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Design and Development of Gear Roll Tester

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Abstract: **Gear roll testers are used to measure and analyse functional performance of gears. Gear testing is a technique that has been used in the gear industry to identify potential manufacturing defects in the design intent of the gear. It is a practical, fast and effective screening tool that can identify when the gear manufacturing process has deviated from an ideal condition that could result in a change in backlash, or an unwanted noise and vibrations in a gear mesh therefore, in the present work it was decided to develop a gear roll tester to analyse effects of different types of defects in gear on its functional performance in terms of run out, pitch errors, backlash, profile errors, noise and vibration. For the present work a spur was selected with the specifications matching with the gear used in automobiles. A test rig was designed and developed for the functional testing of spur gears. Various components were designed and selected according to the standard design procedure. The test rig was fabricated with very high accuracy. Gears with different types of defects were tested on the test rig to ensure the accuracy of it. This test rig is an important tool to the gear manufacturer to test the gears for their functional performance. The test rig can be used further to analyse noise and vibrations along with a Fast Fourier Transform (FFT) analyser.**

Keywords: **gear, noise, vibration, error, conjugate**

1. INTRODUCTION

Gears are machine elements that transmit rotary motion and power by the successive engagements of teeth on their periphery. They constitute an economical method for such transmission, particularly if power levels or accuracy requirements are high. Gears have been in use for more than three thousand years and they are an important element in all manner of machinery used in current times.

In this paper we have performed experiments on gear roll tester and measured various errors in the spur gear.

Double-flank testing is a technique that has been used in the gear industry to identify potential manufacturing defects in the design intent of the gear. It is a practical, fast and effective screening tool that can identify when the gear manufacturing process has deviated from an ideal condition that could result in a change in backlash, or an unwanted noise in a gear mesh. Double-flank composite inspection (DFCI) is a valuable technique that can functionally provide quality control results of test gears quickly and easily during manufacturing. However, the successful use of DFCI requires careful planning from product design, through master gear design and gage control methods in order to achieve the desired result in an application. This document explains the practical considerations in the use of double flank testing for the manufacturing control of spur, helical and crossed-axis helical gearing.

2. LITERATURE REVIEW

The double flank gear roll inspection machine is specially designed for small high-precision gears. It is also suitable for plastic gears. The measuring force can be lowered to 0 N. The sophisticated design is extraordinarily precise and sensitive. The measuring carriage is supported free from backlash on four leaf springs. This so-called parallelogram

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suspension is very sensitive and registers even the smallest change in centre distance. This machine can be driven manually or by motor. The centre distance can be adjusted manually via an adjustable adapter disc.

The measurement results are displayed on a dial indicator. There are many types of Gear tester available in the market. The salient features of the available gear testers are as follows:

2.1 Gear Roll Tester:

Capacity:

Max Gear Dia - 350 mm

Integrated Shaft Gear Length-100 to 500 mm

Master & Component Gear Mandrels Center Distance-70 to 260 mm

Features:

For bore & integrated shaft type Spur, Helical & Involute Gears

`ZERO BACKLASH-DOUBLE FLANK CONTACT' test principle (Meshing Force-1 Kg)

Constructed with graded seasoned CI Casting

Mechanical Dial Indicator (Capacity 10 mm, LC 0.010 mm)

Hand operated or motor operated

Accessories:

Variable speed Electrical Drive with mounting Table having single-revolution auto stop

Sliding Bracket to accommodate extra long integrated shaft Gears (Length 100-650 mm)

Mandrel Assembly to mount bore type Gears

Ball Attachment with Ball Holder

3. OBJECTIVE OF THE PRESENT WORK

Design and Development of Gear Roll Tester, to measure

- ❖ Runout
- ❖ Backlash
- ❖ Vibration

4. CONSTRUCTION

Master Gear Design Considerations

Master gears used in double-flank composite measurements must meet the following criteria in order to mesh properly with a test gear.

• The tip of the master gear must not contact the test gear below the form diameter of the test gear. This applies to initial contact and to any type of secondary contact in the fillet zone due to inadequate clearance.

• The tip of the test gear must not contact the master gear below the form diameter of the master gear. This applies to initial contact and to any type of secondary contact in the fillet zone due to inadequate clearance.

• The minimum contact ratio of the double-flank test must not be less than 1.0 when accounting for maximum tooth thickness, minimum outside diameter, maximum root diameter and maximum tip radius of the test gear. Should the contact ratio drop below 1.0, the meshing action of the gears on test will generate an immediate jump in the double-flank result for every tooth meshing cycle. This happens when the spring of the slide on the composite tester compensates for the loss of mesh force by abruptly pushing the gears together.

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5. WORKING OF GEAR ROLL TESTER

A master gear of known precision is mounted on a fixed base with only rotational freedom. The test gear is mounted on a floating slide mechanism that allows rotation of the test gear and movement along an axis between the line of centres of the master and test gear. A spring (with a preset force) pushes the floating slide, resulting in zero-backlash, double-flank contact (i.e., on both left and right flanks) on both the test gear and the master gear. As the master gear is rotated (by hand or by motor), the test gear follows.

Involute theory dictates that perfectly formed teeth will prevent any movement of the floating slide between the line-of-centres. However, since no gear can be manufactured in absolutely perfect condition, there will always be some movement of the floating slide as the gears rotate. The magnitude of this movement is measured with either a mechanical indicator or electronic detector that contacts the slide mechanism. If the measuring instrument is calibrated to an actual distance reading between the centres of the gears, then an actual tight mesh center distance result can be obtained.

In order to maintain accuracy in the measurement, intimate double-flank contact must be maintained at all times. Therefore the selection of the pre-set spring force and the speed-of-rotation of the gears should be given careful consideration to limit measurement errors. The pre-set force may need to be selected specifically for the test gear's design, taking into account the material's ability to resist deformation under load (i.e., plastic gears), where a large pre-set force may distort the gear into conformity. In addition, if there is excessive resistance coming from the mounting of either the master gear on its mandrel, or, more commonly, of the test gear on its mandrel, then a low, pre-set spring force will result in separation of the two gears out of double-flank contact, creating an error in the measured values. The correct pre-set spring force is the minimum force needed to maintain continuous, double flank contact without distorting the test gear.

6. EXPERIMENTAL SETUP AND PROCEDURE

1. Mount the test gear 1 on driven shaft.
2. Ensure proper meshing of test gear with master gear.
3. Mount the dial gauge with magnetic block. Ensure the probe is in contact with guide way strip.
4. Rotate the gear manually with the handle provided.
5. Observe the deflection on the dial gauge and note down the readings.
6. Supply the lubricant between the gears.
7. Carry out the same procedure and note down the readings.
8. Unmount the test gear 1 and mount test gear 2 and repeat the procedure from pt 1 to pt 7.

7. RESULT

Results obtained for a deflection test on developed gear tester.

Table no 2- Test Gear 1

Without Lubrication (mm)		With Lubrication (mm)	
-0.3 to 0.5	0.4	-0.01 to 0.55	0.28
-0.2 to 0.55	0.285	-0.03 to 0.58	0.305
-0.01 to 0.45	0.23	-0.02 to 0.5	0.26

Table no 1- Test Gear 2

Without Lubrication (mm)		With Lubrication (mm)	
-0.4 to 0.6	0.5	-0.02 to 0.45	0.235
-0.1 to 0.65	0.375	-0.03 to 0.55	0.29
-0.01 to 0.50	0.25	-0.04 to 0.52	0.28

Hence it is clear that this developed setup can be used to measure deflection of gears.

In case of wet condition it leads to smooth meshing of gear which leads to less deflection.

While in case of dry condition friction is more which gives more deflection.

8. CONCLUSIONS

1. We can also conclude than cast iron structure is superior than welded structure in damping the vibration.
2. In gear tester spring stiffness plays an important role. If stiffness is more there won't be any deflection i.e. zero deflection, and run out or form error cannot be detected. Whereas if stiffness is very less the gears may prove apart to a distance that disengages them and upon re-engagement the gears may not mesh correctly and impact of one tooth on other which may lead to tooth breakage.
3. In case of wet condition it leads to smooth meshing of gear which leads to less deflection, less noise, less vibration. While in case of dry condition friction is more which gives more deflection and more noise and vibration.
4. Surface finish of guide rails plays an important role in detection of deflection and form error. Smooth surface leads to proper sliding which gives accurate results with minor error.
5. Vibration isolators can also be used for further damping of vibration.

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