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Creation of E-Glass Epoxy Prosthetic Leg from a Pattern

Harsimran Jeet Singh[1], Vikas Kaushik[1], Manish Sharma[1], Vinod Kumar[1] and Ravneet Kaur[2]

[1]Department of Mechanical Engineering, Chandigarh Engineering College, Jhanjeri, Mohali-140307, Punjab, India
[2]Department of Computer Application, Chandigarh School of Business, Jhanjeri, Mohali-140307, Punjab, India
E-mail: cgccoe.me.hss@gmail.com

Abstract: The Pattern of Socket was made with the help of wood which is taken as pattern material and Plaster of paris was chosen as Pattern material for Shin. Then the setup was made for making the patterns. The common HAND LAYOUT approach was used to create the composite. Epoxy resin and E-glass Fiber are the materials used (araldite AW 106). HV953 IN was used as a hardener. It developed into a two-layered structure. The ratio of the fibre to the matrix was 40:60.After manufacturing, the sample was allowed to cure for 24 hours so that the matrix could thoroughly sink in and dry.

Keywords: Prosthetics, Pattern, Socket, Shin, composite, matrix, Glass fiber, epoxy, PMC etc.

Introduction

An Introduction to Prosthetics

Prosthesis is an artificial extension used in medicine to replace a lost body part. It belongs to the study of utilizing mechanical devices with human muscle, skeleton, and neurological system to help or improve motor control that has been lost due to injury, illness, or malfunction. Prostheses are frequently utilized to enhance damaged or absent body components or to replace missing or congenitally absent elements.

Design consideration taken in prosthetic leg:

1. Performance	2. Energy storage and return
3. Energy absorption	4. Ground compliance
5. Rotation	6. Weight
7. Suspension	8. Cost
9. Ease of use	10.

Parts of Artificial Limb

Prosthetic limbs consists three parts namely, Socket, shaft and foot. Direct and indirect sockets fall under the types of sockets. The biggest and most crucial component, the socket, must be made specifically for each amputee in order to meet their needs.

Material used in making of prosthetic Leg

The choice of composite materials is made in order to provide a low-weight prosthetic leg with good strength. Because they are lighter than other composite materials, polymer matrix composites are preferred (Metal-Matrix composites and Ceramic-Matrix composites).Over the past ten years, PMC usage has significantly increased. The superior mechanical and physical properties of PMCs, which combine high-strength synthetic fibres like carbon, glass, and Kevlar with thermoplastic resins (nylon and polyolefin), thermo set resins (epoxies, polyurethanes), and unsaturated polyesters, have made them a popular choice for structural components.

The structural material is referred to as a composite, when two or more constituents are united at a macroscopic level yet are insoluble in one another. There are two constituents in composite one is called matrix and other which is embedded is called reinforcing phase. The composite material, however, frequently has distinctive properties that are not possible with the individual components alone, such as stiffness, strength, weight, high-temperature performance, corrosion resistance, hardness, and conductivity.

The following three composites are chosen because they are the most frequently utilized while creating prosthetic legs:
(i) E-Glass Epoxy
(ii) Kevlar Epoxy
(iii) Carbon Epoxy

However, we prefer to utilise E-Glass Epoxy over the other two composites because it is more easily accessible and less expensive.

The following steps are used in Pattern making and fabrication of prosthetic legs:
- Set -up used to make the Pattern of Socket
- Set -up used to make the Pattern of Shin
- Procurement of the Glass fiber and Epoxy
- Hand lay-up process to make Socket
- Hand lay-up process to make Shin

Methodology

The steps that make up the process we used to complete our task are as follows:

Pattern

A pattern is a copy or model of the thing that is going to be created. To create the Socket and Shin for the prosthetic leg, a pattern of these parts must be created.

Pattern material

Wood is the primary construction material for the Socket pattern. Wood is the material that is used most frequently, because it is readily available and lightweight. Additionally, it may be shaped and is reasonably priced. However, wood's greatest drawback is its propensity to absorb moisture, which leads to distortions and dimensional changes. The war page might be somewhat reduced with competent construction.

Pine, mahogany, teak, walnut, tun, and deodar are the typical types of wood used to make patterns. In addition to wood, veneer-type plywood boards and particle boards are also used to create patterns. They are used because they are readily available in a range of thicknesses, have a better strength, and don't require seasoning. They can, however, be employed in flat patterns that lack three-dimensional features.

The major reasons why tun wood is chosen to create the pattern for the socket are its simple availability and light weight.

Set -up used to make the Pattern of Socket

Socket is the uppermost part of the prosthetic leg. The Socket is fitted onto the stump of an amputee till the waist level and is strapped with a belt so as to ensure the firm grip. Profile of the Socket is complex and for simplicity a tapering cylindrical profile is chosen as the alternative.

Pattern of Socket is made on wood turning lathe. A wooden piece of size 1’*1’*2’is held between the centers and rough machining is done with rough gouge. Taper turning of the wooden cuboids was done till it reached the final dimension (i.e. diameter 8 cm and 24 cm).

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Figure 2.1 Set -up used to make the pattern of Socket

Pattern material for Shin

Plaster of Paris is used to make the Pattern of the Shin, as the profile of the Shin is more complicated than the Socket, so wood cannot be used here as a Pattern material. The ends of the Shin are less in diameter as compared to its centre, so using wood as a Pattern material will result in not allowing the removal of Pattern from the composite.

2.6 Set -up used to make the Pattern of Shin

Figure 2.2 Set-up used to make the pattern of shin

Shin is the lower most part of the prosthetic leg. The Socket is fitted to the Shin. Profile of the Shin is complex and for simplicity a tapering cylindrical profile is chosen as the alternative. Pattern of Shin is made on wood turning lathe.

The wooden piece is placed between the centers of the wooden lathe. Gypsum powder is mixed with water in such a proportion to make it semi solid form and then applied it on wooden piece. This process continues till the diameter of the wooden piece reaches the value of 80 mm, after that the complex profile of the lower part of the leg is given by using different tools.

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Tools used to make Pattern of Socket and Shin

The tools used are:

(i) Rough Gouge
(ii) Round nose gouge
(iii) Outside caliper

Procurement of the Glass fiber and Epoxy

Glass fiber as shown in figure 26 below was obtained RB Electricals, Delhi-6. The Epoxy was supplied by Bhateja Brothers, civil lines, Roorkee; it is in a paste form of natural colour, pH value approx 6 at 20 0C, boiling point >200 0C, thermal decomposition >200 0C, flash point >210 0C, vapour pressure <0.1 Pa at 20 0C, density 1.15-1.25 g/cm3 at 25 0C, dynamic viscosity30-50 Pas at 25 0C; it is practically insoluble and immiscible in water. The glass fiber in the mat form is shown below.

Figure 2.3 Glass fiber mat

Fabrication and Composite Cutting:

The common HAND LAYOUT approach was used to create the composite. Epoxy resin and E-glass Fiber are the materials used (araldite AW 106). HV953 IN was used as a hardener. It developed into a two-layered structure. The ratio of the fibre to the matrix was 40:60.After manufacturing, the sample was allowed to cure for 24 hours so that the matrix could thoroughly sink in and dry.

Fig 2.4: Composite sample after the final treatment

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Hand Lay-up Process

The most popular technique for creating composite parts is to use thermosetting resins. Particularly for huge, bulky constructions, this is used. Fiber reinforcement is manually put into a single-sided mould during the hand lay-up procedure. Hand rollers are used to push resin through the fibre mats' thickness, and then squeegees are used to remove extra resin. After the part has had time to cure, the mould is removed from it. Heat and pressure are not normally used in this procedure; instead, basic tools and equipment can be used.

Hand lay-up process to make Socket

Glass-Epoxy composite laminates (the prototype of socket prosthesis) were made by hand lay-up with a fibre to matrix ratio of 40:60 at room temperature (25-300C). Prototype of the socket prosthesis made of two layers of glass fibre with symmetrical fibre orientation and a thickness (t) of 1.5 mm. Then, the hardener and epoxy were combined in a 1:1 ratio. The prototype Socket prosthesis was made with two layers of glass fibre that were oriented symmetrically.

Figure 2.5: Socket made of Glass-Epoxy composite

Hand lay-up process to make Shin

Glass-Epoxy composite laminates (the prototype of Shin prosthesis) were made by hand lay-up with a fibre to matrix ratio of 40:60 at room temperature (25-300C). Prototype of the shin prosthesis made of two layers of glass fibre with symmetrical fibre orientation and a thickness (t) of 1.5 mm. Then, the hardener and epoxy were combined in a 1:1 ratio. The prototype shin prosthesis was made with two layers of glass fibre that were oriented symmetrically.

Figure 2.6: Shin made of Glass-Epoxy composite

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Conclusion

The parts have showed encouraging promise for the product's success. It was discovered that the composite created for the prosthetic limb served the objective of providing the desired qualities at a lower weight while also managing to retain a low cost portfolio.

Future scope

Higher functionality can be achieved by using additional attachments, but this has not been done now because the focus is on creating a low weight, cost-effective prosthetic limb. However, the product can be designed to include such a feature.

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