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Design and Analysis of Cotton Seed Separation Machine by using Reliability Index Approach

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Abstract

During the last some years in the world most particularly in the India as the cotton sector is progressing with high efficiently, significant technological advancement have taken place for the improvement in the process of ginning to increase the production of cotton fibre and to preserve the intrinsic quality of cotton fibre obtaining the maximum staple length of fibre without damaging of seed, producing lint free of trash and contaminants at the lowest cost per unit ginned. The function of the gin is to separate lint from gin to create two marketable products, fibre and seed. In order to improve the performance of ginning machines, it is necessary in improvement of the different parameters related to this machine to get the better result. The main objective of this paper is that processes/products are made for designing and analysis point of view so that the fatigue behaviour will be increases against all variations. As well as reliability testing is conducted for the better result for performance of the machine .The primary goal is to keep the variance in the output very low even in the presence of noise inputs. To find most effective parameter of the cotton seed separation machine and improve the performance of the cotton seed separation machine. These improvements are aimed at improving the desired characteristics and simultaneously reducing the number of defects by studying the key variables controlling the process and optimizing the procedures or design to yield the best results.

Keywords: Cotton Seed Separation Machine, Creo Parametric 2.0, ANSYS 14.0, Design, Analysis, Chain Drive, Shaft, Pulley, V Belt, Motor

I. INTRODUCTION

Cotton fibers must be separated from the seed before they used to manufacture textile goods. The first machine to gin cotton was "Charka" gin. The charka gin was most efficient when handling naked seeded varieties with loosely attached fibers. Early American settlers found that the fuzzy seeded varieties that yielded best in this country were difficult to gin on a roller gin. Consequently the fiber was generally pulled from the seed by hand until Eli Whitney patented his ginning machine in 1794. During the last decade in the world more particularly in the India as the cotton sector is progressing with high speed, significant technological advancement have taken place to improve the fundamentals of ginning to increase the outturn and to preserve the intrinsic quality of fiber obtaining the maximum length of fiber without breakage of seed, producing lint free of trash and contaminants at the lowest cost per unit ginned.

II. GINNING INDUSTRY: A LITERATURE REVIEW

Cotton is also called as the WHITE GOLD as it is as valuable as the real gold which is incurred from the mines. In the world there are several types cotton is available. The cotton quality is for every region of the world, so while installation of the cotton seed separation machine plant we have to take count of the following factors:

1) Staple length of the raw cotton need to be processed.
2) Percentage of Trash content in the seed cotton (raw cotton).
3) Percentage Moisture content in the raw cotton.
4) Electrical power cost.
5) Operating cost of the plant.
6) Availability of the raw cotton inside 300 Km area around plant.

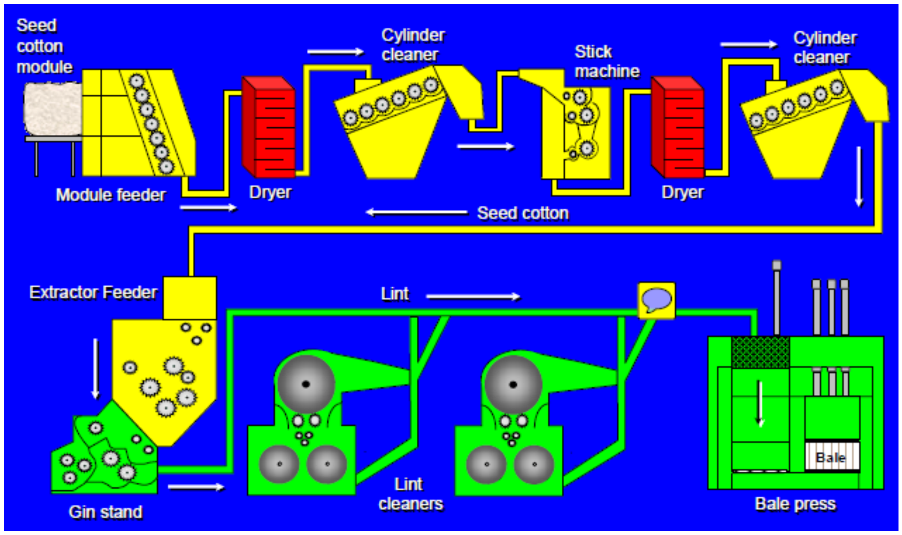
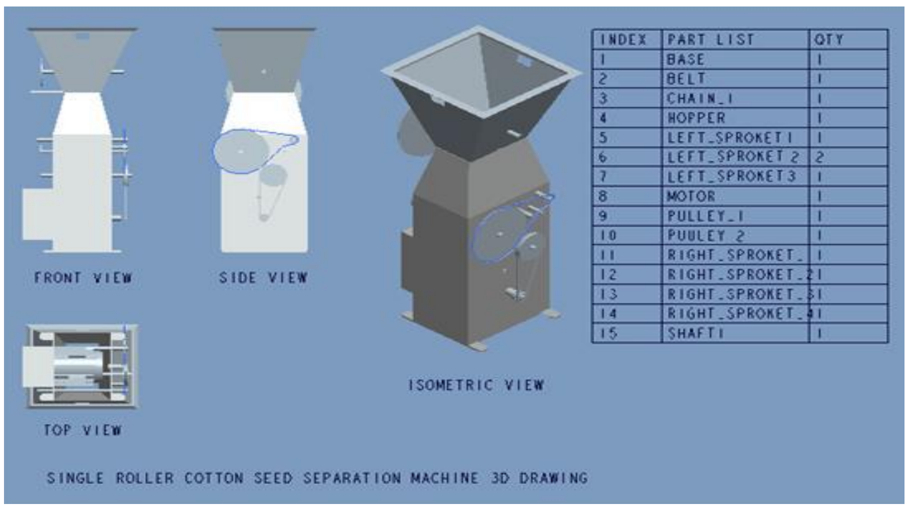


Fig. 1: Design of Single Roller Cotton Seed Separation Machine



INDEX	PART LIST	QTY
1	BASE	1
2	BELT	1
3	CHAIN_1	1
4	HOPPER	1
5	LEFT_SPROKET1	1
6	LEFT_SPROKET 2	2
7	LEFT_SPROKET3	1
8	MOTOR	1
9	PULLEY_1	1
10	PUULEY 2	1
11	RIGHT_SPROKET_	1
12	RIGHT_SPROKET_2	1
13	RIGHT_SPROKET_3	1
14	RIGHT_SPROKET_4	1
15	SHAFT1	1

Fig. 2: 3D Modeling of Ginning Machine.

A. Main Frame

In the Cotton seed separation machine, the Main frame is the supporting membrane of the machine. It acts as a skeleton to the machine. It holds the overall weight of the machine. It carries the motor, pulley, sprockets, chains which move over the sprockets, roller and the shafts. Thus, the body should have the enough strength and rigidity to withstand the load of the various parts of the machine. The frame is made up of the cast iron and has enough strength and rigidity to carry the above mentioned load.

III. METHODS AND METHODOLOGY

- Finding the requirement of small scale firm.
- Identify requirement by discussing with experts in cotton industries.
- Designing of Cotton seed separation machine.
- Designing of Various Components of Machine such as Chain drive system, design of shaft, Design of V-Belt etc.
- Making of 3D model using CAD Software.
- Analysis of Components.

IV. DRIVE DESIGN FOR COTTON SEED SEPARATION MACHINE

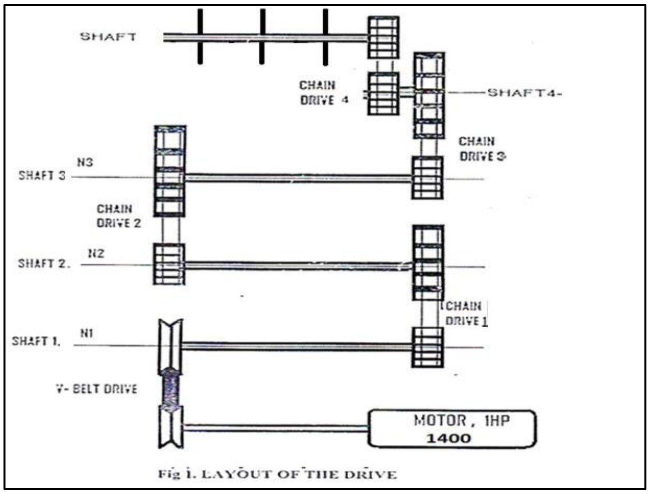


Fig. 3: Drive Design for cotton seed separation machine

V. RESULTS AND CONCLUSION

A. Analysis of Critical Component

The analysis of design components of the cotton seed separation machine is done using analytical softwares like CREO, ANSYS, HYPERMESH. ANSYS software is used for the analysis of various component of machine. It give the information of the component Life, Reliability, Static and linear analysis. Analytical software predict the overall performance of the machine. 3D Model of the Cotton seed separation machine has developed. Prototype of the machine helpful in reducing the heavy fabrication cost.

VI. ANALYSIS OF SHAFT

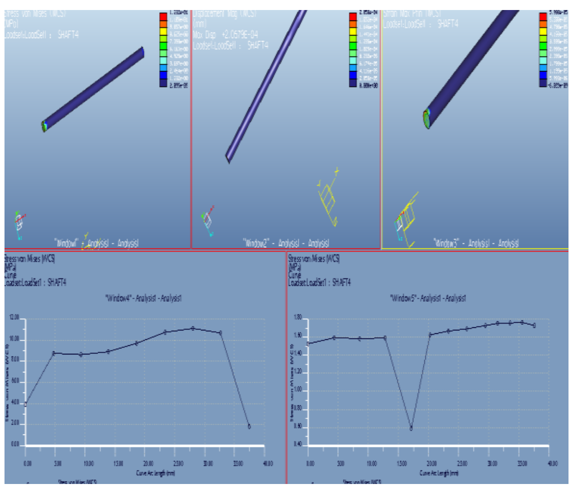


Fig. 4: Analysis of Shaft

Design recommendation is to keep the axial lengths as short as possible to limit bending stress. Simply supported shaft is better than cantilever or overhang shaft. The diameter of the shaft should be such that it with stand the applied loads, after stress concentrations, with a known factor of safety. Robust design of machine is helpful in increasing the performance of the cotton seed separation machine.

VII. RELIABILITY INDEX APPROACH

For a reliability based design, a performance function can be defined as

G = R -S, Where R and S are statistically independent and normally distributed random variables of the resistance and load measurements of the structure. Typically, R can be the yield stress and S the maximum Von Mises stress. The G function is also called limit state function or failure function. The curve G = 0 divides the design space into two regions, the safe region when G

> 0 and unsafe region when $G < 0$. Since we consider R and S to have variation, G will also exhibit variation. The ratio β of the mean value of the G function (μG) and the standard deviation of the G function (σG) is defined as safety index or reliability index. If Φ is the cumulative distribution function and G has a normal distribution then:

$$\beta = \Phi\,(1\text{-Reliability}) = \mu G / \sigma G$$

A possible formulation can be:

Maximize β

Subject to: Load on Spike < Target-Load

Another formulation using the reliability index can be:

Minimize Weight

Subject to: β > Target β

A typical target value β is 3, which corresponds to probability failure of 0.00135. However, it has been observed that Reliability Index Approach exhibits very slow convergence or even divergence for some problems.

VIII. MINIMIZE LOAD ON SPIKE

Subject to: P failure $[\omega 1LCL \le \omega 1 \le \omega 1UCL] \le 5\%$

P failure $[\omega 2LCL \le \omega 2 \le \omega 2UCL] \le 5\%$

A. Design variables

$$Nmin \le N \le Nmax$$
$$Hmin \le H \le Hmax$$

B. Random variables with given variation

Modules of Elasticity with standard deviation 1.0%

Density with standard deviation 0.6%

Where

ω1LCL - ω1UCL is an interval, which the first natural frequency ω1 should avoid

ω2LCL - ω2UCL is an interval, which the second natural frequency ω2 should avoid

Nmin, Nmax is the minimum and maximum values of Spikes on the Shaft

Hmin, Hmax is the minimum and maximum values of the section height H

Uncertainties in structural design are one of the important challenges in the present design engineering. As Reliability Based Design Optimization (RBDO) hand is becoming more reliable approach which suits to the present challenge. The objective of RBDO is to seek a design that achieves a targeted probability of failure and ensures expected optimum performance.

Chen Jianqiao has proposed a method with target reliability(Rt) of 0.99 and optimization of objective function ($f = h1 + h2$), in which computation cost is not effective. As a result, new approach is developed to solve such problems. New approach includes, making it more simplified and optimized which is effective in computational cost.

IX. TSAI – WU FAILURE CRITERION

Tsai–Wu failure criterion is the most reasonable failure criterion for composites. It can be expressed as

$$FI=F1\sigma1+F2\sigma2+F3\sigma3+F11\sigma12+F22\sigma22+F33\sigma32+2F12\sigma1\sigma2+2F23\sigma2\sigma3+2F31\sigma1\sigma2 +F44\sigma42+ F55\sigma52+ F66\sigma62 \le 1$$

Where

$F1 = 1/XT – 1/ XC$, $F2 = 1/YT – 1/ YC$,

$F3 = 1/ZT – 1/ ZC$

$F11 = 1/(XTXC)$, $F22 = 1/(YTYC)$,

$F33 = 1/(ZTZC)$

$F44 = 1/S_2yz$, $F55 = 1/S_2zx$, $F66 = 1/S_2xy$

$F12 = (–1/2)\sqrt{(F11\ F22)}$,

$F23 = (–1/2)\sqrt{(F22\ F33)}$,

$F31 = (–1/2)\sqrt{(F33\ F11)}$

Where XT and XC are tensile and compressive strength in the longitudinal direction, respectively; YT, ZT, YC and ZC are tensile and compressive strength in the transversely isotropic surface, respectively; Sxy, Syz and Szx are shear strength in the transversely isotropic surface. Therefore, the limit state function in terms of Tsai–Wu failure criterion can be expressed

$$G = 1 – FI$$

The material element is in operating state if $G > 0$, in failure state if $G < 0$, and in limit state if $G =0$. G is the Performance Function.

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