10th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2006, Barcelona-Lloret de Mar, Spain, 11-15 September, 2006

DYNAMIC INFLUENCE MODELING OF THE CONTACT BETWEEN MEASURED PROBE AND DISPLACEMENT TRANSDUCERS

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ABSTRACT
In the first part, the paper presents the way in which were obtained the frontal and radial form deviations measuring results of a revolution probe. The deviations values were determined for the static measuring processes, in equidistant points.
In the second part there was took the problem to improve the dimensional control process, in order to adapt it for automatic manufacturing lines. For a high dimensional control precision, in case of rotation probe and continue measuring conditions, there it was studied the problem of the dynamic modelling of the contact between the probe surface and the detecting head of the transducer.
Keywords: dimensional control, transducer, contact

1. THE AUTOMATIC DIMENSIONAL CONTROL PROCESS
As a necessity of the automation of the quality control into the flexible technological manufacturing gauges, the use of the control gauges with computer aided measuring was very highly developed, due to its advantages like measuring high precision, measuring modularization and process time reducing. The improvement regarding the process time reducing, but also the dimensional control precision invokes in this paper a study for a particular case, a symmetrical revolution probe.

2. THE OBTAINING OF THE RESULTS VIA CLASSICAL MEASURING METHODS
As a result of the dimensional measuring, using classical methods, for radial and frontal direction of the revolution probe, there were obtained the results, presented in the table 1. The measuring was made for 32 equidistant points, in this way being possible to obtain the form deviation diagrams.

Table 1 The form deviations of a revolution probe, by equidistant points measuring [1]

Radial deviations measuring			Frontal deviations measuring		
Measured point	The rotation angle of the probe	Form deviation [μm]	Measured point	The rotation angle of the probe	Form deviation [μm]
1	0° / 360°	-76.90	1	0° / 360°	0.00
2	11°. 15'	-71.05	2	11°. 15'	7.00
3	22°. 30'	-67.05	3	22°. 30'	14.00
4	33°. 45'	-56.20	4	33°. 45'	28.10
5	45°	-43.90	5	45°	38.40
6	56°. 15'	-34.60	6	56°. 15'	53.00
7	67°. 30'	-17,80	7	67°. 30'	59.30
8	78°. 45'	0.00	8	78°. 45'	65.50
9	90°	26.10	9	90°	69.20
10	101°. 15'	46.10	10	101°. 15'	70.90
11	112°. 30'	64.80	11	112°. 30'	73.10

Radial deviations measuring			Frontal deviations measuring		
Measured point	The rotation angle of the probe	Form deviation [µm]	Measured point	The rotation angle of the probe	Form deviation [µm]
12	123°. 45’	80.50	12	123°. 45’	71.10
13	135°	88.70	13	135°	69.80
14	146°. 15’	93.10	14	146°. 15’	72.10
15	157°. 30’	95.10	15	157°. 30’	72.50
16	168°. 45’	94.30	16	168°. 45’	74.80
17	180°	88.20	17	180°	68.40
18	191°.15’	80.70	18	191°.15’	65.40
19	202°. 30’	73.40	19	202°. 30’	58.00
20	213°. 45’	59.70	20	213°. 45’	44.90
21	225°	58.40	21	225°	31.40
22	236°. 15’	43.70	22	236°. 15’	14.70
23	247°. 30’	31.90	23	247°. 30’	2.90
24	258°. 45’	7.50	24	258°. 45’	-6.30
25	270°	-12.00	25	270°	-12.30
26	281°. 15’	-26.60	26	281°. 15’	-17.10
27	292°. 30’	-47.90	27	292°. 30’	-14.00
28	303°. 45’	-61.50	28	303°. 45’	-10.80
29	315°	-74.60	29	315°	-7.20
30	326°. 15’	-83.60	30	326°. 15’	-6.80
31	337°. 30’	-84.30	31	337°. 30’	-6.30
32	348°. 45’	-80.60	32	348°. 45’	-2.90

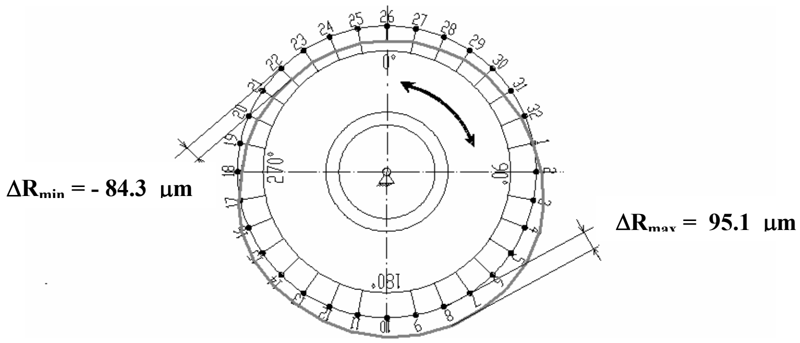
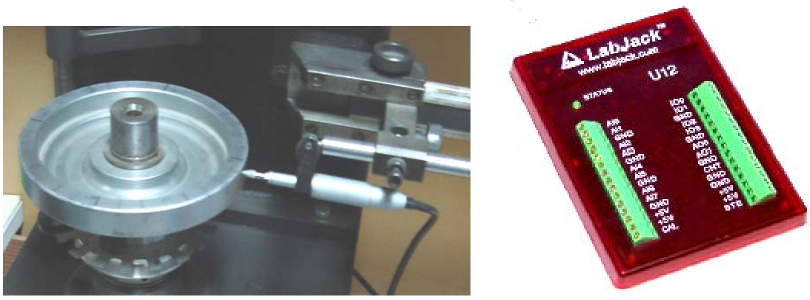


Figure 1 The radial form deviation distribution [1]

3. THE AUTOMATION OF THE MEASURING PROCESS



a) b)

Figure 2. The measuring with inductive transducer: a) the measuring gauge, b) the LabJack U12 acquisition board

The viewing of the aided by computer measuring results was possible duet o a virtual instrument (*vi*) created the LabVIEW 7.1 graphical programmable device.

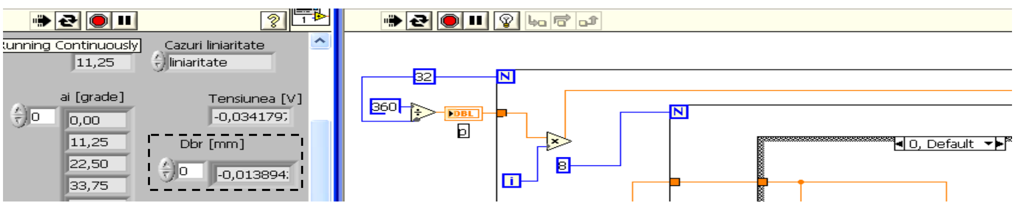


Figure 3. The virtual instrument for the viewing of the computer aided measuring results

Starting to this method, the solution can be improved, by continuously and simultaneous form deviations measuring for both directions, the data storage and the form deviation distribution diagrams printing being possible. The solution for the automatic control could to be obtain by equipping the existing gauge with an engine with rotation speed reducing who transmits the motion to the axis of the probe.

The operating of the probe with to high speed rotations has as a consequence the breaking of the continuous contact between the rod plate of the transducer and the probe surface, that invokes perturbations about the measuring precision. The rotation of the probe with low speed could manage to have times to long for the dimensional control process, so that to non - synchronizations with other conjugated process of the technologic flux manufacturing.

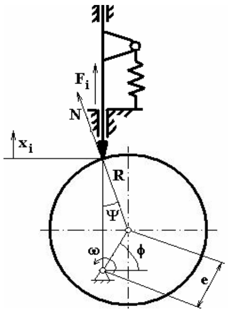


Figure 4. The study of the dynamic influence about the transducer – probe contact evolution [2]

Regarding the radial deviations measuring, the probe being placed in horizontal position on the gauge, the forces equilibration equation is:

$$F_r + F_i - F_a = 0 \quad (1),$$

where F_r represents the reaction of the probe surface about the rod plate, F_i – the inertial forces developed by the rod plate displacement, and F_a is the resort force who replaces the rod plate of the transducer into its initial position. Due to the rod plate geometry, the friction forces between the rod plate and the fram of the transducer could be considered negligible. Expressing the forces by depending of the rod plate displacement, the equation became:

$$N \cdot \cos\Psi + m \cdot \ddot{x}_i - [F_{a\_\min} + k \cdot (e + x_i)] = 0 \quad (2)$$

where N represents the reaction in the normal direction to the surface of the probe on the contact point., ψ - the angle between the reaction force reported to the normal direction, m – the mass of the rod plate, x_i – the displacement of the rod plate, F_{a_min} – the minimal resort force, k – the rigidity of the resort and e – the eccentricity of the probe reported to its rotation axis [2]. Imposing the condition to have the continuous contact between the rod plate and the measuring surface, $N \geq 0$ and expressing the rod plate displacement depending by the rotation speed of the probe, it was obtained (3):

$$F_{a\_\min} + k \cdot (e + x_i) - m \cdot \omega^2 \cdot \sin(\omega \cdot t) \geq 0 \quad (3),$$

where $\varphi = \omega t$ represents he rotation angle of the probe around its real axis. Marking with ω_0^2 the report k/m (ω_0 being the own pulsation of the system) and taking into account the most disadvantageous case ($\omega > \omega_0$ and $sin(\omega t) = 1$), it was possible to express the rotation speed of the probe, depending by the transducer functioning parameters only:

$$\omega \leq \sqrt{2 \cdot \omega_0^{\ 2} + \frac{F_{a\_\min}}{m \cdot e}} \quad (4) \quad [2]$$

Regarding the radial form deviations distribution diagram, it was measured an eccentricity of the probe $e \cong 179,4\ \mu m$. The minimal force of the resort was determined knowing the geometric and functional parameters of the resort. In order to calculate the minimal force of the resort, it was first determined the maximal displacement of the rod plate in radial direction (x_i), the value of the eccentricity being known. The maximum displacement was calculated as the maximum in absolute value between the sum of the positive / negative displacements; there were took into account the displacement in the same sense for two or more successive measuring points. In this way it was established a maximum displacement of the rod plate (positive) $x_i = 193{,}85\ \mu m$.

The radius of the probe is $R = 79\ mm$, so that the highest rotation speed for which the detaching of the rod plate by the probe surface have not take place is $\omega_{max} = 4{,}885\ rot\ /\ s$. It was adopted a maximal rotation speed $\omega = 4{,}5\ rot\ /\ s$.

Regarding the frontal deviations measuring it was realized a similar study, in this case considering that the probe was placed vertical. In the forces equilibrium was took into account also the weight of the rod plate:

$$F_r + F_i - F_a - G = 0 \quad (5) \quad [2]$$

Using the same way it was calculated a maximal rotation speed $\omega_{max} = 5{,}71\ rot\ /\ s$. The study about the analogical model was made because, in case of the vertical placement of the transducer, considering that the rod plate displacements are the same, the loosing of the contact take place for higher rotation speeds than $\omega_{max} = 5{,}71\ rot\ /\ s$, in this case the eccentricity being equal to zero. However it was took the problem to establish the maximal displacement of the rod plate for the frontal deviation measuring case, because there it could appear contact breakings for high deviations domains for lows rotation angle. Corresponding to the table 1, it was established that the highest displacement of the rod plate took place for [180° ÷ 281°,15'] rotation angular domain; the displacement was measured $x_i = -91{,}9\ \mu m$. As a consequence it was established that for this probe, using the same transducer, the maximal rotation speed for which the detaching of the rod plate by the probe surface have not take place is $\boldsymbol{\omega_{max} = 4{,}5\ rot\ /\ s}$.

4. CONCLUSIONS

The results of the study applied for this particular case are valid for the measuring using the MICROLIMIT TI 1B inductive transducer, but this method is also valid for any type of revolution probe with different dimensions. As the following, besides the improvement of the modularized dimensional control, this method can be successfully applied also in case of using of different types of transducers functioning with contact with the probe surface. Besides thus, in case of the automatic technologic gauges, due to this improvement, knowing the ideal functioning parameters of the control gauge, it is possible to realize also an active control of the probes, during the manufacturing. This could be possible by realizing a feed – back between the transducers, the computer and the system for the rotation probe ordering during its manufacturing.

5. REFERENCES:

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