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Modification in Rear-Axle Test Rig Machine for Testing Rear Wheel Braking System

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Abstract: **The rear axle has a housing, tubes for the axle shafts, a final drive (including the differential with reduction gears), and the axle shafts. The rear axle is joined to the frame or body of the motor vehicle (to the supporting body if the motor vehicle has no frame) by a suspension. The rear axle test rig machine is used for testing the braking system of rear axle. The existing machine does not have any mechanism for applying brake. The brake is applied manually and higher force is required for pulling the brake cable. The force applied is in backward direction with the help of hand and applying tensile force on it. More cycle time is required for performing work in existing system. Manual operation increases the operator fatigue. The modified rear axle test rig machine consists of handbrake assembly, clamping fixture (dowel pin), cable fixture, stud, L shaped plates etc. The brake is applied by handbrake by pulling it in upward direction causing tension in wire. The modified rear axle machine reduces cycle time and increases safety for workers. The proper tension in wire helps for proper braking and the tension in wire can be adjusted with help of dowel pin.**

Keywords: **Rear axle, Hand brake, Cable Holder, Clamping Fixture, L shaped plates.**

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1. INTRODUCTION

The rear axle test rig machine is used for checking of differential action, oil leakage, air leakage testing and noise during forward and reverse rotation. The rear axle test rig machine is used for testing the braking system of rear axle. The rear axle assembly is used on rear-wheel drive vehicles. This assembly is the final leg of the drive train. It is often called the final drive or rear end. The rear axle assembly is often mistakenly called the differential. The differential is only part of the rear axle assembly. The rear axle assembly includes the differential assembly, the rear drive axles, and there rear axle housing. An axle test stand with a 10 HP, 2880 RPM variable speed input drive motor to drive the axle unit and torque transmitted is 25 N-m. Two work holding fixtures are situated on a rear axle bed to enable a component to be loaded/unloaded while axle is being tested.

2. PROBLEM STATEMENT

The existing work system is not safe to workers.
More cycle time is required for performing work in existing system. Braking is done manually.
Manual operation increases the operator fatigue.
Higher application of force is required for braking

3. OBJECTIVE OF THE PROPOSED WORK

The modification of rear axle test rig machine is done by application of handbrake which is operated through clamping holder and wire fixture. This proposed modification reduces cycle time and increases human safety. The modified rear

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axle test rig machine consists of handbrake assembly, clamping fixture (dowel pin), cable fixture, stud, L shaped plates etc. The brake is applied by handbrake by pulling it in upward direction causing tension in wire. The modified rear axle machine reduces cycle time and increases safety for workers.

4. DESIGN

A. Selection of material:

Selection of material has a high effect on the structure strength. The most significant factor to evaluate the material strength is by referring to the yield strength, σy and the modulus of elasticity, E of the material. Mott (2004) stated that, yield strength can be defined as the portion of the stress-strain diagram where there is a large increase in strain with little or no increase in stress. He also stated that modulus of elasticity can be define as stress proportionality to strain when the part of the stress-strain diagram is straight. Modulus of elasticity indicates the stiffness of the material or its resistance to deformation. Metal materials: plain carbon steel. All investigators concluded that using these materials it can with stand load and stresses acting on the various parts.

B. Design of Handbrake:

Motor specifications:

Power developed by motor = 10 HP

Voltage V = 440 volts

Current I = 12.5 Amps

Power developed by motor (P) =746 × 10 = 7460 W

Speed= 2880 rpm

We know that,

Power developed by motor, P= $\frac{2\pi NT}{60}$

7460= $\frac{2\pi\times 2880\times T}{60}$

T= 24.735 N-m

Hence, the torque developed by motor , T= 24.735 N-m

Hand brake

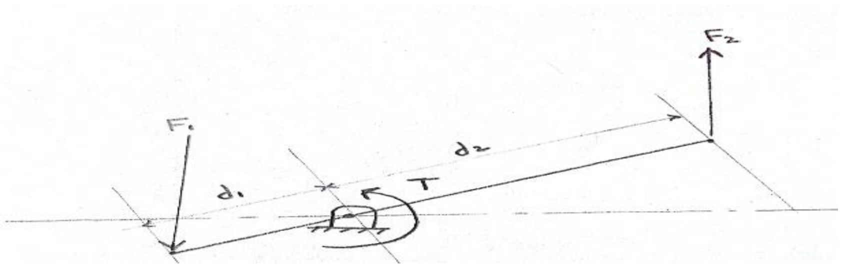

Fig. 4.1.1 FBD for hand lever

F_1 is output force

F_2 is applied force on hand lever.

d_1 is distance between pivot point and lower side of lever

d_2 is distance between pivot point and upper side of lever

d_1=0.08 m

d_2=0.24 m

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$24.735 = F_1 \times (0.08)$

$F_1 = 309.18N$ (31.51 kg)

$F_2 = 103.06$ N (10.51 kg)

Force multiplied by Hand Brake = $\frac{F1}{F2}$

$= \frac{309.18}{103.06}$

= 3

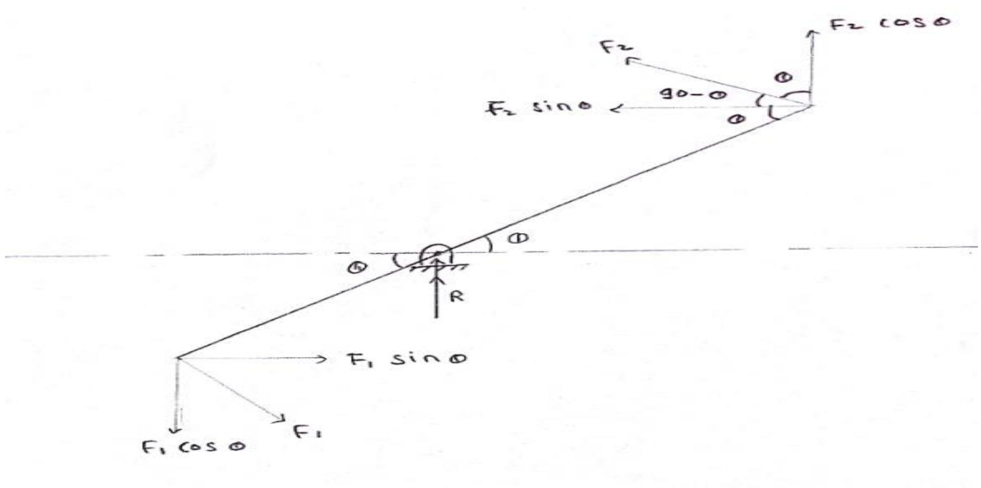

Fig. 4.1.2 FBD of resolution of forces of hand lever

Taking moment about y axis,

$\therefore \sum My = 0$

Taking reaction about y axis,

$\therefore \sum Fy = 0$

$F_1 \cos\theta = R + F_2 \cos\theta$

$R = F_1 \cos\theta - F_2 \cos\theta$

= 309.18 cos 63 – 103.06 cos 63

R=93.51 N (↑)

Hence, the resultant force acting on hand lever is R=93.51 N (↑).

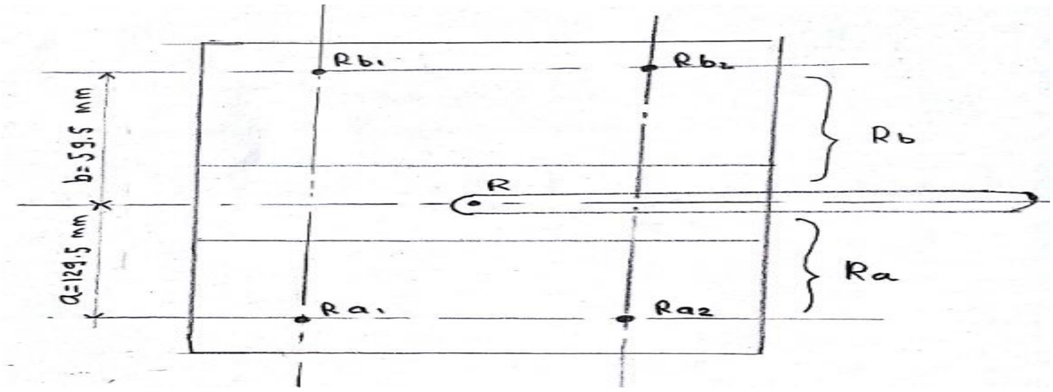

Fig. 4.1.3 Force Analysis

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$R_b = \left(\frac{a}{a+b}\right) \times R$

$= \left(\frac{129.5}{129.5+59.5}\right) \times 93.51$

$R_b = 64.11$ N.

$\therefore R_{b1} = R_{b2} = \frac{64.11}{2} = 32.055$

(In handbrake mounting bolt b_1 & b_2 are fixed at same distance from hand lever. Hence, the reaction at bolt b_1 & b_2 is same.)

$R_a = \left(\frac{b}{a+b}\right) \times R$

$R_a = 29.45$ N.

$\therefore R_{a1} = R_{a2} = \frac{29.45}{2} = 14.72$ N

(In handbrake mounting bolt a_1 & a_2 are fixed at same distance from hand lever. Hence, the reaction at bolt a_1 & a_2 is same.)

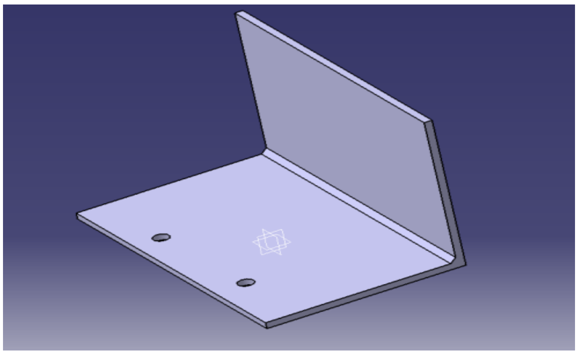

Fig.4.2 L Plate

C. Design Of l – plates

Material: MS 10C4– deep drawn, hot rolled

Properties of 10C4:

a) Tensile strength (min) = 340 to 420 N/mm^2

b) Elongation (min) = 17 % to 26%

c) Load impact value = 55 N-m

Welding: CO_2 welding

Filler material: copper wire

Failure of fillet weld occurs due to shear along minimum cross section at throat.

The shear strength of parallel fillet weld can be estimated as,

$$P = 0.707\, h\, l_1\, \tau$$

Permissible weld stresses for weld metal,

Type of load is shear

Type of weld is fillet

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The reverse load acting on the plate and weld, so permissible shear stress for fillet weld is taken as $35\mathrm{N/mm^2}$ as per code of AWS (American welding society).

We have,

$\tau = 35\ \mathrm{N/mm^2}$

t = 0.707 h

l = 165 mm

Therefore,

$h = \frac{t}{0.707}$

But 15mm should be added to the length of each weld to allow for starting and stopping of weld run.

$l_1 = l + 15$

$= 165 + 15$

$= 180$ mm

P = 0.707×5.657×180×35 = 25.1968 KN

So, tensile force on plate is 25.1968 KN on each plate.

Now, we have the strength of plate,

$\sigma = \frac{P}{A}$

$= \frac{25196.8}{w \times t}$

$= \frac{25196.8}{(165\times4)}$

$\sigma = 38.176\ \mathrm{N/mm^2}$

i.e. $\sigma < \sigma_{allowable}$ ($38.17 < 340\mathrm{N/mm^2}$),

So, design is safe.

D. Design of Cable Holder:

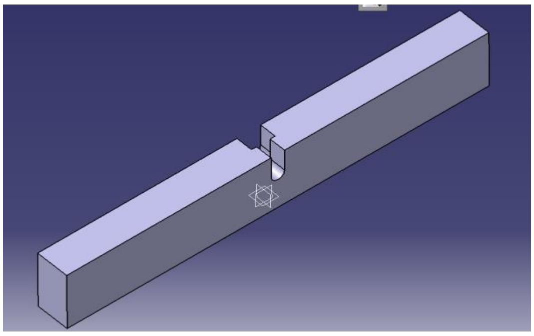

Fig.4.3 Cable holder

The cable holder is used for fixing the cable and allowing the wire to be screwed internally to the dowel pin.

Material: MS 35C8

$\sigma = 550$ to $650\mathrm{N/mm^2}$ … [Reference no.10]

For Wire Cable,

$M_b = f_1 \times d \times \mu$

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= 309.18× (40-19) ×0.3

M_b = 1947.83N-mm

Now,

$$\sigma_b = \frac{Mb}{I}$$

$$Y = \frac{h}{2} = \frac{21}{2} = 10.5\text{mm}$$

$$I = \frac{b^3 d}{12} = \frac{20^3 \times 250}{12} = 166666.67 mm^4$$

$$\sigma_b = \frac{1947.83 \times 10.5}{166666.67}$$

$$= 0.1227 \text{N/mm}^2$$

So, $\sigma_b < \sigma_{allowable}$

Hence, design is safe.

E. Design Of Clamping Holder:

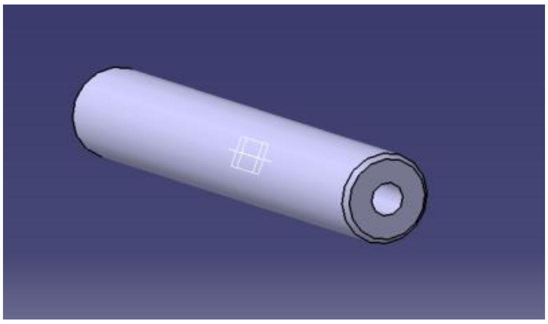

Fig.4.4 Clamping holder

Material: MS 45C8

W=309.18

d=8 mm

σ_t allowable= 630 N/mm^2

τ_s allowable= 50 N/mm^2

Tensile stress in dowel pin:

$$\sigma_t = \frac{W}{\frac{\pi}{4} \times d^2} = \frac{309.18}{\frac{\pi}{4} \times (8)^2}$$

σ_t = 6.1509 N/mm^2

$\therefore \sigma_t < \sigma_{allowable}$

Hence, design is safe in tensile stress

Shear stress induced in threads of dowel pin:

$$\tau_s = \frac{W}{\pi\, d\, t\, z}$$

$$= \frac{309.18}{\pi \times 8 \times 1.25 \times 20}$$

τ_s = 0.492 N/mm^2

$\therefore \tau_{s\ all} > \tau_s$

Hence, the design is safe in shearing.

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5. EXPERIMENTATION

Experimental Set Up:

The rear axle test rig machine is used for testing the braking system of rear axle. It consists of following components:

1. Oil tank
2. Oil Pump.
3. Induction motor
4. Transmission shaft.
5. Universal Joint
6. Oil drainage
7. Clamping fixture
8. Control Panel
9. Machine Bed
10. Coupling
11. Differential oil

Fig 5.1 Experimental setup

Testing:

The rear axle to be tested is lifted from the trolley with the help of pneumatic cranes and the placed on the fixture of the rear axle test rig machine.

The rear axle is tightly fixed in the fixture and the differential is connected to propeller shaft through universal joint to the motor. Oil is filled through the motor to the differential valve and then the valve is tightened. The axle wheels and the propeller shaft are provided with safety covers for workers safety. The motor is switched ON and the axle wheels starts rotating.

The steps involved in testing of rear axle are as follows:

a) The step consists of rotation of axle wheels in forward direction and reverse direction. The differential under goes for oil leakage test and the testing of brake is done by using handbrake which is mounted on the machine bed of the rear axle test rig machine.

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b) The brake cable is clamped in the fixture and the wire is joined to the dowel pin through the stud which is bolted to the bracket of the handbrake.

c) When handbrake is operated, the brakes are applied and the wheel stops rotating while the other wheel rotates due to differential action.

d) The differential is tested for noise during forward and reverse testing. In the same way the wheel are checked for braking on the side of the rear axle test rig machine.

e) The T1, T2 and TX rear axle are tested for differential action on the rear axle test rig machine.

f) After testing of the rear axle the motor is turned off and the oil is drained from the differential through the pipe to the oil tub.

g) The valve is tightened and the cable is removed from the cable fixture and the wire is wound to the axle.

h) The universal coupling is detached from the differential of the rear axle and the tested rear axle is lifted with help of the pneumatic cranes and placed in the accepted trolley.

The total operational time taken to test the rear axle is approximately 14 minutes. The maximum allowable time for testing of rear axle is 17minutes. By modifying the rear axle test rig machine there is increase in safety for workers and reduction in cycle time.

6. RESULT AND DISCUSSION

Table 6.1Cycle Time per Axle

Sr. No.	Operation	Maximum Allowable Time (minutes)	Time Required After Modification (minutes)
1	Loading of rear axle	4	4
2	Differential oil filling and removal	4	4
3	Right hand side testing	2.5	1
4	Left hand side testing	2.5	1
5	Unloading	4	4
Total time :		17	14

Table 6.2 Cycle Time per Day

No. of Axle tested per Day	Time Required Before Modification (minutes)	Time Required After Modification (minutes)	Save In Time per Day (minutes)
56	952	784	168

Table 6.3 Estimation of Force

Sr. No.	Operation	Force Before Modification (N)	Force After Modification(N)
3	Right hand side testing	309.18	103.06
4	Left hand side testing	309.18	103.06

The modified rear axle test rig machine consists of handbrake assembly, clamping fixture (dowel pin), cable fixture, stud, L shaped plates etc.The brake is applied by handbrake by pulling it in upward direction causing tension in wire. The modified rear axle machine reduces cycle time and increases safety for workers. The proper tension in wire helps for proper braking and the tension in wire can be adjusted with help of dowel pin.

7. CONCLUSIONS

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The rear axle test rig machine is operated by application of hand force for braking of rear axle. The force applied is in backward direction with the help of hand and applied force is tensile force. This reduces human safety causing severe accidents**.** The modification of rear axle test rig machine is done by application of handbrake which is operated through clamping holder and wire fixture. This proposed modification reduces cycle time and increases human safety. In this way, we have successfully implemented the modifications

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REFERENCES

[1] “Design & static analysis of rear axle”, Lalit Bhardwaj, Amit Yadav, Deepak Chhabra.

[2] ”Braking Systems: past, present & future”, Akshat Sharma, Amit Kumar, Marwah.

[3] “Power transmission system” Hill Agri

[4] “Design and Optimization, Weight reduction of rear axle banjo housing for light weight vehicle”, S Surya Narayana.

[5] “Failure analysis of rear axle of a tractor with loaded trolley”, K.Acharya, I.Panigrahi, P.C.Mishra.

[6] “Dynamics and vibration analysis of bus body structures”, Asheber Techane, M.Sc. Thesis, Addis Ababa University, Addis Ababa, 2007.

[7] ”Dynamic Stress Analysis of a Bus Systems”, Kim, H. S., Hwang, Y. S., Yoon, H. S, Proceedings of 2nd MSC worldwide automotive conference, MSC, 2000.

[8] “Fatigue Life Analysis of Volvo S80 Bifuel”, M. Fermer, McInally, G., Sandin, G., Proceedings of 1st MSC worldwide automotive conference, MSC, 1999.

[9] “On-Line Diagnostics of Rear Axle Transmission Errors”, V. Milenkovic, S. Shmuter and N. Field.

[10] Design Data Book, V.B. Bhandari

[11] Design of machine elements, V.B. Bhandari

[12] Mechanical engineering design. Shigley JE (1977). McGraw-Hill

[13] Mechanical engineering design. Shigley JE, Mischke C (1989). McGraw-Hill New York.

[14] http://www.forcemotors.com/page/index/company_profile

[15] http://www.testrigs.com/axle-differential-testing.html

[16] http://www.hbm.com/en/menu/applications/torque measurement/application reports/ Siemens