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DEPARTMENT OF MECHANICAL ENGINEERING

BPC PROSTHETIC LEG

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DECLARATION OF OWNERSHIP AND COPYRIGHT

TITLE : BPC PROSTHETIC LEG

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ABSTRACT

Around 360 million people in the world, according to Health Research (NHMS) Malaysia in 2011, shows that the amount of diabetes patient increased from 14.9 % in 2006 to 20.8% in 2011. Hence, this means that every 5 people in Malaysia, there are possibly one person is affected by diabetes. Losing some part of the body especially a leg is a huge lost because it could always be use for many activities like walking, running, daily routine and many more activities. Prosthetic leg has been developed since the World War 1. So, with the help of technology, prosthetic leg industry has advanced, plus the idea of bio-polymer composite prosthetic leg was born. However, current prosthetics are not bio-degradable which will lead to increasing of non-decomposable material in Malaysia that could harm the environment. Due to that issue, with the combination of Kenaf fibre in this BPC prosthetic leg it can be decompose naturally and it will benefit both human and environment. Plus, by using Kenaf a type of natural fibre, it is cheaper compare to carbon fibre, thus this bio-polymer composite prosthetic leg will cut the cost of the original prosthetic leg. In addition, by using Kenaf ,a strong but light in weight fibre , BPC prosthetic leg is lighter compare to other prosthetic material in current market.

ABSTRAK

Sekitar 360 juta orang di dunia, menurut Penyelidikan Kesihatan (NHMS) Malaysia pada tahun 2011, menunjukkan bahawa jumlah pesakit diabetes meningkat daripada 14.9% pada tahun 2006 kepada 20.8% pada tahun 2011. Oleh itu, ini bermakna bahawa setiap 5 orang di Malaysia, mungkin ada seorang yang terkena diabetes . Kehilangan sebahagian badan terutamanya kaki adalah kehilangan yang besar kerana ia sentiasa boleh digunakan untuk banyak aktiviti seperti berjalan kaki, berjalan, rutin harian dan banyak lagi aktiviti. Kaki Prostetik telah dibangunkan sejak perang dunia 1. Oleh itu, dengan bantuan teknologi, industri leg prostetik telah maju, ditambah dengan idea leg prostat polimer komposit dilahirkan. Walau bagaimanapun, prostetik semasa tidak boleh degradasi bio yang akan membawa kepada peningkatan bahan tidak boleh diurai di Malaysia yang boleh menjejaskan alam sekitar. Disebabkan isu itu, dengan gabungan serat Kenaf di kaki prostetik BPC ini boleh diurai secara semula jadi dan ia akan memberi manfaat kepada manusia dan alam sekitar. Selain itu, dengan menggunakan Kenaf sejenis serat semulajadi, ia lebih murah berbanding dengan serat karbon, oleh itu leg sintetik bio-polimer ini akan mengurangkan kos kaki prostetik asal. Di samping itu, dengan menggunakan Kenaf, serat yang kuat tetapi ringan, kaki palsu BPC lebih ringan berbanding bahan prostetik yang lain di pasaran semasa.

CONTENT

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 : INTRODUCTION

1.1 **RESEARCH BACKGROUND**

Nowadays, diabetes increase form years to years which lead to the issue of increasing amputees. Diabetes is a major public health concern in Malaysia, and the prevalence of type 2 diabetes (T2D) has escalated to 20.8% in adults above the age of 30, affecting 2.8 million individuals. This issue has been such a concern but our intentions are leading towards the prosthetic leg.

Plus, non-decomposable materials in Malaysia are increasing and which now makes us among the highest polluted country. Thus, there will be a lot of precautions and new inventions created to avoid the pollution scenario. However, in Malaysia there is a new material that is called as Kenaf . Kenaf is a natural polymer that is created from Kenaf trees, that have been widely planted by Kenaf Institution. This material has a wide source but the development is quite slow.

Hence, with the ideas form these three scenarios that is the issue with amputees , non-decomposable material and wide Kenaf source , we decided to come out with the idea of making a prosthetic leg that is based with Kenaf as a polymer .Prosthetic leg is widely used since the hospital in Malaysia averagely , have 14 amputees that wear prosthetic and there are approximately 513 public hospital and 216 privates hospital which makes around 10,206 prosthetics that has been used in Malaysia .This shows that prosthetic leg in Malaysia is widely used but the development itself is not rapid.

Therefore, this study inspired to combine degradable thermoset with Kenaf to create a brand new material as a prosthetic. This new material is cheaper because of Kenaf is not expensive due to its overwhelming amount of source. Plus, it could be decompose naturally and environmentally friendly since the Kenaf is a natural polymer. So we decided to create this new material as a solution to pollution caused by non-decomposable material and also to make benefit from Kenaf industry.

1.2 PROBLEM STATEMENT

The material used in making a prosthetic leg in Malaysia is commonly polypropylene, polyethylene, fiberglass, Carbon fibre, resin, iron and wood. All the materials are heavy which could lead to the difficulties that will effects the user's walking .Plus, this is the reason why people that wear prosthetic leg walks limply due to the heavy prosthetic leg.

Plus, commonly prosthetic leg will cost RM5000+ and some will reach over RM10000. These prices are not surprising and its really expensive .This is a major problem since not everyone could afford a prosthetic leg that costs around RM5000 and more .This scenario leads to handicap people that are very unfortunate to walk without prosthetics.

Moreover, the material used in the making of prosthetic leg is not decomposable which means it will effects the environment soon or later. This is because the issue of non-decomposable plastics and materials are being brought up nowadays due to our National Solid Waste Managing Department, the second biggest source of waste is plastic based materials. That covers up 9% or exactly RM163000000. As we all know plastic based materials takes hundred thousand years to decompose ,which along that long period , it will be non-decomposable material that will effects the environment. This scenario leads to the making of prosthetics. Averagely, in one hospital in Malaysia, there are 14 handicap people that wears prosthetics. So there are 153 public hospitals and 216 private hospitals, so there are about 5166 prosthetics roughly. This amount is huge and since it is non-decomposable, it will effects the environment in a way or another.

1.3 RESEARCH OBJECTIVES

The objectives to this research are:

i. To create a lighter prosthetic leg, to make it more convenient for disabled people.
ii. Reduce the prosthetic leg price to be more reasonable.
iii. To make prosthetic as a biodegradable material.

1.4 RESEARCH QUESTIONS

This study will answer the following research questions:

i. Is it possible to create a lighter prosthetic that are high in quality?
ii. What type of material that can be used to make prosthetic cheaper?
iii. What are the possibilities of making prosthetic a biodegradable material?

1.5 SCOPE OF RESEARCH

The scopes and limits to this research are:

I. This product could not be exposed to water frequently.
II. This product could decompose naturally.
III. Not suitable for handicap athletes.
IV. Uses Kenaf as a fibre to strengthen the prosthetic leg.
V. Could last for a long time with a good care.

1.6 SIGNIFICANCE OF RESEARCH

Although, the prosthetic legs that are currently used in Malaysia could perform well and people are willing to pay high price for it .However, some disabled people could not afford RM 5000++ worth of prosthetic leg and moreover, the issue of non-biodegradable material in Malaysia is increasing. Thus, the finding of this study will bring a lot of benefits to the disabled people that cannot afford expensive prosthetic. Plus, it will contribute to the Kenaf Institution as well since we are using the material from Kenaf Fibres. Moreover, it will absolutely benefits Malaysia since we are reducing the amount of non-biodegradable material in Malaysia.

1.7 DEFINITION OF OPERATIONAL TERMS

Kenaf : Type of tree with strong fibres that could only be found in Kelantan , Malaysia .

Polypropylene: A type of synthetic resin use for fibres and moulding materials.

Biodegradable: Ability to decompose naturally by bacteria or environment.

Plaster of Paris: A mixture of sand and cement to produce strong hard surface when dried.

1.8 CHAPTER'S SUMMARY

In this chapter, the studies was explained about its origin of ideas and inspirations. All the objectives were made out of all the problem statements. The objective for this project along with the importance will be bio-degradable prosthetic leg that will be cheap and light causing it to be more convenient for amputees, and even the scope of this project only focusing at the bio-degradable prosthetic. Thus, this new prosthetic could be used for daily routine with a really good care for a longer lifetime.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, will be shown three material used in making prosthetic leg in the current markets. These three materials has its own advantages and disadvantages. Hence, all the characteristics of those materials will be compared to our own product which has its own specialties and benefits. Since 300 B.C prosthetic leg are made forms iron and bronze with a wooden core, made my a blacksmith like the way they made swords and armoury. In the dark ages, the prosthetic leg were very bulky and does not function very well. Back in those days, prosthetic leg is only used to cover up their lost of limb because they thought it was embarrassing.

Then its to the pirates era, where they used peg legs with wooden core which pretty much has been used through out that era. The moving on to the 16^{th} century , Ambroise Pare , a French military doctor had actually been working on a lot of amputations . The doctor has made a lot of improvements for amputees , he created a locking knee and also specialized attachment harness. However in the year 1690, Peter Verduyn, later created more advanced improvements such as specialized hinges and leather cuffed for better attachment. In the 18^{th} century , Gustav Herman suggested to use aluminium instead of metal to make prosthetic limb because its lighter and more convenient for the amputees.

In now modern days, prosthetic leg development has been much more rapid and so the materials used a aluminium , plastic and composite material . Plus the prosthetic leg nowadays are lighter compare to what it used to be. So in this chapter, it will be explained about 3 materials that are used to make prosthetic leg and the comparison between those materials and our product material.

2.2 Literature Review : Carbon Fibre Prosthetic Leg

Prepared By Sharifah Nurul Balqis

2.2.1 Introduction

Since the 20th century , carbon fibre or also called as graphite fibre or carbon graphite , consist a very thin strand of the element carbon. Each fibre is 5-10 microns in diameter. To give a sense of how small that is, one micron (um) is 0.000039 inches. One strand of spider web silk is usually between 3-8 microns. Carbon fibre is made from organic polymers, which consist of long strings of molecules held together by carbon atoms. Most carbon fibre (about 90 percent) are made from the polyacrylonitrile (PAN) process. A small amount (about 10 percent) are manufactured from rayon or the petroleum pitch process. Gases, liquids, and other materials used in the manufacturing process create specific effects, qualities, and grades of carbon fibre. The highest grade carbon fibre with the best modulus properties are used in demanding applications such as aerospace. Carbon fibre are twice as stiff as steel and five times as strong as steel, (per unit of weight). They also are highly chemically resistant and have high-temperature tolerance with low thermal expansion.

But however it all began in 1879 , where Thomas Edison created a light bulb with carbon fibre , even though the fibres lack of tensile strength not like the carbon fibres nowadays , it is very ideal back then . Then in the 1950s , high tensile carbon fibres were discovered. The benefits of the high tensile carbon fibres are also well known by all industries so the using of carbon fibres in the market are very rapid and the consumption of carbon fibres increasing throughout all these years.

However each materials used in making any type of product has its own pros and cons in every aspect. Even though carbon fibre is well known because of its strength and stiffness , it still does have a lot of its own disadvantages . In this chapter , it will explain about the benefits , the disadvantages and also the characteristic of this material.

Figure 2.2.1 – Carbon Fibre Prosthetic Leg

2.2.2 Characteristics of Carbon Fibre

Advantages of Carbon fibre

Since the discovery of carbon fibre, it is well known to be very beneficial for the industries and research . Carbon fibre is used in the making of prosthetic leg since the 20th century and has been the most suitable material to make prosthetic leg since due to its benefits and characteristic that fits the prosthetic leg. Out of many benefits of carbon fibre are its stiffness and strength . The stiffness of a carbon fibre is extremely stiff , twice as stiff as metal. While its strength , is five times as metal which make this carbon fibre material is one of the strongest material used in the making of prosthetic leg. The stiffness of a material is measured by its modulus of elasticity. The modulus of carbon fibre is typically 33 MSI (228 GPa) and its ultimate tensile strength is typically 500 KSI (3.5 Gpa). High stiffness and strength carbon fibre materials are also available through specialized heat treatment processes with much higher values. Compare this with 2024-T3 Aluminium, which has a modulus of only 10 msi and ultimate tensile strength of 65 ksi, and 4130 Steel, which has a modulus of 30 msi and ultimate tensile strength of 125 ksi.So this means that the stiffness and strength of a carbon fibre is much more compare to aluminium and metal and it could be increase even more by combining it with other materials.

Other than that carbon fibre is strong and stiff with a low density which means it is very light. In the making of prosthetic leg , the weight of a material is very important due to the convenient of a amputee to use it for walking . Carbon fibre is very light in weight due to its low density and it is even lighter than aluminium. Plus , even though the carbon fibre is very strong and could possibly be as strong as the real leg but it is also 60% lighter. It is very light that it weights around 2kilos -3 kilos which is such a huge benefits for the amputees. It is well explained that a prosthetic leg need to be strong ,stiff but as well as light . Due to the old days materials that are very light , it is not suitable as a prosthetic leg because it is very hard to control the walking for amputees. So carbon fibre really balanced out all the factors which make a really great development in the manufacturing of prosthetic leg.

Furthermore , every material used in the making of prosthetic leg need to be hygiene in terms of resist to corrosion , to bacteria and infection , UV rays and as well to sweats and skin. Carbon fibre are very safe, it will cost no harm or irritations if its exposed to human skin which make this carbon fibre material very suitable for prosthetic leg. Other than that is the elasticity of the material. It is very important for a material in prosthetic leg have the elasticity like a real human leg , for the actions such as leaping or jumping and also running . Compare to other materials , this carbon fibre has the most elasticity element in it , nearest to a real human leg which is very suitable for prosthetic leg.

The disadvantages of Carbon Fibre

Although it is well known that carbon fibre has a lot of benefits to the manufacturing of the prosthetic legs , it is also has its own disadvantages because every materials has its own pros and cons. One of the disadvantages of prosthetic leg is the cost of it . The manufacturing and the material its self is expensive compare to other raw materials. Carbon fibre is used to reinforce composite materials. They are like steel bars in a block of concrete. Right now carbon fibres work with a thermoset resin. Together they make a composite that can be manipulated to take a certain shape. The problem is that once the resin has been shaped and cured in an autoclave, it cannot be modified without compromising its structural integrity. A small mistake means a lot of waste, including time. Thermosetting takes over an hour, which is a long time considering how fast the automotive industry stamps out body panels.

Plus, the process of producing a carbon fibre product takes a lot of time and energy which eventually costs a lot of money. Until scientists or experts in this field comes up with a manufacturing process that costs lower and less time consuming, consumers have to bear with the prices of carbon fibre for now.Other than that , carbon fibre is brittle. It will break if its bent too much, it is not good for certain things but for prosthetic , the user need to use it with full care because if it bend too much or being stretched it will break.

However all these disadvantages does not effect the fact that carbon fibre is one of the strongest and stiff material compare to metals . It does have a lot of benefits but however each materials on earth has its on pros and cons and it is depend to humankind to make the best out of every materials found. By the way, each materials could be used to its fullest potential .

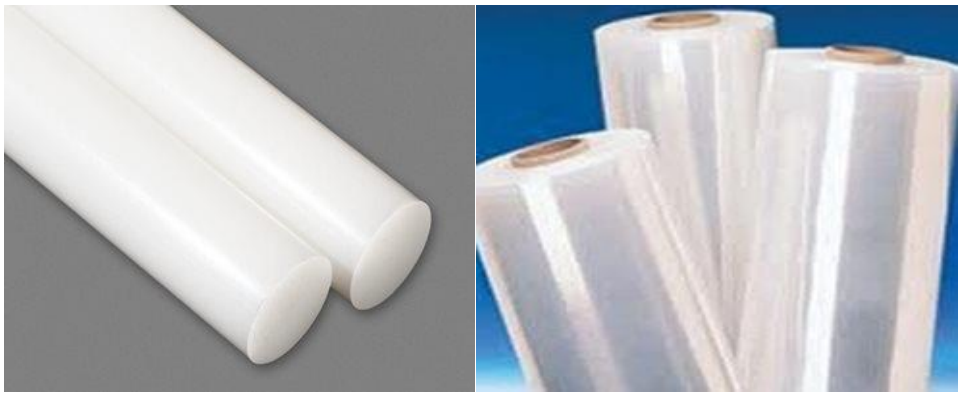
Literature review: Thermoplastic prosthetic leg

Prepared by: Suhaib Bin Muhamad Asmadi

First of all, thermoplastic is a plastic polymer material that becomes pliable or moldable at a certain elevated temperature and solidifies upon cooling. From this definition we define it as a material that easy to shape it under certain heat.

Basically, there's two type of thermoplastic that are currently use on prosthetic leg which is polypropylene and polyethylene. Polypropylene also known as polypropene, is a thermoplastic polymer used in a wide variety of applications. It is produced via chain-growth polymerization from the monomer propylene. Polypropylene belongs to the group of polyolefins and is partially crystalline and non-polar. Its properties are similar to polyethylene, but it is slightly harder and more heat resistant. It is a white, mechanically rugged material and has a high chemical resistance. Polypropylene is the second-most widely produced commodity plastic (after polyethylene) and it is often used in packaging and labelling. In 2013, the global market for polypropylene was about 55 million tonnes.

Polyethylene or polythene (abbreviated PE; IUPAC name polyethene or poly(methylene)) is the most common plastic. As of 2017, over 100 million tonnes of polyethylene resins are produced annually, accounting for 34% of the total plastics market. Its primary use is in packaging (plastic bags, plastic films, geomembranes, containers including bottles and others. Many kinds of polyethylene are known, with most having the chemical formula (C2H4)n. PE is usually a mixture of similar polymers of ethylene with various values of n. Polyethylene is a thermoplastic; however, it can become a thermoset plastic when modified (such as cross-linked polyethylene).



1)Polypropylene 2)Polyethylene

Figure 2.2.2 Polypropylene

Basically, in prosthetic leg, this two-type material are being created by two design of prosthetic leg which is homo-polymer prosthetic leg and co-polymers prosthetic leg. Homo-polymer is the prosthetic leg that make by only one type of thermoplastic polymers for example like polypropylene prosthetic leg or polyethylene prosthetic leg. And the co-polymers is the prothetic leg that make by mixing of thermoplastic polymer either its mix by physically or chemically for example like polypropylene and polyethylene prosthetic leg. Lastly, this prosthetic leg characteristic is easy to shape it under a heat, can be recycle and cannot be compose by naturally.

Figure 2.2.3 - Thermoplastic Prosthetic

2.2 Literature Review by AMAL ASYRAAF B.ABDUL RAHIM.

2.2.3 Introduction

In addition to carbon, polyester can also be used in the manufacture of prosthetic leg, as mentioned above for this material to be used in conjunction with carbon. However, this material can also be used alone without the need for other materials. Before we go any further, the first question to be asked is what is polyester?. Firstly, polyester is a polymer that is irreversibly hardened by curing from a soft solid or viscous liquid pre-polymer or resin. Curing is induced by heat or suitable radiation and may be promoted by high pressure, or mixing with a catalyst. It results in chemical reactions that create extensive cross-linking between polymer chains to produce an infusible and insoluble polymer network.

In another terms, Polyester is a kind of polymer with some specific materials. It is often defined as a long chain of polymers with a composition of 85% ester with a dihydric alcohol and terephthalic acid. It is a type of Polyethylene terephthalate used for any fabric or textile and made using polyester yarns and fiber. It primarily includes naturally occurring chemicals like cutin of plant cuticles and synthetics formed by step-growth polymerization such as polybutyrate. These materials are extensively used in the clothing industry. They are also used for manufacturing number of other products such as bottles, films, tarpaulin, canoes, liquid crystal display, film insulation for insulating tapes and many others.

Majorly these materials can be classified into two broad categories which are:

- Saturated Polyesters- These are those type which has saturated form of backbones. Thus, they are not as reactive as the unsaturated polyesters are. They usually have low molecular liquids and are used as plasticizers or reactants.

- Unsaturated Polyesters- These are kind of materials which have their backbones of alkyl thermosetting resins characterized by vinyl Unsaturation. They are usually used for reinforced plastics. These are the most commonly used and economical family of resins.

One of fact in this chapter is the use of polyester in the fabrication of prosthetics industry requires the use of injection molding methods. Injection molding is a manufacturing process commonly used for fabricating items from plastic trinkets and toys to automotive body parts, cell phone cases, water bottles, and containers. Essentially many of the plastic parts that we use in every-day life are injection molded. It is a quick process to create a mass amount of identical plastic parts. The flexibility in shape and size achievable by the use of injection molding has consistently widened the boundaries of design in plastics and allowed substantial alternatives of traditional materials due to design freedom and light weighting.

As mentioned above, each material used in making any type of product has its own pros and cons in every aspect. Even though carbon fibre is well known because of its strength and stiffness, it still does have a lot of its own disadvantages. In this topic, it will explain about the benefits, the disadvantages and also the characteristic of the polyester and the method that use by this material to make a prosthetic leg.

2.2.3 Characteristics of polyester

Advantages of polyester

Prosthetic leg that made by polyester have a good quality other than material from thermoset. With the advantages it has, it is a good choice to make the prosthetic legs with an environmental resistance, the strength to withstand the load and provide comfort to the user

Polyester is lightweight and extremely strong in nature. It also strong, resistance against abrasion, wrinkle, stretching or shrinking. It is because it has physical properties that allow this ability to be with it. One of physical properties are it Tenacity is 5-7 gm/den. This is because of their crystalline nature and this nature permits formation of highly effective Vander Wall's forces. The fiber inhibits good tenacity due to the hydrogen bonds and this tenacity remains unchanged even if it is wet. Another that is Elastic-Plastic Nature- It has good elasticity. The crystalline nature of fiber prevents wrinkle and crease

Other than that, polyester is water proof. These materials are hydrophobic in nature and dry quickly. This is due to the polarity and the very crystalline nature of resins which resist entry of water molecules. This causes the prosthetic leg that build from this material to have no moisture regardless of whether the moisture is from the environment or from the user himself. This will cause the prosthetic leg to not produce conditions suitable for the growth of microorganisms. If growth of the microorganism occurs there will be infection in the limbs.

Another advantage of polyester is they are durable and resistant to many chemicals. They are resistant towards acids in cold conditions but degrades by asid sulfuric in high temperature. Alkaline conditions are seen in laundering hydrolyze the ester group of the polymer. The crystalline nature prevents from hydrolysis to a great extent and usually, it is the surface which gets hydrolyzed. Polyester also does not

require bleaching and can easily retain its whiteness. If necessary chlorine bleaches are used.

As mentioned earlier, polyester uses injection molding method to produce fake feet. This will result in the results of the product as directed. This is in contrast to the use of materials such as polypropelene, it produces products with little defects that can be corrected by using heat. This demonstrates the advantages of polyester that can produce products once and for all. Polyester also can be reinforced by combining polyester with glass fiber or carbon fiber, this is intended to create a fake foot for users doing sports or outdoor activities. This is in contrast to the polypropelene that cannot to combine with the glass fibre and carbon fibre.

Disadvantages of polyester

It is too difficult and almost impossible to find a material that has no weaknesses, in this sub-topic we will address the weaknesses that this material has. One of the disadvantages of this material is that the product that uses this material will be expensive because of the manufacturing process that uses the injection molding process. This process requires certain equipment, equipment must be complete and it also expensive. In addition to capital in the purchase of materials and equipment, capital in payroll is also high as this method of production requires skilled labor in handling such tools.

The process of making prosthetic leg using this material is a complicated process. The starting material for making polyester is usually malleable or liquid prior to curing, and is often designed to be mold into the final shape. It may also be used as an adhesive. Once hardened, a thermoset cannot be melted for reshaping, in contrast to thermoplastic polymers which are commonly produced and distributed in form of pellets, and shaped into the final product form by melting, pressing, or injection molding. That mean the proses must not have a mistake even small scale if the maker made a mistake, the product cannot be used because every single prosthetic leg have their own size and shape.

Other than that, polyester has some not ergonomic features, that it is not as breathable. This is because like we have earlier polyester is water proof mean there are no fluid that can pass through the product that using this material. This will cause the skin of the limbs to wear this device will become more severe when wearing it without aids such as socks and wearing it for too long.

In addition, polyester is one of the major polymers in the industry that cannot be naturally exposed. This is due to two conditions, the first being that the chemical bond to the material has reached a stable number, so this material does not

react easily to the environment.In addition, as mentioned above, this material is acid-resistant except in heat-treated conditions. This proves that the material is highly resistant to the environment. The second condition is that this substance does not have the natural decomposition as occurs in most natural polymers such as kenaf. So material can last for thousands of years, it may be good news for an engineer but it is bad news for humans as well as nature.

2.3 METHODS OF MAKING PROSTHETIC LEG

2.3.1 Injection Moulding

Prepared by Sharifah Nurul Balqis

There are a few methods that can manufacture and make prosthetic , one of them is injection moulding. Plastic injection moulding was invented in the 19th century and the first moulding machine was made in 1872 by Hyatt brothers , John Hyatt and Isaiah Hyatt. With the machine they invented , plastic manufacturing industry grows rapidly. While in 1930s, it was a decade of invention for plastic manufacturing because thermoplastics were invented during this time.

By 1946, American inventor James Watson Hendry created the world's first extrusion screw injection machine. Using a rotating screw, Hendry was able to better control the injection process itself .This dramatically increase the quality of the products produced .Hendry was not done after creating the extrusion screw injection machine, he went on to develop the first gas-assisted injection moulding process.

The gas-assisted injection moulding process is a pivotal innovation that allowed for the creation of long, complex, hollow products. With materials providing increased strength and reduced weight , plastic production had overtaken steel production by the 1970s .Hendy is one of the remarkable inventors , without his inventions , plastic injection moulding will not be as advanced as today.

Today , the opportunity provided by plastic injection moulding are implemented by essentially every manufacturing sector ; electronics , automotive , house wares and of course , prosthetics . The technology used today is quite similar to the technology used in the past . However , computers have made the whole design and manufacturing process easier . The results are more precise and now plastic injection moulding method has been used widely for advanced technological and scientific applications.

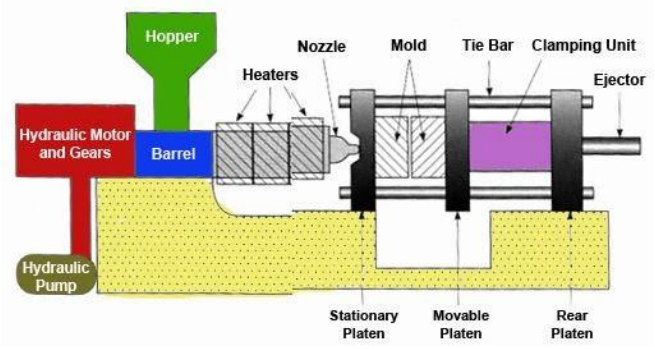


Figure 2.3.1 – Injection Moulding

Advantages of Injection Moulding

Plastic injection moulding companies is one of the most important companies in the prosthetic industries because of all the benefits it carries. The benefits of this plastic injection moulding really help in the growth and manufacture of prosthetics. One of the main advantages of plastic injection moulding is high efficiency. Once the injection moulds have been designed to the customer's specifications and the presses pre-programmed, the actual moulding process is very quick compared to other methods of moulding. Plastic injection moulding process hardly takes times and this allows more parts to be manufactured from a single mould. The high production output rate makes plastic injection moulding more cost effective and efficient. Typically, hot-runner ejection mould systems produce parts with more consistent quality and do so with faster cycle times, but it's not as easy to change colours nor can hot runners accommodate some heat-sensitive polymers

Other than that, the benefits of injection moulding is the enhanced strength. In plastic injection moulding, it is possible to use fillers in the injection moulds. These fillers reduce the density of the plastic while it being moulded and also help in adding greater strength to the part after it has been moulded. In fields where parts need to be strong and durable, plastic injection has an option that other moulding processes do not offer. Plus, the benefit of using this injection moulding method is the maximum use of waste .Part repeatability is very high for injection moulding. Even the sprues and runners (the leftover bits of plastic created by the 'tunnels' through which the plastic material reaches the actual mould) can be reground and the material reused. You can explore this in more detail on our environmental impact of injection moulding page.

Last but not least is the automation to save manufacturing costs. Plastic injection moulding is an automated process. A majority of the injection moulding process is performed by machines and robotics which a sole operator can control and manage. Automation helps to reduce manufacturing costs, as the overheads are significantly reduced. Furthermore, with reduced labour force the overall cost of manufacturing the parts is reduced and this cost saving can easily be passed on to the customer. Furthermore, automation allows for making precise and accurate injection

moulds. Computer aided design (CAD) and computer aided manufacturing (CAM) allow close tolerances during the making of the moulds.

The Disadvantages of Injection Moulding

Every industrial method of manufacturing has its own pros and cons , including this plastic injection moulding method. Although this plastic injection moulding has a lot of benefits in the industry , it does has its own disadvantages. One of the main cons of injection molding are large required lead times, and high tooling costs. Tooling in and of itself is a significant project, and that still covers only a single phase of injection molding. You first need to make a prototype of the part, and then one of the mold tools capable of producing this part in high volumes. After that, the part is injection molded. Taken together, these stages require significant time and money just so you can ensure correctness before mass production starts up. Prototyping an injection molding tool is not unheard of; it is often done for parts intended as multi-cavity tools.The tools typically being steel or aluminum, making changes to them is usually hard. Space for adding plastic to the part could be achieved by clearing away aluminum or steel from the mold, and that is relatively easy. The opposite is hard though – to eliminate existing space meant for plastic, the tool cavity would need to be brought down in size by adding metal. Sometimes, the tool can end up getting scrapped, requiring you to start over. Metal can sometimes be welded into the cavity to make it smaller, but that does not a work.

2.3.2 Hands lay-up method

Prepared By : Suhaib Bin Muhamad Asmadi

Basicly, Hand lay-up is the most common and least expensive open-molding method because it requires the least amount of equipment. Fiber reinforcements are placed by hand in a mold and resin is applied with a brush or roller. This process is used to make both large and small items, including boats, storage tanks, tubs and showers. For our project i used this method to create the socket part of prosthetic leg by lay it at the prosthetic leg sculpture that make from polypropylene powder.

Hand lay-up is an open molding method suitable for making a wide variety of composites products from very small to very large. Production volume per mold is low, however it is feasible to produce substantial production quantities using multiple molds. Hand lay-up is the simplest composites molding method, offering low cost tooling, simple processing, and a wide range of part sizes. Design changes are readily made. There is a minimum investment in equipment. With skilled operators, good production rates and consistent quality are obtainable.

Gel coat is first applied to the mold using a spray gun for a high quality surface. When the gel coat has cured sufficiently, roll stock fiberglass reinforcement is manually placed on the mold. The laminating resin is applied by pouring, brushing, spraying, or using a paint roller. FRP rollers, paint rollers, or squeegees are used to consolidate the laminate, thoroughly wetting the reinforcement and removing entrapped air. Subsequent layers of fiberglass reinforcement are added to build laminate thickness. Low density core materials such as end-grain balsa, foam, and honeycomb, are commonly used to stiffen the laminate. This is known as sandwich construction.

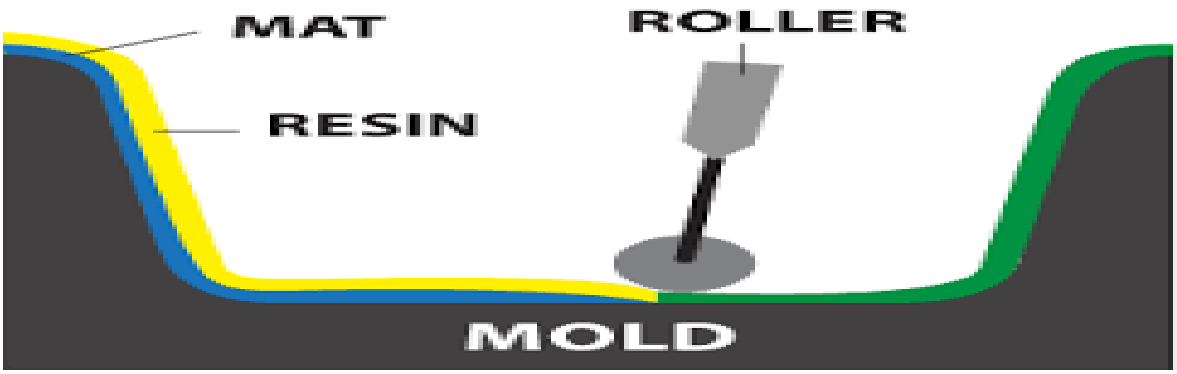


Figure 2.3.2 – Hands Lay Up

From the basic method of hands lay-up. We decide to lay the sculpture of prosthetic leg that make from polypropylene powder by the layer of mat and resin on it, which is the mat is ‘Kenaf’ fibre and the resin is polyester. But after we make an experiment of reaction polyester and polypropylene powder we realise that the reaction of this material is not good to our project because this two material will stick and cannot be separate. we decided to use silicon and lay it on the leg sculpture, after the silicon dry we remove the silicon from the sculpture, we use the silicon because the silicon not stick with the polypropylene powder. After we remove the silicon we filled the cavity of silicon with sand, so the silicon will be hard and can be easy to lay it. After that, we lay the mat and the resin on it ,after it dry we separate the silicon by moving the sand from inside the silicon and the silicon and the lay of mat and resin will saperate.

2.4 MATERIAL SELECTION

HARDENER

By Suhaib Bin Muhamad Asmadi

A hardener is a component of certain types of mixtures. In some mixtures a hardener is used simply to increase the resilience of the mixture once it sets. In other mixtures a hardener is used as a curing component. A hardener can be either a reactant or a catalyst in the chemical reaction that occurs during the mixing process.A hardener may also be known as an accelerator.

Hardeners are almost always necessary to make an epoxy resin useful for its intended purpose. Without a hardener, epoxies do not achieve anywhere near the impressive mechanical and chemical properties that they would with the hardener. The correct type of hardener must be selected to ensure the epoxy mixture will meet the requirements of the application. Research should always be done on both the resin and the hardener to make sure the final epoxy mixture will perform satisfactorily. Common examples of epoxy hardeners are anhydride-based, amine-based, polyamide, aliphatic and cycloaliphatic.

Hardeners are used to cure epoxy resins. However, simply adding a hardener to an epoxy resin may not cause the epoxy mixture to cure quickly enough. If this is the case a different hardener may be required. Also, hardeners with certain additives can be used. These hardener additives serve as catalysts that speed up the curing process.

In our project we use polyestere as a resin and a hardener to to make a chemicle reaction to create a hard palctick material. In this case we are using 99% resim which is polyester and 1% hardener to make a perfect chemicle reaction. If the hardener is more than 1% the mixture will be hot and may crush the mixture because the function of hardener is only to accelerate the process if more hardener added than the reaction will be over accelerate and it might be dangerous to our body and the environment.

Figure 2.4.1 - Hardener

PLASTER OF PARIS

Plaster of paris, quick-setting gypsum plaster consisting of a fine white powder (calcium sulfate hemihydrate), which hardens when moistened and allowed to dry. Known since ancient times, plaster of paris is so called because of its preparation from the abundant gypsum found near Paris.

Plaster of paris does not generally shrink or crack when dry, making it an excellent medium for casting molds. It is commonly used to precast and hold parts of ornamental plasterwork placed on ceilings and cornices. It is also used in medicine to make plaster casts to immobilize broken bones while they heal, though many modern orthopedic casts are made of fibreglass or thermoplastics. Some sculptors work directly in plaster of paris, as the speed at which the plaster sets gives the work a sense of immediacy and enables the sculptor to achieve the original idea quickly. In medieval and Renaissance times, gesso (usually made of plaster of paris mixed with glue) was applied to wood panels, plaster, stone, or canvas to provide the ground for tempera and oil painting.

in our project, we use plaster of paris to build fake foot scuplture. Before we do this, we wrap the patient's foot with POP bandage to produce the negative mold, after drying we remove the negative mold from the patient's foot, after which we insert plaster of paris that has been mixed into the negative mold, after drying we remove it from a negative mold and a positive mold that is a fake foot scuplture

Figure 2.4.2 - Plaster of Paris

KENAF(HIBISCUS CANNIBINUS L.) FIBRE

Prepared by Sharifah Nurul Balqis Bt Syed Abdul Mutalib

Kenaf fiber is one of the famous natural fibers used as a reinforcement in polymer matrix composites (PMC). Kenaf, known as Hibiscus cannabimus L., is an herbaceous annual plant that grows in a wide range of weather conditions, growing more than 3 m within 3 months (Nishino et al., 2003). The highest growth rate may up to 10 cm/day. However, the difference of growth parameter influencing the properties of kenaf fiber such as length of growth season, plant population, cultivar, planting date, photosensitivity, and plant maturity. The stem of the kenaf plant is straight and is not branched along the stem. It is built up by bark and a core. Therefore it is easy to separate the stem by either chemicals or enzymatic retting. The bark has contributed 30%–40% of the dry weight for the stem while the wood-like core makes up the remaining weight. Long bast fiber type was used to make composite boards, textiles, pulp, and paper industry.

Figure 2.4.3 Kenaf

POLYESTER RESIN

You can define the polyester resin as a polymer obtained by the polycondensation reaction between polyacids and polyalcohols. The development of water is the by-product of this polycondensation process. Specifically, the unsaturated polyester resin, also known by the English acronym UPR, is an easily printable liquid polymer which, once cured (cross-linked with styrene, by the use of particular substances, organic peroxides, named hardeners), keeps the solid shape taken in the mold. The items so realized have exceptional strength and durability characteristics. Unsaturated polyester resins are mostly used in combination with reinforcing materials such as glass fibres, that give life to the FRP (an acronym deriving from the English), a polyester reinforced with glass fibres, better known with the name of fiberglass. In this case, the polyester resin has an array function, channelling the forces applied to the material to the fibres that are designed to withstand these forces, increasing the strength and avoiding breakages of the product. Together with or separately from the glass fibres, the liquid unsaturated polyester resin may be loaded with powders or granules of various sizes, which give details of rigidity and resistance characteristics, or aesthetic qualities to the imitation of natural marble and stones, sometimes with better results.
The unsaturated polyester resin is used with great success in many industrial sectors, such as in watersports for the creation of windsurfers and pleasure boats. This polymer has been at the centre of a real revolution in the boat industry, because it can provide great performances and a very high flexibility of use. The unsaturated polyester resins are also commonly used in the automotive sector (car industry), for their great design versatility, light weight, lower system costs and mechanical strength. This material is used also for buildings, especially in the manufacture of hobs for cookers, tiles for roofs, bathrooms accessories, but also pipes, ducts and tanks.

Figure 2.4.4 – Polyester Resin

2.5 STUDIES OF PROSTHETICS AND MATERIALS

Prosthesis is a mechanism designed to substitute the function or appearance of a missing limb or body part (Arvela, Sderstrm, Albck, Aho, Venermo & Lepntalo, 2010). Therefore, ideally, prosthesis must be comfortable to wear, easy to put on and remove, light weight, durable, cosmetically pleasing, functioning well mechanically and requires reasonable maintenance. Bierbaum, Nairus, Kuesis, Morrison and Ward (2002) mention that at present, to have all these qualities in a prosthetic leg is possible but the expensive cost of manufacturing will result in financially burdened wearers having the difficulty to afford these prosthetic legs. Because of this, a solution for more affordable and less expensive parts and components should be sought after to enable many wearers to have the opportunity to enjoy ambulation with less expensive and high quality prosthetic legs, as agreed by McCarthy, Bono and O'Donnell (1997).

An artificial limb is a type of prosthesis that replaces a missing limb or part of the body, such as the arm or leg (Klodd, Hansen, Fatone & Edwards, 2010). The type of artificial limb used is determined largely by the extent of the amputation or loss and the location of the missing limb. Horne and Neil (2009) state that artificial limbs may be needed for a variety of reasons, including diseases, accidents, and congenital defects. A congenital defect can create the need for an artificial limb when a person is born with a missing or damaged limb. Cancer, infection and circulatory diseases are the leading ailments that may lead to amputation. Furthermore, industrial, vehicular and war related accidents are the leading causes of amputation in many developing countries, UNIVERSITI PUTRA MALAYSIA Alam Cipta Vol 5 (1) June 2012 such as Africa.

On the other hand, in most developed countries, such as the North America and Europe, diseases are the leading cause of amputation. Thus, the demand for prosthetic legs is high for many amputees around the world at present. As agreed by Ramachandran, Lakshmi, Arun, Samith Shetty and Snehalatha (2010), the advancement of design and manufacturing in the field of prosthetics has been notable due to the common demands from either the war victims in war-hit countries or those who are handicapped from birth. Thus, as the human body changes over time due to growth or change in body weight, the artificial limbs have to be replaced or adjusted periodically (Kobayashi et al., 2011). This constant need to change may become costly if the material used is expensive especially with regard to the production cost of the parts and components of the prosthetic legs.

2.6 CHAPTER'S SUMMARY

As to conclude this chapter , literature review is important to showcase all the studies of materials and methods to enhance the knowledge on this project. Every thesis and others projects that are related to this bio-friendly polymer composite prosthetic leg is really helpful especially for us to understand it fully .

After a lot of materials and methods were discussed and researches were done , the materials that are the most compatible for our project is thermoset. Due to its characters and advantages, meanwhile the methods that we decided to carry on with is hands lay up method . This is because of its low cost benefits and great for beginners process.

CHAPTER 3 : METHODOLOGY

3.1 INTRODUCTION

What is methodology? A methodology is a plan-of-attack, especially when that plan-of-attack is used repeatedly. This might be obvious, but the word methodology is related to the word method. In fact, a methodology is a system of methods followed consistently. Scientists, for example, use various methodologies as they perform experiments. It might seem like the world is nothing but chaos and disorder. But actually, sometimes there is a method to this madness. And sometimes there's a methodology.

In this chapter , there will be a lot of information about the process and journey through out the making of our final project. There will be flow chart showing the process of us making the whole project . This flow chart will explain the processes we took. Next , is the Gantt Chart , which will show the actual and planning throughout all the 13 weeks of our final year project journey . However in this chapter , we also will show 3 methods we researched to carry our final year project . Although , these 3 methods has its own pros and cons and it will be explained individually by the teammates.

Among those 3 methods are vacuum, injection moulding and hands lay up. Most common way of making prosthetic leg is by using the method of vacuuming. This method has a lot advantages and disadvantages . Hence , in this chapter we will discuss about these 3 methods and which one we chosen.

3.2 FLOW CHART

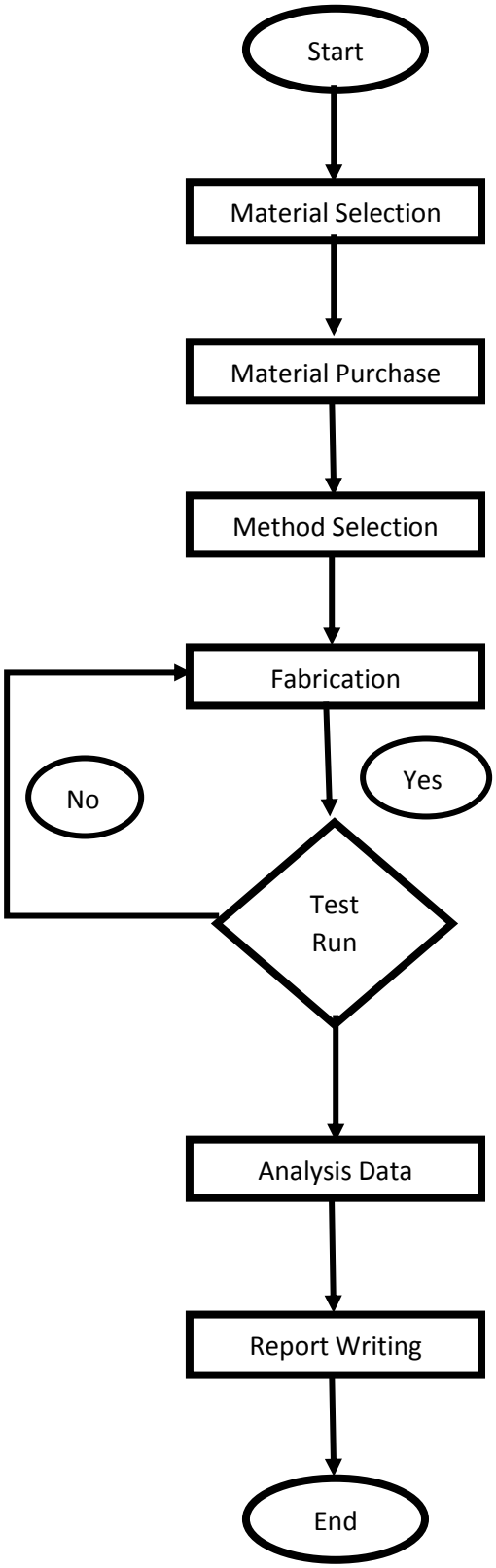


Figure 3.2.1 – Flow Chart

3.3 FLOW CHART EXPLAINATION

Prepared by Sharifah Nurul Balqis Bt Syed Abdul Mutalib

- **Material Selection**

The process of material selection is one of the most important process in this final year project. The main factor of material selection is to discuss and finalized which materials that will be use in the project in order to avoid wasting of money and time. The material selection need to be done precisely so that the risks could be avoided.

1) Polyester Resin

Figure 3.3.1- Polyester Resin

Polyester resins are the most widely used resin systems, particularly in the marine industry. By far the majority of dinghies, yachts and workboats built in composites make use of this resin system. Polyester resins such as these are of the 'unsaturated' type. Unsaturated polyester resin is a thermoset, capable of being cured from a liquid or solid state when subject to the right conditions. It is usual to refer to unsaturated polyester resins as 'polyester resins', or simply as 'polyesters'. There is a whole range of polyesters made from different acids, glycols and monomers, all having varying properties. Thus, we decided to use polyester resin is because of its strength and it is suitable for our project.

2) Resin Hardener

Figure 3.3.2 – Resin Hardener

A hardener is a component of certain types of mixtures. In some mixtures a hardener is used simply to increase the resilience of the mixture once it sets. In other mixtures a hardener is used as a curing component. A hardener can be either a reactant or a catalyst in the chemical reaction that occurs during the mixing process. In this project, the recommended ratio of polyester resin to hardener is 97% : 3% . Over amount of hardener could cause a negative reaction which the mixture will let out hot smoke.

3) Plaster of Paris

Figure 3.3.3 – Plaster of Paris

Plaster of Paris, quick-setting gypsum plaster consisting of a fine white powder (calcium sulfate hemihydrate), which hardens when moistened and allowed to dry. Known since ancient times, plaster of Paris is so called because of its preparation from the abundant gypsum found near Paris. In this project, this plaster of Paris is used in the making of the prosthetic leg cast.

4) Kenaf

Figure 3.3.4 - Kenaf

Kenaf (Hibiscus cannabinus L.) is a fiber plant native to east-central Africa where it has been grown for several thousand years for food and fiber. It is a common wild plant of tropical and subtropical Africa and Asia. It has been a source of textile fiber for such products as rope, twine, bagging and rugs. Kenaf is a promising source of raw material fiber for pulp, paper and other fiber products, and has been introduced since WWII in China, USSR, Thailand, South Africa, Egypt, Mexico and Cuba.Research in the United States to use the kenaf bast (outer bark) fibers for rope began in the 1940's when jute imports from Asia were interrupted by World War II. In the 1950's, the Agricultural Research Service (ARS) of the U.S. Department of Agriculture screened more than 500 plant species as potential fiber sources for pulp and paper manufacturing. In this project, we use Kenaf plant as a fibre ,to strengthen the mixture of resin. Kenaf is proven to be one of the strongest natural fibres.

5) Mirror Glaze Wax

Figure 3.3.5 - Mould wax

This specific extreme mold release wax is used in this project to avoid to risk of resin sticking to the mold . Hence, this extreme mold release wax really help with the releasing of product from the mold.

6) Silicon

Figure 3.3.6 - Silicon

This silicon is use as a separator between the plaster of Paris casting and polyester resin mixture. This silicon has part A and B mixture. Part B is blue coloured to make it easier for beginners to mix the both mixtures.

- **Material Purchase**

The process of materials purchasing is crucial to collect and obtains all the materials needed. In this process a lot of research on the places and suppliers that the materials are going to be purchase is done. This step is important so that the risk of material wasting or money-loss will not happen. However, to carry out material purchasing, a well-made purchasing plan needed to be made. First, the suppliers will be contacted to make sure the availability of the materials. Then, the calculation of the amount of materials needed and also the price of the materials. After that, surveys of price must be carried out to determine the better selling prices. Then finally, the purchases could be made.

- **Method Selection**

This method selection process is important so that the method choose is accurate and suitable for the product. This method selection will avoid money-lost and time taking processes. Hence, it is important to carry out this method selection process. There are three methods that could be carried out:

1) Vacuuming

Figure 3.3.7 - Vacuuming

The below knee vacuum casting technique uses vacuum to draw the plaster against the patient's skin. This process ensures equal distribution of pressure around the residual limb, thus eliminating the need to mould the negative

impression by hand. The amount of vacuum pressure applied to the extremity can be varied depending on the amount of detail desired. This technique is compatible with, and improves the accuracy of, existing casting techniques such as the two and three stage procedures of Fillauer. The vacuum casting technique utilizes standard equipment which is widely available in prosthetics facilities.

2) Injection Moulding

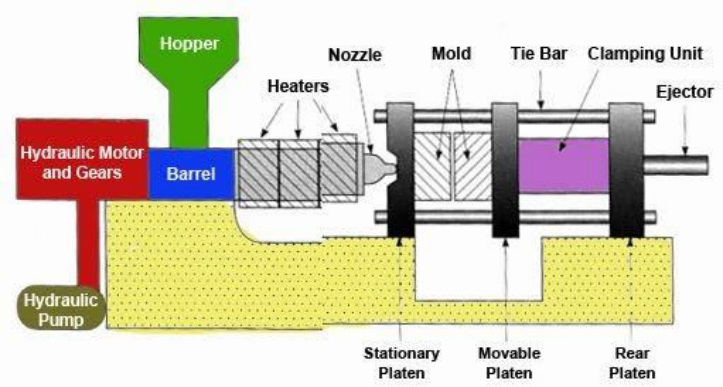


Figure 3.3.8 – Injection Molding

The use of plastic injection moulding for prosthetic parts has become more commonplace, as the durable and light qualities of plastic make it one of the best materials to use, along with being cost-efficient and easy to manufacture. This makes injection moulding companies even more important in the prosthetic industry, as their capabilities allow them to quickly manufacture and distribute more efficiently compared to using other materials. Prosthetic is an important part of the medical industry, and injection moulding will only help push its development forward.

3) Hands Lay Up

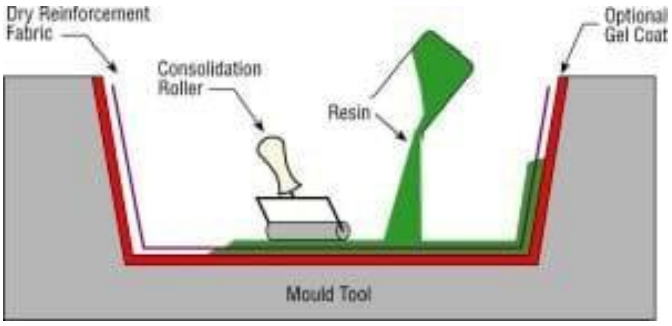


Figure 3.3.9 – Hands Lay Up

Hand lay-up is an open moulding method suitable for making a wide variety of composites products from very small to very large. Production volume per mould is low; however, it is feasible to produce substantial production quantities using multiple moulds. Hand lay-up is the simplest composites moulding method, offering low cost tooling, simple processing, and a wide range of part sizes. Design changes are readily made. There is a minimum investment in equipment. With skilled operators, good production rates and consistent quality are obtainable.

Does the method works?

A lot of discussions, researches and experiments were carried out to find the most suitable method to carry out this bio-friendly polymer composite prosthetic leg. Hence, it is decided to use the hands lay-up process. This is because , the hands lay up method require less cost and less equipment. After a few proposal were send to prosthetic centres for a request to lend and rent their equipment , all of the proposals were denied because prosthetic manufacturing is busy and the equipment used are very well-preserved . Thus , we managed to find another alternative by carrying out this hands lay out method.

- **Fabrication**

Casting

i. Casting is an important process to determine the shape and size of the amputee leg to create a positive moulding. Hence, the first step will be, wrapping the patient leg with polypropylene bandage.

ii. Then, apply a good amount of plaster of Paris layer on top of the bandage, hold it until it hardened.

iii. After the plaster of Paris hardened, slowly pull the cast out and there will be a positive moulding. In our project this process is crucial to obtain the positive mould .

Figure 3.3.10 - Casting

Silicon Layering

i. Silicon is use in this project as a separator from the polyester resin layer and plaster of Paris cast.
ii. Due to its character that is non-sticky and will not chemically or physically combine with any type of materials , silicon is the best material that could be use as a separator.
iii. In this step , a layer of silicon is applied on top of the plaster of Paris cast.
iv. The silicon used is food-grade silicon , by using this type of silicon it is safer and easier to handle with.
v. Furthermore, there are part A and B for this silicon , which part B is blue coloured. The blue coloured mixture helps beginners to mix both part precisely.
vi. This process is successful but however , the layer of silicon is quite thin , which means a few more layers should be added.

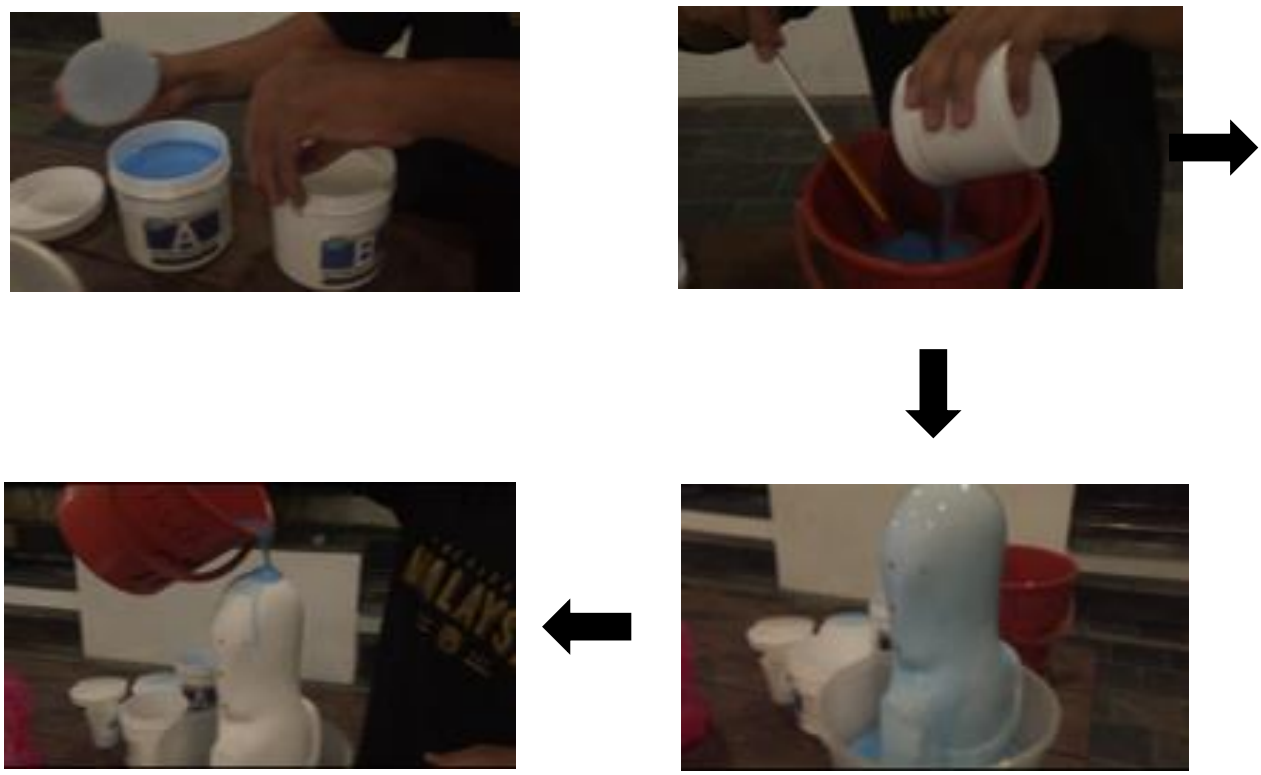


Figure 3.3.11 - Silicon Layer

Hands Lay Up

i. This hands lay up method is carried out by layering polyester resin and kenaf fibre together around the positive mould that was covered with silicon layer.

ii. This method need equipment and apparatus such as polyester resin , resin hardener , kenaf roll , rubber gloves, moulding wax, brush and facemask to avoid over inhaling chemicals.

iii. It was started by layering a layer of polyester resin, then wrap the kenaf rope around the casting tightly , after that another of polyester resin is applied.

iv. Next, wait it till it dries for a few days and the end product could be check and use.

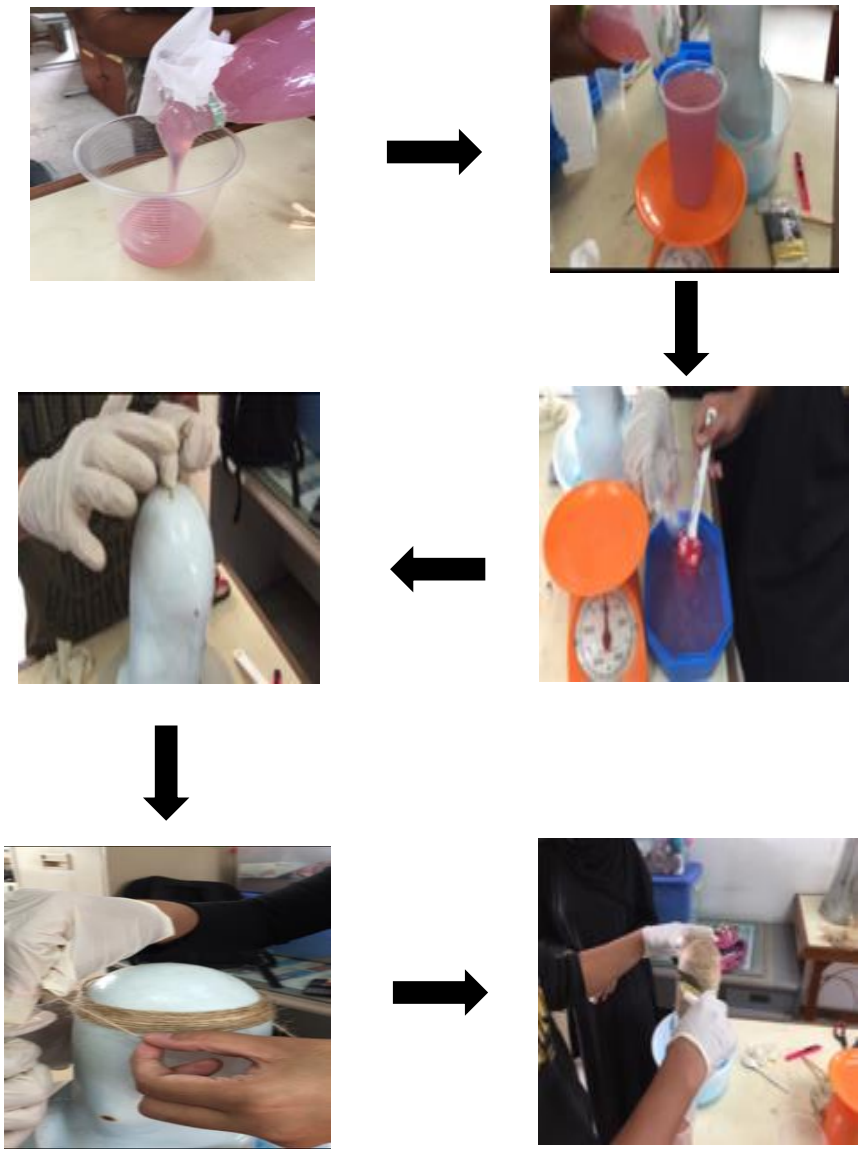


Figure 3.3.12 – Hands Lay Up Method

- **Test Run**

  Test run is carried out to determine the strength and end result of the product . In this test run , Kenaf plate is tested to determine the strength and stiffness .First , bricks were stacked up on top of the kenaf plate to determine its stiffness, after 7 bricks , the kenaf start to bend but did not break at all. Then , another test run is carry out where , we tried to smash the kenaf plate with hammer and turned out the brick below broke but the kenaf is still going strong.

(A) (B)

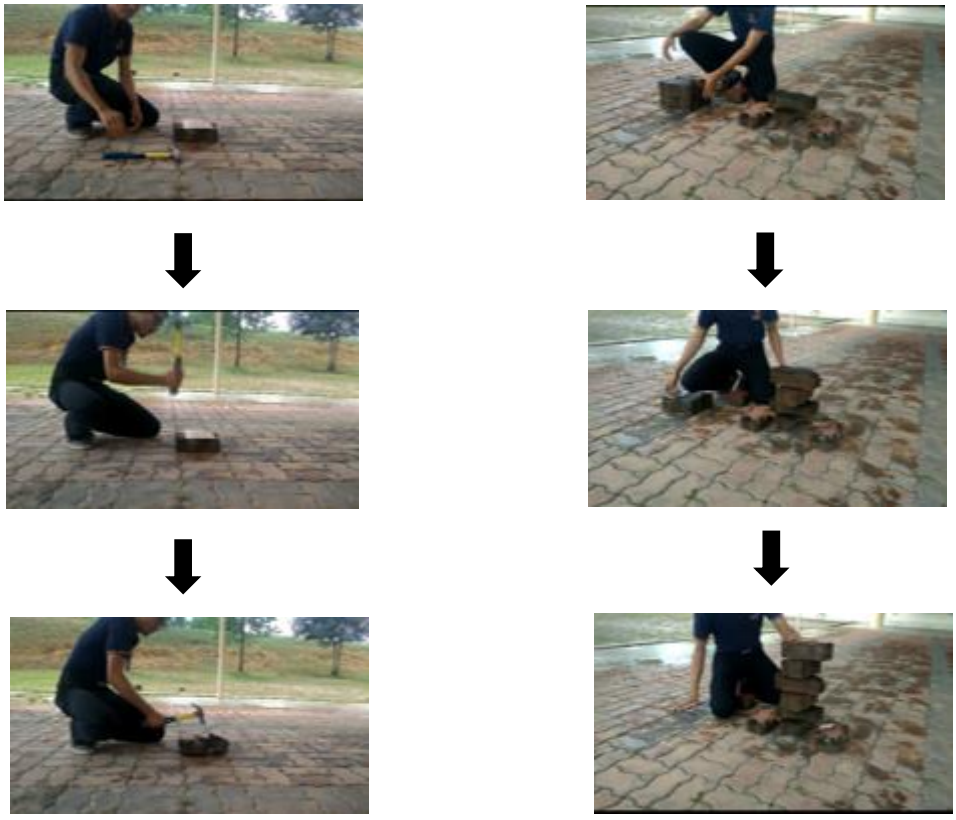


Figure 3.3.13 – Test Run

- **Analysis Data**

The process of evaluating data using analytical and logical reasoning to examine each component of data provided .This form of analysis is just one of the many steps tha

t must be completed when conducting a research experiment . Data from the test run is gathered, reviewed and the analysed to form findings , discussions and conclusion. In this project the data collection is collected from the tensile strength of the material we created.

- **Report Writing**

Report writing is one of the most crucial step in every project invented . Its is important to make a report based on the project , test run and analysis so that future improvements nor expansion of knowledge could be done . Our report writing is based on the analysis and findings that we collected throughout this whole process of completing this project.

3.4 Interview and research

We did an interview with Encik Hafiz at Aspo Prosthetic and Orthotic Trading . There , Encik Hafiz explains all about the methods and materials used for making the current prosthetic leg . Encik Hafiz agrees on our project and was very interested in it since he told us this is the first bio-degradable material that are use in the making of prosthetics leg.Through out all the interview, a lot of questions about currents materials were asked. For example , current materials used in prosthetics are thermoset and thermoplastic . Other than that , the methods currently used is vacuuming method and also injection moulding depending on the type of prosthetic wanted. Also, he told us about the process of making prosthetics leg which consists of casting , moulding and also vacuuming / injection moulding / hands lay up. Then, he did explained about the types of sockets exists in the prosthetics industry. Plus, we were explained about the other types of fibres that were used in the making of prosthetics , such as fibre glass and carbon fibre.

Figure 3.4.1 Encik Hafizz

;Refer to appendix for interview report

3.5 PRODUCT DESIGN

Figure 3.5.1 - Design

Figure 3.5.2 - Socket

3.6 OPERATIONAL METHODOLOGY

Prepared by Suhaib Bin Muhamad Asmadi

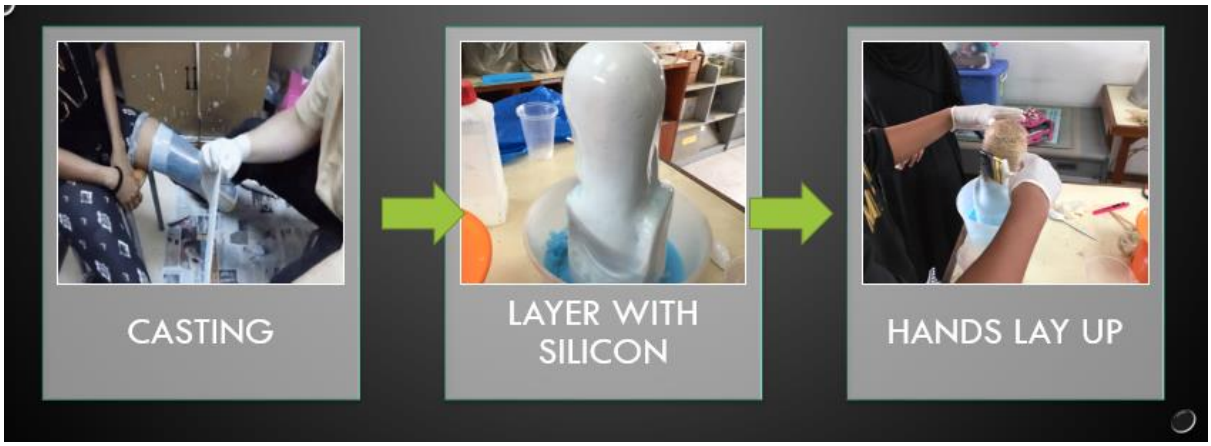


Figure 3.6.1 – Operational Methodology

- **Casting**

  Casting proses is carried out by preparing a polypropylene bandage, plaster of Paris mixture and also an amputee leg. The first step of casting is wrapping the amputee's leg with the polypropylene bandage, the bandage must be wet with a little bit water to make it easier to hardened. After that, smear plaster of Paris mixture on top of the bandage. Hold it and let it dry for a few minutes and the cast is ready to be pull out.

- **Layer with Silicon**

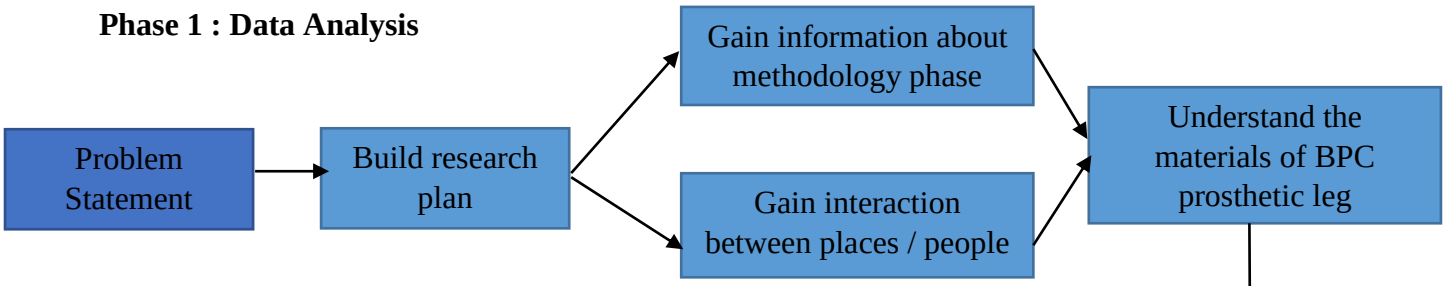
  The purpose of layering with silicon is to make sure that the plaster of Paris cast does not stick with polyester resin. First , the positive mould (plastic of Paris cast) will act as a sculpture for the layering. Then , silicon is poured on top of the sculpture . Let it dry for about 8 hours and the silicon layer is ready.

- **Hands Lay Up**

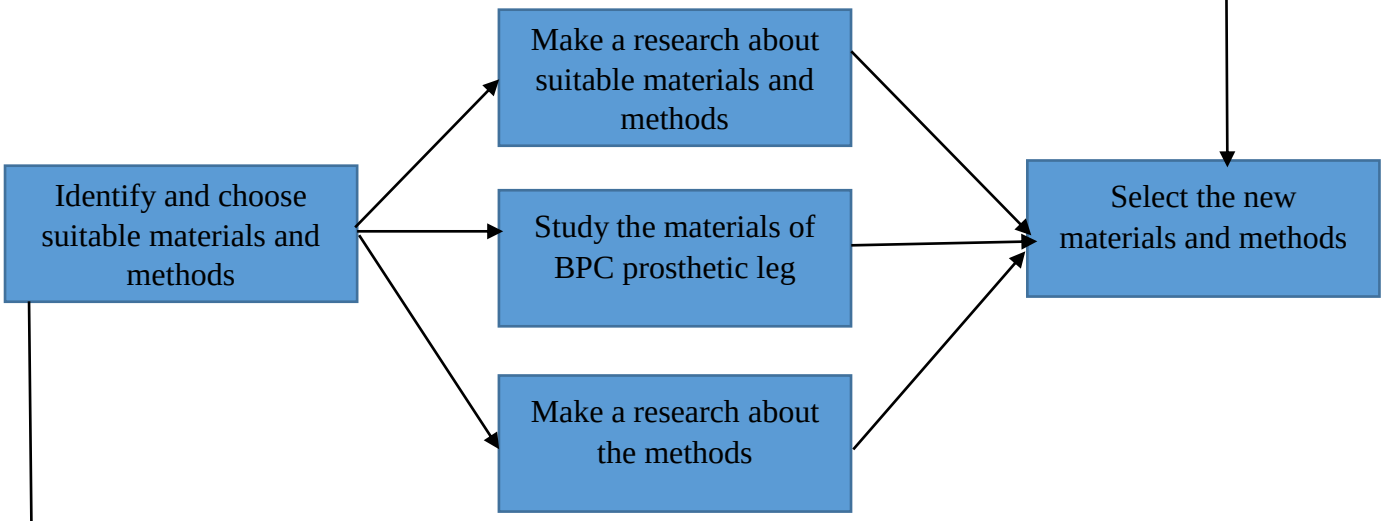
  This hands lay up proses is crucial because this is where the product started to shape. First, polyester resin is mix with hardener with the ratio of 99% : 1% . After that a layer of resin is spread over the silicon . The Kenaf rope is wrapped around the silicon quickly then another layer of resin is added. Let it dry for 3 days and the end product is complete.

3.7 METHODOLOGY PHASE

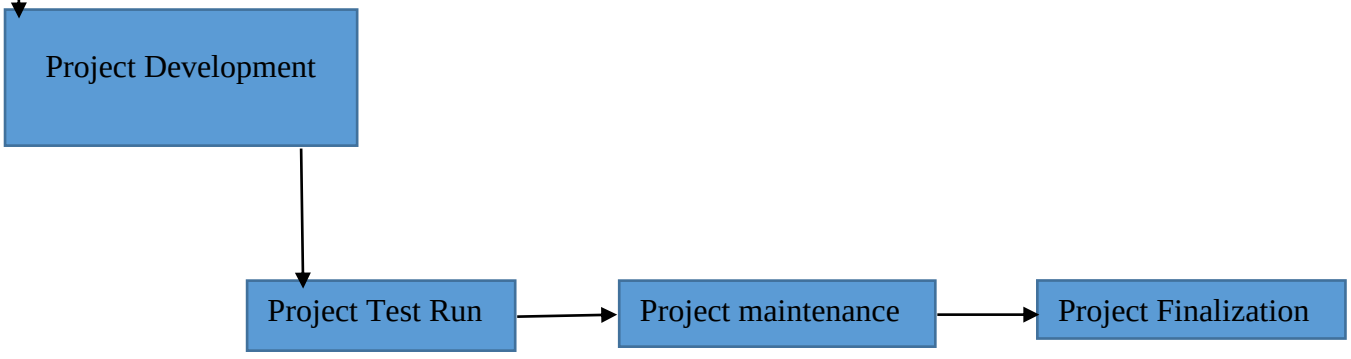
Phase 1 : Data Analysis



Phase 2 : Method and Material



Phase 3 : Preliminary Study



3.7 BUDGET CALCULATION

Prepared By Amal Asyraaf Bin Abdul Rahim

No	Materials / Equipment	Amount	Price
1.	Polyester Resin and Hardener	2kg	RM150
2.	Silicon A and B	500g	RM85
3.	Moulding Wax	1 unit	RM50
4.	Gloves	1 box	RM10
5.	Plaster of Paris Sculpture	1 unit	RM200
6.	Maskers	1 box	RM5
7.	Weighing Scale	1unit	RM16
8.	Thinner	1 litre	RM10
9.	Plaster of Paris Bandage	1 roll	RM45
10.	Plaster of Paris Powder	1kg	RM11
		Total	RM582

Table 3.7.1

3.8 PROJECT ACTIVITY

Project Activity	weeks													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Briefing and Project Planning														
Project Design														
Material Selection														
Materials Purchase														
Method Selection														
Fabrication														
Test Run														
Analysis Data														
Report Writing														
Video and Slide making														
PITEX preparations														
PITEX presentation														

Table 3.8.1

Planning

Actual

3.9 CHAPTER'S SUMMARY

As a conclusion , the methods implemented in this project are very crucial and important to complete the project . Thus, as stated in the interview ,this project is agreed and accepted by Mr Hafizzudin , a prosthetic maker who has been making prosthetic leg more than five years. The materials used in the project will create a light and very strong prosthetic leg yet very cheap , hence this project is very convenient to the amputees and also the environment because of it bio-degradable character. However, this method will effect the result totally if one of the method is change.

CHAPTER 4: FINDINGS AND ANALYSIS

4.1 INTRODUCTION

This chapter combine data and analysis of the Bio-friendly polymer composite prosthetic leg and its materials calculations. This data and analysis are very important for this project to achieve the objectives and scope of the project. This data indicate the successful results of the materials testing. After getting all of this data ,we analyze every single possible to make it perfect .

4.2 ADVANTAGE AND DISADVANTAGE

Prepared By Suhaib Bin Muhamad Asmadi

Every project has its own pros and cons, the pros will help the people and also the environment . However, the cons or the disadvantages must be improved or change for the future so that we could enhance the good and very efficient product that hardly to find disadvantage of the project.

Bio-friendly polymer composite prosthetic leg have a lot of advantages to help amputees and also environment. Besides of the advantages , this project also disadvantages that we must overcome it in the future for the better good.

4.2.1 ADVANTAGES

1) Cheaper than current prosthetic

   The costing of this whole project is RM582 which is very inexpensive which cost very less than current prosthetics that could reach RM10,000. Moreover , the materials that were used throughout this project still have a lot of balance which means the amount of materials we used is less than the cost , due to t\his the price for a BPC prosthetic is very cheap almost reaching RM 300 ++ per part and this will be such a huge convenient to amputees in the terms money.

2) Lighter than current prosthetic

   The BPC prosthetic leg is very light in weight compare to the current prosthetics .Due to this , it really convenient the amputees in term of them doing their daily routines such as walking , strolling or even jumping. Hence , because of the very light weight of this BPC prosthetic leg , the amputees could carry out their daily routine very well and easily without realizing it is even a prosthetic.

3) Biodegradable

   BPC prosthetic leg, is a naturally decomposable or bio-degradable prosthetic which means it could decompose naturally when it comes to time. In this globalization era, non-decomposable materials is a huge issue because our world is dying, yet a very few solutions is in tender. However, with BPC prosthetics, the issue with non-decomposable materials could be reduced by a lot. Hence, this could both benefits humans and environment.

4.2.2 CHALLENGES

1) The end product is really hard to take out of the PP cast
2) End product is bumpy and not smooth
3) Take a long time to dry
4) Difficult to layer the PP cast with Kenaf
5) Inner part of the prosthetic socket is not comfortable for amputees.

4.3 TEST RUN

Prepared by Amal Asyraaf Bin Abdul Rahim

Test Run A

This test run A is carried out to test whether the kenaf and polyester mixture is strong or not. This test run requires kenaf plate and hammer. With a huge effort , we will hit the kenaf plate with hammer to determine its strength . After the kenaf plate was hit with hammer for 3 times , its resulted to the brick that breaks into two. Hence, this proved that the Kenaf and Resin mixture is very strong.

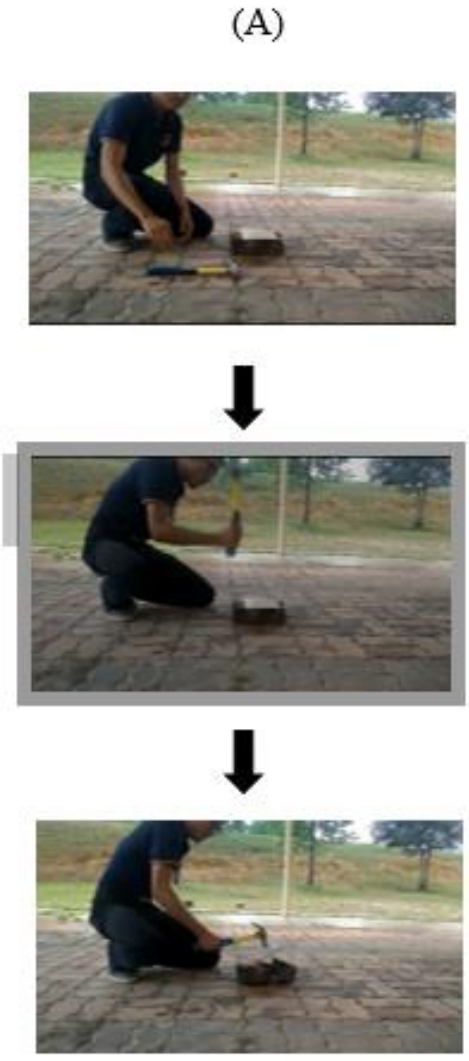


Figure 4.3.1 – Test Run A

Test Run B

This test run is carried out to determine the stiffness of the kenaff and resin mixture. Test run B requires bricks and kenaf plate. By staking bricks by bricks on top of the Kenaf , stiffness of the kenaf could be determined. After more than 6 bricks, the kenaf plate bends but it does not even break.

Figure 4.3.2 – Test Run B

4.4 STRENGTH OF BPC PROSTHETIC LEG

Prepared By Sharifah Nurul Balqis Bt Syed Abdul Mutalib

From the Test Run A it is proven that this kenaf fiber with polyester resin mixture is really strong , however this graft below will shows the relationship between the amount of impact velocity and the size of dents in the kenaf plate. This hypothesis is accepted and it is confirmed that if the amount of impact velocity applied increased , the size of dents in the kenaf plate will increased but the amount of impact velocity needed to make a dent in the kenaf plate is huge.

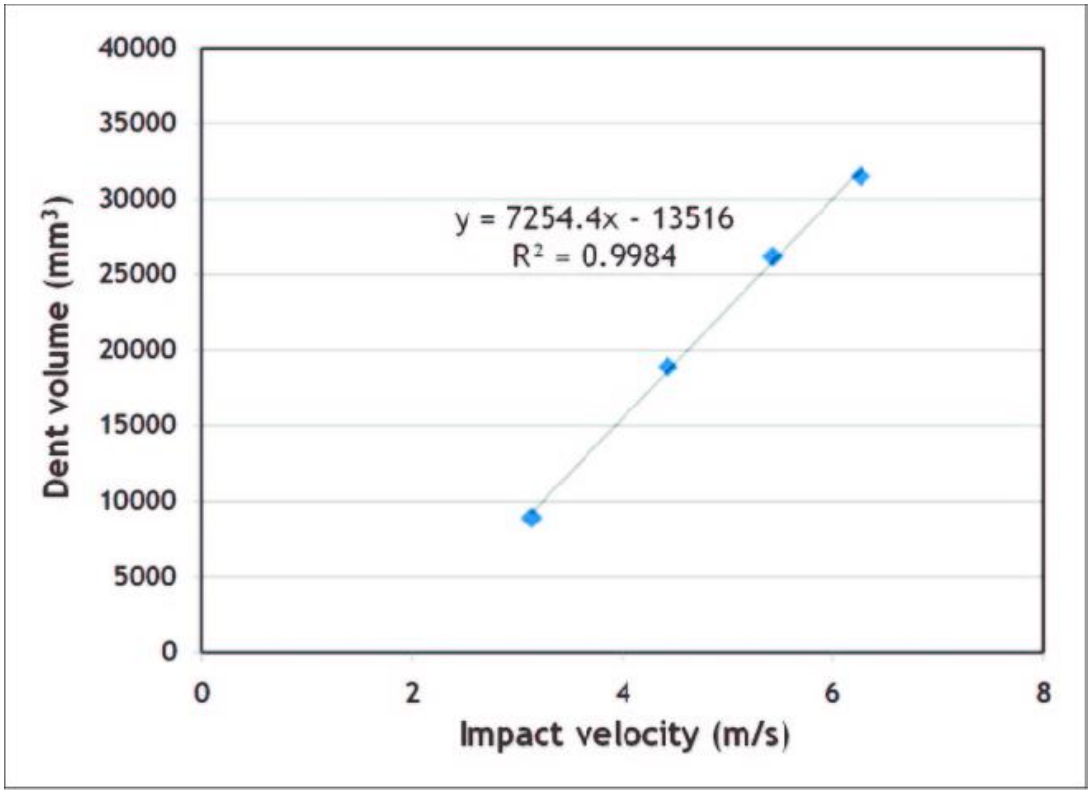


Figure 4.4.1 – Dent Volume Vs Impact Velocity

4.5 STIFFNESS OF BPC PROSTHETIC LEG

Based on the Test Run B , it its shown and proven that this material (Kenaf and polyester resin mixture) is very stiff. Hence. The graft below shows the relationship between the amount of weight and the bending of the kenaf plate. This hypothesis is well accepted since if the amount of weight increase , the bending of the kenaf plate also increases. This proved that kenaf is very stiff and to make it bend , a lot of weight or force is required.

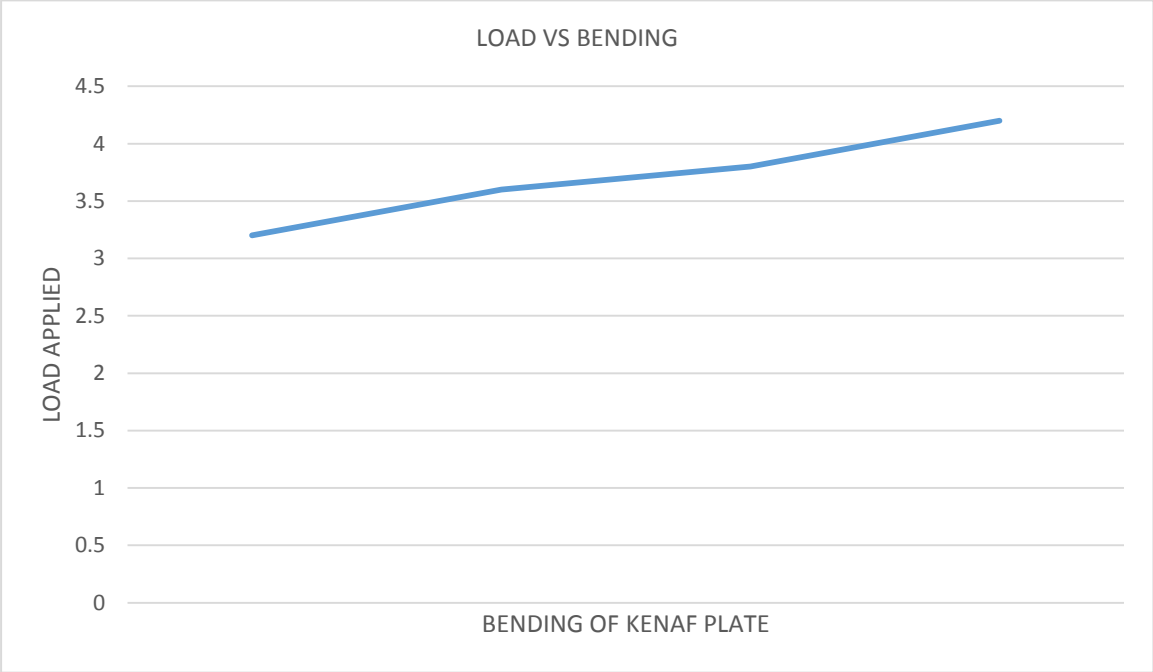


Figure 4.5 – Load Vs Bending

4.6 ANALYSIS DATA

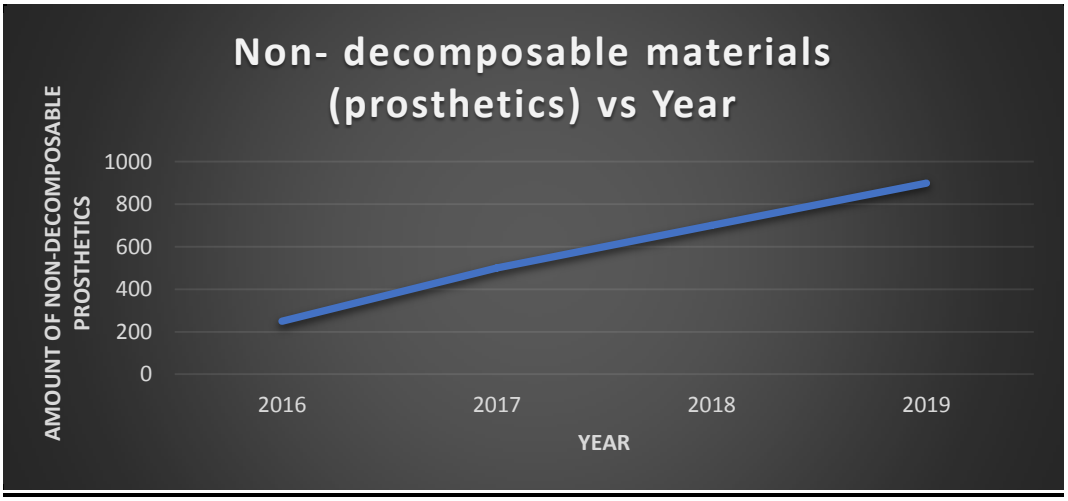


Figure 4.6.1 Line Graph

According to studies, that around 160,000 of Malaysia's current population of 32 million need prosthetic or orthotic devices. The population is projected to reach 38.5 million by 2040 , including approximately 200,000 individuals with a physical disability. According to ISPO, the average number of patients that can be served by a prosthetist, orthotist or technician is 250 patients per year . This estimate suggests that a workforce of 640 is currently needed in Malaysia to provide prosthetic and orthotic services to disabled individuals.

Hence , based on the line graft above it is shown that non-decomposable material as in prosthetics are increasing from year to year and this is one of the reason that the non-decomposable materials in Malaysia are increasing which will absolutely harm the environment and also humans. However , this issue could be avoided nor settled if BPC prosthetic leg is commercially promoted whole Malaysia.

The matter as it is because BPC prosthetic leg or Bio-friendly polymer composite prosthetic leg uses natural fibre and materials that could be naturally decompose, hence this BPC prosthetics is biodegradable. Due to this , its mean that if majority of amputees starts to use BPC prosthetic leg , the problem with non-decomposable materials (prosthetic leg) could decrease drastically .

4.7 CHAPTER'S SUMMARY

As a conclusion for this chapter , the analysis and findings have been made. This BPC prosthetic leg has a lot of advantages however there are every cons to pros. Hence, the challenges are taken as a room for improvements and more developments for future generation and well as to enhance their knowledge on the project we carried out. Test run is carried out to determine the fullest potential of kenaf and it is proven that kenaf plate both very strong and stiff. The relationship is really well shown in the grafts.

CHAPTER 5 : DISCUSSION , CONCLUSION AND UPGRADE PLAN

5.1 INTRODUCTION

This chapter explains about discussion , conclusion and upgrade plan all together for the project . From the data from the test run of the project, the analysis have been done. Hence, the discussion from all the results of test run and analysis will be explain in this chapter. Then , the conclusion will be made based on the discussion and upgrade plan that have been made.

5.2 DISCUSSION

Based on the data we collected , we can agree to the fact that we need to increase the amount of silicon layer on the PP cast (plaster of paris). This is because the process of taking out the project from the plaster of paris cast is very difficult. The process became difficult because the layer of silicon is too thin plus , the shape of the plaster of paris cast is curvy and lumpy . Thus , this causes it to become very hard to take the end product out. However , if we added a few more layers of silicon , the time taken and energy used to take out the end product from the plaster of paris casting may decreases. This is because the amount of silicon layer may causes it to become more slippery and smooth , making it easier to come out from the positive mold.

Other than that , the way of layering the polyester to the kenaf should be better due to the problems that occurs afterhand. The results of the polyester and kenaf layering was a bit rough and very bumpy , this is caused by the way of layering . In order to avoid this bumpy and rough results , the layers could be done by using finner brushes and proper , slow applications. By using that way , the slow and precise brush application will make the surface become more smooth .

Furthermore, the ratio of polyester to the hardener should change. This is because the time taken for the product to dry is long. However , this could be change if the ratio of polyester and hardener is different. The ratio that were used , polyerster to hardener 99% : 1% . Hence based on the previous result of the time taken for the product to dry and the ratio of polyester to hardener , the ratio should be 97% : 3%. Thus , with this ratio , the time taken to dry will decrease to the fact that the ratio of polyester and hardener increase.

Moreover , kenaf that were used is in rope form. However , this couses it to become quite difficult to layer . Hence, to make the layering of kenaf more convenient , it is better to use kenaf mat as the fibre layer. Kenaf mat is more easier to spread out and the time taken to layer the kenaf will decrease. Other than that, we found out that the inner part of our project is quite rough for amputees to wear even though it is wearable. This is because there are no comfortable layer inside of our product . Hence , a thin layer of sponge will do the job. With the sponge ,the amputees leg will be more comfortable.

Then, the hands lay up method we chosed seems to end up with not really great finnishing results . The results of hands lay up method is the process of making a single

prosthetic leg is taking a longer time ,the procedure is tricky and the end product is rough and bumpy. Hence , it is decided that the vacuuming method is more suitable for our project.By using vacuuming method , the time taken to complete a product is less and the procedure is easier , plus the endproduct will be smooth.

Last but not least, the finnishing of our product could be improve by adding a layer of natural wax .By this way, the surface of prosthetic leg could be smooth and comfy to wear.So, based on all these discussions been made , for future improvements , a lot of upgrades could be make to improve the products quality and also to make the time taken of making the product decreases.

5.3 UPGRADE SPECIFICATION

Specification	Upgrades
Amount of layered silicon	Add around 3-4 more layer
Way of layering the polyester	Use finer brush and precise application
Ratio of polyester and hardener	97% : 3% polyester resin to hardener
Form of Kenaf	Mat form for easier layering
Method of project	Vacuuming
Inner part of the prosthetic leg	Add up cushion
Finnishing project	Layer with natural wax

Table 5.3.1

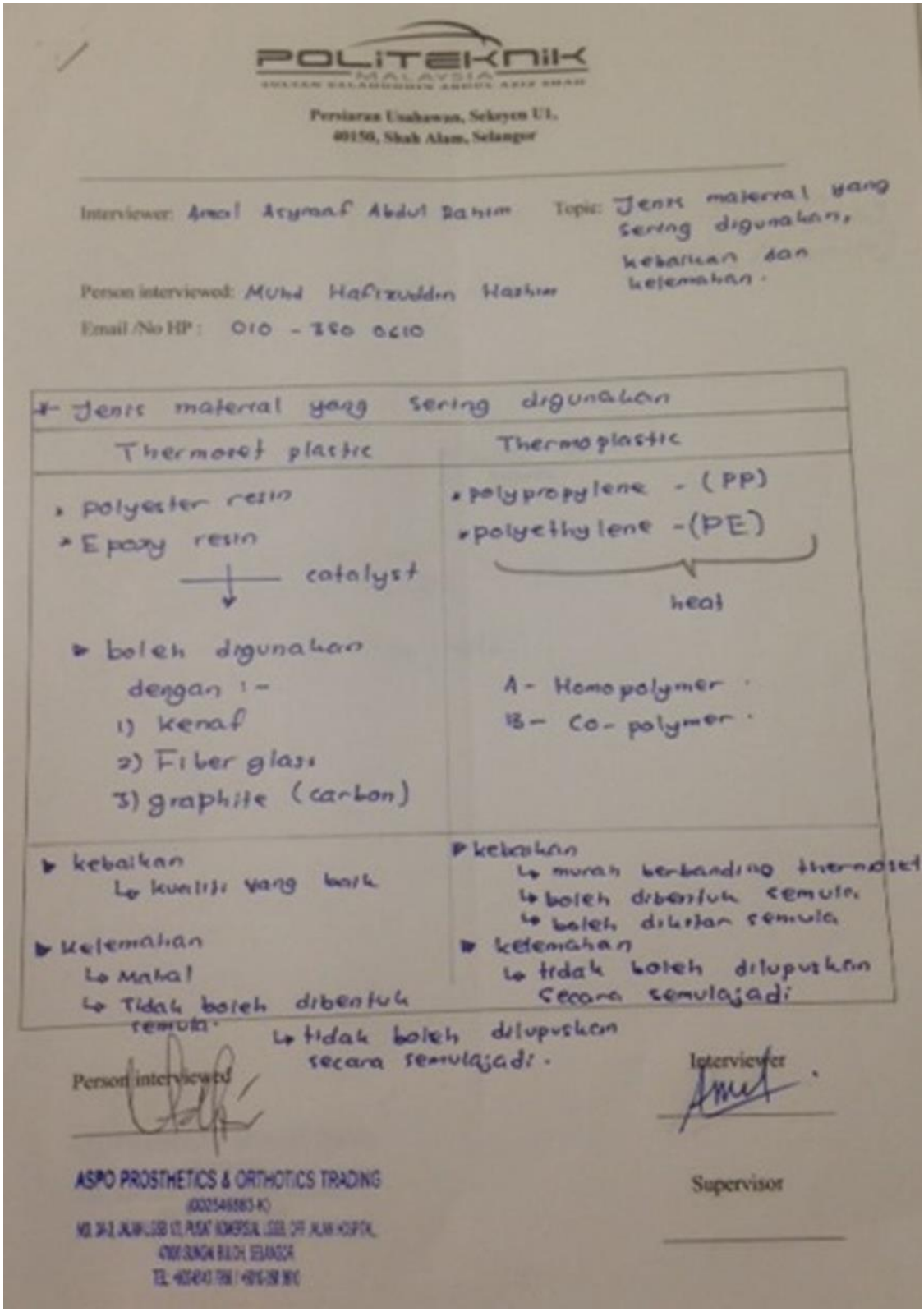
CONCLUSION

Based on this through out project , it is confident to say that this bio-friendly polymer composite prosthetic leg gives alot of benefits not to just humans , but also the environment . Plus , with all the convenient that this BPC prosthetic leg offers to the amputees , it will help them alot especially in the price range area an the weight of prosthetic In hopes that this project could make it to the goverment and non-goverment hospital , to be widely use by all amputees , because it will greatly leave a positive effects to the environment and also human. All the upgrades and improvements will be made so that this project could give more benefits and advantages . Hence, hope that this project could expand even more through out all the upcomings generations.

REFFERENCES

- RK Sirvastava . (2013) ESSENTIALS OF PROSTHETICS & ORTHOTICS WITH MCQS & DISABILITY ASSESSMENT GUIDELINES.
- A.A Abu Bakar. (September 2011) Kenaf fiber reinforced composites. *Material and Design . Volume 32, Issues 8–9, September 2011, Pages 4107-4121*
- Ayadi Rekaya. (December 2016) Hibiscus Cannabinus L. – « Kenaf ». Journal of Natural Fibers 14(4):1-19
- J. Sahari. (April 2012) Natural fibre reinforced biodegradable polymer composites. Reviews on advanced materials science 30(2)
- Takashi Nishino. (July 2003) Kenaf reinforced biodegradable composite. Composites Science and Technology.Volume 63, Issue 9, July 2003, Pages 1281-1286
- Behravesh, E. (October 1999) Synthetic Biodegradable Polymers for Orthopaedic Applications. Clinical Orthopaedics and Related Research (1976-2007): October 1999 - Volume 367 - Issue - pp S118-S129
- Saswata Sahoo. (November 2011) Enhanced properties of lignin-based biodegradable polymer composites using injection moulding process. Composites Part A: Applied Science and Manufacturing.Volume 42, Issue 11, November 2011, Pages 1710-1718.
- M.R. Sanjay. (July 2015) Study on Mechanical Properties of Volume 2, Issues 4–5, 2015, Pages 2959-2967Natural - Glass Fibre Reinforced Polymer Hybrid Composites. Materials Today.

APPENDIX



POLITEKNIK MALAYSIA

Persiaran Usahawan, Seksyen U1,
40150, Shah Alam, Selangor

Interviewer: Amal Asyraf Abdul Rahim Topic: Jenis material yang sering digunakan, kebaikan dan kelemahan.

Person interviewed: Muhd Hafizuddin Hashim

Email /No HP: 010 - 350 0610

* Jenis material yang sering digunakan

Thermoset plastic	Thermoplastic
• polyester resin • Epoxy resin + catalyst ▶ boleh digunakan dengan :- 1) kenaf 2) Fiber glass 3) graphite (carbon)	• polypropylene - (PP) • polyethylene -(PE) heat A- Homopolymer B- Co-polymer
▶ kebaikan ↳ kualiti yang baik ▶ kelemahan ↳ Mahal ↳ Tidak boleh dibentuk semula.	▶ kebaikan ↳ murah berbanding thermoset ↳ boleh dibentuk semula. ↳ boleh dikitar semula ▶ kelemahan ↳ tidak boleh dilupuskan secara semulajadi

↳ tidak boleh dilupuskan secara semulajadi.

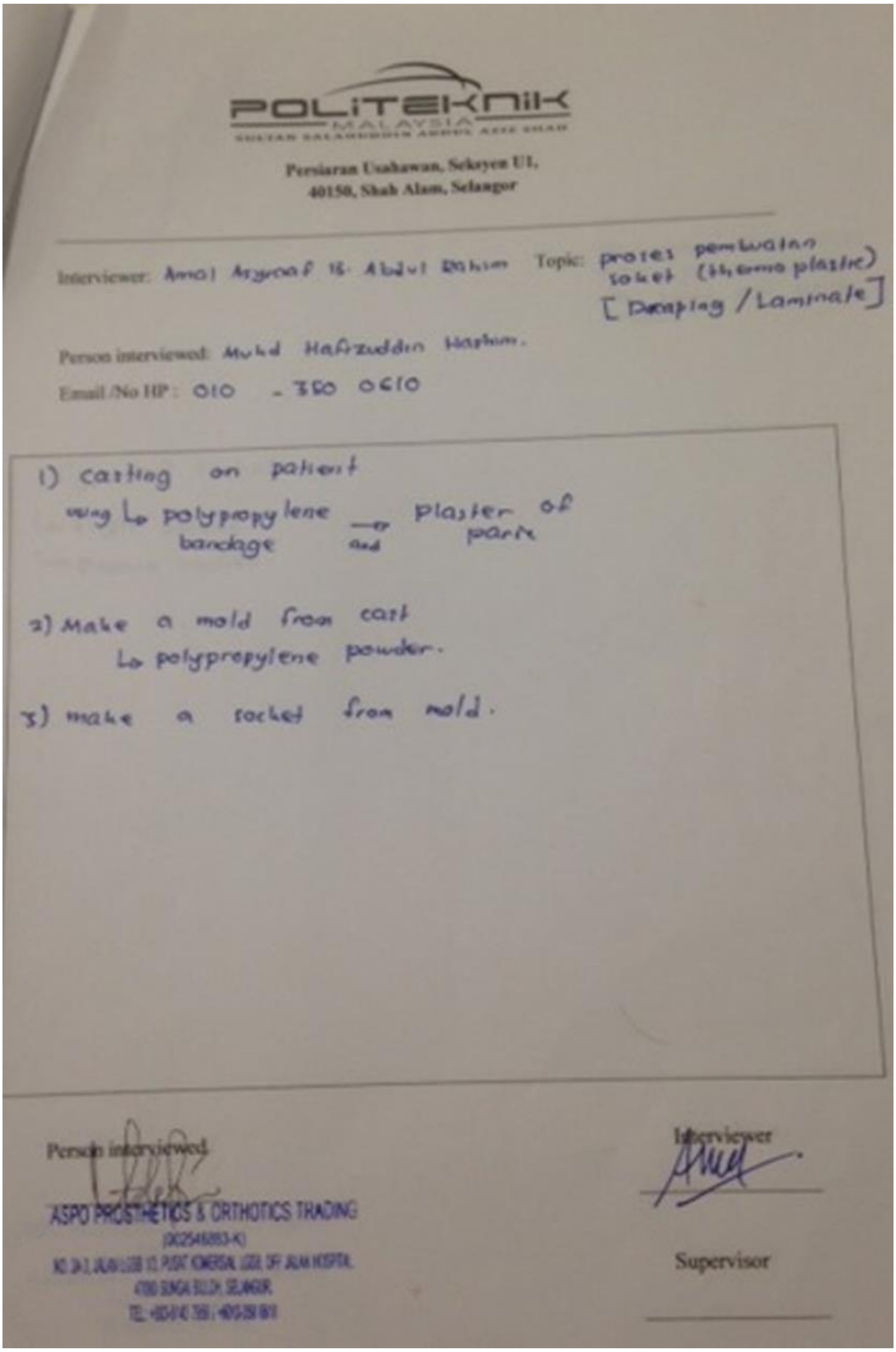
Person interviewed

Interviewer

ASPO PROSTHETICS & ORTHOTICS TRADING

Supervisor

Interview report 1


POLITEKNIK MALAYSIA

Persiaran Usahawan, Seksyen U1,
40150, Shah Alam, Selangor

Interviewer: Amal Asyraaf B. Abdul Rahim

Topic: proses pembuatan soket (thermo plastic) [Drapping / Laminate]

Person interviewed: Muhd Hafizuddin Hashim.

Email /No HP : 010 - 350 0610

1) casting on patient
using ↳ polypropylene bandage → and plaster of paris

2) Make a mold from cast
↳ polypropylene powder.

3) make a socket from mold.

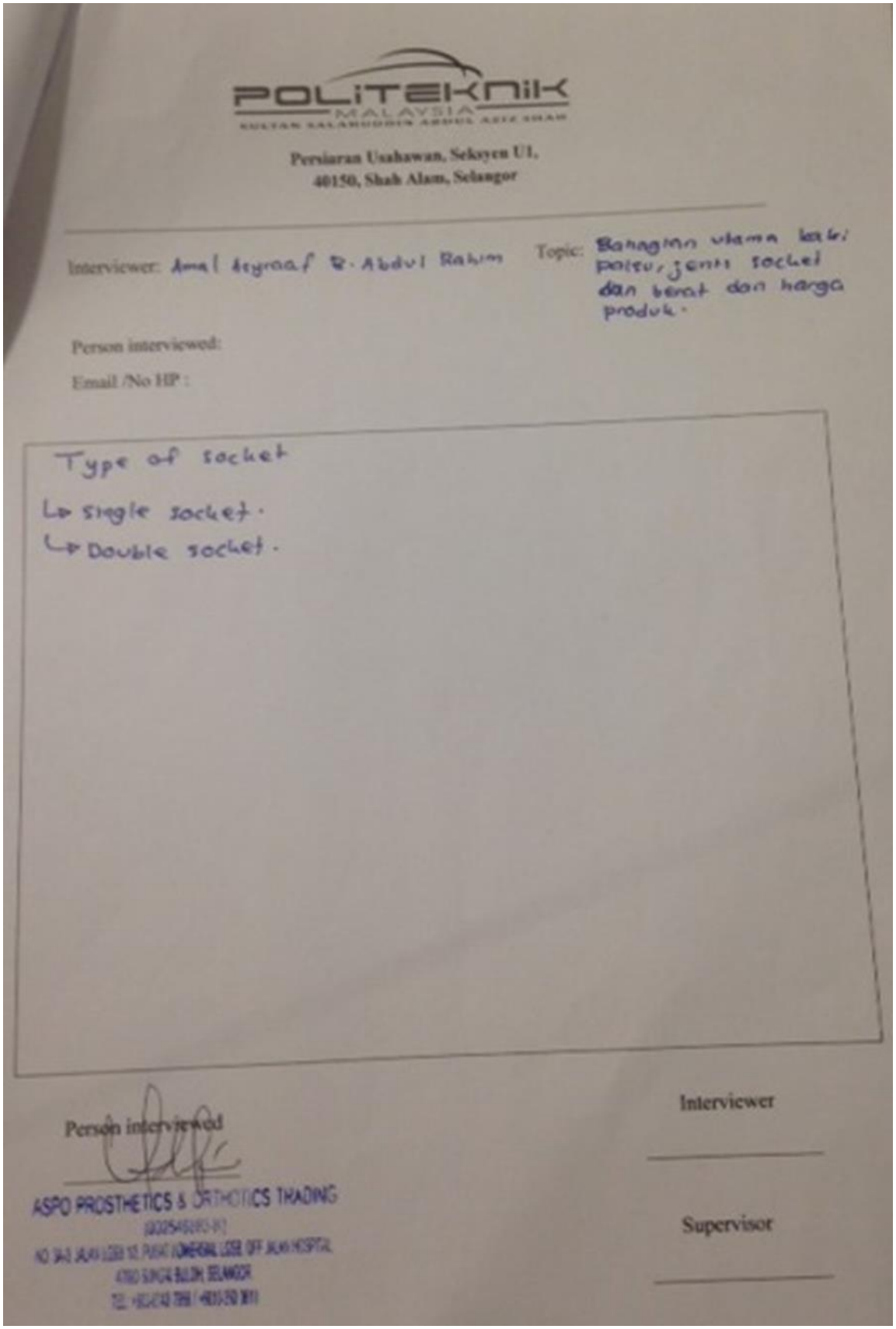
Person interviewed

ASPO PROSTHETICS & ORTHOTICS TRADING

Interviewer

Supervisor

Interview report 2



POLITEKNIK MALAYSIA
SULTAN SALAHUDDIN ABDUL AZIZ SHAH

Persiaran Usahawan, Seksyen U1,
40150, Shah Alam, Selangor

Interviewer: Amal Asyraaf B. Abdul Rahim Topic: Barangan utama kaki: paitu, jenis socket dan berat dan harga produk.

Person interviewed:

Email /No HP :

Type of socket

- Single socket.
- Double socket.

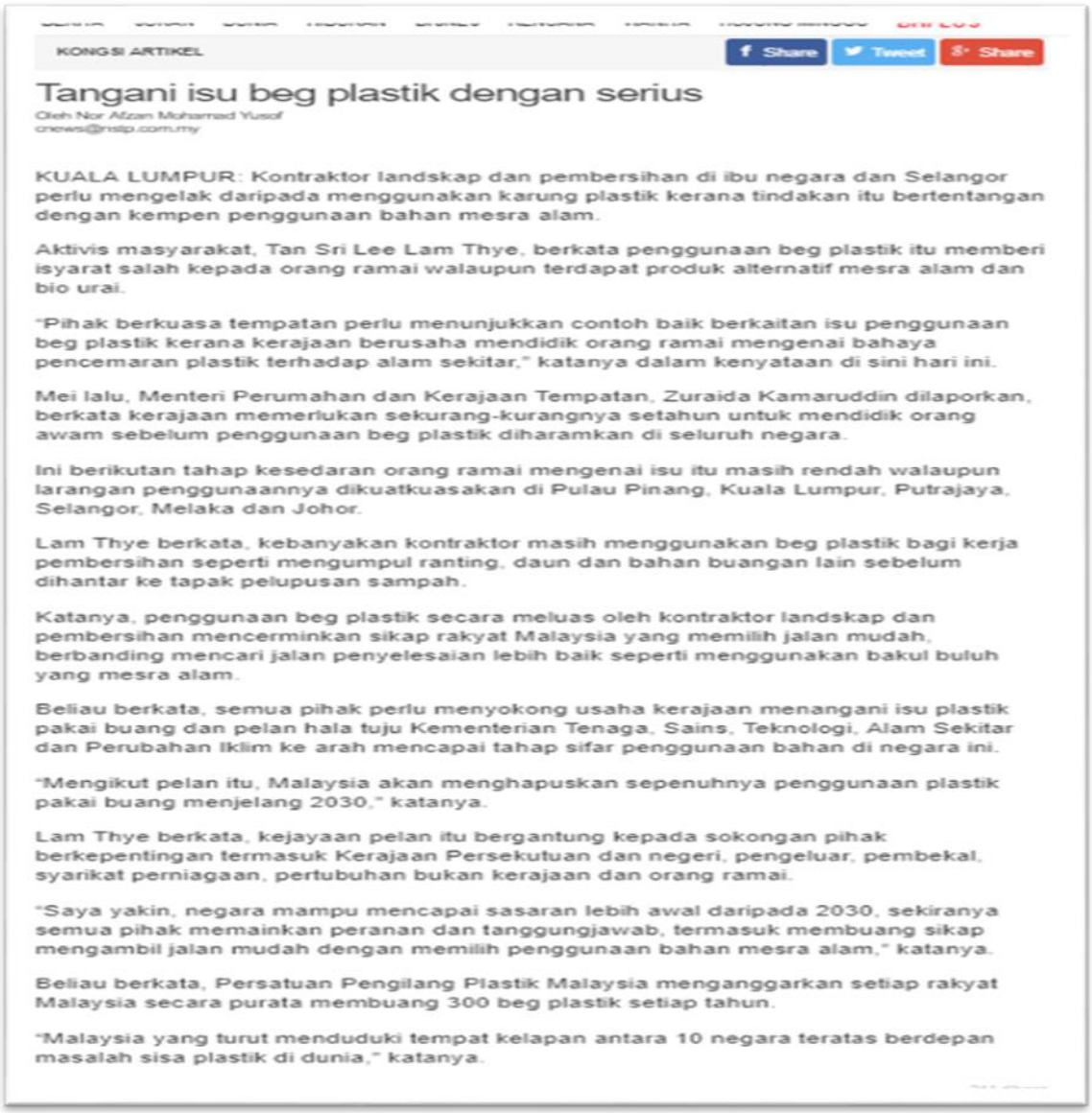
Person interviewed

Interviewer

Supervisor

ASPO PROSTHETICS & ORTHOTICS TRADING

Interview report 3



KONGSI ARTIKEL

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Tangani isu beg plastik dengan serius

Oleh Nor Afzan Mohamad Yusof
cnews@nstp.com.my

KUALA LUMPUR: Kontraktor landskap dan pembersihan di ibu negara dan Selangor perlu mengelak daripada menggunakan karung plastik kerana tindakan itu bertentangan dengan kempen penggunaan bahan mesra alam.

Aktivis masyarakat, Tan Sri Lee Lam Thye, berkata penggunaan beg plastik itu memberi isyarat salah kepada orang ramai walaupun terdapat produk alternatif mesra alam dan bio urai.

"Pihak berkuasa tempatan perlu menunjukkan contoh baik berkaitan isu penggunaan beg plastik kerana kerajaan berusaha mendidik orang ramai mengenai bahaya pencemaran plastik terhadap alam sekitar," katanya dalam kenyataan di sini hari ini.

Mei lalu, Menteri Perumahan dan Kerajaan Tempatan, Zuraida Kamaruddin dilaporkan, berkata kerajaan memerlukan sekurang-kurangnya setahun untuk mendidik orang awam sebelum penggunaan beg plastik diharamkan di seluruh negara.

Ini berikutan tahap kesedaran orang ramai mengenai isu itu masih rendah walaupun larangan penggunaannya dikuatkuasakan di Pulau Pinang, Kuala Lumpur, Putrajaya, Selangor, Melaka dan Johor.

Lam Thye berkata, kebanyakan kontraktor masih menggunakan beg plastik bagi kerja pembersihan seperti mengumpul ranting, daun dan bahan buangan lain sebelum dihantar ke tapak pelupusan sampah.

Katanya, penggunaan beg plastik secara meluas oleh kontraktor landskap dan pembersihan mencerminkan sikap rakyat Malaysia yang memilih jalan mudah, berbanding mencari jalan penyelesaian lebih baik seperti menggunakan bakul buluh yang mesra alam.

Beliau berkata, semua pihak perlu menyokong usaha kerajaan menangani isu plastik pakai buang dan pelan hala tuju Kementerian Tenaga, Sains, Teknologi, Alam Sekitar dan Perubahan Iklim ke arah mencapai tahap sifar penggunaan bahan di negara ini.

"Mengikut pelan itu, Malaysia akan menghapuskan sepenuhnya penggunaan plastik pakai buang menjelang 2030," katanya.

Lam Thye berkata, kejayaan pelan itu bergantung kepada sokongan pihak berkepentingan termasuk Kerajaan Persekutuan dan negeri, pengeluar, pembekal, syarikat perniagaan, pertubuhan bukan kerajaan dan orang ramai.

"Saya yakin, negara mampu mencapai sasaran lebih awal daripada 2030, sekiranya semua pihak memainkan peranan dan tanggungjawab, termasuk membuang sikap mengambil jalan mudah dengan memilih penggunaan bahan mesra alam," katanya.

Beliau berkata, Persatuan Pengilang Plastik Malaysia menganggarkan setiap rakyat Malaysia secara purata membuang 300 beg plastik setiap tahun.

"Malaysia yang turut menduduki tempat kelapan antara 10 negara teratas berdepan masalah sisa plastik di dunia," katanya.

Article on Plastics

BERITA SUKAN DUNIA PERNIAGAAN BISNES KENCANA WANITA HUJUNG MINGGU BHPLUS

LKTN perlu kukuhkan industri kenaf

Oleh Siti Rohana Idris
bhkb@bh.com.my

DATUK Seri Mah Siew Keong (dua kiri) menyampaikan Anugerah Perkhidmatan Cemerlang (APC) kepada penerima sambil diperhatikan oleh Ketua Pengarah Lembaga Kenaf dan Tembakau Negara, Samsuddin Noor sempena Majlis Anugerah Citra 2017 Lembaga Kenaf dan Tembakau Negara. - Foto Nik Abdullah Nik Omar

KOTA BHARU: Lembaga Kenaf dan Tembakau Negara (LKTN) perlu proaktif memperkukuhkan kemajuan industri kenaf ke arah kesejahteraan pekebun kecil dan keseluruhan industri.

Ia bagi memastikan sektor huluan dan hiliran dalam industri itu mendapat manfaat yang maksimum.

Menteri Perusahaan Perladangan dan Komoditi, Datuk Seri Mah Siew Keong, berkata dengan perkembangan teknologi dan inovasi, kenaf bukan saja ditanam untuk mendapatkan 'fibre' dan 'core' semata-mata tapi juga daun kenaf juga dikenal pasti berpotensi untuk dikomersialkan bagi menghasilkan produk makanan dan kesihatan.

"Seperti sedia maklum, industri kenaf menunjukkan perkembangan memberangsangkan dengan peningkatan permintaan domestik dan antarabangsa serta kepelbagaian produk yang dihasilkan tahun demi tahun.

"Sebagai sebuah agensi yang dipertanggungjawabkan dalam kawal selia industri tembakau, LKTN perlu mengambil tindakan proaktif untuk meneliti isu yang dibangkitkan oleh pihak berkepentingan agar sebarang pertimbangan akan dilakukan sebaik mungkin oleh pihak kerajaan," katanya ketika berucap merasmikan majlis Anugerah Citra dan sambutan Aidilfitri LKTN di sini, malam tadi.

Dalam majlis itu 26 kakitangan LKTN terpilih menerima Anugerah Perkhidmatan Cemerlang (APC), 10 kakitangan yang bersara serta seorang menerima penghargaan 25 tahun perkhidmatan.

Yang turut hadir, Pengerusi LKTN, Datuk Mohd Adhan Kechik dan Ketua Pengarah LKTN, Samsudin Noor.

Article on Kenaf

Brochure for PITEX

Poster for PITEX

After test run result

End Product

The inner part of end project

PITEX booth