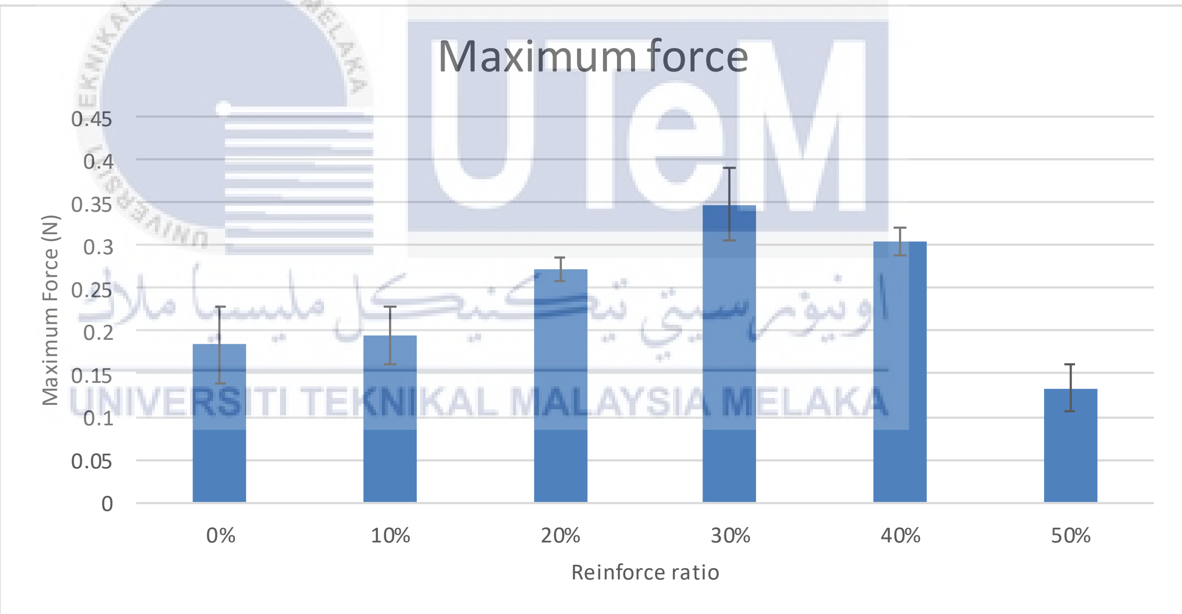

Figure 4.18 Flexural testing result for maximum force for 20mm WEDM electrode waste fiber

Table 4.8 The analysis of variance (ANOVA) of flexural properties for 20mm WEDM electrode waste fiber

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	7785.051	3	2595.017	30.79342	1.08E-07	3.098391
Within Groups	1685.436	20	84.27181			
Total	9470.487	23				

4.4.3 Comparison flexural test perform of 20mm new EDM wire reinforce with EDM wire waste

Based on the study of maximum stress during flexural testing on 200mm fibres, comparing two categories, namely new wire EDM and EDM wire waste. A comparison of the maximum stress that may be applied to each content of fiber in the composite is performed. Figure 4.19 illustrates the value of maximum stress for 200mm new EDM wire compared to EDM wire waste, which shares a similar pattern. Fiber values of 30% and 40% indicate that wire EDM waste has a higher maximum stress value than new wire EDM. At fibre ratios of 20% and 50%, the new wire EDM has a greater maximum stress value. That was most likely because each specimen has a different matrix combination of mass vinyl ester resin with hardener.

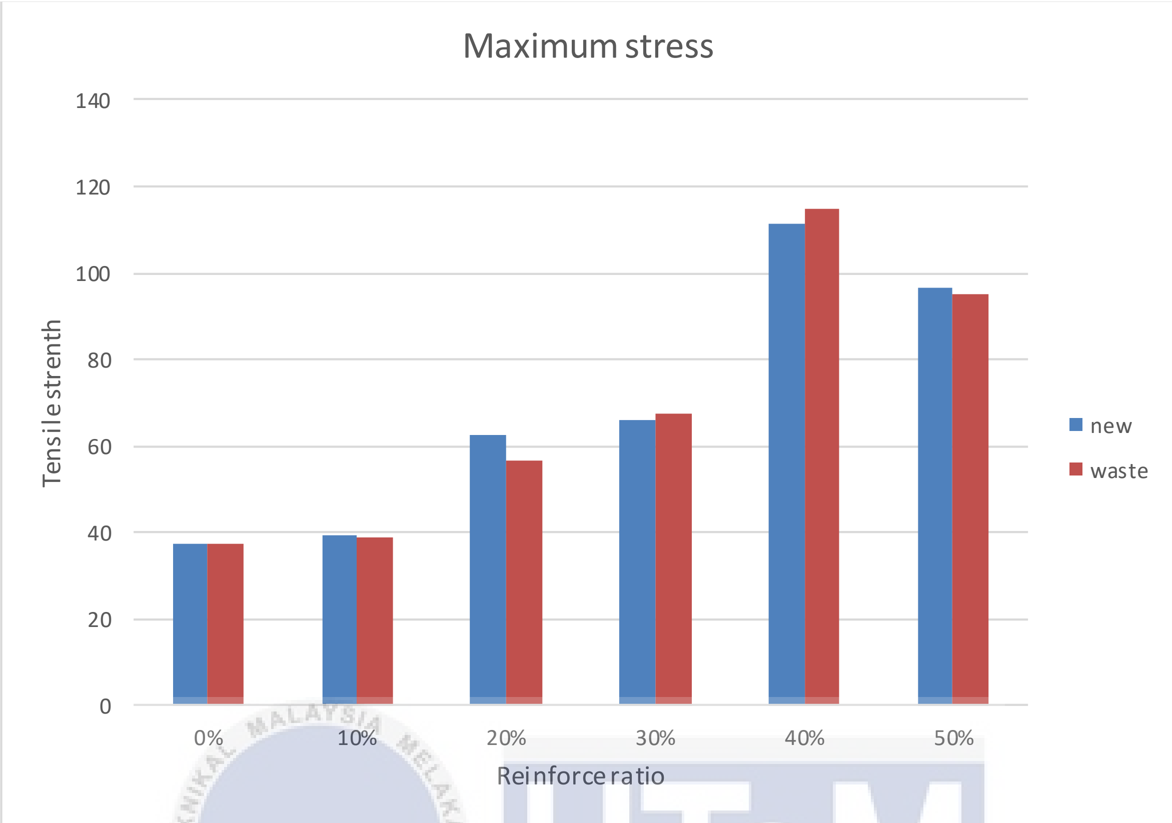

Figure 4.19 Comparison flexural test between of 200mm new WEDM electrode fiber vs 200mm WEDM electrode waste fiber

The flexure test modifies the reinforcement; a comparison of the maximum and minimum tensile strengths on polymer matrix composites in terms of reinforcement and matrix ratio is possible. In comparison to each other, The maximum stress that may be applied to each fibre composition in the composite is compared. Figure 4.20 compares the maximum stress value for fresh 20mm EDM wire to EDM wire waste, which exhibits a similar trend. Fiber percentages of 40% and 50% show that waste wire EDM has a higher maximum stress value than new wire EDM. The new wire EDM has a higher maximum stress value for 10% to 30% fibre ratios. This is most likely due to the fact that each specimen has a different matrix of mass vinyl ester resin and hardener.

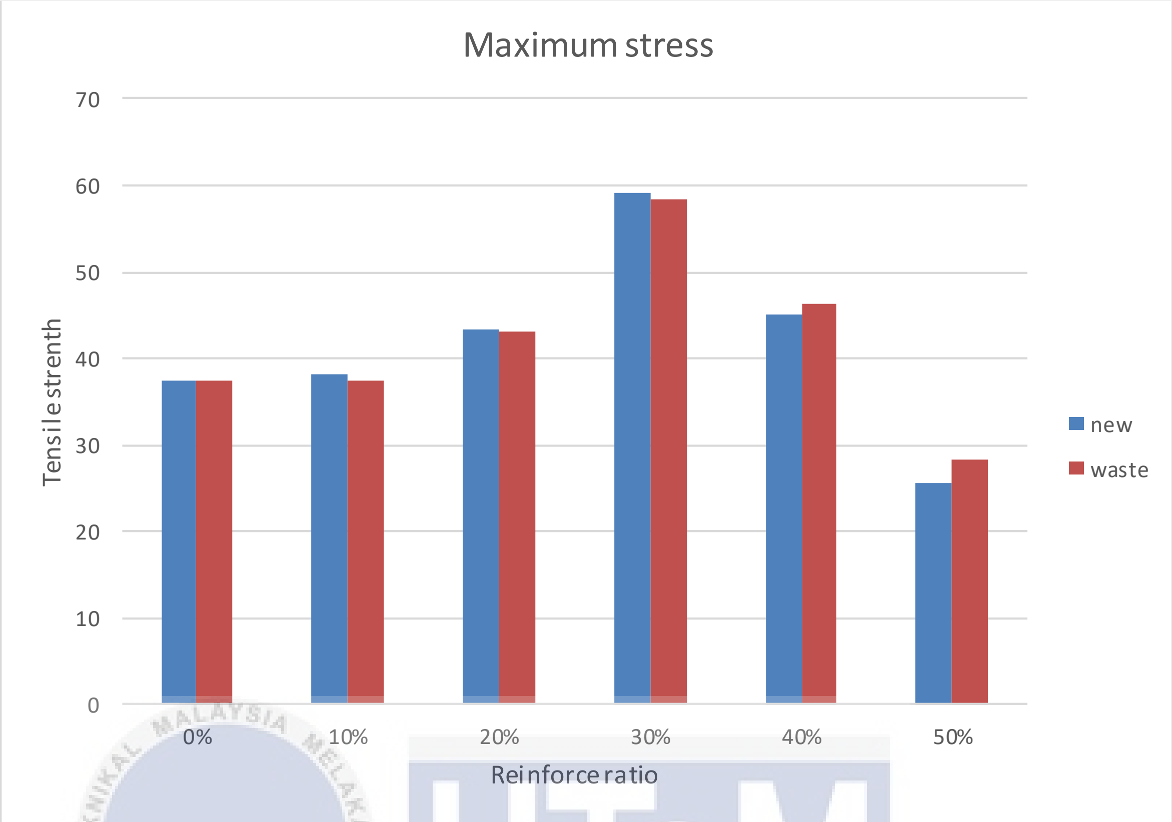

Figure 4.20 Comparison flexural test between of 20mm new WEDM electrode fiber vs 20mm WEDM electrode waste fiber

CHAPTER 5

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

A significant difficulty in waste is the presence of a by-product of human activity that is physically identical to the wide range of compounds in the useful product. While waste is an unavoidable byproduct of human activity, it is also a result of inefficient production processes, the continuous development of which leads to the loss of precious resources. The physical states, physical attributes, reusable potentials, biodegradable potentials, source of production, and degree of environmental effect are frequently used to classify garbage. Rubber ideas and WEDM electrode fibers as reinforcements were not evident in the composites group in the future. Of course, who used a variety of techniques in developing this strategy. Polymer matrix composites reinforced with WEDM electrodes may also impact environmental pollution and commerce. This project uses wire EDM as a reinforcing material in conjunction with the vinyl ester to create a composite matrix polymer. The variations in mechanical qualities between new wire EDM and waste EDM are examined in this research. This study utilised wire EDM as a reinforcing material in conjunction with the vinyl ester to create a composite matrix polymer. The variations in mechanical qualities between new wire EDM and waste EDM are evaluated in this research. WEDM waste electrode fibre can be converted into a new material with great mechanical characteristics. In contrast, eco-friendly waste EDM electrode fiber can be converted into a new material with outstanding mechanical properties.

There are two types of WEDM electrode fibre that have been defined and examined here, particularly new WEDM electrode fiber and discharged WEDM electrode fiber. Numerous comparisons between the new WEDM electrode fiber and the WEDM electrode waste fiber composite are possible. On the mechanical testing, it was discussed and analyzed. Tensile and flexural tests were performed. According to the results, the electrode reinforcement ratio for 40% 200mm WEDM will be the greatest from both tensile and flexural tests. Therefore, amongst 0%, 10%, 20%, and 30%, the maximum fiber ratio is 30% 200mm WEDM electrode. However, the 30% new 200mm WEDM electrode fiber has a higher tensile despotstrength than the 20% waste 200mm WEDM electrode fiber; this is because the WEDM waste had an ongoing electric discharge due to wire electrode breakage during machining, something that results in a decrease in the mechanical strength of the wire electrode.

Furthermore, the data indicates a reduction of between 40% and 50% in the 200mm WEDM electrode. This occurs because the vinyl ester matrix in the composite cannot support 50% of the 200mm WEDM electrode fiber. Whereas for 20mm reinforcement, the WEDM electrode fibre result shows that 30% will be the greatest form of both the tensile and flexural test. Wherefore be found a gap between 20mm new wire EDM with 20mm WEDM waste electrode, it is because the 20mm new WEDM electrode can withstand force that could tear it apart more effectively than 20mm WEDM waste electrode. This flexural between tensile results were almost the same trend because the concentrations will increase when it on 40% 200mm WEDM electrode fiber ratio. It is because of 60% vinyl ester resin bond with 40% 200mm WEDM electrode reinforce give more strength to the composite and it was difficult to bend or to break. Related to the 20mm WEDM electrode that shows on 30% WEDM reinforce fiber ratio give the most strength to the composite compare to other ratio of reinforce. High distribution of reinforcement inside the vinyl ester resin can be observed the composite orientation hand lay-up method.

So, to conclude this part, in general, the finding from this study have shown that for the length of reinforce 200mm WEDM electrode fiber bond in the vinyl ester resin has improved the function at the characteristic greater compared with the 20mm length of reinforce WEDM electrode fiber bond vinyl ester resin. On the other hand, the new WEDM electrode fiber gives a greater value for tensile and flexural test result althougth the reinforcement WEDM electrode from 10% to 20% has improved the function at characteristic compared to the pure material, whichever just contains vinyl ester resin on the composite.

5.2 Recommendations

For future improvements, accuracy of the mechanical testing estimation results could be enhanced as follows:

i) Studies on the new methods to improve the properties of the composite by applying additional other treatments for example heating treatment or coating method.

ii) Further reduce the distance or gap between the wires to close the empty space so that there is no fibre misalignment and space cavity on the fibre.

iii) It would be interesting to assess the effects of the strength of ballistic panel if the wirecut waste done by interplay composite concept.

5.3 Project Potential

Sustainability is critical for assuring the ecosystem's continued implementation and maintenance in order for future generations to sustain present assets. It is also critical to maintain order in our surroundings while meeting human wants and aspirations. It is critical to always strive towards green technologies in order to keep the world from becoming more polluted. Sustainability is becoming a more compelling argument for material selection. The EDM electrode is very sustainable since it is 100% recyclable.

Additionally, wirecut waste (EWW) is chosen since it is not sold, discarded of, or reused and there is no need for wire EDM trash. This results in economic waste and environmental harm, since it is not ecologically friendly. Additionally, many industries that employ EDM wire have disposed of their waste, causing harm to the environment and increasing manufacturing costs more than profit margins. As a result, incorporating this EWW into a hybrid intraply laminated composite is one of the finest steps.

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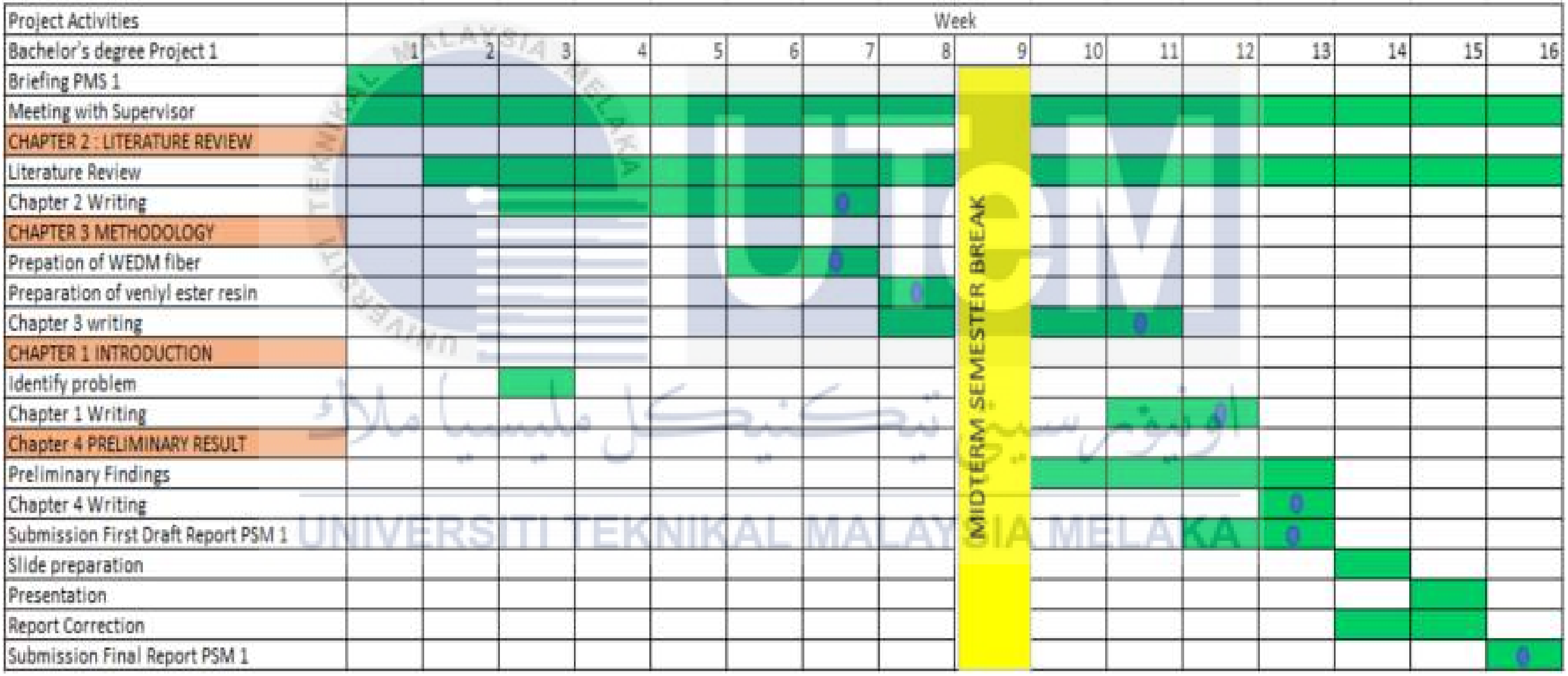
APPENDICES

APPENDIX A Gantt Chart PSM 1.



APPENDIX B Gantt Chart PSM 2

Project Activities	Week															
Bachelor's degree Project 2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Briefing PMS 2									MIDTERM SEMESTER BREAK							
Meeting with Supervisor																
CHAPTER 2 : LITERATURE REVIEW																
Literature Review																
Chapter 2 Writing																
CHAPTER 3 METHODOLOGY																
Prepation of WEDM electrode fiber																
Preparation of veniyl ester resin																
Chapter 3 writing																
CHAPTER 1 INTRODUCTION																
Identify problem																
Chapter 1 Writing																
Chapter 4 PRELIMINARY RESULT																
Preliminary Findings																
Chapter 4 Writing																
Submission First Draft Report PSM 1																
Slide preparation																
Presentation																
Report Correction																
Submission Final Report PSM 1																

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA

TAJUK: MECHANICAL PROPERTIES OF NEWLY DEVELOPED POLYMER MATRIX COMPOSITE – WIRE ELECTRIC DISCHARGE MACHINE(WEDM)

SESI PENGAJIAN: **2021/22 Semester 1**

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Nama pelajar: MOHAMMAD AIDIL AZREEM BIN IBRAHIM (B091810354)
Tajuk Tesis: MECHANICAL PROPERTIES OF NEWLY DEVELOPED POLYMER MATRIX COMPOSITE – WIRE ELECTRIC DISCHARGE MACHINE(WEDM)

3. Hal ini adalah kerana IANYA MERUPAKAN PROJEK YANG DITAJA OLEH SYARIKAT LUAR DAN HASIL KAJIANNYA ADALAH SULIT.

Sekian, terima kasih.

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"KOMPETENSI TERAS KEGEMILANGAN"

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