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FEA approach of Dental restorative material under Structural and Thermal loads

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Abstract

Dental restorative material are widely used in the treatment of cavities which are formed in Dental tooth. 3 different types of restorative material viz. Amalgam, gold alloy and composites are used in the present study. 3D model of mandibular premolar is created using Solidworks with a cavity in it, the cavity is filled with different restorative material and the model is later tested under different combinations of thermal and structural loads in ANSYS.

Keywords: *Dental tooth, restorative material, 3D model, ANSYS*

1. Introduction

Finite element analysis (FEA) is a numerical method of analyzing stresses and deformations in structures which originated from the need for solving complex structural problems in mechanical, civil and aeronautical engineering. In the area of dentistry, FEA has been used to simulate the bone remodeling process, to study internal stresses in teeth and different dental materials, and to optimize the shape of restorations.
Of the different filling\restorative material commonly used are, Amalgam, Gold alloy and composite.

Fig.1 Amalgam filling on a molar tooth

Once a tooth gets carries, then it is treated for the carries infection and the infected area is cleaned, later it is filled by the filling material. The filling material thus becomes a part of the tooth. Over a period of time, the filling material along with the tooth gets exposed to continuous thermal and structural loads, thus changing its dimensions. The filling material should be such to minimize this linear\lateral expansion under both thermal and structural load.

2. Research approach

2.1 Planning:-

Since a dental tooth is under a combination of thermal and structural load which arises due to eating hard material or eating\drinking hot or cold material. So the FEA analysis should also focus both on thermal and structural load.

Generally, tooth geometry has a complex shape, thus; creating an accurate and true shape of the model is wearisome and time consuming. Therefore, an approximate model can be created by using available technologies and the method of Reverse Engineering. The extracted tooth which was reserved for clinical purposes was scanned using a Computer Tomography (CT) scan machine. The scanning takes place in different directions at different angles in order to obtain more accurate shape. The scanned image which was obtained as .DICOM file was converted to 3D model. It is also possible to create the 3D model by using a white light scanner. But creating the model using CT scan machine yields the most accurate result. The scanned image was in DICOM format which was converted to *.sldprt* which is a 3D model format in Solidworks.

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Fig.2 3D Model of the Geometry

3 Design of Experiments

The maximum biting force decreases from the molar to the incisor region, and the average biting force on the first and second molar is about 580N[*]. The maximum and minimum mouth temperatures recorded show that hot fluids can raise the intra-oral temperature of the front teeth to around 70 degrees Celsius and the consumption of iced drinks lowers the same teeth to around 0 degrees Celsius[*].For this purpose, four temperatures, ranges from of 0 to 60 degree Celsius at an interval of 20 degree Celsius was selected. Thus; a total of 48 numbers of experiments should be run (i.e. 3 materials, 4 structural forces and 4 temperatures).For minimizing the trial of runs, Design Expert software was used under the method of Taguchi which gave number of run of experiments as 35[See appendix].

4. Results

For each combination of thermal and structural loading, the problem was solved and the resulting mechanical response(Deformation and Von mises stress) were recorded which were obtained from the analysis done under Ansys for a given combination of Structural and Thermal load.Some of the results obtained are shown:-

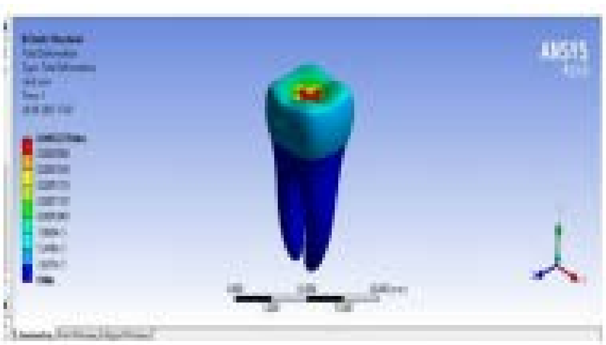

Fig. 3 Deformation analysis of Amalgam at 0 degree Celsius and 80 N

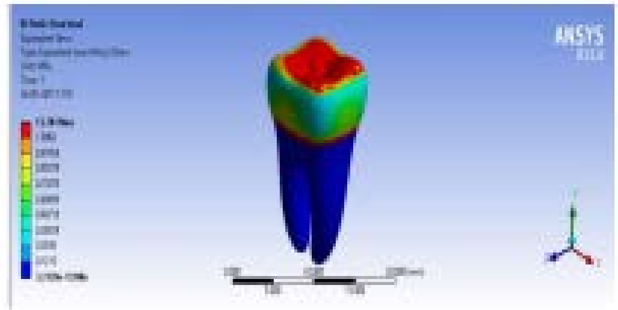

Fig. 4 stress analysis of Amalgam at 0 degree Celsius and 80 N

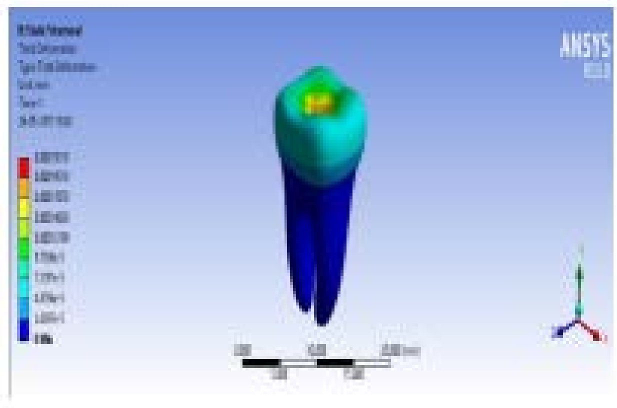

Fig. 5 Deformation analysis for Gold alloy at 0 degree Celsius and 80 N

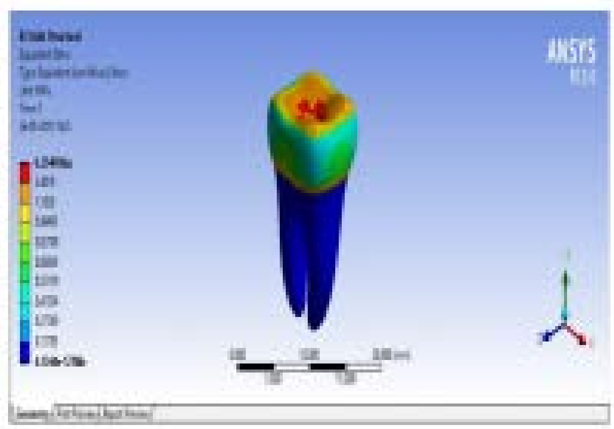

Fig 6.Stress analysis for Gold alloy at 0 degree Celsius and 80N

Plots were also made using qtiplot software for all the filling materials which shows the variation in the Von-mises stress and maximum deformation.

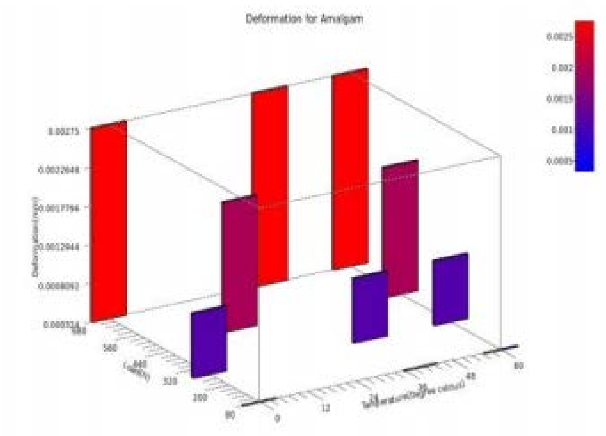

Fig.7 3D graph of Amalgam deformation

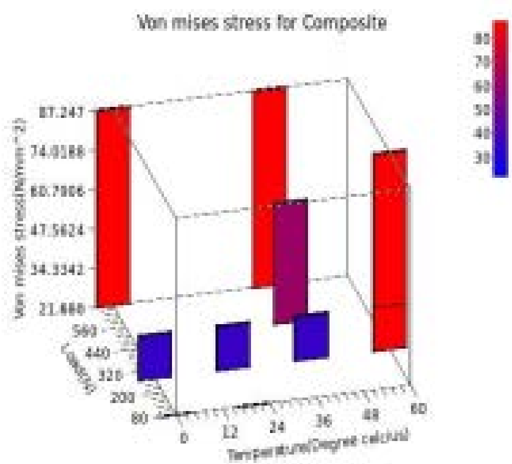

Fig. 8 3D graph of Von –Mises stress for Gold alloy

4. Result discussions and Conclusions

The results obtained from ANSYS analysis above showed that, the maximum deformation occurred at the occlusal surface, specifically on the filling material and increases towards the other four surfaces (mesial, buccal, lingual and distal surfaces) and the roots, while the equivalent (Von-Mises) stress was depicted along the cervical line (a border line between crown and roots) and distributed towards both the crown and the roots. The result also shows that, the increase in the deformation and stress concentration values was contributed by the increase in the structural loads but independent of the thermal loads (temperature between 0 to 60 degree Celsius) used in this work. The non-variation of the result with respect to temperature might be due to the fact that; the of temperature range considered, is much- much less than the melting temperature of all the material used as the filling material.

5. Future scope

Future work in this research can be taken by taking the anisotropic consideration for the tooth material and also by taking the transient analysis for a prolonged thermal and structural load.

References

[1] Ash M.M and Nelson S.J, 2003, Wheelers' Dental anatomy, physiology and occlusion, sounders publishers, eight editions, page 18.

[2] Barclay C,W., Spence D. and Laird W.R.E; Journal of Oral Rehabilitation, 2005; 52(886)

[3] Berlin M, 2003, Mercury in dental-filling materials- an updated risk in environmental medical term, The Dental materials Commission- care and consideration, pp 24-33

[4] Ehsani S., Sadat F.M., Asgarry S.; Finite Element Reconstruction of Mandibular First Molar, Iranian Endodontic Journal (2003); 8(2) pp. 44-47

[5] Kao H., Chung W., Chen F., Hsu M., and Chang K.; Finite Element analysis of different superstructure materials in a single distal implant restoration, J Dent Sci. (2008) vol.3 no.3 pp. 140-149

[6] Kenneth, J.A, 2003, Phillip's science of Dental materials, Elsevier publishers, Eleventh edition, page 3-14

[7]Robert G.C, john M.P, and John C.W, 2004, Dental materials, properties and manipulation, Mosby Inc., eight editions, page 14-31

[8] Sampath K.P, 2004, Dental anatomy and tooth morphology, Jaypeebrothers'publishers (p) ltd- Delhi, page 35-40

[9] http://en.wikipedia.org/wiki/Mandibular_first_molaraccess on 15/01/2015