FACULTY OF ENGINEERING

DESIGN AND PRODUCTION ENGINEERING DEPARTMENT

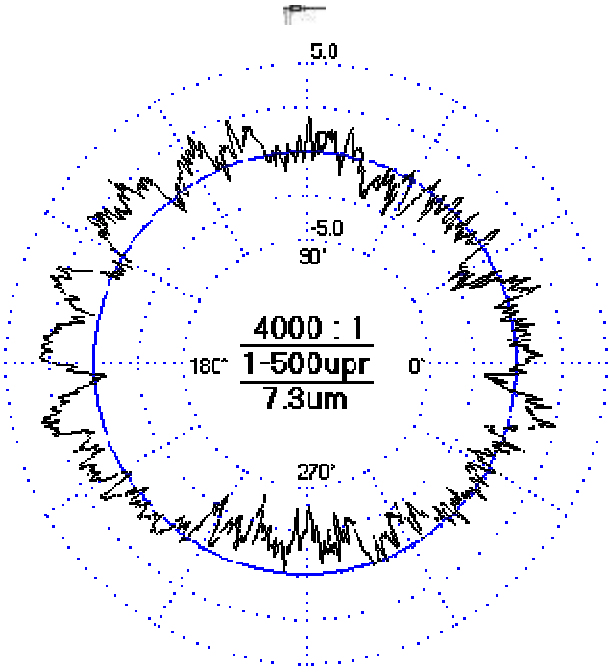
Engineering Metrology

Credit Hour System

Report On:

(3)

Out of Roundness



Metrology laboratory

Student Name	Remark
Class No:	Signature
B.N.	

2016/2017

Out of roundness

Objective

The objective of this experiment is to find out:
The roundness error of a round shaft
The eccentricity of a shaft
The profile of a cam

Equipment:

All measurement will be carried out on the cam shaft tester.

Procedure:

To measure the roundness and eccentricity of a shaft mount it between centers and set it in the cam shaft tester. Adjust the contact element to make contact at any point on the round part of the shaft. Adjust the height of the measuring spindle such that its center line is in the same plane as the center line of the shaft to be measured. Take successive readings on the abbe-measuring head as the shaft is related through equal angular division by rotating the dividing head (say 10^0). The out of roundness and the eccentricity cam then be found by three methods; the first two are graphical and the third is analytical.

1. st graphical method:

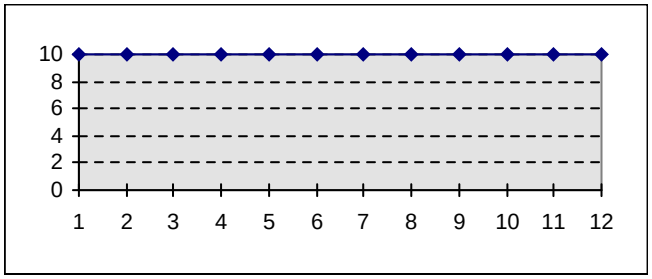
Draw the points on a polar chart as in the figure. Also draw on a transparent paper several concentric circles then try to fit and of these circles with the maximum number of points. The distance between any of the profile drawn between the points and the fitted circle is the out of roundness. Also, the distance between the center of the polar chart and the enter of the fitted circle is the value of eccentricity. The angle made by the line of center and the line of the first reading is the direction of eccentricity.

2nd graphical method.

Draw the points obtained from the experiment on a Cartesian coordinates. If the points were found to be on a line it means that the shaft has no eccentricity and has no out of roundness. If the points were found to form a sine curve it means that the shaft is eccentric but still has no out of roundness. Again if the point were found to be scattered around a line it means that the shaft is concentric but has an out of roundness error. If the points were scattered around a sine curve it means that the shaft is eccentric and has an out roundness error. The value of the out of roundness may be found be measuring the distance between the curve joining the measured points and the curve representing the best fitted sine curve. The value of eccentricity is the amplitude of the sine wave. The angle of eccentricity is the value by which the sine wave is shifted from the origin.

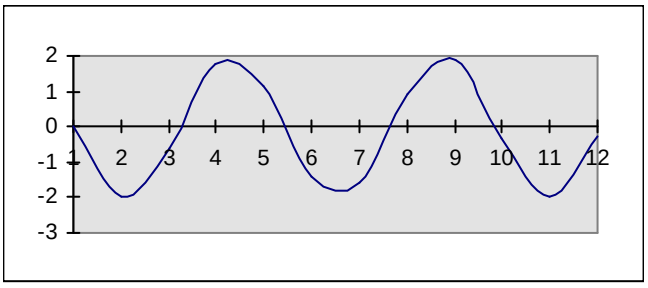
illustration

Angle	
0	10
30	10
60	10
90	10
120	10
150	10
180	10
210	10
240	10
270	10
300	10
330	10



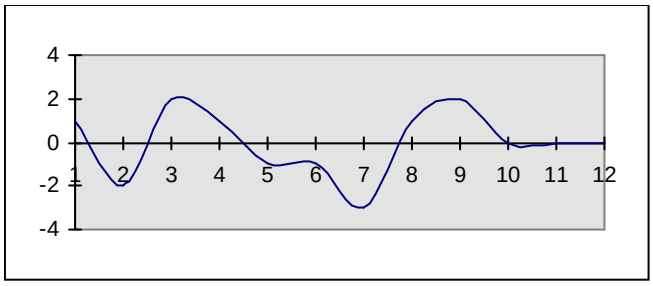
No Eccentricity - No out of Roundness
Pure Round

Angle	
0	0
30	-1.97606
60	-0.60962
90	1.787993
120	1.161222
150	-1.42975
180	-1.60231
210	0.935437
240	1.89089
270	-0.35209
300	-1.99951
330	-0.26476



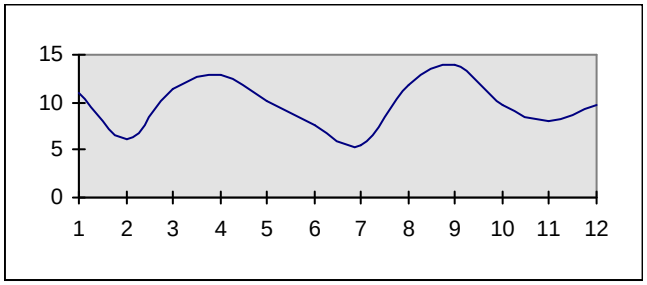
Eccentric - No out of Roundness

Angle	
0	1
30	-2
60	2
90	1
120	-1
150	-1
180	-3
210	1
240	2
270	0
300	0
330	0



No Eccentricity -
out of Roundness Exist

Angle	
0	11
30	6.023937
60	11.39038
90	12.78799
120	10.16122
150	7.570247
180	5.397695
210	11.93544
240	13.89089
270	9.647908
300	8.000488
330	9.735237



Real Part
Eccentric + Out of roundness

Analytical method

Convert the polar coordinates of each point (r,) to Cartesian coordinates (X,y) from the equations:

$X = r.\cos(\theta)$ $Y = r \sin(\theta)$

$A = 2 * \Sigma Xi / n$ $B = 2 * \Sigma Yi / n$

Thus the value of eccentricity is round from the equation:

$$\text{Where } E = \sqrt{(a)^2 + (b)^2}$$

The angle of eccentricity is found from

$$\text{Eccentricity angle } (\theta) = \tan^{-1} (\Sigma Yi / \Sigma Xi)$$

The radius "R" of the best fitted circle is $= \Sigma Ri / n$

The out of roundness at any point (say at point n) is given by:

$$\text{Error at the point n} = r_n - R - E \cos(\theta_n - \theta)$$

Cam Profile

To measure the profile of the cam set the camshaft tester to make contact with the cam under test at the point of zero lift (zero displacement) just before the beginning of the outstroke.

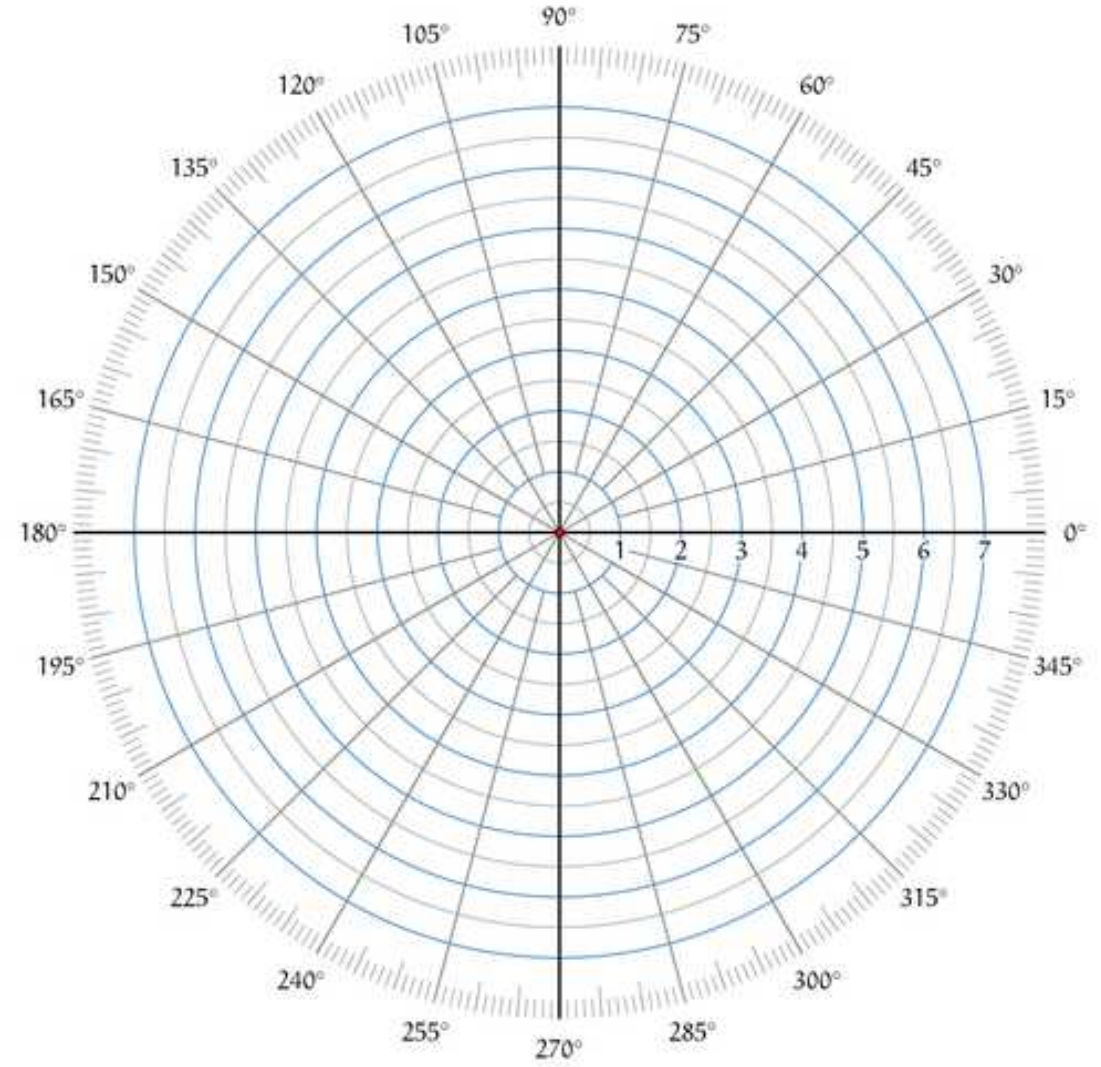
The point can be indicated by the tester when the camshaft is slowly rotated. Take the initial readings of the camshaft tester and the dividing head at this position.

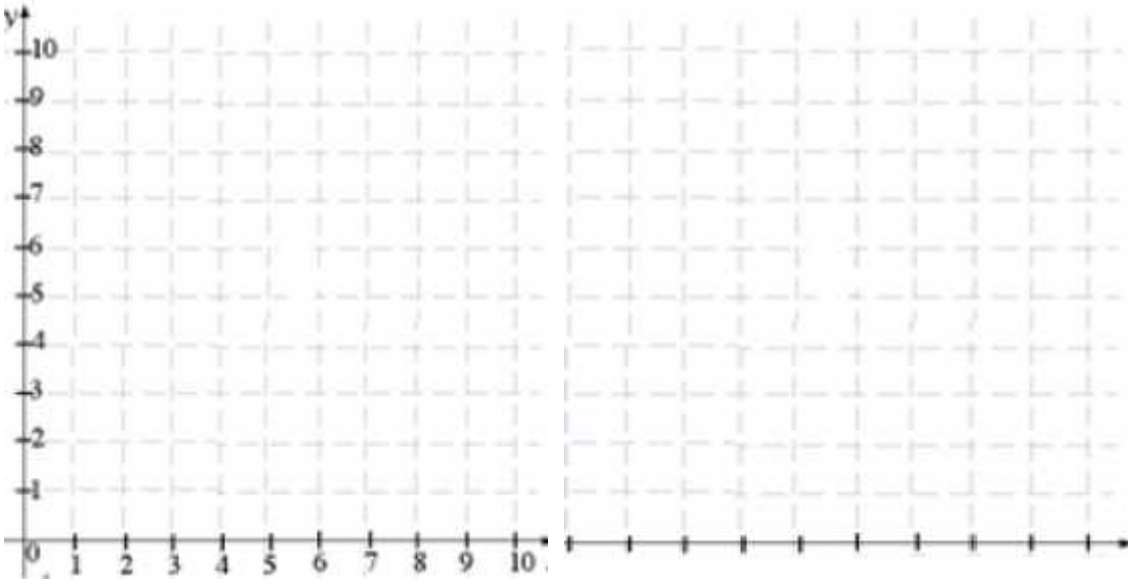
Rotate the camshaft by rotating the dividing head through equal angular division (say 5 degrees) and take the readings of the cam shaft tester at each position, which will indicate the cam lift at the different reading of the tester & then draw the profile of the tester cam and its displacement curve.

Readings

The roundness of a shaft is measured and the following readings were taken every 20^{O}.

Angle	Reading (R)
0	
20	
40	
60	
80	
100	
120	
140	
160	
180	
200	
220	
240	
260	
280	
300	
320	
340	


90°
75°
60°
45°
30°
15°
0°
345°
330°
315°
300°
285°
270°
255°
240°
225°
210°
195°
180°
165°
150°
135°
120°
105°
1
2
3
4
5
6
7


y
10
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
9
10

Solution

Step No. 1

Find the radius of the shaft.

Radius = Sum of the readings/ No of readings =

Step No. 2

Find the Eccentricity (value and angle)

To do so, construct two columns , column No 3 and No 4.

Where Xi= reading * cos (θ)

(Note: θ is the angle at which the reading was taken)

Yi= reading * sin (θ)

(Note: θ is the angle at which the reading was taken)

Angle (θ)	Reading (R)	Xi = R cos θ	Yi= R sin θ
0			
20			
40			
60			
80			
100			
120			
140			
160			
180			
200			
220			
240			
260			
280			
300			
320			
340			
Sum			

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Eccentricity value = $\sqrt{}$ (2 * Σ Xi / n)^2 + (2 * Σ Yi / n)^2

where n = no of readings =

=

Σ Yi =

Eccentricity value (e) =

Eccentricity angle = tan $^{-1}$ (Σ Yi/ Σ Xi)

Eccentricity angle (ϕ) =

Step No. 3

Determination of the effect of eccentricity angle on the readings.

To do so, Construct two columns.

- The first column = difference between measured angle and the Eccentricity angle = (θ - ϕ)
- The other column = cos of difference in angle multiplied by the Eccentricity value = e cos (θ - ϕ)

Angle (θ)	(θ - ϕ)	e cos (θ - ϕ)
0		
20		
40		
60		
80		
100		
120		
140		
160		
180		
200		
220		
240		
260		
280		
300		
320		
340		

Step No. 4

Removing the effect of the eccentricity and the value of radius to get the error in roundness

Angle (θ)	Reading (R)	Eccentricity error	Radius	Roundness error = reading - ecc error- radius
0				
20				
40				
60				
80				
100				
120				
140				
160				
180				
200				
220				
240				
260				
280				
300				
320				
340				

Max Out of roundness = Max Positive + Max. Negative

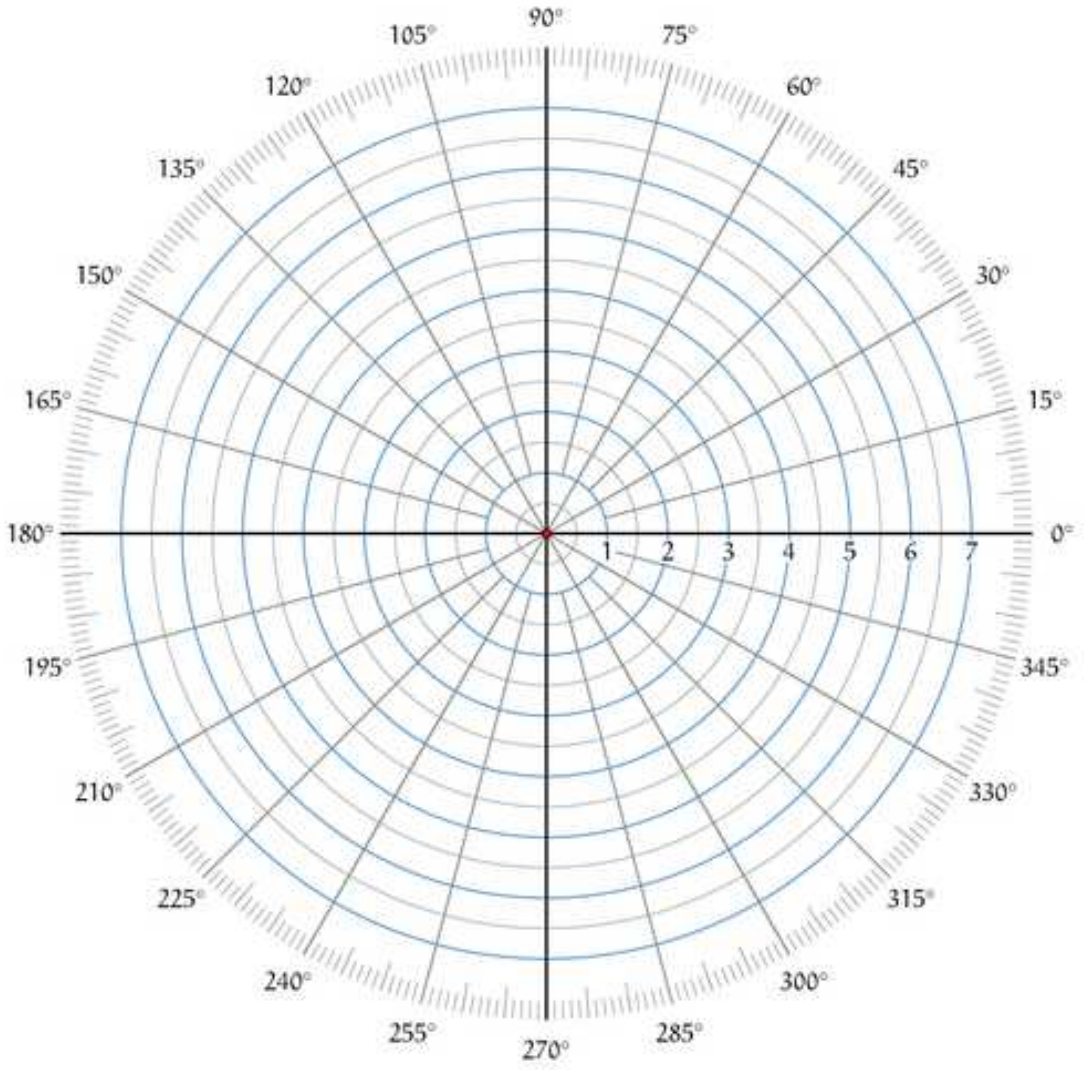
CAM readings

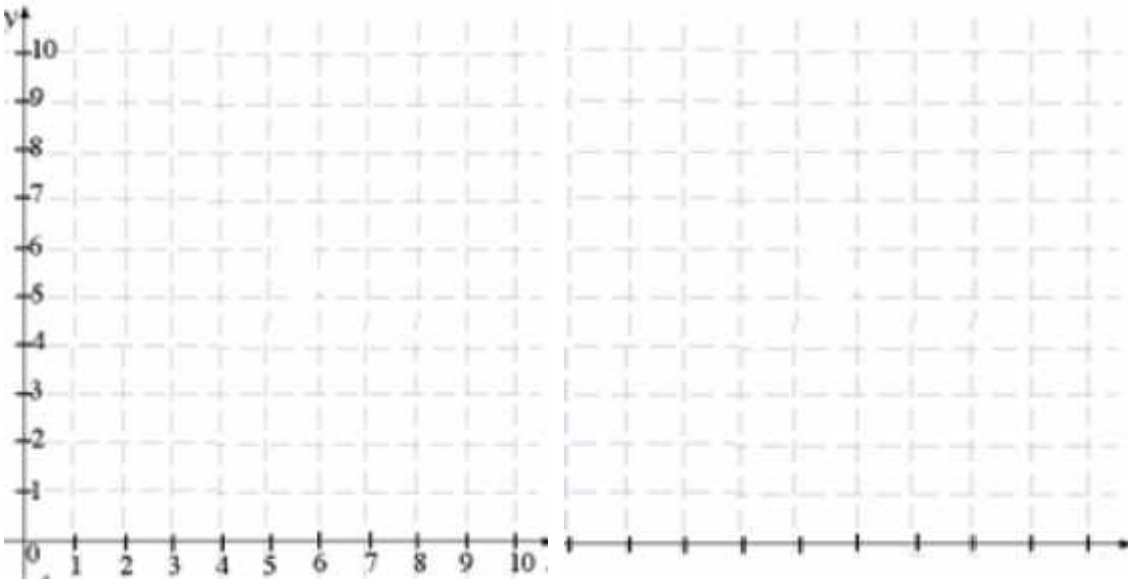
Indexing Angle =

Angle	Reading
0	

Angle	Reading

ROFILE


90°
75°
60°
45°
30°
15°
0°
345°
330°
315°
300°
285°
270°
255°
240°
225°
210°
195°
180°
165°
150°
135°
120°
105°
1
2
3
4
5
6
7


y
10
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
9
10