

## EFFECT OF CLAMPING PRESSURE ON PARTS INACCURACY IN TURNING

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Original scientific paper

The article is focused on problem of deviations generated during the turning process. One of the parameters influencing the deviations in turning is clamping pressure. To verify this presumption a set of experiments was performed on a turning machine with clamping pressure 3,2 MPa. A hollow cylinder with the outer diameter of 60 mm made of low carbon steel EN ISO C16E 1.1148 was used in the experiment. The evaluated parameter was the roundness deviation measured by ZVL MK 300C device using three different filters ( $2 \div 500$ ,  $2 \div 15$ ,  $16 \div 150$ ). It was found that the clamping pressure induces elastic deformations, causing the roundness deviation in machined hollow cylinder and therefore the shape of the part before and after machining is not equal. The roundness deviation proportionally depends on set out of the part from the chuck as well as on clamping pressure. To avoid deformations and obtain lower roundness deviation a different clamping system e.g. collet should be used.

**Keywords:** *inaccuracy, measurement, roundness deviation, turning, workpiece*

### Učinak pritiska stezanja na netočnost dijelova kod tokarenja

Izvorni znanstveni članak

Ovaj članak bavi se problemom odstupanja nastalih tijekom postupka tokarenja. Jedan od faktora koji dovode do odstupanja kod tokarenja je pritisak stezanja. Za provjeru ove pretpostavke izvršen je niz eksperimenata na tokarilici uz pritisak stezanja od 3,2 MPa. U eksperimentu je korišten šuplji cilindar vanjskog promjera 60 mm izrađen od niskougličnog čelika EN ISO C16E 1.1148. Proveravani faktor bilo je odstupanje okruglosti mjereno uređajem ZVL MK 300C uz primjenu tri različita filtra ( $2 \div 500$ ,  $2 \div 15$ ,  $16 \div 150$ ). Ustanovljeno je da pritisak stezanja dovodi do elastičnih deformacija, uzrokujući odstupanje okruglosti u obrađenom šupljem cilindru te stoga oblik dijela prije i poslije obrade nije isti. Ovo odstupanje okruglosti proporcionalno ovisi o postavljanju dijela iz stezne glave kao i o pritisku stezanja. Kako bi se izbjegle deformacije i postiglo manje odstupanje okruglosti trebao bi se koristiti drugačiji sustav pritezanja, npr. stezna kliješta ili čahura za zatezanje.

**Ključne riječi:** *odstupanje okruglosti, mjerenje, netočnost, obradak, tokarenje*

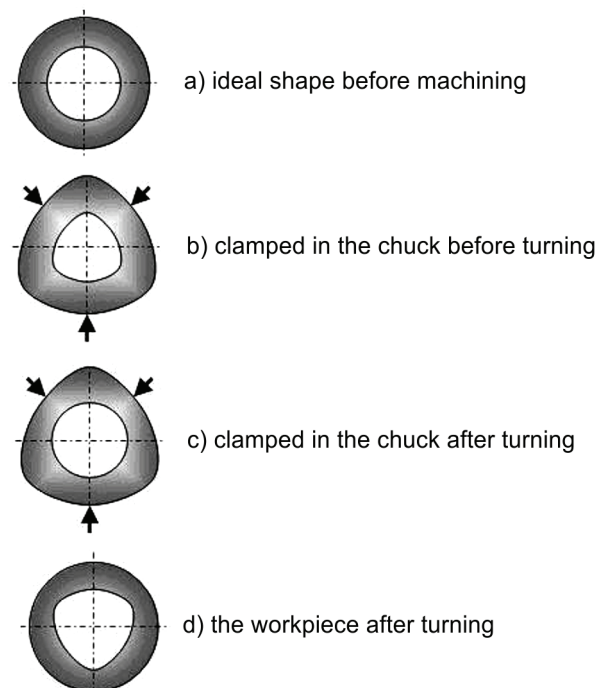
#### 1

#### Introduction

Clamping pressure deforms the part. When the pressure value is relatively low the deformation is elastic, however the higher value of clamping pressure causes plastic deformations. Both plastic and elastic deformations depend on part's rigidity, which is provided by material characteristics of the part and its geometric parameters such as length, diameter, shape and thickness of walls. When a low level of rigidity is employed, high deformations arise and vice versa; the higher level of rigidity, the smaller deformations. In turning the part is usually clamped into three bites chuck, which causes three clamping pressures affecting the surface of the part. Because of low rigidity of the part, the part under the influence of clamping pressure deforms itself, shown in Fig. 1. In turning e.g. inner surface, the machined cylindrical surface is produced on deformed surface of a part. This machined surface has a required shape, accuracy and position in order of other surfaces only when the part is clamped in the chuck. It means that the machined cylindrical surface will remain cylindrical even when clamping pressures are at work. According to a state in turning mainly elastic deformations arise when clamping pressure stops work i.e. the part is not clamped, elastic deformation will fade out and the part will retrieve its original shape without deformation. Therefore the machined cylindrical surface produced under the influence of clamping pressure deforms itself. The principle is shown in Fig. 1, from left to right.

When clamping pressure value is high, yield strength is exceeded and the part deforms partially plastically. When clamping pressure stops work, elastic deformation

fades out, however the part will remain plastically deformed.



**Figure 1** Inaccuracies of a part, caused by clamping pressure

Inaccuracies caused by clamping pressure can be eliminated by the selection of a suitable clamping device – clamping in collet or spike, when clamping pressure is distributed to the whole perimeter of a part, not affecting only three points like in three bites chuck. High levels of accuracy can be achieved in precision machining through the use of highly accurate machine tool elements and

under good machining and environmental conditions. In this work, this method is applied to cylindrical turning.

**1.1 Definition of roundness deviation**

Roundness deviation is the distance between two concentric circles touching and enclosing the extracted circumferential line at the minimum radial distance to each other. Roundness deviation is figured in Fig. 2.

In roundness deviation measurement the deviations from enclosing circles are measured in periodical angular rotation. These deviations are registered into the chart with sized up scale factor. The result is sized up profile of a real circle. Both roundness deviation and run out deviation are evaluated from this chart.

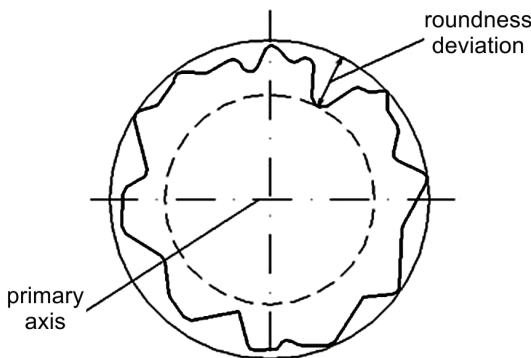


Figure 2 Roundness deviation

Inaccuracies of work piece, raised from clamping device, produce clamping pressure which deforms the workpiece. When the workpiece toughness is at low level in the direction of clamping pressure, the workpiece gets deformed. The material removal is higher than the required cutting depth on the convex deformed surface and lower on the concave deformed surface. During the machining process the geometry and size characteristics of machined surface are as requested, the unclamped part's geometry and size differ because the part changes its shape to the previous state.

**2 Experiment**

The submitted article is focused on experimental verification of clamping pressure influence on roundness deviation. Experimental parts were clamped into three bites chuck (Fig. 3) with clamping pressure value of 3,2 MPa and inner cylindrical surface was machined.

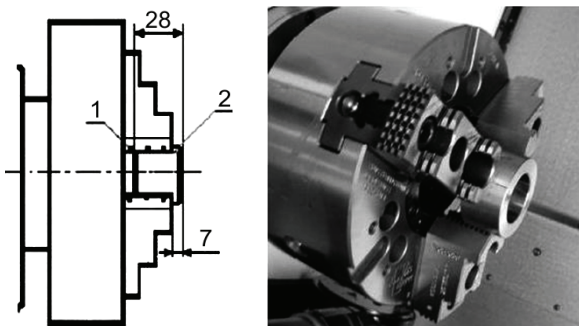


Figure 3 Principle of clamping

Cylindrical workpieces were made of a low carbon steel EN ISO C16E 1.1148 with diameter of  $\varnothing 60$  mm. Five parts were used in experiments with size of  $58 \times 30$  mm (diameter  $\times$  length).

Experiment was realized on DMG CTX Alpha 500 turning machine (Fig. 4), the tool holder CNMG120404RP with blade A-DCLN-KC-95° (Kennametal) was used.



Figure 4 Turning machine DMG CTX Alpha 500

The following cutting parameters and conditions were selected for experimental parts machining:

- feed  $f = 0,2$  mm
- depth of cut  $a_p = 1,5$  mm
- cutting speed  $v_c = 200$  m/min
- No cutting fluid was used.

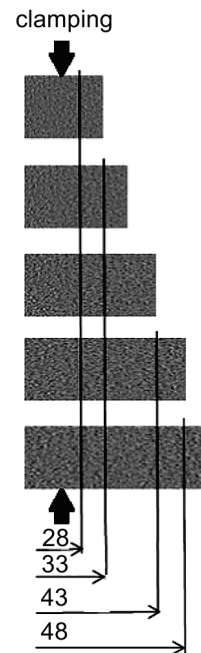


Figure 5 Measurement principle

All experimental parts were clamped at the same distance from the chuck from outer surface with workpiece set-out on the line (Fig. 5) i.e. the line was at the edge of the chuck's bites.

Then inner cylindrical surface was machined with depth of cut  $a_p = 1,5$  mm into inner diameter of  $\varnothing 33$  mm.

In the next step, the face of the part was machined with cutting depth of  $a_p = 0,2$  mm in order to achieve perpendicularity to the part's longitudinal axis.

This is necessary in order to ensure desired position of the part in measurement.

Measurement of roundness deviations was carried out on a ZVL MK 300C (Figs. 6 and 7) device for roundness measurement.



Figure 6 Roundness measurement machine ZVL MK 300C

Measurement was performed as follows (Fig. 6): roundness deviation on part no. 1 was measured at a distance of 28 mm from the line (the same line at which the workpiece was clamped into the chuck). Part no. 2 at a distance of 28 and 33 mm, part no. 3 at a distance of 28 and 33 mm, part no. 4 at a distance of 28, 33 and 43 mm and part no. 5 at a distance of 28, 33, 43 and 48 mm.

Measured values are shown in Tab. 1.

Table 1 Measured values of roundness deviation (in  $\mu\text{m}$ )

$a / \text{mm}$	Part	Filter $2 \div 500$	Filter $2 \div 15$	Filter $16 \div 150$
28	1	10,8	3,6	6,8
	2	3,9	3,3	1,7
	3	9,7	5,1	3,1
	4	11,1	4,7	5,5
	5	4,2	2,5	1,3
	$\Phi$	7,94	3,84	3,68
33	1	×	×	×
	2	8,1	2,4	3,5
	3	4,4	2,8	1,9
	4	7,2	4	4,3
	5	3,3	1,6	1,1
	$\Phi$	5,75	2,7	2,7
43	1	×	×	×
	2	×	×	×
	3	×	×	×
	4	7,6	2,1	5,1
	5	6,5	1,8	4
	$\Phi$	7,05	1,95	4,55
48	1	×	×	×
	2	×	×	×
	3	×	×	×
	4	×	×	×
	5	5,5	1,3	1,7
	$\Phi$	5,5	1,3	1,7

Note:  $a$  – distance from chuck



Figure 7 The workpiece in the measurement device ZVL MK 300C

### 3

#### Measurement results

Fig. 8 shows graphical dependence of mean values of roundness deviation on distance from clamping line. Values are slightly falling down in dependence on distance from clamping line. More filters were used in measurement ( $2 \div 500$ ,  $2 \div 15$ ,  $16 \div 150$ ), however the dependence is the same for all of them. Roundness was approximately 2  $\div$  3 times higher when a  $2 \div 500$  filter was used compared to the  $2 \div 15$  and  $16 \div 150$  filters.

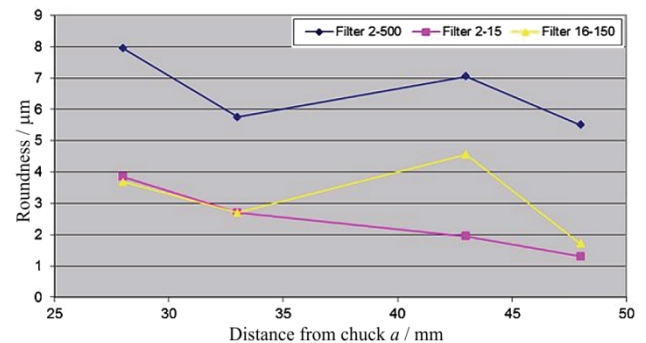


Figure 8 Graphical dependence of mean values of roundness on distance from clamping line

### 4

#### Conclusion

Measured values obtained by experiments and presented in the submitted article show there is a deformation of workpiece while clamping in turning. The deformation affects geometric deviation of machined surface. According to the measurement it is possible to predict the fact that with clamping the deformation increases which has negative effect on geometric accuracy of the part, consequently the deformation causes roundness failure. Roundness failure is highest at the points of clamping, and it falls down along the axis with the distance from the clamping points. It can be explained by a simple fact that with increasing the distance from the clamping points, the deformations decrease since the pressure does not affect the whole part.

## 5

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