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Design and Analysis of 360° Rotable Manual Earth Digger Machine

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ABSTRACT: The manual earth digging machine which is very helpful in digging up a clay pits, huge rocks, breaking the hard material planks, for road construction work, digging up earth crust etc. The machine's manual work is very effective and put very less on the pocket for normal people. Designing the body of machine is a very effective and important task as it should be taken care that the digging force created by the machine must be greater than the resistive force offered by terrine. The research paper mainly put light on the working of the machine that it should be very effective on evacuation method of bucket capacity and the force required for digging so that it can be very effective in light construction work. This method will be very helpful for evaluating digging force which can be used as a path for boundary conditions and loading conditions by which we can analyze the strength and stress and the utility work which digging machine can do trench excavation and handle the pipe by removing another working unit. The separate bucket/vessel for sand and hard rock will effectively help the machine.The aim of our research project work is to design and fabricate manual earth digging machine.

Keywords: Chassis, 360 Degree Rotatable Chair, Tool kit (Link Mechanism), Bucket, Tyres, ANSYS.

I. INTRODUCTION

Earth digging machine is able to do so many heavy duty tasks such as digging up an area, leveling up, carrying material, dumping of soil etc. For all these tasks the machine should have a perfect mechanism and coordination of all the parts of machine for doing a work accurately. The main problem in the study of link mechanisms is calculation of position and orientation of bucket of backhoe joint when the angels are known, this called as forward kinematics. The inverse kinematics problem is too calculating all the set of joint angles which are possible that can be used to get the exact working position and orientation of bucket tip of the hoe attachment. This problem can be solved by both the direct and inverse kinematic models of backhoe attachments. The kinematic modeling proved very useful for digging operation and trajectory issue which can be carried out successfully at proper position by using the exact positioning and orientation of the bucket which leads the digging work as an automated form. To understand and know the concept of relationship between the position and orientation and spatial position of joint links many researcher have done researches. For the random errors in the given research, researchers I. J. Nagtath in 2008, R. K. Mittal and P.K Bhatti in 2001 made a probabilistic model of manipulator kinematics. Based on the probabilistic model, kinematic performance criteria are described to give of behavior of the robotic end effectors. End-effectors Gaussian distributions are assumed for the various manipulator parameters, and the joint efforts are modeled as Markov stochastic processes. Indices called kinematic reliability is called as method to access the performance of a manipulator. The practical approach is technically more involve in the simulation method and is mathematically easier to calculate the performmanc measures of a manipulator. Hsin-Sheng Lee, Shinn-Liang Chang and Kuo-Huang Lin (2002), a CAD/CAE/CAM and remote control integrated system for a pneumatic excavator mechanism were developed. The vector loop method and Visual C++ language were used to generate the position analysis module. The velocity of the link could be obtained easily by differentiating the position of equation with respect to time. Link acceleration is obtained by differentiate the velocity equation. The position analysis defined the working area of the excavator loader and helps the designer to choose the accurate length and link configuration. Fuad Mrad, M. Asem Abdul-Malak, Salah Sadek, and Ziad Khudr (2002), had developed simulation packs using Mat lab with many combined design and analysis tools. Emulation is to be carried out on the RHINO educational robot to check the simulation results. The constructed simulation package offered an mixed environment for trajectory designs and analyze for the excavator by representing the constraints that depend on the excavator structure, safety and stability, and mode of application. Donald Margolis, and Taehyun Shim (2003), a complete pitch/plane model of a backhoe was developed that contains the hydraulic dynamics and kinematics of the control linkage. The model is based on Bond graphs, which gives the pictorial representation of the interactive dynamics of all types of energetic systems. The model gives the unstable observation on the basis of real backhoe, and ready to be used as a design tool for further backhoe process. Emil Assenov, E. Bosilkov, Radoslav Dimitrov, Tzvetan Damianov (2003), had carried out study on kinematics of working mechanism of hydraulic excavator. The mechanism of this manipulator is plane multi linkage, which consist of arms joined and hydraulic cylinders. They had considered the process mechanism as joints of jib, arm and bucket, which are tied by the cylindrical joints and hydraulic cylinders. The computational equation for the length of the cylinder is to be derived. Simplification of such a mechanism is made by using Lagrange equation for the first type by unknown multipliers. The results can be used for creation of a control system of the working process of the hydraulic excavator. Boris Vidolov and Svetoslav Genchev (2005), had developed two approaches for the inverse kinematics of a real 12 MXT MECALAC redundant excavator. They had presented the priority approach and alternating approach. In simplification, the method gives a very smooth complete motion. They had developed a simulator for testing and validate its process. This is important tool that helps us to simplify different kinematics and dynamic models (differential equations systems), and also to solve various control algorithms, and also to study the reaction of the different body, actuators, tools of the studied arms, to quantify the capacity of generated approach to follow particular trajectories path. Daqing Zhang, Qinghua He, Peng Hao and Hai Tao Zhang (2005), have derived the complete kinematic model of the excavator arm, known as the plane manipulator with three degrees (boom, dipper and bucket) of freedom, to find easy method to control excavator's arm and gives autonomous excavation. The exponent product method which based on the screw theory is used to develop the kinematic model of manipulator to get the required trajectory. The analytical result gives better tracking results for boom cylinder under the controller developed. The maximum error is not more than 4 degrees. A.S. Hall and P. R. McAree (2005), have studied on the excavation arm of a large hydraulic mining shovel having a multi-loop kinematic form. They had explained the iterative algorithm that allows the position of the bucket to be tracked from measurements of the linear actuator extensions. The most important use of algorithm is that it is mathematically well-mannered when the link is close to particular configuration. They had also give result for better forward kinematic tracking using a multi-dimensional Newton–Raphson solver which is useful to find the time-varying trajectory from measurements of the cylinder lengths. F. Geu Flores, A. Kecskemethy and A. Pottker (2007), had explained a method based on the topic of "kinematical transformers" for evaluating closed-form solutions for the kinematics of 8 Terex face-shovel excavators RH-340. The work area of an excavator is carried out by the practical face-shovel excavator using the designed software. Hyongju Park, Sanghak Lee, Baeksuk Chu and Daehie Hong (2008), the recurrent neural network was applied for better kinematics control of the excavator for the capability to avoid the obstacles. A recurrent neural network algorithm and joint constraints combination method is used for the effectively achievement of goals for excavation task execution, joint limit control, and avoidance of obstacle at the same time. The further kinematics model of the excavator was established with additional bound constraints, excavator model can perform its job without any problem, such as malfunctioning, spot stop etc. Simulation result proves that why the position errors are small, on the basis of assumption on which the excavator models work has only single available redundancy. Michael G. Lipsett (2009) had described a simple model for assessing the many shovel designs, including kinematic performance of face shovels for surface mining excavation. Basic design assumption for an excavating shovel is necessary for the best performance and long term specifications are based primarily on kinematics. The Terex O&K RH 400 is simulated as a case study; carried out spaces during work, mobility during dig process and maximum applicable cutting forces are present with some evaluated assumptions in the dynamics of the machine.

Also the measures of the models are discussed. Forward kinematics gives the location and arrangement of the bucket lip, and also helps to find the three joint displacements. Dongnam Kim, Kyeong Won Oh, Daehie Hong, Yoon Ki Kim and Suk-Hie Hong (2009), they have developed a novel concept of applying tele-operated devices in the excavator which is used for the remote control of excavator-like dismantling equipment. As a tele-operated system, it is designed to improve the operability of the excavator. They had tried all the necessary kinematic analysis to design the tele-operated system and basic motion control simulations to the real excavator working at construction site are conducted with designed tele-operated system. The design of device is based on the kinematics of the excavator, which can cover 3-dimensional workspace. Hongnian Yu, Yang Liu and Mohammad Shahidul Hasan (2010), have explained model of excavator to find out the kinematic that give the trajectory of the excavator bucket which is based on the trajectory of the excavator arm joints and the inverse kinematics is also give the desired joint variables similar to the desired bucket trajectory. They have applied three control approaches: adaptive control, robust control and iterative learning control which had been developed on the complete actuated robot manipulator.

II. THE OBJECTIVE OF THE PRESENT RESEARCH

Manual earthmoving operations such as digging a trench and leveling a mound of soil and rock and carrying a pile of soil to cutting a geometrically described volume of earth for a trench or foundation footing ,shovel machine reduce the human effort and also minimize the cost.

To find out the design of bucket pin (there are two forces acting on the bucket pin $F_{(pbd)}$ during dumping cycle 1. Due to soil weight inside of bucket (Fm) bucket self weight $F_{(sw)}$

- To check bucket pin for bending failure
- Arm pin design
- To find bucket capacity
- To find bucket curling force (F_b)
- To find arm crowd force (F_s)
- To find pin design between bucket and arm (designed pins are checked for bearing, shear strength and bending strength)

III. DESIGN AND METHEDOLOGY

A. Design Details

Design of digging machine is critical task in context of digging force developed by actuators must be greater than that of resistive force offered by the terrain to be excavated so the paper focuses on the evaluation of the method of bucket capacity and digging forces required to dig the terrain for light duty construction work. This method provides the prediction of digging force. The evaluated digging forces can be used as boundary condition and loading condition to carry out finite element analysis of digging machine for strength and stress analysis. In designing there is designing of each part separately and overall arrangement or assembly of every part in one. Designing is a major part of project, on the basis of designing we come to the conclusion to find the analysis of each part. Designing is distributed in five major parts they are:

1 Chassis
2 360 Rotatable Chair
3 Lever Mechanisms
4 Link Mechanisms
5 Bucket

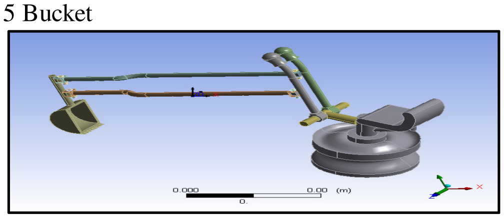

Fig. 1. Overall Assembled Design of Earth Digger Machine.

Table 1: Environmental Temperatures and Structure on the Machine.

Object Name	*Static Structural (A5)*
State	Solved
Definition	
Physics Type	Structural
Analysis Type	Static Structural
Options	
Environment Temperature	22. °C
Generate Input Only	No

B. Methodology

The following steps are involved in the present work:

- Design of experimental setup
- Fabrication of experimental setup
- Selection of concept for tool kit geometry
- Range of operating parameters
- Experimental investigation under simulated condition

C. Design Analysis

Design is analyzed the basis of different parameters like suppressed condition of bucket. Designed bucket is analyzed for the acceleration due to gravity, stresses and pressures. How the direction of bucket changes under different parameters.

Table 2: Earth Gravity Analyses for the Bucket.

Object Name	*Standard Earth Gravity*
State	Fully Defined
Scope	
Geometry	All Bodies
Definition	
Coordinate System	Global Coordinate System
X Component	0. m/s² (ramped)
Y Component	0. m/s² (ramped)
Z Component	-9.8066 m/s² (ramped)
Suppressed	No
Direction	-Z Direction

Table 3: Size and Dimension of Earth Digger Machine.

Object Name	*Geometry*
State	Fully Defined
Definition	
Type	Iges
Length Unit	Meters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	
Length X	1.722 m
Length Y	1.0181 m
Length Z	0.45281 m
Properties	
Volume	3.106e-002 m³
Mass	243.82 kg
Scale Factor Value	1
Statistics	
Bodies	16
Active Bodies	16
Nodes	15374
Elements	6215
Mesh Metric	None
Basic Geometry Options	
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Parameters	Yes
Parameter Key	DS
Attributes	No
Named Selections	No
Material Properties	No
Advanced Geometry Options	
Use Associativity	Yes
Coordinate Systems	No
Reader Mode Saves Updated File	No
Use Instances	Yes
Smart CAD Update	No
Attach File Via Temp File	Yes
Analysis Type	3-D
Mixed Import Resolution	None
Decompose Disjoint Faces	Yes
Enclosure and Symmetry Processing	Yes

Table 4: Values of Moment Of Inertia for the Bucket.

Object Name	*Part 1*	*Part 2*	*Part 3*	*Part 4*	*Part 5*
State	Meshed				
Graphics Properties					
Visible	Yes				
Transparency	1				
Definition					
Suppressed	No				
Stiffness Behavior	Flexible				
Coordinate System	Default Coordinate System				
Reference Temperature	By Environment				
Material					
Assignment	Structural Steel				
Nonlinear Effects	Yes				
Thermal Strain Effects	Yes				
Bounding Box					
Length X	2.1701e-002 m				2.0285e-002 m
Length Y	1.e-002 m				6.8e-002 m
Length Z	2.5058e-002 m				2.3423e-002 m
Properties					
Volume	2.3115e-006 m³				1.3093e-005
Mass	1.8146e-002 kg				0.10278 kg
Centroid X	0.97054 m		-5.8928e-002 m		0.97054 m
Centroid Y	0.1716 m	5.7605e-002 m		0.1716 m	7.718e-002 m
Centroid Z	1.0709e-002 m	9.4567e-002 m	5.2648e-002 m	5.2627e-002 m	9.4564e-002 m
Moment of Inertia Ip1	1.0071e-006 kg·m²				4.5308e-005
Moment of Inertia Ip2	1.0069e-006 kg·m²				4.5309e-005
Moment of Inertia Ip3	1.7098e-006 kg·m²				3.3423e-006
Statistics					
Nodes	473				427
Elements	66				187
Mesh Metric	None				

Table 5: Vector Analysis Dimension for the Machine.

	Global Coordinate System
State	Fully Defined
Definition	
Type	Cartesian
Coordinate System ID	0.
Origin	
Origin X	0. m
Origin Y	0. m
Origin Z	0. m
Directional Vectors	
X Axis Data	[1. 0. 0.]
Y Axis Data	[0. 1. 0.]
Z Axis Data	[0. 0. 1.]

This is the graph showing variation of the structure with respect to acceleration which is under gravity.

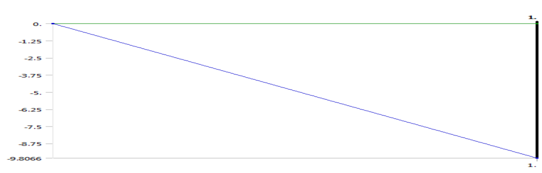

Fig. 2. Structure is analyzed for variation of load

Table 6: Force Analyses for the Bucket.

Object Name	*Fixed Support*	*Frictionless Support*	*Frictionless Support 2*	*Force*	*Force 2*
State	Fully Defined				
Scope					
Scoping Method	Geometry Selection				
Geometry	1 Face	12 Faces	2 Faces	1 Face	2 Faces
Definition					
Type	Fixed Support	Frictionless Support		Force	
Suppressed	No				
Define By				Vector	Components
Magnitude				-800. N (ramped)	
Direction				Defined	
Coordinate System					Global Coordinate System
X Component					50. N (ramped)
Y Component					0. N (ramped)
Z Component					0. N (ramped)

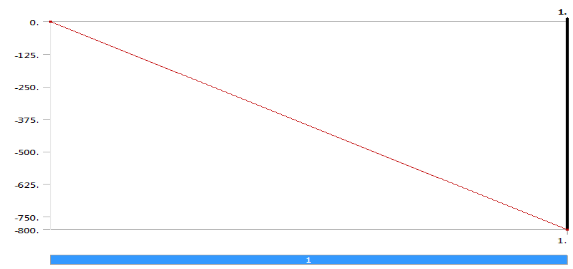

Fig. 3. Graph locating between static structure and load.

D. Part Specifications:

CHASSIS

Chassis is a French arm and was initially used to denote the frame or main structure of a vehicle. The term is now completely used to denote the complete vehicle except the body for the heavy vehicle having a separate body. The chassis contains all the major units necessary to propel the vehicle, direct its motion, stop it, and allow it to run smoothly over uneven surface.

Top view **Side view** **Front view**

Fig. 4. Different views of Chassis.

TYRES

A tyre is a cushion provided with an automobile wheel. It consists of mainly the outer cover i.e., the tyre proper and the tube inside. The tyre tube assembly is mounted over the wheel rim. The air inside the tube carries the entire load and provides the cushion. The tyres are final contact points between the road and vehicle. They take all the load of vehicle. They are flexible and absorb most of shocks when a car in moving on rough roads.

The surface of the tyre has certain patterns which enable it grip the road and provides good traction.

360° ROTABLE CHAIR

360° rotable chairs may have wheels on the base allowing the user to move the chair around their work area without getting up. This type is common in modern offices and often also referred to as office chair. Office swivel chairs, like computer chairs, usually incorporate a gas lift to adjust the height of the seat, but not usually large (e.g. recliner) swiveling armchairs.

0 degree 90 degree 180 degree

Fig. 5. Different view of 360° rotable chair.

BUCKET

Essentially most excavator buckets are intended for digging in a medium which is reflected in specific features of their design. Buckets, whether meant for digging loam, rock or frost, generally adhere to the rule that form follows function. Digging buckets for soft soils have short blunt teeth, while for rock or frost they are pointed and longer to provide better concentration of force and leverage for prying. Bucket width also varies – in hard ground a narrow bucket concentrates ground-penetrating forces along a shorter cutting edge. Another variable is the distance between the stick bucket pin boss and tooth tips. This distance, the tip radius, is generally shorter in buckets intended for hard ground excavation. The shorter distance provides better mechanical leverage for curling and filling the bucket. A well designed digging bucket will employ, depending upon intended use, these and other features to create a durable and efficient tool.

Fig. 6. Fabricated bucket design.

Fig. 7. Fabricated bucket desin of tool kit.

Fig. 8. Overall fabricated earth digger machine.

TOOL KIT

Tool Kit is an assembly of bodies connected to manage forces and movement. The movement of a body, or link, is studied using geometry so the link is considered to be rigid the connections between links are modeled as providing ideal movement, pure rotation or sliding for example, and are called joints. A linkage modeled as a network of rigid links and ideal joints. Linkages may be constructed from open chains, closed chains, or a combination of open and closed chains. Each link in a chain is connected by a joint to one or more other links. Mechanical linkages are usually designed to transform a given input force and movement into a desired output force and movement. The ratio of the output force to the input force is known as the mechanical advantage of the linkage, while the ratio of the input speed to the output speed is known as the speed ratio. A kinematic chain, in which one link is fixed or stationary, is called a mechanism, and a linkage designed to be stationary is called a **structure**.

IV. RESULT AND DISCUSSION

Resisting force offered by ground is 3.916KN which should be less than the bucket curl force so we have to design bucket for more than this force. Using parameters of ISO the bucket curl force is 7.626KN. In storm drain and utility work digging machine can perform trench excavation and can handle the pipe by eliminating a second machine. There are special bucket for everything from light sand to hard rock digging.

E. Capacity

It is expected that, the product will able to fulfill the task required. Firstly proper system is developed. Through the developed system and design of the bucket, the operator now able to control the tool kit from inside the machine.

F. Efficiency

It is a genuine project, which is fully equipped and designed for digger machine .This forms an integral part of best quality .This a project having 60% efficiency it can be used during rainy as well as dusty day. It is more efficient then other manually handed digger device. It can be used for digging in all the direction with help of 360 rotatable chairs.

G. Limitation

The problem that we addressed in 360 rotatable manual earth digging machine is excavation of large area .It cannot be used for cultivation of large area. In order to save the automation we have not used automatic device to carry from one place to another place .Operator is required to move it from one place to another place by them.

V. CONCLUSIONS AND FUTURE SCOPE

This manual earth digger machine reduces cumbersome digging operation and improves operator level comfort. It will give a new dimension of comfort add to the operator to work in garbage handling, constructional work leveling pile of soil hose gardening. In future we work on paddle hydraulic arm for increasing and decreasing, digging force and man efforts. 360 degree manual earth digging machine can be further extended that can be used as follows:

1. Small scale farming system.
2. For economical plantation which will be beneficial for farmers as well as for government from agriculture.
3. Its improvised extension can be automated so it will consume less time to fulfill the purpose
4. From economic point of view we have designed manual earth digging machine which will be affordable to the farmer. Improvisation can be made in particular part like it can be automated in the part of chassis for automatic movement of machine for moving from one part to another. So that it will be handled by even single individual. It can be used in its extension for carrying pile of material like cement mixture which is used in construction of building that will reduce the manpower.

REFERENCES

[1] Tapobrat Pani, Shubham Warate, Ritesh Chandrakar, Vaibhav Adulkar, Akshay Pawnarkar, Design and Fabrication of Two Axis Pneumatic Arm, *International Research Journal of Engineering and Technology (IRJET)* Volume: **03** Issue: 03 | Mar-2016.

[2] S.Sathiyaraj, V. Selvakumar, Design and Fabrication Of Pneumatic Jack For Automobile, Jayalakshmi Institute Of Technology, Thoppur, Dharmapuri 2012.

[3] Hazem I. Ali, Samsul Bahari B Mohd Noor, S. M. Bashi, M. H. Marhaban, "A Review of Pneumatic Actuators (Modeling and Control)" published in *Australian Journal of Basic and Applied Sciences*, **3**(2): 440-454, 2009

[4] Machine Design By Khurmi & Gupta, S. Chand publications

[5] Data hand book By B.D. Shiwalkar

[6] https://en.wikipedia.org/wiki/Pneumatic_cylinder

[7] Theory of Macines By Khurmi & Gupta, S. Chand publications *Geosciences and Engineering*, Vol. **1**, No. 1 (2012), pp. 177–186.

[8] Sümegi, I.: Theoretical examination and developing of cutting mechanism of opencast bucketwheel excavators. PhD. theses. University of Miskolc, 2002.

[9] Ladányi, G.–Sümegi, I.: Cutting edge development for opencast bucketwheel excavator based on examination of winning process. In. Mining Tecniques 2003, *International Conference,* 2003. szeptember 16–19., Krakow–Krynica, Proceeding of the conference, 139–150.

[10] Ladányi, G.–Sümegi, I.: Some issues of the technological design of bucketwheel excavators. In. Mining Tecniques 2005, International Conference, 2005. szeptember 21–23. Krakow-Krynica, Proceeding of the conference, 47–56.

[11] Ladányi, G.–Sümegi, I.: Some issues of the technological design of bucketwheel excavators. *In. Proceeding of University of Miskolc, Mining 2006*, Vol. **70**. 101–112.

[12] Ladányi, G.–Sümegi, I.: Optimisation of buckets of bucket-wheel excavators based on operating experience. In. Mining Tecniques 2007, International Conference, 2007. september 18–21. Krakow-Krynica, Proc. of the confer. 103–110.

[13] Ladányi, G.–Sümegi,I.–Virág, Z.: Laboratory Rock Cutting Tests on Rock Samples from Visonta South Mine. In. International conference of Elektromechanics. Petrosani, Románia. *Proceeding of the conference,* Vol. **1**, 209–218.

[14] Bhaveshkumar P. Patel and Dr. J.M.Prajapati,"A Review On Kinematics Of Hydraulic Excavator's Backhoe Attachment", *International Journal of Engg. Science and Technology (IJEST)* Vol.No.**3.**Issue No.3.March 2011.

[15] Ahmet Erklig and Eyup Yeter,"The Improvements of The Backhoe-Loader Arms", Model Simulation of Material Science, Issue No 3, January 2013, Page No. 142-148.

[16]Rahul Mishra And Vaibhav Dewangan, "Optimization Of Component Of Excavator Bucket" *International Journal Of Scientific Research Engineering And Technology (Ijsret),* Vol. No. **2**, Issue No.2, Page No. 076-078.

[17] Gottvald, J "Experimental And Probabilistic Analysis Of Operational Reliability Of The Bucket Wheel Excavator Schrs 1320/4x30" Ph.D. Thesis, Brno University Of Technology, Brno, P. 205, 2011, (In Czech).

[18] Yuki Sakaida And Daisuke Chugo "The Analysis Of Excavator Operation By Skillfull Operator" The University Of Tokyo, Japan, Isarc 2006, Page No 543-547.