Design And Finite Element Analysis of Crank Shaft Voor Cutting Used In Agricultural Ploughing

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Abstract- *For the present growing population, the development in the agricultural engineering mainly focuses on modernization in using of agricultural equipment, development in latest fertilizers and harvesting Technologies. Agriculture being one of the major occupation in India, it is very essential to discover and implement new idea in this field, though lot of work has been done in this area. It is unfortunate that, these ideas are not been implemented properly in actual field. This is due to high cost and is complicated for rural people. This study deals with changing the design of the existing Equipments, which is used for ploughing methods.*

The objective of the project is to design crank shaft voor cutting machine and perform finite element analysis. The Crank shaft voor cutting machine is a similar type of tillage component but it consists of different cutting tool and topology used in this equipment is similar to crank shaft principle. In this project similar advanced type of tool is designed. Modeling and analysis of Agricultural Plough has to be performed to know normal and tangential interfacial forces acting on the plough due to gravitational weight implantation on the plough. The 3d model required for finite element analysis shall be created in NX-CAD and Ansys software is used for finite element analysis. During the part of the project a dynamic analysis of voor cutting equipment was also carried out. From the dynamic analysis results, mode shapes and frequencies are documented by using FEA software. Harmonic analysis is performed by providing the force i/p to determine amplitude v/s frequency and the graphs are plotted. Finally design optimization of the voor cutting equipment shall be done to increase the factor of safety of voor cutting equipment component.

Keywords- Crank type mechanism, voor cutting machine, structural and dynamic analysis, Agricultural plough.

I. INTRODUCTION

The Crank shaft voor cutting machine is a type of tillage component but it consists of different cutting tool and topology used in this equipment and is similar to crank shaft principle. In this project a similar advanced type of tool is designed and analyzed..

Tillage is the agriculture preparation for soil agitation of various types, like as burrowing, mixing, and overturning. Cases of human-controlled working using hand tools strategies utilizing hand apparatuses incorporate include shoveling, picking, mattock work, hoeing, and raking. Little scale cultivating and cultivating, for family unit nourishment generation or independent venture creation, tends to utilize the littler scale strategies above, while medium-to vast scale cultivating tends to utilize the bigger scale techniques. There is a liquid continuum, be that as it may. Any sort of cultivating or cultivating, however particularly bigger scale business writes, may likewise utilize low-till or no-till techniques too.

Tillage is often classified into two types, essential and auxiliary. There is no strict limit between them to such an extent as a free refinement between tillage that is more profound and more exhaustive (essential) and culturing that is shallower and some of the time more specific of area (optional). Essential culturing, for example, furrowing tends to create an unpleasant surface complete, though optional culturing tends to deliver a smoother surface complete, for example, that required to make a decent seedbed for some harvests. Nerve racking and rot tilling frequently consolidate essential and auxiliary culturing into one activity.

" Tillage " can likewise mean the land that is worked. "Cultivation" has a few detects that cover generously with those of "culturing". In a general setting, both can allude to agribusiness. Inside horticulture, both can allude to any of the sorts of soil disturbance depicted previously. Furthermore, "development" or "developing" may allude to a much smaller feeling of shallow, specific optional culturing of line trim fields that murders weeds while saving the product plants.

1.1 TILLAGE TYPES

1. Reduced tillage:

Reduced tillage leaves in the vicinity of 15 and 30% build-up cover on the dirt or 500 to 1000 pounds for every section of land (560 to 1100 kg/ha) of little grain deposit amid the basic disintegration time frame. This may include the utilization of an etch furrow, field cultivators, or different executes. See the general remarks underneath to perceive how they can influence the measure of deposit.

2. Intensive tillage:

Intensive tillage leaves under 15% product deposit cover or under 500 pounds for each section of land (560 kg/ha) of little grain buildup. This kind of culturing is regularly alluded to as traditional culturing however as conservational culturing is presently more generally utilized than serious culturing (in the United States),it is frequently not fitting to allude to this sort of culturing as customary. Serious culturing frequently includes numerous activities with actualizes, for example, a form board, plate, as well as etch furrow. At that point a finisher with a harrow, moving crate, and shaper can be utilized to set up the seed bed. There are numerous varieties.

3. Conservation tillage:

Conservation tillage leaves no less than 30% of harvest deposit on the dirt surface, or if nothing else 1,000 lb/air conditioning (1,100 kg/ha) of little grain buildup at first glance amid the basic soil disintegration period. This moderates water development, which decreases the measure of soil disintegration. Preservation culturing likewise benefits agriculturists by diminishing fuel utilization and soil compaction. By diminishing the circumstances the agriculturist goes over the field, ranchers acknowledge noteworthy investment funds in fuel and work. In many years since 1997, protection culturing was utilized as a part of US cropland more than escalated or decreased culturing.

Notwithstanding, protection culturing defers warming of the dirt because of the diminishment of dim earth introduction to the glow of the spring sun, subsequently deferring the planting of the following year's spring yield of corn.

- No-till - Never utilize a furrow, plate, and so forth until kingdom come. Goes for 100% ground cover.
- Strip-Till - Narrow strips are worked where seeds will be planted, leaving the dirt in the middle of the columns untilled.
- Rotational Tillage - Tilling the dirt at regular intervals or less frequently (every other year, or each third year, etc.).Ridge-Till
- Zone culturing - This type of preservation culturing is additionally clar

4. Zone tillage:

Zone tillage is a type of changed profound culturing in which just thin strips are worked, leaving soil in the middle of the lines untilled. This kind of culturing disturbs the dirt to help lessen soil compaction issues and to enhance inward soil waste

II. OBJECTIVE OF THE PROJECT

Now a day new Technologies are being developed by human’s knowledge. Agriculture technology is one of them. Development of agriculture field is very costliest. Simple structures and good efficiency of components will increase the utilization and life growth rate of components. These are all performed in design optimization. Tillage operations such as creation of seedbed movements of soil from high to low places, farm road construction, land levelling etc have depend on design of tillage. To good seedbed preparation, design optimization of tillage component is necessary. In this project, the Crank shaft voor cutting machine which is a similar type of tillage component but it consists of different cutting tool is designed and analyzed for different operating conditions. The topology of the voor cutting equipment used in this project is similar to crank shaft principle. The project also includes the documentation of 3D model of voor cutting equipment component by using NX CAD software. Developed 3-D model of voor cutting equipment component is imported into ANSYS using the Parasolid format. The analysis shall be performed in both static and dynamic condition. Modal analysis is performed to understand the dynamic characteristics of the equipment and Harmonic analysis is performed by providing the force i/p to determine amplitude v/s frequency and the graphs are plotted. Design optimization of the voor cutting equipment has to be done to increase the factor of safety of voor cutting equipment component.

III. METHODOLOGY

- The methodology followed in the execution of the project includes the following.
- Perform literature survey and do the requirement gathering.
- Evaluate boundary conditions and loading applicable on the voor cutting equipment from previous journals and from design calculations.
- Develop the 2D drawings and 3D part models of voor cutting components by NX CAD software.
- Perform assembly of voor cutting components in NX CAD software.
- Perform static analysis on the voor cutting assembly and document the deflections and stresses on each part of the voor cutting assembly using ANSYS 11.0 software.

- Perform Modal analysis in ANSYS 11.0 software and plot natural frequencies and corresponding mode shapes of the voor cutting assembly .
- Perform Harmonic analysis of voor cutting assembly in ANSYS 11.0 software and plot the frequency Vs amplitude at different locations of voor cutting assembly.
- Design optimization of the voor cutting assembly is done based on the results obtained from the analyses to increase the factor of safety.

IV. 3D PART MODELING AND ASSEMBLY OF VOOR CUTTING ASSEMBLY

4.1 OBJECTIVE:

The objective of the project is used to generate a 3d model of each assembly component used in crank shaft voor cutting and generate manufacturing drawings. By using assembly techniques each component is assembled to manufacture crank shaft voor cutting machine.

The Voor cutting assembly consist of 10 parts, each part is been listed below and by using above objective process the 3d model of each part is created.

1) Blade
2) Connecting plate
3) Connecting rod
4) Nut & washer
5) Shaft
6) Sleeve support
7) Support box
8) Support box-1
9) Bearing assembly

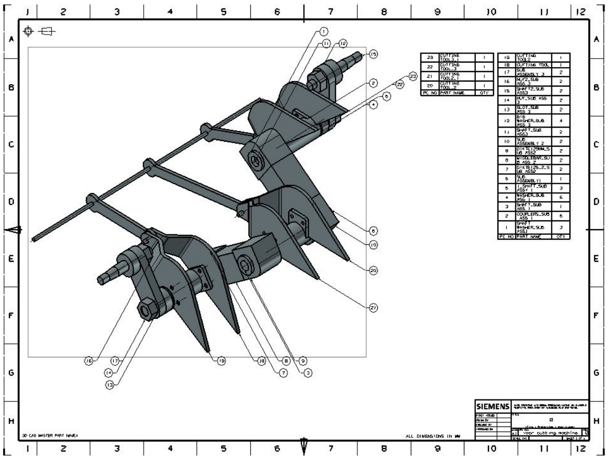


Fig 4.1: Bill of material of Voor cutting assembly

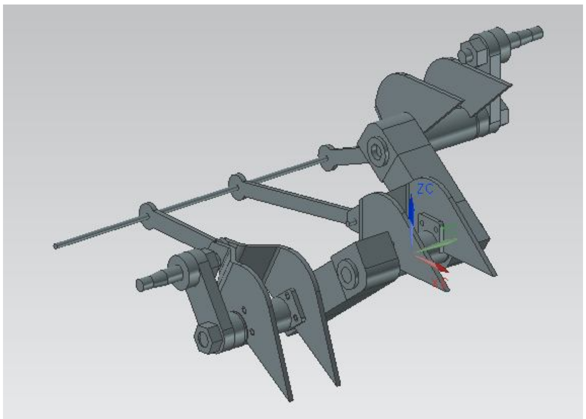


Fig 4.2: Isometric view of Voor cutting assembly

V. FINITE ELEMENT ANALYSIS OF VOOR CUTTING EQUIPMENT ASSEMBLY

5.1 OBJECTIVE

In this project the voor cutting assembly is modeled using NX-CAD and imported into Ansys to perform structural static and dynamic analysis. The static analysis is performed by applying the tangential and soil force obtained from the calculations. From the analysis the deformations and stresses are plotted to check if the values are within the limits of the material. In general any assembly will withstand the static loading condition, but they often fail in dynamic loading. So, a dynamic analysis is carried out in order to check whether the voor cutting assembly is withstanding the dynamic conditions or not. In dynamic analysis first modal analysis was done to understand the natural frequencies of the voor cutting assembly. From the modal analysis natural frequencies and corresponding mode shapes are plotted. later the analysis is extended to harmonic analysis to check the voor cutting assembly response at critical frequencies I.e. the resonance condition. From the harmonic analysis the frequency Vs amplitude at the critical frequency is plotted. Based on the results, the design changes were made to optimize the assembly to with the dynamic conditions as well.

The following parameters were used during the analysis: Blade design has been optimized considering that blade parameters are functions of operating parameters, soil parameters, and tool parameters. The draught requirement of any passive tillage implement T_D in N was found to be function of working depth d in m, travel speed V in km/h, width of the implement w in m, tool geometry characterized by angle θ in degree and length l in m, and soil properties such as bulk density in kg/m3 and cone penetration resistance R in KPa and can be expressed as

$$T_D\ f\ (d\ V\ w\ l\ \theta R)\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

The above equation can also be written as

$$T_D\, f_1(d\ V)\ f_2\ (w\ l\ \theta f_3(R) \ldots\ldots\ldots\ldots\ldots\ldots 2$$

Where f_1, f_2 and f_3 are functions related to operating parameters, implement geometry and soil conditions respectively. In the similar way here, considering a 45 hp tractor for the rotator tests following data are taken:

Tractor Power (P_N) = 45 hp,
Tractor forward speed (L_1) = 0.7 m/s
Typical traction efficiency (η_e□) = 0.8-0.9,
Coefficient of reservation of tractor power (μ_P) =0.7-0.8,

The following are the parameters for Voor cutting assembly used in the study

Work depth (a) = 220 mm,
Work width (b) = 1350 mm,

Operating parameters which were considered during the static analysis are given below:

Rotor rpm = 206,
Blade peripheral velocity = 5.5 m/s,
Total number of blade n = 6,

Number of blades one each side of the flanges e=2 and hence $n_e = e/n$ = 2/6=0.33.

The Tangential force acting on each of the blades (F_t) is calculated by the following equation:

$$F_{t=}\ 75{*}C_r{*}N{*}\eta_t{*}\eta_p/u_{\min}$$

- C_r is the non-reliability factor equal to 1.5 for non-rocky
- soils and 2 for rocky soils,
- N is the power of the machine taken as 33 kW for small
- weeding machine,
- η_t is traction efficiency taken as 80%,
- η_p is coefficient of reservation of power taken as 0.8,
- u min is minimum peripheral velocity taken as 5.5 m/s,
- C_t is coefficient of tangential force taken as 0.8,
- I is numbers of flanges taken as 3,
- e is number of blades on each side of the flange taken as 2

Soil force F_s acting on the sharpened edge of the blade is given by

$$F_s = F_t{*}C_t/I{*}e{*}n_e$$

Then from the above calculations we get

Tangential force F_t=576 kg = 5760 N
Soil Force F_s=290 kg = 2900 N

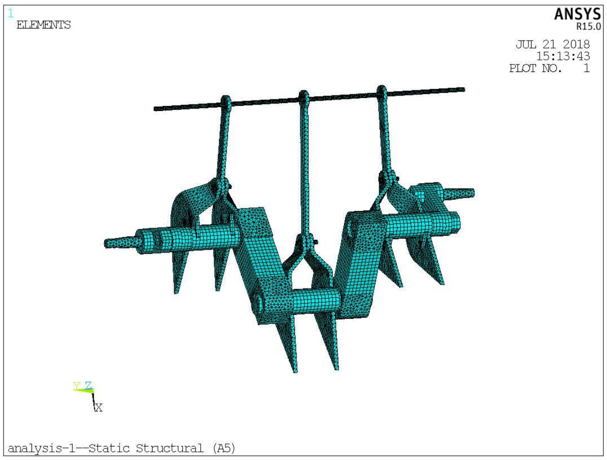


Fig 5.1: Meshed model of Voor cutting assembly

5.2 MATERIAL PROPERTIES:

Grey Cast iron and Carbon steel are the general materials used to fabricate any tillage equipment. As Voor cutting equipment is also a kind of tillage, in this project all the parts of the Voor cutting equipment are assigned with grey cast iron material. The material properties assigned for the parts are shown below.

Material properties of Grey Cast Iron :

- Young modulus(E) = 1.1e11 N/m^2
- Density (ρ) = 7200 kg/m^3
- Yield strength = 500 MPa
- Poison's ratio = 0.28

5.3 STRUCTURAL STATIC ANALYSIS OF VOOR CUTTING EQUIPMENT:

Structural static analysis was performed on the voor cutting assembly to plot deflections and stresses on different parts of the assembly. The analysis was done by applying the tangential and soil force obtained from the calculations. The boundary conditions used for the analysis are shown below.

Boundary conditions and Loading:

- The positions where are Voor cutting equipment attached to the tractor are fixed in all DOF as shown in the below figure.

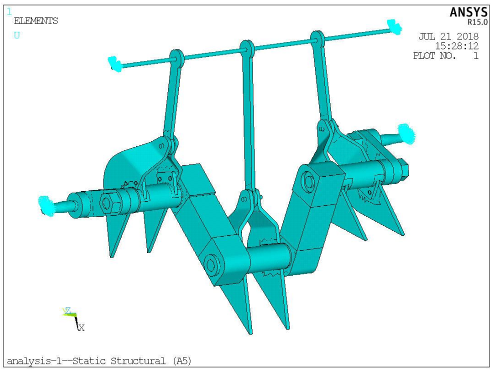


Fig 5.2:Boundary conditions applied on Voor cutting Assembly for static analysis

- Tangential and soil force applied on the blades of the voor cutting assembly as shown in the below figure.

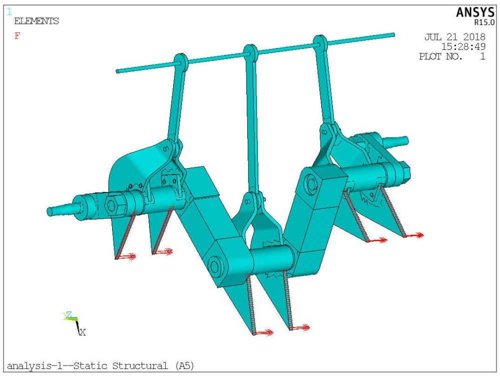


Fig 5.3: Loading applied on Voor cutting Assembly for static analysis

5.4 RESULTS

From the static analysis the deflections and stresses are plotted and are shown in the below figures. The total deflection observed on the Voor cutting assembly for static loading is observed as 0.9 mm as shown in the below figure 5.4.

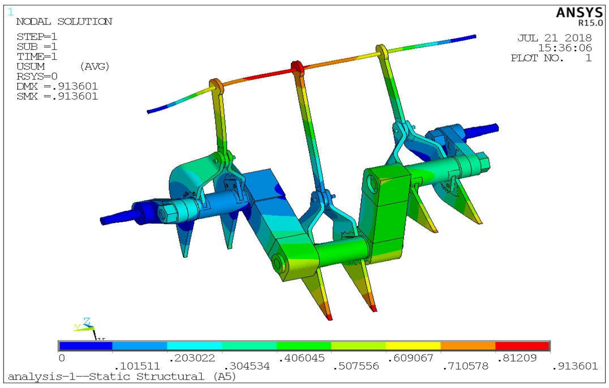
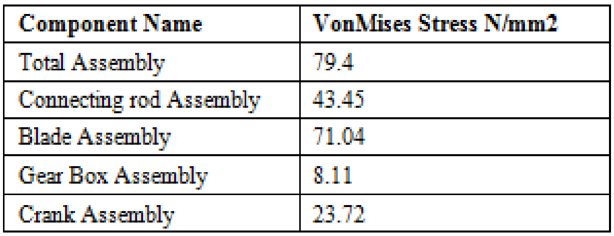


Fig 5.4: Total deflection of Voor cutting assembly for static loading

VonMises Stress: VonMises stress is the maximum stress obtained in Ansys. In this project Maximum stress failure theory is used, which says that the VonMises stress should be less than the yield strength of the material for the design to be considered safe and also factor of safety (FOS) is calculated as Yield strength/VonMises stress. The VonMises stress plot for different parts of Voor cutting assembly are plotted as shown in the below figures. The maximum VonMises stress observed for different parts are listed in the below table and the corresponding plots are shown in the subsequent figures.



Component Name	VonMises Stress N/mm2
Total Assembly	79.4
Connecting rod Assembly	43.45
Blade Assembly	71.04
Gear Box Assembly	8.11
Crank Assembly	23.72

Table 5.1: VonMises stress observed on different parts

VonMises stress on total assembly of Voor cutting equipment is observed as 79.4 N/mm^2

VonMises Stress on Total assembly:

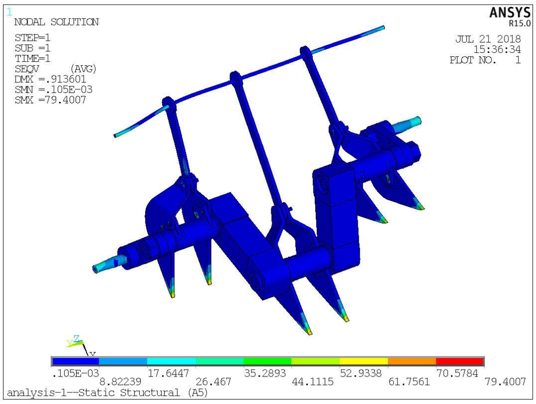


Fig 5.5: VonMises stress on total assembly for static loading

VonMises Stress on Connecting rod assembly: VonMises stress on Connecting rod assembly of Voor cutting equipment is observed as 43.45 N/mm^2

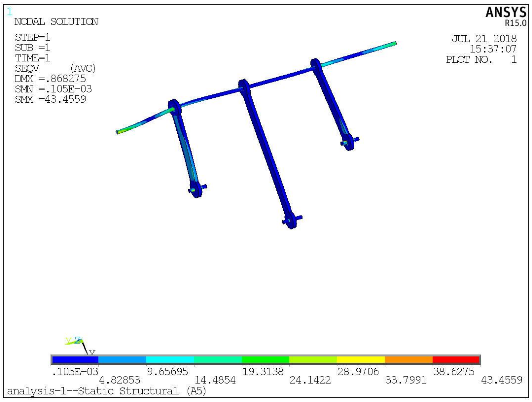


Fig 5.6: VonMises stress on connecting rod assembly for static loading

VonMises Stress on Blade Assembly: VonMises stress on blade assembly of Voor cutting equipment is observed as 71.04 N/mm^2

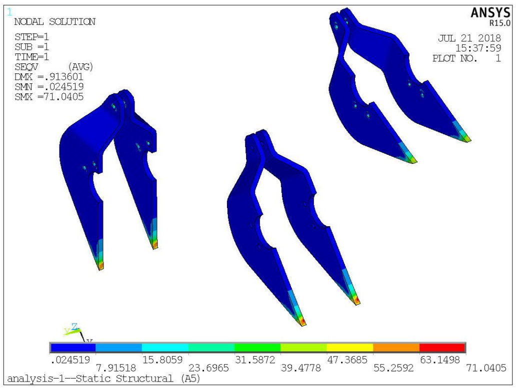


Fig 5.7: VonMises stress on blade assembly for static loading

VonMises Stress on Gear box Assembly: VonMises stress on Gear box assembly of Voor cutting equipment is observed as 8.11 N/mm2

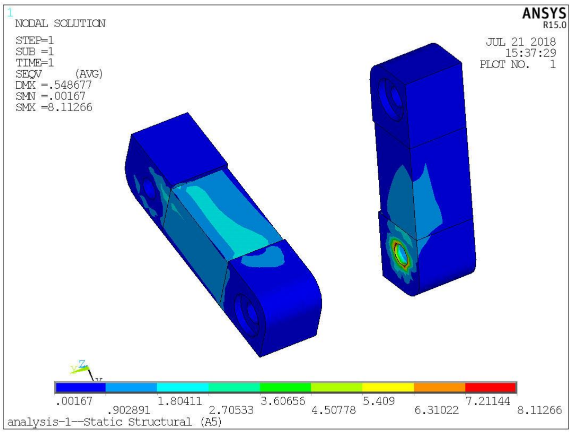


Fig 5.8: VonMises stress on Gear box assembly for static loading

VonMises Stress on Crank Assembly: VonMises stress on Crank assembly of Voor cutting equipment is observed as 23.72 N/mm2

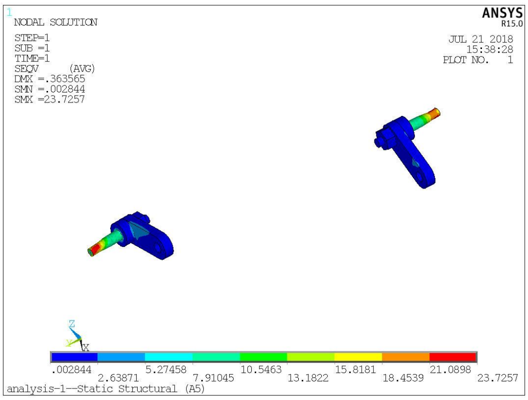


Fig 5.9: VonMises stress on crank assembly for static loading

From the structural static analysis it is concluded that the maximum VonMises stress (79.4 Mpa)is less than the yield strength of the material (500 Mpa).The factor of safety for the static loading is 500/79.4 = 6. Therefore the Voor cutting assembly is safe for the applied operating loads.

Dynamic analysis is carried out on the voor cutting assembly in order to check whether the voor cutting assembly is withstanding the dynamic conditions or not. In dynamic analysis first modal analysis was done to understand the natural frequencies of the voor cutting assembly. From the modal analysis natural frequencies and corresponding mode shapes are plotted.

5.4 MODAL ANALYSIS

Boundary conditions: The boundary conditions applied for the modal analysis are shown below.

- The positions where are Voor cutting equipment attached to the tractor are constrained in all DOF as shown in the below figure.

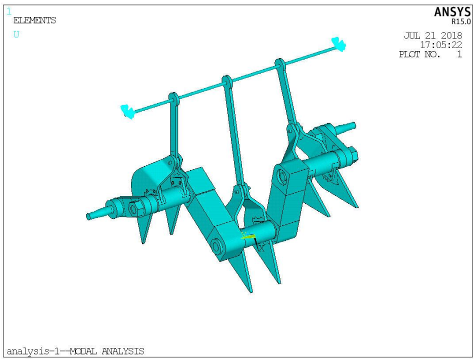


Fig 5.10: Boundary conditions on Voor cutting equipment assembly for modal analysis

From the modal analysis, a total of 3 natural frequencies are observed in range of 0 to 10 Hz. . The frequency values are tabulated in the below table and the corresponding mode shapes for the first 5 natural frequencies are plotted below.

Mode No.	Frequency (Hz)
1	3.5681
2	5.0241
3	6.2892
4	13.358
5	15.938

Table 5.2 : Frequency values for the first 5 natural frequencies

The mode shapes for the above obtained frequencies are shown in the corresponding figures:

Mode shape #1 @ 3.5 Hz: From the below figure it can be seen that the first natural frequency occurs at 3.5 Hz and it is a longitudinal vibration.

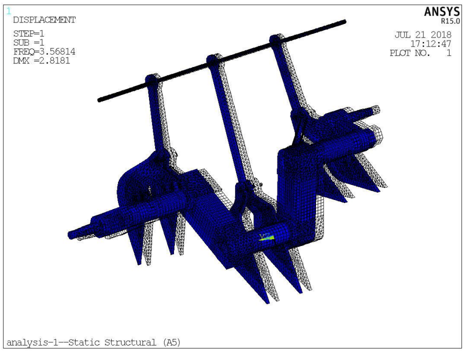


Fig 5.11: 1st Mode shape of Voor cutting equipment assembly@ 3.5Hz

Mode shape # 2 @ 5.02 Hz: From the below figure it can be seen that the second natural frequency occurs at 5.02 Hz and it is a lateral vibration.

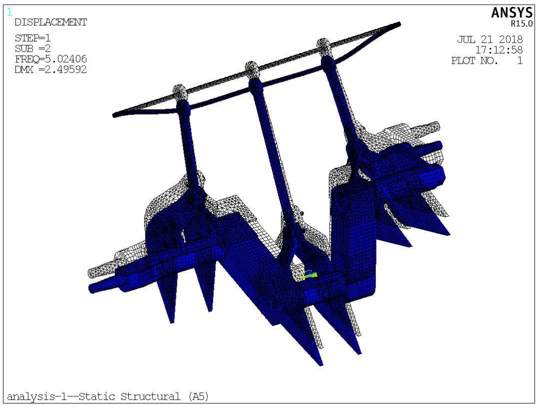


Fig 5.12: 2nd Mode shape of Voor cutting equipment assembly @ 5.02 Hz

Mode shape # 3 @ 6.28 Hz: From the below figure it can be seen that the third natural frequency occurs at 6.28 Hz and it is a lateral and bending vibration.

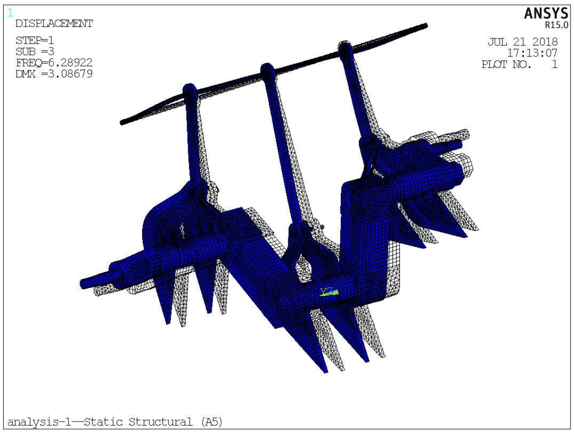


Fig 5.13: 3rd Mode shape of Voor cutting equipment assembly @ 6.28 Hz

Mode shape # 4 @ 13.3 Hz: From the below figure it can be seen that the fourth natural frequency occurs at 13.3 Hz and it is a longitudinal vibration.

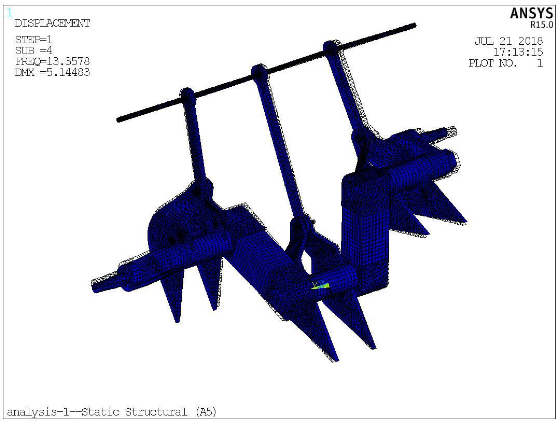


Fig 5.14: 4th Mode shape of Voor cutting equipment assembly @ 13.3 Hz

Mode shape # 5 @ 15.93 Hz: From the below figure it can be seen that the fifth natural frequency occurs at 15.93 Hz and it is a longitudinal and bending vibration.

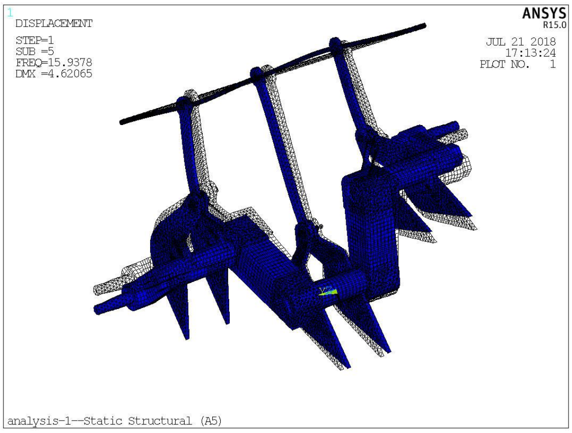


Fig 5.15: 5th Mode shape of Voor cutting equipment assembly @ 15.93 Hz

The following observations were made from the modal analysis:

The first natural frequency of the Voor cutting assembly is occurring at 3.56 Hz (214 rpm). This frequency is very nearer and matching with operating frequency i.e. 220 rpm (3.6 Hz) of the Voor cutting assembly. This frequency is considered to be a critical frequency because both natural frequency and operating frequencies are matching which leads to the resonance. This resonant frequency may damage the Voor cutting equipment assembly when a small excitation is given due to resonance. To check the magnitude values of deflections and stresses at the resonant frequency of 3.56 Hz due to the operating loads, harmonic analysis is carried out on the Voor cutting equipment assembly.

5.5 HARMONIC ANALYSIS OF VOOR CUTTING EQUIPMENT ASSEMBLY

Any sustained cyclic load will deliver a managed cyclic response (a harmonic reaction) in a basic framework. Harmonic response investigation enables you to anticipate the managed dynamic conduct of your structures, along these lines empowering you to confirm regardless of whether your plans will effectively conquer reverberation, exhaustion, and other hurtful impacts of constrained vibrations.

Harmonic response examination is a procedure used to decide the unfaltering state reaction of a straight structure to loads that shift sinusoidally (agreeably) with time. The thought is to ascertain the structure's reaction at a few frequencies and acquire a chart of some reaction amount (normally removals) versus recurrence. "Pinnacle" reactions are then distinguished on the chart and stresses evaluated at those pinnacle frequencies. Harmonic analysis was carried out to determine the deflections and stress of a structure for the resonant frequency of 3.6 Hz.

Boundary conditions: The boundary conditions applied for the harmonic analysis are shown below

- ➢ The positions where the Voor cutting equipment attached to the tractor are fixed in all DOF as shown in the below figure.

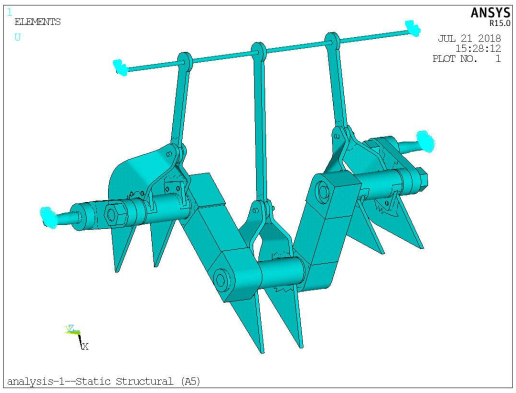


Fig 5.16: Boundary conditions applied on Voor cutting Assembly for harmonic analysis

- ➢ Tangential and soil force applied on the blades of the voor cutting assembly as shown in the below figure.

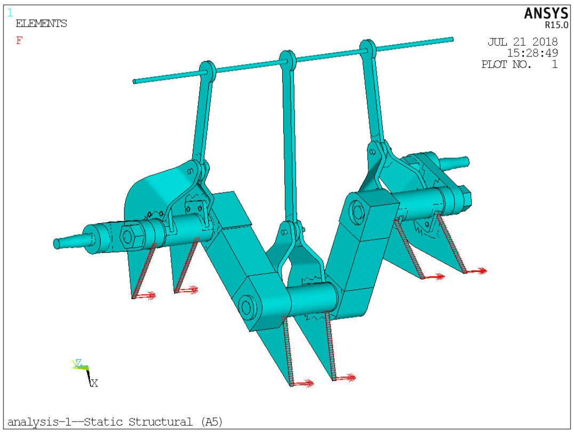


Fig 5.17: Loading applied on Voor cutting Assembly for static analysis

RESULTS:

From the harmonic analysis the deflections and stresses are plotted at the resonant frequency of 3.6 Hz and are shown in the below figures. The total deflection observed on the Voor cutting assembly for harmonic loading is observed as 45.7 mm as shown in the below figures.

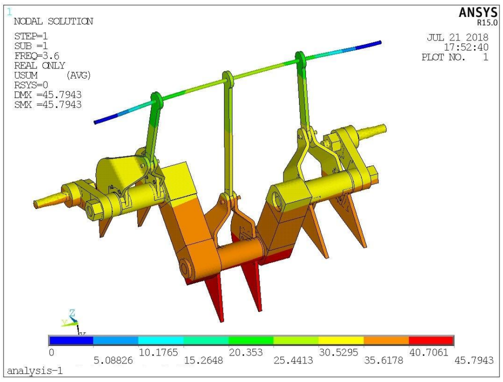


Fig 5.18: Total deflection of Voor cutting assembly for harmonic loading

VonMises Stress: VonMises stress is the maximum stress obtained in Ansys. In this project Maximum stress failure theory is used, which says that the VonMises stress should be less than the yield strength of the material for the design to be considered safe and also factor of safety (FOS) is calculated as Yield strength/VonMises stress. The VonMises stress plot for different parts of Voor cutting assembly are plotted as shown in the below figures. The components for which the VonMises stress exceed the Yield strength of the material are considered to be unsafe for the given operating conditions and are listed in the below table. The maximum VonMises stress plots are shown in the subsequent figures.

Component Name	Component Status
Total Assembly	Not Safe
Connecting rod Assembly	Not Safe
Blade Assembly	Not Safe
Gear Box Assembly	Safe
Crank Assembly	Safe

Table 5.3: Component status observed on different parts

VonMises stress on total assembly of Voor cutting equipment is observed to be more than the yield strength of the material. The grey portion in the below figure shows the locations where the VonMises stress exceeds the Yield strength of the material.

VonMises Stress on Total assembly:

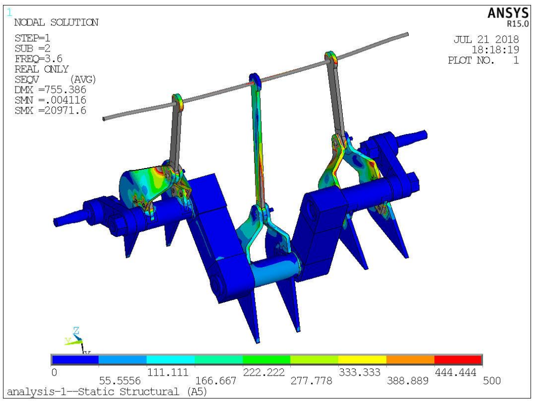


Fig 5.19: VonMises stress on total assembly for harmonic loading

VonMises Stress on Connecting rod assembly: VonMises stress on Connecting rod assembly of Voor cutting equipment is more than the yield strength of the material. The grey portion in the below figure shows the locations where the VonMises stress exceeds the Yield strength of the material.

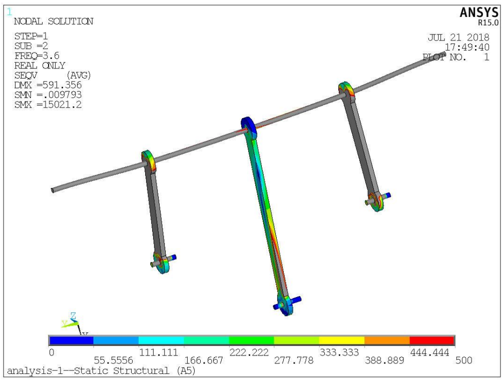


Fig 5.20: VonMises stress on connecting rod assembly for harmonic loading

VonMises Stress on Blade Assembly: VonMises stress on blade assembly of Voor cutting equipment is as more than the yield strength of the material. The grey portion in the below figure shows the locations where the VonMises stress exceeds the Yield strength of the material.

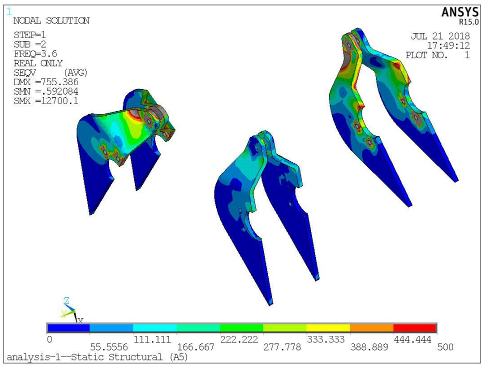


Fig 5.21: VonMises stress on blade assembly for harmonic loading

VonMises Stress on Gear box Assembly: VonMises stress on Gear box assembly of Voor cutting equipment is observed as 388 N/mm2 which is below the Yield strength of the material.

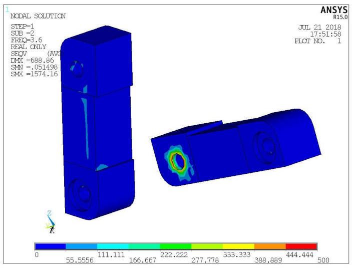


Fig 5.22: VonMises stress on Gear box assembly for harmonic loading

VonMises Stress on Crank Assembly: VonMises stress on Crank assembly of Voor cutting equipment is observed as 55 N/mm2 which is less than the Yield strength of the material.

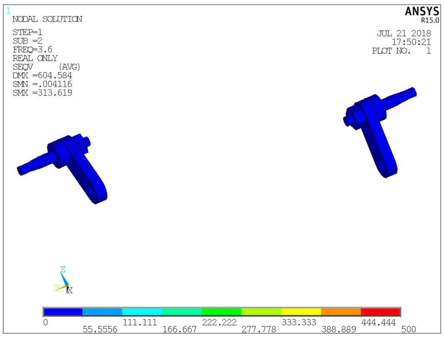


Fig 5.23: VonMises stress on crank assembly for harmonic loading

From the structural static analysis it is concluded that the maximum VonMises stress is more than the yield strength of the material (500 Mpa).The factor of safety for the static loading is also less than 1 for most parts of the Voor cutting assembly. Therefore the Voor cutting assembly is considered to be unsafe for the harmonic loads.

To overcome the stresses and deflections occurred for the harmonic loads the design changes are required such a way that the first natural frequency should be shifted to the higher value. The natural frequency is dependent on the stiffness and material of the component. So ,in this project the material is considered to be constant and only the stiffness of the component is changed. Since the stiffness is the geometric property, the geometry of the Voor cutting assembly is modified and the modifications are shown in the below figures.

5.5 3D MODELING OF MODIFIED VOOR CUTTING ASSEMBLY EQUIPMENT ASSEMBLY

Thus from static and dynamic analysis it is found that the voor cutting machine is sustaining deformations and the stress are in limits of material(Grey cast iron) yield strength for tangential and soil forces. Also the machine was tested to know the natural frequencies for material grey cast iron and it is found that the vibration characteristics are better, but in harmonic analysis it is found that the resonance occurred on component shows that material fails as it can't withstand the load at maximum frequencies.

So, this type of resonance can alter by changing the topology of design module of each part, from analysis it clearly shows there are more stresses and vibrations are on connecting rod and blade. So, there is a possibility to change to the blade profile from round to sharp edge at the back end and by adding some slots with 10 mm thickness in middle of connecting rod. The original model and modified model are shown in below figures for blade and connecting rod.

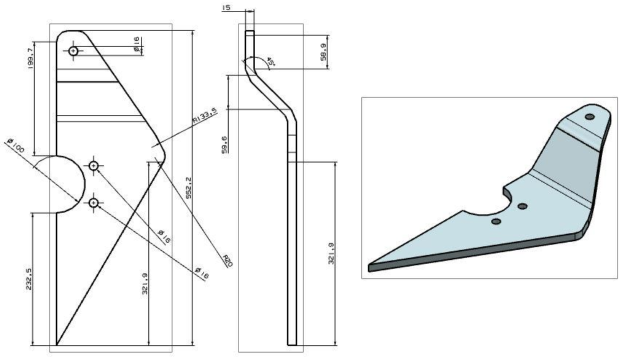


Fig 5.24 : Modified model manufacturing drawing for blade profile

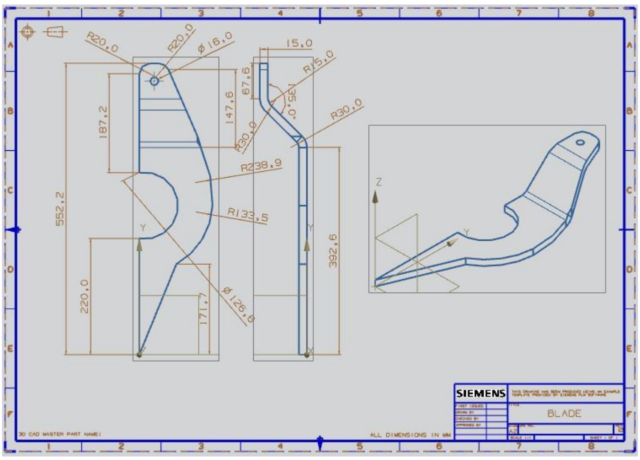


Fig 5.25: Original model manufacturing drawing for blade profile

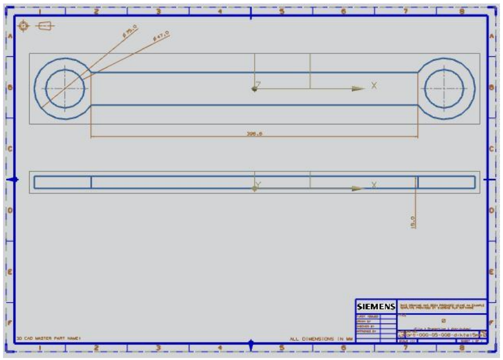


Fig 5.26: Original model manufacturing drawing for connecting rod

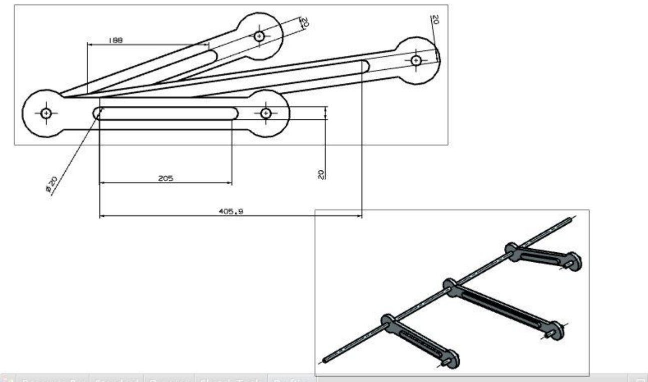


Fig 5.27: Modified model manufacturing drawing for connecting rod

5.6 STRUCTURAL STATIC ANALYSIS OF MODIFIED VOOR CUTTING EQUIPMENT

Structural static analysis was performed on the modified voor cutting assembly to plot deflections and stresses on different parts of the assembly. The analysis was done by applying the tangential and soil force obtained from the calculations. The boundary conditions used for the analysis are shown below.

Boundary conditions and Loading:

- The positions where are Voor cutting equipment attached to the tractor are fixed in all DOF as shown in the below figure.

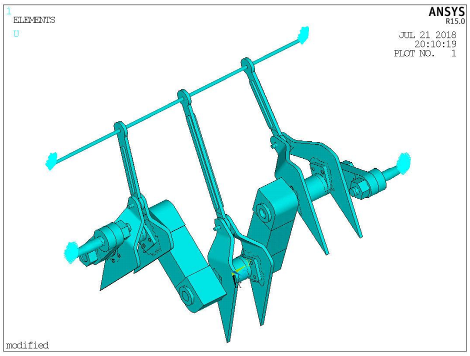


Fig 5.28: Boundary conditions applied on modified Voor cutting Assembly for static analysis

- Tangential and soil force applied on the blades of the voor cutting assembly as shown in the below figure.

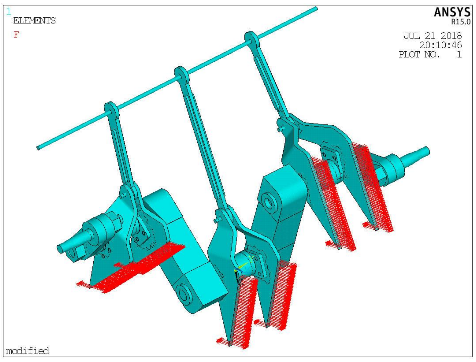


Fig 5.29: Loading applied on modified Voor cutting Assembly for static analysis

RESULTS:

From the static analysis the deflections and stresses are plotted and are shown in the below figures. The total deflection observed on the modified Voor cutting assembly for static loading is observed as 1.15 mm as shown in the below figures.

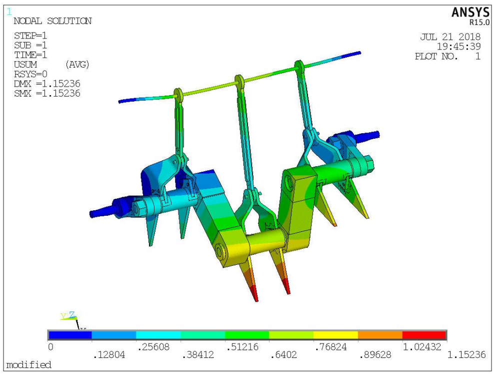


Fig 5.30: Total deflection of modified Voor cutting assembly for static loading

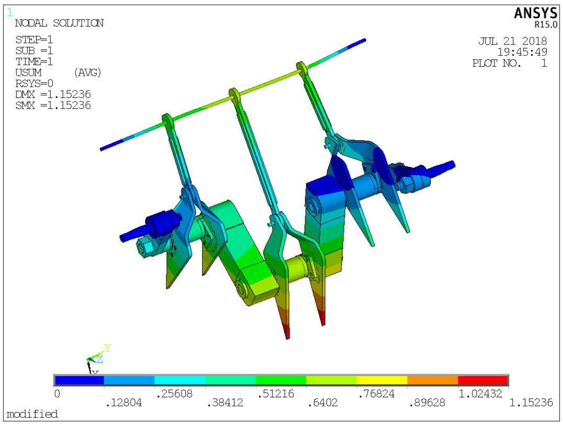


Fig 5.31: Total deflection of modified Voor cutting assembly for static loading for back view

VonMises Stress: VonMises stress is the maximum stress obtained in Ansys. In this project Maximum stress failure theory is used, which says that the VonMises stress should be less than the yield strength of the material for the design to be considered safe and also factor of safety (FOS) is calculated as Yield strength/VonMises stress. The VonMises stress plot for different parts of modified Voor cutting assembly are plotted as shown in the below figures. The maximum VonMises stress observed for different parts are listed in the below table and the corresponding plots are shown in the subsequent figures.

Component Name	**VonMises Stress N/mm2**
Total Assembly	61.7
Connecting rod Assembly	44.06
Blade Assembly	51.57
Gear Box Assembly	10.63
Crank Assembly	61.7

Table 5.4: VonMises stress observed on different parts of modified assembly

VonMises stress on total assembly of modified Voor cutting equipment is observed as 61.7 N/mm^2

VonMises Stress on modified Total assembly:

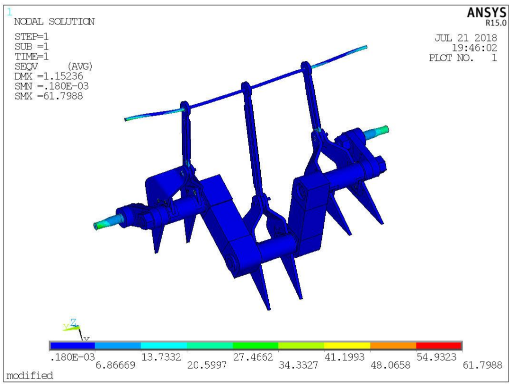


Fig 5.32: VonMises stress on modified total assembly for static loading

VonMises Stress on modified Connecting rod assembly: VonMises stress on modified Connecting rod assembly of Voor cutting equipment is observed as 44.06 N/mm^2

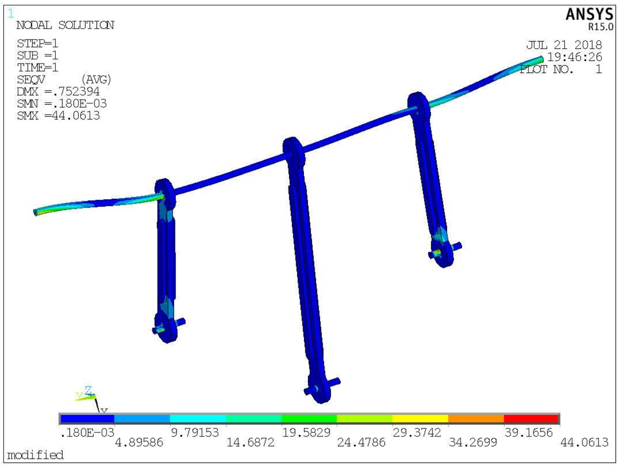


Fig 5.33: VonMises stress on modified connecting rod assembly for static loading

VonMises Stress on modified Blade Assembly: VonMises stress on blade assembly of modified Voor cutting equipment is observed as 51.57 N/mm2

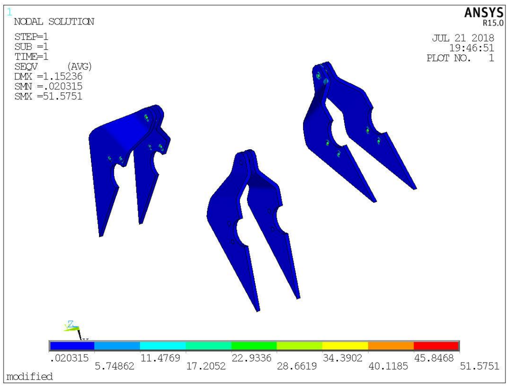


Fig 5.34: VonMises stress on modified blade assembly for static loading

VonMises Stress on Gear box Assembly: VonMises stress on Gear box assembly of modified Voor cutting equipment is observed as 10.63 N/mm2

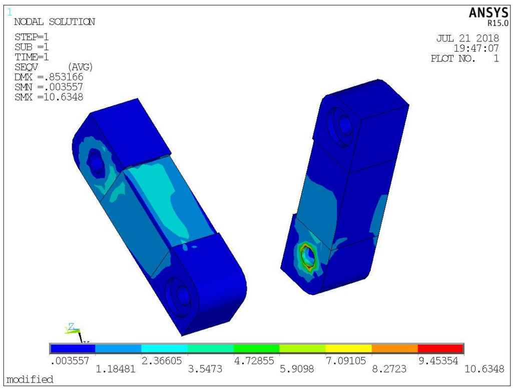


Fig 5.35: VonMises stress on modified Gear box assembly for static loading

VonMises Stress on modified Crank Assembly: VonMises stress on Crank assembly of modified Voor cutting equipment is observed as 61.7 N/mm2

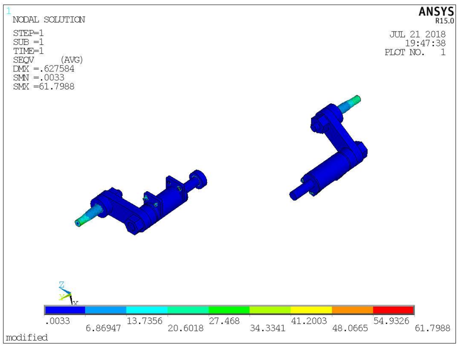


Fig 5.36: VonMises stress on modified crank assembly for static loading

From the structural static analysis it is concluded that the maximum VonMises stress (61.7 Mpa) is less than the yield strength of the material (500 Mpa).The factor of safety for the static loading is 500/61.7 = 8.1. Therefore the modified Voor cutting assembly is safe for the applied operating loads.
Dynamic analysis is carried out on the modified voor cutting assembly in order to check whether the voor cutting assembly is withstanding the dynamic conditions or not. In dynamic analysis first modal analysis was done to understand the natural frequencies of the voor cutting assembly. From the modal analysis natural frequencies and corresponding mode shapes are plotted.

5.7 MODAL ANALYSIS OF MODIFIED VOOR CUTTING ASSEMBLY

Modal analysis was carried out on modified Voor cutting equipment assembly to determine the natural frequencies and mode shapes of a structure. In general, the rpm of the Voor cutting assembly is around 220 rpm (3.6 Hz).In the original assembly the first natural frequency was occurring at 3.56 Hz and is matching with the operating frequency of the Voor cutting assembly. Because of this reason resonance was occurring at the frequency of 3.56 Hz. From the harmonic analysis it was concluded that the original model of Voor cutting assembly was not safe for the harmonic loads.

So design changes were made in the modified model of voor cutting assembly as shown in the above figure. The main objective of the modification was to shift the first natural frequency to the higher so that the first natural frequency will not coincide with the operating frequency (3.6 Hz) of Voor cutting assembly.

So, while doing modal analysis the interested frequency range was 0-10 Hz. The frequency range is selected to check if there is any natural frequency present at the operating frequency of Voor cutting assembly i.e. 3.6 Hz. If a natural frequency is present nearer to operating frequency of modified Voor cutting assembly then resonance occurs which can cause damage to the assembly. For the same reason, modal analysis was carried out to find the first 5 natural frequencies or in range of 0 to 10 Hz.

Boundary conditions: The boundary conditions applied for the modal analysis are shown below.

- ➢ The positions where are Voor cutting equipment attached to the tractor are constrained in all DOF as shown in the below figure.

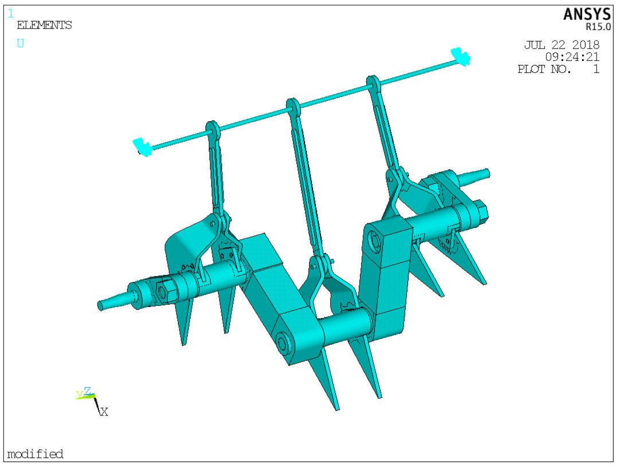


Fig 5.37 Boundary conditions on modified Voor cutting equipment assembly for modal analysis

From the modal analysis, a total of 3 natural frequencies are observed in range of 0 to 10 Hz. . The frequency values are tabulated in the below table and the corresponding mode shapes for the first 5 natural frequencies are plotted below.

Mode No.	Frequency (Hz)
1	20.45
2	52
3	55
4	81
5	90

Table 5.5: Frequency values for the first 5 natural frequencies for modified assembly

The mode shapes for the above obtained frequencies are shown in the corresponding figures:

Mode shape #1 @ 20.45 Hz: From the below figure it can be seen that the first natural frequency occurs at 20.45 Hz and it is a lateral vibration.

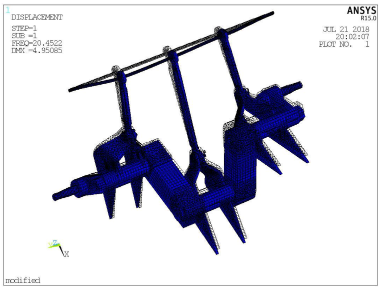


Fig 5.38: 1st Mode shape of modified Voor cutting equipment assembly@ 20.45Hz

Mode shape # 2 @ 52.82 Hz: From the below figure it can be seen that the second natural frequency occurs at 52.82 Hz and it is a longitudinal vibration.

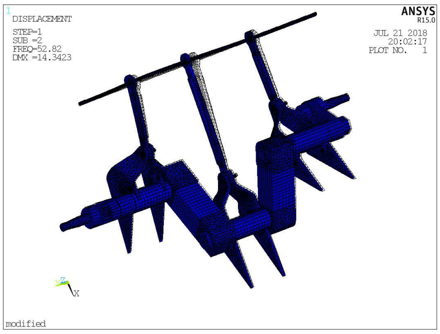


Fig 5.39: 2nd Mode shape of modified Voor cutting equipment assembly @ 52.8 Hz

Mode shape # 3 @ 55.36 Hz: From the below figure it can be seen that the third natural frequency occurs at 6.28 Hz and it is a longitudinal vibration.

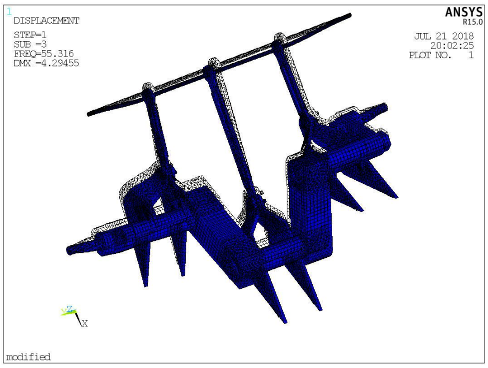


Fig 5.40: 3rd Mode shape of modified Voor cutting equipment assembly @ 55.36 Hz

Mode shape # 4 @ 81.6 Hz: From the below figure it can be seen that the fourth natural frequency occurs at 81.6 Hz and it is a longitudinal vibration.

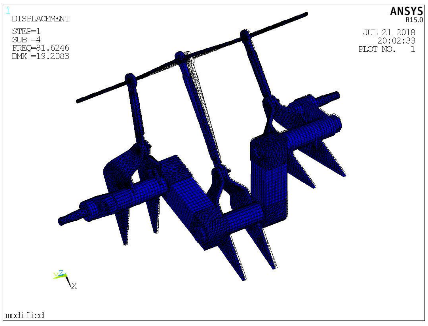


Fig 5.41: 4th Mode shape of modified Voor cutting equipment assembly @ 81.6 Hz

Mode shape # 5 @ 90.49 Hz: From the below figure it can be seen that the fifth natural frequency occurs at 90.49 Hz and it is a combination of longitudinal and bending vibration.

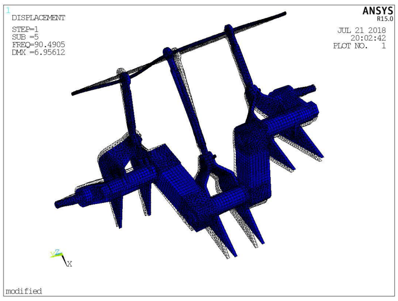


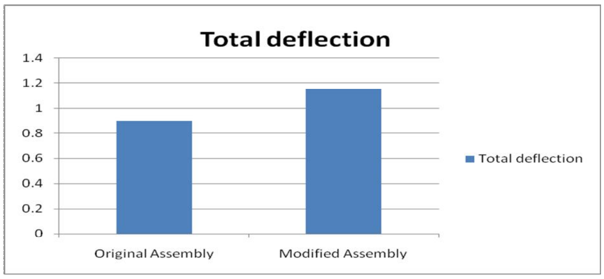
Fig 5.42: 5th Mode shape of modified Voor cutting equipment assembly @ 90.49 Hz

The following observations were made from the modal analysis:

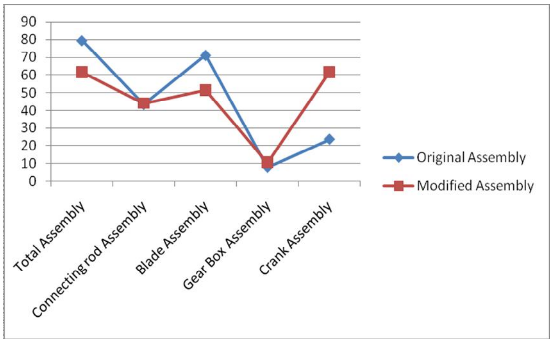
The first natural frequency of the Voor cutting assembly is occurring at 20.45 Hz (1227 rpm). This frequency is very large and far away from the operating frequency of Voor cutting assembly i.e. 220 rpm (3.6 Hz) of the Voor cutting assembly. This frequency is considered to be a safe frequency because both natural frequency and operating frequencies can never coincide there by eliminating the chance of occurrence of resonance. From the modal analysis it can be concluded that the modified Voor cutting equipment assembly is safe for the applied dynamic conditions.

VI. RESULTS AND DISCUSSION

In this project the Voor cutting equipment assembly was modeled in NX-CAD software and was studied for different loading conditions using ANSYS. Voor cutting equipment assembly was simulated for static and dynamic conditions. In the static analysis the boundary conditions and loading were assumed to be constant throughout the analysis. The results obtained from static analysis for original and modified model are compared and shown in the graphs below.

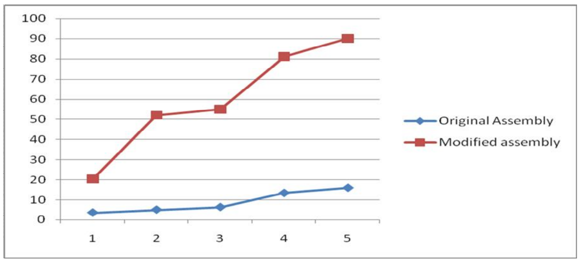


Graph 6.1:Comparision of deflection of original and modified assembly for static loading



Graph 6.2:Comparision of stresses of original and modified assembly for static loading

In the dynamic analysis the mass properties of the assembly and stiffness of the geometry are considered throughout the analysis. The natural frequencies obtained for original and modified Voor cutting assembly are compared and are shown in the below graphs.



Graph 6.3: Comparison of natural frequencies for original and modified assembly

Harmonic analysis was performed on the original model of Voor cutting Assembly for the resonant frequency of 3.56 Hz and found that the original model was not safe for the harmonic load at the resonant frequency of 3.56 Hz. Harmonic analysis was not deformed on the modified model because the first natural frequency observed from the modal analysis is very far away from the operating frequency of Voor cutting assembly. This shows there is no sigh of resonance for modified model ,so harmonic analysis was not required for modified Voor cutting assembly.

VII. CONCLUSION

In this project advanced type of tool crank shaft voor cutting machine was designed. The Crank shaft voor cutting machine is a similar type of tillage component but it consists of different cutting tool and topology. The tangential and soil forces were determined through calculations initially and finite element analysis was done to check if the design was safe or not. In general, all the components which are designed for a specific purpose withstand the static loading conditions but they very often fail in dynamic loading conditions. In this project The original Voor cutting assembly also was safe for static loading with FOS of 6, but from the harmonic analysis it was concluded that the original Voor cutting assembly was not safe for harmonic loads or dynamic conditions due to the occurrence of resonant frequency of 3.56 Hz. So the modified model was proposed with increased stiffness and which was safe for both static and dynamic conditions. So from this project it is concluded that whenever a structural component is designed for a specific purpose the analysis should not be restricted to only static condition but it should be extended to dynamic condition as well.

VIII. FUTURE SCOPE

The dynamic conditions also includes the structure response to shock loads and random vibrations. So, the analysis can be extended to Shock and spectrum analysis to determine the Voor cutting assembly response to shock loads and random vibrations respectively.

REFERENCES

[1] Gopal U. Shinde and Shyam R. Kajale, Design Optimization in Rotary Tillage Tool System Components by Computer Aided Engineering Analysis, International Journal of Environmental Science and Development, Vol. 3, No. 3, June 2012.

[2] Prof. Shinde V.B, Mr. Malve R.N, Mr. Sangle H.S,Mr. Yendhe N.L, Mr. Bari G.E, Design and development of rotavator blade, International Journal of Science, Technology & Management Volume No.04, Issue No. 04, April 2015, ISSN (online): 2394-1537.

[3] Jeevarathinam.A, Velmurugan.C, Design Modification and Analysis of Rotavator Blade, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X PP 43-50.

[4] Dr. Ashok G. Matani, Ankush D. Bhishnurkar, Use of Cad Tool for Design, Analysis and Development of Rotary Tillage Tool, International Journal of Science and Research (IJSR) ISSN (Online): 2319 7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

[5] Pawan Sharma and Prof. (Dr.) Manish Bhargava, Parametric design analysis and FEA simulation of a chisel plow for an agriculture use, International Journal of Recent advances in Mechanical Engineering (IJMECH) Vol.4, No.4, November 2015.

[6] Subrata Kr Mandal, Dr. Basudev Bhattacharya, and Dr. Somenath Mukherjee, Optimization of Design Parameters for Rotary tiller's Blade, proceedings of the 1st International and 16th National Conference on Machines and Mechanisms (iNaCoMM2013), IIT Roorkee, India, Dec 18-20 2013.

[7] C. Manivel prabhu, Dr. N. Sangeetha, T .Ramganesh, Design Modification and Structural Analysis of Rotavator Blade by Using Hyper Works 12.0, International Journal of Scientific Research Engineering & Technology (IJSRET), ISSN 2278 – 0882, Volume 3, Issue 6, September 2014.