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AN EXAMINATION OF THE CONDITION OF WORKING SURFACES OF CRANKSHAFT CRANKPINS AND JOURNALS BASED ON THE MATERIAL FRACTION CURVES

OCENA STANU MIKROGEOMETRII POWIERZCHNI ROBOCZYCH CZOPÓW WAŁÓW KORBOWYCH NA PODSTAWIE PRZEBIEGU KRZYWEJ UDZIAŁU MATERIAŁOWEGO

Key words:

crankshafts, material fraction curve, surface microgeometry

Słowa kluczowe:

wały korbowe, krzywa materiałowa, stan mikrogeometrii

Abstract

The paper focuses on the significance of the microgeometry of the working surfaces of crankpins and the main bearing journals on the durability and reliability of farm tractor engines. Alternative surface roughness parameters for the quantitative description of the material fraction curve are suggested to be applied as factors facilitating the evaluation of the performance properties of the

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working surfaces of the crankpins and main bearing journals. The results of graphometric profile examination of new crankshafts, the crankshafts recognized as run-in, and reworked ones have been provided and the assessment of the results concerned was basis for the evaluation of the proposed methodology for the examination of the microgeometry of the surfaces concerned. The results confirmed the suitability of slope indicators of straight lines describing the behaviour of material fraction as the evaluation parameters of performance properties of the working surfaces of the crankpins and main bearing journals.

INTRODUCTION

New materials and engineering solutions as well as continuous perfection of lubricants contributed to the significant improvement in the reliability of engines. Consequently, failure-free operation time of mechanical units of the engines tends to be equivalent to the durability of the complete technical object. In case of major defects along with the declining interest of repair workshops providing engine repair service due to economic reasons, operators willingly regard the engines as replaceable units. This, however, does not apply to engines of self-propelled farm machines, mainly tractors and harvesters, the repair of which is still to be recognized reasonable, although its scope is rather wide and the cost high. High purchase price and relatively short operation time throughout a year are taken into consideration. Many years of operation with changeable loads, so typical for farming environment, may result in frequent defects that include engine breakdown (confirmed by survey results **[L. 5]**).

Operation conditions of farm machines mainly affect the tribological wear of slide bearings. Long downtime periods between seasons and the intense variability of dynamic load result in the permanent run-in of the nodes concerned **[L. 1, 4]**. Moreover, during the downtime period, tribological processes are enhanced by phenomena taking place in a contact zone, mainly because of electrolytic interaction between non-equivalent materials **[L. 12, 15]**. Consequently, destruction processes in contact zones intensify and cause a higher rate of failure frequency.

The hydrodynamically lubricated farm tractor crankshaft slide bearings are especially exposed to transient operating conditions. During frequent start-ups, stops and operation overloads, working parameters of the nodes concerned are likely to be below critical values for the oil wedge (relative velocity < 0.8 m/s, thrust > 10 MPa **[L. 6]**). Furthermore, during normal operation of farm machines, the parts thereof are subject to increasing mechanical load due to, e.g., changes in tillage (the use of multi-task machinery, plough-free sowing, etc.) or higher and higher yield. Consequently, after long periods of unfavourable conditions, the machines have to cope with requirements for which they have not been designed. In this connection, the operation efficiency of a group of the machines in the study is largely dependent on the quality and time-schedule of the maintenance schemes. As far as kinematic nodes are concerned, there is always the so called ‘rework margin’ that makes it possible to carry out a certain number of consecutive repairs which have to be performed with regard to changeable requirements of the users **[L. 3]**. The common processes applied to restore the initial geometrical shape, surface roughness, and clearance in the case of used parts, as well as in new parts, do not meet a criterion of readiness to accommodate full load by the nodes once putting them into operation.

In this connection, it was found reasonable to look for the assessment criterion applicable to the manufacture and repair of crankshafts with regard to the preparation of working surfaces for actual operation load conditions. Moreover, it was also assumed that the roughness parameters describing the course of material fraction curve proposed by the authors are useful as performance quality determinants of working surfaces of the crankpins and journals. The research lines seem to be in agreement with issues concerning the perfection of friction surfaces in manufacturing processes proposed in the literature **[L. 9, 18]**.

METHODS AND RESEARCH SUBJECT MATTER

The arithmetic mean of profile *Ra* ordinates and the alternative parameters describing the course of material fraction curve proposed by the authors were selected to evaluate the surface condition of the crankpins and journals. The selection of *Ra* parameters was carried out considering the application prevalence and availability of measurement methods both in lab and field conditions.

The *Ra* does not definitely identify geometrical properties of the surface roughness profile **[L. 19]**, that is why the material fraction curve is deemed to provide more complete information **[L. 7, 17]**. In terms of statistics, the curve represents the distribution function of profile ordinate heights and determines the probability of taking on values smaller than *z* by the ordinate of profile *Z*, which is a random variable as follows:

$$F(Z) = P\{Z \le z\} \quad (1.1)$$

Three characteristic sections are distinguished in a graphic representation of the material fraction image that identifies different heights of ridges on the surface: highest protrusions, core roughness, and largest cavities. The most interesting seems to be a possibility to describe each characteristic section of the material fraction curve by means of a straight-line equation. Inclination factors of the straight lines provide for the quantitative assessment of the surface topography, which is not possible in the case of the graphic image of the material fraction curve. The authors’ methodology made it possible to estimate the factors concerned through the use of certain parameters identified based on the course of the material fraction curve **(Fig. 1)** according to the following formulas:

$$a_1 = \frac{Rpk^*}{Mr_1},\ a_2 = \frac{Rk}{Mr_2 - Mr_1},\ a_3 = \frac{Rvk^*}{1 - Mr_2} \qquad (1.2)$$

where: *Rk* – core roughness height, *Rpk** – protrusion height, *Rvk** – cavity depth, Mr_1, Mr_2 – material fraction of protrusions and cavities.

Parameters used in calculations are determined by the secant of the smallest inclination angle in relation to the material fraction curve that runs through two points – the distance between them equivalent to 40% of the material fraction. Abstract values of *Rpk**, *Rk*, and *Rvk** were used to calculate factors a_1, a_2, and a_3, whereas Mr_1 and Mr_2 were expressed by means of measures of probability. It is consistent with the statistical interpretation of the material fraction curve. Furthermore, relatively greater values of the inclination factors were obtained, which facilities a comparison thereof and simplifies the calculations.

The usefulness of the parameters concerned was verified based on a comparative microgeometrical examination of the run-in, reworked (ground and polished), and new crankpins and journals, i.e. exhibiting potentially differentiated performance properties in terms of their stereometric features. Crankshafts of different types of farm tractors were subjected to examination with a HOMMELWERKE T-1000 profilegraphometer combined with TURBO DATAWIN NT software.

Measurements were taken as shown in **Fig. 2**, and crankshafts of 4-cylinder engines were examined (the study included the crankshafts of tractors C-360 and C-385). Three measurements were taken on each crankpin and journal of the elementary distance length according to a standard **[L. 11]**. The measurements were taken along a generating line of the crankpins and journals in three points on a circumference, 120° shift (section A-A). The measurement points were not situated near lubrication holes. Prior to the measurement procedure, the crankshafts were cleaned, counterweights were removed, and the crankshafts were placed on V-blocks situated on a table top, just like the profilegraphometer. Such positioning of parts to be examined provided pre-levelling in relation to the measuring head of a device. The accurate location of a sensor tip along the axis of symmetry and parallel to the surface of crankpins and journals was achieved through settings of profilegraphometer controls. It shall be noted that the examination was performed in different workshops, since the measurement set was portable (profilegraphometer + portable PC). The methodology had to be simplified to some extent due to technical-organization difficulties and differences in the crankshaft design; e.g. it was impossible to provide repeatable and strictly defined measurement spots on different crankshafts. It shall also be noted that, in the case of crankshafts scheduled for

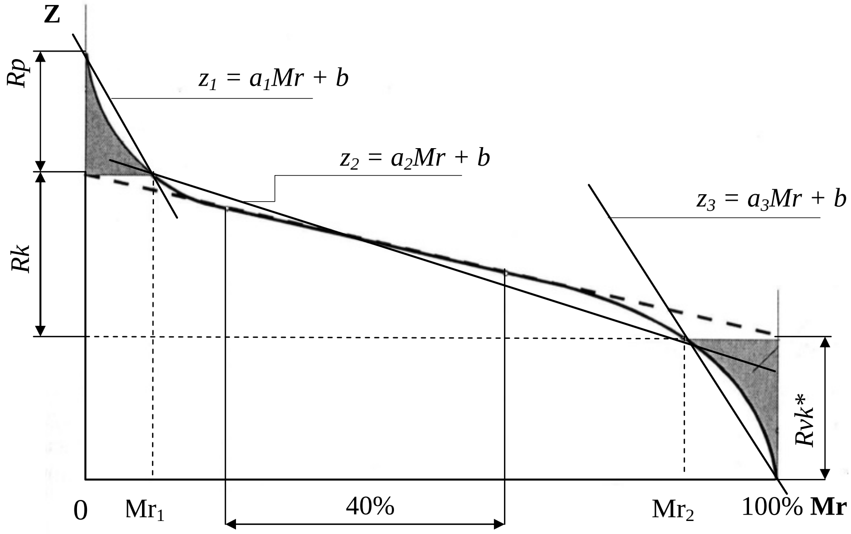

Fig. 1. Graphic interpretation of assumed way of description of material fraction curve: z_1 – straight line representing highest protrusions, z_2 – straight line representing core roughness, z_3 – straight line representing largest cavities, *Rk* – core roughness height, *Rpk – protrusion height, *Rvk** – cavity depth, Mr_1,Mr_2 – material fraction of protrusions and cavities**

Rys. 1. Krzywa materiałowa z interpretacją graficzną sposobu jej opisu prostymi: z_1 – prosta opisująca najwyższe występy nierówności, z_2 – prosta opisująca chropowatość rdzenia, z_3 – prosta opisująca wgłębienia nierówności, *Rk* – wysokość chropowatości rdzenia, *Rpk** – wysokość wzniesień, *Rvk** – głębokość wgłębień, Mr_1, Mr_2 – udziały materiałowe wzniesień i wgłębień

grinding and polishing, the measurements were purposely taken at points identified based on visual inspection. While selecting the measurement points, the requirement of determining roughness parameter values characteristic for run-in areas was taken into consideration.

One of the graphometric profile examination goals was to determine a range of *Ra* and a_1, a_2, and a_3 values for working surfaces of the run- in crankpins and journals. During the operation run-in of the sliding nodes, the “equilibrium roughness” is formed on the friction surface, and the values of parameters correspond to actual operation conditions. The equilibrium state of the friction surface is considered to provide the minimum of potential energy and the least dispersion of energy in certain operating conditions **[L. 8]**, which translates to the high thermodynamic stability and resistance of the top layer to tribological wear **[L. 13]**. In this connection, the equilibrium roughness can be a criterion for the evaluation of the performance quality of the working conditions of the crankpins and journals after the processing and treatment during manufacture and repair **[L. 14]**.

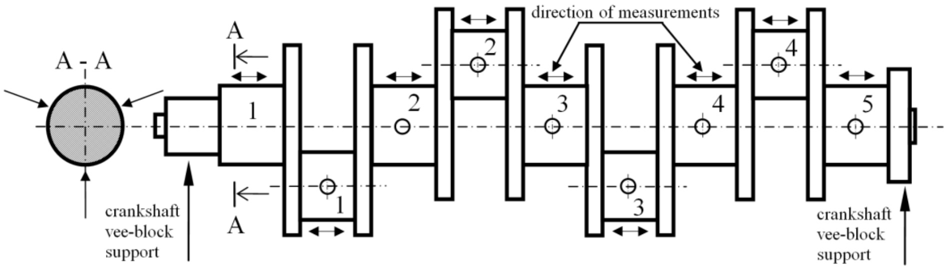

Fig. 2. Crankshaft and the areas of measurement over a circumference of crankpins and journals (section A–A) and measurement directions

Rys. 2. Schemat wału korbowego z oznaczeniem obszarów wykonywania pomiarów na obwodzie czopów (przekrój A–A) oraz kierunkami ich prowadzenia

The microgeometry of the surfaces of the crankpins and journals was examined and studied after the crankshafts were classified for repair, following typical examination actions. It was assumed that parts of the linear wear close to the allowable limits and with no visible signs of pathologic (critical) wear can exhibit areas of the crankpins and journals in which values of the equilibrium roughness parameters are likely to be determined. The assumption resulted in the applicable methodology of measurements of the crankpins and journals in pre-determined areas. The procedure is shown in **Fig. 3**, representing a journal of URSUS C-385 engine crankshaft with a point of the deposited bushing material where measurements had to be taken outside the point concerned.

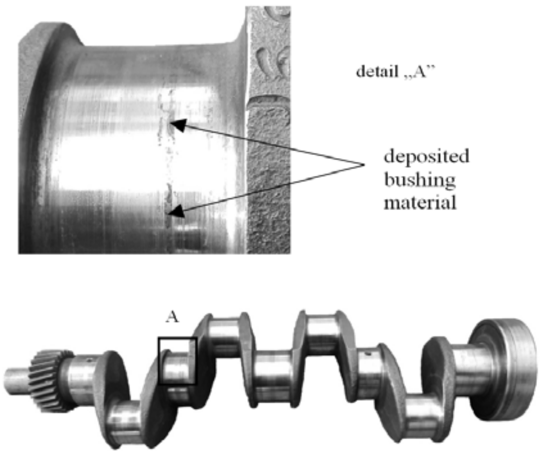

Fig. 3. Crankshaft of URSUS C-385 farm tractor

Rys. 3. Wał korbowy ciągnika URSUS C-385

RESULTS

Tables 1 and **2** contain average values of the *Ra* and a_1, a_2, and a_3, which were estimated based on the examination of the crankshafts of selected farm tractors. Measurement results concerning the run–in parts (qualified for reworking by grinding and polishing, without signs of pathologic wear) and reworked parts are listed in **Tables 1** and **2**, respectively. Values of basic statistical parameters representing the dispersion of the results in groups and the assignment to the crankpins and journals were also provided. Positive values of parameters a_1, a_2, and a_3 result from the applied method of algebraic calculations, whereas, according to the function interpretation corresponding to equations of the straight lines describing the material fraction variations, the results of the inclination factors shall be preceded with a minus sign (-) (decreasing values of profile secants correspond to increasing material fractions).

In the case of the run-in parts, the greater roughness of journal surfaces is noted in comparison with the crankpin surfaces as indicated by average values of the parameters and standard deviations in certain measurement groups. The findings are rather surprising, since the journals are provided with more favourable lubrication conditions due to the kinematics of their motion and the distribution of dynamic loads.

The results of graphometric profiles measurements were subject to statistical evaluation to find out whether the stereometry of the surfaces of the crankpins and journals of the run-in and reworked (ground and polished) crankshafts identified by applied roughness parameter values appears to be significantly different. Average values of the *Ra*, a_1, a_2, and a_3 were subject to Student's test (performed at equal variances of lots) and Cohran-Cox test (for significantly different variances of a lot). A significance level of $\alpha = 0.05$ was assumed to prove that only in case of the average values of parameter a_3, obtained from measurements of URSUS C-360 crankshaft, was there no grounds to reject a null hypothesis of assuming the average values to be equal. Values of the probability of type 1 error for the remaining parameters were several times smaller than the assumed level of significance. Therefore, it can be concluded there are significant differences between the average values of parameters describing the surfaces of reworked and run-in crankpins and journals. The most significant differences regarding the roughness of the reworked and run-in crankshafts were found for the *Ra* and a_2, whereas the differences in case of the a_1 and a_3 are statistically less significant.

Table 1. Results of graphometric profile examination of crankshafts recognized as run-in parts

Tabela 1. Wyniki badań mikrogeometrycznych wałów uznanych za dotarte jednostek napędowych wybranych ciągników rolniczych

Parameter	URSUS C – 360*					Parameter	URSUS C – 385*				
	Item	**Average** [μm]	**s** [μm]	**Min.** [μm]	**Max.** [μm]		**Item**	**Average** [μm]	**s** [μm]	**Min.** [μm]	**Max.** [μm]
Ra	Journals	0.27	0.06	0.17	0.38	**Ra**	Journals	0.25	0.09	0.13	0.50
	Crankpins	0.20	0.05	0.14	0.33		Crankpins	0.20	0.03	0.13	0.28
a_1	Journals	7.89	2.94	3.66	12.33	**a_1**	Journals	5.93	3.07	1.75	14.00
	Crankpins	5.73	3.18	2.32	11.22		Crankpins	5.88	2.09	2.36	9.80
a_2	Journals	0.85	0.21	0.44	1.15	**a_2**	Journals	0.96	0.46	0.35	1.86
	Crankpins	0.68	0.18	0.53	1.09		Crankpins	0.62	0.14	0.47	0.87
a_3	Journals	13.76	9.43	5.88	36.86	**a_3**	Journals	10.06	4.27	4.22	22.27
	Crankpins	11.42	7.36	3.61	24.71		Crankpins	9.75	3.66	5.24	19.56
Parameter	**Massey - Ferguson 225***					**Parameter**	**JOHN DEERE***				
Ra	Journals	0.26	0.06	0.17	0.43	**Ra**	Journals	0.16	0.05	0.07	0.21
	Crankpins	0.23	0.07	0.14	0.34		Crankpins	0.12	0.08	0.03	0.34
a_1	Journals	6.21	1.83	2.80	10.41	**a_1**	Journals	3.86	3.26	1.33	10.13
	Crankpins	5.14	2.94	2.00	11.59		Crankpins	2.84	1.51	1.03	6.56
a_2	Journals	0.92	0.27	0.10	1.36	**a_2**	Journals	0.49	0.17	0.22	0.71
	Crankpins	0.67	0.24	0.30	1.02		Crankpins	0.39	0.23	0.13	0.66
a_3	Journals	9.95	3.76	4.70	19.15	**a_3**	Journals	8.78	4.10	3.76	19.95
	Crankpins	10.53	7.22	4.50	28.22		Crankpins	8.16	3.59	2.47	15.36

* Results developed on basis of measurements: URSUS C – 360 (3 crankshafts), URSUS C – 385 (3 crankshafts), Massey- Ferguson 225 (2 crankshafts), JOHN DEERE (3 crankshafts, part No. RE505921), s – standard deviation

Table 2. Results of graphometric profile examination of reworked crankshafts
Tabela 2. Wyniki badań mikrogeometrycznych wałów regenerowanych jednostek napędowych wybranych ciągników rolniczych

Parameter	**URSUS C – 360***					**Parameter**	**URSUS C – 385***				
	Item	**Average** [μm]	**s** [μm]	**Min.** [μm]	**Max.** [μm]		**Item**	**Average** [μm]	**s** [μm]	**Min.** [μm]	**Max.** [μm]
Ra	Journals Crank-pins	0.59 0.63	0.17 0.16	0.30 0.37	1.07 0.98	**Ra**	Journals Crank-pins	0.51 0.50	0.16 0.13	0.25 0.25	0.82 0.69
a_1	Journals Crank-pins	11.57 13.55	3.93 5.58	5.19 6.04	21.85 27.43	**a_1**	Journals Crank-pins	17.24 10.03	9.65 3.75	3.95 4.29	36.40 20.56
a_2	Journals Crank-pins	2.42 2.53	0.79 0.72	1.18 1.49	4.59 3.94	**a_2**	Journals Crank-pins	1.77 2.52	0.71 0.73	0.90 1.49	3.09 3.94
a_3	Journals Crank-pins	14.94 16.65	6.28 5.62	7.56 6.46	37.62 38.79	**a_3**	Journals Crank-pins	14.26 12.70	7.68 5.62	4.29 5.60	41.46 27.70
Parameter	**Massey- Ferguson 225***					**Parameter**	**JOHN DEERE***				
Ra	Journals Crankpins	0.68 0.64	0.06 0.06	0.59 0.56	0.81 0.79	**Ra**	Journals Crankpins	0.41 0.48	0.06 0.11	0.33 0.28	0.61 0.73
a_1	Journals Crankpins	16.65 17.49	5.44 6.12	8.55 11.38	28.70 26.37	**a_1**	Journals Crankpins	12.51 11.73	3.57 4.26	7.44 8.70	20.81 26.72
a_2	Journals Crankpins	2.29 2.32	0.32 0.65	1.60 1.64	2.70 3.74	**a_2**	Journals Crankpins	1.89 2.15	0.15 0.35	1.59 1.52	2.22 2.56
a_3	Journals Crankpins	18.95 19.03	6.39 5.43	9.44 9.35	40.85 27.56	**a_3**	Journals Crankpins	12.51 13.28	2.56 2.50	8.10 10.33	18.66 19.15

* Results developed on basis of measurements: URSUS C – 360 (3 crankshafts), URSUS C – 385 (2 crankshafts), Massey- Ferguson 225 (2 crankshafts), JOHN DEERE (2 crankshafts, part No. RE505921), s – standard deviation

For comparison, the microgeometry of the working surfaces of the crankpins and journals of new crankshafts was performed. Results listed in **Table 3** and measurements of the dispersion within measurement groups lay the grounds for estimating the condition of the surface of the crankpins and journals developed during the manufacture.

The examination results, especially regarding the values of parameters *Ra* and a_2 obtained on the basis of measurements on crankshafts of JOHN DEERE engines, speak for the very accurate after-machining. The authors do not have complete knowledge on how the microgeometry of JOHN DEERE crankpins and journals was developed, but it has to be assumed that working surfaces were super finished after grinding. Consequently, the similar microgeometry of the surfaces of the run-in and new crankshafts was developed which can be proved by the analysis of roughness profiles and material fraction curves. The evaluation of the topography of the surfaces of the crankpins and journals after the super finish during the rework procedure shows significant quality differences with regard to the roughness of the crankpins and journals of the new and run-in crankshafts. In case of the reworked crankshafts, the *Ra* most often ranged between 0.33–0.63 µm (roughness class 8 according to standard PN-87/M-04251), which is typical for the final grinding.

Table 3. Results of graphometric profile examination of new crankshafts
Tabela 3. Wyniki badań profilografometrycznych wałów korbowych nowych

Pa-ram-eter	**URSUS C – 360***					**Pa-ram eter**	**JOHN DEERE***				
	Item	**Average** [µm]	**s** [µm]	**Min.** [µm]	**Max.** [µm]		**Item**	**Average** [µm]	**s** [µm]	**Min.** [µm]	**Max.** [µm]
Ra	Journals Crankpins	0.30 0.31	0.06 0.06	0.21 0.20	0.47 0.42	**Ra**	Journals Crankpins	0.11 0.15	0.04 0.06	0.07 0.08	0.21 0.29
a_1	Journals Crankpins	6.84 6.32	3.31 3.28	3.25 3.61	16.09 15.48	**a_1**	Journals Crankpins	2.51 3.74	1.09 2.12	0.28 1.03	5.45 8.00
a_2	Journals Crankpins	1.16 1.08	0.19 0.25	0.95 0.73	1.16 1.52	**a_2**	Journals Crankpins	0.37 0.47	0.08 0.19	0.24 0.27	0.49 0.78
a_3	Journals Crankpins	9.04 9.76	4.54 2.82	4.24 5.00	22.31 13.85	**a_3**	Journals Crankpins	6.54 9.68	2.92 3.28	2.23 4.11	13.24 16.80

* Results evolved from measurements: URSUS C – 360 (3 crankshafts), JOHN DEERE (3 crankshafts of the part catalogue No. RE505921), s – standard deviation

Differences in the microgeometry of the surfaces of the new, run-in, and reworked crankpins and journals were compared by means of the graphic presentation of selected results of graphometric profile examination of JOHN DEERE crankshafts. The selection of profiles and corresponding material fraction curves was based on the results of measurements in which parameter *Ra* values correspond to estimated average values of the roughness of journals

(**Fig. 4**). To make the quality assessment (visual) of the roughness profiles and the course of material fraction curves objective, the same zoom (horizontal and vertical) scale was applied. The graphic presentation of the material fraction curve representing the microgeometry of reworked crankpins and journals features a greater inclination angle in comparison with the curve of the material fraction for the new and run-in ones. It shall be noted that the inclination angle of the material fraction curve was even greater in the case of the measurements on the reworked crankshafts of URSUS and Massey-Ferguson engines. Such a situation shall be regarded as unfavourable for the run-in period for a sliding node (crankpin/journal – bushing) to operation circumstances. In transient states (start-up, stops) without conditions facilitating the development of full fluid lubrication, a friction contact between components of the friction node may occur. In such conditions, the hardened surface of a crankpin or journal exhibiting high roughness protrusions and rather low capacity can trigger the accelerated abrasive wear of the bushing. The described condition of the surface is contrary to favourable quality features of the friction surface, i.e. the absence of protrusions and identified cavities that are lubrication oil pits **[L. 2, 10, 16]**.

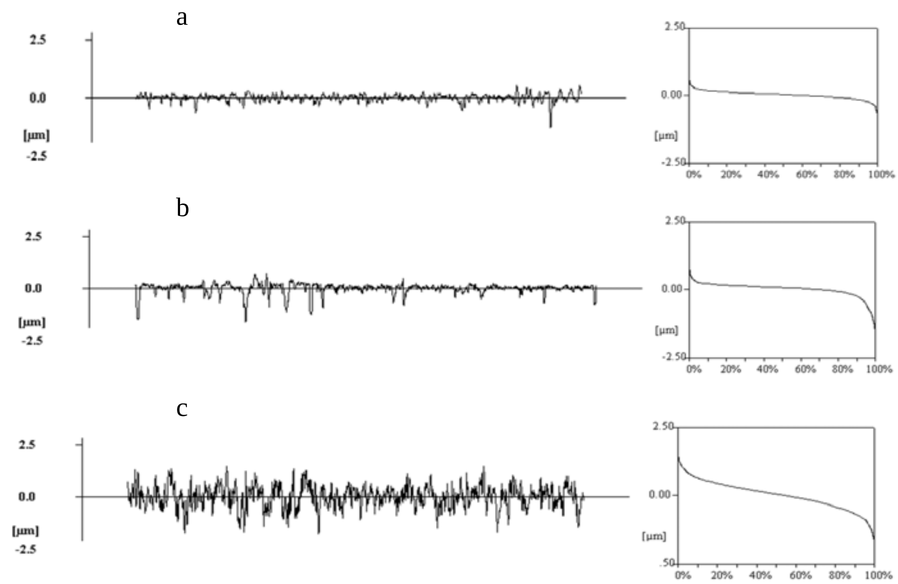

Fig. 4. Selected measurements of the microgeometry of John Deere crankshaft journals: a – roughness profile and material fraction curve of a new crankshaft journal surface (Ra = 0.11 µm), b – roughness profile and material fraction curve of a run-in crankshaft journal surface (Ra = 0.16 µm), c – roughness profile and material fraction curve of a reworked crankshaft journal surface (Ra = 0.41 µm)

Rys. 4. Wybrane wyniki pomiarów czopów głównych wałów napędowych John Deere: a – profil chropowatości i krzywa udziału materiałowego dla czopa wału dotartego (Ra = 0,16 µm), b – profil chropowatości i krzywa udziału materiałowego dla czopa wału nowego (Ra = 0,11 µm), c – profil chropowatości i krzywa udziału materiałowego dla czopa wału poddanego naprawie (Ra = 0,41 µm)

The lower roughness of the new crankshaft crankpins and journals on JOHN DEERE engines in comparison with the run-in ones cannot unequivocally be regarded favourable. Such a condition of the surface can, in the case of the direct contact between sliding node components, foster the development of adhesive-like reactions. In micro-areas of friction contact, adhesions are likely to form, the material of parts in the contact zone can harden (due to plastic-elastic strain), and consequently the displacement of the parts can cause the detachment of metal particles of lower strength.

CONCLUSIONS

The results of the graphometric profile examination confirm the usefulness of inclination factors of straight lines describing the course of material fraction as the parameters of the performance properties of the working surfaces of the crankpins and journals concerned. The quality assessment of roughness profiles and corresponding courses of the material fraction supported by the statistical analysis of mean values of parameters applied to the evaluation of the stereometry of the crankpins and journals give rise to drawing the following conclusions:

– The microgeometry of working surfaces of the reworked and run-in crankshaft crankpins and journals described by means of the mean values of the Ra, a_1, a_2, and a_3, differs significantly in terms of the statistics, whereas the most significant differences were found for Ra *and* a_2.
– Average values of parameters a_1 and a_3 calculated based on the results of the measurements of surfaces of the run-in crankpins and journals of crankshafts can exhibit greater deviation from the equilibrium values rather than the average Ra and a_2. It results from the 'sensitivity' of the parameters to single high protrusions (a_1) and deep cavities (a_3), which were found while performing the quality assessment of roughness profiles of the run-in parts.
– Measurements of the new crankshafts indicate a more sophisticated process of developing the microgeometry of the crankpins and journals during manufacture in comparison with conditions in repair workshops. It means that treatment process changes can be implemented to improve the surface of the crankpins and journals along with the use of the results of the roughness measurements of the run-in parts as the reference for the evaluation of the repair quality. The study confirmed that the Ra and a_2 can be the most useful of the parameters applied to the evaluation of the microgeometry of the surfaces of the crankpins and journals.

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Streszczenie

W artykule wskazano na znaczenie wpływu stanu stereometrycznego powierzchni roboczych czopów wałów korbowych na trwałość i niezawodność jednostek napędowych ciągników rolniczych. Zaproponowano wykorzystanie alternatywnych parametrów chropowatości opisujących w sposób ilościowy przebieg krzywej udziału materiałowego jako potencjalnie pomocnych w ocenie właściwości użytkowych powierzchni roboczych czopów. Przedstawiono wynik badań profilografometrycznych wałów nowych, wałów uznanych za dotarte oraz po ich obróbce wykańczającej w procesie naprawy, na podstawie oceny których wnioskowano o przydatności zaproponowanej metodyki oceny mikrogeometrii czopów. Uzyskano wyniki wskazujące na przydatność współczynników kierunkowych prostych opisujących przebieg udziału materiałowego jako parametrów oceny właściwości użytkowych powierzchni roboczych badanych czopów wałów korbowych.