MODELLING SIMULATION AND KINEMATIC ANALYSIS BASED ON PRO/ ENGINEER FOR BOOM OF BACKHOE LOADER

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Abstract: Pro/Engineer is a parametric feature-based design of 3D software and capable to solve the motion dynamics of the motion, and the reactions at the constraints of the mechanisms can be used as the inputs for any Finite element program to understand the behavior of stresses and deformations of the individual component of the machine to estimate the working life of the machine elements designed for the application. .In this paper researcher describes, the Kinematic study of the Cad model of the Boom of machine is made for the worst case of the maximum load at the bucket (Breakout force) at different conditions.

Keywords: Backhoe; Pro/Engineer; Model Simulation, Dynamic Analysis.

Introduction

An excavator is comprised of three planar implements connected through revolute joints known as the boom, arm, and bucket, and one vertical revolute joint known as the swing joint **[1]**. The backhoe loader is shown Figure1. Kinematics is the science of motion which treats motion without regard to the forces that cause it. Within the science of kinematics one studies the position, velocity, acceleration, and all higher order derivatives of the position variables (with respect to time or any other variables) **[2]**. The excavator linkage, however, is a complex link mechanism whose motion is controlled by hydraulic cylinders and actuators. To program the bucket motion and joint-link motion, mathematical model of the link mechanism is required to refer to all geometrical and/or time-based properties of the motion. Kinematic model describes the spatial position of joints and links, and position and orientation of the bucket **[3]**. The problem of link mechanism control requires both the direct and inverse kinematic models of the backhoe attachment of the excavator **[4]**. The derivatives of kinematics deal with the mechanics of motion with considering the forces that cause it.

Fig. 1: Excavator

Establishments and 3d Modelling of Boom

The Boom is the most stressed part of the backhoe loader. The drawing for the Boom with sectional width is shown in the Figure 2. All the plates welded are of 16 mm thickness, the fillet weld can be measured to be8 to 10 mm strong. The drawing for the Boom with sectional width is shown in the figure. All the plates welded are of 16 mm thickness, the fillet weld can be measured to be 8 to 10 mm strong. The consideration that the weld is stronger than the base metal is kept in mind and thus the weld is not modelled in 3D.

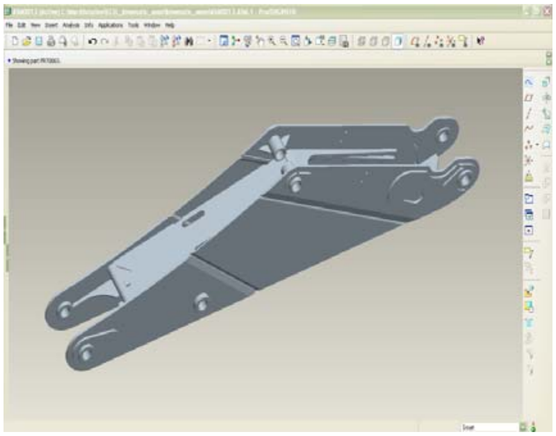

Fig. 2: Cad model of boom

Kinematic & Dynamic Behavior study of Backhoe loader

In order to analyze excavator design in the real world by creating a virtual prototype, Pro/Mechanica was used to implement the excavator kinematic simulation and structure analysis **[5]** .To study the kinematic behavior of the components connected together, the assembly of all the components is done in Pro-E with the use of connection joints in the assembly module of pro-e. The motion is then analyzed in Pro-Mechanism module of pro-e.

Kinematic Analysis

The connections of Pin joint to different parts, to facilitate the motion of the system. While the linear motion of cylinders is done via use of slider mechanism constraint in the assembly mode of Pro-engineer standard module. The closed setting for cylinders is done in the mechanism to exteriorize the dependencies of motion constraint to facilitate the constraint of motions. First the motion of Bucket which is rotational motion to dipper connected joint and the linear motion is synthesized shown in the Figure 3.

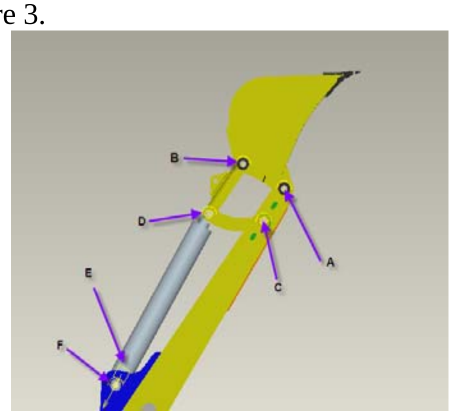

Fig. 4: Connections used in the synthesis of the bucket

The Figure 4 only shows the connections used in the synthesis of the bucket. The Connection “A” is a Pin joint connection in the Bucket and the dipper, connection “B” is in between the bucket and the link. Connection “C” is in between the link and the dipper, Connection “D” is in between the Hydraulic cylinder and the linkages. Connection “E” is the slider connection between the Piston and Cylinder of a Hydraulic Cylinder arrangement. Connection “F” is the Pin joint in between the cylinder and the dipper.

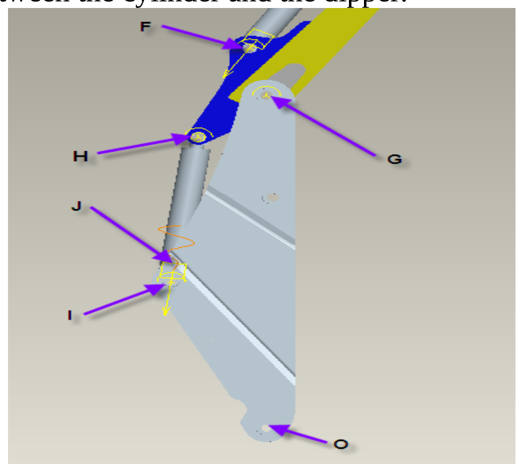

Fig. 4: Joint connections in the boom

The Figure 5 shows the joint connections in the boom, listed as “G” a pin joint connection connecting the dipper to the boom. Pin joint “H” is the connection of the cylinder to the dipper responsible for the motion of the dipper. Pin joint connection “I” will carry the reaction force via the cylinder to the boom. Joint “J” is the slider connection given to simulate the Hydraulic Cylinder. The Rotation motor input is given to the connection “A” for the rotation of the connection to visualize the kinematic synthesis of the bucket **[4].**

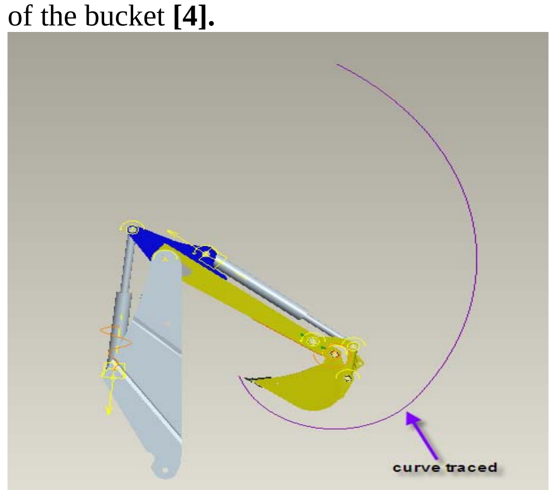

Fig. 5: Curve traced by the toe of bucket

Dynamic Analysis

The dynamic simulation in mechanism module of pro-e is done to calculate the results for forces in the joints at all time frame of the motion. The motion of the bucket is only analyzed and the reaction in the cylinder tilting the bucket was calculated via the force measures created in the mechanism module of pro-e **[6]**. The result window for the force analysis of the cylinder directly shifting the bucket is shown in the below figure for the force graph for the complete range of time.

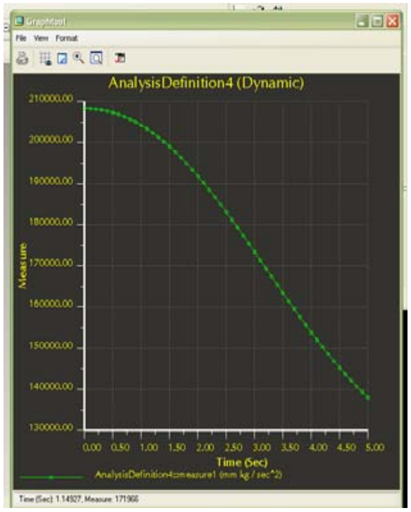

Fig. 6: Result window for the force analysis of the cylinder

The maximum force for the motion comes to 163435 N at the time of 3.5 sec. this can be cross-checked from the maximum pressure involved and the bore diameter of the cylinder. The Bore Diameter of the cylinder is 200 mm, the machine running pressure is 280 bar, while the maximum pressure for the machine is allowed to reach is 310 bar, after which the pressure relief valve connected in the circuit releases the oil to oil tank to maintain the pressure of max 310 bar in the machine. With 280 bars as the working pressure the maximum force a cylinder can develop will reach to 879645.9 N, the same is nearly 8 times the required force to tilt the bucket. Thus the force resulted via the mechanism is acceptable to us. The results of the force developed by the cylinder connected to the boom and the pin is given in the figure below. The Maximum force produces in this case is around 293215 N which is again nearly with factor of safety of 3 with the maximum force the cylinders can develop. The results of the system can be taken to Finite element package where boom can be analyzed for these results.

Conclusion

This study tells the optimization of the Boom for including the strength of welds where welds can be modelled with shell elements along with the boom to take moments can be done to predict the failure stresses of the welds. Localization and stress linearization of the weld can be simulated for calculating the factor of safety for weld strength.

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