MEASUREMENT AND ANALYSIS OF TECHNOLOGICAL HEAD VIBRATIONS IN HYDROABRASIVE CUTTING TECHNOLOGY

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ABSTRACT: The article examines the impact of selected technological parameters and that are the kind of abrasive and feed speed on technological head vibrations creation when cutting abrasion-proof steel Hardox 500 in the production system with abrasive water jet technology. The experiments were carried out on Physics Institute of Technical University in Ostrava. It contains graphical dependences of vibrations acceleration amplitude on frequency, from which are formulated sets of new knowledge.
KEY WORDS: Cutting, hydroabrasive jet, abrasive, cutting velocity, frequency, amplitude.

1 INTRODUCTION

The current state of abrasive water jet technology investigation shows that one of the most important problems is the evaluation of impact in technological parameters changes on vibrations parameters.

Despite the fact that on this issue there is developed a set of solutions containing methodology and experiments evaluation with validity for the specific measurement conditions (Hashish, 1989), (Zeng, 1996), is more and more effort devoted to the examination and analysis of emergence and spread of technological head vibrations (Bičejová, 2010), (Jacko, 2011), (Salokyová, 2012), which can negatively affect reliability and safety of operation.

New findings contained in the article shall complement previous solutions aimed not only to operational state diagnosis of production systems in other progressive technologies (Straka, 2004), (Hrabčáková, 2003).

It contains graphical dependences of vibrations acceleration amplitude on frequency and analysis of impact in abrasive and technological head feed speed changes.

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2 PERFORMING OF EXPERIMENTS AND THEIR EVALUATION

2.1 Plan of experiments

There were made 4 successive experiments according to experiments plan, clearly shown in Figure 1.

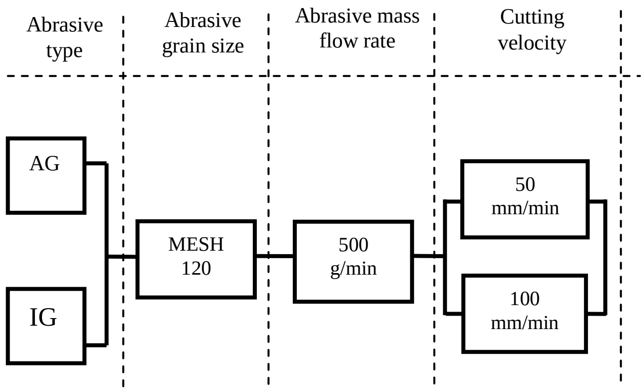


Figure 1 Production system with water jet technology in liquid jet laboratory

2.2 Production system and place of experiments

The experiments were carried out in the Liquid jet laboratory IF HGF VŠB TU in Ostrava using production system with abrasive water jet.

The main structural parts of the production system

- table X-Y CNC WJ1020-1Z-EKO for division applications with abrasive water jet technology

- multiplicator for water pressure creation PTV 19/60 HSQ 5x with flow rate to 1,9 $l.min^{-1}$
- technological head PASER IIITM

2.3 Conditions of the experiment

All measurements were performed from the same starting position X = 320 mm a Y = 370 mm. Other conditions under which were the experiments performed are shown in Table 1.

Table 1 Overview of the experiment conditions

Constant material parameters	cut material indication	Steel Hardox 500
	cut material thickness	10 mm
Constant technological parameters	working medium pressure	380 MPa
	abrasive grain size	MESH 120
	abrasive mass flow rate	500 g/min
	water nozzle diameter	0,25 mm
	abrasive tube diameter	1,02 mm
Changing technological parameters	abrasive type	australian garnet
		indian garnet
	cutting velocity	50 a 100 mm/min

3 HARDWARE AND SOFTWARE FOR DATA PROCESSING

3.1 Hardware

For the vibrations scanning a miniature piezoelectric accelerometer manufactured by Brüel & Kjær type: 4507-B-004 was used. It was fixed by superglue to the water jet technological head so that its axis was in line with the vibrations axis in the direction of the abrasive water jet and the measuring card CompactDAQ NI 9233 with power supply where the analog signal was converted to digital record.

3.2 Software

For the time-based signal evaluation the SignalExpress was used which is a part of LabVIEW programming and development environment from the National Instruments company. The time of selected interval was 10 seconds of steady process record and thereof was a frequency spectrum in the range from 0 – to 10 kHz generated by Fourier Transform. The frequency spectrum envelope was obtained by using the filter algorithm and processed in environment of Microsoft Excel spreadsheet editor.

4 THE MEASURED VALUES

The measured values for investigated kinds of abrasives (AG and IG) and two technological head feed speeds (50 and 100 mm/min) are shown in the form of vibrations acceleration amplitude waveforms. An example of vibrations acceleration amplitude waveforms for both investigated abrasives using feed speeds 50 mm/min is shown in Figures 2 and 3.

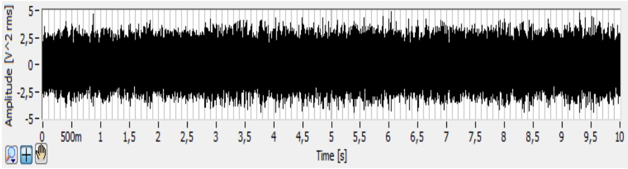


Fig. 2 The time course of vibrations acceleration amplitude for the abrasive type AG

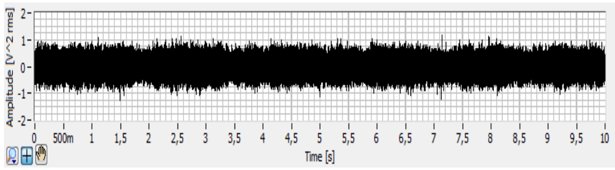


Fig. 3 The time course of vibrations acceleration amplitude for the abrasive type IG

5 OVERVIEW AND STRUCTURE EVALUATION OF EXPERIMENTS

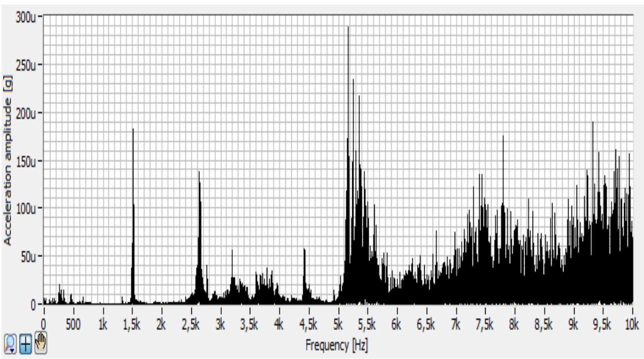
Overview evaluation of experiments is shown in the structure:

- graphical dependence of vibrations acceleration amplitude for the abrasive type AG and feed speed of 50 mm/min
- frequency spectrum envelope for the abrasive type AG and feed speed of 50 mm/min
- graphical dependence of vibrations acceleration amplitude for the abrasive type IG and feed speed of 50 mm/min
- frequency spectrum envelope for the abrasive type IG and feed speed of 50 mm/min
- comparative graphs of vibrations acceleration amplitude envelopes and frequency spectrums specifically for investigated kinds of abrasives and individually investigated technological head feed speeds
- comparative graphs of vibrations acceleration amplitude envelopes and frequency spectrums specifically for two investigated feed speeds and investigated abrasives
- graph with maximum vibrations acceleration amplitude values of technological head in the frequency range from 1,6 kHz – 5,4 kHz

6 EVALUATION OF MEASURED VALUES

The evaluation of measured values consists of technological head vibrations acceleration amplitude frequency spectrums in the frequency range 0 – 10 kHz. For AG abrasive using the feed speed of 50 mm/min is the course of changes of vibrations acceleration amplitude on frequency shown on Fig. 4 and the frequency spectrum envelope on Fig. 5. Analogously graphical dependence of VAA on frequency for IG abrasive using a speed of 50 mm/min shown on Fig. 6, the frequency spectrum envelope is shown on Fig. 7. Similarly were shown graphical dependences of acceleration amplitude and vibration frequency and frequency spectrum envelopes using a speed of 100 mm/min for both investigated abrasives.

Figure 4. The graphical dependence of acceleration amplitude and vibrations frequency for the abrasive type AG at the speed of 50 mm/min



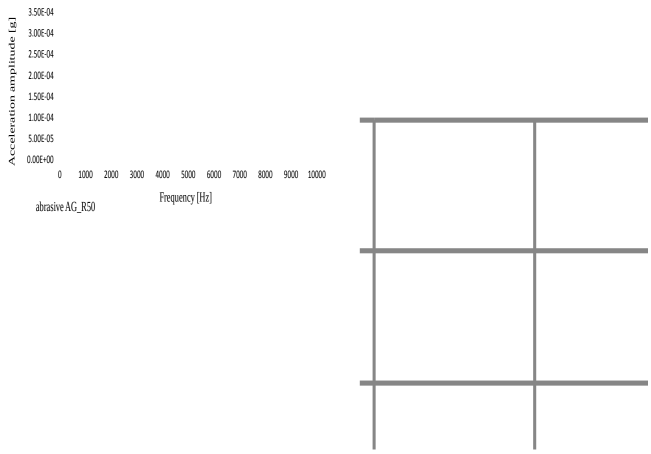


Figure 5. The vibrations frequency spectrum envelope of technological head for the abrasive type AG at the speed of 50 mm/min

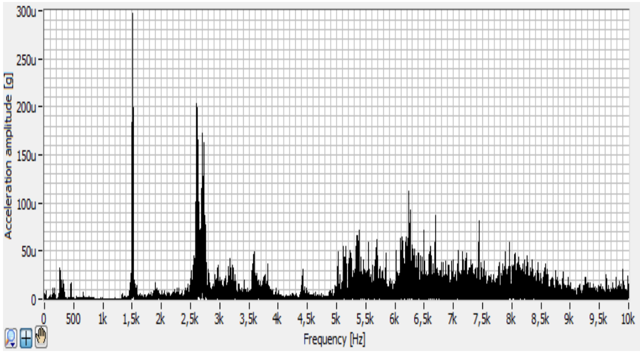


Figure 6 The graphical dependence of acceleration amplitude and vibrations frequency for the abrasive type IG at the speed of 50 mm/min

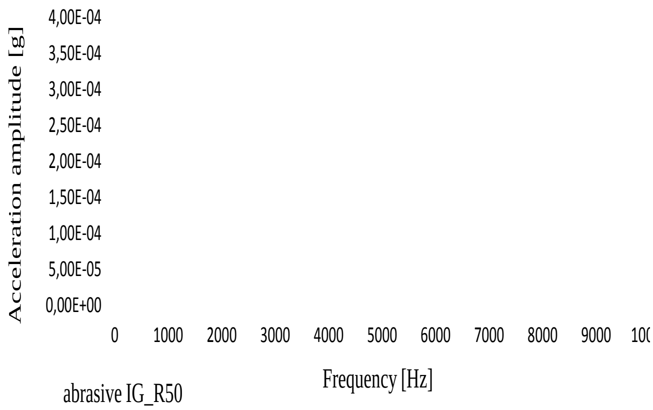


Figure 7 The vibrations frequency spectrum envelope of technological head for the abrasive type IG at the speed of 50 mm/min

The comparative graphs of vibrations acceleration amplitude envelopes and frequency spectrums separately for investigated kinds of abrasives and individual investigated technological head feed speeds are shown on Figures 8 and 9.

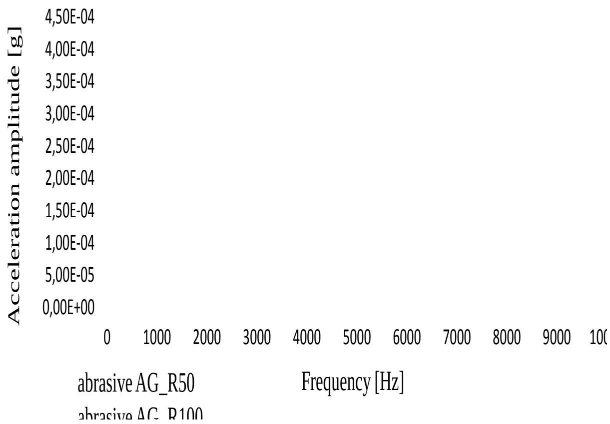


Figure 8 The vibrations frequency spectrum envelopes comparison of technological head for the abrasive type AG at the speed of 50 and 100 mm/min

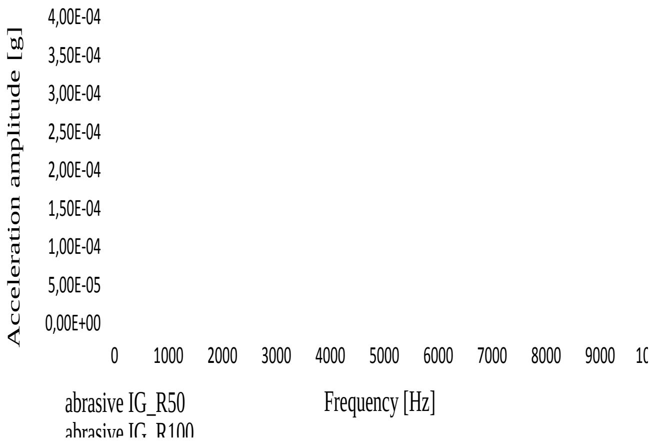


Figure 9 The vibrations frequency spectrum envelopes comparison of technological head for the abrasive type IG at the speed of 50 and 100 mm/min

The comparative graph of vibrations acceleration amplitude envelopes and frequency spectrums individual fot two investigated feed speeds and investigated abrasives are shown on Figures 10 and 11.

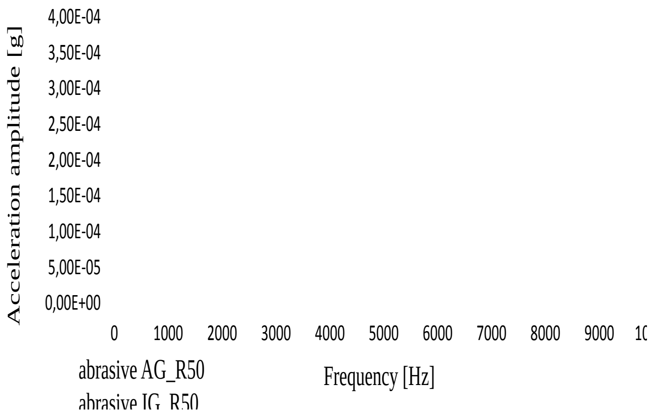


Figure 10 The vibrations frequency spectrum envelopes comparison of technological head at feed speed of 50 mm/min

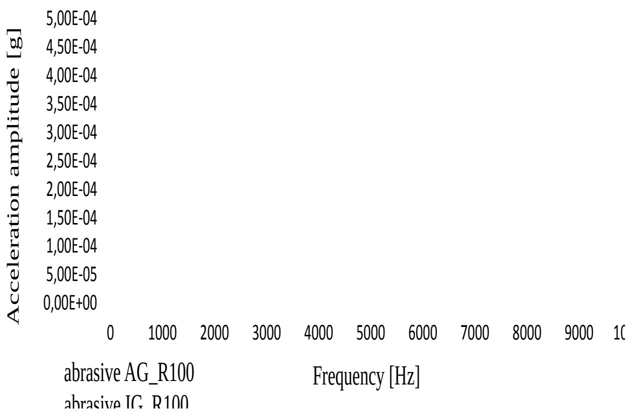


Figure 11 The vibrations frequency spectrum envelopes comparison of technological head at feed speed of 100 mm/min

The maximum technological head vibrations acceleration amplitude values in frequency range from 1,6 kHz to 5,4 kHz for individual investigated kinds of abrasives and technological head feed speeds are shown on Figure 12.

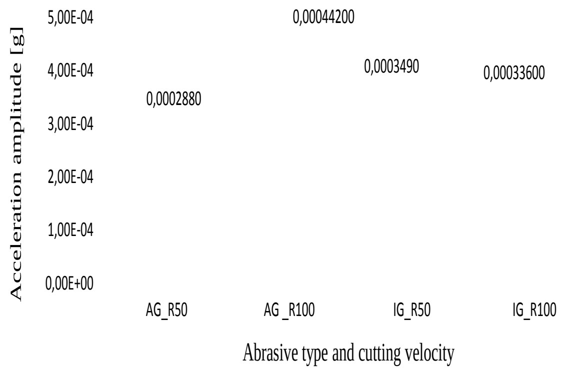


Fig. 12 The graphical representation of vibrations acceleration amplitude maximum values and technological head feed speeds

7 THE FORMULATION OF NEW KNOWLEDGE

From the comparison of graphical dependences and frequency spectrum envelopes of technological head vibrations acceleration amplitude, but also from graph of vibrations maximum values is a set of new knowledge formulated:

- increased values of vibrations acceleration amplitude at AG abrasive and technological head feed speed of 50 and 100 mm/min occur in frequency range from 5,2 to 5,4 kHz and from 5,0 to 6,0 kHz from the monitored range 0 – 10 kHz
- increased values of vibrations acceleration amplitude at IG abrasive and technological head feed speed of 50 and 100 mm/min occur in frequency range from 1,2 to 3,0 kHz with the maximum reached value at a frequency of 1,6 kHz
- from a set of investigated kinds of abrasives using feed speed of 50 mm/min were lower vibrations acceleration amplitude values observed by using australian garnet abrasive. In comparison to indian garnet abrasive this value is lower by 17,47%
- from a set of investigated kinds of abrasives using feed speed of 100 mm/min were lower vibrations acceleration amplitude values observed by using indian garnet abrasive. In comparison to australian garnet abrasive this value is lower by 23,91%
- with increasing feed speed during AG abrasive dividing in the examined range the

vibrations acceleration amplitude increases periodically and it is about 34,84%

- with increasing feed speed during IG abrasive dividing in the examined range the vibrations acceleration amplitude decreased by 34,84%

8 CONCLUSIONS

The article is focused on impact analysis of abrasive kind and technological head feed speed on acceleration amplitude and technological head vibrations frequency by hydroabrasive stream dividing.

From total of 16 evaluated graphical dependences is in the article listed 10 graphical dependences, 4 from them are comparative graphs of frequency spectrum envelopes.

In addition the article also contains comparative graphs with maximum vibrations acceleration amplitude values which occurs in frequency range from 1,6 kHz to 5,4 kHz.

From the evaluation and analysis of graphical dependences, comparative graphs and graph with vibrations acceleration amplitude maximum values is a set of new knowledge formulated, which complement current scientific knowledge of this issue.

The new knowledge shows, that the highest vibrations values during dividing steel HARDOX 500 were achieved by using australian garnet abrasive with technological head feed speed of 100 mm/min.

When applying additional input technological parameters (IG abrasive and speed 50 mm/min) are vibrations acceleration amplitude values lower, what are insignificant values in terms of the adverse impact of vibrations on the reliability and production system operation safety.

9 ACKNOWLEDGEMENTS

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