ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING

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THE EXAMPLE OF TECHNOLOGICAL PARAMETERS INFLUENCE ON QUALITY PARAMETERS AT CUTTING STEEL HARDOX WITH TECHNOLOGY AWJ

Abstract:
The article presents the specimen of technological parameters influence simulation on cut area quality parameters with help of mathematical model created on the basis of experiments and transformed into programs set enabling model utilizing in real time.

Keywords:
cutting, simulation, technological parameter, quality model, programs set

INTRODUCTION

To factors that decisively influence cut area quality, total working cost and also economical efficiency of working belong technological parameters of manufacturing system with technology AWJ. Therefore we devote to technological parameters influence research always greater effort. The important part of this effort is aimed at manufacturing system technological parameters influence simulation on cut material surface quality on the basis of mathematical models.

Simulation rests in this that with substitution of concrete values for certain combination of technological parameters we can obtain with calculation values of cut area roughness corresponding to substituted concrete combination technological parameters values without cutting samples.

Simulation enables with utilizing program where is transformed mathematical model to calculate in real time also extensive sets of cutted area quality parameters values for more demanded combinations of purpose choice sets manufacturing systems technological parameters values.

The article presents the specimen from solution of dissertation work elaborated by doctorand on training working-place-chair of manufacturing processes working Faculty manufacturing technologies Technical University in Košice with seat in Prešov.

EXPERIMENTS

Mathematical model for simulation is compiled on basis of the experiments set evaluation proposed on foundation of experiments planning theory.

The number of watched values combinations of choice technological parameters is stated on basis of experiments plan.

For stating is used the formula:

$$y^x = k \qquad (1)$$

- y = 3 (number of technological parameters levels)
- x = 3 (number of factors – technological parameters)
- k = 27 (resulting number of technological parameters values combinations) it is $3^3 = 27$

It is 3-level fully 3-factor experiment with total number of technological parameters values combinations 27. These 27 combinations were exercised on every from 4 various thickness of sheets (6,10,15,40 mm) and like wise on the thickness of sheet 6 mm+ that was cut with increased speed by 50 percent against the speed "v". From this it follows that from every sheet thickness 9 samples with 3 cut areas were cut. Therefore the most suitable form of samples was choice the form with plan of equilateral triangle.

Planed experiment 3^3 supposes for every set of experiments:

- 27 dependences with one parameter – (1 technological parameter on 1 qualitative parameter, further 2 technological parameters are constant)
- 9 dependences with two parameters – (2 technological parameters on 1 qualitative parameter, 1 technological parameter is constant)
- 3 illustrations of third technological parameter activity – (3 technological parameters on 1 qualitative parameter)

In the case of one parameter dependences it goes for expressing relation of choice technological parameter (e.g. speed of cut head "v") on 1 choice parameter of cut area quality (e.g. roughness of surface Ra) while the other 2 technological parameters (mass flow of abrasive "m_A", pump pressure "p") and 1 material parameter (sheet thickness "h") will be constant.

In the case of dependences with two parameters it goes for expressing relation of 2 choice technological parameters (e.g. mass flow of abrasive "m_A" and pump pressure "p") on 1 choice parameter of cut area quality (e.g. roughness of cut surface Rz), 1 technological parameter (speed of cut head "v") and 1 material parameter (sheet thickness "h") will be constant.

In the case illustration of the third technological parameters activity it goes for expressing dependence of 3 technological parameters (mass flow of abrasive "m_A", pump pressure "p" and speed of cut head "v") on 1 qualitative parameter (e.g. roughness of surface Rz), material parameter (sheet thickness "h") is constant. It is possible to express such a dependence of parameter e.g. by sequence illustration of some following graphical dependences with 2 parameters. So a graphical animation arises that shows activity of third technological parameter together with further 2 technological parameters in dependence on choice qualitative parameter.

MATHEMATICAL MODEL FOR SIMULATION

The models (1), (2) are stated on the basis of experimental measurements evaluation with favourable value of coefficients of correlation.

$$Ra:\ y = 7{,}905 - 0{,}012x_1 - 0{,}007x_2 + 0{,}011x_3 \quad (R^2_u = 0{,}872) \qquad (1)$$

$$Rz:\ y = 39{,}103 - 0{,}049x_1 - 0{,}027x_2 + 0{,}046x_3 \quad (R^2_u = 0{,}902) \qquad (2)$$

The verifying was performed for two mathematical models with three parameters of choice technological parameters functional dependences m_A (x_1), p (x_2), v (x_3) on the surface qualitative parameter of cut area Ra, Rz (y) at sample thickness 10 mm.

Tab. 1 Example of program utilization at simulation

Number of calculation	Thickness h [mm]	Technological parameters	Qualitative parameters			
		Mass flow of abrazive	Pump pressure	Cutting speed	Calculated values	
		m_A (x_1) [g/min]	p (x_2) [MPa]	v (x_3) [mm/min]	Ra^ (y)	Rz^ (y)	
1	15	150	440	30	3,8	21,4	
2		250	360	50	3,5	21,1	
3		330	270	90	4,9	27,7	
		m_A (x_1) [g/min]	p (x_2) [MPa]	v^+ (x_3) [mm/min]	Ra^ (y)	Rz^ (y)	
4	6	160	410	20	2,7	20,3	
5		190	330	55	3,2	21,5	
6		200	260	80	3,7	22,8	
		m_A (x_1) [g/min]	p (x_2) [MPa]	v^- (x_3) [mm/min]	Ra^ (y)	Rz^ (y)	Ø^ (y)
7	40	155	400	19	4,3	22,4	21,3
8		340	290	23	3,3	18,9	16,2
9		210	280	124	5,3	24,3	26,6
		m_A (x_1) [g/min]	p (x_2) [MPa]	v (x_3) [mm/min]	Ra_4^ (y)	Rz_4^ (y)	
10		160	260	24	3,5	21,8	
11		240	300	74	3,7	22,8	
12		150	260	145	5,2	29	

For utilization of mathematical models in real time these models are transformed into program set in programable language C # scribed in programable medium Visual Basic.

In table 1 some examples of program utilization possibilities for simulation is stated (theoretical calculation) of choice qualitative parameters values in dependence on applied values of choice technological parameters that are other than at experimental measurements.

VERIFYING SIMULATION & MATHEMATICAL MODEL

Simulated (calculated) values of surface roughness for competent combinations of technological parameters values were experimentally verified (measured values) as follows. The result of verifying certificated correctness of verified mathematical models and performed simulation as follows (tab. 2).

Tab. 2 The values Ra, Rz simulated - calculated from mathematical models and their experimentally measured values

Number of calculation	Technological parameters			Qualitative parameters Ra, Rz					
	Mass flow of abrasive	Pump pressure	Cutting speed	Calculated values		Measured values		Variation calculated against measured value [%]	
	m_A (x_1) [g/min]	p (x_2) [MPa]	v (x_3) m/min	Ra (y)	Rz (y)	Ra	Rz	for Ra	for Rz
1	160	270	35	4,48	25,58	4,70	26,91	-4,7	-4,9
2	180	285	38	4,17	24,34	4,41	25,22	-5,4	-3,5
3	190	310	45	3,95	23,49	3,84	24,04	2,9	-2,3
4	200	320	50	3,82	22,96	3,95	22,90	-3,3	0,3
5	210	330	57	3,70	22,53	3,90	22,85	-5,1	-1,4
6	230	350	65	3,41	21,37	3,48	22,27	-2,0	-4,0
7	250	360	68	3,13	20,26	3,11	20,95	0,6	-3,3
8	260	370	77	3,04	19,92	2,88	20,08	5,6	-0,8
9	280	390	85	2,75	18,76	2,81	19,55	-2,1	-4,0

The deviation between the values Ra, Rz obtained from simulation and the values from followed verifying experiment is in range – 5,4 up to +5,6 %.

CONCLUSION

The article describes actual and for firms working manufacturing systems with technology AWJ also acute problematics of modelling and simulation of technological parameters influence of manufacturing systems with technology AWJ on cut area quality parameters. It goes out from experiments plan and states two mathematical models and the concrete example of their utilization or cut area quality indicators values simulation on basis of manufacturing systems technological parameters applied values. It contains also specimen from simulated mathematical model verifying. From it is follows that model is with demanded accuracy utilizing for manufacturing systems with technology AWJ and cut material – abrasion resisting steel HARDOX 500 for technological parameters. Their values are from within of the range bounding validity of mathematical model. The solution stated in the article is a part of activities of chair of manufacturing processes working aimed at modelling, simulation and diagnostics of working states of manufacturing and systems

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