to get a stable and reliable hardness value because the former has a very good surface flatness and high hardness. Then, the effect of anvil will be constant for a long time.

For tin-plates, the problems concerning the thickness of tin-layer, combinations of plating materials and mother sheet materials and their hardnesses are left to be studied. This is suggested by the fact that our data for the tin-plates turned out somewhat different from those of Wondris et al⁽⁹⁾.

We must thank Mr. H. Yoda of Tokyo University for the earnest efforts given throughout our investigation.

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On an Apparatus Eliminating the Eccentric Effects for Measuring Cylindrical Part Roundness by Radius Method*

By Kōyū MIYAZAKI**

There are two cases for measuring the roundness of a cylindrical work ; one, that of a work with two center-holes on its sides and the other, that of one without a center-hole.

For the latter case, the author previously published both the theory and the experimental results of the method based on the superposed chain rule, and made it clear that a precise test of roundness can easily be performed by the above method.

Now, for the former case, we are hitherto obliged to do a considerable amount of labour for calculation to eliminate the eccentric terms caused by two center-holes, and so this case is apt to be avoided.

In the present paper, in order to get rid of such inconvenience, the author proposes a new electronic method, and makes it clear that the eccentric effects of two center-holes can be simply eliminated and a precise test of roundness can easily be performed by this method.

1. Introduction

There are two cases for measuring the roundness of a cylindrical work ; one, that of a work with two center-holes on its sides and the other, that of one without a center-hole.

At first, for the latter case, it is well known that the roundness of a cylindrical work has been tested by applying the so-called three-point method. But the above method has several defects, and to get rid of these defects, the author previously published the

new electronic method⁽¹⁾ based on the superposed chain rule, and made it clear that by applying the above new method all these defects can be eliminated, and a precise test of roundness can easily be performed.

Secondly, for the former case, the so-called radius method has been generally employed : A cylindrical work to be measured is supported by two center-holes on its sides and is rotated about the assumed centers and the roundness of the work is tested by reading the deflection of an indicator being placed in contact with the circumference of the work.

The roundness thus obtained is theoretically correct if the eccentric effects may be eliminated,

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** Professor, Faculty of Engineering, Gumma University, Kiryu.

of the pin 9 fixed on the carrier 6, the carrier 4 is rotated, and with it the work 1 is rotated. In this case, as the number of teeth of gear 7 is equal to the one of the gear 8, both the disk 5 and the work 1 rotate in the same phase.

On the other hand, as the stylus 10, one end of the spindle of the dial-gauge 11, is in contact with the circumference of the work 1, and the other end of the spindle is fixed to the iron-core of the differ-

Fig. 1 Reading of the value of y

Fig. 2 The apparatus for recording the value of y

Fig. 3 Graph of y obtained by employing the apparatus shown in Fig. 2

ential transformer 12, the output voltage of 12 is proportional to y , and this output voltage is added to the pen-writing galvanometer 13 through the D. C. amplifier.

Thus, by rotating the disk 5, the graph of y is recorded on the circular recording-paper put on the disk 5 by the pen-writing galvanometer 13. Fig. 3 shows a graph of y obtained in the above manner.

4. Apparatus for eliminating the eccentric effects

The apparatus for eliminating the eccentric effects is shown in both Fig. 4 and Fig. 5.

Now, at first, by putting a tracing-paper over the recording-paper mentioned above, and smearing outside (or inside) of the graph with black ink thickly,

Fig. 4 A view of the apparatus for eliminating the eccentric effects

Fig. 5 The sectional plan of the apparatus shown in Fig. 4

the original of y is made as shown in Fig. 6.

Next, this original is pasted on the upper surface 2 of the light-receiving pot 1 shown in Fig. 5. On the other hand, the photo-cell 3 is set at the bottom of the pot 1, and the surface of the photo-cell 3 is exposed to the light through the original coming from the light-projecting turntable 5 which is rested on the pot 1 through the medium of the steel-balls 4. The turntable 5 has a circular fluorescent lamp, and two transparent glass plates are set below this lamp, and the screen-paper 8, whose shade is different in the circular direction as shown in Fig. 7, is inserted between the above two glass plates.

Thus, the intensity of the light passing through the screen-paper 8 is different in the circular direction, and is proportional to the values of coefficients given in Table 2 in the same direction.

Accordingly, when the turntable 5 is at rest, the intensity of light reaching the surface of the photo-cell 3 after passing through both the screen-paper 8 and the original is proportional to the total sum of products multiplied y at each position by each coeffi-

cient corresponding to the above each position given in Table 2.

The photo-electric voltage thus produced in the photo-cell 3 corresponds to ϵ given by the expression (5), and so, when the turntable 5 is rotated, a similar voltage corresponding to ϵ at each position is obtained without intermission.

Now, these photo-electric voltages are added to the pen-writing galvanometer 9 through the D. C. amplifier, and the graph of ϵ is recorded on the recording-paper put on the disk 10.

5. Experimental results

As a test-work, a roller of a roller-bearing, 25 mm dia. was chosen. Fig. 3 shows the graph of y in this case, and Fig. 6, the original of y .

The roundness obtained from the above original by employing the apparatus illustrated in Fig. 4 is

Fig. 6 Original of y

Fig. 8 Graph of roundness obtained by employing the apparatus shown in Fig. 4

Fig. 7 The screen-paper

Fig. 9 Graph of roundness compared with the one obtained by the numerical method

shown in Fig. 8. It is clear that the eccentric effects are eliminated in Fig. 8 compared with Fig. 3.

On the other hand, the graph comparing the above roundness with the one obtained by the numerical method is shown in Fig. 9. It is clear that both results agree well with each other on the whole.

6. Conclusion

From the above, the following conclusions are made :

(1) In the measurement of the roundness of a cylindrical work by the radius method, the eccentric terms are easily eliminated by using this new appa-

ratus.

(2) It may be considered that this new method is a practically applicable one for measuring precise roundness of a cylindrical work with two centre-holes.

The author hereby expresses his sincere thanks to Dr. O. Taniguchi, Professor of the Tokyo Institute of Technology, and thanks Miss K. Matsui, the cooperator of the above experiments.

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The Lubrication of Bevel Gears*

By Taku UENO**

In bevel gears, the behaviours of the oil in the gear box differ from those in spur gears, presenting conditions worse than the latter. In this paper, the mechanisms of the oil being supplied to the tooth surface and of the oil film formation between the teeth surfaces of pinion and gear are investigated. And it was made clear that jet lubrication is superior to bath lubrication in various points.

1. Introduction

What is important about the lubrication of gears is that the oil should be carried fully to the meshing part to make it form thick films between the mating teeth surfaces and to take off the heat generated by gearing, and on the other hand the churning loss should be little. In bevel gears, the behaviours of the oil in the gear box differ from those in spur gears, seemingly showing the condition worse than the latter.

The object of the present study is in making clear how the lubricant is supplied to the meshing part in bevel gears and how much is its quantity, and also in studying the effects of oiling methods and the operating variables of gears upon the oil film formation between the contact tooth surfaces.

2. Test equipment

2.1 The testing machine The experiments are performed using the power circulating bevel gear testing machine designed and manufactured at Kyushu

University (Fig. 1).

The machine is driven by an 8-hp DC motor, and its speed is changeable from 600 to 5 000 rpm. The capacity of this machine is 100-hp at 1 200 rpm pinion speed. In the case of bevel gears, the tooth bearing changes sensitively depending on the relative setting positions of pinion and gear, and the performances of the gears are greatly under the effect of tooth bearing. This machine is therefore so designed that the setting position of the pinion may be adjustable and its position be indicated by block gage or dial indicator. Since the upper part of the test gear box is made of transparent plastics, we can observe well the behaviours of the gears and lubricants.

2.2 The test gears The dimensions of the gears are shown in Table 1 and Fig. 2. The gear material is Ni-Cr steel (0.3% C, 2.7% Ni, 0.8% Cr). The gears are hardened and ground with the spiral bevel gear generator constructed at Kyushu University. The tooth bearing and the roughness of the ground tooth surface are shown in Fig. 3. The load carrying capacity of the test gears is 24-hp at 1 200 rpm pinion speed.

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** Professor, Faculty of Engineering, Kyushu University, Fukuoka.