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Caster Wheel Endurance Testing Rig

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Abstract: *This paper presents a rig for testing casters. This machine is used for testing the industrial casters of various sizes. By use of various obstacles on the rotating plate real life situations are created which a caster usually undergoes during its application. The load for testing is applied using a hydraulic system and an innovative idea is worked out by applying the Pascal's Law to it. This eliminated the use of a motor to create pressure in the hydraulic system. Sensors are provided on the machine for the data acquisition and to keep a check on various parameters while the casters are being tested. The design of system is made versatile as this system can be easily adopted to test two casters at a time as well as it can also test the wheels. The overall system is compact in size and flexible to be used for testing variety of casters. This system has the potential to adopt higher level of automation if desired in future. This subject is undertaken as the part of Bachelor of Engineering in Mechanical project and was sponsored by Speciality Urethanes Pvt. Ltd., Satara, Maharashtra, India.*

Keywords: *Caster wheel, endurance, rotating plate, frame.*

I. Introduction

The endurance testing machine for caster and wheels assembly is a wheel testing platform capable of simulating realistic use conditions in order to measure, analyze and verify the performance of industrial casters. The endurance testing machine consists of a rotating element on which the caster is mounted. Load according to standard specification is mounted on the caster. The rotating element is rotated with help of ac motor. The caster is in fixed position and as the rotating element starts rotating, it crosses the obstacles which are used to stimulate real life situations. The caster in this direction for certain period of time then stops for some time and then again starts rotating in opposite direction. This cycle goes on repeating for n number of times till failure is detected in caster by sensors of the machine. Thus the results given by this machine are in tabular and graphical form indicating the life of the caster for different loads and different speeds.

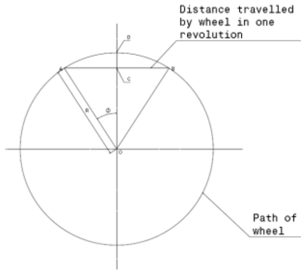
II. Need

A leader in cast polyurethane industry since 1991, Speciality Urethanes Pvt. Ltd (SUPL) is evolved into a name that stands for technological expertise, high quality and reliability. Preferred by major OE manufacturers in India, 'SUPRATHANE' cast polyurethane products cater to every industrial sector. The products of the company are polyurethane wheels, roll coverings, rollers, Stripper bushes for dies and forming pads, abrasion resistant lining. Caster wheel is one of the major products of the company and it needs to be inspected for its endurance limit. This includes the maximum number of cycles it can sustain for specified load at specified speed. This test facility is not available presently at Speciality Urethanes, Satara. As a result this leads to increase in expenditure and time wastage behind the product manufacture.

III. Design And Selection

3.1 Design for rotating plate :-

To find the diameter of the path followed by wheel such that it traces almost straight line.



OA = radius of the path =R
d = diameter of wheel
AB = distance travelled by wheel in one revolution = $\pi \times d$
CD = y
Φ = angle between lines OA and OD

From the above figure we get,

$$R \times \Phi = (\pi \times d)/2$$

$$\therefore \quad \Phi = (\pi \times d)/2R \qquad \ldots\ldots\ldots(1)$$

Now,
CD = OD-OC
We have, OC = $R\cos\Phi$, CD =y, OD = R ....(2)
From equation (1) and (2) we have,
$y = R - R\cos((\pi d)/2R)$

$$\therefore \quad y = R[1 - \cos(\pi d)/2R]$$

To trace a straight line by wheel arc ADB must equal line AB
i.e. y must be equal to zero.

$\therefore \quad y = 0.$
$\therefore \quad 0 = R[1 - \cos(\pi d)/2R]$
$\therefore \quad [1 - \cos(\pi d)/2R] = 0$
$\therefore \quad \cos(\pi d)/2R = 1$

The maximum diameter of the wheel to be tested is of 300 mm.
d = 300mm

$\therefore \quad \cos(\pi \times 300)/2R = 1$

to get this answer approximately we equate,
$(\pi \times 300)/2R = 1$
R = 471.238 mm
Hence, we take the radius of the path of wheel as 500 mm.

3.2 Selection of Motor :-
Maximum speed of wheel,
v = 16 kmph
v = (16 × 1000) / 3600
v = 4.44 m/s
Speed of rotating plate for wheel running at a distance of 500mm radius,
v = r × w
4.44 = 0.5 × w
w = 8.89 rad/sec = 84.88 rpm
Torque required:
T = Torque at the axle bearing of wheels
$T = 2 \times \mu \times m \times g \times R$
μ = coefficient of friction of bearing in axle of wheel
m = 5000 kg
g = 9.81 m/s^2
$R = 40 \times 10^{-3}$
$T = 2 \times 0.057 \times 5000 \times 9.81 \times 40 \times 10^{-3}$
T = 223.66 N-m
Power Required:
P = T × w
P = 223.66 × 8.89
P = 1988.40 W
P = 2.66 HP
A 3 HP motor is selected for this application.

3.3 Selection Of Gearbox:-
Standard motor selected is of 3 HP 1440 rpm.
Required Speed = 85 rpm
Reduction Ratio = 1440/85
= 16.94 = 17
Standard gearbox is of 15:1 reduction ratio
Selected gearbox is of 15:1 reduction ratio for 3HP motor.

3.4 Selection Of Coupling:-
Selection of coupling is done by using equation,
$T = (30000 \times KW)/ (3.14 \times n_{rpm})$
$T = (30000 \times 2.22)/ (3.14 \times 96)$
$T = 222.617$ N-m
Service factor = 1.5
$T = 222.627 \times 1.$
$T = 333.925$ N-m
The coupling selected from catalogue of Utkarsh coupling is Snap Wrap type US 276
Rated Torque = 532 N-m
KW rating at 100 rpm = 5.6 KW
Min. bore = 25 mm
Max. bore = 75 mm
Max. length = 200 mm

IV. Manufacturing

4.1 Fabrication of Frame:-

The frame on which the entire assembly is done is made out of a 150 mm C-Channel. Detailed study showed that the C section channel would provide enough strength for our machine. So by referring to "Westermann Tables" we chose 150 mm - Channel for the frame.

The frame for Motor and gear box is fabricated out of a 65 mm equal angle and 75 mm C-Channel. It proved to be sufficient for the vibrations generated due to motor and gearbox. After procurement of the material it was cut according to the required length. Then each cut part was checked for the bents and if present it was removed. Then the ends of each part were properly grinded for matching the interlocking joints and removing the burr.Then the individual parts were arranged close to each other as per the design and were tac welded after checking with the tube level and set square. Each and every part was tac welded after thorough checking for its tube level. Thus entire frame was initially just tac welded. After a pilot assembly trial of entire machine the frame was then fully welded.

4.2 Rotating plate :-

The material of the rotating plate is mild steel. The plate was ordered and was cut by gas cutting to 1210 mm diameter. Then the plate was machined to 1200 mm diameter and 35 mm thickness on lathe machine. A 100 mm diameter hole at centre was bored on lathe. 8 holes of M20 were drilled on the plate at P.C.D. of 150mm for fastening of hub at the centre.

4.3 Drive Shaft, Hanger Bars, Guide Bars:-

Drive shaft material is EN8 Steel of diameter 50mm. Turning of this shaft is done on lathe machine. Keyways of dimension 14×9 mm is slotted on shaft at two sides exactly opposite to each other. The drive shaft is case hardened. Hanger bars are made from mild steel of diameter 25 mm and length 630mm. These are turned on lathe machine, also tapping of M16 is done on both sides of the shafts Guide bars are designated as SFC 35, and the dimensions are- length 600mm and diameter 35 mm. Guide bars are chrome plated on the surface. Due to this it felicitates easy sliding motion of the connector plate with least amount of friction. The end faces of Guide bars are also drilled and tapped with M18 hole.

V. Assembly

- In the beginning the base C-channel frame was tac welded and the roller support plates were tac welded to it.

- Then the support casters were bolted on the frame.

- After bolting the support casters the bearing was mounted in bearing housing. Firstly the inner race of the bearing was mounted on the shaft and the outer race was press fitted in the bearing housing on press machine and then shaft along with inner race on it was mounted in bearing housing. Then the stool was bolted on the C-channel base frame at centre and the bearing housing was mounted on it.

- Then the hub was fitted in the centre bore of the rotating plate and then the entire assembly was mounted on the shaft. The rotating plate was supported on the four support casters. Then the plate was rotated with hand to check its concentricity and level.

- The entire assembly was disassembled and the base channel frame was given for further fabrication of upper part. After further fabrication of the frame was completed the frame was given for shot blasting and then it was painted with red oxide.

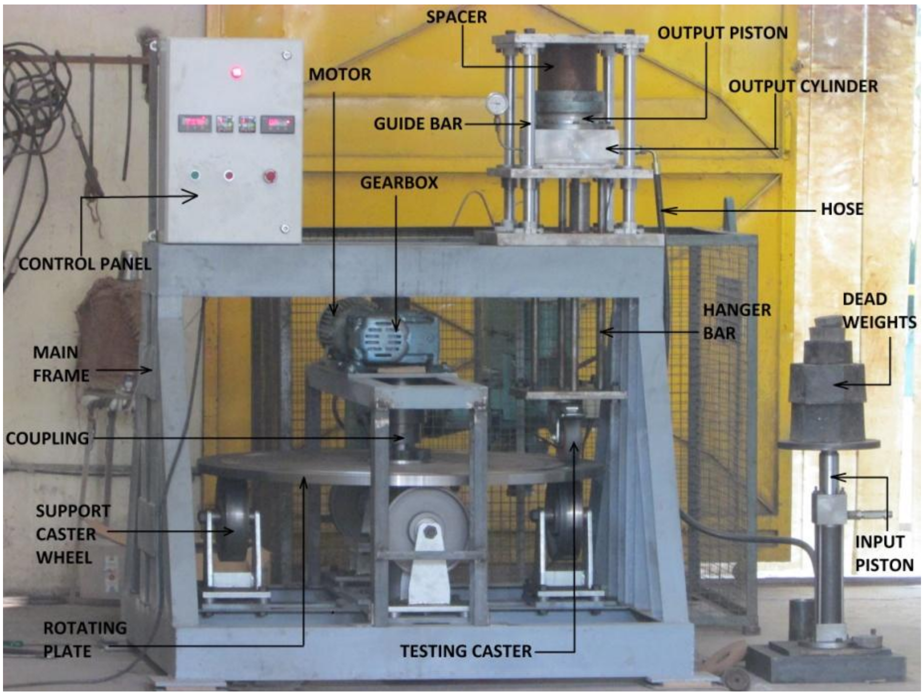
- The support casters, shaft, stool, bearing housing and rotating plate was again assembled and the angle frame for gearbox and motor was bolted on the main base frame. The gear box motor was then bolted on the angle frame and drive was given to rotating plate through gearbox.

- Then the guide bars were bolted on the main frame on its mounting plate.
- The linear bearings were initially slide fitted in the connector plate and the guide bar supporting brackets were bolted on the hydraulic cylinder plate and the guides mount plate. Then these three plates were assembled in the guide bars. The hydraulic system was then bolted to hydraulic cylinder plate and the entire assembly was completed.

VI. Cost Analysis

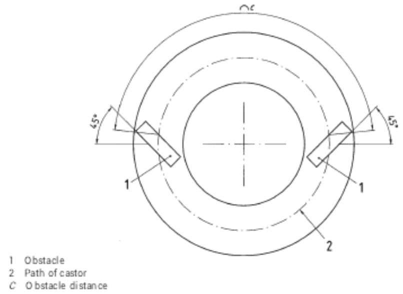
- Cost of bought parts = 2,14,281/- INR
- Cost of manufactured parts = 1,04,754/- INR
- Total cost = 3,19,035 /- INR

VII. Experimental Setup



Apparatus :-
The test apparatus is:

- a machine which has a circular track in a horizontal position (see figure below) with a smooth steel surface and shall be able to run the sample at speeds and loads as required. Rectangular metal obstacles shall be placed on the track at 45^{O} to the running direction, alternately to the right and left of it. The obstacles are 100 mm wide and featuring rounded edges with radius of 1/3 of its height. The obstacles shall be positioned as shown.



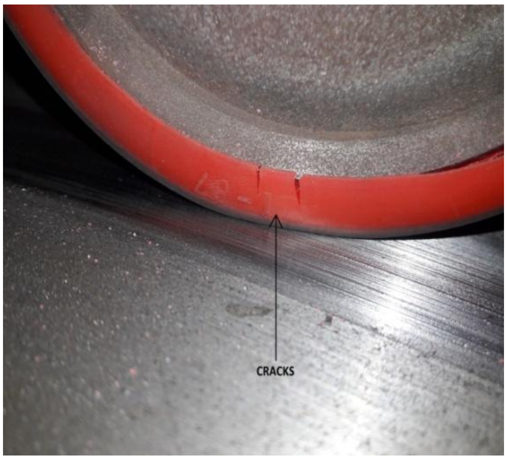
- a time measuring instrument.
- a non contact type temperature measuring sensor.

VIII. Testing And Result

- Wheel diameter = 150 mm
- Wheel width = 50 mm
- Core material = Cast Iron
- Tread Material = Polyurethane
- Wheel Bracket Type = Swivel
- Load Applied = 800 Kg
- Wheel Speed = 5 km/h
- Speed of Rotating Plate = 27 rpm

Type of Test:- Intermittent Running Test
Running time for each interval = 25 min
Rest time = 5 minutes
Number of intervals = 26
Total Running Time = 650 min = 10 hrs 50 min
Total Number of Revolutions = 17,550
Frequency of Obstacles = 1 obstacle/1.57 m of track
Total Distance Travelled = 55,107 m = 55.1 km
Average Temperatures:
At core: 70^o C
At tread: 55^o C
Failure Mode :- Wearing of tread material
Failure Cause :- Due to the obstacles on the track and heating of core and tread there was wearing of the PU material.
Result :-

1. The life of the caster was 55.1 km, for a speed of 5 km/hr , under load of 800 kg.
2. The temperature at failure point was:-
   Core temperature :- 70^0C
   Tread temperature :- 55^0C



IX. Conclusion

In completing our project titled 'Caster Wheels Endurance Testing Machine' as per given time estimate gives us immense pleasure and a feeling of achievement. In this report the design and manufacturing of this machine is presented. The key features of the machine are that various casters ranging from diameter 50 mm to 300 mm can be tested here at various loads and speeds.

During the course of project numerous problems were encountered which were overcame with the able guidance of the project guide. Practical knowledge was inculcated during various operations incurred during the course of completion of the project. Finally it is concluded that by using this machine it is possible to achieve the life time of the caster which will help to increase the life by making certain changes in its constructional features of caster.

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