XVII IMEKO World Congress
Metrology in the 3rd Millennium
June 22–27, 2003, Dubrovnik, Croatia

EVALUATION OF FUNCTIONAL PARAMETERS MEASUREMENT'S ACCURACY FOR A "LEMON"/"BARREL" SHAPED BODY

Eng. Boris Katz, Liron Anavy, Irina Telent

Quality Control Center (Q.C.C) Hazorea Israel

Abstract – These article sums our calculations and experiments of "lemon"/"barrel" shaped bodies; we've analyzed 4 methods for the measurements of the important parameters and calculated the uncertainty of each method.

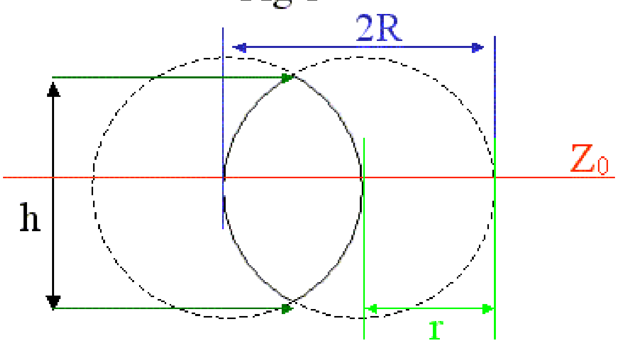
Keywords: measurement, accuracy, rotation-body.

1. INTRODUCTION

Picture 1

When manufacturing rollers of the "lemon" (barrel) shape, picture 1 for instance, one of the most important issues is the metrological support for the large circle's radius (R) and for the location of the maximal planar circle (z_0).

Fig 1



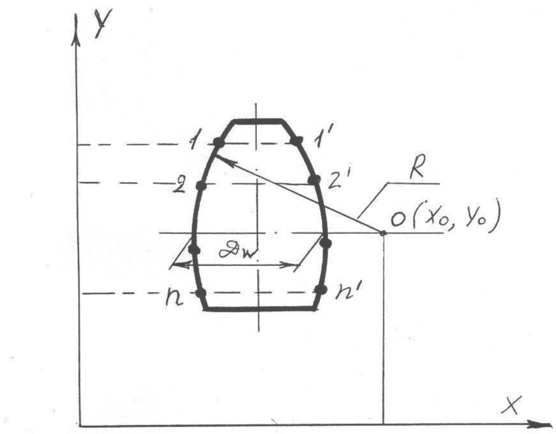
When the radius values are much larger than the roller's height the measurements' uncertainty might become a major problem. Since it's usually the case we've decided to start this investigation.

Picture 2

The problem of the deviance is multiplied when considering objects like the one on picture 2, an object that has many "lemons" in it and will not function unless all of the objects are in tolerance.

2. EXPERIMENTAL SETUP

All measurements were conducted on an optical microscope. X-Y coordinates were defined so Y will be parallel to the symmetric-axis of the roll. Each measurement point is defined as (X_i,Y_i) and is located on an arc. We measured the left arc (1,2,3…n) and the right arc (1',2',3'…n') as in picture 3.



Picture 3

The methods:

1. "Separated Circle Arcs" - Assuming each arc is defined by an equation of circle we used the "least sum squares" method to find the equation's parameters and get the best description for the left arc and the right arc separately. For this purpose we used a program called "Igul" which was developed at QCC Hazorea.

The final parameters are defined as the average of the two arcs

$$X_0 = \frac{X_{l0} + X_{r0}}{2} \quad Y_0 = \frac{Y_{l0} + Y_{r0}}{2} \quad R = \frac{R_l + R_r}{2} \quad (1)$$

For the example of this method we use the results in table I and we get the parameters in table II.

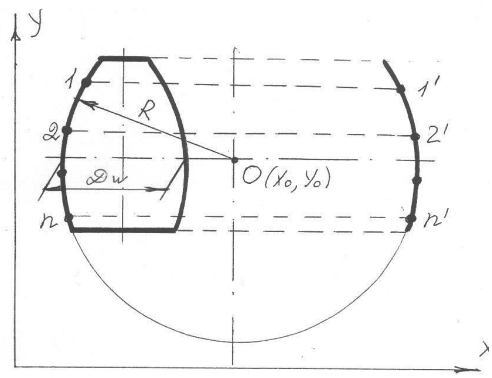
TABLE I. The measurement results

Left	X	Y	Right	X	Y
1	0.700	12.000	1'	19.779	12.000
2	0.168	6.000	2'	20.317	6.000
3	0.000	0.000	3'	20.490	0.000
4	0.191	-6.000	4'	20.300	-6.000
5	0.743	-12.000	5'	19.749	-12.000

TABLE II. Calculated parameters

Parameter	"Combined Arcs Circle"	"Separated Circle Arcs"
R_l	N/A	100.122mm
Y_{l0}	N/A	0.181mm
R_r	N/A	99.575mm
Y_{r0}	N/A	0.127mm
R	99.844mm	99.849
Y_0	0.154mm	0.154

2. "Combined Arcs Circle" –

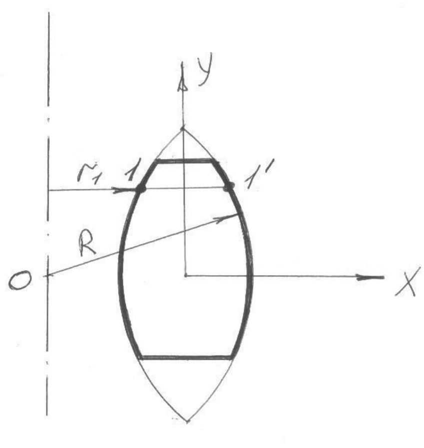


Picture 4

This method requires the measurement of the maximal diameter (D_{max}=20.498mm in the example), the left arc's measurements from table 1, and changing the right arc's X values to 2R-Dmax. Y values remain unchanged.

Using the same equation as for the 1st method we calculate the equation of the circle, which is defined by both arcs simultaneously. Comparing the results with the 1st method we see that it is almost the same (i.e. smaller than the uncertainty)

3. "Keplerian Equation" –



Picture 5

This method is equivalent to the 2nd method. The difference is that this is a more direct method. We start from the equation

$$y = \pm\sqrt{R^2 - (x + r)^2}$$
$$R > r, \quad x \in \{-(R - r), (R - r)\} \quad (2)$$

Using some math over (1) when the X and Y are not in the symmetry Axis of the lens (Cross-section of lemon) we receive:

$$(X - X_0)^2 + (Y - Y_0)^2 = R^2 \quad (3)$$

Which means method 2 and 3 are identical, thus from now on we'll refer to both of them as method 2.

In order to decide which method has lower uncertainty we repeated measuring a roller for many times. The results show that the 2nd method is reducing the standard deviation, but it is a negligible reduction.

4. "Measuring of D_{max}" – this is a suggestion because we lacked the equipment for conducting the measurement. In order to find the maximum diameter we suggest using 2 parallel surfaces on the Lemon shaped body. Assuming the lemon has circular arcs and the surfaces are parallel the distance between the surfaces is the maximal diameter. Using this value we use the 2nd method for calculating the rest of the parameters.

3. CONCLUSIONS

We recommend the 2nd method. We've found that the uncertainty of the parameters of the lemon shaped bodies are almost the same, though the standard deviation of the 2nd method is a bit smaller than the 1st. Additionally conducting a measurement of the 1st method requires symmetry it would be easier to use the 2nd method for most cases.

In some cases it might be easier to calculate the parameters using Kepler's equation directly, but as we've already proved the equivalence of those methods.

Authors: Eng. Boris Katz Q.C.C Hazorea Israel, mail: 30060 Q.C.C Hazorea Israel, phone: 972-4-9592464, fax: 972-4-9899222, E-mail: boris_ka@mba.co.il.

Liron Anavy Q.C.C Hazorea Israel, mail: 30060 Liron Anavy Hazorea Israel, phone: 972-53-990728, fax: 972-4-9899728, E-mail: ph_liron@techunix.technion.ac.il.

Irina Telent Q.C.C Hazorea Israel, mail: 30060 Q.C.C Hazorea Israel, phone: 972-4-9592464, fax: 972-4-989922