Design and Development of Test Setup for Power Lift Assembly of Tractor

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Abstract- *Tractor is a self-propelled power unit having wheels or tracks for operating agricultural implements and machines including trailers. Tractor engine is used as a prime mover for active tools and stationary farm machinery through power take-off shaft (PTO) or belt pulley, among all the parts hydraulic power lift is one of the important part. Power lift assembly of tractor is the hydraulic unit used to lift the Plow which is used in farming for initial cultivation of soil in preparation for sowing seed or planting to loosen or turn the soil. In this project we are developing the test setup to check the performance of the power lift. By Using Finite Element Analysis and detailed analytical calculations model for test set up is designed. This test setup is being design for the Force Motors Ltd. Akurdi , pune-44.*

Keywords- Hydraulic power lift assembly, Test setup, Buckling analysis, Finite Element Analysis.

I. INTRODUCTION

Tractor is a self-propelled power unit having wheels or tracks for operating agricultural implements and machines including trailers. Tractor engine is used as a prime mover for active tools and stationary farm machinery through power take-off shaft (PTO) or belt pulley, among all the parts HYDRAULIC POWER LIFT is one of the important part. Power lift assembly of tractor is the hydraulic unit used to lift the Plow which is used in farming for initial cultivation of soil in preparation for sowing seed or planting to loosen or turn the soil. In this project we are developing the test setup to check the performance of the power lift. In old days this initial soil cultivation operation was performed by the man himself or by taking help of the animals specially OX. But in this case the time taken for initial cultivation of the soil was large and also large amount of efforts needed to complete the work. So to reduced this efforts and to increase the efficiency of the operation various tractor manufacturer companies have develop the technique, which is much more efficient and less time consuming.

WORKING OF POWERLIFT ASSEMBLY

Power lift consist of piston cylinder arrangement which is operated by hydraulic pressure. As shown in fig from the top side of the assembly we insert the SAE30 oil to operate it. the connection in power lift is such that the piston is freely reciprocate inside the cylinder the other end of the piston is connected to the eccentric shaft connector arm, this is special arm connected to the eccentric shaft whose function is that the to transfer the reciprocating motion of piston to the eccentric shaft to rotate if the there is eccentric shaft whose both the ends are connected to the primary lifting arm of the power lift.

NOW,

Firstly with the help of the control unit we open the valve mounted on cylinder head which allows the oil to come inside the cylinder due to oil pressure developed inside the cylinder the piston movement starts the piston applies the pressure on the arm and small swinging moment is developed on the eccentric shaft and it gets rotate and by this way the primary lifting arm gets the motion and rises up or down according to the situation now following two are the important arrangement in the power lift.

- In hydraulic lift assembly generally there are two position of the lifting arm such as
  1. Position control
  2. Draft control
- In case of position control lifting arm is lifted up to 400 to 450 from the initial position and in case of draft control this movement is up to 850.
- While plowing in farm due to any obstacle such as large stones come in line of plow than due to collision with the stone plow may get damage hence by putting lever to position control lifting mechanism adjusted such that it lifts the plow and tractor further moved.
- Many time due to hard soil it is necessary that the plow should come down in soil with the greater force hence for that lever shift to draft control and using adjustable linkage mechanism in comes down with the greater force.

NOW, as discussed above all the operation performed by the power lift are crucial, so after assembly of all the component is done it is very necessary to check the performance of the assembly. For this purpose we are designing and developing the test set up which will check the assembly before it will installed on the tractor it self. To developed this test set up firstly all the sequential operation need to be performed as discussed with detail in BAJAJ TEMPO Standards. According to the functional requirement by using Finite element analysis and various machine design concept we have designed the test setup.

Problem Definition

Design the test set up for checking the performance of power lift assembly of tractor.

II. OBJECTIVES

- Design Test Set up of power lift assembly of tractor according to Bajaj tempo standard BT0061.
- Preparation of Cad model to meet the requirements.
- Analysis and theoretical calculations of Following components of test set up.

1. Base Frame
2. Column structure
3. Sensing mechanism
4. Oil Pressure calculation

- Conduct experimental trials
- Match the experimental values with field failure test values.

III. METHODOLOGY

- Literature review regarding concerned topic.
- Study of Indian standards and Bajaj tempo standards for initial preparation of the design.
- CAD modelling of test setup
- Finite element analysis of critical component by Using HYPERMESH 12.0 as pre-processor and optistruct as solver.
- Validation through Experimental testing on test set up and comparison with field failure values..

IV. DESIGN AND DEVELOPMENT OF TEST SETUP

For designing the test set up for power lift assembly of tractor Bajaj tempo standard no BTS0061 is used various steps involve in it are listed below:

1. Mounting of lift assembly on the test fixture which inbuilt has capacity to store at least 5lit. Oil quantity.
2. Connect the external pressure pipe with quick release coupling to the assembly valve.
3. Fit the sector protector to adjust the valve opening positions
4. Start the pump check for the leakage of oil visually and attached the primary lifting load of nearly 30 kg and operate the angle and control lever to check and to adjust the control position of lifting arm.
5. Lift the arm to fully raised condition in case of draft control by operating the protractor lever and check at the pressure gauge mounted outside that is it maintaining pressure of 120 bar.
6. Carry out same procedure for 6 to 8 times to check whether desired pressure in developing or not inside the cylinder and if it is find ok than only go for the further test otherwise send that lift assembly for reexamination.
7. Shift control lever to draft mode and attached the weight of 650 kgs. And again lift the arm to fully up condition at least for 10 to 12 sec. it must keep in that position if found ok then go for further test otherwise send that lift assembly for re-checking.
8. At last to release the pressure developed in cylinder we must switched off pump supply and the go for sensing mechanisms performance testing using the hydraulic sensing actuation mechanism drain out all the oil from the assembly.

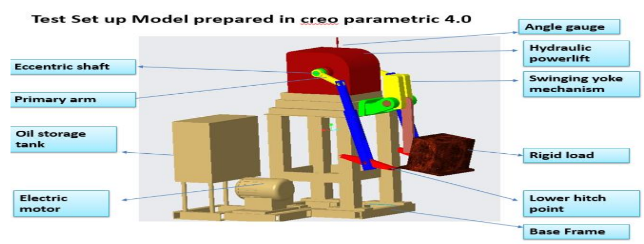

Figure 1. Cad model of Test setup

V. DESIGN OF CRITICAL COMPONENT

1. Oil Pressure required to operate power lift

lifting moment coming on eccentric shaft

= vertical force X horizontal distance

= (650X10) X 0.50

= 3.25KN-m

Now, let calculate the force required to rotate this shaft having diameter = 44mm.

Torque = force X (diameter/2)

So, force required to rotate the eccentric shaft

=147.72KN

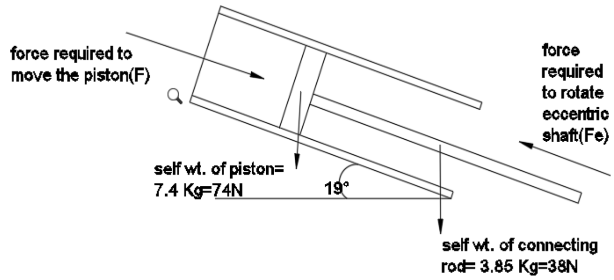

Figure 2.

Fx =0

F= (force required to rotate eccentric shaft)+(Horizontal component of self wt. of piston)+(horizontal component of self wt. of connecting rod) +(friction force)

= (147727) -(74cos19) - (38cos19) +(Fr)

Fy=0

N = 74sin19+ 38sin19=30.27N

friction force = μ X N

= 0.25 x 30.27=7.56(on single side)

From value obtained of friction force it is very small compare to other so we can neglect it and also wall of cylinder is grind to obtained smooth surface finish.

F=117622N

now,

Pressure = force / C.s area of piston

=117622 /2(3.14* 40*40) = 10.983Mpa = 110 bar.

2. Design of tube of rectangular cross section

Linier buckling analysis is being done discussed as below

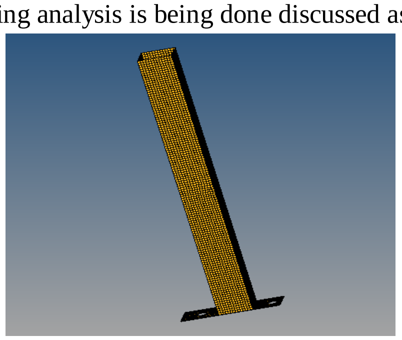

Figure 3. Meshed modeled of column

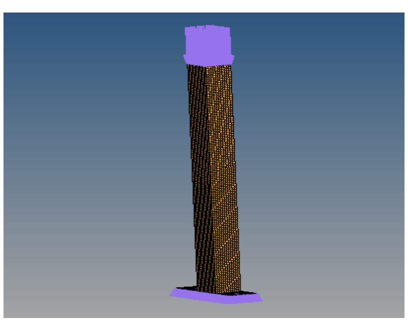

Figure 4. boundary conditions

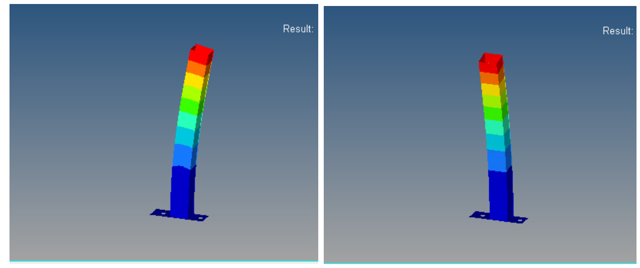

Figure 5. liner buckling load(Mode 1= 38.28KN,mode 2=27.86KN)

This is the allowable value of shear stress that can be induced in the shaft material for safe operation.

3. Design of base frame

Base frame : it is the basic support structure on which all the mountings such as columns, plates, lift assembly is mounted as shown in fig below

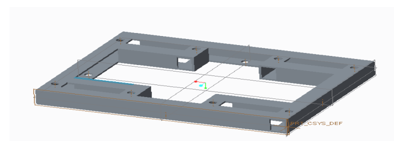

Figure 6. 3D model of base Frames

This base frame contain c type of channel section

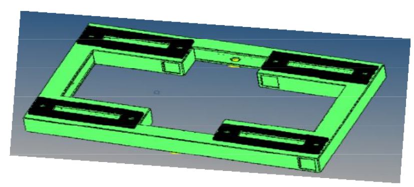

Figure 7. preparation of solution deck for FEM solutions

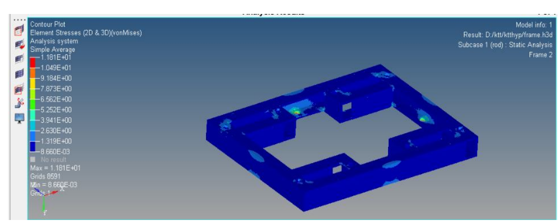

Figure 8. Stress distribution results of base fram

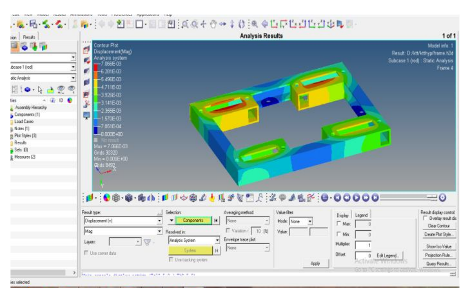

Figure 9. Displacement results

Here maximum stress developed is 18Mpa which shows the complete rigidity of the structure as per requirement that we need very rigid structure to absorbs all shocks hence C channel section with dimension = 50*35*5 is selected. With variable lengths.

4. Design of swinging yoke mechanism

This small and simple mechanism is designed to check the working of sensor spring of the power lift.

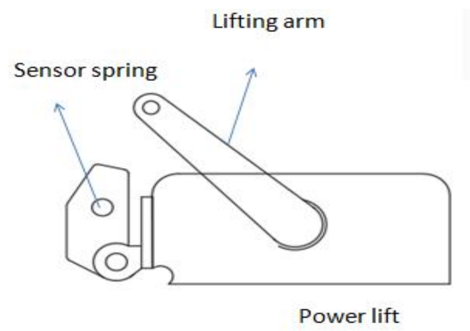

Figure 10.

The cad model of swinging yoke mechanism isshown in fig below.

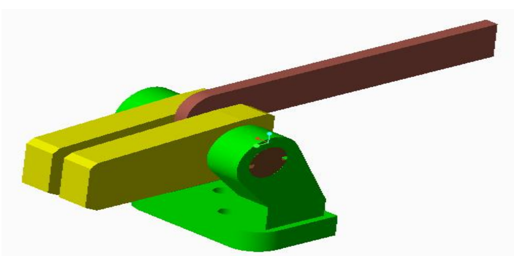

Figure 11. Cad model swinging yoke mechanism

Working of mechanism is discussed below.

- when we push spring forward than it touches the mounting pin and push it further.
- other end of the mounting spring is attached to the valve opening
- as soon as the spring get rotation by swinging yoke mechanism mounting pin touches the valve opening and pressure inside assembly gets removed.
- In case of tractor if sudden force comes on the lifting arm of the power lift while farming action may be due to hard stones of mud the to protect the power lift this arrangement is made.

Calculation for force required to push the spring forward and hydraulic cylinder selection.

$$\frac{T}{J} = \frac{\tau}{r} = \frac{G.\theta}{l}$$

Diameter of shaft = 25mm
Weight of the spring = 10.6 kg.
Modulus of rigidity = 79.3 Gpa
Torsional constant J = 38330 mm4
Angle of rotation = 50

Now, from torsional equation we can get the torque required = 13488 N mm.

Structural analysis of swinging yoke mechanism

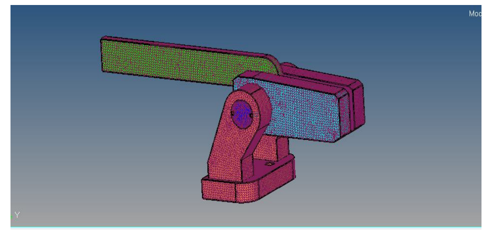

Figure 12. Meshed modeled with maximum mesh size 4mm.

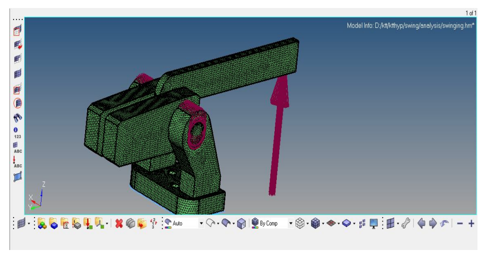

Figure 13. Boundary condition

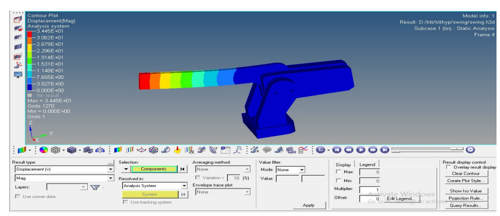

Figure 14. Total deformation

In the above work we have modelled a swinging yoke mechanism the 3D modelling is done through CREO 3.0, Hypermesh 12.0 as a pre-processor and optistruct as solver. It is found that maximum stress by theoretical and analytical methods are well below the allowable limit. Also deformation is small or negligible. Hence the swinging yoke mechanism is under safer side of stresses and deformations.

VI. EXPERIMENTAL ANALYSIS

As mention in IS1224,1987 following tests are conducted to check the accuracy of test set up.

- Test no. 1: Obtain the graph between angle of rotation of primary arm vs. pressure developed inside the cylinder.
- Test no 2: The ability of the lifting system to maintain the load in the lifted position without hydraulic power.

Following graph shows the relation between angle of rotation of the primary arm vs pressure developed inside the cylinder in the actual field failure test

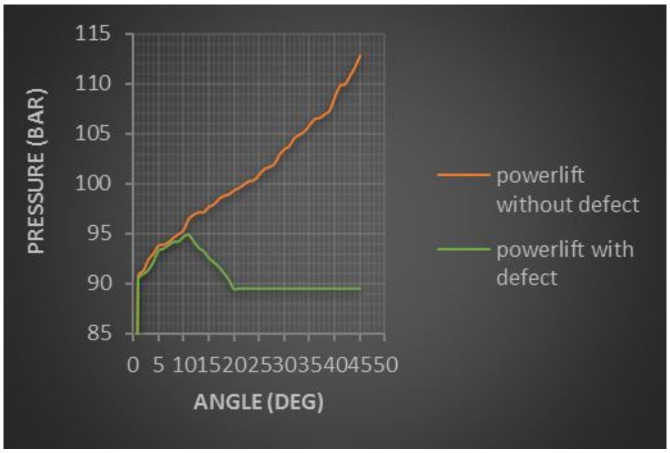

Figure 15.

VII. HYDRAULIC CIRCUIT

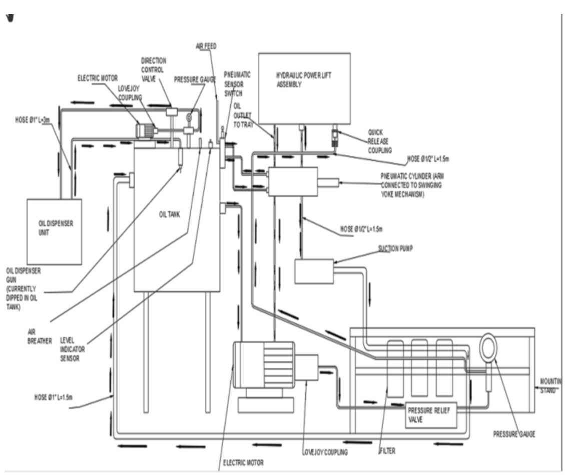

Figure 16. Hydraulic Circuit Diagram

Operation sequence

- Press the push button to start main motor on
- It will start continuous oil supply to dispenser
- Set the pressure of relief valve at 10-12 bar.
- Set quantity for filling
- Fill assembly with the oil
- Set the timer at required timing for extraction
- Push button on the panel of extraction on
- Indication will glow on screen pump will extract the oil from the power lift same will be collected in tank.
- When the oil level in the tank reaches low level sensor will operate relay which will stop the transfer pump automatically.
- Push and repeat the cycle.

VIII. RESULTS

Table 1.

COMPONENT	MATERIALS	YIELD STRENGTH(Mpa)	VON MISSES STRESS(Mpa)	Linear buckling load	Location	COMMENTS
Frame	Mild steel gradeISCG 40	240	18.07	NA	Bolting holes	Rigid
column	Steel grade SAE1012	310	NA	38.28	At top of column	Safe
Swinging yoke mechanism	Mild steel grade S355	340	162.56	NA	At fillet radius	Safe

Above table shows the von misses stress values for the various analysis of the components.

Results for Test no.1

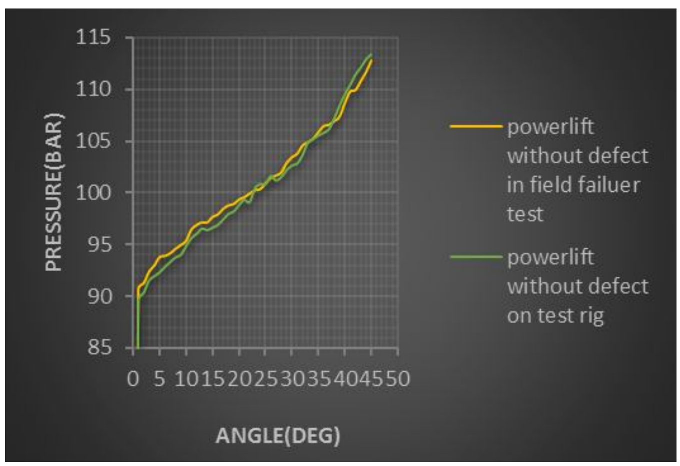

Figure 17. Graph : Angle of rotation of primary lifting arm Vs. pressure developed (On Test set up)

Table 2. shows the comparison between field failure test and experimental test

Angle of rotation	Specification of point	Powerlift without defect		Powerlift with defects	
		Field failure test Pressure in bar	On test setup Pressure in bar	Field failure test Pressure in bar	On test setup Pressure in bar
0°	Oil start entering in cylinder	0	0	0	0
11°	Lifting of weight start with noise change	96.42	95.65	94.88	94.03
20°	Pressure drop observed	99.32	98.88	89.45	89
45°	Fully lifted up condition	112.76	113.43	89.5	89

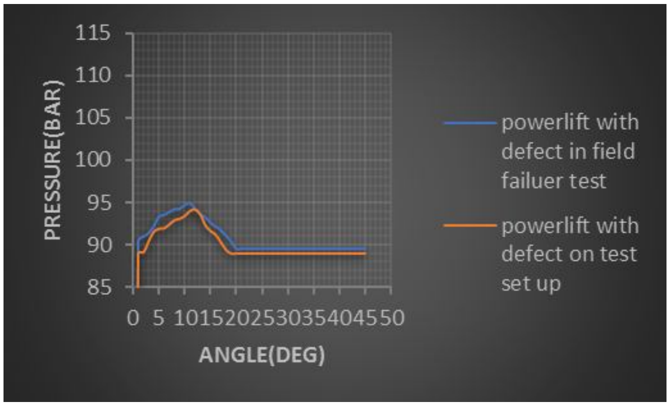

Figure 18. Graph : Angle of rotation of primary lifting arm Vs. pressure developed (On Test set up)

Results for Test no.2

Table 3.

Time(min)	0	4	8	12	16	20	Height (mm)
Powerlift without leakage	620	620	618.6	617.8	616	615.5	
Powerlift with leakage	620	615.8	581.1	520	450	450	

From above values it is clear that from the variation of height worker can easily judge that leakage is present or not.

IX. CONCLUSION

By understanding all the aspects of hydraulic power lift assembly test set is being designed. By using various terms of machine design and the technique of finite element analysis this set up is now developed . This set up is designed for Force motors ltd. In Company's tractor manufacturing plant this set up is going to installed soon.

- From the above comparison we can say that pressure values obtained from test set up are nearly matching with the values obtained in the field failure analysis.
- Ability of the powerlift to lift the load and maintain it to specific time is being observed easily.
- By using finite element analysis technique three important components are being designed such as base frame column and the swinging yoke mechanism.
- As per company's requirement an efficient design of set up is made which is very easy to handle to the worker.
- By using swinging yoke mechanism now testing of sensor spring is easily done with very less time.
- Due to strong and rigid base frame and very efficient hydraulic circuit even at very high production requirement test setup is being fulfilling the requirement.
- On an average 28 to 30 powerlift assembly model are tested per day on test set up.

X. ACKNOWLEDGMENT

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