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Contamination of roughness artefacts – impact on the measurement results

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Abstract

When roughness artefacts are used in the production environment, a contamination with operational residues is possible. There are many methods for the cleaning of technical surfaces, but no specific strategy regarding roughness artefacts is proven suitable. A study on the impact of contamination on the measurement results of roughness artefacts was carried out. Defined, production-related contaminations were applied and the samplings were cleaned with an ultrasonic cleaning system, compressed air, and CO_2 snow blasting to examine the impact of dirt on the roughness parameters. Experimentally it can be shown that certain contaminations like metal swarf and cutting oil can be cleaned easily with different methods, while penetrating oil is hard to remove from the surface. It is possible to evaluate the quality of the cleaning methods and to give recommendations for cleaning.

surface cleaning, roughness artefacts, inline measurement

1. Introduction

An emerging trend in precision engineering is the use of inline measurement systems [1]. A result is the growing need to calibrate measuring instruments in the manufacturing environment. This makes a contamination of measurement artefacts with operational residues more likely. At the University of Kaiserslautern, new roughness artefacts are developed and manufactured. In this paper the influence of the residuals (penetrating oil, cutting oil and metal swarf) and possible cleaning methods (compressed air, ultra-sonic cleaning with isopropanol and snow blasting with CO_2) are investigated.

2. Cleaning of Surfaces – current strategies

Roughness artefacts (Type D of ISO 5436-1 [2]) are sensitive and should be handled carefully when they are contaminated. For technical surfaces there are different cleaning techniques established but rarely specific strategies for measurement artefacts. The German guideline DKD-R 4-2 Sheet 3 states that a microfiber tissue with isopropanol can be used when the wiping is performed parallel to the grooves in order to avoid damages [3]. The scopes of application of this guideline are limited to stylus instruments.

3. Manufacturing

The roughness artefacts were manufactured using an ultra-precision lathe with a high stiffness and movement in the nanoscale. The workpiece was screwed on the spindle and machined in a preceding face turning process to achieve the necessary flat surface. Therefore a monocrystalline diamond (MCD) tool with a large corner radius r_ε was used to achieve a small kinematic roughness. Due to the filigree structure, a MCD- tool with a special tip geometry was used. The process conditions and the tool with a corner angle of 55° and a chamfer of 10 µm are shown in Figure 1.

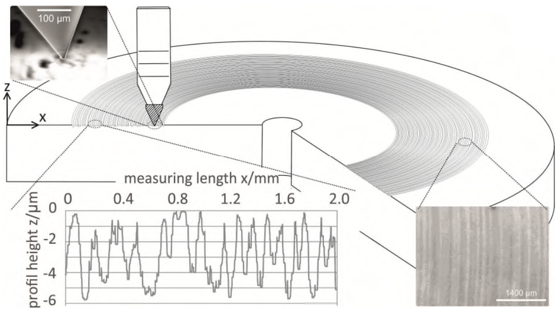

Figure 1. Process conditions

4. Measurement Setup

To pollute the manufactured artefact with typical soil from a production environment penetrating oil (low-viscosity oil to pretend corrosion), cutting oil and metal swarf were applied. The topography was characterized at the same spot before and after the contamination as well as after the cleaning. The confocal microscope NanoFocus µSurf with a 20x objective (numerical aperture of 0.6) was used. The evaluation was performed by using all 512 profiles that are included in the topography dataset in order to calculate the roughness parameters according to ISO 4287 and to calculate the mean parameters and their standard deviation considering all profiles. Filters were applied according to ISO 16610-21 with the wavelengths lc = 0.8 mm and ls = 2.5 µm. The reference state was determined with a first measurement. Then, after every pollution and every cleaning another measurement at the same spot was executed.

5. Results and Discussion

Roughness parameters (ISO 4287) and the characterisation of optical artefacts are considered. The integral parameters R_a und R_q are used for each profile because they allow a conclusion for the overall state of the surface. The evaluation length is 640 µm. Because of the profile curvature according to the turning process and positioning deviations not the entire measuring length can be evaluated. The start of the evaluation length is detected for each profile and the mean values and the standard deviations of the parameters considering all profiles are calculated. A contamination with penetrating oil was applied three times at the same spot and each time another cleaning method was used afterwards. The roughness parameters of the reference state and after each contamination and cleaning are shown in Table 1.

Table 1 Results of penetrating oil, mean value and standard deviation

	R_a / µm	R_q / µm
Reference state	*1.406±0.012*	*1.618±0.013*
Contamination 1	0.957±0.015	1.108±0.020
Compressed air cleaning	*1.282±0.039*	*1.502±0.044*
Contamination 2	0.940±0.020	1.103±0.074
Ultra-sonic cleaning	*1.329±0.011*	*1.526±0.022*
Contamination 3	0.927±0.016	1.074±0.018
Snow blasting	*1.414±0.062*	*1.660±0.169*

Without cleaning, the penetrating oil has a big impact on the measurement results. There are high adhesive forces that complicate the cleaning. The oil is specially designed to wet the surface reliably. An impact on the measurement results is still visible after all cleaning methods. Compressed air spreads the oil on the surface. The deviations could be corrected with the Ellipso-Height Topometer (EHT) [4], which measures the topography and the material properties in order to correct material dependant topography deviations [4]. The EHT is examined within the CRC (Collaborative Research Center) 926 "Microscale Morphology of Component Surfaces".

An analogue approach was chosen to quantify the effect of cutting oil. Cutting oil is easier to clean than penetrating oil because it is less viscid. After the cleaning the reference parameters are achieved within the measurement uncertainty (see Table 2). All cleaning methods lead to good results. When the topography is observed (see Figure 2), there is still a visible impact on the surface after the cleaning. The optical artefacts that change the roughness parameters can be demonstrated when the averaged profile of all 512 profiles is examined as shown in Figure 3.

Table 2 Results of cutting oil, mean value and standard deviation

	R_a / µm	R_q / µm
Reference state	*1.395±0.011*	*1.611±0.011*
Contamination 1	0.958±0.016	1.129±0.019
Compressed air cleaning	*1.405±0.011*	*1.620±0.012*
Contamination 2	1.856±1.194	2.617±1.910
Ultra-sonic cleaning	*1.390±0.012*	*1.606±0.016*
Contamination 3	0.936±0.014	1.088±0.018
Snow blasting	*1.389±0.013*	*1.605±0.017*

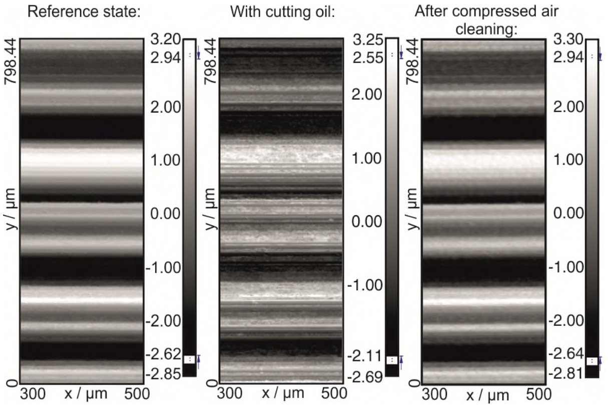

Figure 2. Impact of cutting oil on the topography

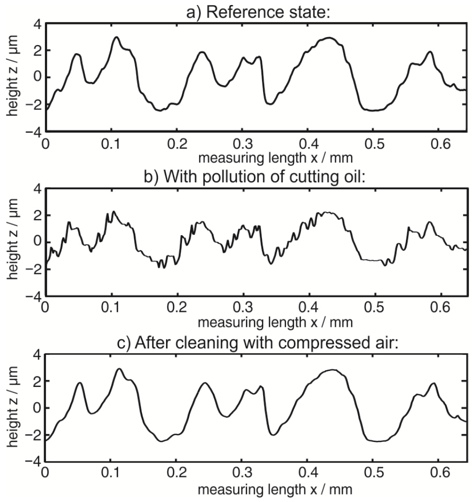

Figure 3. Averaged profile, cutting oil cleaned with compressed air

Swarf has a random effect on the measurement: if there is swarf within the measurement area, depending the size, no meaningful evaluation is possible. The cleaning of swarf is very easy. The results of all cleaning processes (Table 3) deviate within the measurement uncertainty. Swarf has no high boundary forces towards the surface.

Table 3 Results of swarf, mean value and standard deviation

	R_a / µm	R_q / µm
Reference state	*1.416±0.015*	*1.632±0.014*
Contamination 1	16.978±21.727	26.221±33.219
Compressed air cleaning	*1.413±0.016*	*1.630±0.016*
Contamination 2	18.874±34.265	24.848±43.803
Ultra-sonic cleaning	*1.410±0.013*	*1.624±0.014*
Contamination 3	44.040±43.011	64.141±49.205
Snow blasting	*1.412±0.013*	*1.625±0.013*

6. Conclusion

A careful handling of roughness measurement artefacts is essential. Contamination causes artefacts and heavy deviations of the roughness parameters, not only when optical measurement instruments are used. Generally, there are methods that work for the cleaning of technical surfaces as well as for measurement artefacts. However, the cleaning strategy has to be chosen in regard to the application and contamination of the surface. Normally, cutting oil and swarf are easy to clean while penetrating oil still has an impact on the parameters. In future work the combination of these methods should be investigated and cleaning strategies defined.

Acknowledgement

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References

[1] Seewig J, Beichert G, Brodmann R, Bodschwinna H, Wendel M 2009 Extraction of Shape and Roughness using Scattering Light, *Proc. of SPIE* **73890N**

[2] ISO 5436-1 2000 Geometrical Product Specifications (GPS), Surface texture: Profile method, Measurement standards

[3] German Calibration Service (DKD) 2011 Guideline 4-2 Sheet 3, „Calibration of instruments and artefacts for the roughness measurement", German guideline

[4] Leonhardt K, Droste U, Tiziani H-J 2003 Interferometry for Ellipso-Height-Topometry – Part 1: Coherence Scanning on the base of spatial coherence *Optik* **113** 12 513-19