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CONTRIBUTION TO MORE COMPLEX DIAGNOSTICS AND EXAMINATION OF OPERATING CONDITION OF PRODUCTION SYSTEMS BY AWJ TECHNOLOGY

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ABSTRACT: The paper presents a solution, which enables widening of more objective diagnostics and examination of operating conditions of production systems by AWJ technology following their economic effectiveness and competitiveness with the use of modelling and simulation. It contains the base of more complex diagnostics and factors, on which it is built. It presents a suggestion of experiment set for more complex diagnostics and the suggestion of sets for its evaluation. It also mentions expected benefits of the realisation of more complex diagnostics of operating conditions.
KEYWORDS: production system, AWJ technology, diagnostics, operating condition, modelling, simulation, optimation, machined surface quality, machined surface size, cutting time, operational costs, economic effectiveness of operation, competitiveness

INTRODUCTION - BRIEF CHARACTERISTIC OF RECENT STATE OF ART

Recently most works dealing with the problem of production systems operation (PS) by AWJ technology aim at examining the influence of technological parameters of PS by AWJ technology and material parameters of machined material on the quality of machined surface often finishing by modelling, simulation and optimation with the aim to find, for example, suitable combinations (alternatives) of values of technological and material parameters for required parameters of the quality of machined surface. In lesser degree it similarly examines the influence of technological parameters, material parameters and the length of machined track on machining time. What is missing, are mainly the solutions enabling modelling, simulation and optimation of the influence of technological parameters, material parameters and the length of machined track, all at the same time, on the quality of surface of machined surface and machining time following economic effectiveness of machining time and competitiveness of companies operating PS by AWJ technology.

THE ESSENCE OF MORE DETAILED EXAMINATION OF MODELLING, SIMULATION AND OPTIMATION OF THE OPERATION OF PS WITH AWJ TECHNOLOGY

More detailed examination is based on the fact that apart from separate examination of the influence of technological and material parameters on the quality of machined surface and machining time, their mutual influence completed by the size of machined area following operational costs, economic effectiveness of PS with AWJ technology and competitiveness of companies operating PS with AWJ technology.

Determination of optimal, compromise ratio of values of quality of machined area and machining time. Also little shortening of piece machining time (obtained by small increase in machining time) can have, with large number of pieces, have important influence on shortening of total machining time with positive following effect on decreasing operational costs, increasing economic effectiveness of operation and competitiveness.

Shortening machining time in the experiment mainly means decreasing the speed of movement of technological head.

BRIEF ANALYSIS OF MACHINING TIME ON ECONOMIC EFFECTIVENESS AND COMPETITIVENESS

Shortening machining time by the optimisation of values of technological parameters creates, within original time range (without optimisation), time space usable for machining other pieces, by which benefits (B) increase considerably.

Their considerable increase with much smaller costs (C) means important increase of economic effectiveness according to the relation for the calculation of economic effectiveness coefficient K_{ef}:

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$$K_{ef} = \frac{P}{N} \quad (1)$$

Besides this, there will come improvement of competitiveness of the company operating PS by the fact that they are able to perform larger volume of work in certain time than other (competition) companies and they are able to apply for larger orders, the amount of which other companies do not have possibility to complete in customer required time.

FOR DETERMINED

↓

1. Material parameters (type and thickness of machined material)
2. Quality parameters of machined material surface
3. Total length of active track of technological head (track length for one piece times total number of machined pieces)

↓

IT IS NECESSARY TO DETERMINE

↓

suitable, optimal combination of values of technological parameters

↓

TO OBTAIN

↓

Minimum value of total machining time (cutting) of required pieces number

Fig. 1. Explanation of the base of more detailed examination

PROCEDURE OF SOLUTION COMPLETING AND SPECIFICATION OF RECENT STATE OF ART

The specifications of recent state of art are:

- *Characteristics and analysis of recent state of art about the diagnostics of operating conditions and optimisation of operation in AWJ technology;*
- *Suggestion for widening diagnostics and examination of operating conditions of PS with AWJ technology following their economic effectiveness and competitiveness;*
- *Experimental examination and analysis of the influence of material parameters, technological parameters and length of machining track (track length corresponding with a piece times number of pieces) on machining time and quality of machined surface;*
- *Evaluation of experimental measurements;*
- *Determination of mathematical models on the base of evaluated experimental measurements;*
- *Transformations of mathematical models into the set of programs for the simulation of the influence of material parameters, technological parameters and length of machining track (length of track corresponding with a piece times number of pieces) on machining time and the quality of machines area. Transformation will enable to use mathematical models in real time.*

EXAMPLE OF SUGGESTION OF EXPERIMENS FOR MORE DETAILED EXAMINATION OF DIAGNOSTICS OF OPERATING CONDITIONS OF PS WITH AWJ TECHNOLOGY AND THEIR EVALUATION

Example of experiment suggestion

Suggestion of experiment set containing following the type and thickness of machined material, technological head movement speed, abrasive mass flow, machining time (cutting) and surface quality (roughness) of machined material is graphically pictured in Tab. 1.

Table 1. Example of experiment set suggestion

Material M	Thickness h_r [mm]	Speed v_R [mm.min^{-1}]	Abrasive flow volume Q_a [g.min^{-1}]	Cutting time t [min]	Roughness R_z [μm]
M_1 S355	10 mm	60 ÷ 290	250	0,12 ÷ 0,58	23,32
	15 mm	40 ÷ 180		0,19 ÷ 0,87	21,59
	20 mm	20 ÷ 130		0,27 ÷ 1,73	19,24
M_2 1.4301	10 mm	60 ÷ 290	250	0,12 ÷ 0,58	21,22
	15 mm	40 ÷ 180		0,19 ÷ 0,87	19,50
	20 mm	20 ÷ 130		0,27 ÷ 1,73	18,97
M_3 AlMg3	10 mm	160 ÷ 840	250	0,04 ÷ 0,22	33,62
	15 mm	100 ÷ 520		0,07 ÷ 0,35	32,83
	20 mm	70 ÷ 290		0,12 ÷ 0,50	27,72

Example of recording measured data

Sample of table head for recording measured data is shown in Tab. 2.

Table 2. Table head for recording measured values

	Sample No.: / Parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Input	h_R [mm]	10					15					20				
	v_R [mm/min]	60 ÷ 290 (input value of speed)					40 ÷ 180 (input value of speed)					20 ÷ 130 (input value of speed)				
	Q_a [g/min.]	250														
Output	t_r [min]	0,12 ÷ 0,58					0,19 ÷ 0,87					0,27 ÷ 1,73				
	R_z roughness [μm]	19,16 ÷ 25,78					18,21 ÷ 26,44					17,07 ÷ 20,57				

Example of experiment evaluation

Experiments will be evaluated on two levels.

First level evaluation is done vertically, for example for one type of material, its one thickness and each of changing speeds of technological head movement area, corresponding machining time and machined surface roughness values are measured separately (subtracted). Taken values are recorded in the graph for different speeds of technological head movement.

Second level evaluation is done horizontally, for example for several types of examined materials and the same thickness and other constant parameters, corresponding values of machining time and machined surface roughness are recorded into graph.

Example of set on level I:

For material M_1, material thickness, abrasive mass flow Q_{a1} and technological head movement speeds v_1, v_2, v_3, machining times t_1 , t_2 , t_3 and surface roughness R_{z1}, R_{z2}, R_{z3} are evaluated. The result are graphical dependencies of t_1 , t_2 , t_3 and R_{z1}, R_{z2}, R_{z3} on v_1, v_2, v_3 for material M1, its thickness h_1 and for Q_{a1} and other constant technological parameters.

$$t_1 , t_2 , t_3 \text{ a } R_{z1}, R_{z2}, R_{z3} \quad \rightarrow \quad v_1, v_2, v_3 \ (M1, \ h_1 , Q_{a1})$$

Example of set on level II:

For materials M_1, M_2, M_3, and for material thickness h_1 and abrasive mass flow Q_{a1} same for examined material, machining times t_1' , t_2', t_3' and surface roughness R_{z1}', R_{z2}', R_{z3}' are evaluated. The result are graphical dependencies of t_1 , t_2 , t_3 and R_{z1}, R_{z2}, R_{z3} on material type M_1, M_2, M_3, for the same material thickness and abrasive mass flow, for example h_1 , Q_{a1} and other constant technological parameters.

$$t_1' , t_2' , t_3' , R_{z1}', R_{z2}', R_{z3}'. \quad \rightarrow \quad M_1, M_2, M_3, (h_1, Q_{a1})$$

Expected benefits from the realisation of the concept of knowledge solution

Objective and quick determination of optimal combination of technological parameters and their values for determined material parameters and required parameters of quality of machined areas securing the increase in economic effectiveness of operation and improving competitiveness.

CONCLUSIONS

Realisation and evaluation of the experiments and procedures for more detailed diagnostics, the suggestion of which is presented in the paper, will complete previous solution of the Department of production processes operation, Faculty of Production Technologies, Technical University in Košice with the seat in Prešov (KPVP FVT TU) aimed at diagnostics of operating conditions of PS with progressive technologies with main accent at AWJ technology.

It is also a partial subject of cooperation of KPVP FVT TU in Košice with the seat in Prešov with the company WATTING Prešov and Liquid jet workplace of Institute of Physics, Faculty of geology and mining, Technical University in Ostrava, aimed at the connection of physical and operating examination of PS with AWJ technology.

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