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FINISHING OF THE METAL MATRIX COMPOSITE COATINGS APPLIED TO REGENERATED PARTS OF SHIP MACHINERY

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Abstract

Most elements of ship machinery parts are regenerated during the cruise ship. Engineer often regenerates cylindrical outer surfaces (for example torque pump shaft neck). The welding technology of applying alloy and composite coatings is very common. The technology of infrasound thermal spraying of metal matrix composite coatings was presented. It is a simple technology and a very useful one in ship machinery regeneration during the cruise craft (e.g. internal combustion engines, torque pumps, separators). The metal matrix composite coatings must undergo finishing due to high surface roughness after application. The most popular is machining (e.g. turning or grinding). The authors also propose the application of finishing through turning. The paper should influence of the type of inserts on the geometric structure of the alloy Ni-5%Al and composite Ni-5%Al-15%Al_2O_3 coatings. Nickel - aluminium matrix composite coatings on were sprayed with a torch Casto-Dyn 8000 a steel substrate, and then turned lengthwise. In order to determine the optimum geometry of indexing, it is now synonymous with the selection of the optimum shape and dimensions of the insert and an appropriate holder. The insert was used in different shapes and geometries: square, triangular, trigon, made tungsten carbide and cubic boron nitride (CBN).

***Keywords**: finishing coatings, metal matrix composite coatings, flame spraying, regenerated parts of ship machinery*

1. Introduction

The processes of production and regeneration of the applied metal matrix composite coating products are recognized among engineers, technologists, because of the possibility of increasing the performance characteristics of the surface layer (strength, tribological, corrosion and decorative). Metal matrix composite and metal alloy and coatings of metal matrix dispersion inclusions of non-metallic phase is characterized by high resistance to tribological wear and corrosion [1÷10]. Metal matrix composite are used in such fields of technology, such as: aerospace, electronics, energy, industry, defense, automotive, aviation, shipbuilding, and more. Based on a literature review, the study assumed composite coatings based on nickel with aluminum and with a variable content of alumina [11÷15]. Coatings obtained by flame spraying have a large surface roughness. Therefore, these coatings must be subjected to finishing (eg, turning finishing, grinding). Flame sprayed coatings are applied taking into account the allowance for finishing. Finishing should ensure not only the thickness of coatings related to the nominal dimension of the object, but also to obtain the required surface roughness and waviness. Choosing parameters (feed rate, depth, cutting speed) machining coatings must be remembered that the tool does not always cut sprayed particles, but may cause them breaking the surface. This occurs primarily in coatings of high porosity. Cutting knives, cutting elements should be made of cubic boron nitride or diamond, also allows the insert tool made of tungsten carbide is recommended by "Castolin-Eutectic" [16].

On ships, outboard water systems (eg, a central cooling system), often used in centrifugal pumps. In the case of pump shafts are the most common disability shaft neck wear (corrosion and friction) at the installation location of seals (stuffing-box). Currently, the primary method of regeneration is the shaft bushing. As an alternative to the method used to repair worn of centrifugal pumps shafts neck proposed flame spraying. The flame sprayed technology is inexpensive and easy to implement. Therefore it can be successfully used for regeneration of machine parts by the crew of ship engine room. Flame sprayed coatings are characterized by porosities, oxide inclusions and the presence of a strongly developed surface float. In order to obtain a suitable surface texture coatings finishing must be used. For this purpose, the turning and grinding. The paper proposes turning the finishing flame sprayed coatings. Alloy coatings were investigated Ni-5%Al and composite Ni-5%Al-15%Al_2O_3 powders obtained by flame spraying. Using a torch "Casto-Dyn 8000" Messer Eutectic Castolin company. In practice, the thermally sprayed coatings are machined using the same tool as machined surface. For example, a company Messer Eutectic Castolin proposed multi tool with a square or cylindrical inserts. Machining alloy coatings were carried out for the cutting speed V_c=214m/min in the case of treatment with inserts of CBN, V_c=107m/min cutting plates for tungsten carbide, used feed f_n=0.06mm/rev and depth of cut a_p=0.3mm. Metal cutting the surface of steel samples coated with a composite coating containing, conducted for the cutting speed V_c=157m/min when machining with CBN inserts and for V_c=83m/min inserts with tungsten carbide for feed f_n=0.06 mm/rev and depth of cut a_p=0.3mm. On ships during the voyage is made of many elements of the repair of ship engines. Often the cylindrical surfaces are regenerated (eg pump shaft). Technologies are widely applied welding coating alloy and composite. This paper proposes the use of technology subsonic flame thermal spraying and surface treatment by turning alloy and composite coatings. These are simple technologies, useful for repair of ship engines (such as engines, pumps, separators) during the voyage.

2. Research methodology

Alloy and composite coatings were applied for degreased samples stainless steel. Coatings on nickel-based alloy was flame sprayed powder material 21021 ProXon company "Castolin", where the percentage share of the mass was: Ni - 93.45%, Al - 5%, B - 0.8%, Fe - 0.34% , Cr - 0.18%, Si - 0.15%, C - 0.08%. Coatings for metal matrix composite MMC, were sprayed with a mixture of powdered ProXon 21021 and MetaCeram 28020 (Al_2O_3 - 97.7%, TiO_2 - 2.2%, SiO_2 - 0.1%). These powders were manufactured by Castolin. Composite coating material consisted of a matrix of Ni-5%Al and 15% of the disperse phase volume fraction of alumina (Al_2O_3). Spray torch was used, "Casto-Dyn 8000", the company Castolin. Flame spraying alloy coatings and composites were carried out assuming the following process parameters: pressure flammable gas - acetylene: 0.07MPa oxygen pressure: 0.4MPa, air pressure: 0.1MPa, the speed of the torch 25m/min, feed rate: 3mm/rev, the distance from the torch surface to be sprayed: 150mm, the number of superimposed layers: 6. Steel substrate pre-heated in the temperature range 60÷100°C. Flame spraying was carried out at temperatures exceeding 250°C. Then the coating have been subjected to very thorough turning straight. To determine the parameters of machining alloy coatings and composites based on nickel flame sprayed onto the substrate steel, preexperimental study was conducted longitudinal turning high precision. Fought with different cutting speed (V_c = 45 ÷ 214 m/min), feed rate (f_n = 0.06 ÷ 0.2 mm/rev) and depth of cut (a_p = 0.05 ÷ 0.3 mm). Based on analysis of test results determined that the best surface quality obtain samples of coated steel, nickel based alloys for the cutting speed V_c = 214 m/min in the case of treatment with inserts of borazon, V_c = 107m/min platelets treated with cemented carbide cutting. Then determined that the best gain of the sample surface quality of coated steel composite for cutting speed V_c = 157 m/min, in the case of treatment with CBN inserts, Vc = 83 m/min after treatment cemented carbide inserts.

For machining alloy coatings and composites used feed f_n=0.06mm/rev and depth of cut a_p=0.3mm.

Longitudinal turning, were subjected to a thorough external cylindrical surfaces of steel samples of alloy and composite coatings ϕ41mm in diameter with a thickness of 2 mm. To determine the optimal geometry of the cutting tool, now it is synonymous with the selection of the optimum shape and dimensions of the insert and the appropriate holder, edged square tiles were chosen, round, triangular, trigon, made of tungsten carbide (with grades: GC2015, GC3205, GC3210, GC3215, GC4015, H10F) and cubic boron nitride (CBN, grade CB7015). The research program is presented in Table 1. Surface texture of the alloy and composite coatings was measured with a Hommel Tester T1000 profilometer. During the turning of alloy and composite coatings is usually short durability of the insert. It is therefore important to determine the spiral cutting length. This is the length cutting, which are chosen for recommended cutting, thus allowing for a reliable process. Spiral cutting length is applied to the insert, geometry, and grade, depth of cut and material that shall be subject machined. Spiral cutting length (SCL, m) can be calculated from the formula [17]:

$$SCL = \frac{\pi \ D_m}{1000} \frac{l_m}{f_n} \tag{1}$$

where: D_m - the diameter of the workpiece in the machined surface, mm (ϕ41mm),
l_m - length of the machined surface, mm,
f_n - feed rate, mm/rev.

Table 1. The shape and grade inserts

Sample Number Alloy Coating	Sample Number Composite Coating	Insert Shape	Insert Type	Holder Type	Insert Grade
1	1.123	Square	SNGA 120408 S01030A	DSDNN 2525M 12	CB7015
2	2.123	Round	N123J1-0600-RE	RF 123J13-2525BM	CB7015
3	3.100	Triangular	TNMX 160408 - WM	DTGNR 2020K 16	GC4015
4	4.100	Triangular	TNMG 160408 - 23	DTGNR 2020K 16	H10F
5	4.020	Trigon	WNMG 080408 - WF	DWLNRL 2525M 08	GC2015
6	5.123	Trigon	WNMG 080408 S01030A	DWLNRL 2525M 08	CB7015
7	6.100	Trigon	WNMA 080408 - KR	DWLNRL 2525M 08	GC3205
8	6.020	Trigon	WNMG 080408 - KM	DWLNRL 2525M 08	GC3205
9	6.003	Trigon	WNMG 080408 - KM	DWLNRL 2525M 08	GC3210
11	4.003	Trigon	WNMG 080408 - KF	DWLNRL 2525M 08	GC3215

3. Results of research

Samples with applied alloy and composite coatings was turned by turning tools the different types of inserts by Sandvik-Coromant. The study allowed for determination, that there are relationships between the surface texture of alloy and composite coatings and the type of grade used and the shape of the inserts. Trigon insert WNMG 080 408 S01030A and round insert N123J1-0600-RE 7015 of CBN was characterized by a smaller flank wear as compared to a square insert with SNGA 120 408 S01030A 7015 of CBN.

Table 2. Surface texture parameters turned alloy coatings Ni-5%Al

Sample Number	**R_a, μm**	**R_z, μm**	**R_k, μm**	**R_{pk}, μm**	**R_{vk}, μm**	**$R_{mr(50.0\%)}$, μm**	**M_{r1}, %**	**M_{r2}, %**	**R_{sk}, μm**	**W_t, μm**
1	1,07	5,79	3,29	1,60	0,91	4,78	13,1	91,1	0,481	3,99
2	0,39	3,29	1,26	0,62	0,99	2,16	13	86,2	-0,336	2,05
3	0,49	2,87	1,29	0,57	0,61	1,95	6,7	88,8	-0,156	2,35
4	0,82	4,21	2,96	1,41	0,38	3,97	15,3	97,4	0,882	12,24
5	0,51	3,52	1,71	0,96	0,69	2,57	10,6	92,1	0,555	2,39
6	0,47	2,79	1,51	0,81	0,55	2,58	9,6	88,3	0,546	1,63
7	0,79	5,22	2,41	0,71	1,25	3,27	7,1	84,2	-0,456	2,65
8	0,85	5,86	2,54	0,54	1,58	2,61	7,1	85,1	-0,685	1,38
9	0,65	4,20	2,09	0,61	0,95	1,89	8,6	87,9	-0,317	2,53
11	0,54	3,79	1,52	0,45	1,26	1,54	6,7	83,2	-0,904	3,07

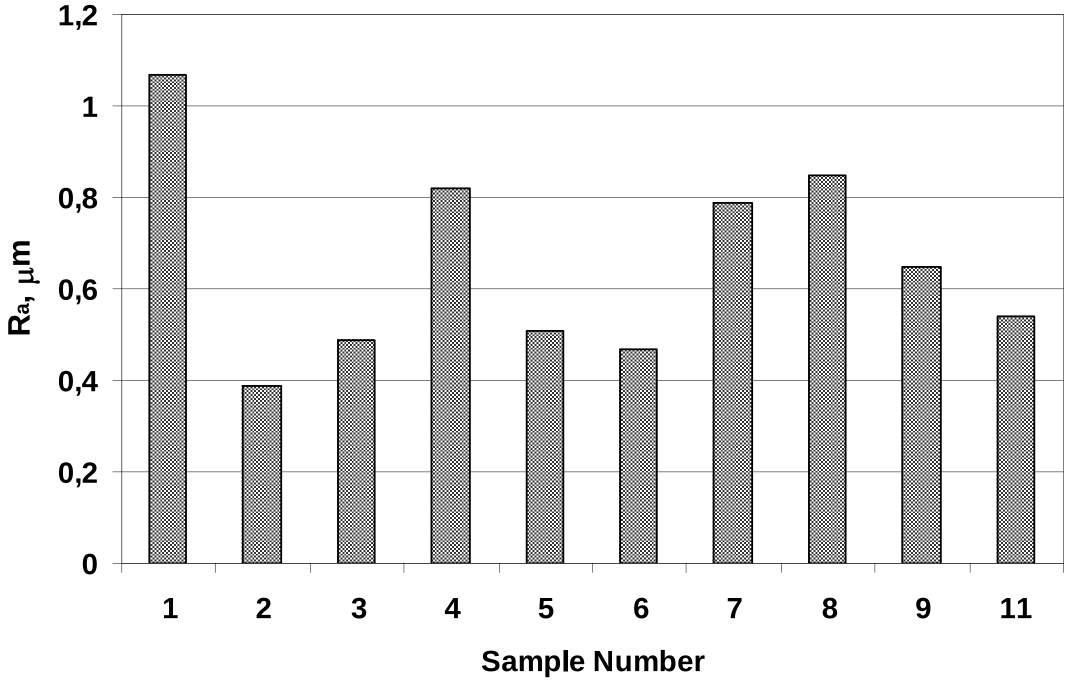
Surface roughness (refer with: Table 2) of the surface texture alloy coatings of Ni-5%Al turned insert trigon (R_a=0,47μm) and round (R_a=0,39μm) is nearly three times smaller than the roughness of the coatings faced a square insert (R_a=1,07μm). Using the trigon insert made of tungsten carbide determined that the minimum surface roughness of alloy coatings are obtained for grade GC3215 (R_a=0,54μm). After turning composite Ni-5%Al-15%Al_2O_3 using square insert SNGA120408S01030A 7015, specifies that the arithmetical mean deviation of the assessed profile reached a lower value of R_a=1.08μm (refer with: Table 3) in comparison to the roughness of the surface texture with the trigon insert made of the same grades (CB7015) and also with the trigon of tungsten carbide (about the grades: GC2015, GC3205, GC3210, GC3215) and tungsten carbide (for grades: GC4015, H10F) for triangular inserts. The lowest surface roughness R_a=0.65μm (refer with: Table 3) is achieved, composite coating turned insert round N123J1-0600-RE 7015. Round insert after turning composite coatings are characterized by the lowest flank wear compared to the square, trigon and triangular.

Table 3. Surface texture parameters turned composite coatings Ni-5%Al-15%Al_2O_3

Sample Number	**R_a, μm**	**R_z, μm**	**R_k, μm**	**R_{pk}, μm**	**R_{vk}, μm**	**$R_{mr01(50.0\%)}$, μm**	**M_{r1}, %**	**M_{r2}, %**	**R_{sk}, μm**	**W_t, μm**
1.123	1,08	6,72	3,34	1,49	1,28	4,89	11,9	88,1	0,224	4,69
2.123	0,65	6,33	2,68	0,81	2,23	2,82	7,1	89,9	-1,775	5,89
3.100	2,98	17,45	6,96	2,59	8,73	9,56	9,1	79,9	-1,148	19,87
4.100	3,04	18,98	7,24	1,93	7,65	7,85	6,7	79,1	-0,926	10,26
4.020	2,74	15,70	3,57	1,82	9,94	5,73	8,6	72,2	-1,721	6,58
5.123	1,51	13,6	3,89	2,93	6,42	6,58	8,3	84,9	-1,864	11,99
6.100	3,00	20,63	6,40	2,33	9,12	7,87	6,5	76,2	-1,619	13,03
6.020	3,55	23,82	8,24	1,97	9,27	9,05	6	75,9	-1,181	17,32
6.003	3,71	21,19	9,24	4,09	9,42	13,58	4,8	79,7	-1,062	14,85
4.003	3,75	22,73	9,08	2,21	10,13	8,84	7,0	79,3	-0,948	11,63

Figure 1 and Figure 2 shows the arithmetical mean deviation of the assessed profile for turned alloy Ni-5%Al and composite Ni-5%Al-Al_2O_3 coatings.

a)



b)

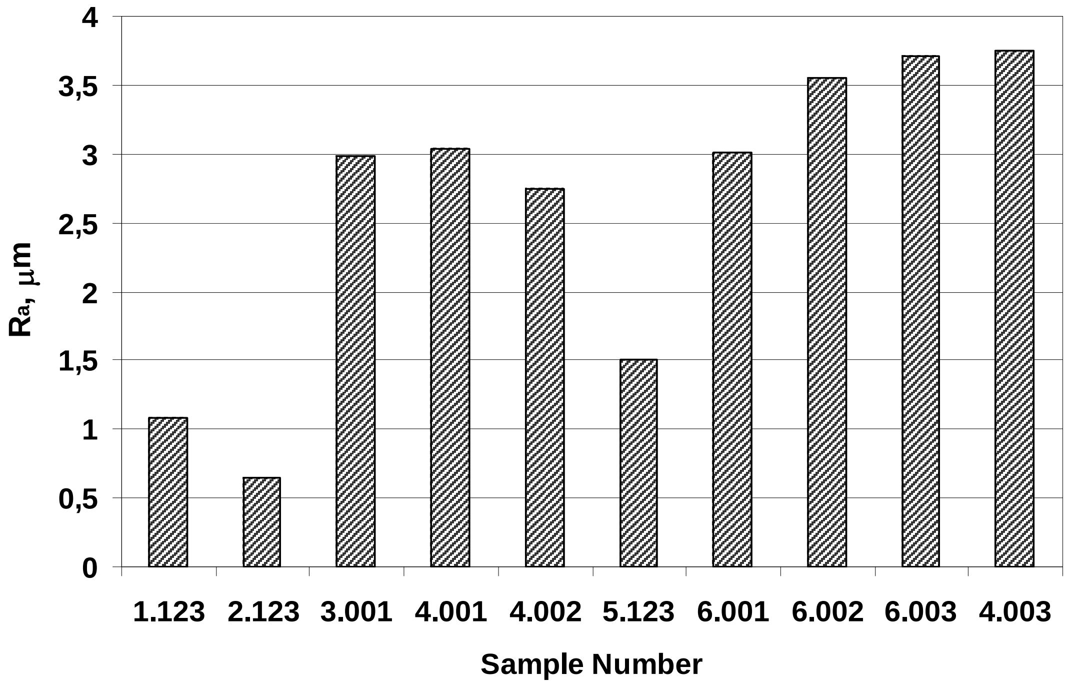


Fig. 1. The arithmetical mean deviation for coatings: a) alloy Ni-5%Al and b) composite Ni-5%Al-15%Al_2O_3 for turned samples inserts according to the research program

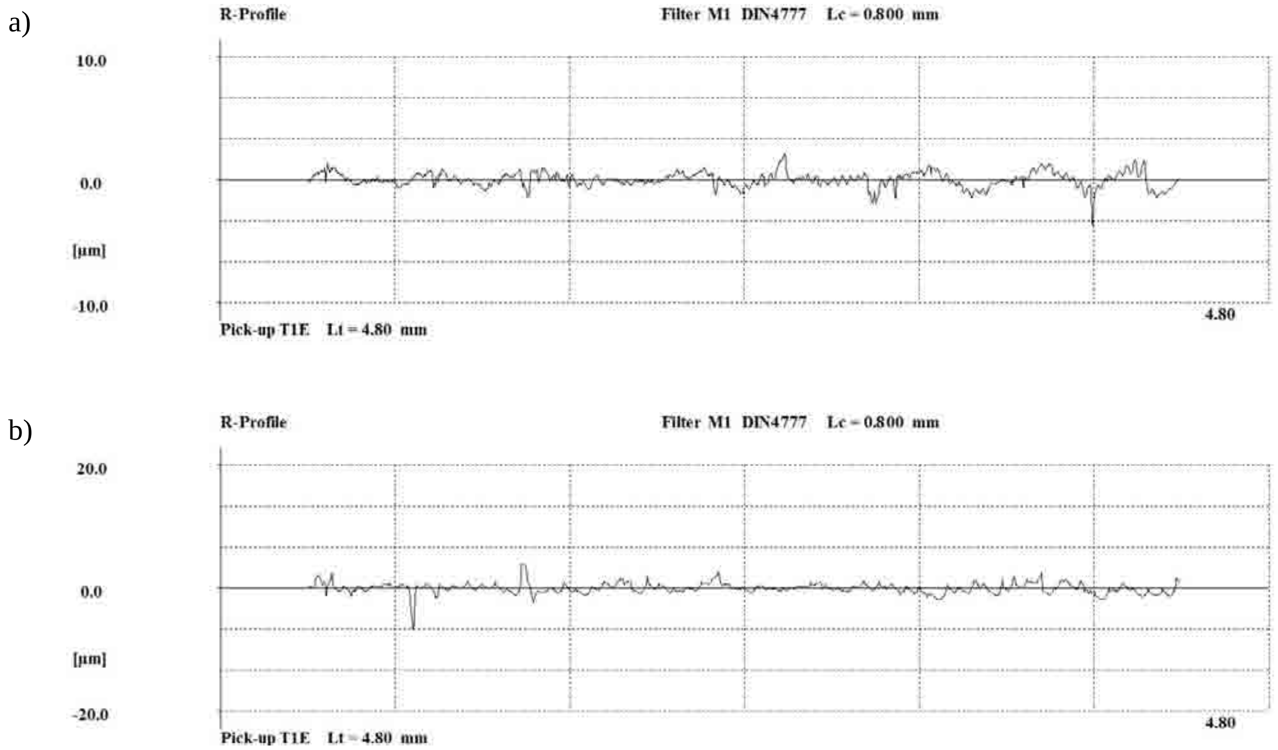


Fig. 2. The arithmetical mean deviation for coatings a) alloy Ni-5%Al (R_a=0,39μm) and b) composite Ni-5%Al-15%Al_2O_3 (R_a=0,65μm) for round insert N123J1-0600-RE 7015

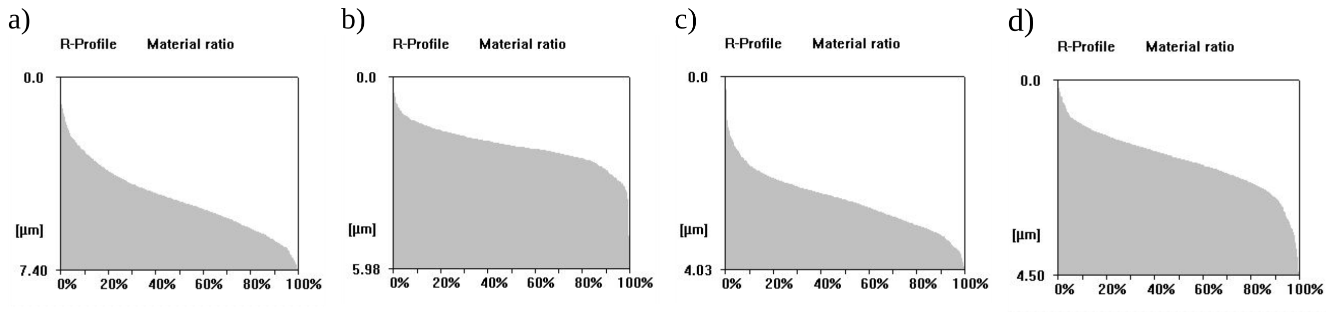


Fig. 3. The Abbott-Firestone curve surface roughness alloy coatings Ni-5%Al for inserts with CB7015: a) square SNGA120408S01030A (No. 1) and b) round N123J1-0600-RE (No. 2) and c) trigon WNMG 080408 S01030A (No. 6) and d) trigon WNMG 080408 - KF with GC3215 (No. 11)

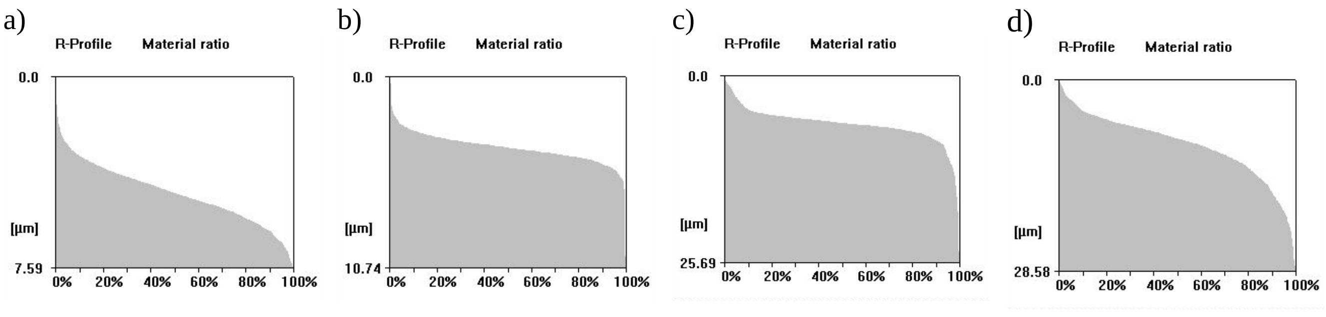


Fig. 4. The Abbott-Firestone curve surface roughness composite coatings Ni-5%Al-15%Al_2O_3 for inserts with CB7015: a) square SNGA120408S01030A (No. 1.123) and b) round N123J1-0600-RE (No. 2.123) and c) trigon WNMG 080408 S01030A (No. 5.123) and d) trigon WNMG 080408 - KF with GC3215 (No. 4.003)

Turning surfaces of have been subjected to the external cylindrical stainless steel samples of coated alloys and composites. After experimental studies determined that there are relationships between surface texture and the type of material used and the shape of the tool inserts. Based on analysis of test results determined that due to obtaining the smallest surface roughness alloy coatings, it was expedient to use trigon inserts made of tungsten carbide with grade GC3215 and cubic boron nitride grade CB7015 and round inserts (CB7015). For samples No. 2 coated Ni-5%Al subjected to turning determined that the arithmetical mean deviation of the assessed profile and the Abbott-Firestone curve surface roughness parameters take the smallest value (refer with: Fig.3).
Based on analysis of test results determined that due to obtaining the smallest surface roughness turned alloy coatings of Ni-5% Al, with the least wear on the insert flank face and tool face, for a constant spiral cutting length (SCL = 1073m), targeted to was the use of trigon inserts made of cubic boron nitride on the grade CB7015 and a insert grade GC3215 and the round profile of the CB7015. Roughness of the surface texture of Ni-5%Al subjected to turning by trigon insert with CBN is three times smaller than the roughness of the alloy coatings a square insert. Thus, it is advisable not use square inserts for machining alloy coatings. Based on analysis of experimental results after turning composite coatings can be determined that the roughness profile parameters and parameter values of the bearing area curve reached the lowest values for samples No. 2.123 (refer with: Fig. 4).

Conclusions

Surface texture is very important where it has a direct influence on the quality of the elements machine parts. Therefore, it has to be defined as precisely as possible with the help of standardized surface texture parameters. The best tool contour and angles, selected the required shape and grade the inserts, you need to obtain a minimum surface roughness. After you finish turning of studies of alloy and composite coatings determined that due to obtaining the smallest surface roughness, with the least wear on the insert flank face and tool face, for a constant spiral cutting length, targeted to be the use of inserts round with CBN.
Alloy and composite coatings used in the production and regeneration, it appears possible to achieve the technological quality of the elements machine parts (eg shafts of centrifugal pumps).
It can be argued that due to the surface quality coatings and durability of the turning inserts:

- for turning shafts of centrifugal pumps with a coating alloy would need to be round and trigon inserts with grade CB7015 and trigon with grade GC3215,
- for turning shafts of centrifugal pumps with composite coatings should be applied round inserts with grade CB7015.

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