STUDY AND ANALYSIS OF TIRE CHANGING MACHINE COMPONENTS

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Abstract - Now a days in automobile field new features and new generation are rapidly increases, due to this regularly do maintenance of vehicle is main role of user. So our study is focus on the safety of operator in service centre. In service centre mostly used machine is tire changing machine for removing and mounting of tire from rim. Safety and less effort of operator is important when operating this machine. Also study the gearbox design of Tire changing machine.

Key Words: *Tire Changing Machine, Gear Box, Design, safety, Helping arm, Cost*

1. INTRODUCTION

This machine is use for tyre removing and fitting on Rim of wheel. In this machine wheel is clamped on the mounting base. The wheel rim is tightly fixed on the mounting wheel. This tyre removing and fitting machine used to help tire technicians dismount and mount tyres of automobile wheels. After the wheel and tyre assembly are removed from the automobile, the tyre changer has all the components necessary to remove and replace the tire from the wheel. This machine allow technicians to replace tyres on automobiles, motorcycles and heavy-duty. The very regular tyre changer process is manually tyre changer may involve high force to remove tyre from heavy wheels or tyres. It also involves bending, reaching and twisting. This can cause musculature injuries to the shoulder, lower back, wrist and knees. Injuries can occur suddenly or gradually over time. Some other major factor is taken in consideration while doing this paper are as follows, Cost of powered tyre removing and fitting machine is much higher as compared to traditional manual tyre removing and fitting process. Removing or fitting of tyre on rim of wheel by manual is very effort full process and time consuming. Some time, hand tool which is use for removing the tyre from rim of wheel is damage the tube and tyre of wheel due to it is not properly handle, or due to human handling error. Manually removing and fitting of tyre on rim wheel is very skilled and experienced operator is required.

1.1 Tire changing machine

There are two basic types of tyre changers: the turn table clamp style, and the center post style. There are turn table clamp changers that will do a fine job in any dealership, and there are more automated models and changers that specialize in handling high performance and tyres. Some turn table models will automatically lock to preset wheel diameter and width positions. The more expensive automated models like the center post style changer above can handle tyres of various diameters and feature a high torque motor.

2. RESEARCH OBJECTIVES

The main objectives of this research to study and understand the Construction and operation of 'tire-changer' equipment and safety from machine. This research helps to develop new design feature of machine. A number of operational functional and design problems have been identified during the field trials.

2.1 Marketing survey

In the marketing survey we understand the problems, improvements and opinions of customers about tire changing machine.

Opinions of customers:

Reducing the cost as well as required human effort. Increase safety about operating machine operator. Increase sureness of design and create self design of important device.

3. DESIGN OF GEAR BOX

The main purpose of a gearbox is to transmit power required or demand to variable needs from an input power source to the desired output machine. A Gearbox is a mechanical device that is used to provide desirable different Speed and Torque transfer to output gearbox shaft to machine input shaft. As the speed of the shaft increases, the torque transmitted decreases because speed and shaft is inversely proportional to each other so gearboxes are used in applications which require frequent changes to the speed or torque at the output shaft. Gearboxes work on the principle of meshing of teeth, which result in the transmission of motion and power from the input source to the output.

Some of the primary components used in a Gearbox are listed below.

1. Gears
2. Bearings
3. Shafts

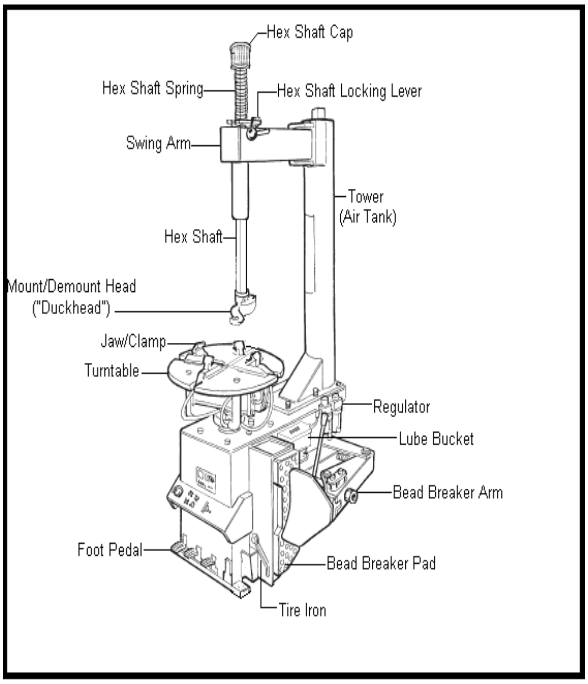

Fig. 1. Tire Changing Machine

3.1 Calculations

Initial Specifications for the Gearbox

Given data -

Motor speed = 1440 rpm

1. Gear box output speed = 7-10 rpm
2. Input power – 2 -3 Kw
3. Geometric progression ratio (Ø) = $\sqrt[5]{10}$ = 1.5848 - (automatic or semi automatic machine)
4. Range ratio (Rn) = $\frac{Nmax}{Nmin} = \frac{1440}{10}$ =144
5. Speed steps (Z) =?

$$Ø = Rn^{\left(\frac{1}{z-1}\right)}$$

$$Z = \frac{\log(Rn*Ø)}{\log(Ø)} = \frac{\log(144*1.5848)}{\log(1.5848)} = 11.796 = 12$$

Calculate speed steps (spindle speeds)

Table 1 speed steps (spindle speeds)

Speed steps	spindle speeds (rpm) Equations	Output speeds
1	$n_1 = n_{min}$ = 10	10
2	n_2 = Ø*n_1 = 1.5848 * 10 =15.848	15.848
3	n_3 = Ø*n_2 = 1.5848 * 15.848 = 25.1159	25.1159
4	n_4 = Ø*n_3 = 1.5848 * 25.1159 = 39.8036	39.8036
5	n_5 = Ø*n_4 = 1.5848 * 39.8036 = 63.0800	63.080
6	n_6 = Ø*n_5 = 1.5848 * 63.080 = 99.970	99.970
7	n_7 = Ø*n_6 = 1.5848 * 99.970 = 158.433	158.433
8	n_8 = Ø*n_7 = 1.5848 * 158.433 = 251.085	251.085
9	n_9 = Ø*n_8 = 1.5848 * 251.085= 397.91	397.91
10	n_{10} = Ø*n_9 = 1.5848 * 397.91= 630.63	630.63
11	n_{11} = Ø*n_{10} = 1.5848 * 630.63 = 999.41	999.412
12	n_{12} = Ø*n_{11} = 1.5848 * 999.41 = 1583.86	1583.683

To find pulleys diameters by using speed ratios

$$\frac{n_{i/p}}{n_{motor}} = \frac{D_{motor}}{D_{i/p}} = \frac{126}{1440} = \frac{D_{motor}}{D_{i/p}}$$

$$D_{i/p} = 11.4285\,D_{motor}, D_{motor} = 38.1mm$$

$$D_{\frac{i}{p}} = 38.1 * 11.4285 = 435.42\ mm$$

Structural diagram

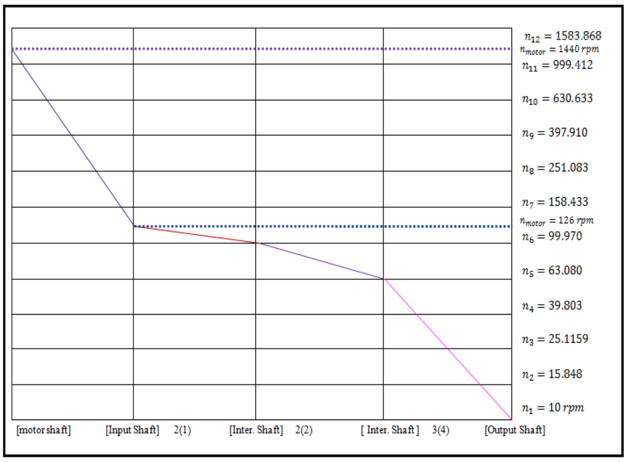

Fig.1 Speed Ray diagram

Calculate number of gear teeth on each gear by using spindle speeds ratio and we get,

1] For first stage gears

I. $\frac{Z_{1i}}{Z_{1o}} = \frac{99.970}{126} = 0.7934$

$Z_{1o} = 1.2574\, Z_{1i}$

II. $\frac{Z_{2i}}{Z_{2o}} = \frac{158.433}{126} = 1.2574$

$Z_{2i} = 1.2574\, Z_{2o}$

Assume, Module is same for all gears,

$Z_{1i} + Z_{1o} = Z_{2i} + Z_{2o}$

$Z_{1i} + 1.2574\, Z_{1i} = 1.2475\, Z_{2o} + Z_{2o}$

$2.2574 Z_{1i} = 2.2574\, Z_{2o} \quad Z_{1i} = Z_{2o}$

Assume, $Z_{1i} = Z_{2o} = 18$

$Z_{1o} = 1.2574 * 18 = 23$

$Z_{2i} = Z_{1o} = 22$

Similarly, stage second and third calculated and get,

Calculate number of gear teeth on each gear by using spindle speeds ratio and we get ,

1] For first stage gears

III. $\frac{Z_{1i}}{Z_{1o}} = \frac{99.970}{126} = 0.7934$

$Z_{1o} = 1.2574\, Z_{1i}$

IV. $\frac{Z_{2i}}{Z_{2o}} = \frac{158.433}{126} = 1.2574$

$Z_{2i} = 1.2574\, Z_{2o}$

Assume, Module is same for all gears,

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3.2 Gear Module Calculations

Module is calculated on the basis of bending strength and wear strength of pinion and gear.

1. Using levies factor

$Y_P = 0.6889 < Y_G = 0.7179$

Pinion is a weaker part, so design is based on it

1. Bending Strength Basis,

$S_b = 6_b * b * m * Y_p$

Wear strength basis,

$S_w = d_p * b * Q * K$

$S_b = 2669.487\, m^2 > S_w = 1140.48\, m^2$

Above relation observation we understand the $S_b > S_w$, so design is based on wear strength.

Effective load is,

$$F_{eff} = \frac{k_a * k_m * F_t}{K_v} \quad N/mm^2$$

$k_a = 1.25\ \&\ k_m = 1.3\, , K_v = \left(\frac{6}{6+V}\right)$

$$F_{eff} = \frac{86.2096(6 + 9.4247m)}{m} \quad N/mm^2$$

Estimate the load in order to avoid the wear failure,

$S_w = N_f * F_{eff}$

$N_f = 1.28\ to\ 2.5$

$1140.48\, m^2 = 2.5 * \frac{86.2096(6+9.4247m)}{m} \quad m = \mathbf{1.50}$

Table 2 No Of Teeth and Diameter Of Gear

Sr. No.	Stages	Number of teeth		Diameters of gear module 1.50 (mm)
		input	output	
1	stage 1st	$Z_{1i} = 18$ $Z_{2i} = 22$	$Z_{1o} = 22$ $Z_{2o} = 18$	$d_{1i} = d_{2o} = 27$ $d_{2i} = d_{1o} = 33$
2	stage 2nd	$Z_{3i} = 46$ $Z_{4i} = 18$ $Z_{5i} = 32$	$Z_{3o} = 18$ $Z_{4o} = 46$ $Z_{5o} = 32$	$d_{4i} = d_{3o} = 27$ $d_{3i} = d_{4o} = 69$ $d_{5i} = d_{5o} = 48$
3	stage 3rd	$Z_{6i} = 90$ $Z_{7i} = 18$	$Z_{6o} = 18$ $Z_{7o} = 90$	$d_{7i} = d_{6o} = 27$ $d_{6i} = d_{7o} = 135$

3.2 Calculation Of Shaft Diameter

$$P = \frac{2*\pi*n*T_e}{60}$$

$$3*10^3 = \frac{2*\pi*126*T_e}{60}$$

$$T_e = 227.36\ N/mm^2$$

This equivalent torque value we select diameter from stranded table (Design Data Hand Book)

$$d_1 = 29.21\ mm = 30mm$$

Similarly, second shaft, third shaft & forth shaft diameters calculated,

$$T_e = 286.56\ \frac{N}{mm^2} = d_2 = 30mm$$

$$T_e = 454.15\ \frac{N}{mm^2} = d_3 = 34.6mm = 35mm$$

$$T_e = 2864.78\ \frac{N}{mm^2} = d_4 = 54.61mm = 55mm$$

Selection of Bearing

Bearing is selected from the standard table.

1. for shaft first and second, $d_1 = d_2 = 30\ mm$
   Bearing number – 6006
   $D = 55\ mm$
   $B = 13\ mm$
   $C = 13300\ N$ $C_0 = 6800\ N$
2. For shaft third, $d_3 = 35\ mm$
   Bearing number – 16007
   $D = 35\ mm$
   $B = 9\ mm$
   $C = 12400\ N$ $C_0 = 5950\ N$
3. For shaft forth diameter, $d_3 = 55\ mm$
   Bearing number – 61811
   $D = 72\ mm$
   $B = 9\ mm$ $C = 8320\ N$ $C_0 = 5600\ N$

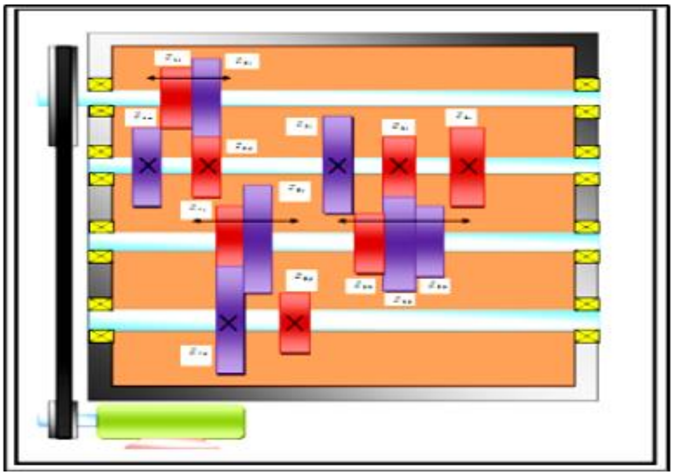

Fig.No.3 Layout Of Gear Box

4. DESIGN OF HELPING ARM

The main objective of this design and analysis of 'tire-changer' equipment parts (supporting arm) develop semi automatic machine due to this increases safety of operator from machine opportunities and help eliminating extra man power in service center workshops. Material used for supporting arm is low carbon steel.

4.1 Specification of steel bar,

Material of bar – low carbon steel

Yield strength $= 355 - 400 N/mm^2$

$Tensile\ strength = 500\ N/mm^2$

$Thikness = $ 16mm to 40mm

$Density = 7850\ kg/\ m^3$

$Youngs\ modulus - 200\ Gpa.$

$Ultimate\ strength - 440\ mpa.$

$Elongation - 15\%.$

$Hardness - 119 - 235\ brinell.$

$Carbon\ content - 0.18 - 0.32$

$Poisson\ ratio$ – 0.29

4.2 Design calculation

$PARAMETERS$

$Material\ Grade$ – $Low\ Carbon\ Steel$ (1020)

$Dimension$ – $40*40*4\ mm$

$Length - 650\ mm$

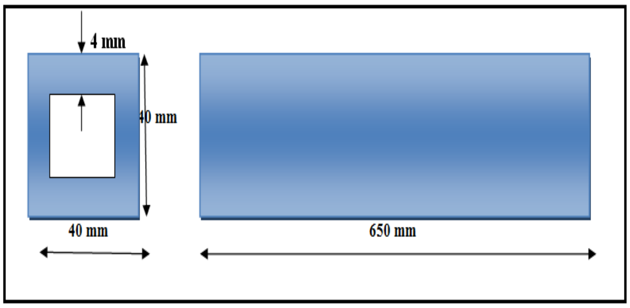

Fig.4. Steel bar

Stress Calculation,

$Resultant\ stress - \sigma_r = \sigma_d + \sigma_b$

$Direct\ stress, = \sigma_d = \frac{P}{A}$

$\sigma_d = 4000/40 * 650$

$\sigma_d = 0.1538 N/mm^2$

$Bending\ stress, \sigma_b = P * e * \frac{y}{I}$

$= 4000 * 325 * 20/125952$

$= 206.4278\ N/mm^2$

$Resultant\ Stress = 0.1538 + 206.4278$

$\sigma_r = 206.5816\ N/mm^2$

$So, permissible\ stress = FOS * working\ stress$

$= 2.12 * 206.5816$

$= 437.952\ N/mm^2$

$After\ calculation,$

$working\ stress < permissible\ stress < ultimate\ stress$

$206.5816 < 437.952 < 440$

$so, calculated\ design\ is\ within\ safe$

4.3 Deformation & Slope Calculation,

$Deflection$

$y' = wl^3/48EI$

$= 4000 * 650^3/48 * 205000 * 125952$

$= 7.3mm$

$Slope$

$y'' = wl^2/16EI$

$= 4000 * 650^2/16 * 205000 * 125952$

$y' = 0.02343 rad$

3D Model of tyre changing machine in creo software

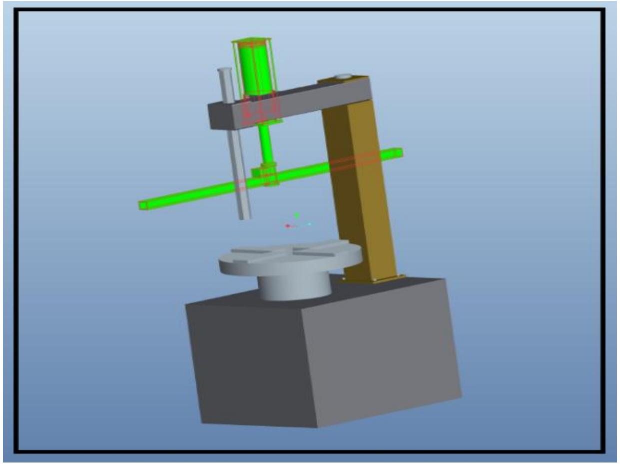

Fig.no.5. 3D Model of tyre changing machine

Static Analysis of Helping Arm by using Ansys 14.5 workbench

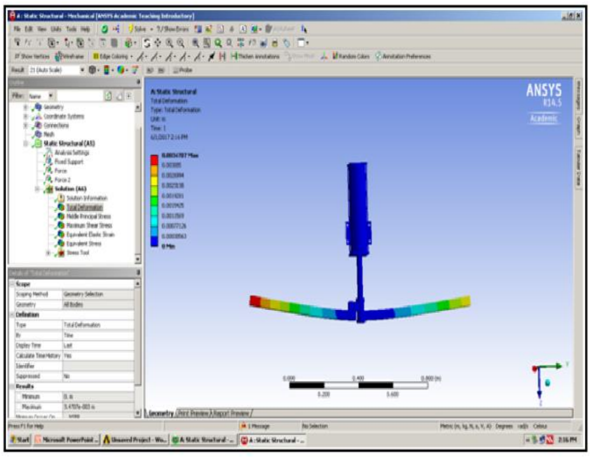

Fig.no.7. Total Deformation

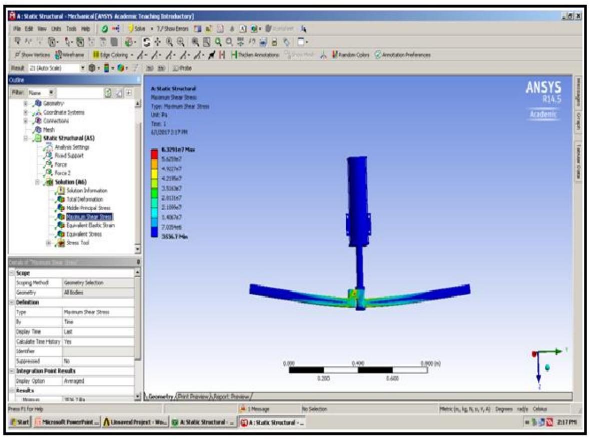

Fig.no.8. Maximum shear stress

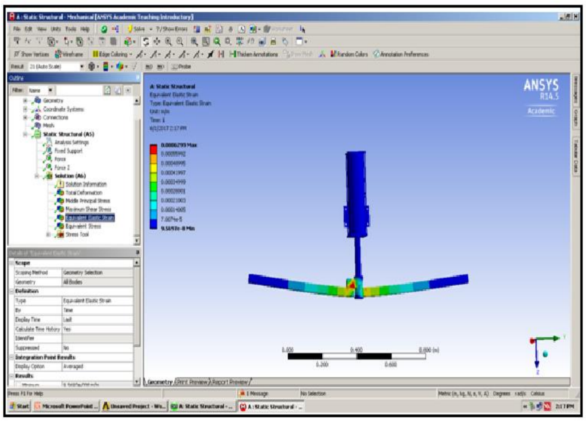

Fig.no.9. Equivalent Elastic Strain

5. CONCLUSION

We conclude that tyre changing machine increase the use daily life so reduce operator effort as well as reduce operating time and safety of operator.

Reduce the cost of machine by developing self design of tyre changing machine components and increase sureness of designed components of machine.

Most of machine Important component are imported from foreign country this will be stop and manufacture all components in India due to this automatically other charges are reduce and total cost reduce.

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