ANNALS OF THE ORADEA UNIVERSITY
Fascicle of Management and Technological Engineering
ISSUE #1, MAY 2015, http://www.imtuoradea.ro/auo.fmte/

THE INFLUENCE OF COOLING FLUIDS TO ENERGY CONSUMPTION DURING TRANSVERSAL TURNING

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Abstract**—**Authors focus on an issue of cutting medium effect on possibilities to reduce energy consumption in a cutting process. The method was designed to monitor an energy consumption and factor of friction under different cutting media at turning. First measured data was statistically processed and then, using software Mathematica this data was overlapped with surface and overlaid with a power - function selected machining parameters curve. Using neural networks method a simulation model is presented. It can give a conception of cutting media behavior when different parameters of machining are used, which were not an object of tests.

Keywords**—** cutting fluid – friction factor – cutting output – energy balance

I. INTRODUCTION

NOWADAYS, the research on energetic demands of the machining process represents a priority question of evaluating production efficiency. When evaluating individual machining techniques, not only the quality of produced components and their productivity but also power saving is taken into consideration – the energetic balance showing the energy consummated during the cutting process and thereby also the energy costs of the technological process. The analysis evaluating the impact of the cutting environment on the energy balance of the machining process proved, that the problem has not been solved so far and that the objective results as presented by both producers and consumers of the cutting environment are not complex.

Reasons for such behavior on the side of both producers and consumers of cutting fluids are evident from the implementation of the products on the market, where thy impact of the cutting environment on the stability of the machining process and the quality of the machined surface represent the primary criteria for employing the given cutting environment in the machining process. The amount of consummated energy of individual machining methods is conditioned by the particular conditions of machining. The field offers space for a vast research that could be defined as a „need for optimizing cutting conditions with regard to the minimum of consummated energy." In this context, on the basis of published outcomes and own experience, it can be claimed that, for instance, the consummated energy during turning on universal lathes amounts for 1,3 to 16,4 % .[1]- [10]

If you as part of the research carried out, a methodology of comparative machining trials was designed and applied, focused on the impact of the given cutting environment on the electric power consummation for selected machining parameters (v_c – cutting speed, f – feed, a_p – depth of cut, geometry of the cutting wedge of the given tool). With different technological parameters, the same fluid achieves different levels of impact on the machining process, i. e. the impact on the quality of machined surface, residual tension on the surface layers, size and orientation of the cutting forces, precision of machining, stability of the machining process, and, last but not least, the field of or research: the impact on the energy consummation. [11]

As for the availability of production facilities and the possibilities of collecting data measured by these facilities, the control research has been carried out for turning as machining technique. The findings published in this paper are focused on measuring the input electric power of a selected production facility (SN50 lathe) on defined samples of machined material (steel 12050.1) for chosen matrix of technological conditions and selected cutting environments for transversal turning.

II. PROCEDURE FOR PAPER SUBMISSION

For experiments we had at our disposal 26 different cutting fluids thinned with water in precisely prescribed ratio and produced different producers. For steel 12050.1 machining, a 5 % solution of delivered cutting fluids was selected. The percentual concentrate of the cutting fluid thinned with water is given by the producer, with regard to the type of the machined material. For experiments, 26 emulsion cutting environments by 9 producers were selected. The cutting environments were marked by code system RP.1 – RP.26 for the experiment outcomes to be left undisclosed and because of a missing agreement with the cutting environment supplier regarding the publishing of findings.

In order to precisely determine the concentrations of tempered cutting environment we used graduated vessels for determining the volumes of both water and the concentrate of the cutting environment. The percentage of concentration was monitored by a refractometer.

With regard to high volume demands of the reservoir of the cutting environment on SN 50 lathe, an external system of delivering the cutting fluid to the point of cutting was constructed, [11].

For measuring the electric power consummation during the cutting process, the Hioki 3196 wattmeter was used, plugged into 3 phases by means of four grip ampere-meters and four clamps, which measured the current voltage before the individual phases achieved the main electromotor.

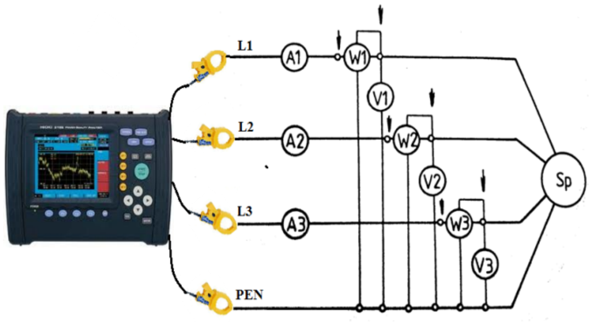


Fig. 1. The scheme of connection of the measuring

The measuring facility enables to monitor and record the phenomena connected to the quality of controlled machine supply. Its functioning rests on scanning the changes in current take-off (I), value of the voltage (U) and phase shift, on the basis of which the facility is able to calculate the real input power of the lathe's electromotor. The values are recorded in real time in defined time interval. In the course of real time, measured data are used for computing the average value and thus give statistical evaluation as the fundament for result evaluation. The facility is also able to record data from one month of uninterrupted measuring in its internal memory. It is also possible do save data on both a PC card (ATA flash cards) or into internal memory. It is also equipped with the HTTP server function, which eliminates the need of special interface and in application enables to use any usual internet browser (e. g. Internet Explorer) for full distant monitoring and operation.

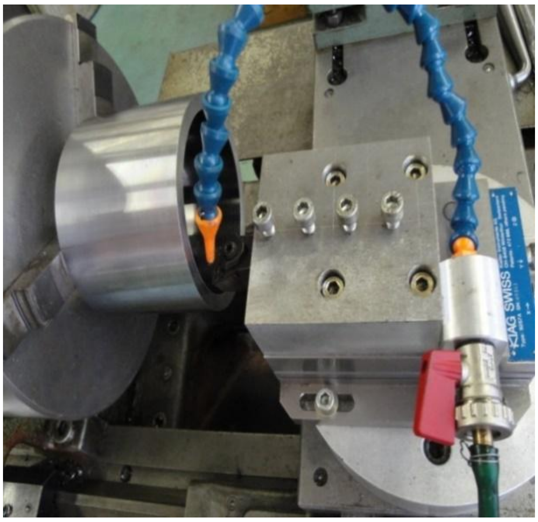


Fig. 2. Experimental measuring for transversal turning

III. EXPERIMENTAL CONDITIONS

For the proposed experiment, following technological parameters of machining were selected. The matrix of the experiment, i. e. the cutting conditions for 26 chosen and supplied cutting environments, was defined as follows:

- Depth of the cut **a_p** = 0,5, 1, 1,5 (mm)
- Cutting speed **v_c** = 152 (mpm)
- Transversal feed **f** = 0,2, 0,36, 0,56 (mmprev.)

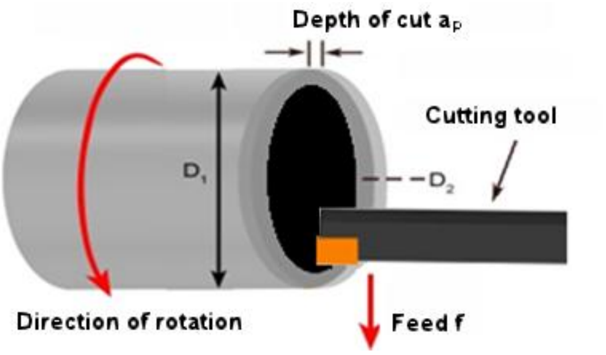


Fig. 3. Scheme of the machining with given process parameters

IV. RESULTS OF THE EXPERIMENTS

TABLE 1 displays the summary of the statistical procession of all measured parameters. The authors of the paper were not given producers' permission to publish particular names of cutting fluids.

An example of processed data for the cutting fluid no. 1 is displayed in the Fig. 4, Diagram 1. The measured data were statistically processed and then, using the Mathematica programme, they were converted into surfaces characterizing the function of calculating the input power as related to selected machining parameters (See *Fig. 4, Diagram 2*)

TABLE I

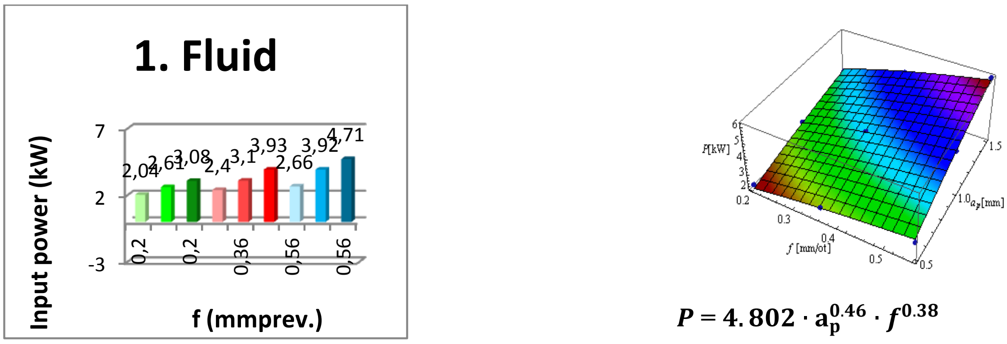
Technological conditions		**Average energy consumption (kW)**												
		14	15	16	17	18	19	20	21	22	23	24	25	26
ap=0,5	f=0,2	1,77	1,78	1,87	1,88	1,81	1,88	1,75	1,83	1,85	1,89	1,80	1,78	1,77
ap=1	f=0,2	2,31	2,38	2,43	2,42	2,39	2,36	2,42	2,43	2,44	2,46	2,40	2,39	2,44
ap=1,5	f=0,2	2,75	2,82	2,87	2,82	3,80	2,79	2,79	2,99	2,93	2,87	2,91	2,91	2,92
ap=0,5	f=0,36	2,10	2,12	2,18	2,14	2,13	2,16	2,10	2,05	2,09	2,19	2,09	2,05	2,15
ap=1	f=0,36	2,83	2,91	2,89	2,94	2,95	2,90	2,84	2,93	2,89	2,98	3,08	2,96	2,97
ap=1,5	f=0,36	3,50	3,63	3,67	3,72	3,63	3,66	3,58	3,77	3,85	3,75	3,75	3,76	3,69
ap=0,5	f=0,56	2,54	2,44	2,47	2,50	2,47	2,50	2,48	2,46	2,43	2,51	2,49	2,48	2,41
ap=1	f=0,56	3,42	3,52	3,57	3,63	3,71	3,64	3,59	3,79	3,82	3,59	3,56	3,76	3,70
ap=1,5	f=0,56	4,61	4,36	4,62	4,58	4,63	4,65	4,59	4,63	4,73	4,62	4,81	4,57	4,65

CONSUMPTION OF ELECTRIC POWER DURING TRANSVERSAL TURNING FOR 26 DIFFERENT CUTTING FLUIDS (V_C =152 MMPM)

TABLE II

Technological conditions		**Average energy consumption (kW)**												
		1	2	3	4	5	6	7	8	9	10	11	12	13
ap=0,5	f=0,2	2,04	1,94	2,03	1,97	1,97	2,01	1,94	1,86	1,86	1,89	1,92	1,75	1,70
ap=1	f=0,2	2,61	2,56	2,61	2,60	2,57	2,48	2,58	2,44	2,50	2,48	2,38	2,40	2,31
ap=1,5	f=0,2	3,08	2,93	2,99	3,07	3,05	3,01	2,96	2,99	2,90	2,91	2,82	2,83	2,80
ap=0,5	f=0,36	2,40	2,38	2,45	2,37	2,18	2,24	2,20	2,20	2,16	2,17	2,21	2,10	2,09
ap=1	f=0,36	3,10	3,21	3,28	3,20	3,20	3,28	3,25	3,05	2,95	3,02	2,91	2,93	2,87
ap=1,5	f=0,36	3,93	3,86	3,96	3,97	3,92	3,93	3,84	3,80	3,81	3,76	3,55	3,64	3,59
ap=0,5	f=0,56	2,66	2,55	2,73	2,74	2,78	2,77	2,51	2,58	2,56	2,53	2,58	2,52	2,50
ap=1	f=0,56	3,92	3,90	3,90	3,88	3,88	3,76	3,48	3,82	3,89	3,62	3,65	3,53	3,45
ap=1,5	f=0,56	4,71	4,85	5,10	4,67	5,13	5,02	4,61	4,84	4,76	4,57	4,65	4,36	4,52

An example of processed data for the cutting fluid no. 1 is displayed in the Fig. 4, Diagram 1, [12]-[15].



$$P = 4.802 \cdot a_p^{0.46} \cdot f^{0.38}$$

(a) Diagram 1: The consumption of electric energy during transversal turning

(b) Diagram 2: The development of the electric energy consumption in the relationship to a_p f.

Fig. 4 Processed data of measuring the changes in energetic demands on the cutting fluid no. 1

The measured data were statistically processed and then, using the Mathematica program, they were converted into surfaces characterizing the function of calculating the input power as related to selected machining parameters (See *Fig. 4, Diagram 2*)

V. CONCLUSION

On the basis of the results achieved by the paper it can be concluded, that the knowledge of the impact of experimentally proved cutting environments on the process of transversal machining have been broadened. A method of evaluating the cutting environment in the relationship to the consumption of electrical power for the given machining operation or for the given matrix of technological parameters of machining was designed and verified.

A contribution of the carried-out research is to be seen in valuable experience for the producers of cutting fluids who can closely examine the question of chemical composition and production technology of cutting fluids, i. e. it can foster the producers of cutting environments to considers the impact of individual components (EP substances) in the greasing qualities in the relationship to the energy consummated in the process of machining.

The measured data were statistically processed and then, using the Mathematica program, they were converted into surface and function of calculating the input power in relationship to selected parameters of machining.

Then, a simulation model was created with a usage of neuron nets, giving us a picture of the behavior of a given cutting environment when using such machining parameters which were not an object of the carried-out tests.

As a conclusion it can be claimed that the cutting environment really represents an intensifying factor of machining processes: it not only positively influences the exploitation qualities of produced parts but also offers an opportunity to considerably save energy consumption during the machining process. When comparing 26 samples of cutting environment, our experiment proved a 16-pecent saving of energy.

ACKNOWLEDGMENT

The authors would like to thank the employees of firmes Castrol, Slovnaft, RhenusLub, Charvát, s.r.o, ML-Lubrication, Hosmac, Houghton, Blaser Swisslube, Chesteron for their willingness to supply the produced cutting fluids as well as for their valuable advices during carrying out the research. This study was supported by the Slovak Research and Development Agency under the contract VEGA MŠ SR No. 1/0670/15 *Evaluating of cutting medium effect on energy balance of machining process.*

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