CONCLUSIONS

The tillage process optimization by tillage tool modeling and the structural analysis using computer aided design analysis software for the precision field operational services of tools and the custom need of the farmer for different combinations. The multipurpose use of tillage tools with the conceptual design and development resulting the following important achievements for selected two cases of present research work.

CASE-I: A Sweep Tillage Tool: CULTIVATOR

The modified tillage tool called flexible tillage tool results the following tillage process optimizing parameters by computer aided engineering analysis.

1. Width of cut : 7cm-16cm (Traditional) and 8 cm -18 cm (F.T.T.) cultivator
2. Depth of cut : 6cm-15cm (Traditional) and 8 cm -17 cm (F.T.T) cultivator
3. The Speed of operation : 2.5Km/hr (Traditional) and 4.2km/hr (F.T.T) cultivator
4. Theoretical Field capacity : 0.24ha/hr (Traditional) and 0.42ha/hr (F.T.T) cultivator
5. Field efficiency : 65% (Traditional) and 78% (F.T.T) cultivator
6. Field capacity : 0.23 ha/hr (Traditional) and 0.33ha/hr (F.T.T) cultivator
7. Theoretical draft : 10 kN (Traditional) and 6.5kN. (F.T.T) cultivator
8. Cost of Operation : Rs.695.00/ha (Traditional) and Rs.597.00/ha (F.T.T) cultivator
9. Assembly Combinations : Only-Shovels can be exchanged in case of traditional sweep where as all three components Shovel, Tine, Row-distance adjustments with balancing Tillage Wheel can be exchanged with different combinations.

- The Flexible cultivator introduces 24 types of combinations which can be useful for different types of crop patterns, Cereals and horticultural crops.
1. The draft force is 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 design combinations of tillage tool such as
1. Cultivator has aesthetics look, can be applied for 45-60Hp tractors.
2. The Elliptical frame with adjustable tine fixtures arrangements for different crop-pattern.
3. Three types of tines C, L and S type can be used.
4. The Five types of Shovels are selectively used some of them are Invented
5. Tillage-wheels are used to break the soil clods, easy to transport and balancing operations.

- Maximum and minimum width of cut 18cm & 8cm. Maximum and minimum depth of cut 17cm & 8cm. Speed of operation 4.2km/hr. Field capacity 0.42ha/hr. Field efficiency 78%.
- Theoretical field capacity and draft are 0.33ha/hr and 6.5kN respectively. The Cost of operation Rs 597.6ha. The Computer aided design is created and tested with actual field condition parameters and found a maximum von misses stress noted 138 N/mm2 and No plastic strain in the model.

CASE-II: A Rotary Tillage Tool: ROTAVATOR

A rotary tillage tool such as Rotavator is designed in computer aided design software. The rotary motion and soil surface interaction is considered with respect to the soil Vs. tillage tool dynamics by considering the following factors

a. effecting the tillage operation such as tractor power (hp),
b. maximum peripheral force (N),
c. rotavator tine velocity (m/s),
d. tractor transmission efficiency (0.9 for concurrent revolution & 0.8-0.9 for reversed rotary),
e. soil resistance to 0.7-0.8,
f. radius of rotary (mm)

The design analysis executed

- The maximum deformation 5.994mm at frequency 40.799Hz observed during simulation was at frame and Cover component of Rotavator.
- The minimum deformation amongst the all components within an assembly of rotavator was 0.248 mm at 56.556Hz in the side gearbox.
- The overall frequency range is from 0.0350509 to 66.299Hz stepped to observe a modular analysis, however the deformation up to 30Hz in the rotavator components particularly
Frame and cover rises from 1 mm to 6 mm and after 40 Hz, the deformation in Independent top mast rises from 0.5 to 2.883 mm.

- Maximum Peripheral force on rotary blade 6031.08975 (for 35 hp) N and 7041.17 N (for 45 hp)
- Torque = 270600 N-mm (for 35 hp) and 315920 N-mm.

Blade analysis
1. The maximum Displacement vector sum in: 6.757 mm (35 hp) and 7.893 mm (45 hp)
2. The maximum Von Misses Stress: 417.03 Mpa (35 hp) and 503.20 Mpa (45 hp)
3. The maximum principle stress for 35 hp tractor is 490 Mpa was observed in blade section.
   (This stress value is less than yield stress of blade material i.e 690 Mpa)
4. The maximum principle stress for 45 hp tractor is 577 Mpa was observed in blade section.
   (This stress value is less than yield stress of blade material i.e 690 Mpa)

The design optimization of both tillage tools by use of advance software tool can be useful to confirm the precision manufacturing specifications.