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FABRICATION AND ANALYSIS OF HUMAN PROSTHETIC TEETH BY USING 3D PRINTING MACHINE FOR MEDICAL ASSISTANCE

S.BASHEER AHAMED[1], R.VISHNUVARDHAN REDDY[2]

[1]*M.tech student, Department of Mechanical Engineering*
JNTUA College of Engineering, Pulivendula, Andhra Pradesh, India.

[2] *Assistant Professor(Adhoc), Department of Mechanical Engineering*
JNTUA College of Engineering, Pulivendula, Andhra Pradesh, India.

Abstract— ***Now a days, many people are suffering with teeth problems. It is due to increase in cavities of the teeth. These cavities may eat the teeth and gums in the mandible. Cavities may leads to breaking of teeth. This partial dentures and effected teeth may create brutal problems to the patients. While having accidents there is a chance to breaking of teeth and may leads to severe problem to the patients. In order to decrease these problems doctors choose to replace original teeth with artificial teeth. In recent methods these artificial teeth is made up of chromium and zirconium materials, by using these types of materials it may cause high cost and time taking process for manufacturing artificial teeth. To reduce these factors a new innovative 3D printing technology is used to prepare artificial teeth.***

In this work an attempt has been made to manufacture artificial teeth by 3D printing technique using PLA material. By using this PLA material prototype model should be printed to give demonstration for medical students and improve the awareness of the patients. At first MRI scan/CT scan digital images of human teeth are taken and these images are converted to .STL (Standard tessellation language) file using 3D Slicer software. The required components were designed using the Modeling software (SolidWorks). These components are converted into .STL file. These components are printed by using 3D printing machine with PLA material. This is mainly used for medical guidance purpose.

Keywords— Human teeth, 3D Printing machine. 3D Slicer Software, Solid works Software, Ansys software

I. INTRODUCTION

Additive Manufacturing is a process of joining materials to make objects from 3D model data, usually layer upon layer. The basic principle of this technology is that a model, initially generated using a 3D CAD model, can be fabricated directly without the need for process planning. Now a day's RP plays an important role in manufacturing sector, to decrease the cost and time of the product to be manufactured.

3D printing is additive manufacturing process.. From here on the printing methodology varies by development, starting from work zone printers that disintegrate a plastic material and lay it down onto a print stage to broad present day machines that use a laser to specifically condense metal powder at high temperatures.

II. LITERATURE SURVEY

[1] **Dr. Mostafa Omran Hussein et al.** made an attempt on partial dentures. In this experiment they select the partially endulous stone cast to indicating mandibular kennedy class I. The cast was scanned by using desktop scanners to generate 3D model. The 3D model is converted into .STL file and then imported into universal reverse engineering software. The cast was digitally surveyed to selected path of insertation. The frame work volume then created by thickening the shell surface followed by smoothening. Finally the frame work was fine tuned using sculpt tool. The final frame work 3D model was generated layer by layer using the 3D printer machine. The final frame work was checked for the errors and fitness. Finally they conclude that RP technique for RPD framework manufacturing becomes a popular successful alternative to the conventional technique.

[2]. **YU-AN JIN et al.** made an attempt to protect limb. In this study the custom foot orthoses (FO) ankle. Foot orthoses and prosthetic socket is review and compare to the conventional plaster molding manufacture techniques. A study was first conducted at the university of Michigan orthoses and prosthetics center to study the quantity of prosthetics. The current manufacturing process at umopc and a clear re-examine of the plan and AM research of these 3 types of orthoses and prostheses in the last 25 years are investigated. Finally they conclude the AM technology had capable to manufacture FO'S,AFO'S and prosthetic sockets with fine fit and sufficient strength.

III. PROBLEM STATEMENT

Teeth are the mostly usable part in the human body. The function of the teeth plays a very important role in eating a food. Due to improper cleaning of teeth, bacteria forms in between the teeth and the mandible, it may leads to generation of cavities. These cavities may eat the teeth and gums in the mandible. Cavities may leads to breaking of teeth. This partial dentures and affected teeth may creates a brutal problems to the patients whenever they consume cool drinks and sweets. While having accidents the breaking of teeth may occur and leads to severe problem to the patients. In order to reduce these problems doctors choose to replace the original teeth with artificial teeth.

Some common dental problems which have seen in patients are Tooth Decay, Oral Cancer, Mouth Sores, Tooth Erosion, Tooth sensitivity and Toothaches. These problems also leads to inconvenient in patients due to these also doctors replace the original teeth with artificial teeth.

Fig: 1 Tooth decay Problem

Fig: 2 oral cancer

Iv. PROBLEM SOLUTION

Additive Manufacturing is the process in which material will lay up layer by layer to produce the required part. Additive Manufacturing is also called as 3D printing. 3D printing is aid for prototyping industry. 3D printing has new and growing specialized social and monetary effect especially in prototyping. 3D printing permits mass customization in industries like car, health care's aviation, training, customized blessings and shopper parts. Prototyping is the main one which utilizes 3D printing. 3D printing machines produces physical items layer by layer to fabricate the required 3D model. It can make physical model as per structure, model might be made in Modeling software's CATIA, PRO-E, SOLIDWORKS, AUTOCAD and so on. 3D model is converted into .STL format. As indicated by the .STL file 3D printing machine going to print the part.

V.EXPERMENTAL PROCEDURE

A. 3D SLICER:

3D slicer is a free and open source software package. It is a modular platform for image visualization and analysis. 3D Slicer can be extended to enable development of both interactive and batch processing tools for a variety of applications. 3D slicer plays an important role in medical sector; particularly in orthopaedic and identify the cracks and defects in the bones. 3D slicer is very useful for the doctors to perform surgery and reduces the operation time.

1) 3D Slicer Work bench:

- The DICOM data is imported in to 3D slicer software by using FILE – IMORT – DICOM – OK.
- Importing the DICOM file in to 3D slicer software the 2D views are displayed.

2) Volume rendering :

- In first step the 2D digital data can be converted in to 3D data by clicking volume rendering. 3D data is visible on the right side of the screen.
- click on present option and again selected CT MIP then the bones are displayed in 3D view.

3) Crop volume :

- In part of this work separate the human mandible and teeth by clicking on crop icon on that again Select display ROI icon.

4) Creating label and building model :

- After cropping is done labels should be generated by using the editor tool to create 3D model. The 3D model should be saved in a.STL (Standard Tessellation) format.

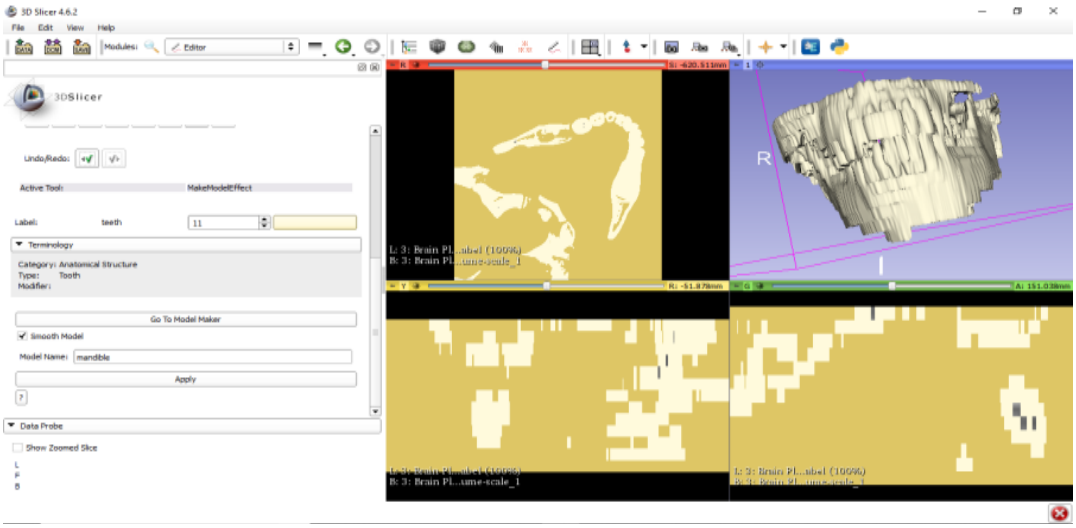


Fig 3: Loading and saving condition in 3D slicer software.

B. SOLIDWORKS:

Solid Works is 3D solid modeling software which allows users to develop full solid models in a simulated environment for both design and analysis. In Solid Works, sketch ideas and experiment with different designs to create 3D models. Solid Works is used by students, designers, engineers, and other professionals to produce simple and complex parts, assemblies, and drawings. Solid Works is published by Dassault Systems.

1) SolidWorks – Let's Begin:

- By default, no file is opened automatically when you open the software.
- To create a new file, click on File > New or click the New File icon in the main toolbar.
- Let's begin by creating a required part. To do this, click on Part, then Ok.
- Once part is created a new modeling view is appeared which contains several toolbars.
- Using these toolbars perform the required operations to gain exact shape and size.

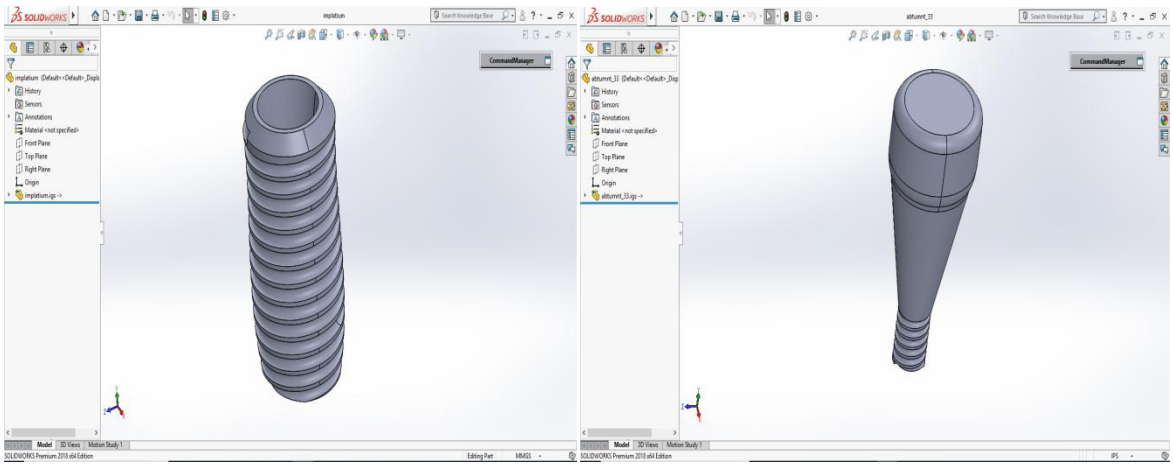


Fig: 4 Modeling of Human teeth Implant and Abutment

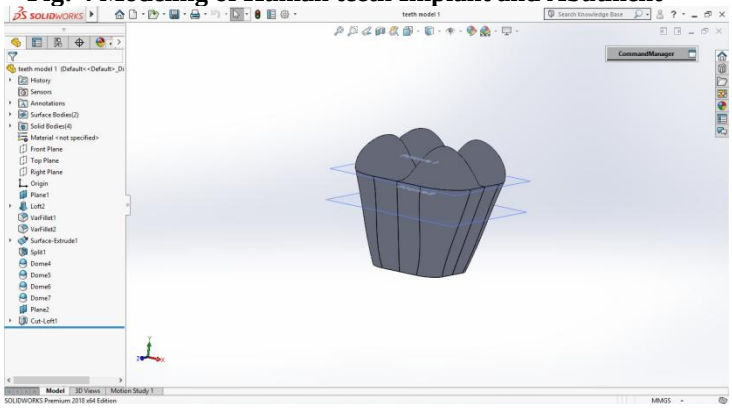


Fig: 5 Modeling of Human teeth.

- The 3D model should be saved in a .STL (Standard Tessellation) format.

C. 3D PRINTING:

3D printing is a Additive manufacturing process. In which 3D model is fabricated by adding material layer by layer. It plays a very vital role in the medical industry mostly in orthodonatics, bone replacements and other surgeries. It reduce the operation cost and time. Complex geometric shapes also fabricated within a short period.

- Load the .STL file in the fracktory software.
- Provide the required specifications to print the model.
- Save the data in the external device and load in 3D printing machine.
- Print the model by giving PLA filament properties.

1) Printing conditions of PLA filament in FDM machine:

The printing conditions for the imported .STL files on 3D printing machine for PLA material is as follows.

PROPERTIES	PRINTING CONDITIONS
Layer height	0.1mm
Top/bottom thickness	1.2mm
Shell thickness	1.2mm
Nozzle temperature	215^0c
Bed temperature	60^0c
Fill density	80%
Filament flow	100%

Table 1: Printing conditions for PLA material

- The saved .STL files are loaded into fracktory workbench as shown in below figure.

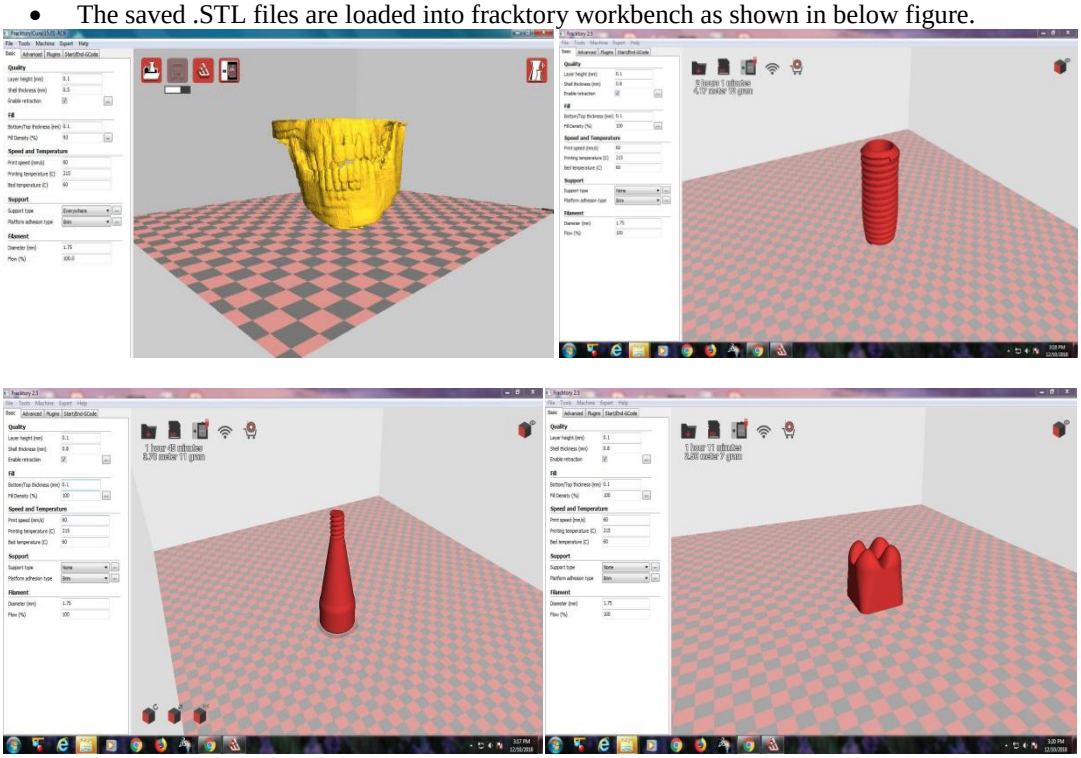


Fig 6: Loading condition on fracktory work bench.

- Then adjust the printing conditions for PLA material mentioned in the table.
- Artificial Teeth implants are printed with PLA material.
-

Fig 7: Final 3D printed components

VI. NON-LINEAR ANALYSIS

A nonlinear analysis is an assessment where a nonlinear relation holds between applied forces and displacements. Nonlinear impacts can begin from geometrical nonlinearity's (i.e. extensive disfigurements), material nonlinearity's (i.e. elasto-plastic material), and contact. These impacts result in a stiffness matrix which isn't steady during the load application. This is against the linear static analysis, where the stiffness matrix stayed steady. Thus, an alternate illuminating system is required for the nonlinear examination and along these lines an alternate solver.

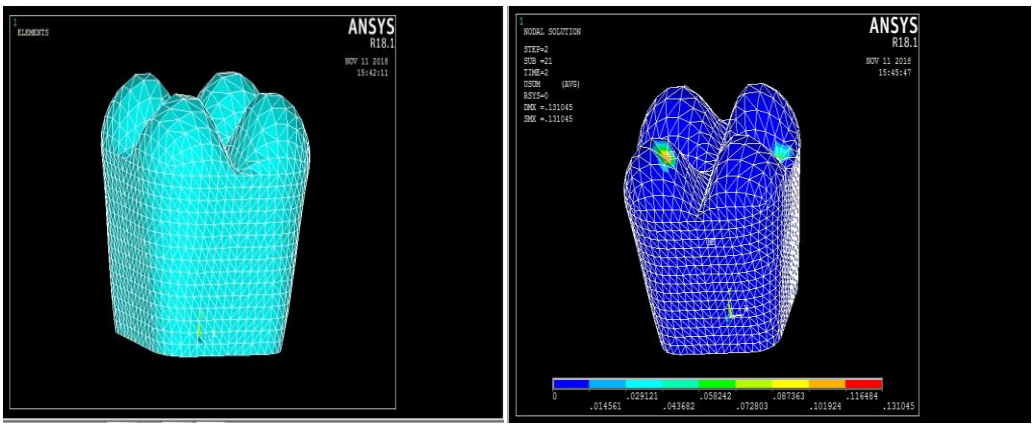
1) PROCEDURE FOR NON-LINEAR ANALYSIS:

- First import the teeth solid model in the working platform of ANSYS.
- Select the element type in that select solid 187.
- Give the required material properties of PLA.

DENSITY	1.2-1.4 $g.cm^{-3}$
TEMPERATURE	$190\text{-}215^{0c}$
YOUNG'S MODULUS	2.7-16Mpa
POISSON'S RATIO	0.5

Table 2: Properties of PLA material

- Generate the 3D mesh by using meshing.
- After meshing the load is applied on the solid part.
- After loading we have to go to solutions.
- Finally go to results.



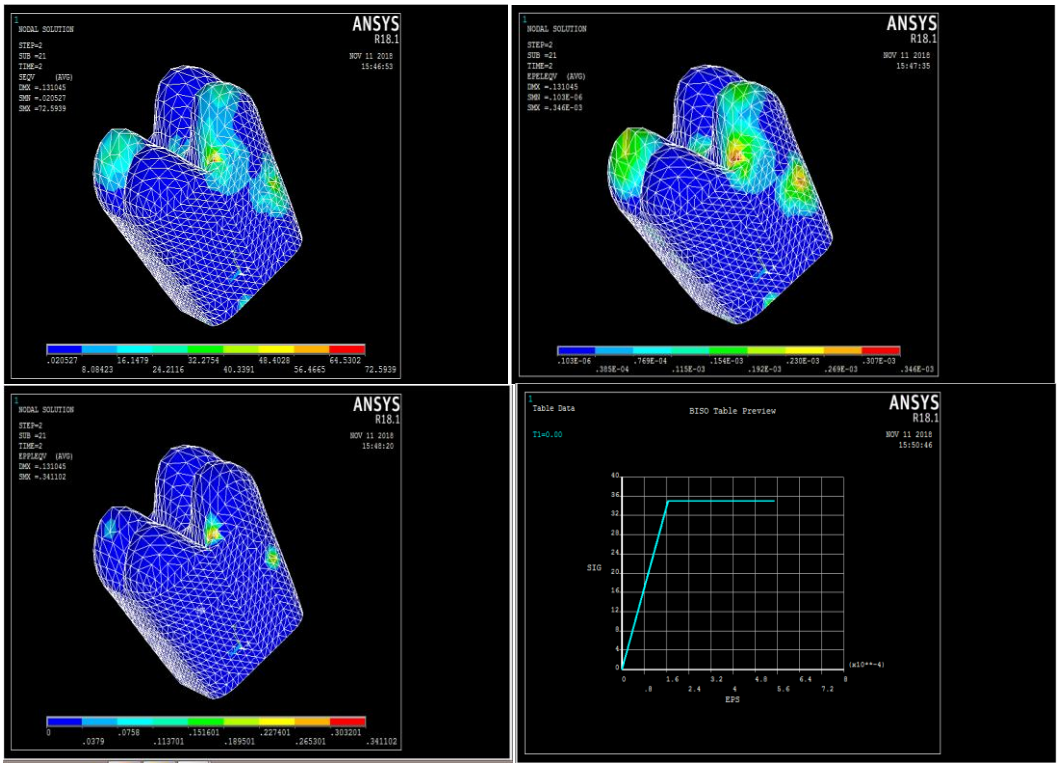


Fig 8: Loading and solutions of non-linear analysis

VII. RESULT AND DISCUSSIONS

In this work an attempt has been made to manufacture artificial Human teeth by 3D printing technique. CT/MRI scan digital images of human skull are taken and these images are converted to 3D printing language using 3D Slicer. Design the implant, abutment, teeth by using Solid Works software. The artificial teeth implant is printed by 3D printing machine through PLA filament. The 3D printed teeth implant is used mainly for medical demonstration. Artificial teeth implant with ceramics and zirconium materials can be manufactured traditional method as per the dimensions requires more cost and time required. By doing these the ordering cost as well as processing time can be reduced. And Compare the total strain of a PLA with percentage elongation of plastic.
The Result is as follows

MATERIAL	% ELONGATION
PLASTIC	5%
PLA	1%

VIII. CONCLUSIONS

In this work an attempt has been made to fabricate artificial Human Tooth Implant by 3D printing technique. 3D printing offers the original prospective to fabricate organized tissue constructs. CT scan digital images of Human skull are taken and these images are converted to 3D printing language using 3D Slicer, and Solid Works software's. The Human Tooth is printed by 3D printing machine through PLA filament. This prototype model is used to give demonstration for medical students and improve the awareness of the patients. It may reduce the total cost and time to manufacture artificial teeth.

By doing nonlinear analysis, conclude that the Total strain is less than allowable limit of percentage of elongation of the PLA material.

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