Modified Parkinson's Gear Tester

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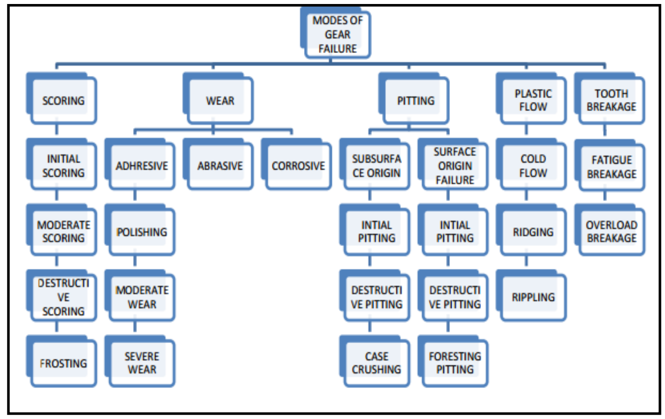
Abstract-*In gear test rig all the gears will be mounted on a plate which may be fixed or stationary as per the requirement of the measurement. In order to check the combined tooth error different types of gear testing machines are used. Various machines have its ability to check specified parameters only. Highly precise machine required special installation and space. For the purpose of checking gear in machine shop while performing machine required such an arrangement which is robust and quick one. This purpose can be solved using gear test rig. This test rig can be used in shop floor as it requires less space and operator can use it as per need without wasting much time. The test rig can be developed for different parameter as per measurement requirement. There are various test rigs which can be used for that particular designed condition.*

Keywords-spur gear, Parkinson's gear test rig., master gear

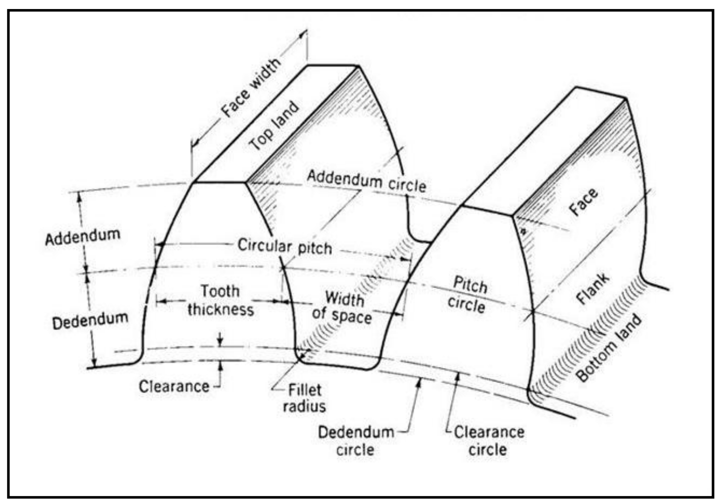
I. INTRODUCTION

Today world requires speed on each and every field. Hence rapidness and quick working is the most important. Now a day for achieving rapidness, man manufactures various machines and equipments. The engineer being constantly conformed to the challenges of bringing ideas and new design in to reality. New machines, equipments and the techniques are being developed continuously to manufacture various products at cheaper rates and high quality. Design & Development of Parkinson gear tester for spur gear to check the Flank Surface being compact and portable equipment, which is skilful and is having something precise in testing the gears being manufactured.

In order to check the combined tooth error different types of gear testing machines are used. Various machines have its ability to check specified parameters only. Highly precise machine required special installation and space. For the purpose of checking gear in machine shop while performing machine required such an arrangement which is robust and quick one. This purpose can be solved using gear test rig. This type of gear test rig can be used for mass production of gears of a particular gear box. Gear test rig is such arrangement which simplifies the measurement and saves the labour time and labour cost with greater accuracy. In gear test rig all the gears will be mounted on a plate which may be fixed or stationary as per the requirement of the measurement. While measuring the one gear remaining will act as a master gear. This will help in finding the composite error. This test rig can be used in shop floor as it requires less space and operator can use it as per need without wasting much time. Various modes of gear failure are given as follows,



II.GEAR TERMINOLOGY AND ERRORS IN GEAR



Errors In Gear

1)Profile error
Maximum distance of any point on tooth profile form to the design profile

2) Pitch error
Difference between actual and design pitch

3) Cyclic error
Error occur in each revolution of gear

4)Run out

Total range of reading of fixed indicator with contact point applied to surface rotated, without axial movement, about fixed axis.

5) Eccentricity

Halt the radial run out

6) Wobble

Run out measured parallel to axis of rotation at a specified distance from axis

7) Radial run out

Run out measured perpendicular to axis of rotation

8) Undulation

Periodical departure of actual tooth surface from design surface

9) Axial run out

Run out measured parallel to the axis of rotation at a speed

10) Periodic error

Errors occurring at regular intervals

Need Of Inspection

- In old days the production was on a small scale, different component parts were made and assembled by the same craftsman. If the parts did not fit properly at the time of assembly, he used to make the necessary adjustments in either of the mating parts so that each assembly functioned properly.

- Therefore, it was not necessary to make similar parts exactly alike or with same accuracy as there was no need of inspection.

- Due to technological development new production techniques have been developed. The products are being manufactured on a large scale due to low cost methods of mass production. So, hand fit method cannot serve the purpose any more. The modern industrial mass production system is based on interchangeable manufacture, when the articles are to be produced on a large scale.

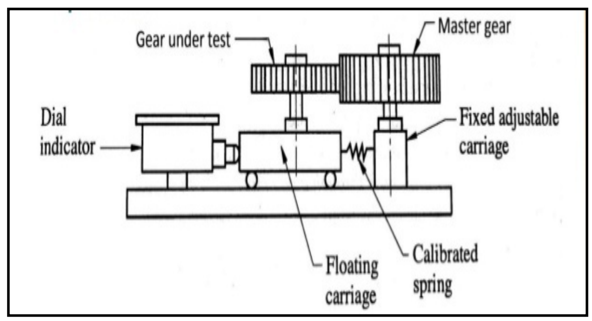
- In mass production the production of complete article is broken up into various component parts. Thus the production of each component part becomes an independent process. The different component parts are made in large quantities in different shops. Some parts are purchased from other factories also and then assembled together at one place. Therefore, it becomes essential that any part chosen at random should fit properly with any other mating parts that too selected at random. This is possible only when the dimensions of the component parts are made with close dimensional tolerances. This is only possible when the parts are inspected at various stages during manufacturing.

III. PROBLEM STATEMENT

In conventional gear test rig there is scope for checking the composite error of any one kind of gear so that for checking different type of gears in manufacturing process it required to have different test rigs, also accuracy of checking composite error must have to increase. This problem gives out a way to develop modified gear test rig in form of parkinson's gear tester.

Development of test rig

In development of test rig manual operating is used to rotate the master gear against the gear to be tested. The gear to be tested is installed on the trolley gear shaft. The trolley being spring loaded is in continuous close contact with the master gear. The master gear shaft is extended and is coupled with the bevel gear assembly which is manually operated by handle. When the pair of master gear and the gear to be tested is rotating and if there is any mis-run of the gear to be tested then the same deflection is shown thus the operation of gear testing machine is done.



Its special features are:

- It applies the accuracy up to 1 micron.
- It is light in weight and hence it is portable.
- Weight of machine is 10 kg. (approx.)
- It requires very low maintenance.
- Its setting time is less.
- It requires very low floor space area.
- Its manufacturing cost is also very low.
- It is compact. Total length of machine is400mm.

Advantages

1. Equipment suitable for mass production for inspection of gear.
2. Quick results can be obtained.
3. Permanent records can be obtained on charts, and on analysis any modifications in existing manufacturing setup can be made if required any.
4. Results in the form of profiles are obtained so errors can be identified without actual measurement.

5. Generally 100 mm max diameter of gear can be measured as per our setup.
6. There is low friction in movement of floating carriage and a high sensitivity of sensing unit is important.
7. The accuracy is of the order of ± 1 micron
8. Rolling test does not reveal all errors since the device is sensitive to cumulative position errors.
9. Errors are not clearly identified for type profile, pitch, and helix, tooth thickness, indistinguishably mixed.
10. Measurements are directly dependent on master gear.

Applications

- Used to check as well measure the errors in tooth form.
- Detect error in pitch.
- Detect errors in concentricity of pitch line.
- Detect the Total Composite Error: Double Flank.
- Composite errors can be checked by measuring the variations of centre distance when gear under test is rolled under spring pressure against a master gear.

Material Selection

Metrology is a science of measurement, for every kind of quantity measured, there must be a unit to measure it. This will enable the quantity to be measured in number of that unit. Further, in order that this unit is followed by all; there must be a universal standard and the various units for various parameters of importance must be standardized. It is also necessary to see whether the result is given with sufficient correctness and accuracy for a particular need or not. This will depend on the method of measurement, measuring devices used etc. Thus, in a broader sense metrology is not limited to length and angle measurement but also concerned with numerous problems theoretical as well as practical related with measurement.

Material for manufacturing of test rig. to be selected based on following factors

- Availability and cost of material
- Strength and rigidity
- Resistance to fatigue
- Impact resistance
- Hardness
- Weight
- Mach inability and weld ability
- Corrosion resistance

Sr.no.	Name of the component	Specification	Material	Quantity
1.	Base Frame	400mm x 200 x 5mm	M.S.	01
2.	Frame as slider	150mm x 100mm x 5mm	M.S	01
3.	Work table	400mmx200mm	M.S.	01
4.	Supporting Strips	25mmx12mmx 5mm	M.S.	04
5.	Master gear with shaft	25Φ x 100 mm long	STD	01
6.	Inspection gear with shaft	25Φ x 50 mm long	M.S./Al	01
7.	Bearing		STD	
	a) Housing bearing		--	02
	b) Bearings for slider		--	04
	c) Pedestal bearing		--	01
8.	Support spring	Wire dia 0.6mm 65 mm length	STD	02
9.	Wheel shaft	25Φ x 300 mm long	M.S.	01
10	Wheel bearing	SKF 6205	STD	
11	Sliding rods	10Φ x 120mm long	M.S.	02
12	Dial indicator	--	STD	01
13	Bevel gear pair		STD	01
14	Handle	300 mm x 50mm x 5mm	M.S.	01

Selection & Design Of Components

A) Design of Base Frame

Due to the load of machine structure, load of trolley & balancing load, the mild steel angle may buckle in two planes at right angle to each other. For buckling in the vertical plane (i.e.in the plane of the angles), the angles are considered as hinged at the middles and for buckling in a plane perpendicular to the vertical plane, it is considered as fixed at the middle and the both the ends.

Here, The maximum load due to above factors = 40kg (including friction) F= 40kg = 40 x 9.81 = 393 N.
We know that the load on each angle, F1 = 393/4 = 99 N.
Wcr = 99 N Let, t_1= Thickness of the angle and b_1= width of the angle So, cross sectional area of the angle = A = t_1x b_1
Assuming the width of the angle is three times the thickness of the angle, i.e.b_1= 3 x t1, Therefore A= t_1x 3 t_1 = 3 t_1^2
And moment of inertia of the cross section of the angle,
I = 1/12 $t_1 b_1^3$ = 2.25 t_1^4
We know that I = AK^2, where k = radius of gyration.
K^2 = I/A = 2.25 t_1^4 / 3 t_1^2 = 0.75 t_1^2
Since for the buckling of the angle in the vertical plane, the ends are considered as hinged, therefore, the equivalent length of the angle L = l = 300 mm. And Rankin's constant, a = 1/ 7500 = 1* 10^{-4} Now using the relation,

$$Wcr = \frac{F*A}{1 + a\,(L/K)^2} \quad , \quad \text{Here } f = 0.47 \text{ N / mm}^2$$

$$99 = \frac{0.47 \times 3 \times t_1^2}{\left(1 + 1 * 10^{-4} 300^2 / 0.75 t_1^2\right)}$$

$$99 = \frac{1.41\, t_1^2}{1 + 12 / t_1^2}$$

$1.41t_1^4 – 99t_1^2 –1188 = 0$
t_1 = 8.3 mm
b_1 = 3 x t_1 = 3 x 8.3 = 24.9 mm.
But the standard angle available of 25 x 25 x 8 hence for safer side we have selected it. Which can bear the impact loading. Hence our design is safe.

B) Design Of Welded Joint:-

Checking the strength of the welded joints for safety

The transverse fillet weld welds all the angle and the edge, the maximum load which the weld can carry for transverse fillet weld is P = 0.707 x S x L x fs, Where, S = size of weld, (5 mm for starting &Stopping of weld) L = contact length = 30mm. The load along with the friction is 40 kg = 393 N
Hence, 393 = 0.707 x 5 x 30 x fs, Hence let us find the safe value of 'fs'

$$\text{Therefore fs} = \frac{393}{0.707 \times 5 \times 30} = \text{fs} = 3.70 \text{ N/mm}^2$$

Since the calculated value of the shear load is very smaller than the permissible value as fs=56 N/mm^2. Hence welded joint is safe.

C) Design Of ShaftInCombined Bending And Torsion

Following stresses are normally adopted in shaft design

Max^m tensile stress = 143 N/mm^2, Max^m bending stress = 143 N/mm^2 , Max^m shear stress = 65 N/mm^2 , Shaft design on basic of study. We know torque on shaft = 90000 N-mm
Calculation of Maximum Bending moment. Mmax = force x distance = 202 x 230 =465000 N – mm. Equivalent Bending moment on shaft.Me = ½ x [M +$(M^2 + T^2)^{1/2}$].Me = ½ x [46500+$(46500^2 + 90000^2)^{1/2}$ = 220600 N-mm
This bending moment is act on master gear shaft,
Me = 220600N-mm
Considering bending failure of shaft Me = 3.14 / 32 x fb d^3
220600= 3.14 / 32 x 143x d^3 , d = 25.05 mm
Equivalent twisting moment on the shaft
$Te^2 = (M2 + T^2) = (46500^2 + 90000^2)^{½}$ = 101302 N-mm
Now using the relation Te / J = Fs / r, Te = 3.14 / 16x fs x d^3
101302 = 3.14 / 16x 65 x d^3 therefore d = 19.95 mm
Taking maximum value from above two value i.e25 mm dia of shaft.

D) Design Of Support Spring

This spring is use to support the overhang magnification linkage arrangement. The spring is subjected to tensile load; so spring is design for tensile failure. We select general purpose spring and check it in applied load condition.

Spring required to with stand the pull of 0.5 kgf (max) = radial thrust.
G = 0.84 x 10^6 kg / cm².
Number of springs = 2
Fs = 4200 kg / cm² for spring steel.
To find the diameter of spring wire,
Torque = T = w x D/2 = 0.5 x 1.1 / 2 = 0.5 x 0.55 = 0.275 kg– cm.
Torque = 0.275 = (3.14 / 16) x 4200 x d³ hence d³ = 0.275 x 16 / (3.14 x 4200) , d = $\sqrt[3]{0.00033}$, d = 0.06 cm., d = 0.6 mm
Hence we have taken the spring wire of diameter as 0.6 mm. The length of spring is taken as per requirement, which is taken as 65 mm.

E) Selection Of Bearing

Radial load on shaft (Fr) = 300 N
Equivalent dynamic load
Pe = Fr*Ka= 300*1.5 = 450 N
Using load life relationship Assume life of Bearing
Lh10 = 10,000hrs, L10 = Lh10*60*n/106
L10 =10,000*60*420/106
L10 = 39752 million revolution, **L10 = $(C/Pe)^{10/3}$**,

$C = (39752)^{0.3} * 450$, C = 10.79 KN

By selecting Bearing number **6205** from manufacturer catalogue.

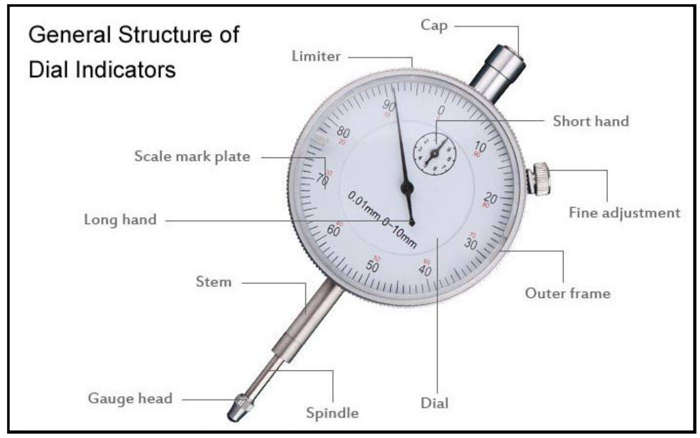
bearing number	d mm	d1 mm	d mm	d2 mm	b mm	r mm	r1 mm	static capacity kgf	dynamic capacity kgf
6205	25	31	52	46	15	1.5	1	710	1100

F) Selection Of Master Gear

- According to design of shat the master gear is selected having following data which suitable to shaft design.
- Material of master gear is 40C8 i.e. plain carbon steel.
- Ultimate tensile strength, S_{ut} = 420 N/mm2
- Standard module, m = 5
- Outer diameter of master gear, do = 100
- Number of teeth on gear, Z_g = 20
- Face width, b = 10m = 50 mm
- Factor of safety = 3
- Tooth system is 20° full depth involute
- Addendum, h_a = 1m = 5 mm
- Dedendum, h_f = 1.25m = 6.25 mm
- Circular pitch, P_c = 15.7 mm

G) Dial Indicator

Indicators may be used to check the variation in tolerance during the inspection process of a machined part, measure the deflection of a beam or ring under laboratory conditions, as well as many other situations where a small measurement needs to be registered or indicated. Dial indicators typically measure ranges from 0.25mm to 300mm (0.015in to 12.0in), with graduations of 0.001mm to 0.01mm (metric) or 0.00005in to 0.001in (imperial/customary). Various names are used for indicators of different types and purposes, including dial gauge, clock, probe indicator ,pointer, test indicator, dial test indicator, drop indicator, plunger indicator, and others.



Modified Parkinson's Gear Test Rig

IV. CONCLUSION

- This project brought together several components and ideas to achieve a common goal viz. person can check the composite error with higher accuracy.
- As springs and slider table provide with roller it will provide flexibility of checking composite errors of different types of gear.
- Ultimately it overcomes the limitation of test rig for checking only spur gears.
- It provides flexibility of checking gears having maximum outer diameter upto 150mm.
- Reduces time for checking composite error, initial cost and maintenance cost of test rig.
- It is very useful in mass production of any types of gear.

FUTURE SCOPE

- In above test rig one can use stepped shaft of different diameters at different distances so that there is scope to check different types of gears along with different internal diameters and different outer diameters too.
- By using stepped shaft there is possibility to check two or more different types of gear simultaneously by providing more number of master gears on same test rig.
- Instead of using handle electric motor with slow speed will also use as prime mover.

NOMENCLATURE

	Description	symbol	unit
1.	Critical load on each angle	Wcr	N
2.	Load	F	N
3.	Diameter	d	mm
4.	Moment of inertia	I	mm^4
5.	Radius of gyration	k	mm^2
6.	Rankin's constant	a	--
7.	Length of angle/ length of weld	L	mm
8.	size of weld	S	mm
9.	Max^m tensile strength	Sut	N/mm^2
10.	Max^m yield strength	Syt	N/mm^2
11.	Maximum bending moment	M_e	N-mm
12.	Equivalent twisting moment on the shaft	Te	N-mm
13.	width of the angle	b1	mm
14.	Thickness of the angle	t1	mm

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