Affordable and Light Weight Handheld Cotton Picker for Biotechnological Applications in India

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ABSTRACT

Cotton today is one of the major crops in India. Huge population in this world depend on cotton for their livelihood directly or indirectly. Recently, The cotton production over the years have increased tremendously, but the cotton farmers in the developing countries are facing large problems like high labor wages, unavailability of labor with low market price to cotton. Also inconsistent climatic conditions play a major role especially during cotton harvesting. Most of the cotton picking is done manually in India. Cotton picking manually is time consuming with large wastage during picking. Farm mechanization is one of the major works which can be carried out to get maximum work within less time, money, labor. An attempt has been made to mechanize cotton picking in this paper. It also covers the anatomy of cotton plant, production, and its importance in Indian economy. Indian cropping pattern are studied in detail and various mechanism discussed and their pros and cons are evaluated. In this paper a portable hand held light weight cotton picker was designed to suit Indian farmers of different farm categories as it can save time and can be cost effective. Current labor wages which constitute about 35% of the total cost of cultivation can be reduced to about 10% with the use of cotton picker over a period of time. Also the problems like child labor and bleeding of fingers by burs can be prevented. This new development in agricultural sector can benefit millions of farmers across cotton producing nations in Asia.

KEY WORDS: Cotton Picker, Mechanization, Defoliation, Cotton Boll, Spindle.

1. INTRODUCTION

Cotton finds its significance presence in the modern biotechnology applications. India has emerged as a major player in cotton production as well as cotton products. Cotton is generally planted in the month of June in India and first picking can be done by October end and picking goes on till February. Cotton is grown in black clayey soil. The rainfall requirement is about 75-100 cm for cotton. Most of the cotton in India is planted in rain fed areas while very few are in irrigated land. India is second largest producer, consumer & exporter of cotton. Many people directly or indirectly depend on cotton for their livelihood, cotton is grown Central, West, North & South India .Major cotton producing states are Maharashtra, Gujarat, Telangana, Andhra Pradesh, Punjab. Cotton of all types can be grown in India (i.e. Asian, American, Egyptian and African). The main use of cotton is for making clothes and industrial products, cotton seed is high source of protein and used as animal fodder, and also the seeds can be used as fertilizer for plants. The linters on the cotton seed contain cellulose and can be used for automobile cushion, plastics and explosives.

Cotton is either picked manually or by machine. The percentage of cotton picked by hand and by machine in different cotton producing countries in shown in table 1.While Asian countries like India, Pakistan, Bhutan go for hundred percent manual cotton picking ,countries like USA, Israel, Australia have cent percent mechanized cotton picking. Manual picking is tedious and laborious job. Female labors and children are basically employed to pick cotton as they have slender and small fingers which suits manual cotton picking. Quite large amount of cotton is wasted by labors during picking; also labors have to face problems like bleeding of fingers because of boll pricking and pain in back. There has been acute shortage of labors and farmers have to book labors in advance before the picking season and pay them advance money to ensure their availability; at times farmers also have to bring labors from nearby villages and provide transportation. For machine harvesting though labors required are quite less there are other problems associated with it. Maximum farmers cannot pay for the high cost of machinery. Also the field needs to be defoliated before harvesting to avoid contamination and for better quality of cotton. As Indian farmers go for multiple picking ranging from 5-7 and most of the fields do not have irrigation facility, the use of defoliant is not possible as the crop is almost destroyed. Also the Indian varieties of cotton do not have synchronized boll opening; thus using harvester does not result in maximum yield which is not true for countries like USA, Australia where there is synchronized boll opening and the farmers go for another crop once the cotton is harvested. There is also damage to the plant is the driver of the harvester is not experienced and well trained. Indian farmers own small farms so lot of space is wasted in the farms which has to be left vacant so that the harvester can move without damaging the plant; also taking harvesters to the fields can be a troublesome affair as the roads are small, farms not connected directly by roads, small hills and rivers has to be crossed at times. Another disadvantage of machine harvesting is that the high density planting has to be adopted to get maximum yield, this result is high cost of seeds, fertilizers as well has high chance of spread of pest due to high density planting .There has been considerable demand from the labors to rise the wages given to them by farmers, the market rate been very less for cotton and increasing problems by labors the problems of the farmers are on a rise.

Table.1. Percentage of hand and Machine Picking in major countries

Country	Hand Picking	Machine Picking
Argentina	25	75
Australia	0	100
Brazil	90-95	5-10
China (Mainland)	100	0
Pakistan	100	0
USA	0	100
Uzbbekistan	60-70	30-40

2. EXPERIMENTAL SETUP

A few concepts (Concept 1-4, Fig. 1-4) were designed after brainstorming and a final concept was selected considering the advantages and disadvantages of the concepts.

Concept.1:

Design Parameter:

Mechanism	Power transmission by gear and belt drives
Motor Position	In body ,perpendicular to picking shaft
Cotton Passage	Through the handle in the backpack
Picking Mechanism	Cam mechanism for teeth
Vacuum System	Fan in the backpack and hose pipe into the handle

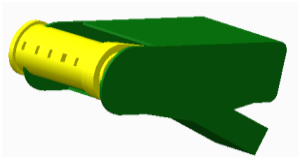

Figure.1. Gear & Belt Drive Concept

Concept.2:

Design Parameter:

Mechanism	Power transmission by two belt drives
Motor Position	In handle perpendicular to the picking spindle
Cotton Passage	Through body in the waist pack
Picking Mechanism	Cam mechanism for teeth
Vacuum System	Fan to the body cotton in waist pack

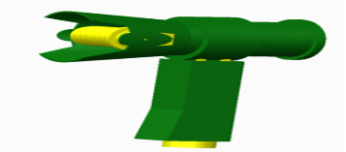

Figure.2. Double Belt Drive Concept

Concept.3:

Design Parameter:

Mechanism	Power transmission by belt drive
Motor Position	Offset to the picking spindle
Cotton Passage	Through the handle in the backpack
Picking Mechanism	Cam mechanism for teeth
Vacuum System	Fan in the backpack and hose pipe into the handle

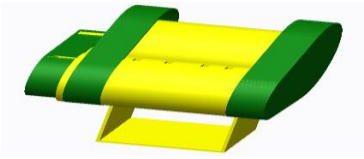

Figure.3. Belt Drive Concept

Final Concept:

Design Parameter:

Mechanism	Power transmission by belt drive
Motor Position	Parallel to picking spindle
Cotton Passage	Through the handle in the backpack
Picking Mechanism	Cam mechanism for teeth
Vacuum System	Fan in the backpack and hose pipe into the handle

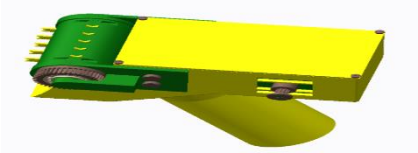

Figure.4. Selected Concept

3. RESULTS

Timing Belt & Pulley Design: The purpose of the timing belt is to transmit power from the motor to the shaft. Timing belt is preferred over flat or V belt. Speed ratio of 3.33 is selected for transmission. The bigger pulley has 40 teeth and runs at 1750 RPM while smaller pulley has 12 teeth and runs at 5800 RPM. The center distance is 93 mm. MXL belt is selected for power transmission.

Customized Bigger Pulley: Fig. 5 shows a bigger pulley with 40 teeth and 25.8 mm outer diameter, the pulley has splines on one end which meshes with the picking shaft and rotates it at 1750 RPM, thus the power is transferred from the motor to the picking shaft via timing belt and cotton is collected by the rotation of teeth inside the picking shaft. The point of concern in the pulley is the small spline on one side of the pulley, Initially the dimension of the spline was 1×1.5 mm, as a result of these small dimensions the spline failed when it was tested in Ansys 16.0 under given load, Further dimensions of the grooves were changed and FEA Analysis of Pulley and Picking shaft was carried. The splines were safe for both ABS & Aluminum material. The dimensions were selected by trial and error method to suit the model. The current dimensions are 3.5×2.6 mm. A load of 27.25 N was applied on the pulley covering 21 teeth as discussed in the calculation of timing belt. Four Unbounded contacts were developed to study the stresses in splines and grooves.

Finite Element Analysis:

Figure.5. Bigger Pulley

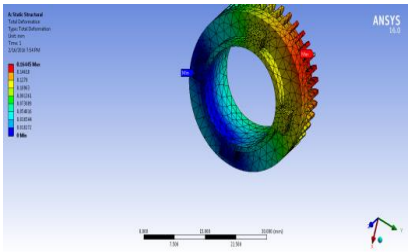

Figure.6. Deformation in Spline

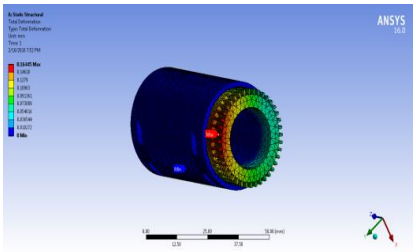

Figure.7. Stresses in pulley

Deformation: Fig.6.shows the max deformation of the spline which is around 0.1279 mm and is quite safe.

Von Misses Stress: Fig.7.shows max stress on the spline is around 24.78 MPa which is due to sharp corners on the edge and can be neglected. The stress value is safe for both Aluminum and ABS. The flexural yield strength of ABS is 73.1 MPa, while that of Aluminum (AlSi) is 230 MPa, Fig. 5 - 7 shows that the larger pulley splines is safe for both ABS and Aluminum, (Fig. 5 – 7) the grooves in the picking shaft the stresses developed in the grooves might be greater than permissible limit for ABS while it is safe for Aluminum, Thus by slightly changing the dimensions the picking shaft can be made safe for ABS.

Smaller pulley: The small pulley is mounted on the motor shaft which rotates at 5828 RPM, it has 12 teeth and its outer diameter is 7.9 mm. The shaft diameter of 3 mm is susceptible to failure as the pulley rotates at high RPM. The shaft of the motor is made of Structural steel, while the pulley is of Aluminum. A load of 27.3 N was applied on five teeth surfaces of the pulley.

Finite Element Analysis:

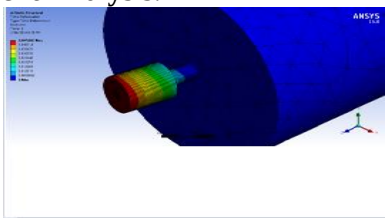

Figure.8. Deformation in Smaller Pulley

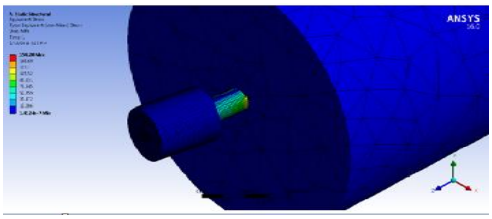

Figure.9. Von Misses Stress in Smaller Pulley

Deformation: Fig.8 shows that the deformation obtained in the pulley is 0.0458 mm.

Von Misses Stress: The Equivalent max stress is 158.28 MPa on the motor shaft which is within safe limits for structural steel as seen in Fig. 9.

Plates Design: There are two plates connecting the main outer body to the picking shaft and supporting the picking shaft. The offset hole is provided on the shaft as shown in fig 10; pulley is mounted on the deep groove boll bearings which are placed on the shaft, the outer race of bearing rotate with the pulley. Initially it was decided to have the plates of ABS for light weight purpose, while latter considering the importance of picking assembly, it was decided to make the complete assembly of Aluminum alloy. The Ribs are provided as supports. The shaft region was considered as a delicate section as it was supported like a cantilever beam and therefore FEA analysis was performed to study the deformation and stresses on the section by the rotating pulley and bearing.

Finite Element Analysis:

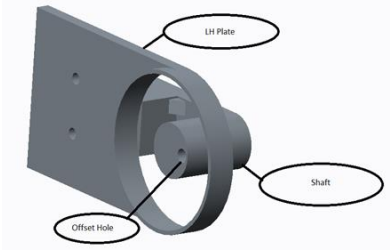

Figure.10. Left Hand Plate

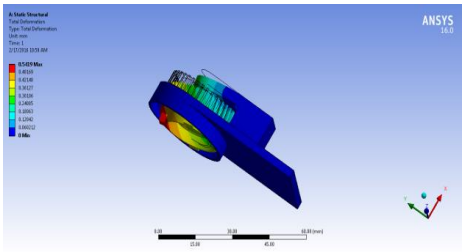

Figure.11. Deformation of LH Plate for ABS

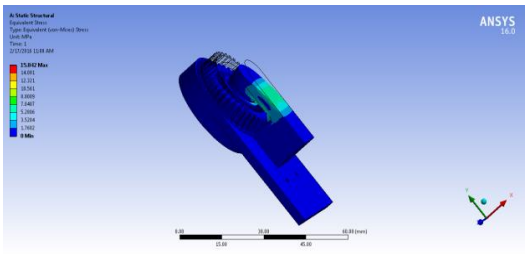

Figure.12. Von Misses Stress in LH Plate

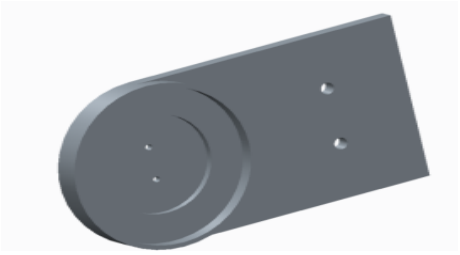

Figure.13. Right Hand Plate

Deformation: Fig.11 shows deformation for ABS Plate was found to be 0.5419 mm. Fig. 12 shows that max stress in Aluminum is about 8 MPa. The Cantilever beam type structure is safe as it is supported by ribs at corners and the thickness of the plate increased to 4 mm as a precautionary measure.

The RH plate as shown in Fig. 13 provides a supporting end to the Picking assembly, a small disc as show above is fitted inside the bearing and screwed to the plate, this provides the support to the small shaft from the other end, while the bearing can rotate along with the picking shaft. The thickness of the disc is greater than the bearing so that the bearing does not touch the plate.

Picking Mechanism: The picking mechanism consists of picking head, teeth, shaft, Spacers. Fig. 14 shows the assembled picking shaft with teeth, as seen in the diagram there are two sets of teeth on the shaft at different angle, as shown one end of the teeth picks cotton and brings it in the picker, the other set of teeth take the first position and the process continues. The teeth are fitted into the grooves and slide on the shaft changing positions as the picking head rotates. The teeth retract into the picking head after picking cotton, thus the cotton attached to the teeth is removed. The picking head consist of two halves which are joined one's the teeth are fitted inside using screws, this facility provides ease in replacing the teeth in case some teeth breaks, without changing the complete picking head. Also this reduces the complexity in assembly. The spacing between the teeth is so adjusted that the cotton is picked in one rotation of the spindle as it saves time and helps in fast operation. The effective length of the picking shaft is around 46.5 mm; from literature it is found that the average length of the fully open cotton bowl is 56 mm. The other end of the picking shaft has a slot about 5 mm inside the picking head in which a bearing is attached, inside the inner diameter of bearing is a small disc with offset hole so that it provides support to the shaft as discussed above in RH Plate.

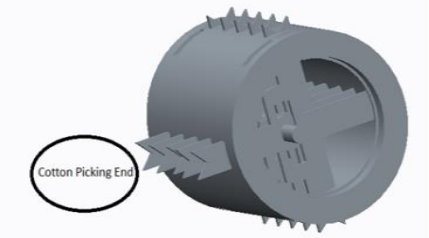

Figure.14. Cotton Picking Assembly

Bearing Selection: Among the various types of bearings available ball bearing were selected as they can be used for small and medium load. Total bearing requirement was three. Two bearings of same type on the LH Plate shaft with inner diameter 12 mm and outer diameter 21 mm are considered while one bearing of inner diameter of 15 mm and outer diameter of 24 mm are required.

The bearing on the LH Plate is 61801-2z SKF bearing as it matches the required dimensions. The width of the bearing is 5 mm. Thus according to dimensional requirement as well as from static and dynamic rating 61801 2z bearing satisfy the conditions and can be used.

Finite Elemental Analysis:

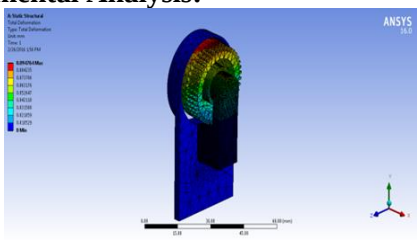

Figure.15. Deformations in Bearing

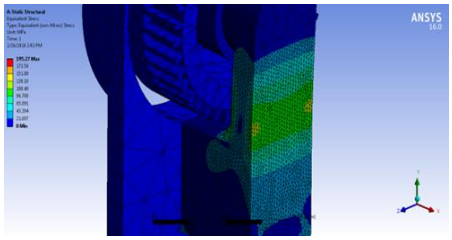

Figure.16. Von Misses in Bearing

Deformation: From Fig 15 it was found that the max deformation is 0.0947 mm when a load of 271 N was applied to press fit the bearing on the pulley.

Von –Misses Stress: From Fig. 16 the max stress of 194 MPa was obtained and that stress is within safe limits when a force of 271 N is applied on the bearing.

The Bearing on the RH Plate is 61802 -2Z which has a width of 5mm and the outer diameter of 24mm and inner diameter of 15mm [8].This bearing is fitted on other end of the picking shaft in the groove provided and rotates with the picking shaft. Another small disc which supports the other end of the shaft having rotating teeth is supported by this bearing.

Outer Body: The outer body of the cotton picker is as shown above. The picking assembly is attached at the front with small passage below which guides the picked cotton into the hole from where it passes through the handle into the hose pipe connected to the bag at the back. The outer body is totally closed except for the opening for cotton so that an effective suction pressure is created. The motor plate separates the cotton from entering the motor chamber and guides it to the hose pipe. The body cover plate is screwed at the top to make it a closed one.

4. CONCLUSION

Based on the above study, the portable Cotton Picker advantages are concluded as follows:

a) The problem of labor availability is a big issue and portable cotton picker will help to overcome it to certain extend.

b) With no possibility of new variety of seeds coming up in near future, the unsynchronized boll opening can be used to advantage for cotton picker.

c) The problems that labors or farmers face during picking will be completely eliminated.

d) There is considerable increase in cotton picking per day compared to manual picking.

e) The amount of trash collected by the picker is less compared to manual picking.

f) The wastage in cotton picking is reduced considerably.

g) Over a period of time the profit of farmers will increase as harvesting constitute 35% of total crop production.

h) Now men can also harvest cotton using machine so the cases of Child Labor and Women exploitation can be decreased.

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