DESIGN DEVELOPMENT AND ANALYSIS OF QUARTER CAR TEST RIG FOR MEASUREMENT OF TYRE PRESSURE WITH DIFFERENT CONDITIONS

SWAPNIL N. KADAM
ME student, Dept. of Mechanical (Design) Engineering, DYPSOE, Pune, India, swapnil474444@gmail.com

PROF. AMOL N. PATIL
ME Coordinator, Dept. of Mechanical (Design) Engineering, DYPSOE, Pune, India, amolp@dypic.in

ABSTRACT:

Under or over Inflated tyres increases rolling resistance, which not only reduces fuel economy, but can also wear out tyres and reduce vehicle safety through poor handling. Maintaining correct tyre pressures and monitoring for uneven tyre wear (which can be caused by poor wheel alignment) can help to ensure optimum vehicle performance. For testing of automatic tyre inflation sytem we designed a quarter car (Single wheel) test rig with condition of traction change, speed change and road condition variance to determine the damping parameter provided by the air pressure in tyre.

KEYWORDS: wear, handling, traction change, speed change, variance.

1. INTRODUCTION:

Now day's inflation in tyres is done manually once in a month or twice, this is time consuming and if tyre pressure is not proper as described by manufacturer it may lead to wear of tyres, poor handling and reduction in fuel efficiency. Our idea is to keep the tyre pressure constant by inflating the tyres in running condition by using a hybrid mechanical valve. So for testing whether the tyre pressure is constant after installation of the hybrid mechanical valve we first designed a test rig with different condition of traction change, speed change and road condition variance. We designed critical parts of system and validated using Ansys software. We could use vehicle speed, traction, and amplitude of bumps as process variables and measure the tyre pressure, vibration, tractive load which will help in further analysis and recommendation in design of the mechanical hybrid valve.

2. DESIGN:

System design mainly concerns the various physical constraints and ergonomics, space requirements, arrangement of various components on main frame at system, man + machine interactions, No. of controls, position of controls, working environment of machine, chances of failure, safety measures to be provided, servicing aids, ease of maintenance, scope of improvement, weight of machine from ground level, total weight of machine and a lot more.

For designed parts detailed design is done & distinctions thus obtained are compared to next highest dimensions which are readily available in market. This amplifies the assembly as well as postproduction servicing work. The various tolerances on the works are specified. The process charts are prepared and passed on to the manufacturing stage. The parts which are to be purchased directly are selected from various catalogues & specified.

In system design we mainly concentrated on the following parameters:-

1. System Selection Based on Physical Constraints
2. Arrangement of Various Components
3. Components of System
4. Man Machine Interaction
5. Chances of Failure
6. Servicing Facility
7. Scope of Future Improvement
8. Height of Machine from Ground
9. Weight of Machine

2.1 DESIGN OF BELT CONVEYOR SHAFT:

Material - EN24 (UTS=800 N/mm^2)

$$f_{s_{max}} = \frac{UTS}{FOS} = \frac{800}{2} = 400\ N/mm^2$$

This is the allowable value of shear stress that can be induced in the shaft material for safe operation. Check for torsional shear failure of shaft,

$$T = \frac{\pi}{16} \times t_e = \frac{\pi}{16} \times f_s \times d^3$$

$$f_{s_{act}} = \frac{16 \times 0.25 \times 10^3}{\pi \times 16^3}$$

$$f_{s_{act}} = 0.310\ N/mm^2$$

$$f_{s_{act}} < f_{s_{all}}$$

Thus shaft is safe under torsional load.

2.2 DESIGN OF COUPLER DISK FOR ROLLER OF BELT CONVEYOR:

Material - EN24 (UTS=800 N/mm^2)

$$f_{s_{max}} = \frac{UTS}{FOS} = \frac{800}{2} = 400\ N/mm^2$$

Check for torsional shear failure,

$$T = \frac{\pi \times f_{s_{act}}}{16} \times \left(\frac{D_o^{\,4} - D_i^{\,4}}{D_o}\right)$$

$$0.25 \times 10^3 = \frac{\pi \times f_{s_{act}}}{16} \times \left(\frac{36^4 - 16^4}{36}\right)$$

$$f_{s_{act}} = 0.028\ N/mm^2$$

$$f_{s_{act}} < f_{s_{all}}$$

Coupler disk is safe under torsional load.

2.3 DESIGN FOR BEARING OF INPUT SHAFT:

Bearing selection- ISI No. 2AC04

$$P = XF_r + YF_a$$

Neglecting self-weight of carrier and gear assembly,

For our application F_a =0.

$\Rightarrow P = X F_r$

Where,

$$F_r = P_t = \frac{0.25 \times 10^3}{\text{Radius of pinion}} = \frac{0.25 \times 10^3}{22 \times \frac{1.7}{2}}$$

$F_r < e \quad \Rightarrow X = 1$

Max radial load = F_r =13.4 N.

P= 13.4 N

Calculation of dynamic load capacity of bearing,

$L = \left(\frac{C}{P}\right)^m$, Where m= 3 for ball bearings

For m/c used for eight hour of service per day;

L_H = 4000 hr

But,

$$L = \frac{60nL_H}{10^6} = \frac{60 \times 1900 \times 4000}{10^6}$$

L= 456 (1900 rpm)

Now,

$$45 = \left(\frac{C}{13.4}\right)^3$$

C= 103.1N

⇒As the required dynamic capacity of bearing is less than the rated dynamic capacity of bearing;

⇒ Bearing is safe.

2.4 DESIGN OF WHEEL HUB:

Material- EN8 (UTS=520 N/mm²)

$$F_{s_{max}} = \frac{UTS}{FOS} = \frac{520}{2} = 260\ N/mm^2$$

This is the allowable valve of shear stress that can be induced in the shaft material for safe operation.

Assuming 100 % efficiency of transmission

⇒ T design = 0.252 Nm

$$T_d = \frac{\pi}{16} \times f_{s_{act}} \times \frac{D^4 - d^4}{D}$$

Outside diameter of drum boss =D_0 = 37.5 mm

Inside diameter of drum boss =D_i =26mm

$$f_{s_{act}} = \frac{16 \times T_d \times D}{\pi \times (D^4 - d^4)} = \frac{16 \times 0.252 \times 10^3 \times 37.5}{\pi \times (37.5^4 - 26^4)}$$

$$f_{s_{act}} = 0.03\ N/mm^2$$

$$f_{s_{act}} < f_{s_{all}}$$

⇒ Wheel Hub is safe under torsional load.

3. ANALYSIS:

3.1 ANALYSIS OF WHEEL SHAFT

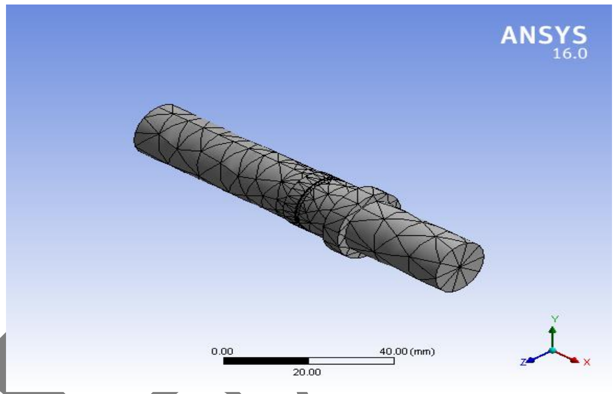

Figure 3.1: Meshing of wheel shaft

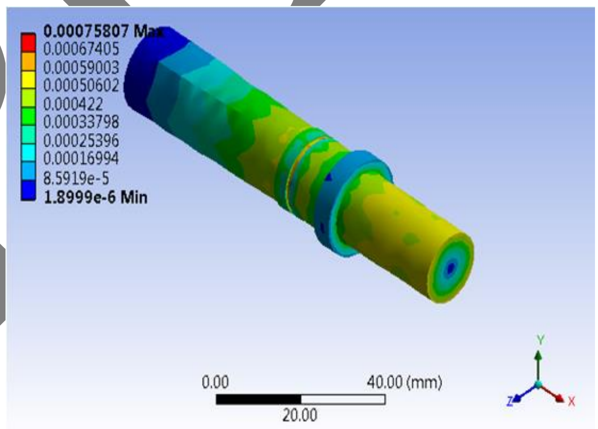

Figure 3.2: Equivalent von-mises stress for wheel shaft

3.2 ANALYSIS OF LEFT HAND COUPLER DISK FOR ROLLER OF BELT CONVEYOR:

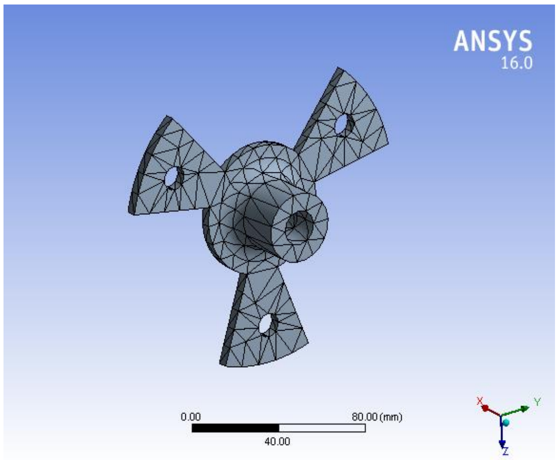

Figure 3.3: Meshing of Coupler Disk for Roller of Belt Conveyor

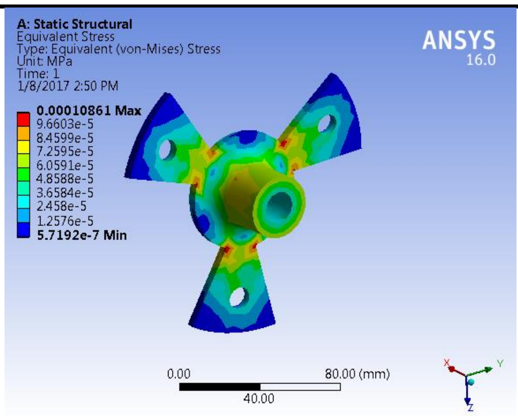

Figure 3.4: Equivalent von-mises stress for Coupler Disk for Roller of Belt Conveyor

3.3 ANALYSIS OF WHEEL HUB:

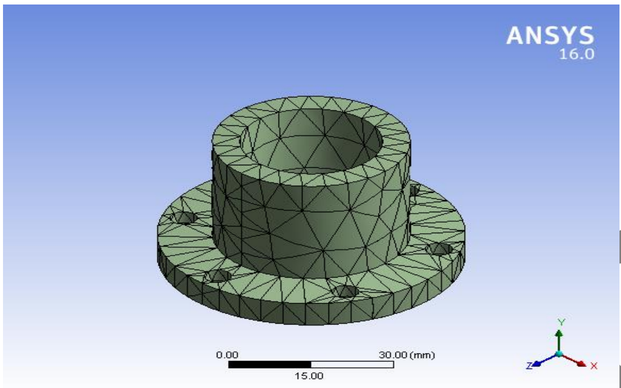

Figure 3.5: Meshing of wheel hub

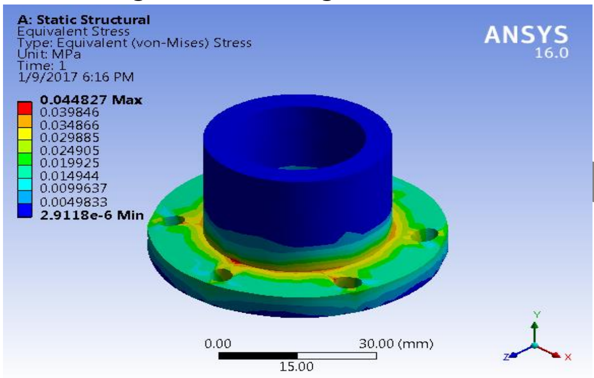

Figure 3.6: Equivalent von-mises stress for wheel hub

4. TEST AND TRIAL:

4.1 EXPERIMENTAL SET UP:

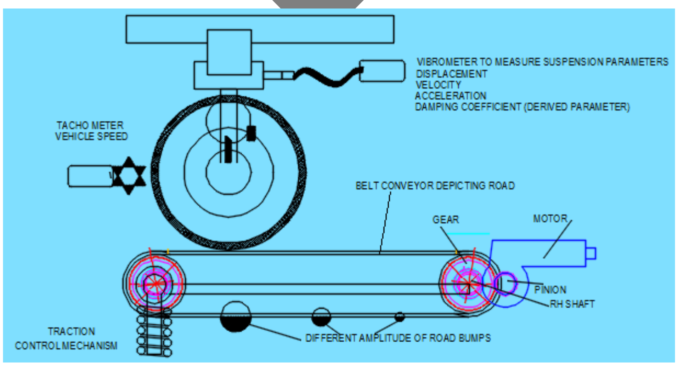

Figure-4.1: Experimental Setup

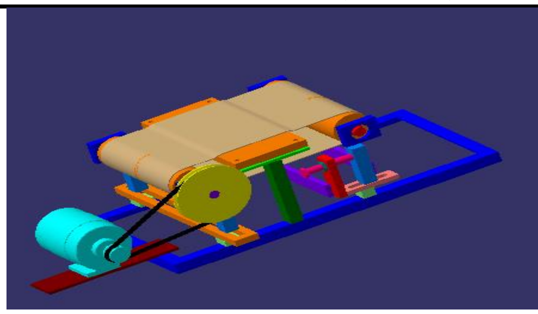

Figure 4.2: Model of Test Rig

4.2 PROCESS VARIABLES:

1. Vehicle speed
2. Traction
3. Amplitude of bumps

4.3 MEASURED PARAMETERS:

1. Tyre pressure (electronic tyre pressure gage)
2. Vibration (damping parameters owing to tyre pressure)
   a) Displacement
   b) Velocity
   c) Acceleration
3. Tractive load

4.4 DERIVED PARAMETERS:

Damping coefficient of the tyre pressure system at various road conditions (excitation provided by the road bumps).

4.5 EXPECTED OUTCOME OF TRIAL:

1. Rate of tyre pressure refill at various vehicle speeds.
2. Vibration parameters and there by the damping provided at various road conditions.
3. Tractive effort at various tyre pressures during refill operation.
4. Effectiveness of system as to time taken for refill with single unit valve.
5. Recommendation to be made as to number of valves required.

ACKNOWLEDGMENT:

I take this opportunity to thanks Prof. A. N. Patil for valuable guidance and for providing all the necessary facilities, which were indispensable in completion of this work. Also I sincerely thank all the other authors who worked on same area.

REFERENCES

1) Ajas. M. A, Janahanlal P.S., "*Tyre Pressure Monitoring and Automatic Air Filling System*", International Journal of Research in Engineering & Advanced Technology, Volume 2, Issue 2, Apr-May, 2014.

2) D.Johny, G.Kabilan, "*Design and fabrication of automatic tyre inflation and deflation system*", International Journal of Advanced Research and Innovative Ideas in Education, Vol-2 Issue-3 2016.
3) Tawanda Mushiri, Allan T. Muzhanje, "*Design of an automatic tyre pressure inflation system for small vehicles*", International Conference on Industrial Engineering and Operations Management Detroit, Michigan, USA, September 23-25, 2016.