# STRUCTURAL ANALYSIS AND PERFORMANCE EVALUATION OF MULTI PURPOSE AGRICULTURAL EQUIPMENT

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**Abstract— A Study has been carried out on structural analysis and performance evaluation of multi purpose agricultural equipment, which performs major agricultural operations like goods carrying, pesticide spraying, laddering, inter-cultivating and digging operations of sandy loam deep soils, to increase the efficiency and reduce the production and handling cost. the analysis was first fallowed by an solid works model fallowed by meshing using hyper mesh software and anal sizing it by ansys software, it was found that the stresses produced was 150Mpa and deformation was 20 mm under 800 kg's load ,it is proved to be safe when compare to allowable stresses of material. This paper also gives the information regarding performance evaluation of NCET kissan all in one.**

**NCET kissan all in one-agricultural equipment name**

## I. INTRODUCTION

FINITE ELEMENT ANALYSIS (FEA) IS A FAIRLY RECENT DISCIPLINE CROSSING THE BOUNDARIES OF MATHEMATICS, PHYSICS, AND ENGINEERING AND COMPUTER SCIENCE. THE METHOD HAS WIDE APPLICATION AND ENJOYS EXTENSIVE UTILIZATION IN THE STRUCTURAL, THERMAL AND FLUID ANALYSIS AREAS. THE ADVANTAGES OF FEA ARE NUMEROUS AND IMPORTANT. A NEW DESIGN CONCEPT MAY BE MODELED TO DETERMINE ITS REAL WORLD BEHAVIOR UNDER VARIOUS LOAD ENVIRONMENTS, AND MAY THEREFORE BE REFINED PRIOR TO THE CREATION OF DRAWINGS, WHEN FEW DOLLARS HAVE BEEN COMMITTED AND CHANGES ARE INEXPENSIVE. ONCE A DETAILED CAD MODEL HAS BEEN DEVELOPED, FEA CAN ANALYZE THE DESIGN IN DETAIL, SAVING TIME AND MONEY BY REDUCING THE NUMBER OF PROTOTYPES REQUIRED. AN EXISTING PRODUCT WHICH IS EXPERIENCING A FIELD PROBLEM, OR IS SIMPLY BEING IMPROVED, CAN BE ANALYZED TO SPEED AN ENGINEERING CHANGE AND REDUCE ITS COST.

**Preprocessing,**

In which the analyst develops a finite element mesh to divide the subject geometry into sub-domains for mathematical analysis, and applies material properties and boundary conditions. There are different types of Preprocessing packages in market

- Hyper mesh
- Ansa
- Msc.Patran
- Gambit

**Hyper mesh**

Altair Hyper Mesh is a high-performance finite element pre-processor to prepare even the largest models, starting from import of CAD geometry to exporting an analysis run for various

As long list of CAD formats ensures a high level of CAD interoperability. Altair's connector technology automatically assembles individual parts with their Finite Element representation. Hyper Mesh is entirely customizable. An extensive API library can be used to automate repeating tasks or do complicated math operations or modal generation.

With a focus on engineering productivity, Hyper Mesh is the user-preferred environment for

- Sold geometry modeling
- Surface geometry modeling
- Shell meshing
- Solid mesh generation
- Automatic Mid-surface generation
- Detailed model setup

**Benefits of Hyper mesh:**

- Open-Architecture Design

With the broadest set of direct CAD and CAE interfaces coupled with user defined integrations, Hyper Mesh fits seamlessly within any simulation environment.

- High-Speed, High-Quality Meshing

With both automatic and semi-automatic shell, tetra- and hexa-meshing capabilities, Hyper Mesh simplifies the modeling process of complex geometries.

- Advanced Model Morphing

A flexible set of morphing tools allows users to modify existing meshes to meet new designs and reduce model development costs.

- Increases End-User Modeling Efficiency

Batch Masher technology eliminates the need to perform manual geometry clean-up and meshing, thus accelerating the model development process.

- Reduces Training Time and Cost Through Elimination of Redundant Tools

An easy-to-use, intuitive graphical user interface makes it simple for anyone to learn the software, which further increases modeling efficiency and reduces training cost.

- Closes the Loop Between CAD and FEA

Create surfaces from finite elements enabling analysis engineers to communicate results and design modifications back into the design environment.

- Reduces Model Assembly Time

Leverage highly automated methods for rapid model assembly that create connections such as bolts spot welds, adhesives and seam welds.

**Methodology**

The overall process comprises of four main components namely Geometrical Design, Finite Element Modeling, Modal and Static Structural Analysis, Geometrical Design is the CAD part of work, where 3D structure of Agricultural Equipment is designed using Solid works software. After completing the geometrical design part, the Agricultural Equipment geometry is discretized to Finite Element model known as meshing, the Agricultural Equipment is meshed using tetrahedral elements and this can be achieved by using Hyper mesh tool. Finite Element model is then exported for analysis. Loads and Boundary conditions are applied and the structure is solved for given load
Condition using Ansys Workbench for Modal & Static structural analysis.

**Geometry details of Agricultural Equipment**

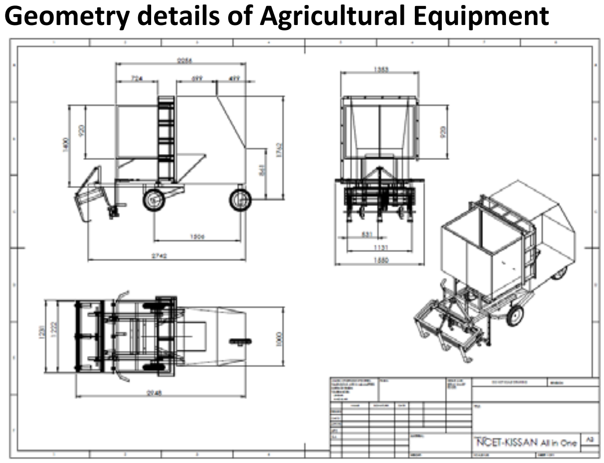



**Fig 1 Detailed 2D drawing of Agricultural Equipment**

Figure 1 shows the detailed dimensions of NCET kissan all in one

**Fig 2 The 3D model for the Agricultural Equipment**

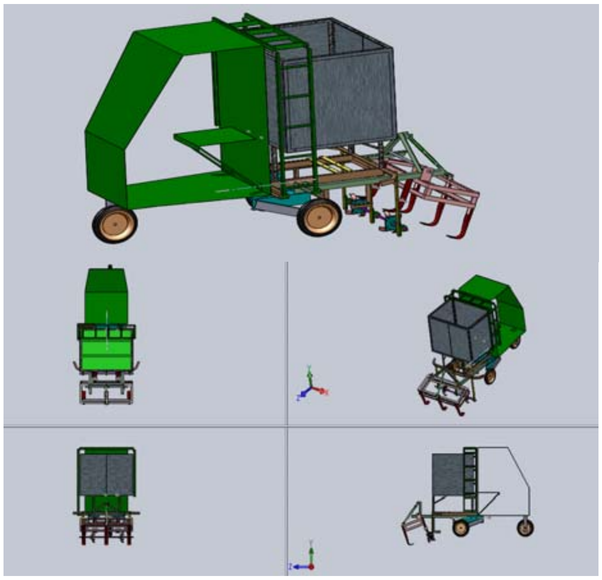
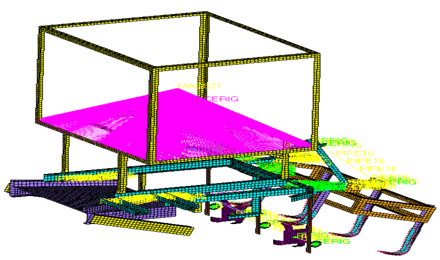
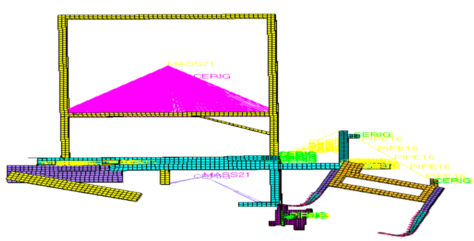


Figure 2 shows the 3D model of NCET kissan all in one

**Meshing of overall agricultural equipment assembly**



**Meshing of overall agricultural equipment assembly (side view)**



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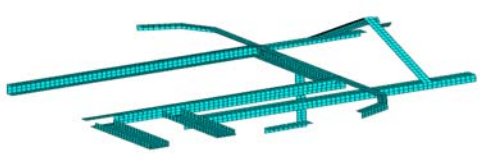
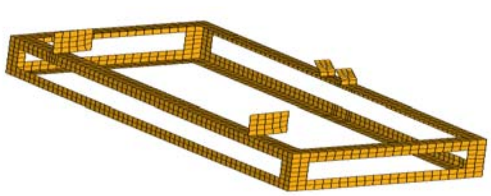
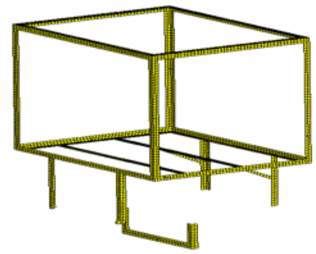
**Meshing of rear engine main frame**



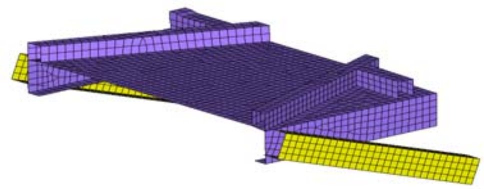
**Meshing of plough main frame**



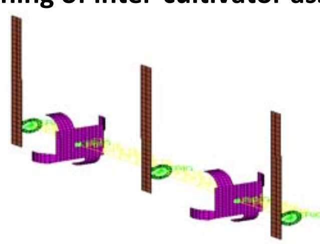
**Meshing of goods carrying container main frame**



**Meshing of front cabin main frame**



**Meshing of inter-cultivator assembly**



**Element Details**

| SL NO | TYPE OF ELEMENT | NUMBER OF NODES | NUMBER OF ELEMENTS |
|---|---|---|---|
| 1 | SHELL 63 | 12816 | 10870 |
| 2 | PIPE 16 | 31 | 29 |
| 3 | MASS-21 | 2 | 2 |

**Table 1 shows the type of element used.**

**Material Properties, Boundary and Loading Conditions**

**Material Properties**

Base material of the Agricultural Equipments Mild Steel and cast iron. Table 2 shows material properties of Mild Steel .

**Table 2 Material property of Mild Steel**

| SL NO | MATERIAL | DENSITY KG/M³ | YOUNGS MODULES | YIELD STRESS | ALLOWABLE STRESS |
|---|---|---|---|---|---|
| 1 | MILD STEEL | 7850 | 210000 | 250 MPA | 160 MPA |

**Boundary Condition**

Structural Boundary conditions are in the form of zero displacements, Boundary conditions specify to act on all directions (X, Y and Z) or in certain directions only. In this case, Boundary conditions (BC) are applied on the Main bed of Chassis of Agricultural Equipments show in fig 3 allowing the modal deformation as a whole.

**Loading Condition**

Loading condition is defined to be forces distributed on the surfaces of the Agricultural Equipments shown in fig 5 .An engine mass of 23 kg's, load on cabin (goods carrying) 400 kg's ,load on plough (each blade) 90 kg's has been imposed on to the equipment.

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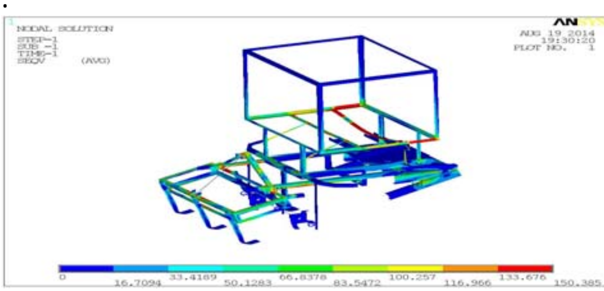


**Fig-3, stresses of entire assembly under 800 kg's load**

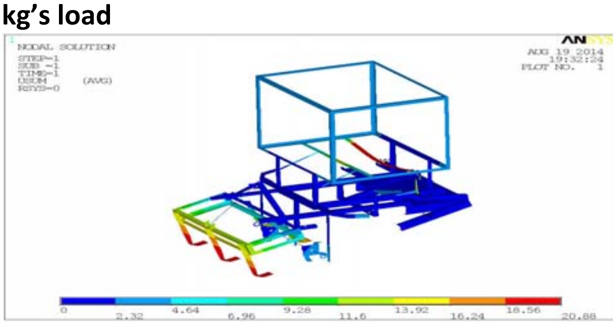


**Fig-4, displacement of entire assembly under 800 kg's load**

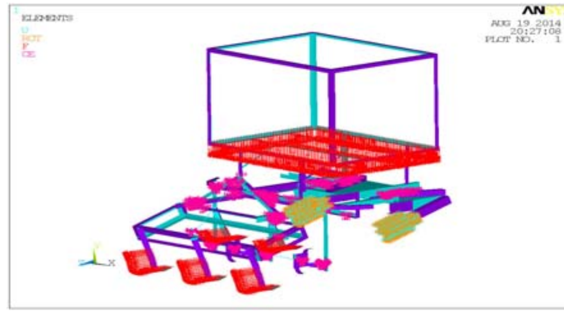
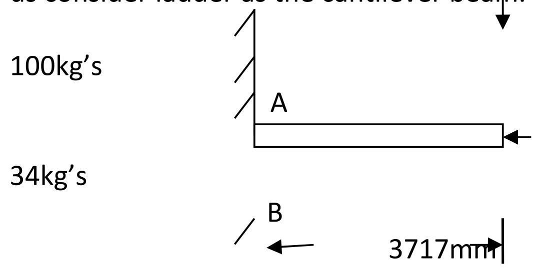


**Fig-5, loads of entire assembly**

**Design of ladder**

The ladder is fixed (hinged) on one end, and supported on the other end, hence let us consider ladder as the cantilever beam.




Here , the overall length of ladder is 3717mm from the vehicle base, and an 100 kg's of load is applied in tensile direction considering the weight of human body, and 34 kg's of load is applied in compressive directions considering the weight of ladder.

The ladder is subjected to both axial and bending load, hence the critical points are A&B. Direct stresses due to axial load.

$$\sigma_1 = \frac{F}{A} = \frac{-333.44}{[illegible]} = -2.09 * 10^{-3}$$

$$\sigma_b = \frac{Mb}{I}.C$$

Where $I = \frac{bd^3}{12} = \frac{360*20^3}{12} = 240000m^4$

$$= \frac{981*3717}{240000} * \frac{20}{2}$$

$$\boxed{\sigma_b = 151.93\ N/mm^2}$$

Now, considering at point A,

$$\sigma = \sigma_1 + \sigma_b$$

$$= -2.09 * 10^{-3} + 151.93$$

$$= 151.927 (tensile).$$

Maximum normal stress at A

$$\sigma_{max} = 151.927 \frac{N}{mm^2}.$$

Minimum normal stress at A

$$\sigma_{min} = 0\ (compressive).$$

Maximum shear stress at A

$$\tau_{max} = \frac{\sigma_{max}}{2}$$

$$= \frac{151.927}{2}$$

$$\tau_{max} = 75.96 \frac{N}{mm^2}.$$

Now, considering at point B,

$$\sigma = \sigma_1 - \sigma_b$$

$$= -2.09 * 10^{-3} - 151.93$$

$$= 151.927 (tensile).$$

Maximum normal stress at B

$$\sigma_{max} = 0 \ (tensile).$$

Minimum normal stress at A

$$\sigma_{min} = 151.927 \ N/mm^2 (compressive).$$

Maximum shear stress at B

$$\tau_{max} = \frac{\sigma_{max}}{2}$$

$$= \frac{-151.927}{2}$$

$$\tau_{max} = -75.96 \ N/mm^2.$$

Hook's law states that stress is directly propositional to strain

$$E = \frac{\sigma}{\epsilon}$$

From DHB the material properties of mild steel where E (young's modulus)=210Gpa

$$= \epsilon = \frac{\sigma}{E}$$

$$= \frac{151927}{210000}$$

$$\epsilon = 0.0007234.$$

We know that,

$$\epsilon = \frac{change \ in \ length}{orginal \ length}$$

$$= \frac{\Delta l}{l}$$

$$= \Delta l = \epsilon * l$$

$$= 0.0007234 * 3717$$

$$\Delta l = 2.6888mm.$$

**Results and discussions**

**Performance evaluation**

**Abstract**

To determine the efficiency of two stroke Bajaj Re auto rickshaw engine with help of brake drum dynamometer.

**Introduction**

A two stroke petrol engine performs only two strokes to complete one working cycle this works on theoretically Otto cycle it consists of a cylinder with one end fitted with the cover ,on the other end it is fitted with a sealed crank case3 so that it can function as a pump in conjunction with piston two openings known as inlet port and exhaust port are provided in below and on circumference of cylinder. The lower one adjusts the petrol engine and air mixture in the crank case and through upper one spent gases are expelled out of cylinder.

A transfer of the port provided diametrically opposite to the exhaust port. Serves as passage for the transfer of petrol and mixture from crankcase to cylinder

**First stroke**

At the beginning piston is at lower end spark plug initiates the compressed petrol and air mixture. The combustion of petrol will release the hot gases which increases the pressure to the cylinder.

**Second stroke**

In this stroke piston ascends when it covers the transfer port the supply of petrol and air mixture is cut off and when it further moves upward covers the exhaust port.

**Methodology**

- First check fuel level in the tank if necessary fill it.
- Start the engine and keep the rpm as constant for desired rpm.
- Apply the load on the engine and set the rpm to the initial level speed.
- Now measure the fuel consumption for 10cc speed and spring balance volume
- Repeat the same for different loads and calculate the efficiencies.

**Technical specifications**

| | |
|---|---|
| Diameter of bore (D) | 57mm |
| Stroke length (L) | 57mm |
| Compression ratio | 0.7:1 |
| Number of cylinders | 1 |
| Rated speed | 5200 |
| Radius of brake drum | 0.125m |
| Calorific valve of fuel (Cv) | 48070 kJ/kg |
| Density of petrol | 720 kg/m$^3$ |
| Specific gravity of oil | 0.72 |

**Table 3, shows technical specifications of engine used in NCET kissan all in one.**

**Formulas**

$S=S_1-S_2$= load acting on a brake drum in kg's.

Where $S_1$ and $S_2$ are spring balance reading in kg's

t=time taken to consume 10cc of petrol in seconds

$m_f$ =mass of fuel consume 10cc of petrol in seconds

$v_f$ =volume of petrol consumed in m$^3$/sec

$h_w$ = monometer reading in m of $H_2o$

$N_e$ = speed of engine

$N_b$ = speed of brake drum = Ne/G.R

$m_f = v_f*S_g*1000/10^6*t$

T = torque =S*Db* 9.81/2 in Nm

Db=dia of brake drum

BSFC = brake specific fuel consumption in kJ/kw hr

$\eta_{bt}$=BP*100/$m_f$*Cv

BSFC=$m_f$*3600/Bp in kg/kw hr

$\eta_v$ =Va/Vs

Where Va=actual volume of air supplied

Vs=stroke volume

Va= $C_d*ao\sqrt{2000*g*h_w/\rho_a}$

Vs=$\pi*D^2*l*Ne/4*60$

Cd of orifice =0.62

Where D = dia of engine cylinder in m

L =stroke length in m

Ne =speed of engine

$\rho_a$ = atmosphere pressure = 1.013*100 KN/m$^2$

T=room temperature in Kelvin

Air fuel ratio =$m_a/m_f$

Where $m_a$ =loss of air in kg/sec=$v_a*\rho_a$

**Graphs**

**BP v/s BSFC**

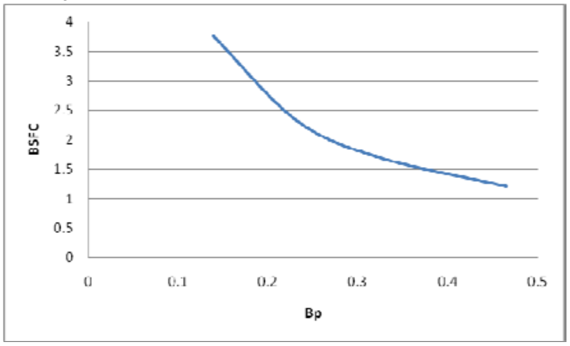



**Fig 6, graph of BP v/s BSFC**

The above graph shows as the brake power produce is increased the amount of fuel is consumption is less and vice versa.

**Air fuel ratio v/s $\eta$ volumetric**

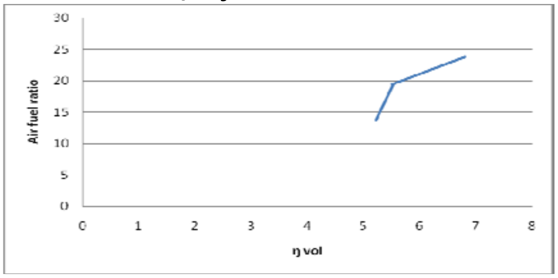



**Fig 7, graph of Air fuel ratio v/s $\eta$ volumetric**

The above graph shows that as air fuel ratio is increased the volumetric efficiency is also increased and vice versa

**Speed v/s BP**

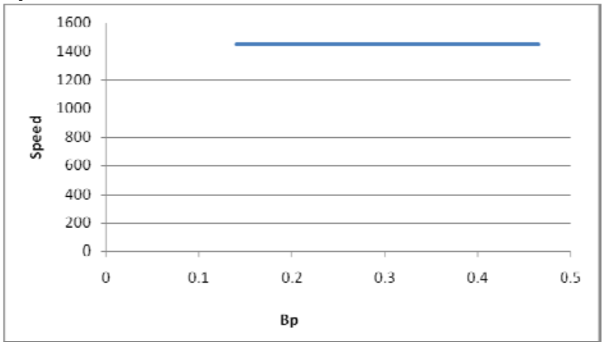



**Fig 8, graph of speed v/s Bp**

Fig 6.3 shows the graph of speed v/s Bp where as the speed is increased relatively the Bp is also increased and the graph fallows an straight line as shown the graph.

**5.17 performance evaluation by field test**

- Amount of fuel consumed per distance travelled (millage) =25 km/ltr.
- Maximum speed of vehicle in up gradient = 28 km/hr
- Maximum speed of vehicle in down gradient = 44 km/hr
- Maximum speed of vehicle in level roads = 36 km/hr
- Gross weight of goods carrying container = 90 kg's
- Gross weight of ploughing assembly = 55 kg's
- Gross weight of inter-cultivator assembly = 25 kg's
- Gross weight of two engines = 46 kg's
- Gross weight of water pump assembly = 8 kg's
- Gross weight of ladder = 34 kg's
- Gross weight of vehicle body and other upholstery attachments = 90 kg's
- Gross weight of vehicle including all attachments =348 kg's
- Net load can be carried through the vehicle (FOS 2) = 400 kg's
- Overall length of vehicle =2948 mm
- Overall width of vehicle = 1550 mm

Conclusion

The induced stress was $\sigma = 151.927 \text{ (tensile)}$.

The deformation $\Delta l = 2.6698 mm$

Hence, the allowable stress is 160 Mpa; since the induced stress is 151 Mpa the design is safe

REFERENCES

[1] J.S MAHA, A.S BAL and G.S MANES "Performance evaluation of commercial sunflower threshers and their role in Punjab", Journal of agricultural engineering, Vol, 40(1): January. March, 2003

[2] B.VELAZQUEZ AND E.FERNANDEZ "Analysis of process of biomass harvesting with collecting chippers fed by pick up headers in plantations of olive trees", science direct Bio systems engineering 104(2009)184-190

[3] V.K CHANDEGARA "design and developing of bullock drawn multi-purpose implement for sandy loam soil", Journal of agricultural engineering, Vol, 40(4): October December, 2003

[4] TEIJO PALANDER, LAURI VESA, TIMO TOKOLA "Modeling the stump biomass of stands for energy production using a harvester data management system" Biosysytems Engineering 102 (2009) 69-74

[5] JADO M. SERRANO, JOSE O. PECA "The effect of liquid ballast and tyre inflation pressure on tractor performance" Biosysytems Engineering 102 (2009) 51-62