

ANALYSIS OF FACTOR‘ EFFECTS IN RELATION TO VIBRATIONS ON THE TECHNOLOGICAL HEAD DURING CONSTRUCTION STEELS SPLITTING BY HYDRO ABRASIVE SPLITTING

Štefánia Salokyová[1]

[1]Faculty of Manufacturing Technologies, Department of ManufacturingProcessesOperation, TechnicalUniversity of Košice, Bayerova 1, 080 01 Prešov, Slovakia, stefania.salokyova@tuke.sk

ABSTRACT: The article is focused on evaluation of the effects of factors of technology of high speed hydro abrasive jet during splitting of construction steels 12 050 and 11 523 by the means of factor experiment. This experiment observed the effect and significance of two selected factors (type of material and movement speed of the technological head). Measured values are displayed through graphic and numeric dependencies, based on which new knowledge and recommendations for operators are formulated. In conclusion contributions are matched basic parameter vibration - RMS and Peak to peak.The basic goal of vibration observation is to provide basic information about the operation and technical state of the device in production system.

KEY WORDS: Material cutting, abrasive water jet, feed rate, technological head,vibration

1. INTRODUCTION

Presently the AWJ technology is still the subject of research, which is proven by a number of publications. The research of this field is oriented mostly on the understanding of the removal mechanism [1], [2], [3] and optimization of factors, which in their mutual combination affect the surface quality [4], [5]. Except for many experimental studies, which task is the understanding of factors affecting the splitting process performance, many works have dealt with modelling the process between the jet and cut material for the purpose of understanding the physical background [6], [7]. Partial analyses of input technological factors stating the effect on occurrence and spreading of vibrations are processed in doctoral theses [8], [9], [10]. New knowledge contained in this article gained by examination of the effects of movement speed and type of material on vibration occurrence on the technological head supplement previous solutions. The work contains mostly original graphic dependencies and analysis of changed factor’s effects on vibration acceleration amplitude and vibrations frequency of the technological head. Except for this it supplements significant knowledge focused on modelling and diagnosis processes in the technology of water jet solved at the Institute of Physics of the Technical University in Ostrava [11], [12].

2. PERFORMANCE OF EXPERIMENTS

2.1 Plan experiments

There were made 6 successive experiments according to experiments plan, clearly shown in Figure 1.

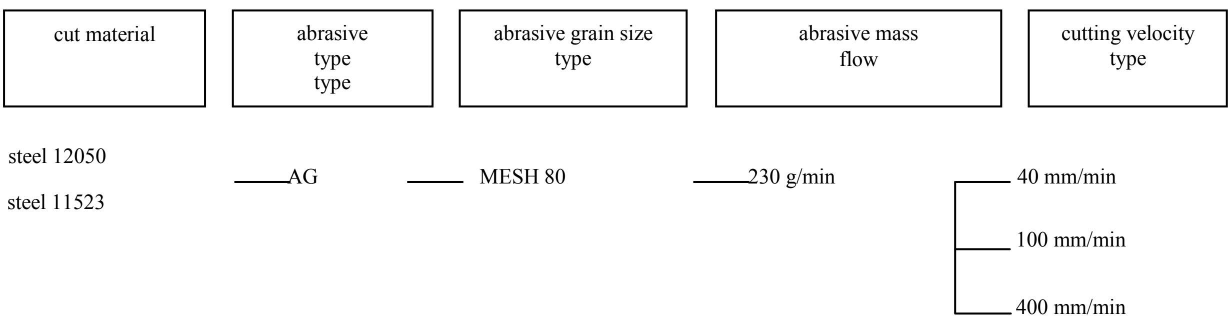

Figure 1. Graphical representation of the experiments plan

2.2 Conditions of the experiment

All measurements were performed from the same starting position X = 320 mm a Y = 370 mm. The distance between the water jet and split material is 2 mm. Other conditions under which were the experiments performed:

Constant material parameters:

- cut material thickness 10 mm

Constant technological parameters:

- working medium pressure 380 MPa
- abrasive type australian garnet (AG)
- abrasive grain size MESH 80
- water nozzle diameter 0.25 mm
- abrasive tube diameter 1.02 mm

Changing material parameters:

- cut material indicationsteel 12 050, steel11 523

Changing technological parameters:

- cutting velocity 40 mm/min, 100 mm/min, 400 mm/min

2.3 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

3. OVERVIEW AND STRUCTURE EVALUATION OF EXPERIMENTS

- the time course of vibrations acceleration amplitude for the cut material 12 050 at the feed rate of 40 mm/min
- the time course of vibrations acceleration amplitude for the cut material 11 523 at the feed rate of 40 mm/min
- the graphical dependence of acceleration amplitude and vibrations frequency for the cut material 12 050 at the feed rate of 40 mm/min
- the vibrations frequency spectrum envelope of technological head for the cut material 12 050 at the feed rate of 40 mm/min
- comparison graphs of vibration acceleration amplitude covers and frequency ranges individually for two selected types of material and examined movement speeds
- comparison graphs of vibration acceleration amplitude covers and frequency ranges individually for examined movement speeds
- graph with maximum vibrations acceleration amplitude values of technological head in the frequency range from 6.8 kHz – 7.3 kHz [8]

4. EVALUTION OF MEASURED VALUES

Measured values for selected split materials (steel 12 050 and 11 523) and two technological head movement speeds (50 and 100 mm/min) are depicted in the form of time lapses of the vibration acceleration amplitude. Example of time lapse of vibration acceleration amplitude for both split materials is depicted in Figure 2 and 3 with used movement speed 40 mm/min [8].

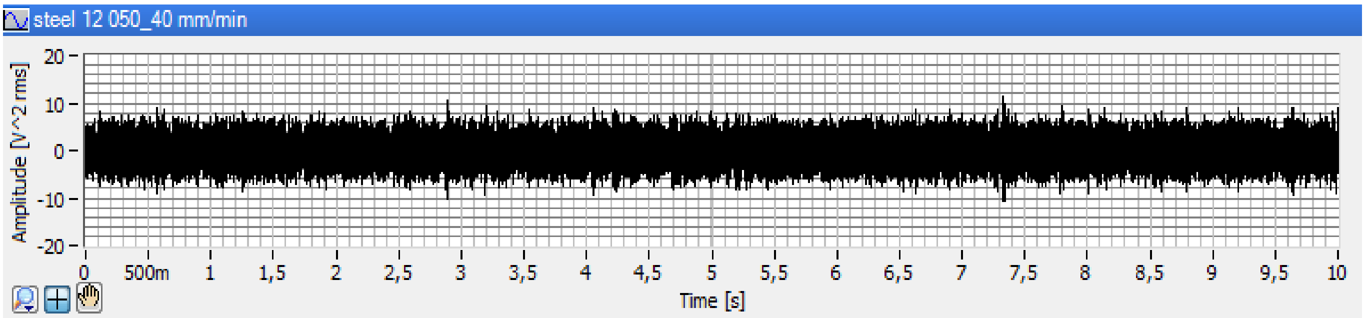

Figure 2. The time course of vibrations acceleration amplitude for the cut material 12 050 at the feed rate of 40 mm/min

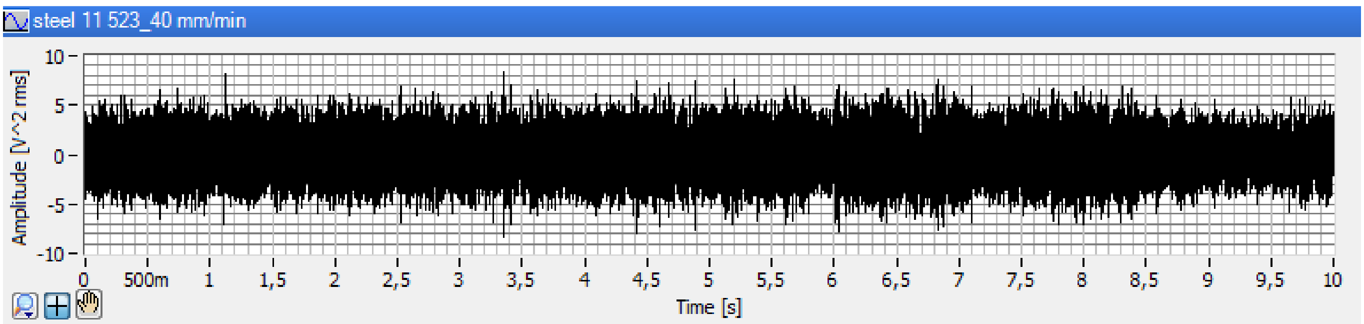

Figure 3. The time course of vibrations acceleration amplitude for the cut material 11 523 at the feed rate of 40 mm/min

Measured vibration acceleration amplitude values gained by the Fourier transformation from the time lapse of the vibration acceleration amplitude for steel 12 050 and 11 523 are depicted in Table 1 in the frequency range 100 Hz through 10 kHz with frequency step 100 Hz [8].

Table 1. Measured vibrations acceleration amplitude values with a 100 Hz frequency step

	Steel 12 050			Steel 11 523		
	40 mm/min	100 mm/min	400 mm/min	40 mm/min	100 mm/min	400 mm/min
Frequency	**Vibrations acceleration amplitude [g]**					
100	0,0005513	0,0000543	0,0000252	0,001557	0,0000107	0,00000667
200	0,0000819	0,00000607	0,00000589	0,0000582	0,00000959	0,0000046
↓	↓	↓	↓	↓	↓	↓
9800	0,000101	0,0000189	0,000133	0,0000777	0,0000195	0,0000169
9900	0,0000894	0,0000183	0,00018	0,0001	0,0000112	0,0000184
10000	0,00012	0,0000117	0,00011	0,000136	0,0000127	0,0000129

Evaluation of measured values consists of creating graphic dependencies and vibration acceleration amplitude frequency ranges of the technological head in the frequency range 0 – 10 kHz. For split material steel 12 050 with used movement speed 40 mm/min, the curve change of vibration acceleration amplitude on frequency is depicted in Figure 4 and frequency range cover in Figure 5. Similarly the graphic dependencies and cover have been evaluated also for used movement speeds 100 and 400 mm/min. Analogically the graphic dependencies of acceleration amplitude and vibrations frequency and frequency range cover have been depicted for split material steel 11 523 and technological head movement speed (40, 100 and 400 mm/min) [8].

Comparison graphs of vibration acceleration amplitude covers and frequency ranges individually for two selected types of material and examined movement speeds 40, 100 and 400 mm/min are depicted in Figure 6 and 7 [8].

Comparison graphs of vibration acceleration amplitude and frequency ranges individually for examined movement speeds are depicted in Figure 8, 9 and 10 [8].

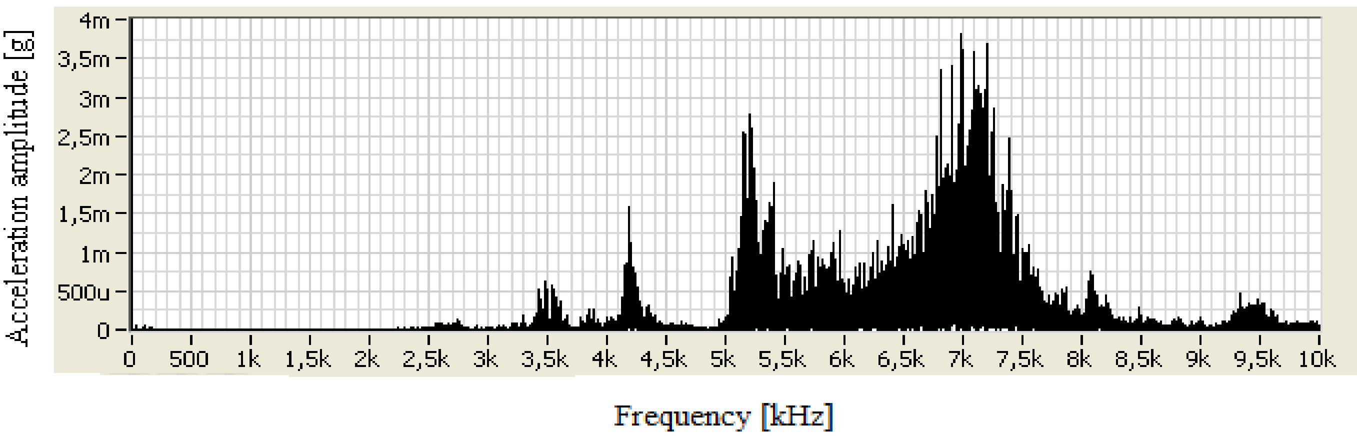

Figure 4. The graphical dependence of acceleration amplitude and vibrations frequency for the cut material 12 050 at the feed rate of 40 mm/min

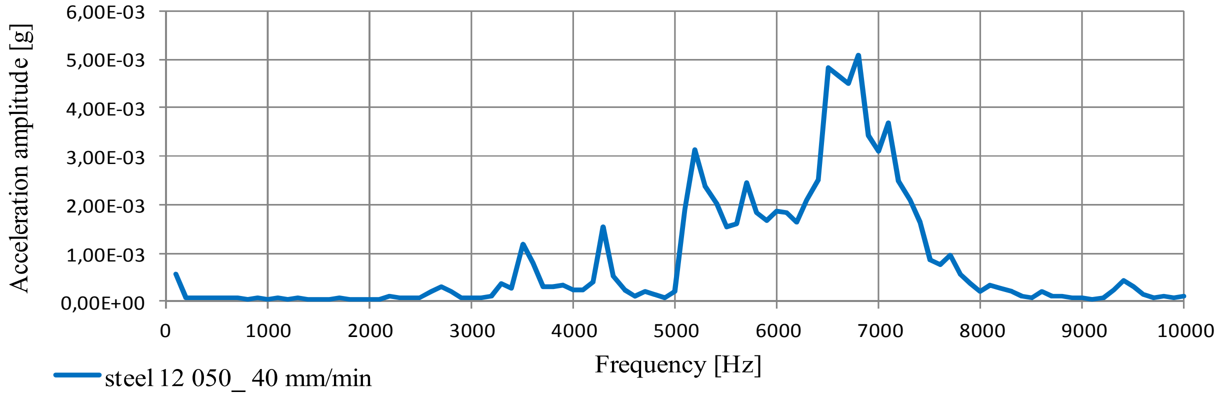

Figure 5. The vibrations frequency spectrum envelope of technological head for the cut material 12 050 at the feed rate of 40 mm/min

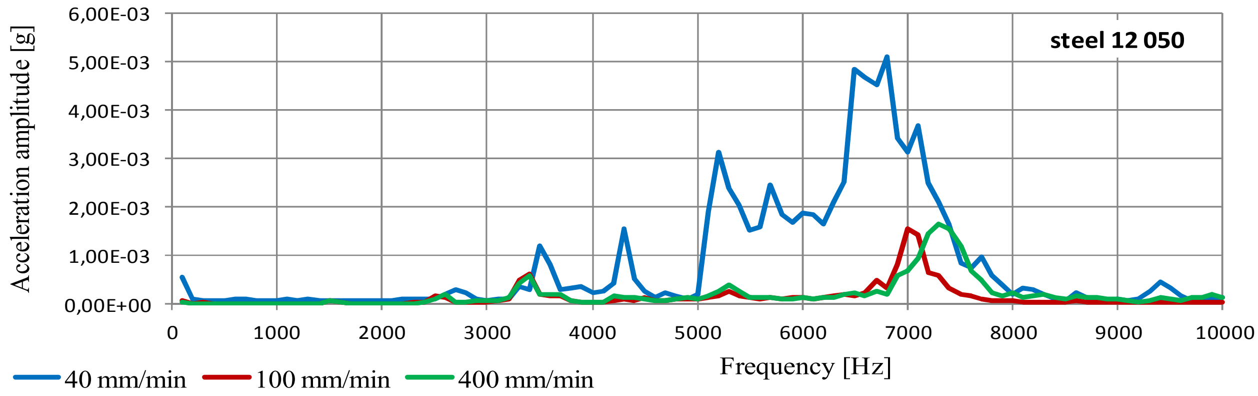

Figure 6. The vibrations frequency spectrum envelopes comparison of technological head for the cut material 12 050

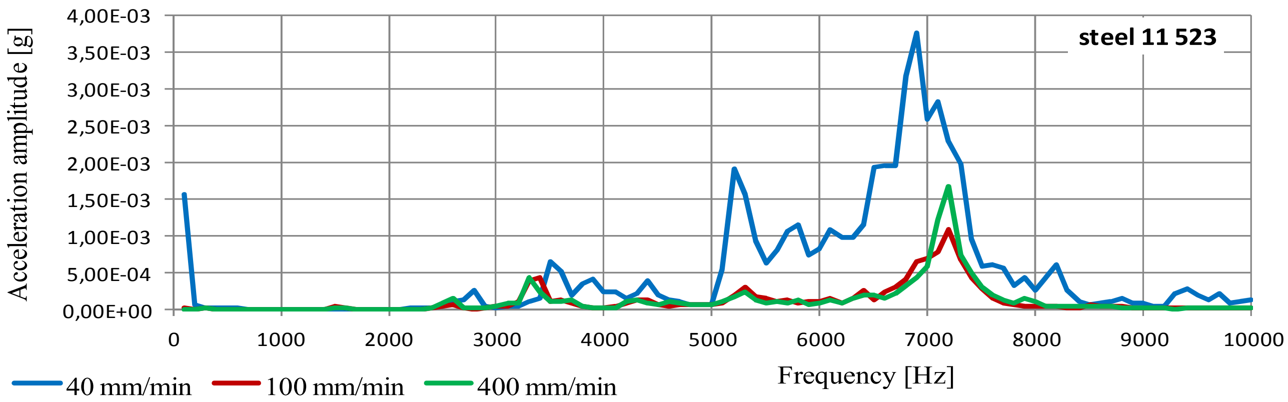

Figure 7. The vibrations frequency spectrum envelopes comparison of technological head for the cut material 11 523

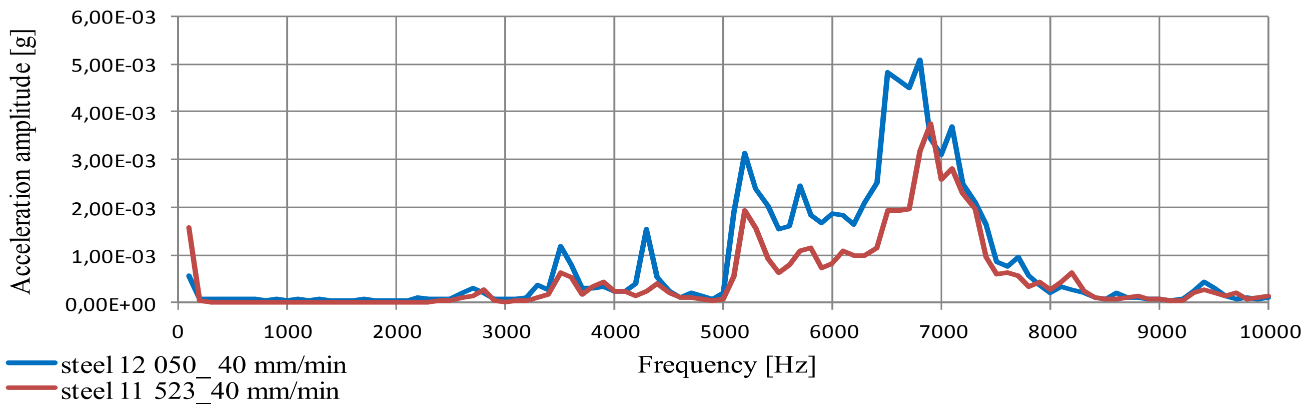

Figure 8. The vibrations frequency spectrum envelopes comparison of technological head using at the feed rate of 40 mm/min

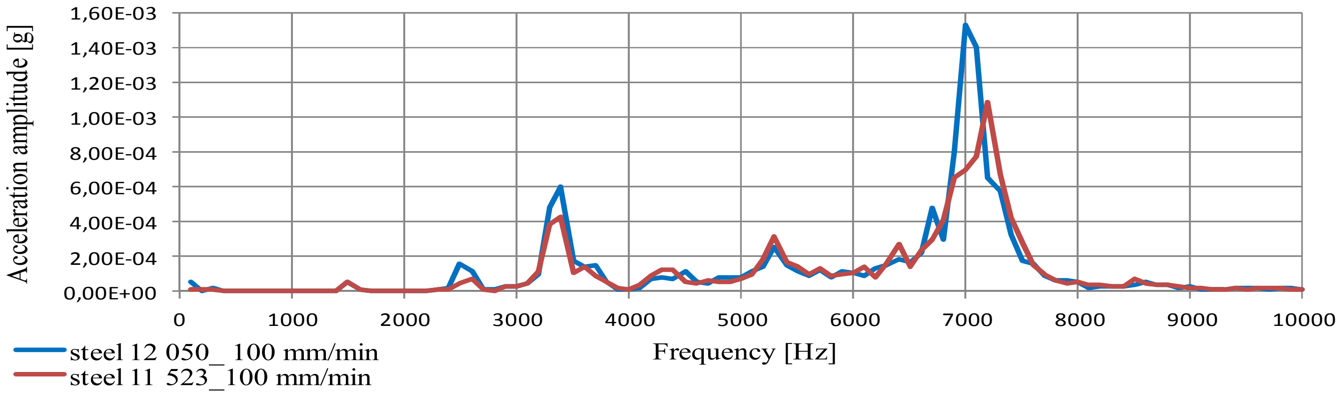

Figure 9. The vibrations frequency spectrum envelopes comparison of technological head using at the feed rate of 100 mm/min

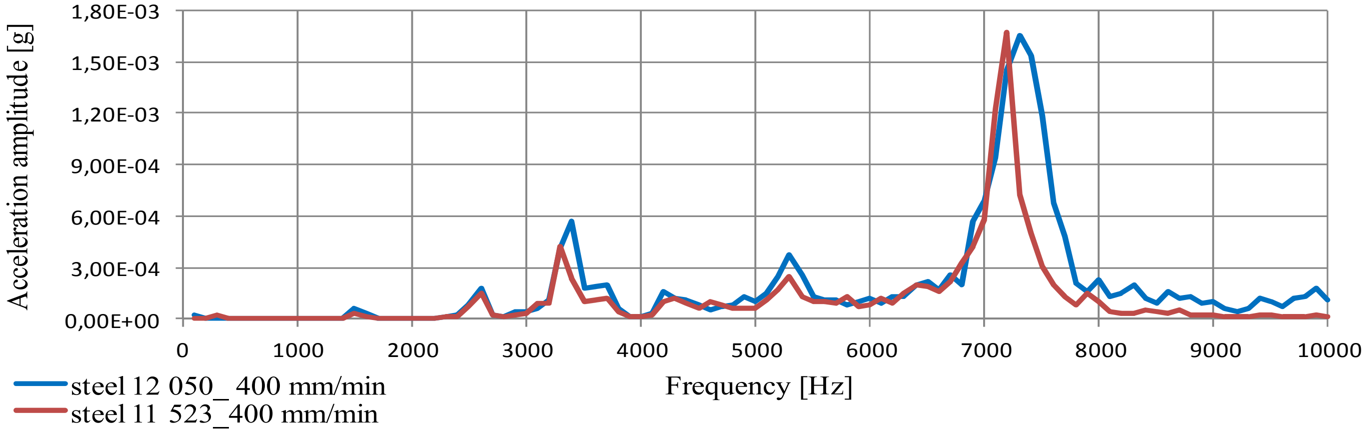

Figure 10. The vibrations frequency spectrum envelopes comparison of technological head using at the feed rate of 400 mm/min

Maximum values of the vibration acceleration amplitude of the technological head in the frequency range 6.8 kHz – 7.3 kHz for selected split steels 12 050 and 11 523 and technological head movement speed are depicted in Figure 11, dependent on vibration acceleration amplitude on movement speed.

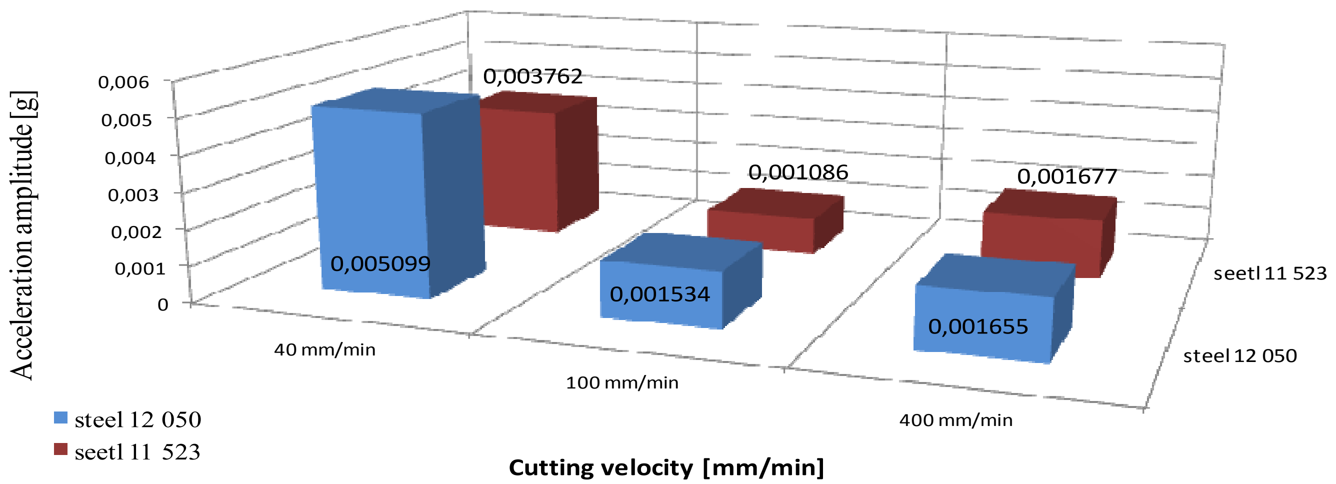

Figure 11. Graphic depiction of maximum values of the vibration acceleration amplitude for examined set of materials and technological head movement speeds

5. COMPARISON OF PARAMETERS OF VIBRATION

The basic parameters of vibration signal contain effective value (RMS) and Peak to Peak value. RMS is an important measure of its amplitude. It is numerically equal to the square root of the average of the squared value of amplitude. To calculate this value, the instantaneous amplitude values of the waveform must be squared and these squared values averaged over a certain length of time. This time interval must be at least one period of the wave in order to arrive at the correct value. The squared values are all positive, and thus so is their average. Then the square root of this average value is extracted to get the RMS value. Peak to Peak Amplitude is the distance from a negative peak to a positive peak. Dependency of RMS on movement speed for steel 12 050 and 11 523 is depicted in Figure 12 and graphic dependency Peak to Peak on speed for steel 12 050 and 11 523 in Figure 13.

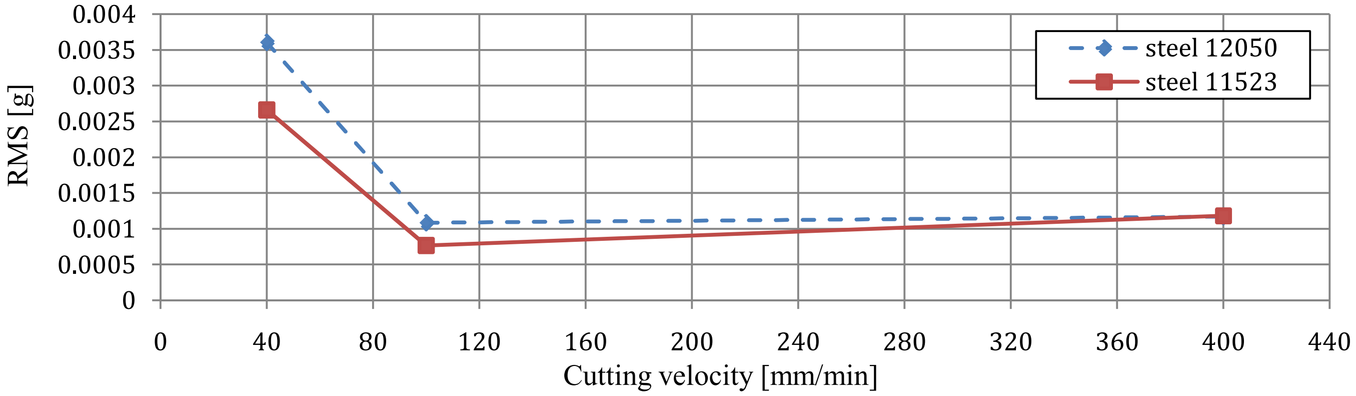

Figure 12. Graphic dependency of RMS on movement speed for steel 12 050 and 11 523

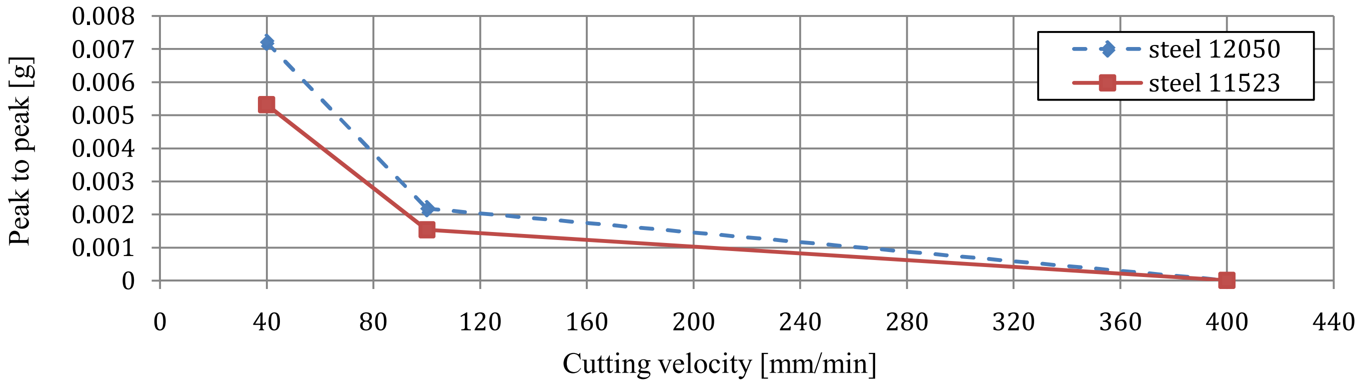

Figure 13. Graphic dependency Peak to Peak on movement speed for steel 12 050 and 11 523

6. DISCUSSON

Based on measured values a set of most important knowledge is formulated, valid for splitting of steel 12 050 and 11 523 by the abrasive water jet technology, in accordance with the conditions of this experiment, summed up in these points:

- highest values of vibration acceleration amplitude at three examined technological head movement speeds during the splitting of both selected materials can be found in the frequency range 6.8 kHz through 7.3 kHz in examined range 100 Hz through 10 kHz
- with growing numerical value of movement speed during splitting of material steel 12 050 in examined range, the vibration acceleration amplitude first drops and then slightly grows. In comparison for speed 40 mm/min and 100 mm/min it drops 69.91 %.
- with growing numerical value of movement speed during splitting of material steel 11 523 in examined range, the vibration acceleration amplitude drops at first as well and then slightly grows steadily. In comparison for speeds 40 mm/min and 100 mm/min it drops 71.13 %.
- size of vibration acceleration amplitude for both materials in examined range reaches highest value at speed 40 mm/min (5.099 mg resp. 3.762 mg)
- when comparing individual movement speeds for examined types of material individually, the biggest difference in maximum values of vibration acceleration amplitude (26.22 %) is reached at speed 40 mm/min

7. RECOMMENDATIONS FOR OPERATORS

When processing steel 12 050 and 11 523 under conditions, under which the experiments have been carried out it is suitable to:

- not use movement speed 40 mm/min

- use movement speed 100 and 400 mm/min, because at these speeds the lowest value of vibration acceleration amplitude is reached and operating costs are reduce

8. CONCLUSIONS

This article presents results of the analysis of the effect of selected technological parameters (type of material and movement speed) on acceleration amplitude and vibration frequency of the technological head under operation of production system with the abrasive water jet technology.

For examined set of materials and technological movement speed, of a total of 23 original graphic dependencies evaluated, this article states 9 graphic dependencies, 5 of which are comparison graphs of frequency range covers. Except for this, the article contains also graphic depiction of maximum values of vibration acceleration amplitude in the frequency range 6.8 – 7.3 kHz.

Based on created and evaluated graphic dependencies there are 5 most important findings and 2 recommendations for operators formulated in this article, which supplement current scientific knowledge of this issue and at the same time comprise the basis for cooperation of scientific research and practice.

9. ACKNOWLEDGEMENT

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