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Failure Investigation & Analysis of Agricultural 9 tyne cultivator Used in various Soil condition:-A Review Study

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Abstract

The process optimization in advance Cultivator tool system conceptually designed, fabricated and failure Investigation & Analysis by computer aided engineering analysis techniques. The Software testing a field performance is taken in the soil bed preparation as well as in the various crop patterns. It was found most use full in obtaining high weed removal efficiency.

The Computer aided design is created and tested with actual field condition parameters and found a maximum von misses stress noted 142 N/mm^2 without plastic strain in the model. The revised design specifications are decided after confirmation in software testing.

The precision geometry, optimum energy utilization, multi-operational design, easy transport and flexible attachments are some of the features which results in achieving some of the important parameters such as width of cut Max.18cm &Min. 8cm, depth of cut Max.22cm and Min.8cm, Speed of operation 5.5 km/hr. Field capacity 0.65ha/hr. and Field efficiency 55%. Theoretical field capacity 0.33ha/hr. Theoretical draft 7.2 kN.Cost of operation 1200 Rs. //ha. (Rs. 630/ha)

.

Keywords: **: flexible cultivator tool, sweep cultivator, cad-model, structural analysis, shank removal efficiency, von misses stress.**

1. Introduction

1.1Cultivetors Tools:

Cultivator tools are directly energy in to the soil to cause some desired effect such as cutting, breaking, inversion or movement of soil. Soil is transferred from an initial condition to a different final condition by this process. Soil working tools such as mould board ploughs, disc ploughs and ridges have long been accepted and successfully used by farmer under average field condition. Seedbed preparation greatly contributes towards the overall cost of farm operations, employing that significant savings are possible through optimized design and development of tillage machinery.

Primary and secondary soil manipulation is the basic operation required for cultivation of any kind of crop. Soil manipulating tools should withstand adverse field conditions, such as the presence of a hardpan, small rocky formations stumps stable during soil engagement without failure. Soil working tools such as mould board ploughs, disc ploughs and ridger has long been accepted and successfully used by farmers under average field conditions.

The duck foot sweep is another kind of soil engaging tool that is popular amongst farmers for secondary field operations because of its large wing width, which causes better coverage of soil manipulation between two furrows. Cultivators groups such as small, farm, field and row types can be described as

A) Small cultivators: it is used for gardening, powered by small motors, and controlled by an operator walking behind. Garden cultivators can be used to mix soils with manures and fertilizers in preparation for planting

B) Farm cultivators: A tractor-mounted tiller Cultivators are pulled by tractors and can vary greatly in size and shape, from 10 feet (3 m) to 80 feet (24 m) wide. Many are equipped with hydraulic wings that fold up to make road travel easier and safer..

C) Field cultivator: Field cultivators are used to complete tillage operations in many types of arable crops fields. The main function of the field cultivator is to prepare a proper seedbed for the crop to be planted into, to bury crop residue in the soil (helping to warm the soil before planting), to control weeds, and to mix and incorporate the soil to ensure the growing crop has enough water and nutrients to grow well during the growing season.

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D) Row crop cultivator: The main function of the row crop cultivator is weed control between the rows of an established crop.

- Types of cultivator on the basis of geometrical features

Disc cultivator: It is cultivator fitted with disc.
Tine cultivator: It is a type fitted with tines having blades.
Rotary cultivator: It is a cultivator with tines or blades mounted on a power driven-horizontal shaft. Depending upon type of power available for the implements, the cultivator can be classified as: ***1.Tractor drawn 2.Animal drawn***.
a) Trailed type cultivator: It consists of a main frame which carries a number of cross members to which tines are fitted. A pair of wheel is provided in the cultivator. The lift is operated by both wheels simultaneously so that draft remains even and uniform.
b) Mounted cultivator: Tractors fitted with hydraulic lift operate the mounted type cultivators.
c). Cultivator with spring loaded tines: A tine hinged to the frame and loaded with a spring so that it swings back when an obstacle is encountered, is called spring loaded tine.
d) Cultivator with rigid tines: Rigid tines of the cultivator are those tines which do not deflect during the work in the field.
e) Duck foot cultivator: It is type of rigid cultivator which is used mostly for shallow ploughing, destruction of weed and retention of moisture.
f) Animal drawn cultivator: Depending upon local conditions, soil and climate, different types of cultivators have been designed and are being used extensively throughout country. Three tined cultivators with seeding attachment are popular in some part of the country.

1.2. Nomenclature of various components of tillage tool:

1.2.1. Tyne:-The three types of tynes are used for the testing of the flexible cultivator. The tynes are S, C and L types. The thickness of tynes is 22 mm and height is 22 mm.
1.2.2. Shovel:-The plane tooth shovel, saw tooth shovel, step tooth shovel, reversible shovel, and harrow type shovel are used for the testing purpose.
1.2.3. Frame:-The elliptical frame is for the flexible tillage tool cultivator. These frames minimize the breakage in the frame.
1.2.4. Hitching Arrangement:-The three point linkage is used for the hitching arrangement.
1.2.5. Ground wheel:-The use of the ground wheel for clods breaking. The diameter of wheel is 33 centimeter & thickness is 43.01mm; thickness of teeth is 6mm no. of teeth on wheel is 22 diameter of wheel plate fixture are 23mm.

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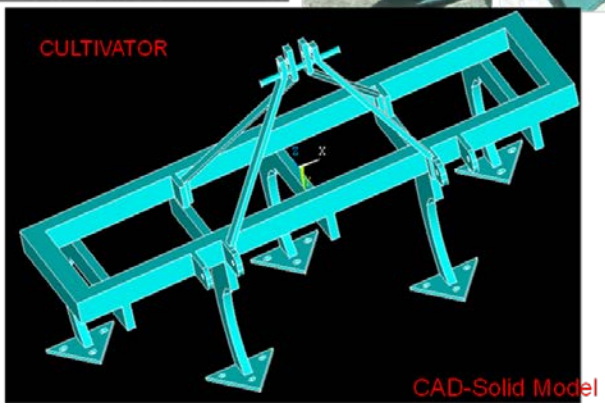

1.4.The Concept of flexibility by flexible tillage tool operations influencing the following factors .
1. **Distance** between tines as required according to row crop spacing.

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2. **Types of Tynes** used as Shank for different Shovels by different angles.
3. **Types of Shovels** used as soil cutting tool geometry for soil bed preparation and weed control.

It is a cultivator in which different part can be assembled with ***custom requirements*** of tool services during tillage operation. The elliptical frame with holes specifying the distances between the tynes to be arranged according the crops .**C, L & S types of** tines can be attached to elliptical frames. The Shovels such as triangular, triangular with Saw tooth, triangular with step tooth, reversible and blade harrow with saw tooth like different geometry are the *main highlights* of this thesis work.

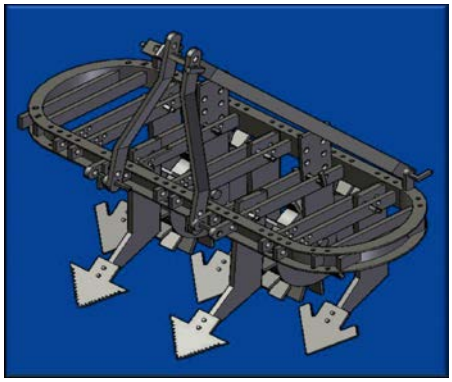
1.5 Objectives of project work:-

1. The CAD-Model of traditional Cultivator design is to be created with software testing report

2. To propose the scope in the design modification to introduce the flexible tillage tool cultivator with:

a) Distance spacing adjustment for row crop pattern.
b) Different types of tines such as S, C and L applications.
c) Different types of shovel such as plane, saw tooth, step tooth, reversible & blade harrow etc.

3. Testing and evaluation of flexible cultivator by 18.5 and 45HP Tractors. The Conceptual design *see Fig.1*.and its fabrication is decided by using design testing software .The following geometric Solid model is to be fabricated and tested.



Proposed-Model Fig.1

II. MATERIALS AND METHODS

2.1. Design of Flexible Tillage Tool Cultivator Headings and Footnotes

Actual Dimensions of traditional Cultivator is taken while preparing CAD-Solid model

Frame size: 180 x 60 cm	Tines spacing: 21 cm
Tine size: 45 x 10 x 2 cm	shovels size: 60 mm.

Major headings are to be column centered in a bold font without underline. They need be numbered. "2. Headings and Footnotes" at the top of this paragraph is a major heading.

Experimental setup:

1. Pro-E software Server machine for CAD Model and Ansys software server machine for analysis
2. Measuring equipment such as venire scale, angle protector, UTM machine etc.
3. Existing model of CULTIVATOR of Krishi-Udyog for CAD-solid model preparation

The Procedure for CAD-Solid model preparation and its analysis is as follows:

1. The physical dimensions of the selected Cultivator model are drafted with its exact geometry.
2. It is verified with enclosure of areas, surfaces and volumes on it.
3. The Meshing is done with Tri or quad method to occupy the maximum geometric surfaces on the parts to create nodes for getting the optimum results of stresses.
4. The material specification, Young's modulus and other constant factors are assigned in the software.
5. The Boundary conditions are set by assigning the degree of freedom, axis wise moment condition and the prefix constants if any.
6. The loading condition such as the Soil resistance acting as resistive force against tyne, Frame and shovel if applied within frame structure of Cultivator.

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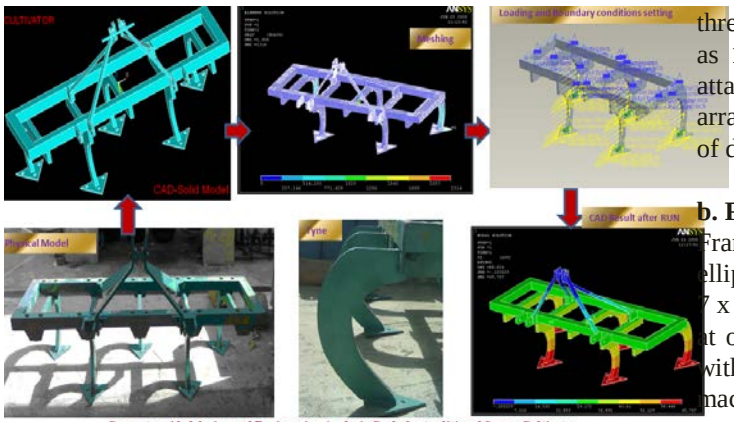
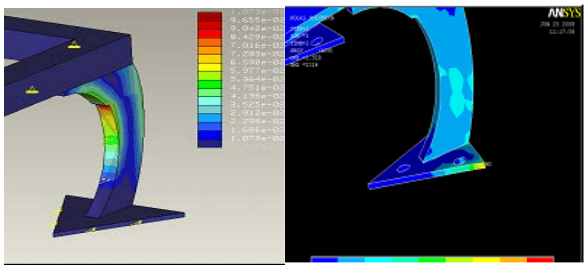


Computer aided design and Engineering Analysis Cycle for traditional Sweep Cultivator



The simulation is done by taking actual field condition parameters *see Appendix-I* the report generated with max and min von misses stresses and deformations.

The CAD-Solid model of CULTIVATOR prepared in ANSYS or Pro-E software is tested for the structural analysis as per the field condition that

Max Von misses Stress =8.2 N/mm2

Maximum Displacement = 14 1e-4.

The plot for different force conditions are as shown in above indicates the scope of design changes in various sections where from material can be removed to reduce the weight of the cultivator .

The failure diagnosis will help in the defining the geometry and various factors affecting the design of Cultivator.

The field test tool variables included rake angle to the horizontal of 12.5, 17.5 and 22.5°, working depths of 70, 110 and 150 mm and forward velocity of 1.08, 1.55 and 2.08 m sec^{-1}. The draft force in different trials varied from 42 to 202.5 daN.

2.2. Design of Flexible Tillage Tool Cultivator:

Cultivator consist the following main part are as follows:

a) Hitch arrangement
b) Tyne
c) Shovel
d) leveler
e) Toothed wheel
f) Hitch arrangement

a. Hitch arrangement

A standard three-point hitch arrangement was design from 50x 10 mm M.S. flat for mounting the frame to the tractor three-point linkage. The plate thickness for top link is kept as 10 mm and two plates are spaced at 50 mm spacing attached to each other with a spacer in between them. This arrangement was decided by considering hitching system of different 18 HP tractors.

b. Frame

Frame is made up of mild steel. Frame is having C-channel elliptical type shape. A C-channel having dimension 3.5 x 7 x 3.5 cm. Frame is bent with the help of bending machine at one side and joined by gas welding. Holes (Φ=12mm) with different spacing are made with the help of drilling machine.

c. Tine

The tine assembly consisted on the periphery of the frame, it made up of mild steel flat having carbon content ranging from 0.15 to 0.25%. Tyne has 'L' & 'C'shape having angle 136^0 with vertical tool and46^0 with soil.

Five tines are attached to the frame with the tine fixture. Tines are fitted between two fixtures with the help of nut-bolt.

d. Shovel

d. i. Plane Shovel

Blade is made up from carbon steel. Triangular arrow shaped blades are used which actually cuts the soil. Three blades are used.

d. ii. Saw Tooth Shovel

These are made up of carbon steel. It has performed for cutting stem of weed which comes during cultivation.

d. iii. Reversible Shovel

These are made up of carbon steel. These are also use to cut the soil surface.

d. iv. Blade Harrow Shovel

These are made up of carbon steel. These are used to level the soil surface, so that the land becoming leveled and loss due to rain fall is reduces. And by leveling the soil with cultivator leveling operation is saved

.

d. v. Step Tooth Shovel

These are made up of carbon steel. These type of shovels are use to remove the deep rooted weeds.

e. Toothed Wheel

These are made up from mild steel. Two toothed wheels having diameter 30 cm are attached on cultivator with fixture. It breaks the soil clods which come in travel.

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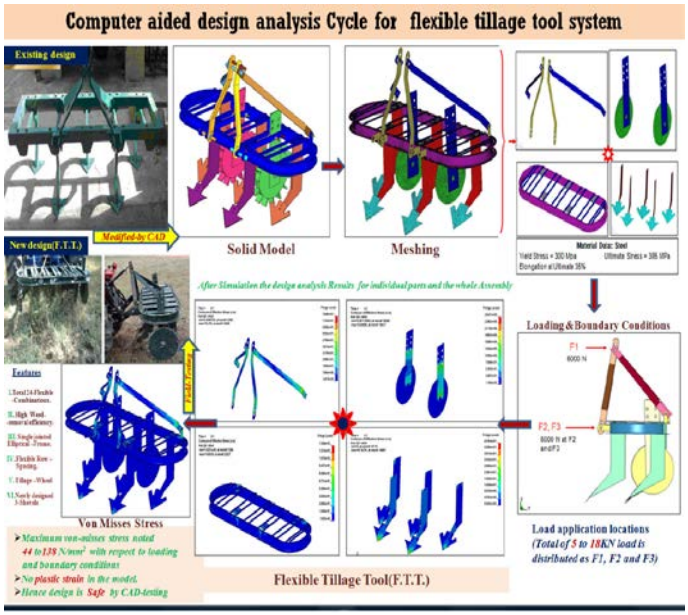
f. Tyne fixture

Tine fixture are use to hold tines on the frame. They are support to tines. The tine fixtures not only supported to the tine but also balanced the implement.

The Procedure for CAD-Solid model preparation and its analysis is as mentioned above is done in CAD-analysis Software to obtain a von misses stresses and strains with the same field parameters .see the CAD analysis cycle below.



3. SUMMARY AND CONCLUSION

The tillage operations introduces a quality parameters and development scope in obtaining a width of cut , depth of cut, Speed of operation**,** field capacity
field efficiency, field capacity**,** theoretical draft the rate of work, quality of work, draft measurement etc. The modification in traditional cultivator after fabrication and field testing leads the following observations:

1. The draft force are increased with increasing rake angles,
   forward velocity and working depth.
2. The soil inversion is increased with the width of the shovels.
3. The depth of the cut is more in the step tooth shovels.
4. The width of cut is more in the blade harrow shovels.

Flexible Cultivator breaks the clods and pulverized the soil. There are toothed blades on tines are used for remove the weeds and roots are come out. The selective design combinations of tillage tool introduces additional features .

1. Cultivator introduces elliptical frame with uniform homogeneous Section with only one joint in the structure
2. Tines can be adjustable by distance between subsequent tines, different type of shovels.
3. Shovels with tine combination can be made according to crop pattern. Step tooth triangular shovels have high weed removal efficiency.
4. Wheel used for breaking clods, smooth tillage operation, easy transport.
5. The flexibility counts with 24 possible combinations as mentioned in the Appendix-II

By field experiment it was seen that as follows:

- Maximum and minimum width of cut 18cm & 8cm.
- Maximum and minimum depth of cut 17cm & 8cm.
- Speed of operation = 4.2km/hr.
- Theoretical Field capacity = 0.42ha/hr.
- Field efficiency = 78%.
- Field capacity = 0.33ha/hr.
- Theoretical draft = 6.5kN.

The comparison between traditional and flexible tillage tool is given in table –I and also different combinations in Appx.-II.

4. Future scope

The flexible cultivator is fabricated and tested in the year 2010.The future scope for this secondary tillage implement are also below:

1.) The flexible cultivator with different combinations can be combined with seed cum fertilizer operation.
2.) The turmeric digger blade can be used in place of triangular blade for turmeric harvesting operation.
3.) The Whole assembly can be fixed by Pin-sockets so that assembling time can be minimized
4.) Flexible tillage tool can be also used by animal power

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Appendix-I

This RESULT REPORT is generated in Pro-E (Mechanica) Software

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Mechanica Structure Version L-01-41.xpg
Summary for Design Study "Copy_of_culti_ana_5"
Tue May 20, 2008 11:04:41

Run Settings
Memory allocation for block solver: 1024.0
Parallel Processing Status
Parallel task limit for current run: 2
Parallel task limit for current platform: 64
Number of processors detected automatically: 2
Checking the model before creating elements...
These checks take into account the fact that AutoGEM will automatically create elements in volumes with material properties, on surfaces with shell properties, and on curves with beam section properties. Generate elements automatically.
Checking the model after creating elements...
No errors were found in the model.
Mechanica Structure Model Summary
Principal System of Units: millimeter Newton Second (mmNs)

Length:	mm
Force:	N
Time:	sec
Temperature:	C
Model Type:	Three Dimensional
Points:	376
Edges:	1348
Faces:	1568
Springs:	0
Masses:	0
Beams:	0
Shells:	0
Solids:	596
Elements:	596

Standard Design Study, Static Analysis "Copy_of_culti_ana_5":

Convergence Method: Single-Pass Adaptive
Plotting Grid: 4
Convergence Loop Log:
(11:04:43)

>> Pass 1 <<
Calculating Element Equations (11:04:43)
Total Number of Equations: 10032
Maximum Edge Order: 3
Solving Equations (11:04:43)
Post-Processing Solution (11:04:44)
Checking Convergence (11:04:44)
Resource Check (11:04:45)
Elapsed Time (sec): 5.03
CPU Time (sec): 4.02
Memory Usage (kb): 1062840
Wrk Dir Dsk Usage (kb): 11305

>> Pass 2 <<
Calculating Element Equations (11:04:45)
Total Number of Equations: 15762
Maximum Edge Order: 7
Solving Equations (11:04:46)
Post-Processing Solution (11:04:47)
Checking Convergence (11:04:47)
Calculating Disp and Stress Results (11:04:48)

RMS Stress Error Estimates:

Load Set	Stress Error	% of Max Prin Str
LoadSet1	9.19e-01	10.4% of 8.81e+00

Resource Check (11:04:49)
Elapsed Time (sec): 9.50
CPU Time (sec): 8.36
Memory Usage (kb): 1072052
Wrk Dir Dsk Usage (kb): 21545

Total Mass of Model: 2.689382e-04
Total Cost of Model: 0.000000e+00

Mass Moments of Inertia about WCS Origin:
Ixx: 2.39012e-01
Ixy: -3.20215e-10 Iyy: 1.13154e+00
Ixz: -2.37684e-10 Iyz: -3.06899e-02 Izz: 9.95822e-01

Principal MMOI and Principal Axes Relative to WCS Origin:

	Max Prin	Mid Prin	Min Prin
	1.13816e+00	9.89205e-01	2.39012e-01
WCS X:	-2.92415e-10	-3.99679e-10	1.00000e+00
WCS Y:	9.77536e-01	2.10770e-01	3.70087e-10
WCS Z:	-2.10770e-01	9.77536e-01	3.29068e-10

Center of Mass Location Relative to WCS Origin:
(-7.98802e-10, 6.74014e+00, 4.82096e+00)

Mass Moments of Inertia about the Center of Mass:
Ixx: 2.20543e-01
Ixy: -3.21663e-10 Iyy: 1.12529e+00
Ixz: -2.38720e-10 Iyz: -2.19510e-02
Izz: 9.83604e-01

Principal MMOI and Principal Axes Relative to COM:

	Max Prin	Mid Prin	Min Prin
	1.12861e+00	9.80281e-01	2.20543e-01
WCS X:	-3.10890e-10	-3.74043e-10	1.00000e+00
WCS Y:	9.88736e-01	1.49671e-01	3.63371e-10
WCS Z:	-1.49671e-01	9.88736e-01	3.23299e-10

Constraint Set: ConstraintSet1: **CULTIVATOR**
Load Set: LoadSet1: CULTIVATOR

Resultant Load on Model:
in global X direction: -3.880420e-13
in global Y direction: 1.266001e-14
in global Z direction: 6.867000e+00

Measures:

max_beam_bending:	0.000000e+00
max_beam_tensile:	0.000000e+00
max_beam_torsion:	0.000000e+00
max_beam_total:	0.000000e+00
max_disp_mag:	8.371072e-04
max_disp_x:	1.195327e-04
max_disp_y:	-2.435034e-04
max_disp_z:	8.346681e-04
max_prin_mag:	-8.806019e+00
max_rot_mag:	0.000000e+00
max_rot_x:	0.000000e+00
max_rot_y:	0.000000e+00
max_rot_z:	0.000000e+00
max_stress_prin:	8.190232e+00
max_stress_vm:	7.869850e+00
max_stress_xx:	-2.385657e+00
max_stress_xy:	3.786511e+00
max_stress_xz:	-1.584193e+00
max_stress_yy:	-6.426477e+00
max_stress_yz:	1.484521e+00
max_stress_zz:	-2.899898e+00
min_stress_prin:	-8.806019e+00
strain_energy:	1.954048e-03

Analysis "Copy_of_culti_ana_5" Completed
(11:04:49)

Memory and Disk Usage:

Machine Type: Windows NT/x86
RAM Allocation for Solver (megabytes): 1024.0

Total Elapsed Time (seconds): 9.72
Total CPU Time (seconds): 8.58
Maximum Memory Usage (kilobytes): 1072052
Working Directory Disk Usage (kilobytes): 21545

Results Directory Size (kilobytes):
7218 .\Copy_of_culti_ana_5

Maximum Data Base Working File Sizes (kilobytes):
18432 .\Copy_of_culti_ana_5.tmp\kel1.bas
3072 .\Copy_of_culti_ana_5.tmp\oel1.bas

Run Completed
Tue May 20, 2008 11:04:49

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Appendix-II

Sr. no.		Type of tine used	Types of shovels used	Combinations
1	'L'	5T1	3 S1-2 S2	5T1-3 S1-2 S2
2.		5T1	5 S1	5T1-5 S1
3.		5T1	3 S3-2 S1	5T1-3 S3-2 S1
4.		5T1	3 S1-1 S4	5T1-3 S1-1 S4
5.		5T1	3 S3-2 S2	5T1-3 S3-2 S2
6.		5T1	3 S3-1 S4	5T1-3 S3-1 S4
7.	'C'	5T2	3 S1-2 S2	5T2-3 S1-2 S2
8.		5T2	5 S1	5T2-5 S1
9.		5T2	3 S3-2 S1	5T2-3 S3-2 S1
10.		5T2	3 S1-1 S4	5T2-3 S1-1 S4
11.		5T2	3 S3-2 S2	5T2-3 S3-2 S2
12.		5T2	3 S3-1 S4	5T2-3 S3-1 S4
13.	'L' & 'C'	2T1-3T2	3 S3-1 S4	2T1-3T2-3 S3-1 S4
14.		2T1-3T2	3 S1-2 S2	2T1-3T2-3 S1-2 S2
15.		2T1-3T2	5 S1	2T1-3T2-5 S1
16.		2T1-3T2	3 S3-2 S1	2T1-3T2-3 S3-2 S1
17.		2T1-3T2	3 S1-1 S4	2T1-3T2-3 S1-1 S4
18.		2T1-3T2	3 S3-2 S2	2T1-3T2-3 S3-2 S2
19.		2T2-3T1	3 S1-2 S2	2T2-3T13 S1-2 S2
20.		2T2-3T1	5 S1	2T2-3T1-5 S1
21.		2T2-3T1	3 S3-2 S1	2T2-3T1-3 S3-2 S1
22.		2T2-3T1	3 S1-1 S4	2T2-3T1-3 S1-1 S4
23.		2T2-3T1	3 S3-2 S2	2T2-3T1-3 S3-2 S2
24.		2T2-3T1	3 S3-1 S4	2T2-3T1-3 S3-1 S4

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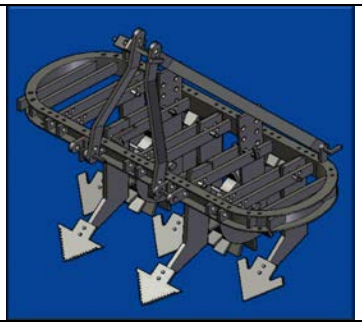
Appendix-III

Sr. No.	**Sweep-Cultivator**	
	Traditional	Flexible Cultivator(F.T.T.)
1	Rectangular Frame with Four weld Joints	Elliptical Frame with continuous cross section and single weld joint
2	Permanent structure with the only provision of shovel exchange	Flexible structure with the provision of tine, shovel and adjustable distance between tines
3	Tines are fixed with permanent weld joints or nuts and blots	Different types of Tines can be joined in the slots provided in the frame
4	Fail-break design	Fail-safe design with fuse bolts
5	Two type possible combinations	Twenty Four type possible combinations
6	Weed removal efficiency is low during soil bed preparation or row crop tillage operations	Weed removal efficiency is high during soil bed preparation or row crop tillage operations
Fig.		

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