Scientific Journal Impact Factor (SJIF): 5.278
International Journal of Modern Trends in Engineering and Research
ISSN (ONLINE) : 2349 - 9745 ISSN (PRINT) : 2393 - 8161

DESIGN AND ANALYSIS OF EXCAVATOR BUCKET TOOTH

Y Madhu Maheswara Reddy[1] and Dr. P Shailesh*[2]
[1,2]Mechanical Engineering, Methodist College of Engg. & Tech

Abstract— Proliferate growth of industry of earth moving machines is assured through the high performance mining and construction machineries with complex mechanism and automation of construction activity. During the excavation operation unknown resistive forces offered by the terrain to the bucket. Excessive amount of these forces adversely affected on the machine parts and may be failed during excavation operation. A better tool design in the excavation process has been always a challenging task for the engineers. A poorly designed tool always results in poor excavation of the ground, higher wear of the tool, wastage of the time, and power. It has been observed that the existing bucket tooth material of backhoe excavator gives the satisfactory results. Also it has been found that deformation and stresses values are safe. In order to increase the life of backhoe excavator bucket tooth other two materials i.e. HSS and HCHCr has been analyzed for the similar force and boundary conditions. 3D model was prepared in Solidworks and software in FEM domain was utilized for analyzing the model or excavator bucket tooth behavior. Computational approach will give the results more close to practical values through simulation. CAE can drastically reduce the costs associated with the product lifecycle.

Keywords—Excavation, 3D Model, Bucket Tooth, Tooth Material, Construction, Design.

I. INTRODUCTION

In the era of globalization and tough competition the use of machines is increasing for the earth moving works, considerable attention has been focused on design of the earth moving equipment's. Today hydraulic excavators are widely used in construction, mining, excavation and forestry applications. The excavator mechanism must work reliably under unpredictable working conditions. Poor strength properties of the excavator parts like boom, arm, bucket and tooth limit the life of the excavator. Therefore, excavator parts must be strong enough to cope with caustic working conditions of excavator.

An excavator bucket is an attachment for heavy equipment which is designed to be used to be used in site excavation. Excavator buckets are made of solid steel and present tooth protruding from the cutting edge, to disrupt hard material and avoid wear and tear of the bucket.

The excavator bucket tooth have to bear heavy loads of materials like wet soil and rock and also subjected to abrasion wear due to the abrasive nature of soil particles when tooth acting to break up material generally alloy steel is used to make an excavator tooth and hard facing of some wear resistant material can be applied on the material of bucket tooth, so that its life will improve against abrasive wear.

Bhavashkumar and J.M.Prajapatihas [1] studied the mini hydraulic backhoeexcavator attachment is developed to perform excavation task for light duty construction work. Juber Hussioainqureshi and Manish Sagar [2] described its basic structure, stress characteristics and the engineering finite element modeling for analyzing, testing and validation of backhoe loader parts under high stress zones

Figure 1: Teeth's with excavator bucket

Nowadays, an excavator tooth has to be replaced after approximately a working week, causing an elevated cost which represents an important economic factor in the mining industry. Design engineers have great challenge to provide the better robust design of excavator bucket parts which can work against unpredicted forces and under worst working condition. Software in FEM domain was utilized for analyzing the model or excavator bucket tooth behavior with various materials namely AISI 1040, HSS and HCHCr. Computational approach will give the results more close to practical values through simulation. CAE can dramatically reduce the costs associated with the product lifecycle

II. PROBLEM DEFINITION

This digging task is repetitive in nature and during the operation the entire link mechanism working under the dynamic forces the backhoe mechanism may fail. Higher damage rates lead to higher maintenance downtime (lower machine availability) which subtracts from the net capacity of the machine to produce. The excavator mechanism must work reliably under the unpredictable working conditions. Therefore it is challenging job to design such an excavator which can work under unpredictable working environment and also prolong all kind of forces without any kind of failure. In this work, emphasis was laid on the bucket tooth which come first contact with soil for its contact deformation as well as the stress generation in it for doing various types of operations at various sites. So to find the solution this analysis is done. Finite element analysis (FEA) is the most powerful technique and is used in the strength calculations of the structures working under known loads and boundary conditions.

Figure 2: Failure in tooth due to impact loading and abrasion wear

III. METHODOLOGY

Based on the literature survey it was found that the research work which was carried out with AISI 1040, HCHCr, HSS materials is very much scanty. An attempt was made on three different materials AISI1040, HCHCr and HSS, a better tool design in the excavation process is always challenging task for the engineers. Strength of the tool depends on material used, to know the best material for the tooth design this analysis. AISI 1040 is the standard material for making of excavator tooth and tooth adopter, by using this analysis I compared the results of HSS and HCHCr with AISI 1040 with the help of Ansys workbench 14.5 and the cad model is prepared in solid works and model was imported into Ansys workbench with IGES file format.

3.1. Bucket Tooth Development

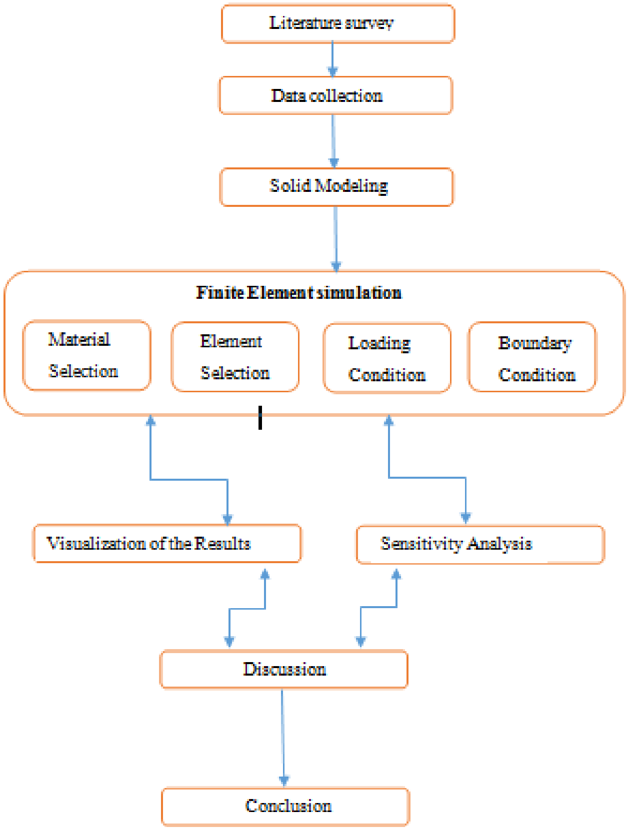


Figure 3: Process involved in Development of Bucket

3.2. Design Requirements

Solidworks software was used to develop a 3D model of a proposed excavator bucket tooth. Solidworks software is most advanced 3D modeling software, all the modeling tools are very user friendly, by using this software we can make a 3D model, this cad model can send to the computer aided machining. To carry out the analysis Ansys was used.

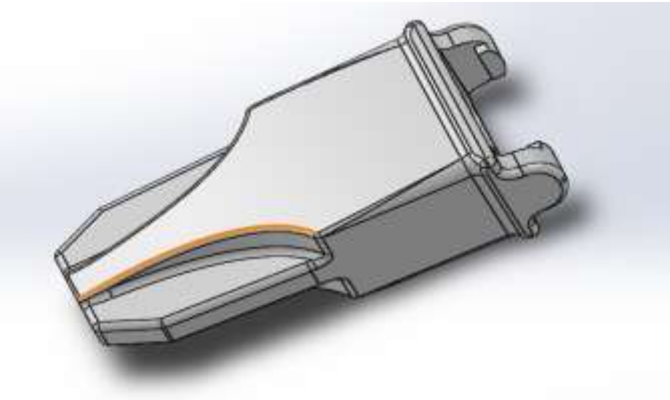


Figure.4: Tooth 3D model

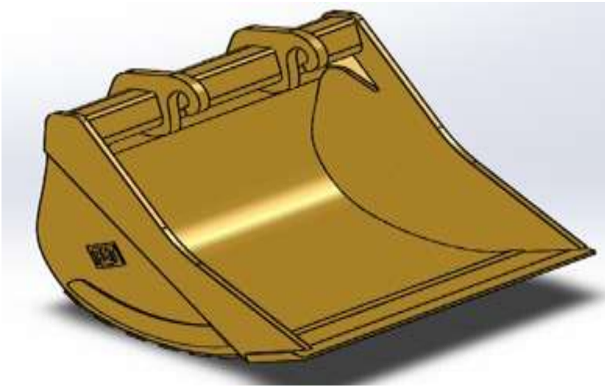


Figure 5: 3D model of excavator bucket

International Journal of Modern Trends in Engineering and Research (IJMTER)
Volume: 5, Issue: 04, [April– 2018] ISSN (Online):2349–9745 ; ISSN (Print):2393-8161

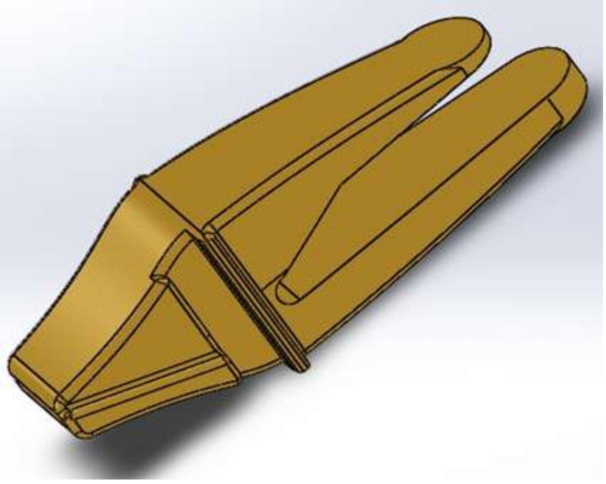


Figure 6: 3D model of Tooth Adaptor

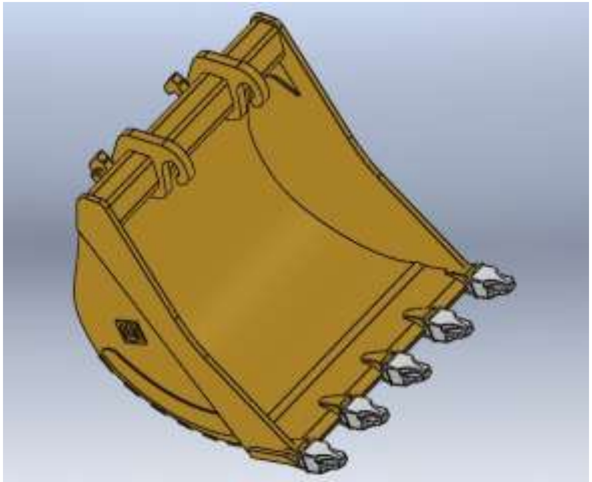
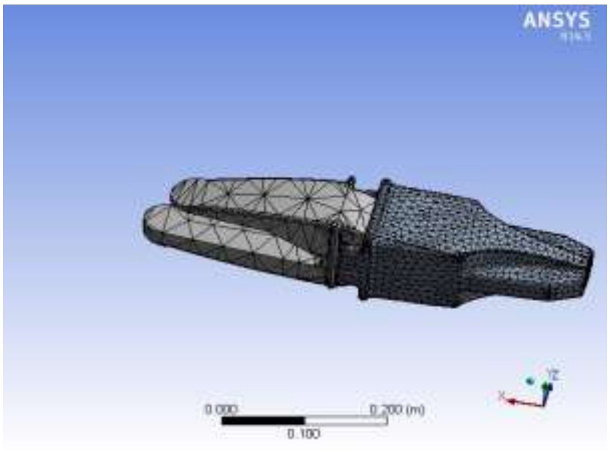


Figure 7: Assemble of excavator bucket

3.3. Material Properties

Table 1: Properties of Materials

Material→	AISI 1040	HSS	HCHCr
Chemical composition (%)			
C	0.370-0.440	0.78-1.05	1.40-1.60
Mn	0.60-0.9	0.15-0.40	0.60
Si		0.20-0.45	0.60
Co			1.00
Cr			11.00-13.00
Mo		4.50-5.50	0.70-1.20
V		1.75-2.20	1.10
P	≤0.040	0.03	0.03
Ni		0.3	0.30
Cu		0.25	0.25
S	≤0.050	0.03	0.03
Fe	98.6-99		
W		5.50-6.75	
C	0.370-0.440	0.78-1.05	1.40-1.60
Physical properties			
Density(kg/m^3)	7840	8160	7700
Tensile strength(MPa)	620	635	685.77
Elastic modulus(GPa)	205	210	210
Poisson's Ratio	0.27-0.3	0.27-0.3	0.2-0.3
Thermal Expansion Coefficient($/^0C$)	$11.3x10^{-6}$	$10.4\ x10^{-6}$	$10.4\ x10^{-6}$
Hardiness	63	65	64
Izod impact(J)	65	67	77



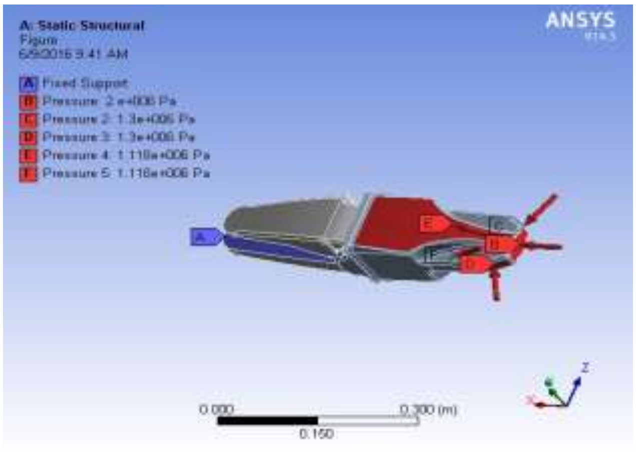


Figure 8: Meshed Tooth and tooth adapter   Figure 9: Meshed Tooth and tooth adapter with boundary conditions

IV. RESULTS

4.1. Results of tooth adapter and tooth using AISI 1040 (Structural)

Table 2: Result of AISI 1040 (Structural)

Bounding Box	
Length X	0.545 m
Length Y	0.115 m
Length Z	0.12949 m
Properties	
Volume	3.6487e-003 m³
Mass	28.633 kg
Statistics	
Active Bodies	2
Nodes	39718
Elements	24572
Analysis Type	3-D

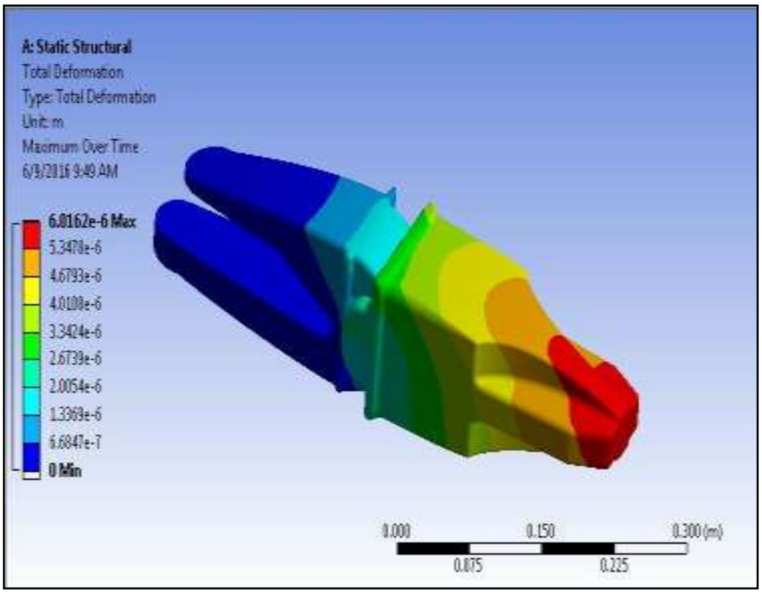
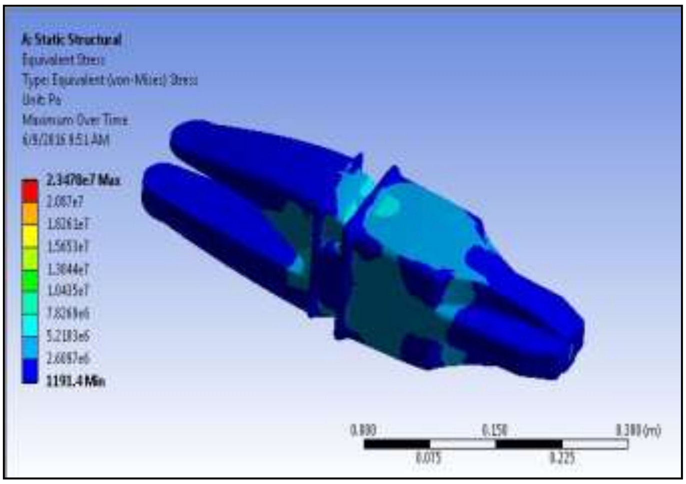


Figure 10: Total deformation of tooth

Definition			
Type	Total Deformation	Directional Deformation	Equivalent (von-Mises) Stress
Results			
Maximum	6.0162e-006 m	5.4274e-006 m	2.3478e+007 Pa



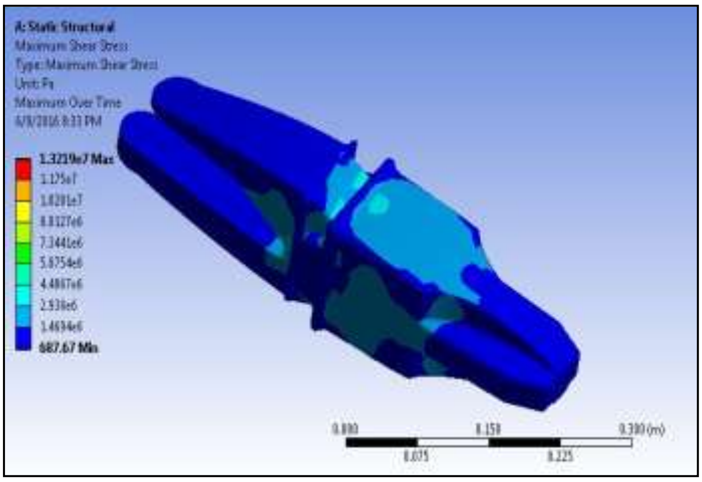


Figure 11: Equivalent stress on tooth adapter and tooth **Figure 12: Maximum Shear Stress of tooth adapter and tooth**

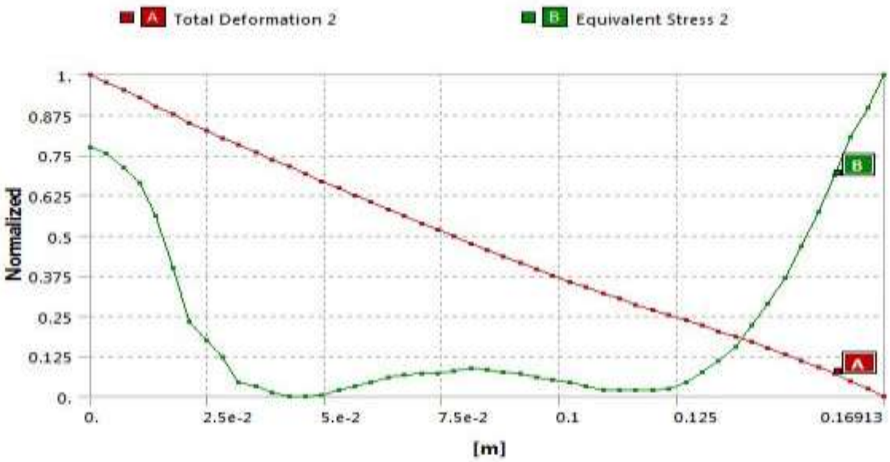


Figure 13: Total Deformation Vs Equivalent Stress

4.2. Results of tooth adapter and tooth using AISI 1040 (Couple field analysis)

Table 3: Result of AISI 1040 (Couple field analysis)

Bounding Box	
Length X	0.545 m
Length Y	0.115 m
Length Z	0.12949 m
Properties	
Volume	3.6487e-003 m^3
Mass	28.633 kg
Statistics	
Active Bodies	2
Nodes	39718
Elements	24572
Analysis Type	3-D

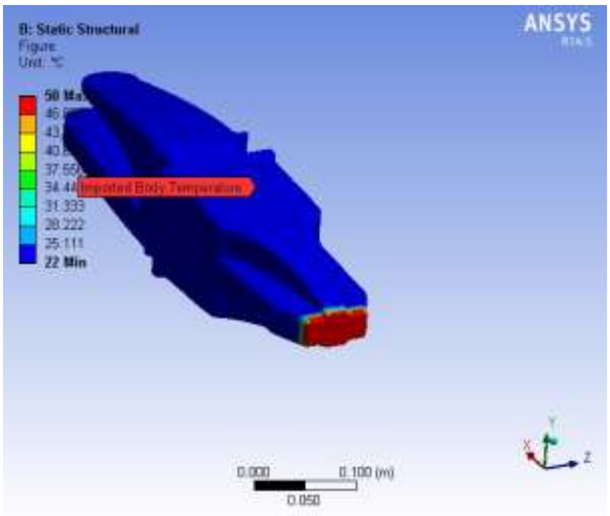
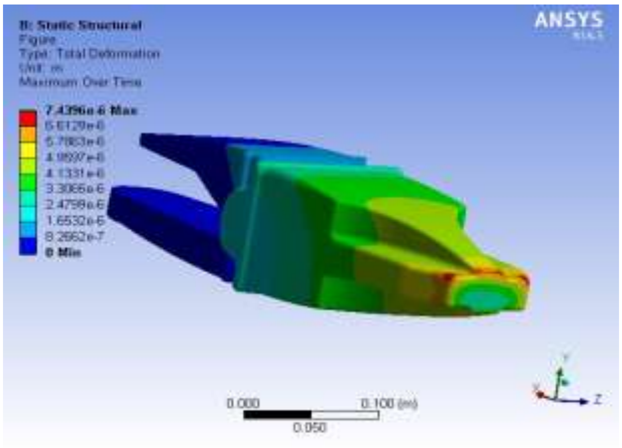


Figure 14: Heat flow

Volume: 5, Issue: 04, [April– 2018] **ISSN (Online):2349–9745 ; ISSN (Print):2393-8161**

Definition			
Type	Total Deformation	Equivalent (von-Mises) Stress	Max Shear Stress
By	Maximum Over Time		
Results			
Maximum	7.44e-006 m	4.80e+007 Pa	2.62e+007 Pa



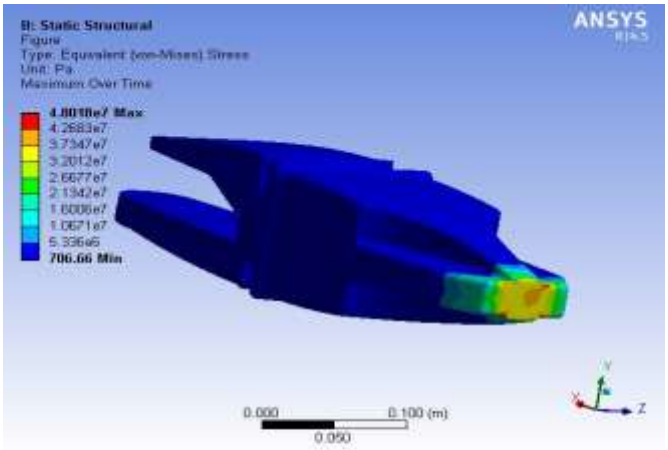
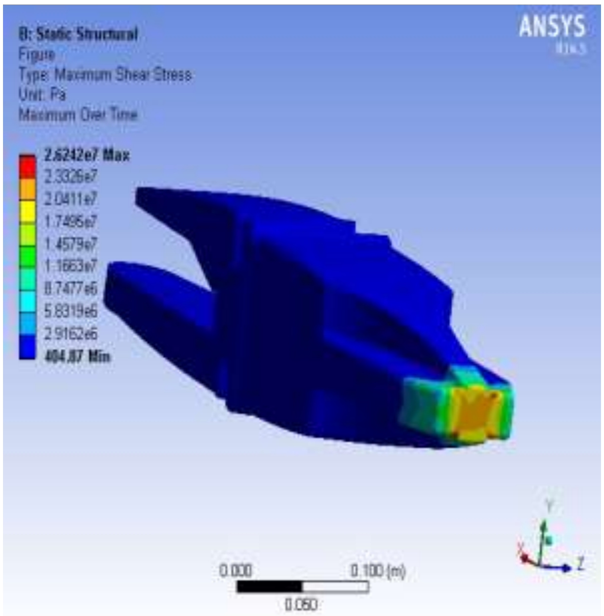


Figure 15: Total deformation of tooth in couple field analysis Figure 16: Equivalent Stress in couple field analysis



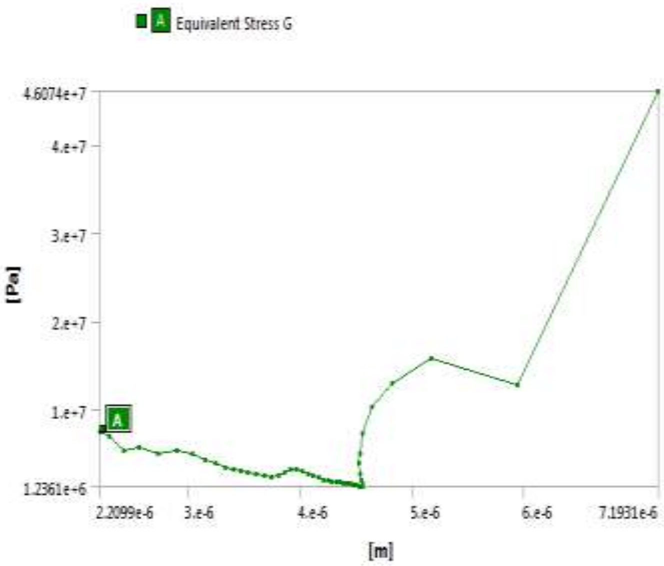


Figure 17: Maximum shear stress of tooth in couple field analysis Figure.18: Total deformation Vs. Equivalent Stress

4.3. Results Comparison

Table 4: Results Comparison

Material→	AISI 1040	HSS	HCHCr
Structural			
Deformation (M)	6.0162×10^{-6}	5.9645×10^{-6}	6.1539×10^{-6}
Equivalent stress (MPa)	23.47	23.58	23.29
Max Shear Stress (MPa)	13.2	13.3	13.1
Couple Field Results (Thermal & Structural)			
Deformation (M)	7.44×10^{-6}	6.36×10^{-6}	6.90×10^{-6}
Equivalent stress (MPa)	57.9	48.0	55.6
Max Shear Stress (MPa)	33.0	26.2	31.4

V. CONCLUSION

By modeling and analysis of backhoe excavator bucket tooth it has been observed that, although, the values of von-misses or equivalent stresses for existing and optimized bucket become less difference, but the area of stress in optimized backhoe excavator bucket tooth is reduced as compared to existing one.

Also, the value of deformation and stress intensity optimized by using material HSS, therefore the values of the HSS is become 5.9645×10^{-6} M and 23.58MPain static structural analysis, 6.36×10^{-6} M and48.0 MPa in couple field analysis respectively, are less as compared to other materials. Failure of excavator bucket tooth is due to abrasive wear and impact loading. This failure can be minimize by changing material or improving the material properties and the design of the tooth, from this analysis there is a vernation of deformation by comparing material AISI 1040, HSS Steel and HCHCr. HSS steel is the batter material for the excavator bucket tooth the deformation is very less when compared to the AISI 1040 and HCHCr.

REFERENCES

[1] Bhaveshkumar, P Patel, J M Prajapati, " Static analysis of mini hydraulic backshole excavator attachment using finite element analysis approach" , international journal for mechanical engineering and robotic research, Oct 2012.
[2] Juber Hussiain Qureshi, Manish Sagar, "Study And analysis of boom backhoe loader with the help of Finite element tool". International journal of modern engineering research (IJMER), May-June (2012).
[3] J.A.Sachidrian, P.Segarra, L.M. Lopez, "On loader productivity, rock strength, and explosive energy in metal mining", Universidad Polytechnic de Madrid. ETSI Minas, Rios Rosas 21, 28003 Madrid, Spain (2011).
[4] Kalpak, S.Dagwar, R.G. Telrandhe, "Excavator Bucket Tooth failure analysis", DMIETR, IJRMET may (2015).
[5] Manish, P.Tupkar, Prof. S.R.Zaveri "Design and analysis of an excavator bucket" Rajiv Gandhi collage of engineering research. (IJRMET) March (2015).
[6] Swapnil S. Nishane, Dr.S.C.Kongre,Prof. K.A.Pakhare "Modeling and Static Analysis of Backhoe Excavator Bucket" Shankarprasad Agnihorti college of enginnering. (IJRAT) March 2016.
[7] Bhaveshkumar P.Patel, Jagdish M.Prajapati "Evaluation of Bucket Capacity, Digging Force calculation and Static Force Analysis of Mini Hydraulic Backhoe excavator" JJT University (Rajasthan), M.S University of Baroda (Gujarat). Machine Design, vol.4(2012).
[8] Rahul Mishra, Vaibhav Dewangan "Optimization of Component of Excavator Bucket" Shri Rawatpura Sarkar Institute of technology-II, New Raipur. IJSRET vol.2 May 2013.
[9] Sachin B. Bende, N.P.Awate "Computer Aided Design of Excavator Arm: FEM approach" GHRCE, Nagapur. Mechanica Confab Vol.2 January 2013.
[10] Atul Sambhaji Jadhav, Prof. A.P Shrotri, Swapnil Kulkarni "Design Optimization for Front Loader Tooth of Earthmoving Equipment" PVPIT, Budhgaon, Sangli (IJAERS) 2014.