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"DESIGN MODIFICATION AND ANALYSIS OF DOUBLE ROLLER MINI GINNING MACHINE"

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ABSTRACT:- *Indian Cotton Ginning Industry is the second largest in the world. Cotton ginning plays very important role of separation of fibers from cotton seed and converts field crop into a saleable commodity i.e. lint. Ginning acts as a bridge between cotton farmer and textile industry. In India, cotton is ginned on double roller gins manufactured domestically. Indian Ginning Industry has been transformed into remunerative business enterprise and has achieved global leadership in supply of quality cotton to domestic as well as international textile mills .There is a need to design and enhance the Double roller Ginning Machine to benefit the textile industries. The analysis of existing design has been carried out. This research presents design modifications and CAD model of Double Roller Ginning Machine. The analysis of modified design has been performed and the results were critically discussed.*

Keywords: *Lint, Ginning Machine, Double roller, Cotton.*

I. INTRODUCTION

Ginning is the mechanical process for separating cotton into its constituents namely lint (Cotton Fiber) and Cotton Seed. The Seed Cotton that comes from the field has to be subjected to various treatments in the ginning factories depending upon its inherent characteristics such as trash contents, moisture contents, length of the fiber, variety of seed i.e. fuzzy or black, method of seed cotton transportation, storage practices, handling practices inside the ginning factories and finally subjected to ginning process for separation of fiber and seed before packing into bales etc.

Ideally the quality of the constituents i.e. cotton fiber and cotton seed before ginning and after ginning must be more or less same however it is seen that substantial damage is caused to quality parameters during processes in the ginning factories.

The selection of cotton for spinning is made on the basis of fiber quality and any damage in the same during the process of ginning reduces the value of the fiber and results in lowering down of value in total textile value chain. The development of high speed spinning and weaving machinery has necessitated requirement of better cotton fiber parameters and any damage in quality caused while ginning cannot be rectified later and the defect is carried forward to yarn and fabrics during spinning and weaving process.

The economics of ginning operation depends upon the proper selection of ginning technology suitable for various characteristics of the seed cotton to optimize the quality parameters and operational costs, thus the selection of suitable ginning technology is of paramount importance.

II. DOUBLE ROLLER GINNING MACHINE:

It consists of two spirally grooved leather roller pressed against a fixed knife and a pulley and belt drive mechanism. Two moving blades combined with seed grids constitutes a central assembly known as beater which oscillates by means of a crank or eccentric shaft, close to the fixed knife.

When the seed cotton is fed to the machine in action, fibers adhere to the rough surface of the roller are carried in between the fixed knife and roller in such a way that the fibers are partially gripped between them. The oscillating knife beats the seed and separates the fibers. This process is repeated for number of times and due to push-pull-hit action the fibers are separated from the seed, carried forward on the roller and dropped out of machine. The ginned seeds drop down through the grid which is oscillating along with beater.

III. DATA ACCUMULATION & CALCULATIONS

In present study, we have accumulated all the essential and necessary data of existing DR Ginning machine and carried out the design calculations to create the existing CAD model of DR Ginning machine.

Existing machine Data:

Data obtained from the existing machine:

Rated Power = 1 HP , Power factor = 1.1

Speed = 1425 RPM

The machine output capacity is 25-30 kg/hr.

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The optimum roller speed is 140 rpm
The leather roller available is of diameter of 150 mm
Two rollers rolling in opposite direction with roller speed of 140 RPM,
1HP motor with 1425 RPM used
Roller 1 is connected with motor by means of belt and pulley reduction mechanism
Roller 2 is connected with motor with gear reduction and small pulley reduction mechanism
as shown in below,

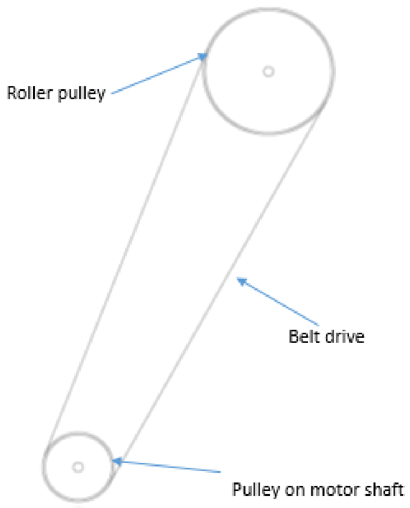
Roller 1 drive mechanism:
Roller 1 drive mechanism
Rated Power of motor

$P_R = 746\ Watt$

Design Power,

$P_d = P_R \times K1$

$P_d = 746 \times 1.1 = 820.6\ Watt$



From design data book
Designation A,
Normal width of pulley = 13mm
Nominal thickness = 8mm
Motor Pulley diameter(D1) = 75mm
Roller pulley diameter = D2
No. of strands = 6
Speed of motor (N1) = 1425 rpm
Speed of roller pulley = N2

$$\frac{N1}{N2} = VR = 10.17$$

$$\frac{D1}{D2} = VR$$

$$D2 = 75 \times 10.17 = 765mm$$

Length of belt,
Center distance = 75 + 765 = 840 mm

$$L = \left(\frac{\pi}{2}\right)(D1 + D2) + 2C + \frac{(D1 + D2)^2}{4C}$$

$$L = \left(\frac{\pi}{2}\right)(75 + 765) + 2(558) + \frac{(50 + 508)^2}{4(840)}$$

$$L = 3208.8\ mm$$

Consider coefficient of friction between belt and pulley,
$\mu = 0.3$
For an open belt angle of contact,

$$\sin \propto = \frac{r1 - r2}{x}$$

$$\propto = \sin^{-1}(0.41)$$

$\propto = 24.2$

$\theta = 180 - 2(24.2) = 131.6$

$\theta = 131.6 \times \frac{\pi}{180} rad = 2.29\ radian$

T1 = tension in tight side

T2 = tension in slack side

$\frac{T1}{T2} = e^{\mu\theta}$

$\frac{T1}{T2} = e^{0.3 \times 2.29} = 1.987$

$T1 = 1.987T2$

Where velocity of belt,

$v = \frac{\pi d_2 N_1}{60}$

$v = \frac{\pi \times 75 \times 1425}{60}$

$v = 5.6\ m/s$

$P = \frac{(T1 - T2)v}{1000}$

$0.746 = \frac{(T1 - T2) \times 5.6}{1000}$

$(T1 - T2) = 133.2\ N$

Substitute the value of T1 from tension ratio

$1.987T2 - T2 = 133.2$

$T2 = 134.95N$

$T1 = 268.14\ N$

Initial Belt tension,

$To = \frac{T1 + T2}{2}$

$To = 201.5\ N$

Pulley1 is connected directly on motor shaft

Pulley1 torque = 5 N.m

Torque acting on Driven pulley

$Tdriven = \frac{(T1 - T2)Ddriven}{2}$

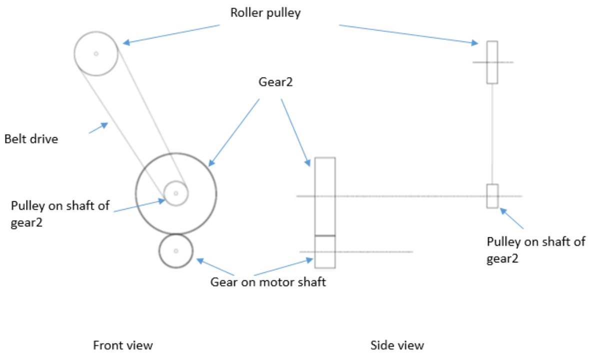
$T_{driven} = \frac{(200.1) \times 0.508}{2} = 50.8\ N.m$

Pulley Torque and speed ratio,

$Tdrive \times N1 = Tdriven \times N2$

$N2 = \frac{5 \times 1425}{50.8} = 140\ RPM$

Roller 2 drive mechanism:



Roller 2 drive mechanism

Rated Power of motor

$P_R = 746\ Watt$

Design Power,

$P_d = P_R \times K1$

$P_d = 746 \times 1.1 = 820.6\ Watt$

Gear1 of 19 teeth connected on the motor

shaft, meshed with gear2of 89teeth
Hence,
t3 = 19 and t4 = 89
N3=1425 rpm
Gear ratio is given by,

$$\frac{t4}{t3} = \frac{N3}{N4}$$

$$N4 = 304rpm$$

Small pulley rotating on the same shaft of
gear2 and large pulley on roller2,
Small pulley speed (N5) = 304 rpm
roller pulley (N6) = 140 rpm
From data book
Designation A,
Normal width of pulley = 13mm
Nominal thickness = 8mm
Pulley diameter(D5) = 75mm
Roller pulley diameter = D6
No. of strands = 6

$$\frac{N5}{N6} = VR = 2.17$$

$$\frac{D5}{D6} = VR$$

$$D6 = 75 \times 2.17 = 162.8\,mm = 163\,mm$$

Length of belt,
Center distance = 75 + 163 = 238mm

$$L = \left(\frac{\pi}{2}\right)(D5 + D6) + 2C + \frac{(D5 + D6)^2}{4C}$$

$$L = \left(\frac{\pi}{2}\right)(75 + 163) + 2(238) + \frac{(75 + 163)^2}{4(238)}$$

$$L = 909mm$$

Consider coefficient of friction between belt and pulley,
μ = 0.3
For an open belt angle of contact,

$$\sin \propto = \frac{r1 - r2}{x}$$

$$\propto = \sin^{-1}(0.18)$$

$$\propto = 10.36$$

$$\theta = 180 - 2(10.36)$$

$$\theta = 159.28 \times \frac{\pi}{180}\,rad = 2.78\,radian$$

T3 = tension in tight side
T4 = tension in slack side

$$\frac{T3}{T4} = e^{\mu\theta}$$

$$\frac{T3}{T4} = e^{0.3 \times 2.78} = 2.3$$

$$T3 = 2.3T4$$

Where velocity of belt,

$$v = \frac{\pi d_5 N_5}{60}$$

$$v = \frac{\pi \times 75 \times 304}{60}$$

$$v = 1.194\,m/s$$

$$P = \frac{(T3 - T4)v}{1000}$$

$$0.746 = \frac{(T3 - T4) \times 1.194}{1000}$$

$$(T3 - T4) = 624.8\,N$$

Substitute the value of T3 from tension ratio

$$2.3T4 - T4 = 624.8$$

$$T4 = 480.6\,N$$

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$T3 = 1105.38\,N$

Initial Belt tension,

$$To = \frac{T3 + T4}{2}$$

$To = 792.9\,N$

Actual RPM and torque transmission
from motor to roller:

Motor RPM = 1425 RPM

Motor Power = 746 watt

Torque of motor,

$$P = \frac{2\pi N Tmotor}{60}$$

$$746 = \frac{2 \times \pi \times 1425 \times Tmotor}{60}$$

$Tmotor = 5\,N.m$

Gear speed and Torque ratio,

$$\frac{Tgear1}{Tgear2} = \frac{t1}{t2}$$

$$Tgear2 = \frac{89}{19} \times 5 = 23.4\,N.m$$

Gear 2 and pulley 1 is connected on same shaft,

pulley1 torque = 23.4 N.m

Torque acting on Driven pulley

$$Tdriven = \frac{(T3 - T4)Ddriven}{2}$$

$$T_{driven} = \frac{(1105.38 - 480.6) \times 0.163}{2} = 50.9\,N.m$$

Pulley Torque and speed ratio,

$Tdrive \times N5 = Tdriven \times N6$

$$N6 = \frac{23.4 \times 304}{50.9} = 140\,RPM$$

The critical design parameters were identified and design modifications in the existing design has been carried out.

Trail 1:

To determine the capacity of machine theoretically.

Roller length= 500 mm, Roller speed= 140 rpm

The weight of cotton that occupies the space where the ginning is taking place= 30gms

Rotation of roller to process 30gms of cotton= 20 rotation of 140 rpm.

Cotton processed in 1 min= 140/20 x 30 = 210gms/min

Cotton processed in 1 hr= 210 x 60 = 12600gms = 12.60Kg/hr

Therefore, 12.60Kg/hr is the capacity of one roller For two rollers = 2 x 12.60 = 25.20 kg/hr Hence theoretically the capacity of the machine will be approximately 25-30 kg/hr.

If Roller length= 700 mm, ii. Roller speed= 140 rpm)

The weight of cotton that occupies the space where the ginning is taking place= 42gms

$$\frac{700 * 30}{500} = 42\text{gms}$$

Rotation of roller to process 42gms of cotton= 20 rotation of 140 rpm.

Cotton processed in 1 min= 140/20 x 42 = 294gms/min

Cotton processed in 1 hr= 294 x 60 = 17640gms = 17.64Kg/hr

Therefore, 17.64Kg/hr is the capacity of one roller For two rollers = 2 x 17.64 = 35.28 kg/hr

Hence theoretically the capacity of the machine will be approximately 35-40 kg/hr.

Trail 2:

Line diagram of ginning machine:

Neglecting gear mechanism used for opposite rotation,

Mechanism with pulleys shown in the figure rotating in the clockwise direction

Separate lint collector and feed required

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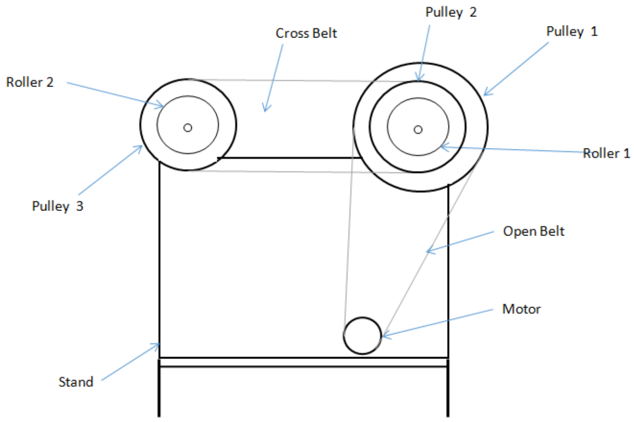

Knife Tool Life Calculations:

Stainless steel blade bears the following calculated loads,
Force required to separate 1 seed is 34.76 N (mean of observed value) assuming 8 seeds will come in contact with blade while operation
Hence, Force = 8 x 34.76 = 278.32 N
This is the force on blade due to seed separation.
Tool wear calculations:
Failure by gradual wear, which is inevitable cannot be prevented but can be slowed down only to enhance the service life of tool.
The cutting tool is withdrawn immediately after it fails or if possible just before it totally fails. for that one must understand that the tool has failed or is going to fail shortly. It is understood or considered that the tool has failed or about to fail by one or more of the following conditions.

- Total breakage of tool or tool tip
- Massive fracture at the cutting edge
- Excessive increase in cutting forces and vibrations
- average wear (flank and crater)

Assuming Tailors tool life equation,
This relationship is credited to F. W. Taylor (~1900)

$$vT^n = C$$

where v = cutting speed; T = tool life; and n and C are parameters that depend on feed, depth of cut, work material, tooling material, and the tool life criterion used

• n is the slope of the plot
• C is the intercept on the speed axis

Typical Values of *n* and *C* in Taylor Tool Life Equation

Tool material (ft/min)	n	C (m/min)	C
High speed steel:			
Non-steel work	0.125	120	350
Steel work	0.125	70	200
Cemented carbide			
Non-steel work	0.25	900	2700
Steel work	0.25	500	1500
Ceramic			
Steel work	0.6	3000	10,000

Fig. Typical values of n and C

considering High Speed steel with non steel work,
n = 0.125
C = 350
v = 140 rpm = 66 m/min

$$66 \times T^{0.125} = 350$$
$$T = 625421.8\ cycle$$

PARTS	Existing machine	Modified Machine	Description
Pinion	89	89 teeth	-
Gear	19	19 teeth	-
Pulley1	600 mm	Diameter = 765mm	For Equal speed of both rollers at 140 rpm
Pulley2	100 mm	Diameter = 75 mm	For Equal speed of both rollers at 140 rpm
Pulley3	202 mm	Diameter = 163 mm	For Equal speed of both rollers at 140 rpm
Gear Mechanism(Experiment 1)	Present	Remove	Both Rollers rotate in same direction
Roller Length(Experiment 2)	500 mm	700 mm	Productivity of M/C may increase

IV. CAD Modeling

Cad model of the DR ginning machine as per the calculation presented in the previous article.

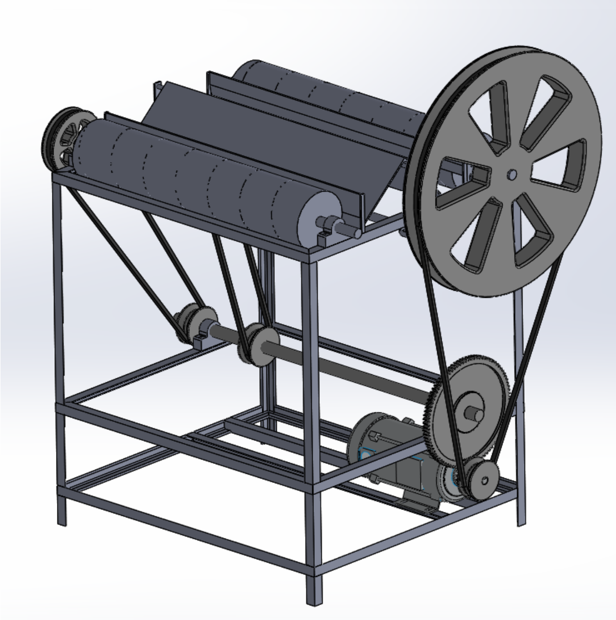

Fig 1: CAD Modelling of Modified machine

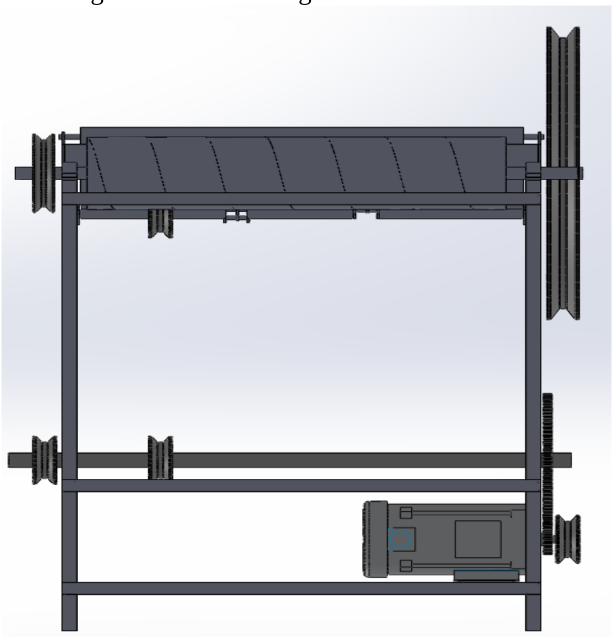

Fig 2: Side view of existing machine

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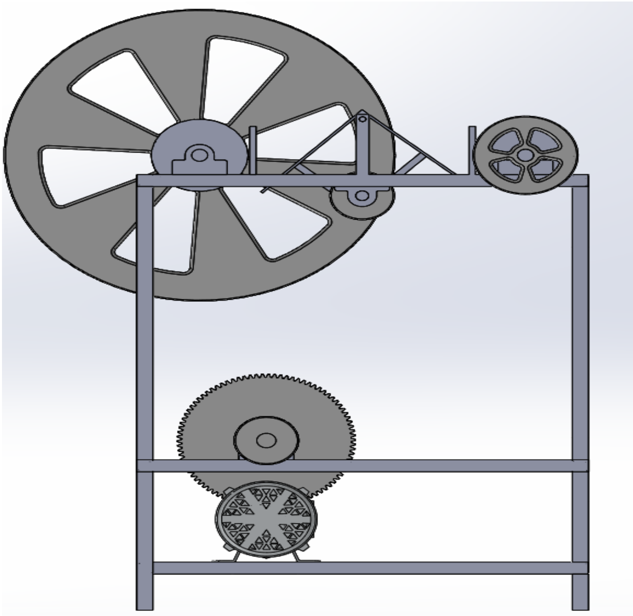


Fig 3: Front view of Modified machine

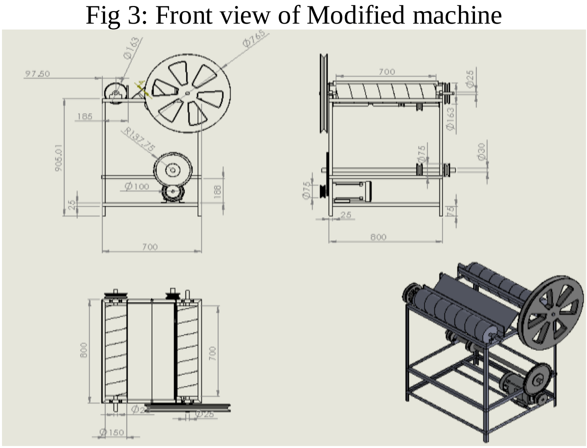
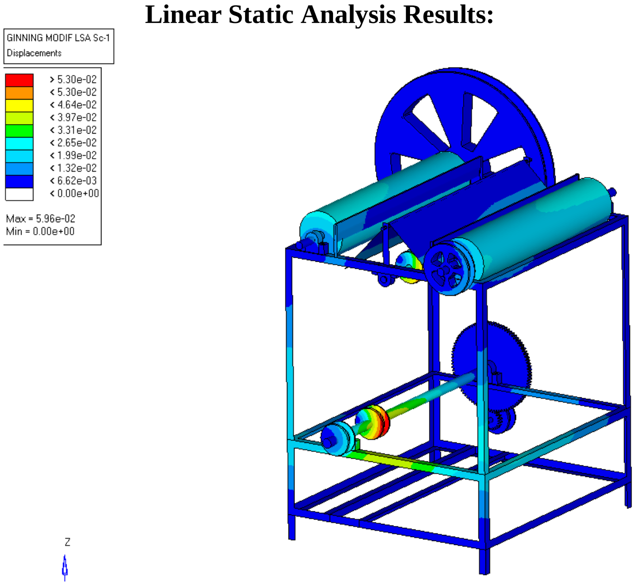


Fig 4: Detailed view of Modified ginning machine

V. FINITE ELEMENT ANALYSIS

A linear static analysis is carried out with the following boundary conditions.
Base of the machine is constraint and motor torque of 5000 N.mm applied.

Linear Static Analysis Results:



Maximum Displacement = 0.06 mm

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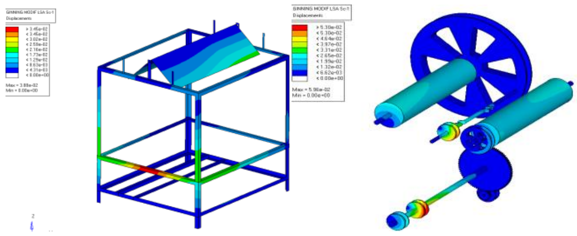
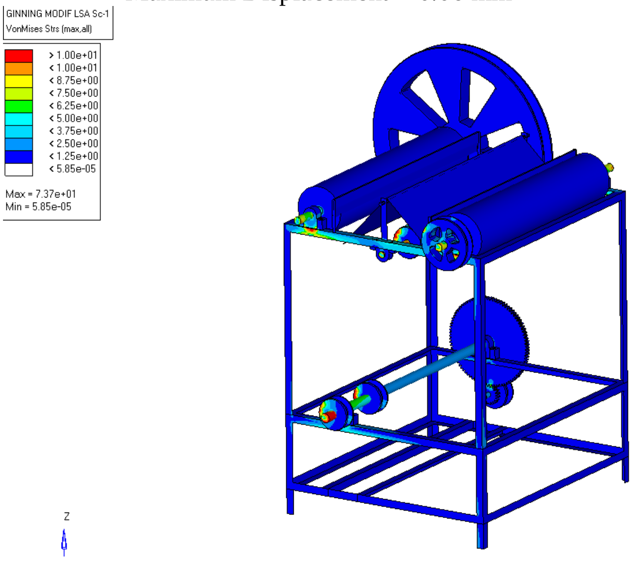
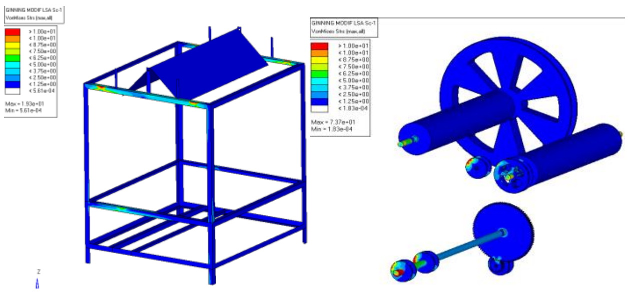


Maximum Displacement = 0.06 mm



Maximum Stress = 73.7 MPa



Maximum Stress = 73.7 Mpa

VI. RESULT DISCUSSION

From the design calculations both fiber rollers rotating at 140 rpm in opposite directions with the help of 4 pulleys and 2 gears and it seen that with 700mm length fiber rollers rotating at 140 rpm we can achieve 35-40 Kg/hr capacity. From the life expectancy calculation we have obtained the life of knife more than 1 year(approx) of working.
From the Linear static analysis, maximum stresses developed in the structure is 74 MPa. It is observed that maximum stress (74 MPa) developed in the structure are considerably less than the yield stress (250 MPa) of structure material.

VII. CONCLUSIONS

The result of the research predicts the considerable enhancement in the tool life. The modifications in design of DR ginning machine removes almost all difficulties found with existing machine. Hence it can be concluded that the productivity will increase to a considerable extent. The down time required for overhauling and restoring the components in machine like belts, etc as observed in existing machine, will be reduce significantly and thus the reliability of the product will be increased.

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