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Reducing Cost of Walking with Fused Deposition Modelling Rendering Point Cloud Data

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***Abstract*: In the present work, FDM technique has been used over the traditional plaster moulding technique. ABS polymer was used in the fabrication of the AFO. The main focus has been done on finding an easy method to fabricate AFO. A healthy subject of 24 years of age was taken and his lower limb was scanned.**

Custom AFO 's are traditionally manufactured using plaster moulding that requires multiple patient visits and extensive labour and production time. Fused deposition modelling (FDM) technique has been used in the present work to produce the AFO, which helps with custom fitting, reduces costs, has good strength bearing properties and requires fewer patient visits. Analysis of the parameters and their impact on the time and cost of production of AFO was conducted.

A layer height of 0.2mm was used with an infill density of 25% and with a speed of 50mm/sec of nozzle was used. The cost of the AFO using ABS came out to be 271.625 Indian rupees which is way less than 600-100 Indian Rupess used in traditional plaster moulding technique.

***Keywords* : Fused deposition modelling, finite element analysis (FEA), scanned data, 3D printing**

I. INTRODUCTION

Fused deposition modelling (FDM), sometimes also called filament freeform fabrication, is a 3D printing process that uses a continuous filament of a thermoplastic material[1]. Filament is fed from a large coil through a moving, heated printer extruder head, and is deposited on the growing work. The print head is moved under computer control to define the printed shape. Usually the head moves in two dimensions to deposit one horizontal plane, or layer, at a time; the work or the print head is then moved vertically by a small amount to begin a new layer. The speed of the extruder head may also be controlled to stop and start deposition and form an interrupted plane without stringing or dribbling between sections. Fused deposition modelling is now the most popular process. Although other processes like photo polymerisation and powder sintering can be used but they are much costly. Fused deposition modelling uses wide variety of polymers including acrylonitrile butadiene styrene (ABS), polylactic acid (PLA), Carbon fibre, nylon and even blends of polymers.3D printing, also referred to as additive manufacturing (AM), involves manufacturing a part by depositing material layer by layer [2]. Now Ankle-foot orthoses (AFO 'S) are instruments that are used to enhance the gait performance of people with neuromuscular and musculoskeletal impairments such as stroke, multiple sclerosis, cerebral palsy and others [3]. There are two kinds of AFOs passive and active AFOs. Plaster casting is the traditional approach of producing AFOs [4]. In this method A 'negative' cast will be taken of the leg/s as required by rolling plaster bandage around the leg, waiting until it sets (3-6 minutes), and taking it off again. From this cast the AFOs will be made. The production process takes 3-4 weeks until the AFOs are ready to fit. Recently, as alternative to the plaster casting approach, Additive manufacturing was introduced [5]. Khaled A. Olama et al. [6] published a study on the role of three side supporting ankle-foot orthoses in enhancing the balance of spastic diplegic cerebral palsy among infants. The results were that rigid AFOs could improve the efficiency of the gait. AFO's are the best orthoses for gait enhancement as they compensate for muscle weakness around the affected foot and improve peripheral stability. AFOs seem to have positive effects on the alignment of the hip, knee, and foot[7].AM method has the ability to result in increased customization and reproducibility. AM proponents claim that these approaches can improve production times, reduce waste, decreases costs, and improve performance of AFO. In this paper we will compare plaster moulding and Fused deposition modelling and prove that FDM is more effective than plaster moulding by creating a model first onSolidWorks and will use ABS and will then analyse various parameters.

II. OBJECTIVES

The primary objective of the paper is to present a method using fused deposition modelling which is cheaper than plaster moulding technique. Specifically, the aim of the research is to prove that fused deposition modelling technique is less costly, takes less time and labour and the design can be manipulated before actual fabrication. Secondarily to check various parameters of Fused deposition modelling.

III. METHODOLOGY

In the subsequent study following steps were taken (A) Obtaining the subjects 3D scan (B) Taking measurements from the scan (C) making solid model in SolidWorks© (D) checking various parameters on ANSYS© (E) Analysis on Cura and Fabrication of the AFO.

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A. Obtaining the Subjects 3d Scan

Obtaining a 3D model with the CAD software is difficult as an AFO model does not have a fixed geometry or they have a freeform geometry. Nevertheless, scanning technology provides a full 3D AFO model for study in a Finite Element Analysis (FEA) program. This technology generally converts the data into a point cloud data which is triangular in nature. This data then can be converted into a meshed surface which then can be converted into a solid CAD model. For this task we will useMeshmixer© software to take the measurements of the subject's lower limb as these will be more accurate then taken physically as the chances of the human error will be nil.In present work, a healthy subject of 24 years of age was taken for the 3D scan performed using 3D sense® device. (fig 1(a)) and mesh model was developed using the same (fig 1(b)) software. The subject's right foot scan was taken and the mesh file was generated.

(a) 3D Sense® device **(b) Generated mesh model**

Figure 1 Generation of mesh model through scanned data

IV. PREPARE YOUR PAPER BEFORE STYLING

B. Taking measurements from the scan

The measurements can be taken manually but the chances of human error increases. For making a customized AFO accuracy is must. Therefore, use of Meshmixer© was done. It is a good software for performing variety of tasks on STL files like smoothening, joining of two or more STL files, cutting and joining, taking measurements of STL files and various other tasks.

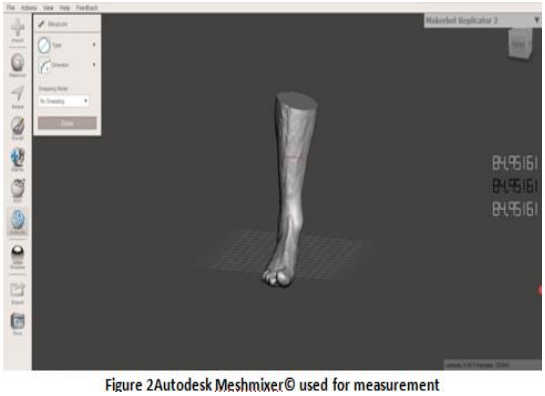

Figure 2Autodesk Meshmixer© used for measurement

C. Making solid model in SolidWorks©

After taking measurements from the Autodesk Meshmixer© the model was created on SolidWorks© as it will give more accurate dimensions and the problem of the freeform geometry will also be solved. In the software eight planes were taken to replicate the geometry of the leg. The using the loft command the planes were joined together to form a model of the AFO. The model obtained had a curved geometry from inside also so that after fabrication it is easy to wear the AFO for the patient. Also due to less curvatures on the surface it will be easy for the 3D printing machine to fabricate the AFO in less time.

Figure 3. Model of the AFO obtained in solidworks©

D. Checking various parameters on ANSYS© and Cura©

The Solid model so obtained was then tested on ANSYS 19.2© for force analysis. A force of 50N/mm was applied on the posterior calf enclosure. Assigning ABS as the material and taking base A as fixed part. The Finite element analysis (FEA) was carried using static structural.

D.1 Total Deformation Obtained

During FEA a maximum deformation of 4.3404mm was obtained using ABS as material which shows that the AFO obtained will be not to flexible nor to rigid and will support the lower leg with ease.

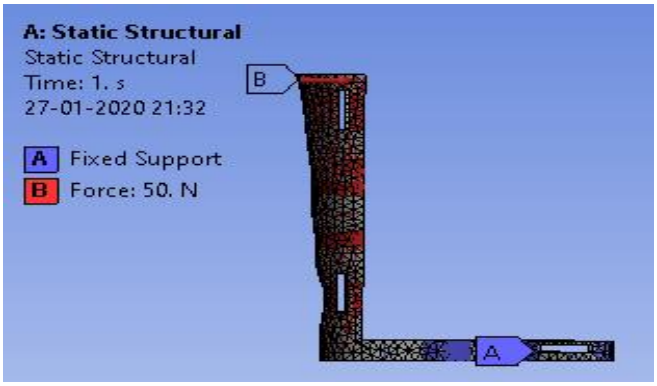

Figure 4 Applying force of 50N/mm on posteriorcalf of lower

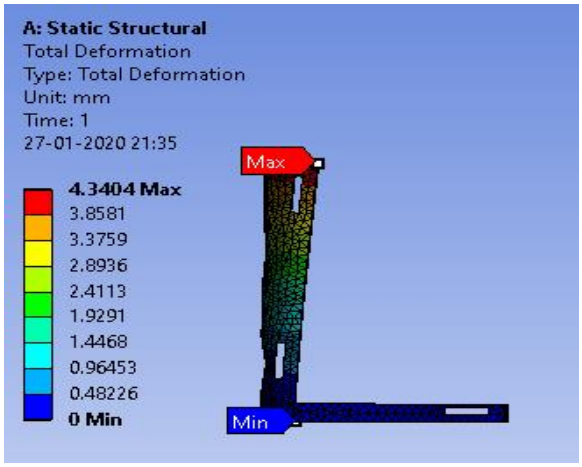

Figure 5 Total deformation obtained

D.2 Equivalent elastic strain

On applying a force of 50n/mm on the posterior calf a maximum elastic strain of 0.0052061mm/mm and a minimum of 1.4786e-17mm/mm of elastic strain was obtained. Which is good for manufacturing of AFO.

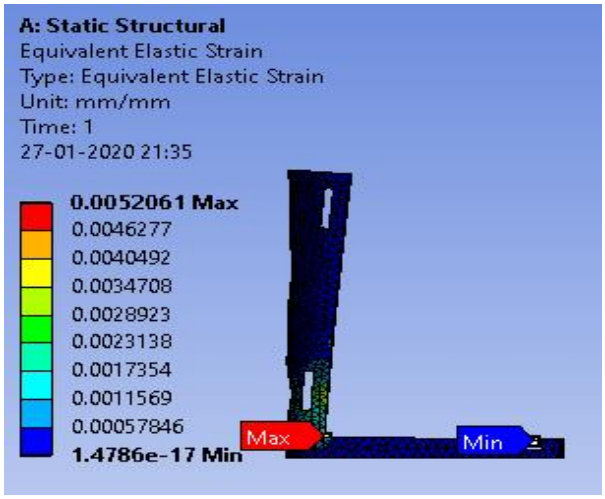

Figure 6 . Equivalent elastic strain

D.3 Equivalent stress obtained

On applying a force of 50N/mm on the posterior calf a maximum equivalent stress of 8.8936MPa was obtained and a minimum stress of 3.5242e-14MPa was obtained.

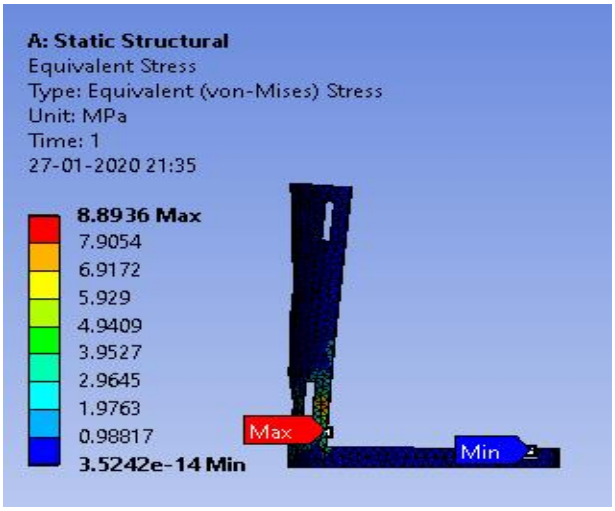

Figure 7 Equivalent stress obtained

D.4. Factor of safety

It is defined as how much stronger a system is than it needs to be for an intended load. In this case a factor of safety of 4.6551 was obtained.

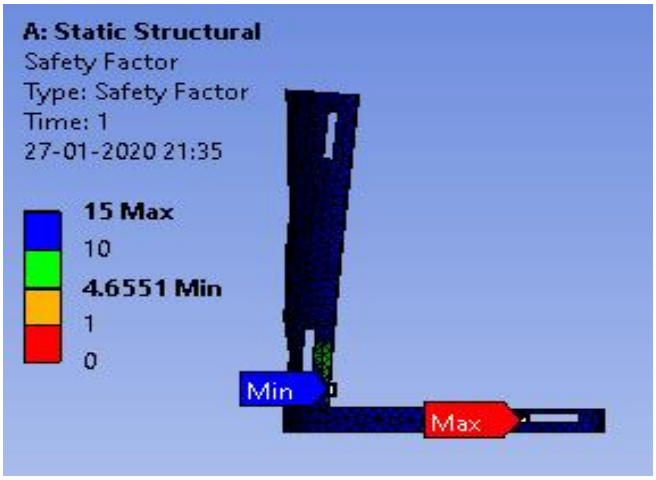

Figure 8 Factor of saftey

E. Analysis on Cura©

For analysis for the fabrication of AFO cura©19.1 was used. Layer height of 0.2mm was used with a speed of 50mm/sec of the nozzle with temperature of 210°C was used. Following results were obtained.

- Time of 1 day 10 hours and 42 minutes were obtained for manufacturing of the AFO.
- 265gm material was used in the production of AFO.

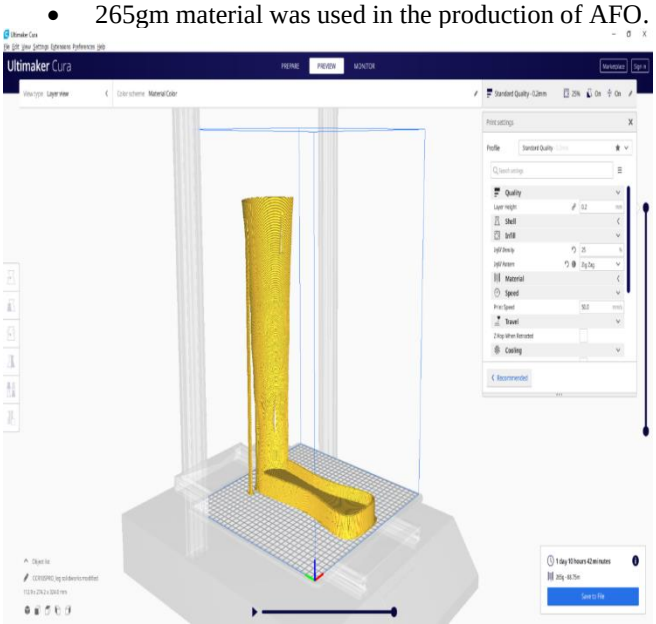

Figure 9 Analysis on cura©

E.1 Fabricated AFO

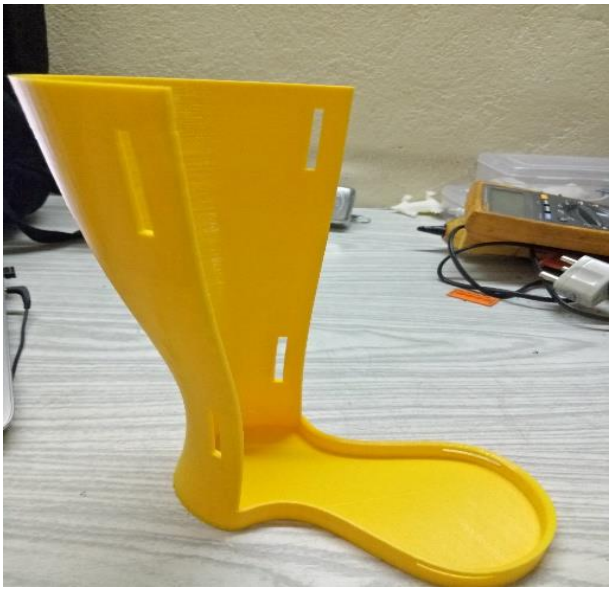

Figure 10 Fabricated AFO

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IV. RESULT AND DISCUSSION

Using the present framework, it is quite easy to manufacture AFO as compared to the traditional plaster moulding technique as discussed in the paper. Also, the time taken by the FDM technique reduces which in turn reduces the labour cost. The cost of fabrication came out to be 271.625 Indian Rupees which is way less than traditional method which is 600-1000 Indian Rupees.

V. CONCLUSION AND FUTURE SCOPE

In this paper mechanical properties of ABS are studided using ANSYS along with a method to easily fabricate AFO which will save both time and labor and is going to be very helpful technique in the long run. As most of the part is covered in the present paper, polymer blends can be used in the design and manufacture of AFO. Fatigue analysis of AFO may be conducted for more detailed results.

REFERENCES

1. Hamzah, Hairul Hisham; Saiful, Arifin Shafiee; Aya, Abdalla; Patel, Bhavik Anil (2018). "3D printable conductive materials for the fabrication of electrochemical sensors: A mini review". Electrochemistry Communications. **96**: 27–371. doi:10.1016/j.elecom.2018.09.006.
2. Gibson, I; Rosen, D W; Stucker, B (2010). Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing. Boston, MA: Springer. ISBN 9781441911193.
3. Telfer S, Pallari J, Munguia J, Dalgarno K, McGeough M, Woodburn J. Embracing additive manufacture: implications for foot and ankle orthosis design. BMC musculoskeletal disorders 2012; 13: 84
4. International Committee of the Red Cross's Physical Rehabilitation Program. Manufacturing Guidelines: Ankle Foot Orthosis; 2010.
5. Faustini, M. C., Neptune, R. R., Crawford, R. H., & Stanhope, S. J. (2008). Manufacture of Passive Dynamic Ankle–Foot Orthoses Using Selective Laser Sintering. IEEE Transactions on Biomedical Engineering, 55(2), 784–790. https://doi.org/10.1109/TBME.2007.912638
6. Olama, K. A., El-Din, S. M. N., & Ibrahem, M. B. (2013). Role of three side support ankle-foot orthosis in improving the balance in children with spastic diplegic cerebral pals.
7. Guerra Padilla, M., Molina Rueda, F., & Alguacil Diego, I. M. (2014). Effect of ankle-foot orthosis on postural control after stroke: A systematic review. Neurología (English Edition), 29(7), 423–432. https://doi.org/10.1016/J.NRLENG.2011.10.014.

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