An analysis of influence of sampling strategy and scanning speed on estimation of straightness and flatness deviations with CMMs

KRZYSZTOF STĘPIEŃ

Krzysztof Stępień (kstepien@tu.kielce.pl), Kielce University of Technology, Poland

How to cite: K. Stępień. An analysis of influence of sampling strategy and scanning speed on estimation of straightness and flatness deviations with CMMs. Advanced Technologies in Mechanics, Vol 2, No 2(3) 2015, p. 2–7.
DOI: 10.17814/atim.2015.2(3).17

Abstract:

The paper deals with the problem of influence of scanning speed and measuring strategy on results of flatness and straightness deviations with CMMs. The straightness was studied for various numbers of sampling points and for various scanning speeds. The flatness was investigated for various measurement paths and for various levels of scanning speeds. The results of the study indicate that applied measurement speed and selected measurement path can change obtained results very significantly.

KEYWORDS: **form deviation**, **flatness**, **straightness**, **CMM**

1. Introduction

Dynamic development of in the field of metrology of geometrical quantities affects more and more sophisticated methods of measurements of form deviations [1-3]. Usually, at least a few measurement strategies are available to apply, i.e. a path along which measuring sensor moves on studied surface. Users can also change the number of sampling points as well as control a measurement speed [4-6].

Considering factors given above, following questions arises: how sampling strategy, the number of sampling points and measurement speed affect results of measurements of form deviations. This is why at Kielce University of Technology a study was conducted that aimed at determination of influence of selected measurement parameters and strategy on evaluation of form deviation values. Following form deviations were investigated: straightness and flatness. All measurements were conducted with the use of coordinate measuring machine Prismo Navigator by Zeiss, equipped with a scanning probe-head.

2. Mesurements of straightness deviations

In this part of the study measurements of straightness deviations STRt of a cylindrical workpiece were conducted. Firstly, measurements were carried out with a constant scanning speed equal to 10 mm/s and we changed the number of sampling points on the profile that was equal to 70, 140, 350, 700 and 1000 points.

In fig. 1 and fig. 2 measurement protocols are shown generated for the sampling point number equal to 70 and 1000 points, respectively.

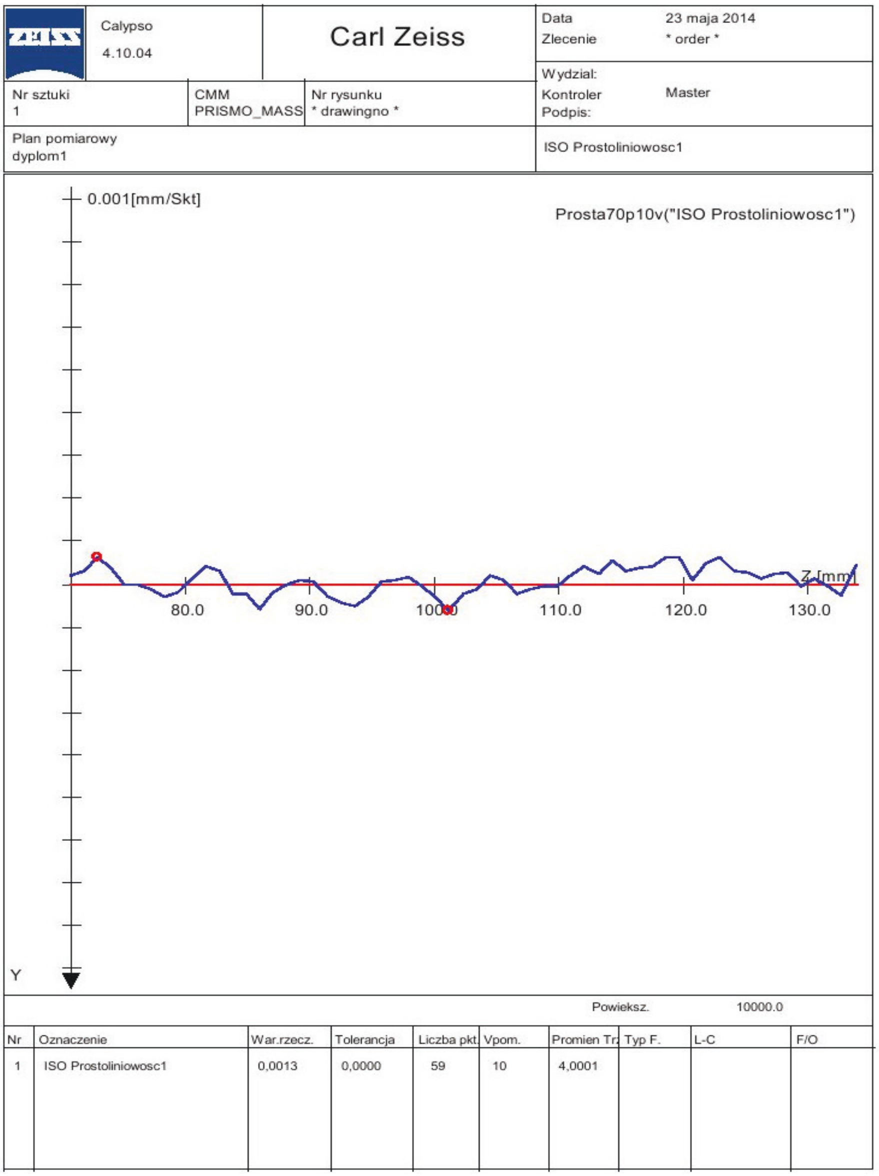


Fig.1. Straightness measurement protocol for scanning speed 10 mm/s and sampling point number 70

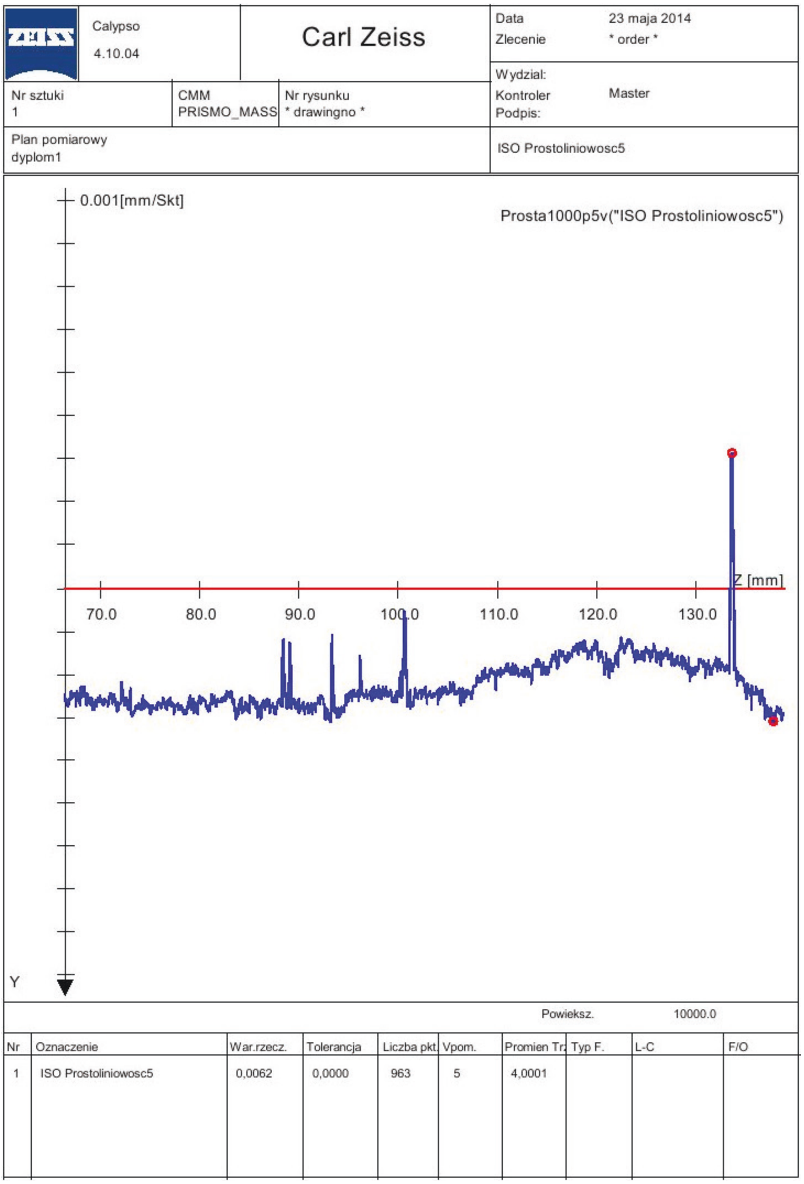


Fig.2. Straightness measurement protocol for scanning speed 10 mm/s and sampling point number 1000

An analysis of fig. 1 and 2 indicates that sampling points number affects results significantly. Some information of irregularities of the surface is lost when the sampling points number is equal to 70 (the surface is more smooth than the one obtained for 1000 points). The results of this part of the study are given in table 1.

Table 1. Results of the study on the influence of sampling points number on measurement results of straightness deviations

Scanning speed [mm/s]	Sampling points number	Straightness deviation STRt [mm]
10	70	0,0013
10	140	0,0044
10	350	0,0061
10	700	0,0067
10	1000	0,0062

Results presented above show that when sampling points number increases the straightness deviation STRt firstly increases and after exceeding some critical value of sampling points becomes approximately constant and reaches about sixty micrometers. The threshold for sampling points number was 350 points.

The second stage of this study aimed at investigation of influence of scanning speed on straightness measurement results. Four measurements of the generatrix of the cylinder were conducted applying following measurement speed values: 5, 10, 15, and 20 mm/s. The number of sampling points was constant and equal to 1000 points. The results of the study are given in table 2.

Table 2. Results of the study on the influence of scanning speed on measurement results of straightness deviations

No.	Scanning speed [mm/s]	Sampling points number	Straightness deviation STRt [mm]
1.	5	1000	0,0062
2.	10	1000	0,0060
3.	15	1000	0,0051
4.	20	1000	0,0044

Results given above indicate that the straightness deviation increases along with the increase of scanning speed. The relative difference between the maximum and minimum value is equal to about 50 %.

3. Mesurements of flatness deviations

In order to measure flatness deviations an option „raster" was used. This term refers scanning density of the surface and describes the number of longitudinal sections of the measurement path.

In presented research five measurements of flatness deviations were conducted that differed in the number of rasters (5, 10, 15, 20 and 25). One of the measurement paths applied in the study is shown in fig. 3.

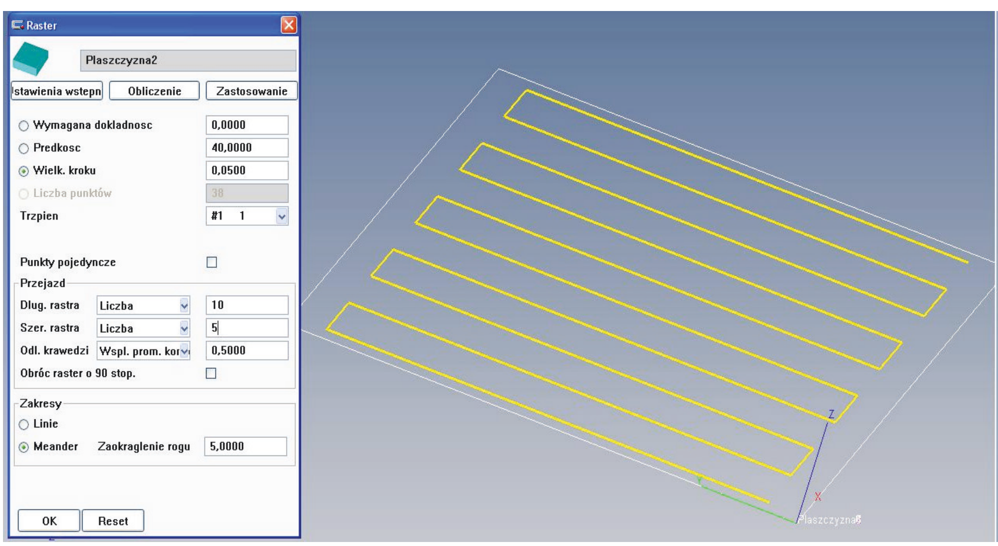


Fig. 3. One of applied measuring strategies (measurement paths): raster 5

Protocols from measurements for raster 10 and 15 are show in fig. 4 and 5. table 3 provides all measurement results obtained during the experiment.

Table 3. Results of the study on the influence of density of measurement path on results of flatness deviations measurements

No.	Raster	Flatness deviation FTLt [mm]
1.	5	0,0017
2.	10	0,0085
3.	15	0,0043
4.	20	0,0094
5.	25	0,0024

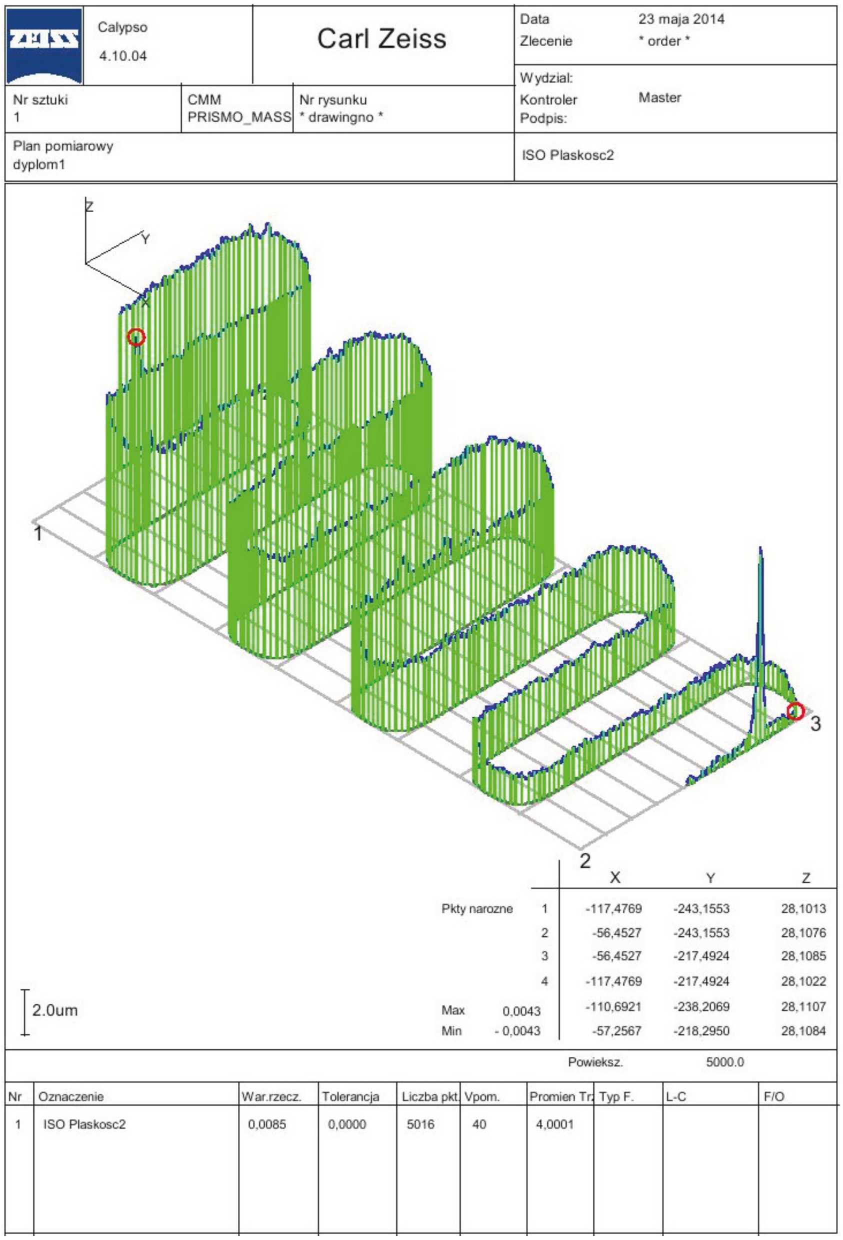
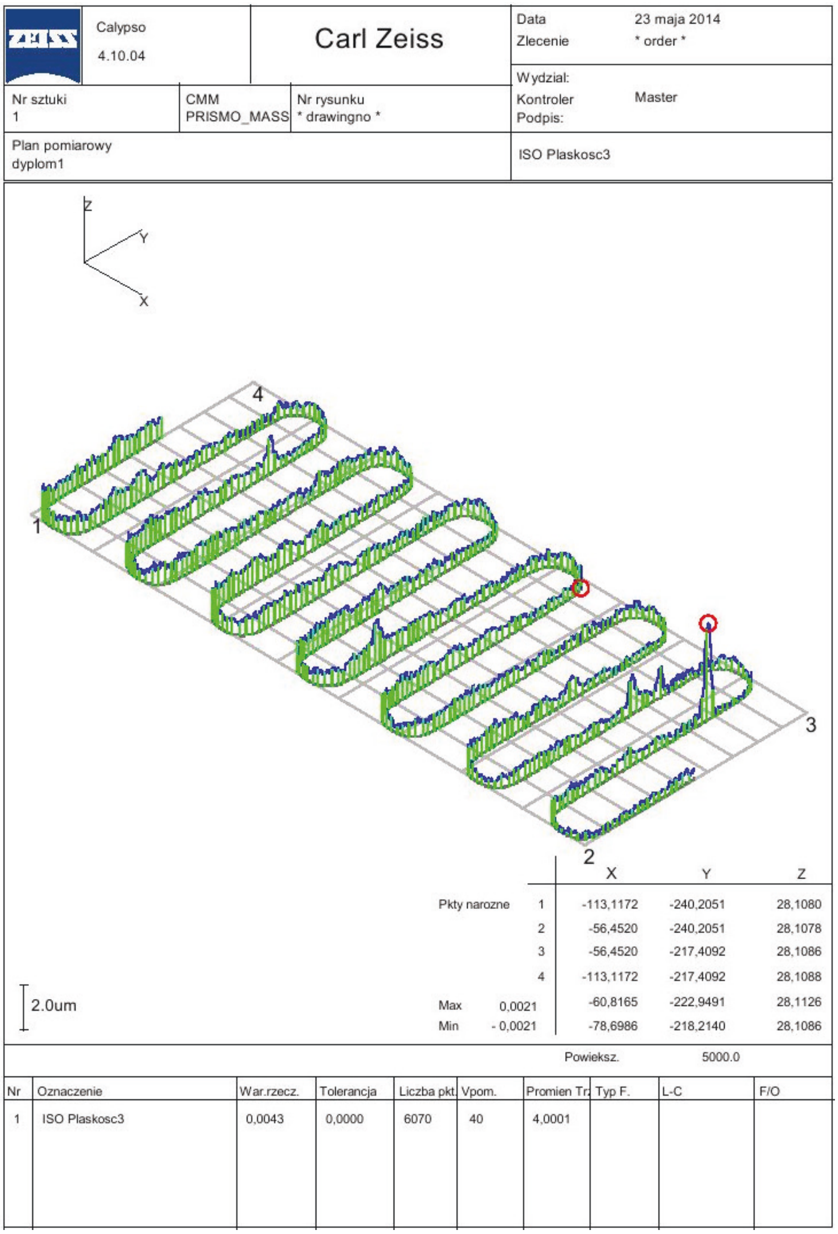


Fig. 4. The protocol for flatness deviation measurement with the use of raster 10



ZEISS	Calypso 4.10.04	Carl Zeiss	Data 23 maja 2014 Zlecenie * order *
Nr sztuki 1	CMM PRISMO_MASS	Nr rysunku * drawingno *	Wydzial: Kontroler Master Podpis:
Plan pomiarowy dyplom1			ISO Plaskosc3

		X	Y	Z
Pkty narozne	1	-113,1172	-240,2051	28,1080
	2	-56,4520	-240,2051	28,1078
	3	-56,4520	-217,4092	28,1086
	4	-113,1172	-217,4092	28,1088
Max	0,0021	-60,8165	-222,9491	28,1126
Min	- 0,0021	-78,6986	-218,2140	28,1086

Powieksz. 5000.0

Nr	Oznaczenie	War.rzecz.	Tolerancja	Liczba pkt	Vpom.	Promien Tr	Typ F.	L-C	F/O
1	ISO Plaskosc3	0,0043	0,0000	6070	40	4,0001			

Fig. 4. The protocol for flatness deviation measurement with the use of raster 15

4. Summary

Presented study revealed that measurement parameters and sampling strategy can influence values of form deviations very significantly.

Research on straightness deviations showed that depending of the number of sampling points, the difference between measurement results can reach even 500%. The study indicates also that after exceeding a certain number of sampling points the results do not change significantly. The experiment showed also that measurement speed can affect estimated values of straightness deviations. The difference between a minimum and maximum value of the deviation was about 50%, where the highest values were obtained for the lowest measurement speed.

The study on flatness measurements revealed that the sampling strategy can significantly affect values of flatness deviations. Flatness deviations values obtained for various strategies were completely different. Probable reason of this was that investigated surface contained large local irregularities randomly distributed on the investigated area. If surface topography had been more regular the results could have been more similar to one another.

Taking into account results of all stages of the experiment we should note that high measurement speeds should be avoided when evaluating form deviations. When selecting measurement strategy a preliminary measurements should be conducted to approximately evaluate the characteristic features of the surface. If the preliminary study shows that large local irregularities appear on the surface, then the sampling strategy should be applied that assures sufficiently high density of sampling points.

Another conclusion from the research is that measurements can be erroneous if the number of sampling points on the profile is too low. However, it should be noted that modern measuring devices usually make it possible to conduct scanning measurements where the number of sampling points is very high.

References

[1] Adamczak S., Miko E., Cus F. A model of surface roughness constitution in the metal cutting process applying tools with defined stereometry, Strojniski Vestnik 55 (2009) 45-54.

[2] Poniatowska M, Werner A.: Fitting spatial models of geometric deviations of free-form surfaces determined in coordinate measurements. Metrology and Measurement Systems, nr 12/4, 2010, 599–610.

[3] Zawada-Tomkiewicz A: Estimation of surface roughness parameter based on machined surface image, Metrology and Measurement Systems, nr 17/3, 2010, 493-504.

[4] A. H. R. Salah, The influence of fitting algorithm and scanning speed on roundness error for 50 mm standard ring measurement using CMM, Metrology and Measurement Systems 15/1 (2008) 33 – 54.

[5] Żebrowska –Łucyk S., Cyfrowe metody pomiaru odchyłki walcowości. Model matematyczny, oprogramowanie, wyniki badań. Konferencja „Metrologia Wspomagana Komputerowo”, Zegrze k. Warszawy, 1993, t.2/B, s.269.

[6] Wiśniewska M., Żebrowska –Łucyk S., The problem of accuracy in roughness measurement with the use of the form measuring machine Talyrond 365, Proceedings of the 11th International Symposium on Measurement and Quality Control – ISMQC 2013, Sept. 2013, Cracow-Kielce, Poland.