International Journal of Mechanical Engineering and Technology (IJMET)
Volume 9, Issue 11, November 2018, pp.2361–2367, Article ID: IJMET_09_11_250
Available online at http://www.iaeme.com/ijmet/issues.asp?JType=IJMET&VType=9&IType=11
ISSN Print: 0976-6340 and ISSN Online: 0976-6359

ANALYSIS OF BIOMATERIALS FOR DESIGNING PROSTHETIC LIMBS

S.Sriram, P.Mohan Kumar, B.Subha, A.Vanitha
Department of Biomedical engineering,
PSNA College of Engineering and Technology, Dindigul, TamilNadu, India

ABSTRACT

When a person becomes a limb amputee, they need some devices to withstand in their normal life. Throughout the world there are about 18 million people who are in need of prosthetic limbs. The amputee requires a prosthetic device which becomes a life-long event. Prosthesis is an artificial material that replaces a missing body part such as an upper or lower body extremity. Prosthetics is the science of fusing mechanical device with human body. This study is based on the analysis of various parameters for selection of prosthesis such as condition of patient, availability, cost, material properties, compatibility and comfort for suggesting the better material to design a foot. So, a foot has been designed with the help of SOLIDWORKS software. Comparison and analysis of different low-cost and comfortable biomaterials are done by evaluating the values of their material property and simultaneously verifying these results with the help of ANSYS software. By performing theoretical study as well as material analysis of the four biomaterials namely Polystyrene, Polypropylene, Nitrile, and Silicone, it was found that Polypropylene proves to be a better choice for foot prosthetics in terms of the tested parameters. Material properties such as stress, strain, deformity, density etc were quantified.

Keyword: Prosthesis, Silicone, Biomechanics.

Cite this Article: S.Sriram, P.Mohan Kumar, B.Subha and A.Vanitha, Analysis of Biomaterials For Designing Prosthetic Limbs, International Journal of Mechanical Engineering and Technology, 9(11), 2018, pp. 2361–2367.
http://www.iaeme.com/IJMET/issues.asp?JType=IJMET&VType=9&IType=11

1. INTRODUCTION

A Prosthesis is an artificial material that replaces a missing body part such as an upper or lower body extremity. An artificial limb is a type of prosthesis that replaces a missing extremity, such as arms or legs. Artificial limbs may be needed in various cases, including disease, accidents, and congenital defects. There are four main types of artificial limbs. These include the transtibial, transfemoral, transradial, and transhumeral prostheses. A transradial prosthesis is an artificial limb that replaces an arm missing below the elbow, at some point along the radial bone. This type of surgery leaves ones elbow and most of ones arm intact, which makes recovery easier. A transhumeral prosthesis is a prosthesis designed for people with an arm amputated above the elbow. A transtibial prosthesis is a amputation of the lower leg between the ankle and the knee. It is also called as below-knee amputation. A transfemoral prosthesis is an artificial limb that replaces a leg missing above the knee. Transfemoral amputees can have a very difficult time regaining normal movement. This amputee must use approximately 80% more energy to walk than a person with two whole legs.

2. METHODOLOGY

The first process is to take various measurements of the foot. Then a foot is designed with the help of SOLIDWORKS software, Finally the stress, strain, deformity and weight of the various selected materials such as polypropylene, polystyrene, nitrile and silicone are analysed.

Measurement of foot

Four measurements were taken: Height, arm, span, palm lengthened foot length. These values were taken as per as age and the ratio of foot length while other three was calculated. Foot length is measured between the back of one's heel and the tip of one's longest toe. Care is taken to measure the longest dimension of both feet. There is a difference of half a centimetre between each measurement. At maximum 1 foot (ft.)-12 inches,1 yard(yd.)-3feet is maintained.

There is an another method for measurement which is to compare the normal foot with the diseased foot, Which helps to design an artificial foot.

Design of foot

SOLIDWORKS software is used to design a foot. Solidworks is a solid modelling computer-aided design(CAD) and computer-aided engineering(CAE) computer program that runs on Microsoft windows. SOLIDWORKS is published by Dassault Systems.

Solidworks is a solid modeler and utilizes a parametric feature-based approach to create models and assemblies. Parameters measured determines the shape or geometry of a model or assembly. Parameters can be either numeric parameters, such as line lengths or circle diameters or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical etc.

Building a model in solidworks usually starts with a 2D sketch. The sketch consist of geometry such as points, lines, arcs, conics and splines. Dimensions are added to the sketch to define the size and location of the geometry.

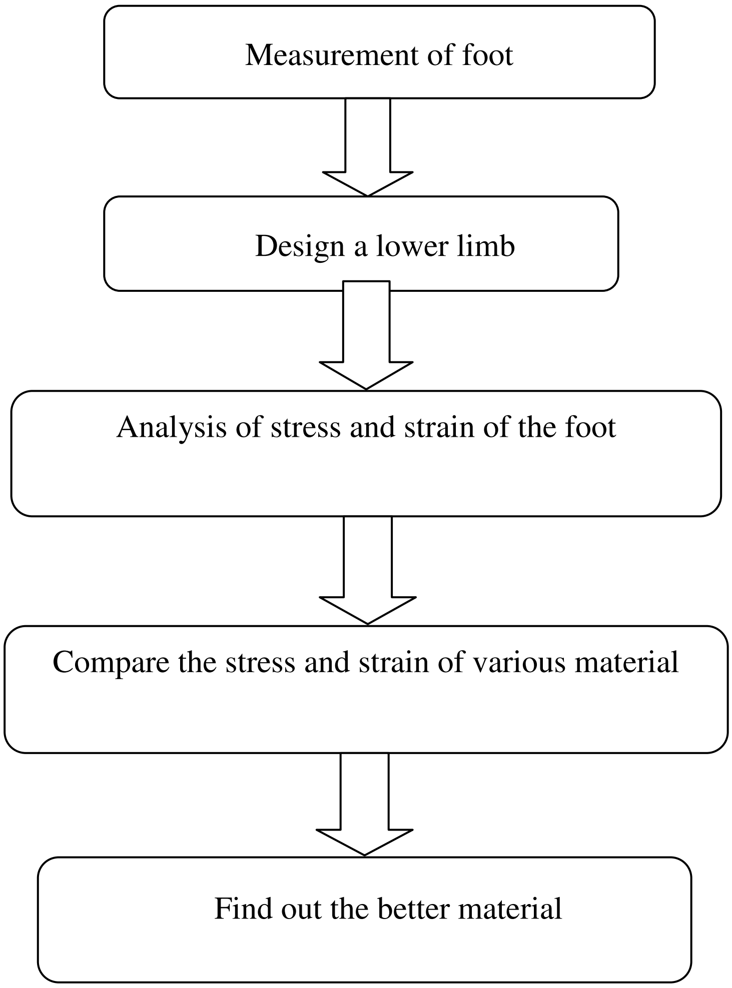


Fig 2.1 Methodology

Analysis of stress and strain of the foot:

ANSYS software is used for analysis. It is computer simulation tool for simulating the response of materials to short duration for severe loadings from impact and high pressure.

ANSYS mechanical is a finite element analysis tool for structural analysis, including linear, nonlinear and dynamic studies. This computer simulation product provides finite element to model behaviour, and supports material models and equation solvers for a wide range of mechanical design problems. ANSYS mechanical also includes thermal analysis and coupled physics capabilities involving acoustics, piezoelectric, thermal-structural and thermo-electric analysis.

3. RESULTS AND DISCUSSIONS

The proposed process has been applied on the prosthetic limbs. The upcoming images show the designing of artificial limbs and the analysis of various materials with the help of ANSYS software. Finally it was concluded that the polypropylene is the better material for the design of foot when compared to other materials considered in this work.

Table 3.1 Results

Parameters	Polypropylene	Polystyrene	Nitrile	Silicone
Stress(max)	1334.917	1477.571	1477.571	985.9086
Stress(min)	60.047	58.753	58.628	136.14
Stress(avg)	697.482	768.162	768.0995	561.0243
Strain(max)	0.09894	0.16871	0.1081	0.1496
Strain(min)	0.010073	0.0208	0.0098364	0.051906
Strain(avg)	0.0499	0.094755	0.0545	0.07739
Deformation	0.0135	0.2808	0.01330	0.02735
Weight	9288.3126	9386.085	12710.3158	9777.171

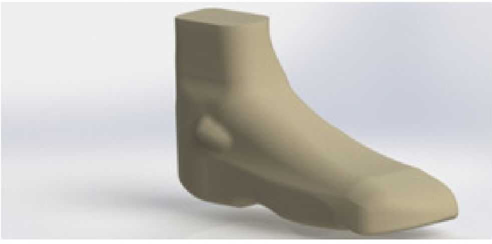


Fig 3.1 Designed foot.

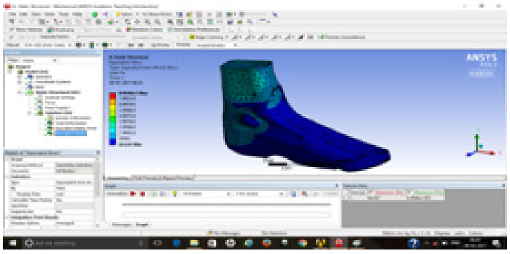


Fig 3.2 Polypropylene stress

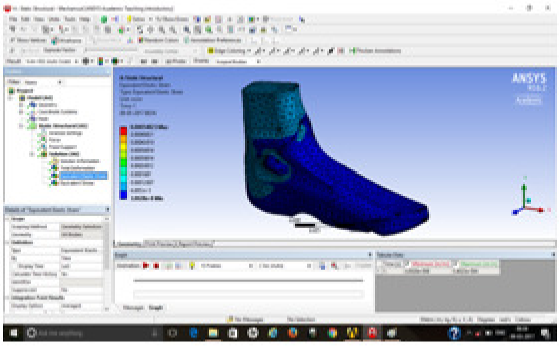


Fig 3.3 Polypropylene strain

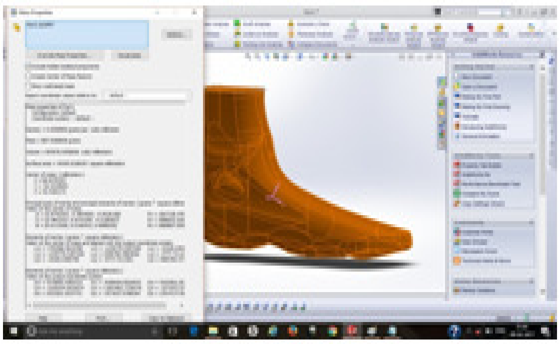


Fig 3.4 Polypropylene weight

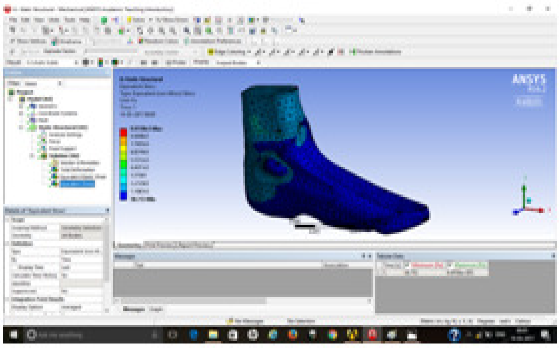


Fig 3.5 Polystyrene stress

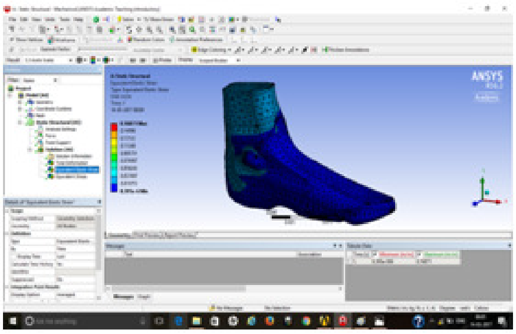


Fig 3.6 Polystyrene strain

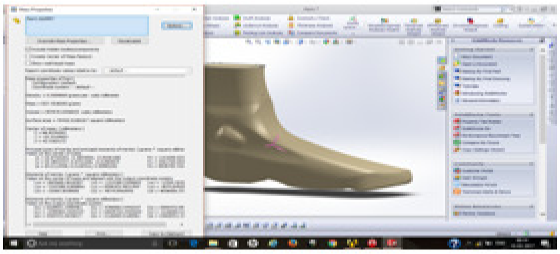


Fig 3.7 Polystyrene weight

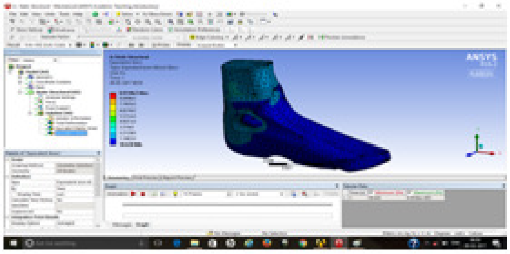


Fig 3.8 Nitrile stress

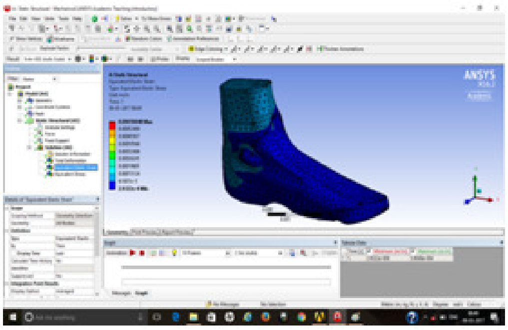


Fig 3.9 Nitrile strain

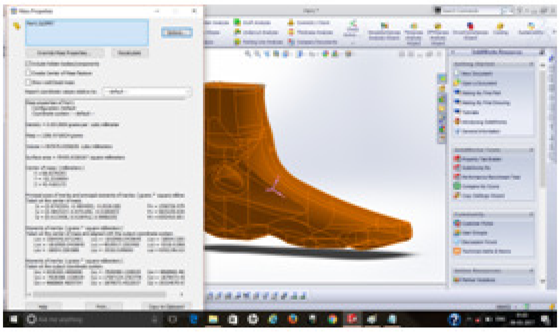


Fig 3.10 Nitrile weight

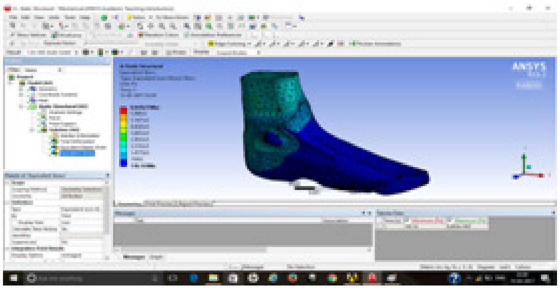


Fig 3.11 Silicone stress

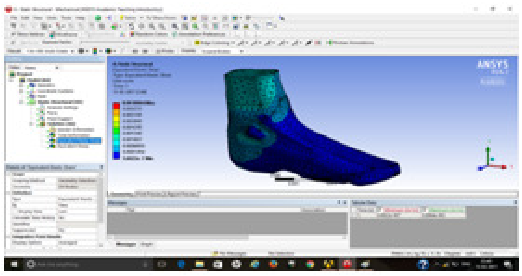


Fig 3.12 Silicone strain

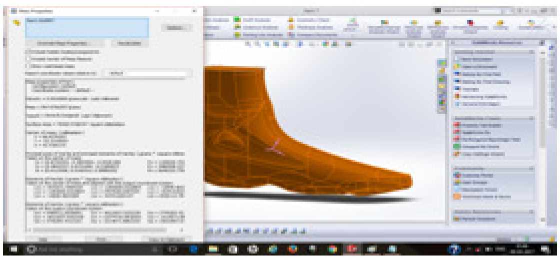


Fig 3.13 Silicone weight

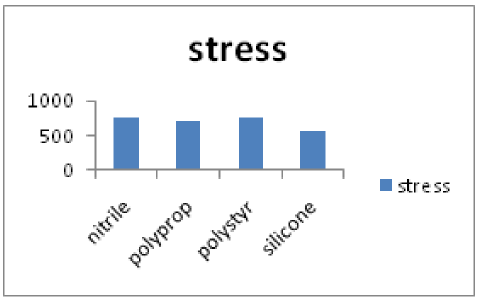


Fig 3.14 Stress analysis

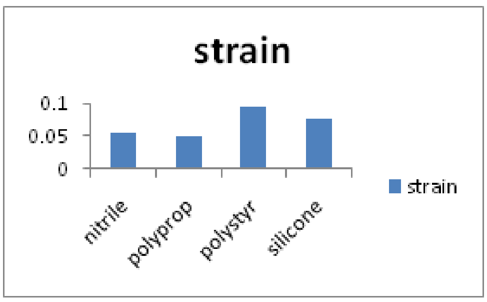
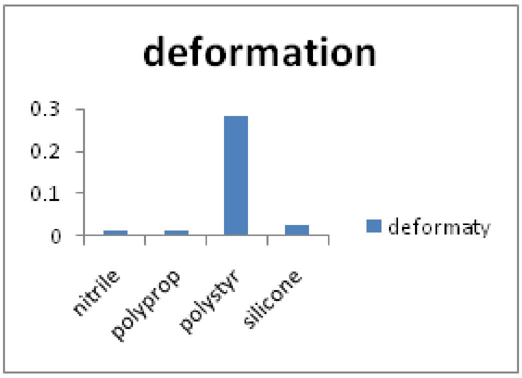


Fig 3.15Strain analysis



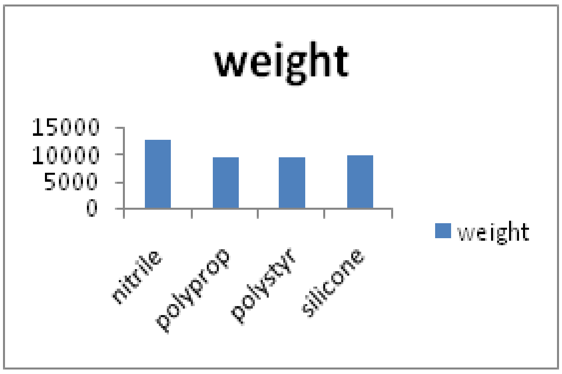


Fig 3.16 Deformation analysis **Fig 3.17** Weight analysis

4. ACKNOWLEDGEMENT

The authors would like to acknowledge Rehabilitation Centre, Kasturba Hospital, Chinnalapatti, Dindigul and the Students of Biomedical Engineering N.Diddha, S.Deen shamreena and N.Vimala for their contribution in doing the ground work for this concept.

5. CONCLUSION

This project proposed a better biomaterial to design a prosthetic limb. The Methodology is based on the Structural analysis of the foot (artificial limb). Results shows that the presented methodology is achievable and it offers better accuracy.

Results obtained encourage future works which includes: The real time design of the prosthetic foot with the above said biomaterial. After the artificial limb is fit with the amputee, the analysis of comfort, wear ability and lifetime can be done.

REFERENCES

[1] Dale A. Berry, C.P., “Composite Materials for Orthotics and Prosthetics”, Orthotics and prosthetics, vol 40, p-35-43, 1978.

[2] DanielPaluskaaHughHerrb, “The effect of series elasticity on actuator power and work output: Implications for robotic and prosthetic joint design”, Robotics and Autonomous Systems, 54(8), 2006, pp 667-673.

[3] Edith M. Arnold, Samuel R. Ward, Richard L. Lieber and Scott L. Delp “A Model of the Lower Limb for Analysis of Human Movement”, 3 December 2009.

[4] Etavi Mahida, Dhiren Mahida, “Jaipur foot: An attempt to replicate Jaipur model in Surat City”, National journal of community medicine.

[5] Gallagher, P, MacLachlan, M. “Adjustment to an artificial limb: a qualitative perspective”, Journal of Health Psychology, 2001, 6(1), pp 85–100.

[6] Hagberg, K, Branemark, R., “Consequences of non-vascular trans-femoral amputation: a survey of quality of life, prosthetic use and problems”, Prosthet Orthot Int, 2001; 25(3), pp186–194.

[7] Hagberg.K, Branemark R, GunterbergB.Rydevik, B,“Osseointegrated trans-femoral amputation prostheses: prospective results of general and condition-specific quality of life in 18 patients at 2-year follow-up”, Prosthet Orthot Int, 2008; 32(1), pp 29–41.

[8] Mari Lundberg,Kerstin Hagberg,Jennifer Bullington, "My prosthesis as a part of me: a qualitative analysis of living with an osseointegrated prosthetic limb", Prosthetics and Orthotics International, vol. 35, 2: June 22, 2011, pp. 207-214.

[9] Markus Hauschild;Rahman Davoodi;Gerald E. Loeb, "A Virtual Reality Environment for Designing and Fitting Neural Prosthetic Limbs" IEEE Transactions on Neural Systems and Rehabilitation Engineering, 15(1), March 2007.

[10] Pendegrass, CJ, Goodship, AE, Blunn, GW. "Development of a soft tissue seal around bone-anchored transcutaneous amputation prostheses", Biomaterials, 2006;27(23), pp 4183–4191.

[11] Priya Sharma, Shubhda Sharma, S. Vidhya, M. K. Mathur, "Comparative Finite Element Analysis of Jaipur Foot and Polyurethane Foot", Engineering, 2013, 5, 518-521.

[12] Rosalam che me,Alam cipta,"Natural Based Composite Material for Socket Fabrication" Volume 5, June 2012.

[13] M.Scholz, J.P.Blanchfield, L.D.Bloom, B.H.Coburn, M.Elkington, J.D.Fuller, M.E.Gilbert, S.A.Muflahi, M.F.Pernice, S.I.Rae, J.A.Trevarthen, S.C.White, P.M.Weaver, I.P.Bond, "The use of composite materials in modern orthopaedic medicine and prosthetic devices: A review", Composites Science and Technology, Volume 71, Issue 16, 14 November 2011, Pages 1791-1803

[14] P.K.Sethi, "The Jaipur Foot", The bone and joint journal, doi: 10.1302/0301-620X.90B11.21131, December 2008.

[15] P. K. Sethi, M. P. Udawat, S. C. Kasliwal and R. Chandra, "Vulcanized rubber foot for lower limb amputees", Prosthetics and orthotics international, 1978, 2, 125-136.

[16] P.K.Tomaszewskia, M.Van Diesta, S.K.Bulstrab, N.Verdonschotcd, G.J.Verkerkead

[17] "Numerical analysis of an osseointegrated prosthesis fixation with reduced bone failure risk and periprosthetic bone loss", Journal of Biomechanics, Volume 45, Issue 11, 26 July 2012, pp 1875-1880

[18] Tejbinder Singh, "Simulation of a Low Cost Powered Ankle-Foot Prosthesis during Stair Ascent and Descent Gaits". International journal for science and research, India, Volume 5, Febraury 2016.

[19] Virgil Faulkner, C.P.O.Martha Field, M.S, John W. Egan, M.S, Norman G. Gall, M.D, "Evaluation of High Strength Materials for Prostheses", Orthotics and prosthetics, Vol 40, pp 44-58.