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Modeling of the number of stubble stuck elements after abrasive jet machining-processing

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Abstract

Sticking of abrasive grains into the surface is the effect of abrasive jet machining processing. For prosthetic works burnt the clay, it may deteriorate the quality of metal-clay connection. Parameters of sandblasting have the significant influence on the amount of stubble elements stuck into the base. The aim of the research is examining possibilities of applying neuron networks for modeling this process. Examples were sandblasted using alternating parameters (pressure of working factor, angle of sandblasting, size of grains). As a next the amount of stubble elements stuck into the base were calculated. Study results allowed to work out a set of 180 standardized teaching patterns. Next, a group of 150 randomly selected neuron networks was submitted to teaching process. The aim was to select net architecture with the highest adjustment for discussed issue. Finally, a MLP (Multi Layer Perception) was chosen. Training process of the net involved presentation of process entrance parameters to the net, followed by presentation of researched proportional partaking of stuck elements. In following training cycles the error was decreasing systematically. After finishing the training, the average medium error between the real measurement and the one anticipated by the net was about 5 per cent. Additional number of abrasive jet machining processing was done to verification experiments. As the study shows, designed artificial neuron net stimulates real dependencies appearing during abrasive jet machining-processing in a proper way and can be used for estimating proportional part of grains stuck into base after this processing. It turns out that this phenomenon can be modeled, and its model can be used in a practical way without using mathematical or physical equations.

Keywords: Abrasive Jet Machining- Processing, Stubble Stuck, Parameters Of The Abrasive Jet Machining-Processing

1. Introduction

Since the most frequent prosthetic technology used for making bridges and crowns is the technology of burning the clay on metal, proper preparation of metal surface (so-called basis) in metal-clay connection plays a significant role. The aim of such a course is receiving needed quality and liability for mixing those two materials, as well as receiving the most précised and optimal final effect of prosthetic filling.

One of the most common method used in a prosthetic studio is sandblasting of metal surfaces with aluminum oxide. This technique is widely known and used in prosthetic works. It aims at removing excess of material (micro-machining of basis), shaping the elements during processing, and receiving suitable and optimal surface of prosthetic fillings. Abrasive jet machining-processing is performed at different stages of doing prosthetic works, for cleaning the surface or preparing it for next technological stages.

Abrasive jet machining processing of metal and alloy surface is performed with corundum -Al_2O_3 which is not toxic and is thought to be chemically neutral for the organism. Important parameters are size of grains, pressure of working factor, and angle of sandblasting, since they influence the received coarseness (and adhesion of clay to the surface). During processing corundum grains hit the metal surface with high speed and pressure which causes disorders in the metal inner structure, wide extending and enlarging of its structure and developing high temperatures. This process is a kind of mechanical purification of metal surface, moreover, it enlarges the surface adhesion and increases its loose energy, what decreases parietal angle of adhesion and improves moistening ability [1, 2, 3].

The diameter of aluminum oxide grains during metal surface sandblasting is usually 50, 110 or 250 μm. The structure of metal or alloy surface under abrasive jet machining-processing then depends on aluminum oxide grains diameter, gas pressure, as well as the kind of metal or alloy used. Sandblasting uses kinetic energy of stubble elements in the stream of coupled gas. In consequence, during the process stubble elements stuck into the material making with metal one structure and surface. It is a defect of abrasive jet machining-processing, as the surface of metal or alloy becomes contaminated and more vulnerable to corrosion. Occasionally, stubble elements stuck into metal structure, may deteriorate the quality of metal-clay connection what may lead to lowered durability and clay sustenance, e.g. micro-cracks, or chipping [4, 5].

Parameters of sandblasting influence the amount of stubble elements stuck into the base [6, 7]. The number of Al_2O_3 elements stuck has significant influence on connection of metal and clay structure in prosthetic works. The greater number of these elements, the weaker the metal-clay bonds, moreover, high pressure of sandblasting causes micro-cracks of alloy, which then influences spreading of cracks to the surface of burnt clay and its chipping off. What is more, surface coarseness increases and in consequence moistening weakens, the base becomes more hydrophobic, and the burnt clay adhesion to the surface becomes poor. Larger granulation of Al_2O_3 influences better surface extending and durability of metal and clay bond.

2. The aim of the research

The research aims in analyzing the influence of sandblasting parameters on the amount of stubble elements stuck in the example of chromium-cobalt alloy and aluminum oxide grains, as well as examining possibilities of applying neuron networks for modeling this process.

3. Material and study methods

The study was performed in the surface made of cobalt-chromium alloy Heraenium®P devoted to base for clay burning. Cylinders of 8 mm diameter and 7 mm long were submitted to mechanical abrasion with abrasive paper of diminishing grains, and finally polished. Due to this process, the surface prepared to abrasive jet machining processing was standardized. Sandblasting was performed with using Al_2O_3 elements. Fitted handles were applied to processing for samples with various surface tilting. The nozzle of the mono-sandblasting machine was set in vertical position. Alternating parameters of abrasive jet machining-processing were as follows: sandblasting angle (30°, 45°, 60° and 90°), size of grains (50 μm., 110 μm., 250 μm.) and working pressure (0,2 MPa, 0,4 MPa, 0,6 MPa). After abrasive jet machining-processing samples were rid of loose elements and dried. Next, using the electron scanning microscope estimation and observations were made, and pictures of particular samples were taken. The number of Aluminum oxide stuck in the surface was performed with quantity metallographic methods, using Met-Ilo v.5.1. computer programming. The aim was to establish the average proportional part of the surface covered by stubble elements fused with processed surface.

4. Results and analysis

Tables 1-3 present results of calculations obtained due to Met-Ilo v.5.1. programming.

Table 1.
Proportional part of surface covered by stubble elements after 50 μm grain processing

Nr	P [MPa]	Glancing angle [°]	Grain [μm]	Proportional part of stubble elements stuck	
				Result %	Standard deviation %
1.	0,2	30	50	9,11	1,47
2.	0,4	30	50	9,91	1,49
3.	0,6	30	50	15,23	1,91
4.	0,2	45	50	16,95	0,64
5.	0,4	45	50	17,90	2,37
6.	0,6	45	50	15,14	1,06
7.	0,2	60	50	19,52	2,10
8.	0,4	60	50	13,35	2,04
9.	0,6	60	50	19,09	2,04
10.	0,2	90	50	25,08	0,73
11.	0,4	90	50	23,19	3,32
12.	0,6	90	50	26,91	1,07

Table 2.
Proportional part of surface covered by stubble elements after 110 µm grain processing

Nr	P [MPa]	Glancing angle [°]	Grain [µm]	Proportional part of stubble elements stuck	
				Result %	Standard deviation %
1.	0,2	30	110	10,27	0,56
2.	0,4	30	110	10,82	1,17
3.	0,6	30	110	9,17	2,07
4.	0,2	45	110	15,85	1,24
5.	0,4	45	110	16,80	2,34
6.	0,6	45	110	15,47	2,37
7.	0,2	60	110	13,12	1,29
8.	0,4	60	110	15,53	5,75
9.	0,6	60	110	14,66	2,68
10.	0,2	90	110	21,79	2,14
[illegible]	0,4	90	110	18,28	8,56
12.	0,6	90	110	20,87	3,80

Table 3.
Proportional part of surface covered by stubble elements after 250 µm. grain processing

Nr	P [MPa]	Glancing angle [°]	Grain [µm]	Proportional part of stubble elements stuck	
				Result %	Standard deviation %
1.	0,2	30	250	5,45	1,32
2.	0,4	30	250	8,34	2,82
3.	0,6	30	250	10,67	1,59
4.	0,2	45	250	13,16	2,05
5.	0,4	45	250	14,45	3,16
6.	0,6	45	250	20,94	2,89
7.	0,2	60	250	10,17	4,00
8.	0,4	60	250	11,42	2,17
9.	0,6	60	250	20,63	5,06
10.	0,2	90	250	23,15	2,67
11.	0,4	90	250	21,62	1,32
[illegible]	0,6	90	250	27,17	3,96

The results shown above illustrate quantitative inclusions of stubble with alternating processing parameters suitable for alternating processing parameters of technology used in prosthetic studio. They allow to estimate huge amounts of Al_2O_3 stuck in the base reaching in case of some parameters almost 30 per cent of surface covering.
It is noticeable that graduation of the number of elements is directly proportional to the stream of coupled gas. Definitely, the least amount of material stuck is noticed with the surface setting at sharper angle toward the stream of stubble. No significant variations of regularities such as size of the elements were noticed. Larger elements are claimed to get stuck in the processed surface less which may be due to their crumbling in the alloy surface.

5. Modeling the number of grains stuck after processing

Study results allowed to work out a set of 180 standardized teaching patterns. Next, a group of randomly selected neuron networks was submitted to teaching process. The aim was to select net architecture with the highest adjustment for discussed issue. Finally, a MLP (Multi Layer Perception) was chosen. Its entrance layer, as well as latent layer involved three neurons, while the initial layer included only one (Fig. 1).

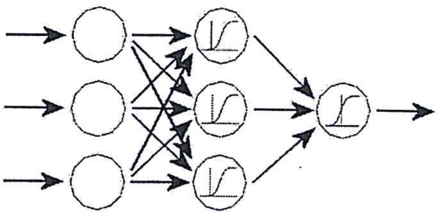

Fig. 1. Architecture of neuron net, modeling sandblasting with aluminum oxide of chromium-cobalt alloy base

The net entrance involved: sandblasting angle, size of the grain, and working pressure. In case of latent neurons, logistic function was taken as activating function and sinusoidal function for initial neuron. The proportional part of base including stuck aluminum oxide grains became the net's initial signal. Training process of the net involved presentation of process entrance parameters to the net, followed by presentation of researched proportional partaking of stuck elements. In the beginning, the net did not range to real examinations, however in following training cycles the error was decreasing systematically. After finishing the training, the average medium error between the real measurement and the one anticipated by the net was about 5 per cent. Chart 2 shows net anticipation of aluminum oxide partaking in base depending on pressure and glancing angle of Al_2O_3. What significant, the net anticipated decline of stubble proportional participation for the set of following parameters: glancing angle 60°, processing pressure about 0,3 MPa, and the size of grains 150 µm. Despite, the tendency does not manifest itself in real data analysis (the data concerned 0,2 and 0,4 MPa, what made the authors to conclude 0,3 MPa measurements will be of average quality).
The measurements were carried out againg, with using other nets (the number of latent neurons was changed, as well as all the net architecture), however, in any case, a characteristic "saddle" shape appeared.

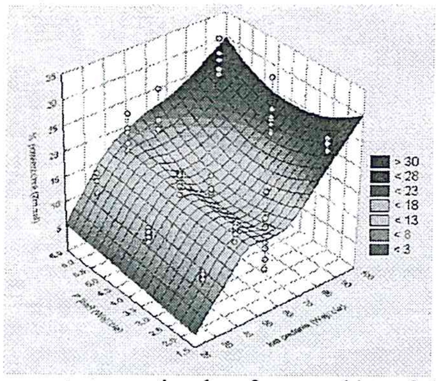

Fig. 2. It presents proportional surface partaking of aluminum oxide grains stuck into chromium-cobalt base in the function of glancing angle and processing pressure

6. Experimental verification

Verification experiments were carried out to estimate a degree of the predictability for the area interpolated by it. Additional number of abrasive jet machining processing was done with 150 µm grains followed by measuring proportional partaking of grains stuck into base. During examination of samples after abrasive jet machining-processing, a method of taking measurement in five randomly chosen places in the surface for each sample was applied. As the range of results of every single sample was 12.8% standardized measurements values for the needs of verification were taken.

Processing parameters for net entrance and qualities generated by the net initially were reported in parallel. Results of measurement and net predictability are set and shown in Table 1.

Table 4.
Comperative list of verification examination and predictive abilities of neuron net

Nr	P [bar]	Glancing angle	Grain [µm]	Proportional part of stubble elements stuck		Error [%]
				n net	Measure ment	
1.	2	30	150	11,2	17,3	6,1
2.	4	30	150	13,6	29,0	15,4
3.	6	30	150	12,2	29,3	17,1
4.	2	45	150	16,6	41,6	25,0
5.	4	45	150	16,8	35,5	18,7
6.	6	45	150	14,6	24,9	10,3
7.	2	60	150	13,4	29,1	15,6
8.	4	60	150	13,8	26,5	12,7
9.	6	60	150	19,0	24,3	5,3
10.	2	90	150	25,4	37,0	11,6
11.	4	90	150	20,0	32,4	12,4
12.	6	90	150	26,9	28,2	1,3

The average error of net response to parameters settings to which it was not trained was 12.6 %. The model of the process created by the selected neuron net should be taken as sufficient for practical needs.
It has been noticed, however, that the neuron net tends to lower the results in comparison to results obtained during empirical measurements. The conclusion is that the "saddle" shape presented in chart 2, is the effect of too little teaching data, and not due to physical conditions of the phenomenon.

7. Conclusions

As the study shows, designed artificial neuron net stimulates real dependencies appearing during abrasive jet machining-processing in a proper way and can be used for estimating proportional part of grains stuck into base after this processing. It turns out that this phenomenon can be modeled, and its model can be used in a practical way without using mathematical or physical equations.

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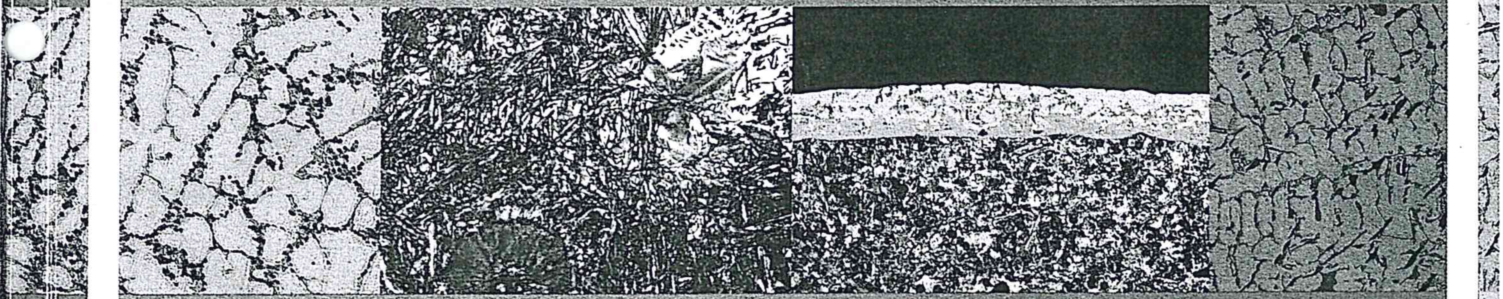

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Archives of Foundry Engineering continues the publishing activity started by Foundry Commissio of Polish Academy of Sciences (PAN) in Katowice in 1978. The initiator of this action was the fir Chairman Professor Dr Eng. Waclaw Sakwa - Corresponding Member of PAN, Holder of the Honora Doctorate of Czestochowa University of Technology and Silesian University of Technology, Preside of CIATF. This periodical, previously entitled **"Solidification of Metals and Alloys"**, enable publication of results achieved in the field of the Basic Problems Research Cooperation. The themat scope was related to periodical title and concerned widely understand problems of metals and alloy crystallization in a casting mould. Within 1978-2000 the 44 issues have been published. Since 200 the Foundry Commission has had patronage of the annually published **"Archives of Foundry"** ar since 2007 quarterly published **"Archives of Foundry Engineering"**. Periodical thematic scop includes scientific issues of foundry industry:

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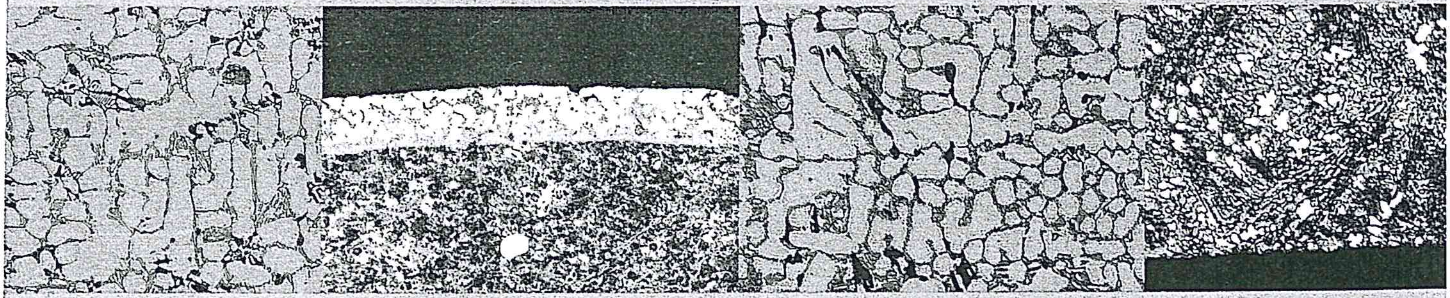

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