International Journal of Agriculture Sciences
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 13, Issue 2, 2021, pp.-10656-10662.
Available online at https://bioinfopublication.org/pages/jouarchive.php?id=BPJ0000217

Research Article

COMPUTER AIDED DESIGN OPTIMIZATION AND PERFORMANCE EVALUATION OF PNEUMATIC SUCTION BASED COTTON PICKING MACHINE

TEKALE D.D.[1], SHINDE G.U.*[2] AND RAVI KUMAR K.[3]
[1,2]Department of Farm Machinery and Power Engineering, College of Agricultural Engineering and Technology, Vasantrao Naik Marathwada Agricultural University, Parbhani, 431402, M.S., India
[2,3]NAHEP-CAAST-DFSRDA, Vasantrao Naik Marathwada Agricultural University, Parbhani, 431402, M.S., India
*Corresponding Author: Email - gushindevnmkv@gmail.com, ddtekale@gmail.com

Received: February 01, 2021; Revised: February 25, 2021; Accepted: February 26, 2021; Published: February 28, 2021

Abstract: The cotton picking is the major problems faced by the small and farmers due to scare of harvesting labor and affordable technology near about 30% cost of cultivation of the cotton crop is required for harvesting of cotton in India. Manual picking of cotton is labor intensive, requiring average 1565 man hours per hectare. The proposed research work introduces a computer aided design optimization and fabrication of pneumatic suction based solar operated cotton boll picking machine with single man/women operator. The performance of newly developed machine is compared with manual picking method. The Cost of cotton boll picking Rs. /ha of cotton boll picking machine for variety PDKV-2BG-II and Hybrid of Bt. cotton NHH 44 bt. for suction hose pipe length 1.50 m and 120x30 cm plant spacing observed as Rs. 12809.35, and14697.60 per ha cotton harvested respectively whereas by manual method its observed was Rs.13630.50 and 20285.70 per hectare for two varieties respectively.

Keywords: *Pneumatic suction, Cotton picking machine, Solar panel, Invertor, Hose pipe*

Citation: Tekale D.D., *et al*., (2021) Computer Aided Design Optimization and Performance Evaluation of Pneumatic Suction Based Cotton Picking Machine. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 13, Issue 2, pp.- 10656-10662.

Academic Editor / Reviewer: Dr Vipul N Kapadia, Dr Amatul Muhee

Introduction

Cotton crop is gloriously influenced as white gold product amongst farming community. However, with present farming trends India's cotton production will decline by nearly two percent to 280 lakh 4.593 metric ton (36.85 million 170-kilogram bales/ 6.26 MMT) in marketing year 2020-21, due to lower harvested area at 312 lakh acres. The farmer's cotton production decisions are primarily driven by their expected price realization and current market conditions indicate that farmers will likely shift a part of the acreage to alternate crops. Despite a large government minimum support price (MSP) procurement program, farmers did not obtain adequate prices in marketing year 2019-20. However, with large raw cotton carryover stocks, prices are expected to remain suppressed in FY 2020-21. Additional factors such as the relative cost of production of competing crops, water availability, central/state government support, and a timely monsoon are also crucial in farmers' planting decisions. Post anticipates cotton area to fall by 656,000 hectares(2019-20) to 12.64 million hectares for MY 2020-21 as seed cotton farm-gate prices for MY 2019-20 are almost 10 percent lower than the previous year(refer to [Table-1]. Low farm-gate cotton prices, unsatisfactory price realization from MSP procurement, and the recent increase in the maximum retail prices of cotton seeds will prompt farmers to consider planting lower cotton acreage. Another factor, while not as significant, is the frequent incidence of pest infestation in the cotton crop.

Output is expected to improve by three percent compared to the last year on the expectation of normal monsoon season. The uncertainty due to COVID-19 situation impacted long-term cotton consumption and trade. Post estimates mill consumption to decline by 6 percent to 22 million 480-lb. bales. European markets and the United States have been affected significantly by COVID-19, leading to the cancellation/deferment of many orders due to market uncertainty. World cotton use is expected to grow at 1.5% p.a. as a result of economic and population growth; reaching 28.3 Mt.

Utilization of cotton in China is expected to fall down to 6.9 from the year 2010, at the same time India is the world's largest country for cotton mill utilization (8 Mt) up to 2025. The cotton harvesting is the major problems faced by the farmers by using female or male labour and near about 30% cost of cultivation of the cotton crop is required for harvesting of cotton in India. Manual picking of cotton is labour intensive, requiring 1565 man hours per hectare. Also, day by day availability of labors is going to decreasing and small hand operated cotton pickers are not suitable for harvesting cotton on large areas creates substantial potential for cotton production to expand in the next decade. While the medium-term prospects are for sustained growth, there may be potential short-term uncertainties in the current Outlook which may result in short-term volatilities in demand, supply and prices. A sudden slow-down in global economy, a sharp drop in global textiles and clothing trade, quality and price competition from synthetic fibers and changes in government policies are important factors that can affect the cotton market. The unprecedented high stock level is a key driver of the world cotton price.

Mechanical cotton harvester, as the name implies, collection of seed cotton from open cotton bolls and leave the empty burs and unopened bolls on the plant and leaves the trashes of the plant by using only one operator. New developed cotton boll harvester harvests 2 rows of cotton plants at a speed of 1.0 to 1.5 meters per second. When the cotton harvester collecting bag gets filled with seed cotton, the machine is driven to a cotton trailer at the edge of the field. As the bag is opened and dump to store.

There were many critical issues for cotton production cycle from sowing to harvesting; however, the problem of harvesting is serious due to scare of farming labor participation and costlier mechanization technology that is unaffordable to small and marginal farmer cotton cultivators. The present proposed research introduces a new innovation in design and working mechanism features of cotton picker machine.

There are many kinds of design features with different working mechanism features in global market and farmers are practicing on it however this practice and proposed cotton picker machine has found success after exhaustive trials for different cotton verities with different cropping pattern systems on various farmers production plot.

The proposed method of research introduces a systematic procedural step for entering in to design, fabrication and performance validation to finalize the final mass production of cotton picker machine using software environment working on pneumatic suction-based cotton harvesting mechanism.

Materials and Methods

The design and development of cotton picker machine under this chapter is divided in to two main sections Theoretical traditional designing procedure and computational engineering analysis by using CAE-Software such as ANSYS workbench 2020 R_1. The computer aided design and drafting is done in workbench and CFD analysis in ANSYS Fluent module. The CAD-solid geometric solid models with details of each component and finite meshing with loading and boundary conditions are assigned with different speed, vacuum pressure is assigned for simulation cycle.

The precise dimensional specifications fitting for safe and secured designed predicted by several iterations and post simulation process. Thus, the final technical specification of each components and entire cotton picker assembled machine confirms the manufacturing features.

In second section the fabrication of cotton picker machine is done and tested in laboratory as well as in field for its validation and mass production.

I. Theoretical Design Procedure

1.Design of Shaft

Battery power = 1300 watt;
Engine power = 1.3 kW.;
Speed = 20,000 RPM;
KL= Load Factor = 1.15;
π = 3.14
Power (P),kW = (2πNT) /(60 X 1000) X KL

2.Torque

T= (P X 60 X 1000) / (2 π N X KL)
T= (1.30 X 60 X 1000) / (2 X 3.14 X 20,000 X1.15)
T= 78,000 / 144440
Torque (T) = 0.54 N-m or 540 N-mm

3. Assume material SS-304 and FOS is 3.

Tensile Strength (σ) = 620 MPa = 620 N/mm2
Share stress (Ƭ) = (Tensile Strength (σ) X 0.5)/(FOS)
Share stress (Ƭ) = (620 X 0.5) / 3
Share stress (Ƭ) = 104 N/mm^2
$T= (\pi/16)\ Ƭ.D_s^3$
D_s= (16 X T) / (πX Ƭ)
D_s= (16 X 0.54X 1000) / (3.14X 104)
D_s= 8640 / 326.56
D_s= 28 mm
Standardizing Diameter of Shaft (D_s) = 28 mm

4. Design of Impeller:

The diameter of the impeller eye, D_o, is dependent on the shaft diameter, D_s, which must initially be approximate. The hub diameter, D_H, is made 5/16 to ½ inch larger than D_s. After estimating D_s and D_H, D_{oi} is based on the known flow rate. The inlet vane diameter, D_1, made about the same as D_o to ensure smooth flow.

The hub diameter, D_H, is made from 5/16 to ½ in. larger than D_s

$$D_H = \frac{5}{16}28+28$$

D_H =36.75mm
D_H=Consider diameter of hub is 38 mm

Diameter of suction pipe is 42 mm (stander Diameter).
Velocity of impeller (V) = πDN
V = (3.14 X 42 X 20,000)/(1000 X 60)
V = 2,637,600/60,000
V = 44 m/s
Selected impeller of discharge is (Q) = A. V.

$$= \frac{\pi}{4} X\ d^2\ X\ V$$

= 3.14/(4 X 1000 X 1000) X 42 X 42 X 44
= 0.0609 m^3/sec
The required discharge is 0.0609m^3/sec with respect to velocity of 44 m/s.
Since, required suction pipe diameter is 42 mm.

Discharge in impeller (Q) = V_0 X $\left[\frac{\pi X D_o^2}{4} - \frac{\pi X D_H^2}{4}\right]$ Where,

V_0 = Velocity of air in impeller, 44 m/s ; D_H = diameter of hub is, 38 mm
D_0 = diameter of delivery pipe

$$0.0609 = 44X\left[\frac{3.14\ XD_o^2}{4} - \frac{3.14\ X38\ X38}{4}\right]$$

D_0^2=(0.0609 X 4 X 1000 X 1000)/(44 X 3.14)+1444
D_0^2=243600/138.16+1444
D_0^2 = 3207.17
D_0= 56.63 mm
Standard diameter D_0= 58 mm

Outlet velocity at impeller
V_1= πD_0N
V_1= (3.14 X 58 X 20000)/(1000 X 60)
V_1= 60.70 m/sec
Outlet Diameter of Impeller is (D1) 113 mm (From impeller)
V_2= πD_1N
V_2= (3.14 X 113 X 20000)/(1000 X 60)
V_2= 118 m/sec

5. Pressure Calculation:

Pressure created by impeller at the outlet.

$$P = 249.08\ X\ 1.1\ \left(\frac{N\ X\ D1\ X\ 39.37}{153\ X\ 10^4}\right)$$

$$P = 249.08\ X\ 1.1\ \left(\frac{20000\ X\ 113\ X\ 39.37}{1.53\ X\ 10^4}\right)$$

P = 249.08 X 1.1X 5815.43 X 5815.43
P= 9266.06 Pa.

6. Design of cotton collection Tank

Tank capacity: The maximum capacity of collection tank was determined by following equation.

Q_t = C x t

Where, Q_t = tank capacity, kg; C = collection rate, kg/min
t = picking time, minutes; Q_t = 0.26 x 60 = 15.60 kg
Volume of collection tank: Volume of collection tank was determined from following equation.
$V_T = W/B_d$
Where: V_T = volume of drum, m^3 ; W = weight of cotton in the drum, kg and
Bd = bulk density of cotton, kg/m^3 (178 kg/m^3)
V_T = 15.60/178 m^3 ; V_T = 16.00 kg.

CAE-Analysis

The computer Aided Engineering Analysis (CAE) is very important software tool which can be useful to perform a pre-fabrication diagnosis of the machine components and entire machine assembly assessment for its fitness towards a sustainable design and can proceed to fabrication work with virtual confirmation by structural, cumulative fluid dynamics, electromagnetic stresses like analysis required to design and can functionally evaluate to optimum design parameters.

Thus, the steps in CAE-Analysis cycle can be created by the following standard procedural steps as discussed below

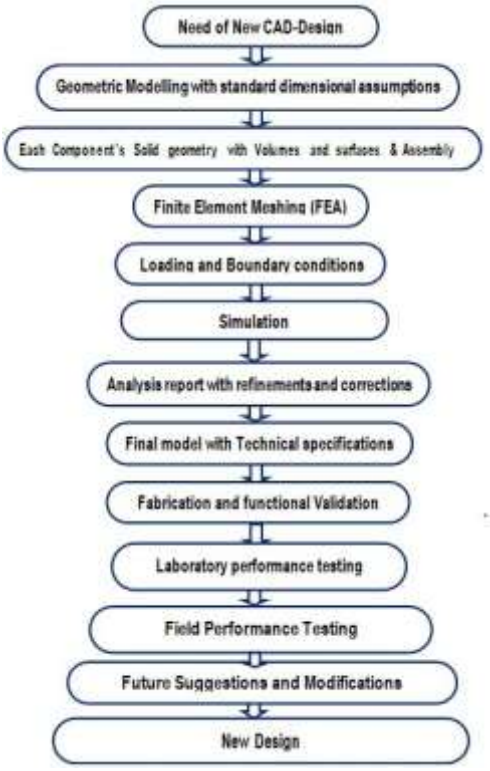

Fig-1 Computer Aided Engineering Analysis (CAE) Process Flow Chart

The computer aided design and drafting is done in Ansys is done in ANSYS workbench 2020 R_1 as below

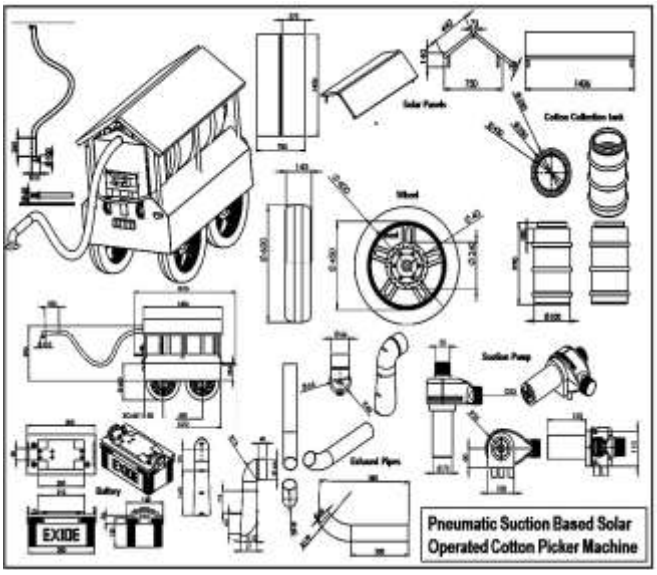

Fig-2 CAD-drawings of Pneumatic Suction Based Solar Operated Cotton Picker machine

Fig-3 CAD-Solid model of Pneumatic Suction Based Solar Operated Cotton Picker machine

Structural Analysis

Selected RPM: 15000, 17500, 20000

a) Deformation; b) Elastic Strain; c) Shear Stress

CFD-Analysis: selected Parameter:

a) Velocity: 44m/s^2 ; b) Temperature: 400 to 450

c) Pressure: 3500 to 9000 Pa

CAE-Analysis

The cotton picking machine designed and fabricated by constraining the features with conceptual geometric modeling and fabricated by design confirmation on the basis of CAE-analysis using ANSYS R1 2020 Software. The technical specifications of cotton picking machine were decided.

II. Laboratory test

The Battery charging by electricity takes 4.25 hrs

Battery charging by electricity with solar panel takes up 4.30 hrs

Battery discharging time takes 1.50 hrs., Speed of impeller, RPM 20000

III. Field Performance test

The field plot of size 25.00× 6.00 m was selected randomly for trials.

Field trials were taken by using suction pipe of 1.50 m length and plant spacing 120x30 cm.

The trials on two Bt. cotton varieties such as PDKV-2BG II and Hybrid variety of Bt. Cotton NHH44 bt. were taken.

There were three replications of each trial conducted and average results were calculated. The observations taken during the trials were recorded in Table No 5.3 for developed cotton picker machine and manual picking method

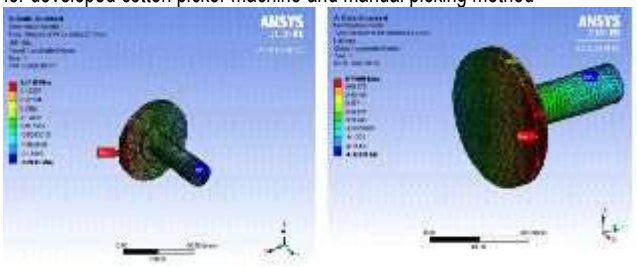

Fig-4 Deformation of impeller for 15000 RPM and 17500 RPM speed

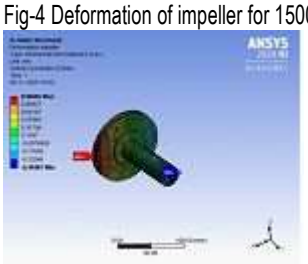

Fig-5 Deformation of impeller for 20000 RPM speed

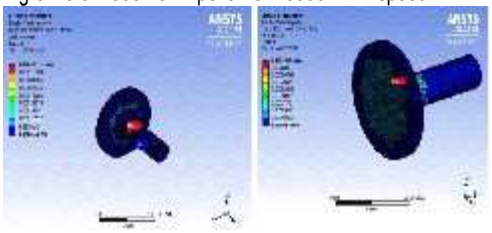

Fig-6 Elastic strain of impeller for15000 RPM and 17500 RPM

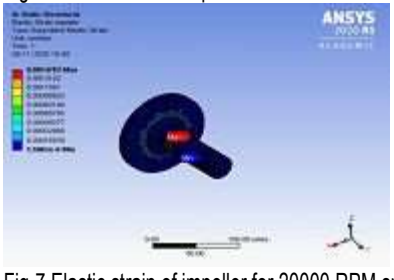

Fig-7 Elastic strain of impeller for 20000 RPM speed

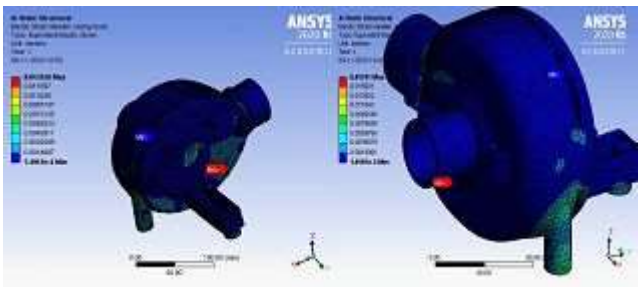

Fig-8- Elastic strain of impeller casing for 15000 RPM and 17500 RPM speed

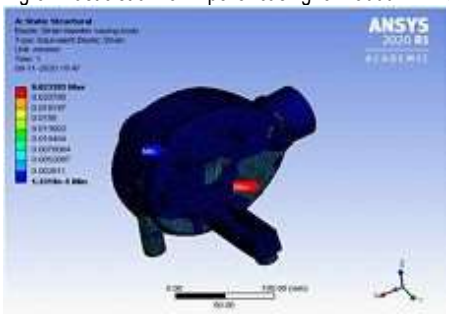

Fig-9- Elastic strain of impeller with casing body for 20000 RPM speed

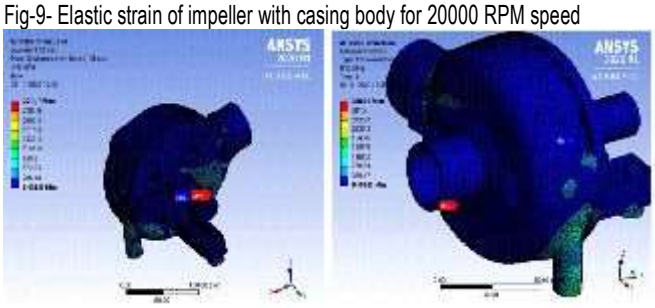

Fig-10- Equivalent stress of impeller casing body for 15000 RPM and 17500 RPM speed

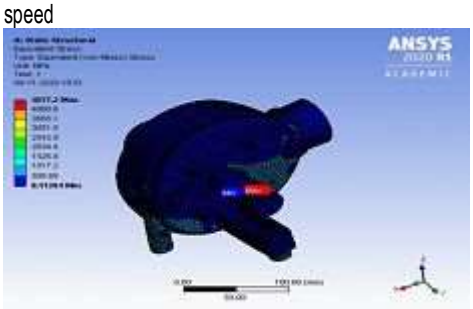

Fig-11 Equivalent stress of impeller casing body for 20000 RPM speed

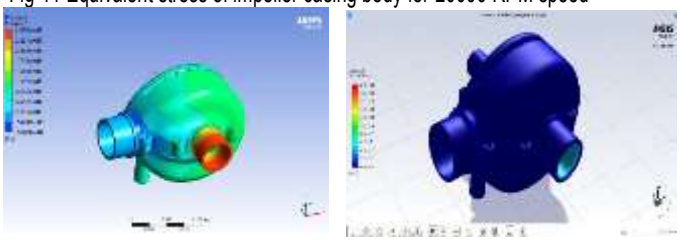

Fig-12 CFD Analysis of Velocity & Pressure of suction pump at 20,000 RPM

Fabrication of Pneumatic suction-based cotton boll picking machine

The design and fabrication of Pneumatic suction-based cotton boll picking machine was manufactured at workshop of Department of Farm Machinery and Power Engineering, College of Agricultural Engineering and Technology, VNMKV, Parbhani. The newly developed picking machine fabricated and tested in field is as shown in [Fig-12] The main functional components of the developed Pneumatic suction-based solar operating cotton boll picking machine as shown in [Fig-2]-, shows following components

1. Electric motor with suction pump,
2. Inlet suction hose pipe,
3. Outlet hose pipe,
4. Battery,
5. Inverter
6. Solar panels,
7. Cotton Storage tank;

The whole components of Pneumatic suction-based cotton boll picking machine mounted on frame made from stainless steel material. Description of these components is given in following subsections. The Pneumatic suction-based cotton boll picking machine was operated by one person or labour in the field. The developed Pneumatic suction-based cotton boll picking machine specifications after CAE analysis and optimum that confirms the dimensions are given in [Table-1].

Table-1 *Specifications of suction-based cotton boll picking machine*

SN	Particulars	Specifications
1	Overall dimensions (LxBxH) mm	1810 x 790 x1200
2	Electric motor	D. C. Motor 1.3kW 20,000 RPM
3	Battery, volt	12v ,100Ah (2Nos)
	Exide Solar hybrid UPS, VA	2200 VA, 24 volt
4	Speed of impeller, RPM	20,000
5	Size of trolley, mm,	1406 x790 x890
6	Diameter of Trolley wheels, mm	600
7	Capacity of cotton boll collection Tank, kg	20
8	Total length of suction pipe, mm	1500
9	Total length of outlet pipe with bend, mm	450
10	Diameter of suction pipe, mm	55
11	Diameter of outlet pipe, mm	60
12	Type of cotton suction and pickup Pipe	PVC hose pipe
13	Type of suction pipe mechanism	Pneumatic suction
14	Solar panel no's and size, mm	4nos, 600 x 450 mm,
15	Capacity of each solar panel, watt	50
16	Total capacity of solar panel, Watt	200
17	Total weight of the machine, kg	180
18	No. of Operator require	1

1. Prime mover

The pneumatic suction-based cotton boll picking machine was powered by 1.3 kW electric dc motor with suction pump having 20,000 RPM impeller speed.

2. Battery with inverter

Two Batteries having capacity of each battery is 12v, 100 Ah attached with Exide Solar hybrid inverter having capacity 2200 VA, 24 volts connected and fitted below the electric dc motor.

3. Collection Tank

A PVC container of 200 litre capacity was used as a collection tank for collecting cotton bolls picked by the machine. It was fixed on the steel body frame and the top of the collection tank was attached to the outlet pipe of the machine to collect the cotton bolls.

4. Suction hose pipe

Suction hose pipe of 1.50 m length having 60.00 mm diameter made of PVC material used for harvesting the cotton bolls from plant with the help of mechanical type of rotating spindle attached to the one end of suction pipe and another end of suction pipe was attached to the inlet of suction pump.

5. Outlet pipe

Outlet pipe of 0.75meter length having 60.00 mm diameter made of PVC material were attached to the outlet of suction pump and another end of outlet pipe attached to the collection tank with the help of holding clips for collecting the cotton bolls.

6. Frame

The different components of pneumatic suction-based cotton boll picking machine was mounted on steel frame which was light weight, durable and anticorrosive. It was fabricated from light weight stainless steel pipe material. The dimensions of frame *i.e.* Length, width and height were 1810, 790 and 1200 mm respectively.

7. Transport wheel

The pneumatic suction-based cotton boll picking machine was provided with four motor cycle wheels for easy transportation of machine from one field to the other. The diameter of transport wheel was 600 mm. Each wheel was provided with five spokes made from aluminium casting material.

These spokes were welded at one end to the inside of the rim having diameter 450.00 mm and at other end to the transport wheel bush. The 40 mm inside diameter bush was provided on both the side for easy motion. These transport wheels were mounted on 20 mm diameter M.S. shaft of 100 mm length.

Result

The optimum design parameters of cotton picker machines after theoretical design procedure and CAE analysis were confirmed to fabricate and test in the laboratory as well as cotton field for its validations and identifying necessary corrections if any. It is observed that the machine performance was satisfactory with justification as per farmer's requirement and desired quality parameters.

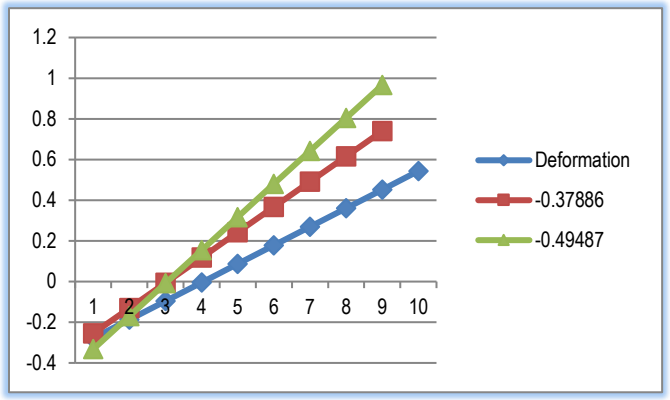

Fig-13 Field performance of newly developed Cotton picker machine

CAE-Results

The computer Aided Engineering Analysis is done before manufacturing process to confirm the optimum technical specifications. Initially the conceptual CAD model is prepared and finite meshing is tested by simulation cycle with assignment of different loading and boundary conditions. The structural stresses and strains by deformation for three 15000, 17500 and 20000 RPM values were tested for suction pump design by CAE analysis.

Stresses, Elastic strain and Deformation of Suction pump with impeller

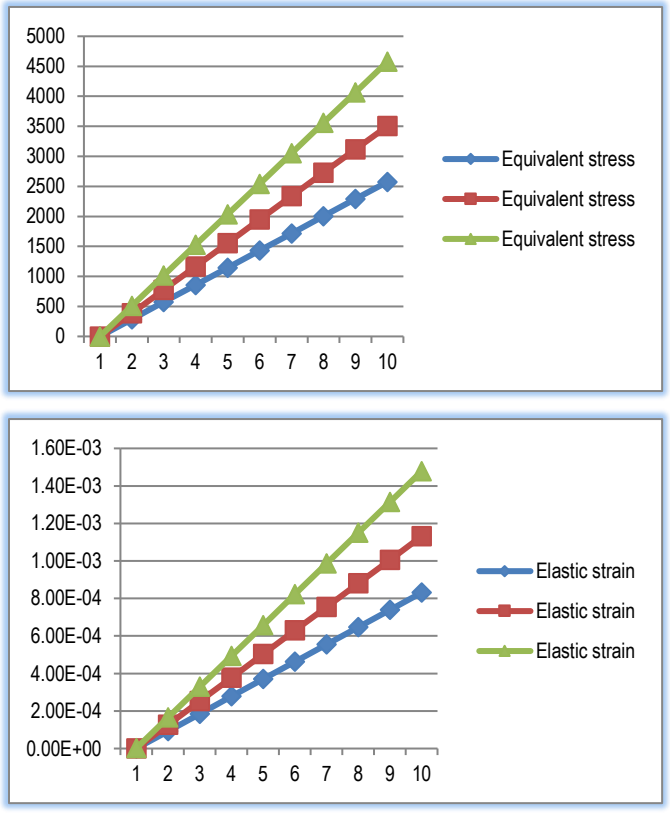

Fig-13 Equivalent stress and elastic strains trends for three different speeds

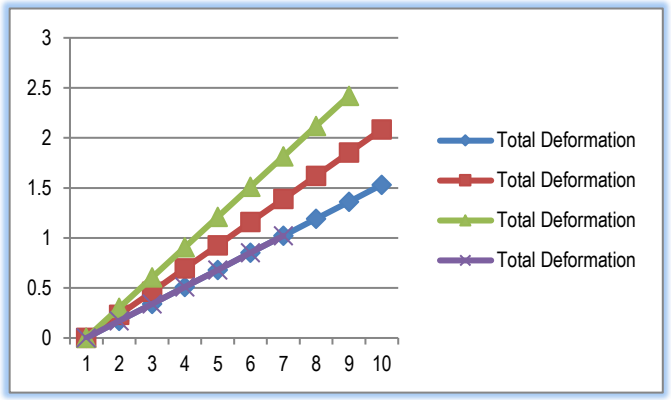

Fig-14 Total deformations trends after observations for three different speeds.

The CAE report generated as shown in table below

Table-2 *CAE-simulation cycle results for suction pump*

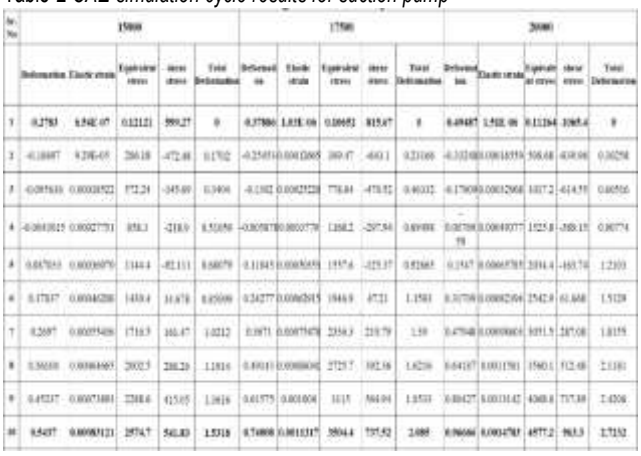

Table-3 *CFD Analysis of suction pump for pressure and velocity at 20,000 RPM*

SN	Velocity	Pressure distribution
1	0.00E+00	2.65E+05
2	2.17E+01	2.35E+05
3	4.34E+01	2.05E+05
4	6.51E+01	1.75E+05
5	8.68E+01	1.45E+05
6	1.09E+02	1.15E+05
7	1.30E+02	8.46E+04
8	1.52E+02	5.45E+04
9	1.74E+02	2.44E+03
10	1.95E+02	5.69E+03
11	2.17E+02	3.58E+04

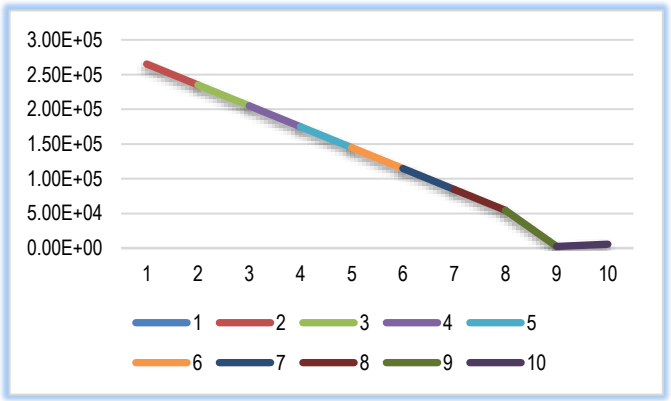

Fig-15 CFD Analysis pressure distribution of suction pump at 20,000 RPM

It was observed that, From the [Table-3] by CFD Analysis of suction pump for pressure and velocity at 20,000 RPM velocity increases linearly from 0 m/s to 217 m/s and pressure gradually decreases from 265 MPa to 35.8 MPa which was sufficient for sucking the cotton boll from plant to cotton collection tank.

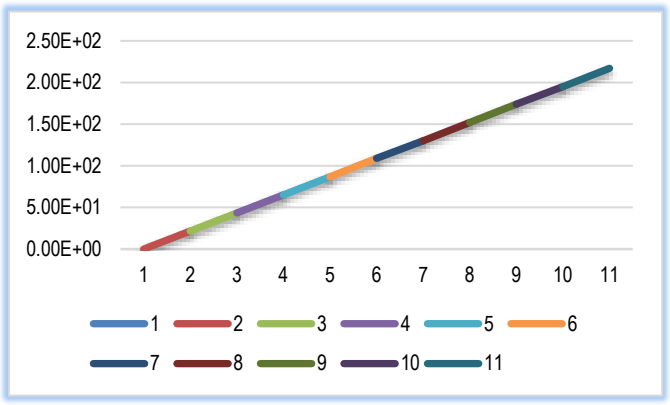

Fig-16 CFD Analysis of velocity of suction pump at 20,000 RPM

Table-4 *Output capacity kg/hr of machine Vs manual method*

	Machine	Manual
PDKV-2BG-II	12.39	2.14
NHH-44, Bt	15.31	2.84

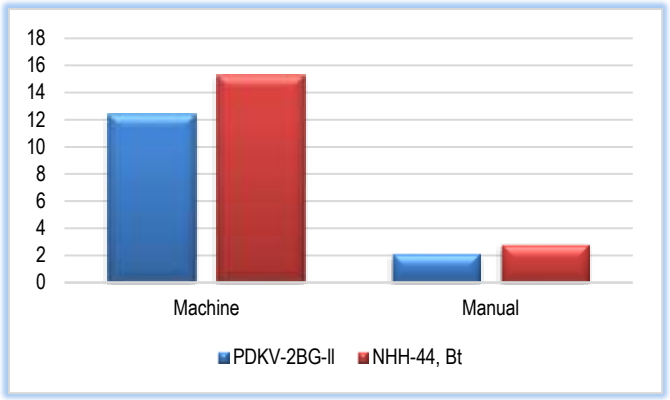

Fig-16 output capacity of cotton boll picking machine with manual picking method

From the [Fig-16] it was observed that, there was significant difference in output capacity of the cotton picking machine in comparison with manual cotton picking method. The output capacity of cotton boll picking machine for variety PDKV-2BG-II and Hybrid of Bt. cotton NHH 44 Bt. for suction hose pipe length 1.50 m and 120x30cm plant spacing observed aboutm12.39, 15.31 kg/hr cotton harvested respectively. As compare to manual cotton picking method the output capacity observed was 2.14 and 2.84 kg /hr respectively which were five times less as compared to the cotton boll picking machine.

Results and discussion

Field-Results

The observations taken during the Field performance evaluation trials of cotton boll picking machine with manual picking Method for variety PDKV-2BG-II, Hybrid of Bt. Cotton NHH-44, Bt, spacing 120x30 cm and Suction hose pipe length 1.50 were given in [Table-5]. From the [Table-5] it was observed that effective field capacity of cotton boll picking machine for variety PDKV-2BG-II and Hybrid of Bt. cotton NHH 44 bt. was for suction hose pipe length 1.50 m and 120x30 cm plant spacing respectively observed was 0.0065, 0.0070 ha/hr respectively. As compare to manual cotton-picking method the effective field capacity observed was 0.00139 and 0.00140 ha/hr respectively. From these results it was predicted that for NHH - 44 Bt. Variety with 120x30 cm plant spacing gets higher effective field capacity in cotton boll picking machine as compared to manual cotton picking method respectively.

From the [Table-5] it was also observed that field efficiency of cotton boll picking machine for variety PDKV-2BG-II and Hybrid of Bt. cotton NHH 44 bt. was for suction hose pipe length 1.50 m and 120x30 cm plant spacing respectively observed was 86.02, 90.13 percent respectively. As compare to manual cotton-picking method the field efficiency observed was 85.74 and 86.35 percent respectively. From these results it was predicted that for NHH - 44 Bt. Variety with 120x30 cm plant spacing gets higher field efficiency in cotton boll picking machine as compared manual cotton picking method respectively.

Table-5 *Comparison of Field performance evaluation of cotton boll picking machine with manual picking Method*

SN	Particulars	Suction hose pipe length 1.50 m		Manual Picking method	
1	Variety and hybrid of Bt. Cotton	PDKV-2BG-II	NHH-44, Bt	PDKV-2BG-II	NHH-44, Bt
2	Spacing between R-R & P-P, cm	120x30	120x30	120x30	120x30
3	Size of plot, m	25.0x6.0	25.0x6.0	25.0x6.0	25.0x6.0
4	No. of plants per plot	416	416	416	416
5	Average height of plants, cm	113	119	112	117.33
6	Average no. of bolls per plant	28	33	26	33
7	Average no. of pick-bolls per plant	23	28	23	29
8	Percentage of open bolls	83.27	85.3	85.07	87.24
9	Average no. of closed cotton bolls	4.3	5	3	4.33
10	Percentage of closed cotton bolls	16.93	14.68	16.44	12.74
11	No. of boll picked, no.	23	29	23	29.61
12	Picking efficiency, Percent	83.22	85.3	85.07	87.24
13	Suction hose pipe length, m	1.5	1.5	-	-
14	Width of operation, m	1.5	1.5	1.2	1.2
15	Average speed of operation, kmph	0.051	0.052	-	-
16	Total time need for picking plot, min	118	123.66	630	640
17	Theoretical field capacity, ha/hr.	0.0076	0.0077	0.00157	0.00162
18	Effective field capacity, ha/hr.	0.0065	0.007	0.00139	0.0014
19	Field efficiency, percent	86.02	90.13	85.74	86.35
20	Seed cotton collected, kg	24.33	31.5	22.41	30.33
21	Output capacity, kg/hr.	12.39	15.31	2.14	2.84
22	Trash content, g	823.33	860	596.66	657.33
23	Percentage of trash content,	3.38	2.72	2.66	2.15
24	Seed cotton collected, Kg/ha	1906.15	2187.14	1363.05	2028.57
25	Cost of cotton boll picking Rs. /kg	6.72	6.72	10	10
26	Cost of cotton boll picking Rs. /ha	12809.35	14697.6	13630.5	20285.7

There was significant difference in output capacity of the cotton-picking machine in comparison with manual cotton-picking method. The output capacity of cotton boll picking machine for variety PDKV-2BG-II and Hybrid of Bt. cotton NHH 44 Bt. for suction hose pipe length 1.50 m and 120x30 cm plant spacing observed about 12.39, 15.31 kg/hr cotton harvested respectively. As compare to manual cotton-picking method the output capacity observed was 2.14 and 2.84 kg /hr respectively which were five times less as compared to the cotton boll picking machine. it was also observed that the average-picking efficiency for the cotton boll picking machine and manual cotton-picking method for variety PDKV-2BG-II and Hybrid of Bt. cotton NHH 44 bt. for suction hose pipe length 1.50 m and 120x30 cm plant spacing observed about 83.22, and 85.30 percent respectively. As compared to manual cotton-picking method the picking efficiency observed was 85.07 and 87.24 percent respectively. From these results it was predicted that for NHH - 44 Bt. Variety with 120x30 cm plant spacing gets higher picking efficiency in cotton boll picking machine as compared manual cotton picking method respectively.

Also, from the [Table-5] it was also observed that Percentage of trash content, in Percent observed less in Hybrid of Bt. cotton NHH -44 Bt. Variety as compared to PDKV-2BG-II variety for suction hose pipe length 1.50 m and 120x30 cm plant spacing which was found to be 3.38 and 2.72 percent as compared to 2.66 and 2.15 percent respectively for cotton harvested by cotton boll picking machine as compared manual cotton picking method respectively.

From the [Table-5] it was also predicted that that Seed cotton collected, Kg/h by cotton boll picking machine for variety PDKV-2BG-II and Hybrid of Bt. cotton NHH 44bt. for suction hose pipe length 1.50 m and 120x30 cm plant spacing respectively observed was 1906.15, and 2187.14, kg/ha respectively. As compared to manual cotton-picking method the Seed cotton collected, Kg/ha observed was 1363.05 and 2028.57 kg/ha respectively. From these results it was predicted that for NHH - 44 Bt. Variety with 120x30 cm plant spacing gets higher Seed cotton collected, Kg/ha, by using cotton boll picking machine as compared to manual cotton-picking method respectively.

There was significant difference in Cost of cotton boll picking Rs. /ha of the cottonpicking machine in comparison with manual cottonpicking method. The Cost of cotton boll picking Rs. /ha of cotton boll picking machine for variety PDKV-2BG-II and Hybrid of Bt. cotton NHH 44 bt. for suction hose pipe length 1.50 m and 120x30 cm plant spacing observed about Rs. 12809.35, and14697.60 per ha cotton harvested respectively. As compare to manual cottonpicking method observed was Rs.13630.50 and 20285.70 per hectare respectively which was more as compared to the manual picking method respectively.

Conclusion

1. From field performance comparison results of cotton picking machine found that Hybrid of Bt. cotton NHH - 44 Bt. with 120x30 cm plant spacing and 1.50 meter suction pipe length observed higher effective field capacity 0.0070 ha/hr, and field efficiency 90.13 percent as compared to manual cotton picking method.
2. From the results it was also observed that for Hybrid of Bt. cotton NHH - 44 Bt. with 120x30 cm spacing found more seed cotton collected 2429.41 kg /ha and percentage of trash content2.48 percent, output capacity 20.65 kg /hr as compared to manual picking method.
3. It was found that cotton picking machine observed less cost of cotton boll picking Rs. 14697.60 per hectare, and picking efficiency 85.30 percent respectively as compared to manual cotton picking method. for Hybrid of Bt. Cotton NHH-44 bt.
4. In manual picking method for varietyPDKV-2BG-II observed that less effective field capacity 0.00139 ha/hr, field efficiency85.74 percent, output capacity 2.14 kg /hr and seed cotton collected 1363.07 kg /ha as compared to cotton picking machine,
5. In manual picking method for Hybrid of Bt. cotton NHH-44 bt. Observed more cost of cotton boll picking Rs. 20285.70 per hectare, picking efficiency 87.27 percent respectively as compared to cotton picking machine,

Application of Research: The use of pneumatic suction type cotton picking machine helps to reduce the cost and time of cotton boll harvesting.

Research Category: CAE Analysis, Cotton harvesting

Abbreviations: CAE-Computer Aided Engineering, R-R: Row to Row, P-P: Plant to plant, ha/hr.: Hectare per hour, kg/hr: Kilogram per hour, g: Gram, m: Meter, cm: Centimeter, Rs./kg: Rupees per kilogram, Rs./ha: Rupees per hectare, RPM: Revolution per minute, CAD: Computer aided design, CFD: Computer fluid dynamics, kW: kilo watt, N-m: Newton meter, N-mm: Newton millimeter, m^3/sec: meter cube per second, m/sec: meter per second, kg/m^3 : kilogram per meter cube, m^3/hr: meter cube per hour, kg/m: kilogram per minute, hrs.: hours, fig: Figure, VA; Volt ampere, Ah: ampere hour, PVC: Polyvinyl chloride, no: Number, kmph: kilometer per hour, Pa: Pascal, MPa: Mega Pascal, m/s: meter per second.

Acknowledgement / Funding: Authors are thankful to Department of Farm Machinery and Power Engineering, College of Agricultural Engineering and Technology, Vasantrao Naik Marathwada Agricultural University, Parbhani, 431402, M.S., India. Authors are thankful to NAHEP-CAAST-DFSRDA, Parbhani, 431402, M.S., India for financial support for this research.

****Research Guide or Chairperson of research: Dr Gopal U. Shinde**
University: Vasantrao Naik Marathwada Agricultural University, Parbhani, 431402, M.S., India
Research project name or number: Ph.D. Thesis

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Agricultural engineering & Agriculture cotton field.

Cultivar / Variety / Breed name: Bt. Cotton Variety PDKV-2BG-II & Hybrid of Bt. Cotton NHH 44

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

References

[1] Ambati R. A. and Mujumdar G. (2013) International Journal of Agriculture Innovations and Research, 2(1), 104-107.
[2] Dhokne A., Zingare M., Mahure A. and Lutade S. (2017) International Research Journal of Engineering and Technology, 4, 2.
[3] Mahalle N.G., Sirsat P.M., Sontakke S.V., Waseemraja S. and Walekar S.S. (2017) IJMPERD, 7(5),199-208.
[4] Murugesan R., Shukla S.K., Arude V.G.and Patil P.G. (2004) Agricultural Engg. Today, 28(1-2), 54-58.
[5] Murugesan R., Shkla S.K., Arude V.G. and Patil P.G. (2004) Agricultural EngineeringToday, 28, 0970-2962.
[6] Muthamilselvan M., Rangasamy K. and Sampathrajan A. (2007) Indian J. of Agricultural Research, 41(2), 86-91.
[7] Gedam N. and Mahalle A.K. (2015) International Journal of Engineering research and General Science, 3(3), 206-214.
[8] Nikam M. D. and Khambalkar V. P. (2016) International Journal of Pure and Applied Research in Engineering and Technology, 5(2), 606-612.
[9] Muthamil S.M., Rangasamy K. and Divaker Durairaj C. (2004) Madras Agricultural Journal, 91(7-12), 433-440.
[10] Muthamil S.M., Rangasamy K. and Sampathrajan A., (2007) Indian Journal Agriculture Research, 41(2), 86 - 91.
[11] Muthamil S.M., Rangasamy K. (2011) Madras Agriculture Journal, 98 (4-6), 193-196.
[12] Shinde G.U. (2011) International Journal of Agricultural and Biological Engineering, 4, 3.
[13] Shinde G.U. (2012) International Journal of Environmental Science and Developments, 3, 279-282.
[14] Shinde G.U. (2011) International Proceedings of Chemical, Biological & Environmental Engineering, 15.
[15] Shinde G.U. (2013) 5th Asian Conference on Precision Agriculture (ACPA), Jeju South Korea, Proceedings, 51.
[16] Shinde G.U. (2015) International Journal of Mechanical and Production Engineering Research and Development, 5(4), 53-60.
[17] Shinde G.U. (2015) 6th International Scientific Agricultural Symposium, Agrosym, Proceedings, 1063-1069.