A REVIEW PAPER ON MODELLING AND 3D PRINTING OF JCB ARM

Mr. K. Dayakar[1], Md Taha Siddique[2], Syed Omar Farooq[3], Syed Talha Mohammed[4], V. Anil Naik[5]

[1] Assistant Professor, Dept. Of Mechanical Engineering, Gurunanak Institute Of Technology, Khanapur, India.
[2,3,4,5] UG Scholars, Dept. Of Mechanical Engineering, Gurunanak Institute Of Technology, Khanapur, India.

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Abstract-The Hydraulic excavator machines are heavy duty earth movers consisting of a boom, arm and bucket. It works on principle of hydraulic fluid with hydraulic cylinder and hydraulic motors. The Hydraulic excavator arm operation require coordinated movement of boom, arm and bucket. The important criteria for the design to be safe is that, the digging forces developed by actuators must be greater than that of the resistive forces offered by the surface to be excavated. The main objective of this paper is to perform design and analysis Excavator Arm for the calculated Force. The CATIA software is used for making the 3D model of the excavator arm linkage. By using ANSYS workbench software analysis of the excavator arm is done at existing digging force and lifting force. Excavator bucket is very crucial element of hydraulic excavator. The whole loads of excavated materials have been carried out by this element. As the present mechanism used in excavator arm is subjected to deformation and bending stresses during lifting and digging operation respectively, because of which failure occurs frequently at the bucket end of the arm.

Keywords: Excavator arm, Digging force, CATIA, ANSYS 16.0.

1.LITERATURE SURVEY

Rosen Mitrev and et.al **[1]** in their paper they have studied the dynamic stability of a hydraulic excavator during performing lifting operations. The developed dynamic model with six degrees of freedom considers the base body elastic connection with the terrain, the front digging manipulator links, and the presence of the freely suspended payload swinging. They have found that the excavator overturning stability while following a vertical straight-line trajectory decreases during the motion from the higher to the lower part of the trajectory. If the stability coefficient is close to 1, the payload swinging can cause the separation of a support from the terrain; nevertheless, they have found that the excavator overturning stability can be restored.

Bilal Pir Muhammed Shaikh and et.al **[2]** in their paper they taken the maximum digging force condition as the boundary condition and loading condition to carry out static finite element analysis for different excavator bucket tooth. They have found that the Stresses below yield strength obey Hook's law, so deformation in elastic limits. From results it can be seen that stresses are still below safe stress/ allowable stress value so more material can be removed. They have found in the results that the tiger and twin tiger teeth stresses are above safe stresses.

B. Govinda Reddy and et.al [3] in their paper they have done the analytical and Ansys results percentage error. The stress at the Tip of teeth of an Excavator bucket is calculated 86.39 MPA and stress due to shearing of rivet is calculated 187.67 MPA by analytically. The stress at the tip of the teeth is calculated 112.98 MPA and stress due to shearing of rivet 157.47 is calculated. Percentage error between analytical result and Ansys result are 13.69 % and 6.72 %. From the above results they have suggested that the bucket used for the excavation purpose should be properly checked for its application on the basis of the soil strata.

Bhavesh Kumar and P. Patel and et.al [4] in their paper they have developed a dynamic model of the backhoe in digging mode using L-E approach. The proposed dynamic model can be used as the basis for automating the digging operation of the backhoe. This can be accomplished by designing the controller so that the entire system can be operated in autonomous mode.

Takashi Yamaguchi and et.al [5] in their paper they reports on the results of performing experimental measurements of the motion of a hydraulic excavator operated by a human operator and analysing the data obtained by the measurements in order to achieve autonomous control of excavating and loading work by hydraulic excavators based on the skill of experienced operators. the ground materials that are the object of the excavation and loading work by a hydraulic excavator have non-uniform properties, so it is difficult to know the properties in the entire work range before performing the work.

Sharan gouda and et.al [6] in their paper they have calculated the forces acting on the excavator bucket teeth according to the standard SAE J1179 as 60 KN and also the bucket capacity is calculated according to the standard SAE J296 as 0.75 m3. The stress at the tip of teeth of an excavator bucket is calculated. As per the analysis results, they have suggested that the bucket used for the excavation purpose should be properly checked for its application on the basis of the soil strata.

Dharmesh h. Prajapati and et.al [7] in their paper they have concluded that the capacity of bucket has been increased up to 300 kg from 150 kg. they have modified design and increased capacity also by adding two more teeth to full feel the functional requirements. They have checked the design of excavator bucket under different loads. They have increased the volumetric capacity as well as reduce the total deformation of modified bucket.

Altaf S. Shaikh and et.al [8] in their paper, the forces on the excavator are calculated and the forces flowing to excavator arm are determined. The analysed part shows there is a scope for optimization. The optimizations of the excavator part are carried out by different iterations and finally the optimized results are obtained. Excavator arm is fabricated and experimentally tested. The FEM results and experimental results are made a comparable study and the validation shows close variance. From comparison of weight of existing model and optimized model it is seen that Overall weight reduction of 5% approximately has been achieved.

Sachin B. Bende and et.al [9] in their paper they have modified the Design of the excavator arm and analysis of the design. From the analysis results, they have proved that the design is safe for the calculated digging force. During designing of excavator arm, they have taken the important factors into account they are productivity and fuel consumption. Since, dislocation of the pin at bucket end and the cracking at the adapter end is eliminated by reducing the digging force. But reduction in digging force directly affects the productivity. So, the bucket capacity is increased to compensate for the loss in production due to the reduction in digging force. Also, fuel consumption is less due to the reduction in digging force. Finally, the results of the proposed model are compared with the existing model.

A. V. Pradeep and et.al [10] in their paper they have designed excavator bucket and analysis is done for three materials, i.e. steel, wrought iron and cast iron. They have found out the von-mises stresses, deformation and the strain energy for all the three materials.
They have made the comparisons among them. Steel and wrought iron has lesser stresses developed when compared to cast iron. Form the results they have concluded that the steel can be replaced with wrought iron.

P. Govinda Raju and et.al [11] in their paper, the static structural analysis of the arm and bucket is done and the maximum shear stress and deformation developed in the model is shown. From their study the total weight of the arm is reduced by 50%. The capacity of the bucket is also increased.

G. Ramesh and et.al [12] in their paper topology optimization approach is presented to create an innovative design of an excavator Lower Arm. Final comparison in terms of weight and component performance illustrates that structural optimization techniques are effective to produce higher quality products at a lower cost. The Lower Arm has further undergone weight reduction using the material selection through the usage of ALTAIR RADIOSS SOFTWARE. 9.28% of weight is reduced from the base model and it is stiffer.

Roshan and et.al [13] in their paper, the backhoe-loader bucket have been analysed with the maximum loads and boundary conditions using FEM. Analyses have been carried out for the maximum hydraulic cylinder forces. Symmetrical boundary conditions have been examined along with the fatigue life. The theoretical life cycle of any component in ANSYS is considered as 106 and in the present study the estimated life cycle is 0 for very small region. This can further be improved by changing the shape of the feature. It is also observed that the life of the component reduces considerably as it undergoes fatigue loading.

Niteen S. Patil and et.al [14] in their paper all the iterations have been carried out the final iteration shows the better results. Therefore, they have been concluded that it would be a better replacement for the conventional model. After the optimization the total weight reduction of approximately 120 kg is achieved in turn it would increase to the performance of the boom and hence the cost reduction. As the yield strength of the material is 1000MPa, the stresses are within limit and hence the design is safe (3.45 factor of safety).

R M Dhawale and et.al [15] in their paper the mini hydraulic backhoe excavator attachment is developed to perform excavation task for light duty construction work. Based on static force analysis finite element analysis is carried out for individual parts as well as the whole assembly of the backhoe excavator with and without consideration of welding. It is clearly depicted that the stresses produced in the parts of the backhoe excavator attachment are within the safe limit of the material stresses for the case of with and without consideration of welding.

Janith Raj and et.al [16] in their paper the FEA of excavator boom was done in various operating states, simulating actual working conditions in software. The studies shown that mostly higher stress concentration occur at bottom plate of the boom near boom cylinder connecting seat. The forces at each hinge point were calculated mathematically.

Sujit Lomate and et.al [17] this paper basically focused on an Analysis and Optimization of Excavator Bucket. The results were supported with an experimental validation for verifying the actual distortion and FEA results. Following are concluding remarks based on the analysis performed on bucket model & Bucket validation at ARAI. Model of Bucket is analysed under 4 different loading conditions to find out the bucket distortion, and bucket distortion is compared with regular bucket. It is observed that the stresses in 1.8 cum design when analysed for 1/3 offset and for full offset are lesser than 1.9 cum Current production bucket.

Chinta Ranjeet Kumar and et.al [18] in their paper the main changes in the model are done by adding rectangular ribs, round ribs and half sphere ribs to the inner surface of the bucket and also EN19 Steel material was replaced with AISI1059 Carbon Steel for better results. Static and buckling analysis on the excavator bucket is done. By observing the analysis results, the stress values for half sphere ribs are less than other three models. When, they compare the results for materials, the stress value is less for AISI 1059 Carbon steel and also its weight is less compared with EN19 Steel.

Swapnil S. Nishane and et.al [19] in their paper by modelling and analysis of backhoe excavator bucket they have been observed that, the values of von-mises or equivalent stresses for existing and optimized bucket become less difference, but the area of stress in optimized backhoe excavator bucket is reduced as compared to existing one. Also, the value of deformation and stress intensity optimized HORDOX-400 excavator bucket becomes 2.138mm & 201MPa respectively, are less as compared to other materials. The life of existing bucket material is of 22760 min cycles. but by analysing and comparing with different materials, they have been found that the life of optimized HORDOX-400 excavator bucket 66102 min. which is better than existing & optimized – 500 material.

Khedkar Y and et.al [20] in their paper Analytical soil-tool interaction models are utilized to calculate resistive forces exerted during digging operations. The digging force is higher than the resistive force so the bucket design is proficient for digging. From the graphs, it's clear that resistive force is increasing as the tool depth below the soil, bucket width and rack angle so it's necessary to select optimum value of bucket width and rack angle while designing bucket. With the static force analysis, we come to know about forces acting at joints of the bucket for each angle of lift and digging.

Y Madhu Maheshwara Reddy and et.al [21] in their paper by modelling and analysis of backhoe excavator bucket tooth it has been observed that, 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.

R. Jaison and et.al [22] in their paper a detachable backhoe and loader components are designed to be fitted on a agricultural tractor to lift a load of 2000N and 6000N respectively. This attachment can be removed once its work is completed and the tractor can be used for other purposes like ploughing, carrying loads etc. This backhoe is preferred for trenching and digging in the fields where the trenching process will be carried out often and to carry waste from fields through the loader.

Dhanpal N [23] in his paper Analytical soil-tool interaction models are utilized to calculate resistive forces exerted during digging operations. The digging force is higher than the resistive force so the bucket design is proficient for digging. From the graphs, it's clear that resistive force is increasing as the tool depth below the soil, bucket width and rack angle so it's necessary to select optimum value of bucket width and rack angle while designing bucket. With the static force analysis, we come to know about forces acting at joints of the bucket for each angle of lift and dig.

P Mahesh Babu and et.al [24] in their paper the digger arm is developed to perform excavation task for light duty construction work. Based on static force and dynamic force loads, finite element analysis is carried out for digger arm. It is clearly depicted that the stresses produced in the component of the digger arm are within the safe limit of the material stresses for the case of static and dynamic load conditions. It is also clearly depicted that the fatigue life cycle of the digger arm is more by 42.6% for modified digger arm compared to original digger arm. Based on results they have conclude that optimization can help to reduce the initial cost of the digger arm as well as to improve the functionality and life cycle as the digger arm operates in worst working conditions. The optimization also helps to avoid frequent failure of digger arm which may cause the entire system become idle and lead to a commercial loss to the owner.

Rahul Mishra and et.al [25] in their paper the capacity of bucket has been calculated according to SAEJ296. The bucket specification is the most superior when compared to all other standard model. The breakout force is calculated by SAEJ1179. The SAE provide the breakout and digging force. For max. breakout force condition but for autonomous application it is important to understand. Which are improved bucket geometry for more efficient digging and loading of material. And heavy-duty robust construction for increased strength and durability.

J Subba Raju and et.al [26] in their paper Working range in one of the important characteristics of backhoe mechanism. To estimate the working range, a forward kinematical modal and its computer algorithm was developed. Working range computed from computer algorithm was validated with virtual and physical prototype of BEML designed excavator. Results were consistent and proved to be right. This paper emphasizes the significance of structural parameters of backhoe, sequence of design and design validation procedures. This work lays foundation for analyzing the backhoe from stability and digging forces point of view Also, developing a customised tool in MSC Adams, which adapts the concept of mathematical modelling and its computer algorithm, will reduce the design efforts.

Zhi Ren and et.al [27] in their paper, the accurate calculation of the theoretical digging force shows many applications, not only in the optimal design of the excavator and the evaluation of the excavator's digging performance, but also in trajectory planning and control automation. In TDFCM model the normal resistance and resistance moment are simplified and ignored. Based on the resistance characteristics, the LDF model is established in this paper, simultaneously taking the tangential force, normal force, and the bending moment into consideration. Taking the digging resistance by testing for a 35t hydraulic excavator with backhoe attachment as the standard, this research compares.

2. CONCLUSION

We designed an Excavator bucket by using CATIA V5 software and analysis is done by ANSYS 16.0 software. From the analysis results, it is proved that the design is safe for the calculated digging force. During designing of excavator arm, the important factors taken into account are factor of safety, breakout force and maximum lifting capacity. The maximum stress values were found at the cylinder mountings. The material used is the medium strength alloy steel. Yield strength of the material is 450Mpa. From the analysis results it is observed that the stress developed due to applied force is less than the yield strength of the material for boom, arm and bucket. The deformation values are also less than the plate thickness i.e.,6mm. from the modal analysis, the deformations developed due to the natural frequencies levels is also less.

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