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Computer Aided Design of Ginning Machine Gear Box and its Performance Evaluation

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Abstract—*In India, the double roller (DR) ginning machines are used for ginning about 80% of its total cotton production. But studies reveal that slow ginning rates are the limitations of the DR ginning machine. The main objective of present research work was to design and develop a modified double roller ginning machine that had a higher ginning rate and to avoid the failure of pinion of ginning machine which is frequently failure part during ginning process.*

1. INTRODUCTION

Cotton is the principal raw material for a textile industry in India. Ginning is the process by which seed cotton is separated into lint (fibers) and seed; and the machine used for its separation is called a gin. There are mainly two types of gins (i) the roller gin (rotary-knife roller gin and the reciprocating-knife double roller gin) and (ii) the saw gin, which are commercially used for ginning worldwide. Several research workers have reported that the saw gin is highly productive, energy efficient and produces un-contaminated lint but its harsher treatment to the cotton fiber results in deterioration of some fiber characteristics. On the other hand, the double roller gin is less productive, less energy efficient, but being gentler, better preserves some fiber characteristics. In India, the DR gin is mostly used for commercial ginning. About 50,000 DR gins are in operation in India which produced 3.32 million tones of fibers (about 80 % of total cotton lint production) during the 2008-2009 production

Ginning Machine Manufacturing Company uses two stage reduction gearbox for this Double Roller ginning machine. This company was facing some problem with related to performance of the Double Roller ginning machine gear box because of improper design of gear box. Our task was to redesign the gear box so as to give output speed of rollers are 120rpm instead of present roller speed 91rpm. The gearbox was suitability redesign for various gears used in the gear box. They are tested by using computer aided analysis & suitable modifications in the material used.

This project work deals with computer aided design and analysis of gearbox used for double roller ginning machine manufactured by Ginning Machine Manufacturer. The output speed of the roller of existing gearbox of the said ginning machine is suitably redesign so as to give the output speed of roller shaft is around 120rpm for optimize the production rate of ginning machine. The company also want to increase the strength of pinion(16Teeth). Following are the objectives of this work.

1.1 Objectives of Work

- Understanding the mechanism and working of ginning machine gearbox.
- Analytical design of ginning gearbox for different speed of output roller shaft.
- Computer added modeling, Meshing and FEA analysis of the gears of ginning gear mechanism for various rang of speed.
- Investigate systematically the effect of change in diameter of small pulley on the roller speed and suggest suitable diameter of small pulley which is mounted on motor shaft.
- Suggest the suitable materials for pinion and gears.
- Suggest the required modification in the parts of double roller ginning machine.

1.2. Methodology[7]:

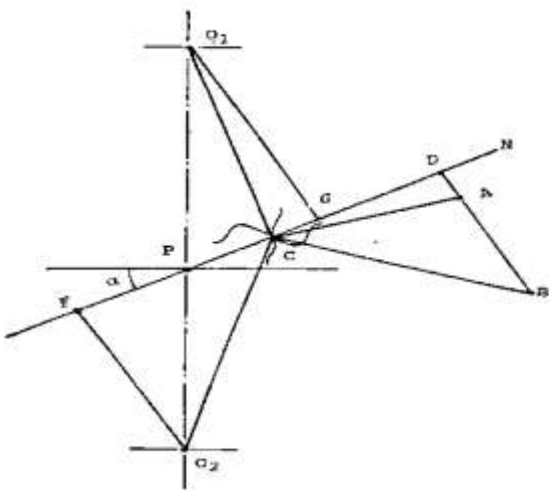

Figure. 1.1. Low of Gearing

The fundamental law of gearing states "The common normal to the tooth profile at the point of contact should always pass through a fixed point, called the pitch point, in order to obtain a constant velocity ratio"

Refer to the following figure O_1 &O_2 are centers of two gears rotating with angular velocity ω_1 & ω_2 resply. C is the point of contact between teeth of two gears & NN is a common normal at the point of contact.

CA is the velocity of point c, when it is consider on gear 1, while CB is velocity of point C, when it is consider on gear 2, also.

CA O_1C and CB O_2C the projections of the two vectors CA and CB i.e CD, along the common normal NN must be equal, otherwise the teeth will not remain in contact &there will be a slip

$CA=\omega_1 \times O_1C$

$CB=\omega_2 \times O_2C$

$\omega_1/\omega_2=O_2C/O_1C \times CA/CB$

Since ΔO1CG & ΔCAD are similar

$O_1C/CA = O_2G/CD$ …………. (C

From (b) &(c)

$CA/CB=O_1C/O_2C X O_2F/O_1G$……….. (d)

From (a) &(d)

$\omega_1/\omega_2= O_2F/O_1G$……………….. (e)

Since ΔO_2FC & ΔO_1GP are similar triangle, therefore

$O_2F/O_1G= O_2P/O_1P$…………… (f)

From (e)& (f)

$\omega_1/\omega_2=O_2P/O_1P$………… (g)

Also $O_1P+O_2P=O_1O_2$= Constant

Therefore for a constant velocity ratio (ω_1/ω_2), P should be a fixed point. This point P is called the pitch point.

1.3 Force Analysis [7]

In gears, power is transmitted by means of a force exerted by the tooth of the driving gear on the meshing tooth of the driven gear. According to the fundamental low of gearing, this resultant force Pn always acts a long the pressure line as shown in below figure. The resultant force Pn is resolved In to two components Pt and Pr

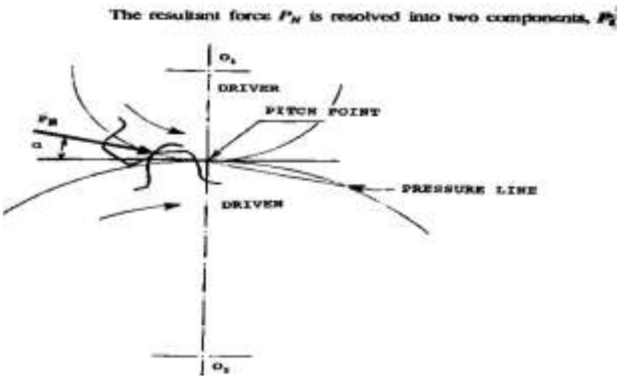

Figure 1.2 gear tooth force

The tangential component Pt is a useful load because it determines the magnitude of the torque and consequently the power which is transmitted. The redial component Pr is a separating force which is always directed toward the center of the gear. The torque transmitted by the gear is given by the equation.

Mt=60x10 (kw)/2πN

Where Mt = torque transmitted by gears (N-mm)

Kw= Power transmitted by gear (kw)

N== speed of rotation (rpm)

The tangential component Pt acts at the pitch circle radius. There fore

Pt x d/2=Mt

Pt=2Mt/d

Pr= Pt tan α

The resultant force Pn is given by

Pn=Pt/cosα

The above analysis of gear tooth force is based on the following assumption:-

1. The resultant force Pn changes, This efficiency is neglected in the above analysis.

2. It is assumed that only one pair of teeth takes entire load.

3. The analysis is valid under static condition e.g. when the gear are running at very low velocity. In practice there are dynamic forces in addition to forces due to power transmission. The effect of these dynamic forces is neglected in the analysis.

Design of Gears train

Jadhao Gears Pvt. Ltd. MIDC Amravati (MS) is the manufacturer of ginning machine. The Double Roller ginning machine manufactured by Jadhao Gears Pvt. Ltd. (MIDC) Amravati. This Company uses two stage reduction gearbox for this Double Roller ginning machine

The layout of a two stage ginning gear box is as shown in figure 1.3

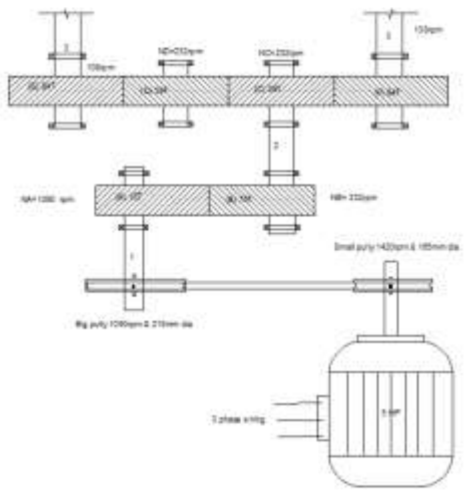

Figure 1.3 of Lay out of two-stage gearbox.

The existing system consist of following gears, the numbers of teeth on the gears are as follows.

G_A=16Teeth

G_B=75Teeth

Gc=39Teeth

G_D=39Teeth

G_E=G_F=84Teeth

The pinion gear G_A rotates at 1090 rpm. The gear G_B rotates at 232rpm.The shaft no.2 rotates 232rpm. The gear (C) & (D) rotates with 232rpm. There are two output shafts. The input power given by motor having 5HP.The small pulley is mounted on motor shaft and having diameter 165mm and the big pulley is mounted on pinion shaft having diameter 211mm.With this configuration the speed of output shaft was 108rpm. However as per the manufacture requirement the desired output speed should be at least 120rpm.This variations in output speed is to be achieved by changing small pulley "Q" on motor shaft.

A simple spread sheet based program was used for calculating output speed of roller, torque transmitted and tangential forces acting on the gear teeth. The gear box was thus suitably redesign so as to get the desired output speed of roller shaft. The propose design was then analyzed by using ANSYS software for its failure. Effect of material used on safety of gear box was carefully studied.

Summary of design is provided in table no 1.1; 1.2; 1.3. Sample calculations for output Speed of Roller, Torque Transmitted and Tangential Forces acting on different gears tooth are shown in Appendix no.1.

The result of this analysis is summarized in table no 1.1 and 1.2 and 1.3

Table No 1.1 The Speed of different shafts

Speed	When Q= 139mm	When Q =165mm	When Q=190mm
Shaftno.1	918 rpm	1090 rpm	1208 rpm
Shaft no.2	196 rpm	232 rpm	258 rpm
Shaft no.3	91 rpm	108 rpm	122 rpm

Table No 1.2 The Tangential Force (P_t) acting on different gears

Tangential force	When Q = 139mm	When Q = 165mm	When Q=190mm
Shaft no.1	$(Pt)_{AB}$=1367.327 N	$(Pt)_{AB}$=1151.599 N	1038.548N
Shaft no.2	$(Pt)_{DE}$=2629.553 N	$(Pt)_{DE}$=2214.614 N	2020.034N
Shaft no.3	91 rpm	108 rpm	122 rpm

*$(Pt)_{DE}$=$(Pt)_{CF}$

Table No 1.3 The Ttorque Transmitted through different shaft

Torque trans-mitted	When Q= 139mm	When Q =165mm	When Q=190mm
$(Mt)_1$	38286.290 N-mm	32244.785 N-mm	29079.370N-mm
$(Mt)_2$	179466.99 N-mm	151147.43 N-mm	137867.372 N-mm
$(Mt)_3$	386827.67 N-mm	325548.31 N-mm	296945.110 N-mm

It is thus clear from the above tables that to get the minimum required speed of 120rpm of the roller shaft, the diameter of the pulley on the motor shaft should be of 190mm, at that time we get speed of roller shaft 122rpm, for this the corresponding Tangential Forces on shaft no.1 and shaft no.2 are given in table no3.2 are 1038.548N & 2020.034N respectively.

Similarly the Torque Transmitted by shaft no 1, shaft no 2, shaft no 3 will be 29079.370N-mm and 137867.372N-mm and 296945.110N-mm respectively.

This design is then analyzed for failure safety using ANSYS software.

ANALYSIS OF GEARS

ANSYS Workbench Report

Case 1: Material Cast Iron

1st Pair of Gears 16-75

When Tangential Force $(Pt)_{AB}$=1038.54

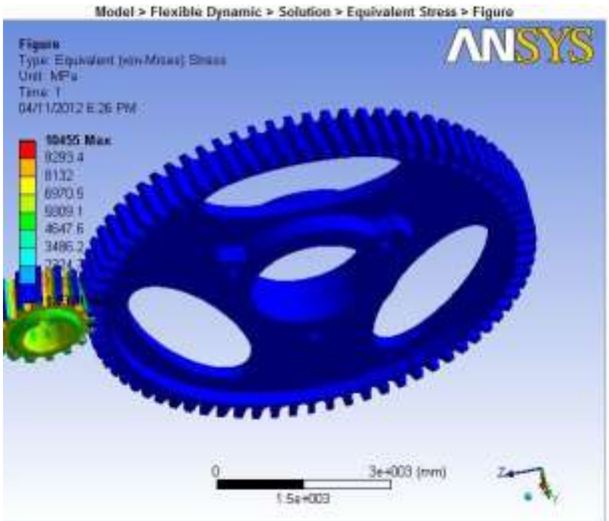

Figure No. 1.4 Equivalent Stress

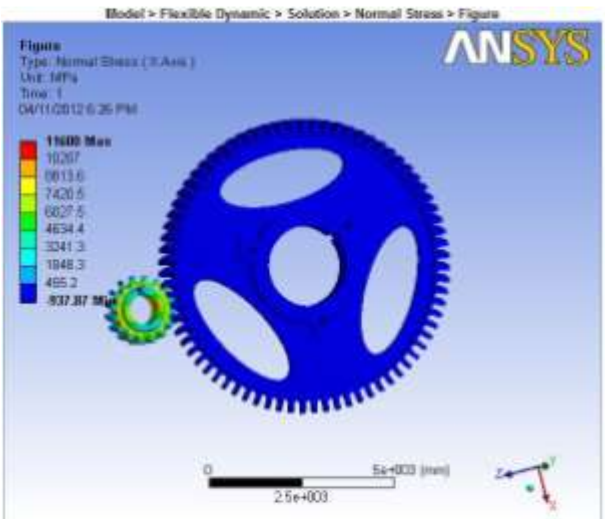

Figure No. 1.5 Normal stress

Explanation about analysis of Case-I :-

The analysis using ANSYS software shows that for the proposed design the pinion gear is likely to fail due to over stressing. The over stressing occur in pinion(16T) because the material used for the pinion and gear are same and that is Cast Iron. Due to that Cast Iron material the over stressing occur in 16T pinion as shown in figure 4.5. So the pinion may fail at the time of working of ginning machine. The failure of pinion gear can be avoided by using better material for pinion instead of cast iron. The suitable material for pinion is EN8 and suitable material for other gears are Cast Iron.

Now by changing the Cast Iron material of pinion to the new material EN8, we further analyzed the first pair of gear 16T and 75T.The results occurs are represented as follows.

ANSYS Workbench Report

Case:2 Material EN8 & Cast Iron

1st Pair of Gears 16-75

When Tengential Force (Pt) $_{AB}$=1038.54N

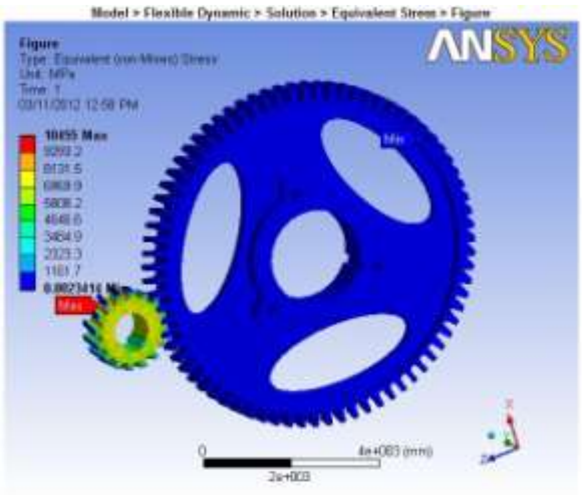

Figure No 1.7 Equivalent Stress

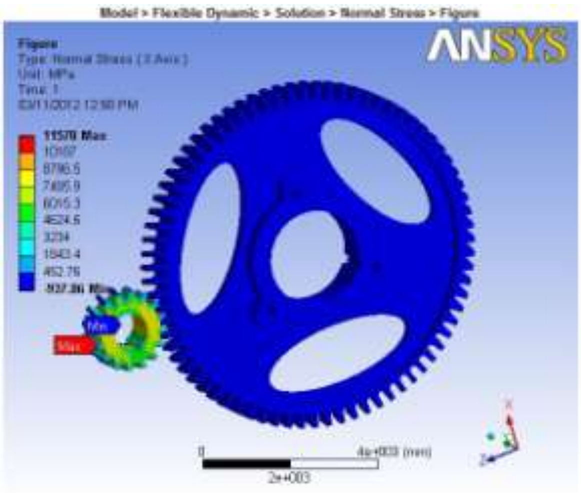

Figure No 1. 8 Normal stress

Explanation about analysis of Case-II :-

The analysis using ANSYS software shows that for the proposed design the pinion gear is likely to fail due to over stressing in Case study -I. The over stressing occur in pinion (16T) because the material used for the pinion and gear are same and that is Cast Iron. Due to that Cast Iron material the over stressing occur in 16T pinion as shown in figure 4.5. So the pinion may fail at the time of working of ginning machine The failure of pinion gear can be avoided by using better material for pinion instead of cast iron. The suitable material for pinion is EN8 and suitable material for other gears are Cast Iron.

Now by changing the Cast Iron material of pinion to the new material EN8, we further analyzed in the case-II the first pair of gear 16T and 75T.The results occurs are represented in above case study –II. From the result it is observed that the over stressing of pinion is avoided by using EN8 material for pinion.

2. CONCLUSIONS

1. This work leads to following conclusions
2. Gear box was redesign to get the desired output speed of roller
3. The new design consist of 190mm diameter small pulley on motor shaft instead of 139mm diameter of existing pulley so as the output speed of roller shaft will increase to 120 rpm which is the desired speed for manufacturer to evaluate the performance of existing ginning machine.
4. The proposed design was analyzed for failure safety using ANSYS. It was found that the stress induced in the pinion made up of Cast Iron exceeded the limiting values of its stresses, all other pairs of mashing gears were found working within safe limit.
5. The new material,EN8 was then proposed for pinion. It was found that when the material used for pinion is EN8 instead of Cast Iron, the stresses induced in the pinion are within stress limit.
6. Recommendations based on this analysis were submitted to Ginning Machine manufacturing Industries which were immediately implemented by them. Feedback shows that the gear box is now working satisfactory.

3. CALCULATIONS OF OUTPUT SPEED FOR DIFFERENT DIAMETER OF PULLEYS

1) For 139mm diameter of small pulley “Q”

The existing system consist of following gears and small pulley diameter 139mm

The numbers of teeth on the gear are as follows.

G_A=16Teeth G_B=75Teeth Gc=39Teeth G_D=39Teeth G_E=G_F=84Teeth

N_Q=1420rpm; N_P=? RPM; D_P=215rpm; D_Q=139

Now the diameter of pulley “ Q” from 139mm

Calculated the torque transmitted through shaft no.(1) is

Torque transmitted $(Mt)_1=60\times10^6(Kw)/2\pi N_1$

$(Mt)_1=60\times10^6(735.5\times5\div1000)/2\pi(918)$

$(Mt)_1=60\times10^6(3.6787)/2\pi(918)$

$\mathbf{(Mt)_1=38286.291}$ **N-mm**

Now tangential component of force $(Pt)_{AB}$

$(Pt)_{AB}\times d_A/2=(Mt)_1$

$(Pt)_{AB}=2(Mt)_1/ d_A$…………….. (1)

$\mathbf{(Pt)_{AB}=1367.368}$**N**

Now calculate the torque transmitted to the shaft no.(2)

$(Mt)_2=(Pt)_{AB} \times d_B/2$

$(Mt)_2 = 1397.368 \times 262.5/2$

$\mathbf{(Mt)_2 = 179466.99}$ **N-mm**

Now the tangential component of force between gearC or D to E OR CtoF

$(Pt)_{DE}=2(Mt)_2/ d_C$ …………..(3)

$(Pt)_{DE}=2 \times 179466.99 / 136.5$

$\mathbf{(Pt)_{DE}=2629.553}$ **N**

And $(Pt)_{DE}=(Pt)_{CF}$

Therefore $\mathbf{(Pt)_{CF}=2629.553}$ **N**

Now calculated the torque transmitted through shaft no.(3) is

$(Mt)_3 = (Pt)_{CF} \times d_F/2$

$\mathbf{(Mt)_3 = 386827.67}$ **N-mm**

It is thus clear from the above tables that to get the minimum required speed of 120rpm of the roller shaft, the diameter of the pulley on the motor shaft should be of 190mm, at that time we get speed of roller shaft 122rpm, for this the corresponding Tangential Forces on shaft no.1 and shaft no.2 are given in table no 1.2 are 1038.548N & 2020.034N respectively.

Similarly the Torque Transmitted by shaft no 1, shaft no 2, shaft no 3 will be 29079.370N-mm and 137867.372N-mm and 296945.110N-mm respectively.

4. FUTURE: SCOPE FOR FUTURE WORK

The hardening of pinion gear may also be tried. This can avoid necessity of using EN8 for pinion.

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