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STUDY OF THE VIBRATION LEVEL IN CASE OF MANUFACTURING ON A CNC MACHINE-TOOL

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Abstract

The paper presents the results of an experimental research performed on a CNC machine tool type ISEL-GFV considering the vibration level developed during the manufacturing of different pieces of particleboard at six processing regimes. There were recorded signals on both time and frequency domains on the three main directions. Based on recorded data there are presented the main conclusions referring to the level of vibrations and the frequencies associated to the highest levels.

Key words: *vibrations; wood manufacturing; frequency analysis.*

INTRODUCTION

Wood processing is based on two main wood properties: plasticity and divisibility. Wood structure is an anisotropic one, inhomogeneous, with fibres that have different strength values according with the cutting directions. Comparing with the metal cutting another particularities are given by a small strength and a high level of specific heat aspects that permits to be used high cutting velocities (up to 100 m/s) and toll feed velocities up to 120 m/min (Budău and Ispas 2014).

As a manufacturing process, one can say that wood processing is a complex one that offers a lot of challenges regarding with modelling, analysing, tool wear, cutting force, power consumption, dynamics and vibrations. From technological point of view there are three main cutting directions (Cristóvão 2013): 90º–90º (rip sawing); 0º–90º (veneer cutting); and 90º–0º (planing). Kivimaa defined these three cutting directions since 1950. The first number represents the orientation of the cutting edge with respect to the wood grain, and the second one represents the direction of the movement of the cutting tool with respect to the wood grain.

In many papers there were done discussions about different dependences were done according with cutting forces vs. cutting geometry, workpiece properties and cutting parameters. In the same time, there were done studies about the rake angle, clearance angle, chip thickness, feed velocity, wood species and grain, and wood mechanical properties (Csanády and Magoss 2013).

One important aspect in manufacturing is represented by the level of vibrations developed during the cutting process (Wilkowski and Górski 2011).

OBJECTIVE

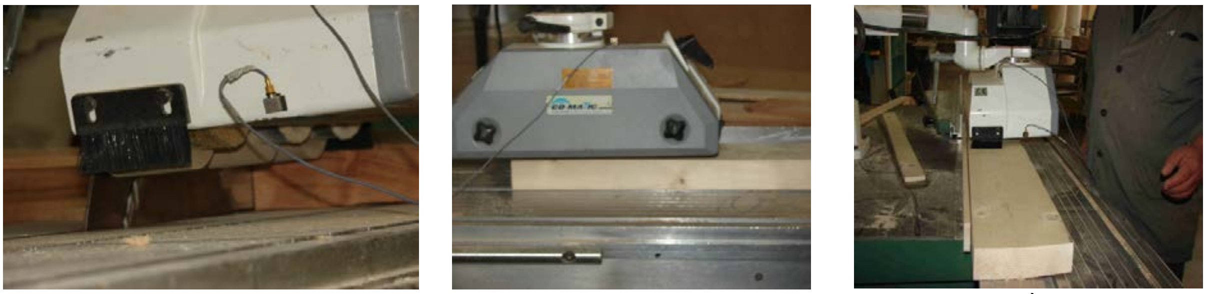
The main objective of the present work is to present the study of the vibration level developed during the longitudinal processing of spruce wood with circular saws. Based on recorded data there were obtained both time and frequency responses for each manufacturing condition.

MATERIAL, METHOD, EQUIPMENT

Tested material was spruce wood that was mounted on CNC machine tool, in the frame of the manufacturing laboratory from the Faculty of Wood Engineering. There were considered two different head angular velocity of 1500 rot/min and 3000 rot/min and three feed velocities of 1.5 m/s, 3 m/min, and 5 m/min.

The used equipment consisted in three accelerometers type 4507B (Brüel&Kjær) mounted on three different positions on the saws head (Fig. 1), the platform PULSE 12 consisting in a unit of data and processing unit (Fig. 2) and adequate soft for time/domain signals analysis. As soft modules there were used specialised Brüel&Kjær codes: signal recording program (type 7709), time domain analysis program (type 7770-6), and frequency domain analysis program (type 7771-6).

In order to obtain accurate records it was done a pre and post transducers calibration. For the calibration it was used a calibration unit type 4294 (Bruel&Kjaer) (Fig. 3). Tests were done on different pieces of particleboard.



a) b) c)

Fig. 1.
Accelerometers position: a) accelerometer mounted on the X direction (along the circular saw table); b) Accelerometer mounted on the Y direction (perpendicular to the table saw, in the vertical direction); c) Accelerometer mounted on the Z direction (perpendicular to the table saw, horizontally)

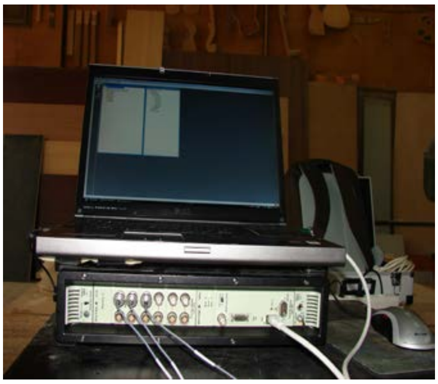
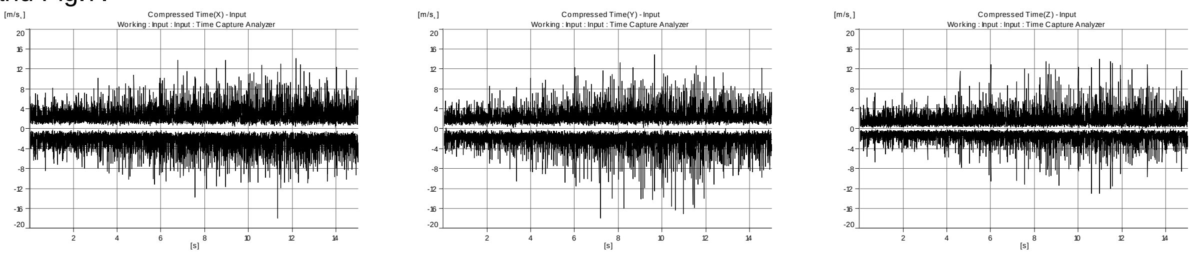


Fig. 2.
Data acquisition system PULSE 12

Fig. 3.
Calibrator type 4294

The measurements were done for three different materials and different feed velocities. For the beginning it was done a test of the vibration level for the case of backlash in case of a turning velocity of 1500 rot/min and 3000 rot/min. The recorded data for an angular velocity of 1500 rot/min are presented in Fig. 4 and Fig. 5, and for the angular velocity of 3000 rot/min are presented in Fig. 6 and Fig.7.



a) b) c)

Fig. 4.
Signal recorded in time domain for backlash for an angular velocity of 1500 rot/min: a) on X direction; b) on Y direction; c) on Z direction

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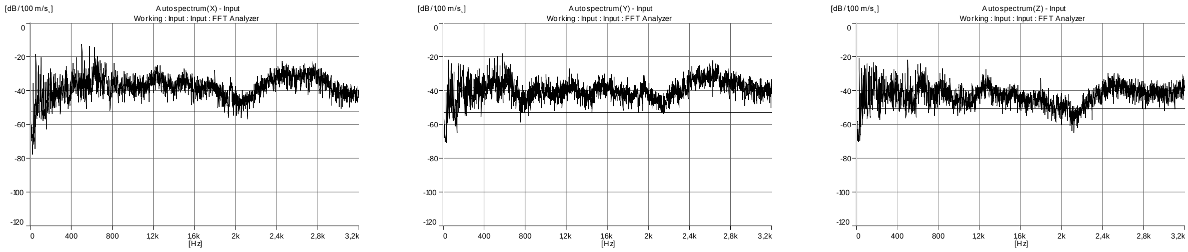
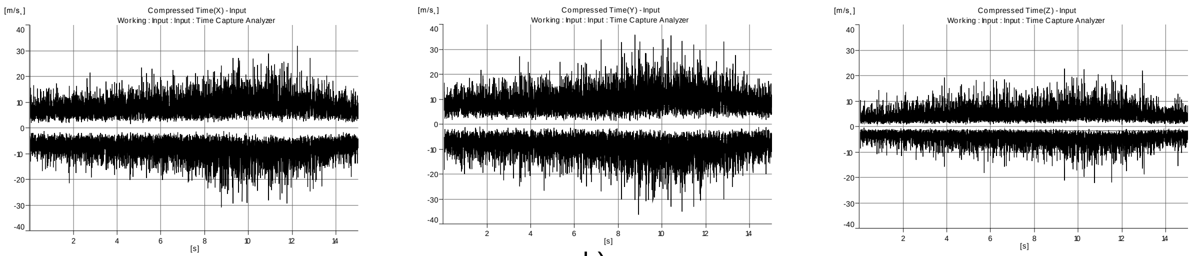


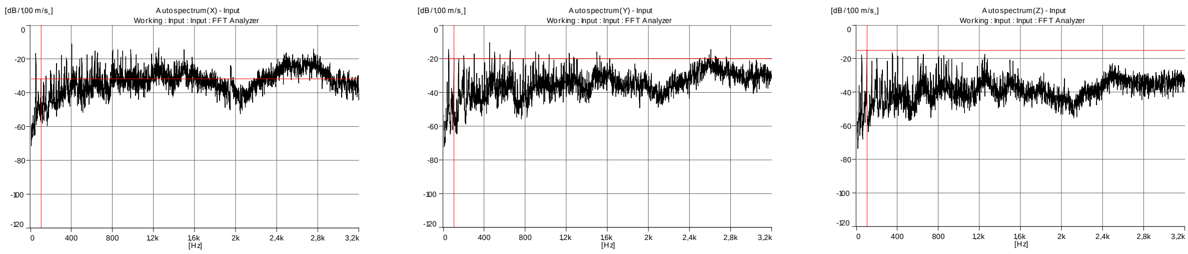
a) b) c)

Fig. 5.
Signal recorded in frequency domain for backlash for an angular velocity of 1500 rot/min: a) on X direction; b) on Y direction; c) on Z direction



a) b) c)

Fig. 6.
Signal recorded in time domain for backlash for an angular velocity of 3000 rot/min: a) on X direction; b) on Y direction; c) on Z direction



a) b) c)

Fig. 7.
Signal recorded in frequency domain for backlash for an angular velocity of 3000 rot/min: a) on X direction; b) on Y direction; c) on Z direction

As it can be seen from Fig. 4 ÷ 7 the level of vibration is higher for the angular velocity of 3000 rot/min comparing with the angular velocity of 1500 rot/min. This aspect was took into consideration at the tests.

RESULTS AND DISCUSSION

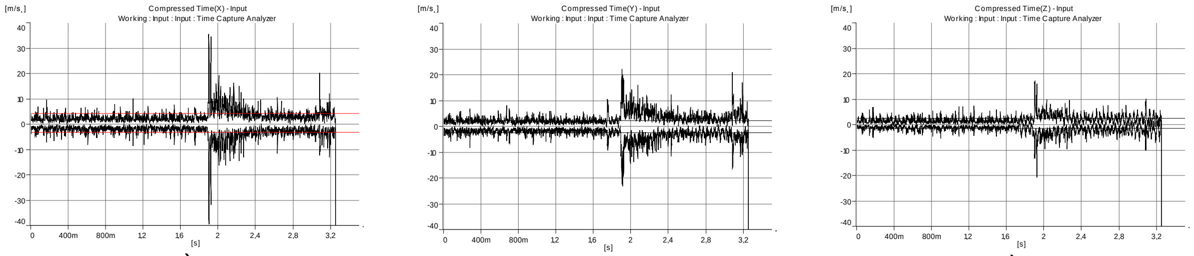
Measurements for an angular velocity of 1500 rot/min

There were considered three different feed velocities: 1.5 m/min, 3 m/min, and 5 m/min. The obtained results are presented in the following. For the beginning it was considered the case of feed velocity of 1.5 m/min. The time and frequency domains results are presented in Fig. 8 and Fig. 9.

As it can be seen (Fig. 8) in the moment of entrance of the tool in the piece it is a high level of vibration and for a period of 0.5 seconds (from t = 1.9s to t = 2.4s) it is a transient regime.

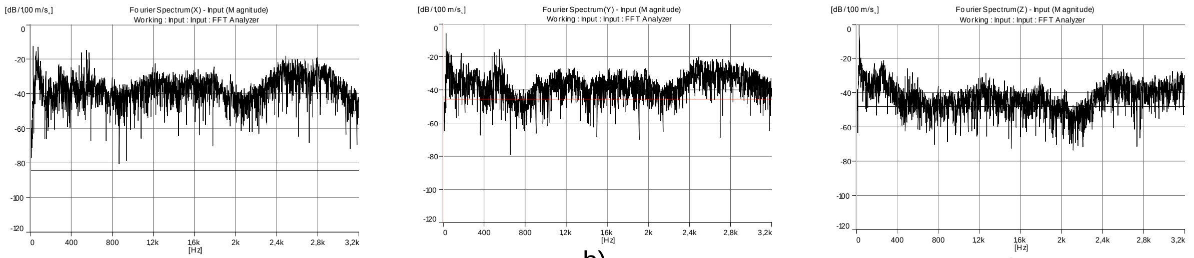
Based on frequency analysis (Fig. 9) one can conclude:

a) There are high level of vibrations amplitude on X direction for frequencies of 25 Hz, 50 Hz, and 75 Hz;
b) On all three directions there were recorded high amplitudes at the frequencies of 471 Hz, 497 Hz, 521 Hz, 546 Hz, and 571 Hz.



a) b) c)

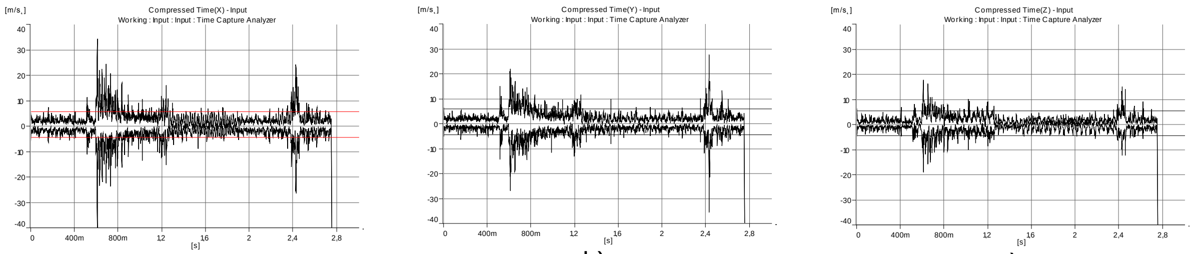
Fig. 8.
Signal recorded in time domain for an angular velocity of 1500 rot/min and a feed velocity of 1.5 m/min: a) on X direction; b) on Y direction; c) on Z direction



a) b) c)

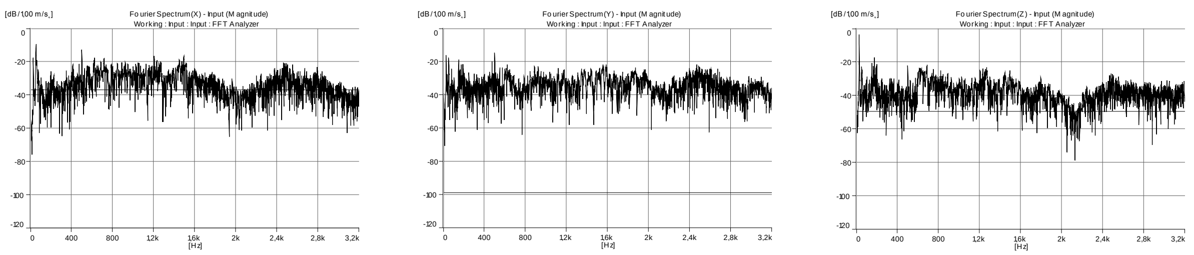
Fig. 9.
Signal recorded in frequency domain for an angular velocity of 1500 rot/min and a feed velocity of 1.5 m/min: a) on X direction; b) on Y direction; c) on Z direction

The second test was done considering the feed velocity of 3 m/min.



a) b) c)

Fig. 10.
Signal recorded in time domain for an angular velocity of 1500 rot/min and a feed velocity of 3 m/min: a) on X direction; b) on Y direction; c) on Z direction



a) b) c)

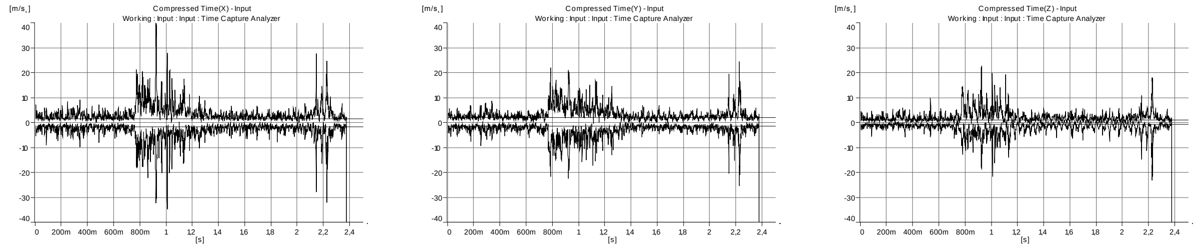
Fig. 11.
Signal recorded in frequency domain for an angular velocity of 1500 rot/min and a feed velocity of 3 m/min: a) on X direction; b) on Y direction; c) on Z direction

From Fig. 10 it can be seen that in the time range 0.6s ÷ 1.3s it is a transient regime. If in the previous test the transient range was about 0.5 seconds, in the second test the range is 0.7 seconds.

Based on Fig. 10 and Fig. 11 one can conclude:

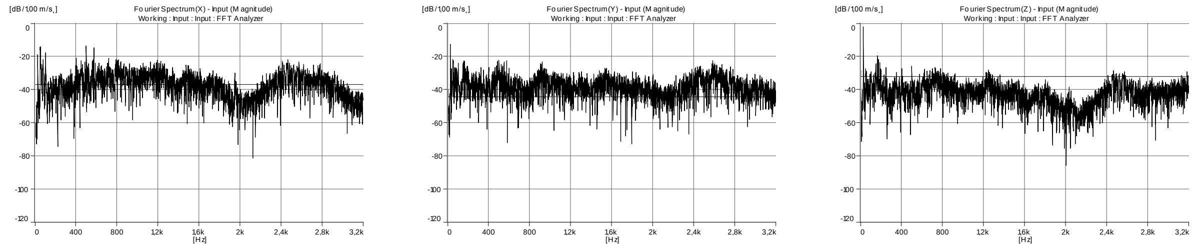
a) On directions Y and Z there were recorded the highest level of the amplitudes at the frequencies 147 Hz, 173 Hz, and 198 Hz;
b) On all three considered rectangular directions there were recorded high levels of amplitudes at the frequencies 25 Hz, 50 Hz, 75 Hz, 473 Hz and 500 Hz.

The third test was for the case of a feed velocity of 5 m/min. The obtained results there are presented in the following figures.



a) b) c)

Fig. 12.
Signal recorded in time domain for an angular velocity of 1500 rot/min and a feed velocity of 5 m/min: a) on X direction; b) on Y direction; c) on Z direction



a) b) c)

Fig. 13.
Signal recorded in frequency domain for an angular velocity of 1500 rot/min and a feed velocity of 5 m/min: a) on X direction; b) on Y direction; c) on Z direction

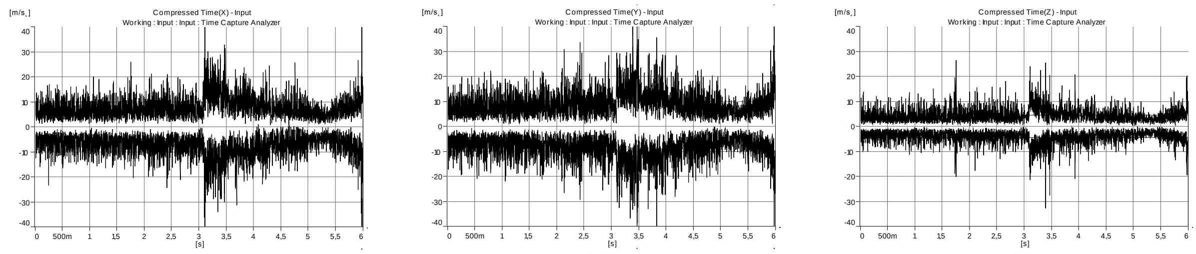
As is seen in Fig. 12 the transient period is about 0.9 seconds. Based on recorded data results the following:

a) On the X direction there were recorded high values of amplitude at the frequencies of 103 Hz, 498 Hz, and 572 Hz;
b) On all three directions the frequencies with high level of amplitudes are 25 Hz and 50 Hz;
c) On Z direction the level of vibrations is poor.

Measurements for an angular velocity of 3000 rot/min

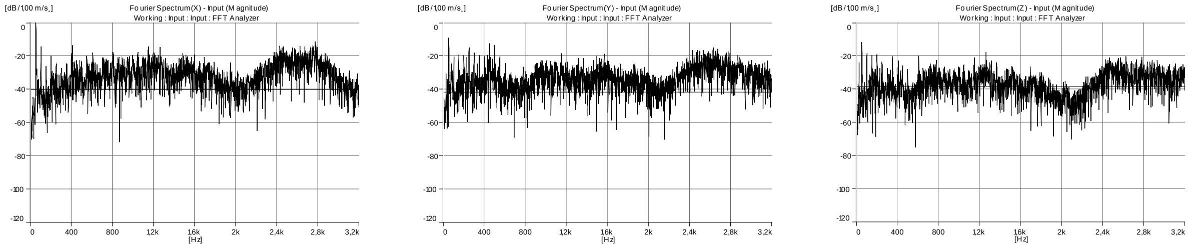
The second test sets were done for an angular velocity of 3000 rot/min considering the same feed velocities: 1.5 m/min, 3 m/min, and 5 m/min. The obtained results are presented in the following.

For the beginning it was considered the case of feed velocity of 1.5 m/min. The time and frequency domains results are presented in Fig. 14 and Fig. 15.



a) b) c)

Fig. 14.
Signal recorded in time domain for an angular velocity of 3000 rot/min and a feed velocity of 1.5 m/min: a) on X direction; b) on Y direction; c) on Z direction



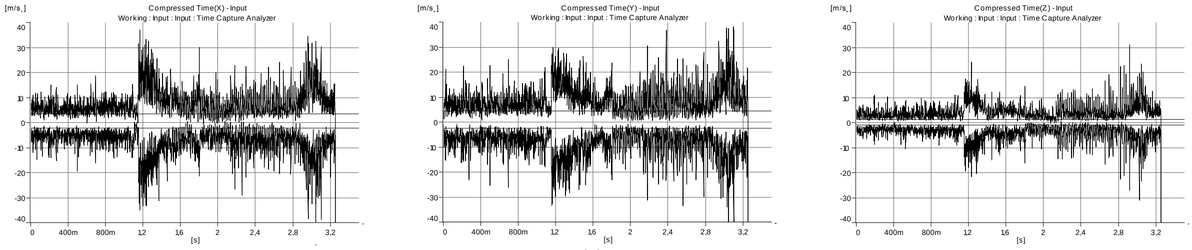
a) b) c)

Fig. 15.

Signal recorded in frequency domain for an angular velocity of 3000 rot/min and a feed velocity of 1.5 m/min: a) on X direction; b) on Y direction; c) on Z direction

From the measured data it can be seen that the highest amplitudes correspond to the frequency of 50 Hz, and its corresponding harmonic frequencies on all three directions.

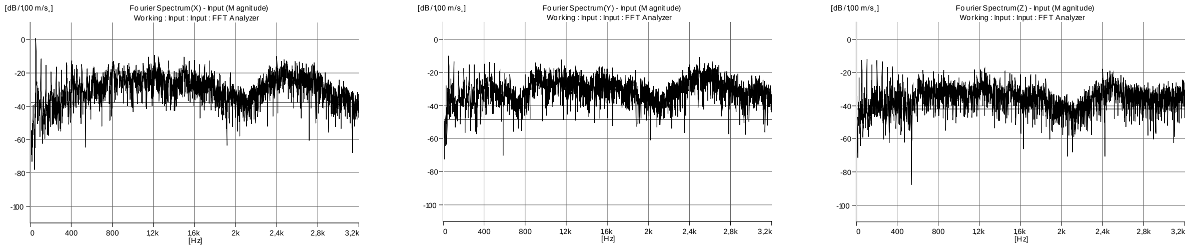
The nest test was done for a feed velocity of 3 m/min.



a) b) c)

Fig. 16.

Signal recorded in time domain for an angular velocity of 3000 rot/min and a feed velocity of 3 m/min: a) on X direction; b) on Y direction; c) on Z direction

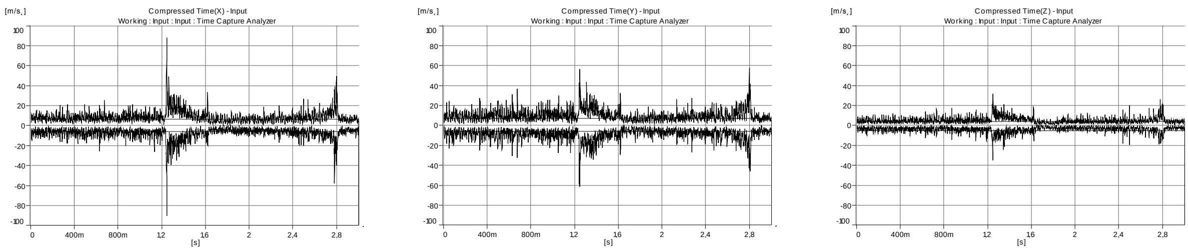


a) b) c)

Fig. 17.

Signal recorded in frequency domain for an angular velocity of 3000 rot/min and a feed velocity of 3 m/min: a) on X direction; b) on Y direction; c) on Z direction

As in the previous test it can be seen that for the frequency of 50 Hz, and its corresponding harmonic frequencies there are maximum values of amplitude on all three directions.



a) b) c)

Fig. 18.

Signal recorded in time domain for an angular velocity of 3000 rot/min and a feed velocity of 5 m/min: a) on X direction; b) on Y direction; c) on Z direction

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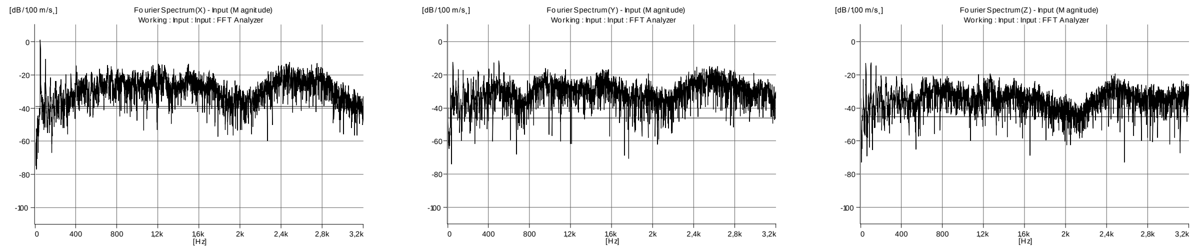

a) b) c)

Fig. 19.
Signal recorded in frequency domain for an angular velocity of 3000 rot/min and a feed velocity of 5 m/min: a) on X direction; b) on Y direction; c) on Z direction

As it can be seen the time of transient response is around 0.2 seconds (Fig. 18) and is strong on X direction (the cutting direction). The frequency analysis (Fig. 19) shows that the strongest response is for 50 Hz (frequency corresponding for the angular velocity of 3000 rot/min) and for the corresponding harmonic frequencies.

CONCLUSIONS

In the present paper it is presented a study of the vibration level during different particleboard manufacturing. There were considered two angular velocities of 1500 rot/min and 3000 rot/min for three feed velocities 1.5 m/min, 3 m/min and 5 m/min.

Based on the recorded data one can conclude the followings:

a) there at each cutting process it is at the beginning a transient regime that is different as range according with the angular velocity and feed velocity;
b) at each test there two groups of dominant frequencies: one that is connected with the angular velocity and another that consists of different frequencies that can be tied with parts of the machine tool (e.g. bearings);
c) the level of vibrations is directly influenced both by the material quality (its structure) and by different parts of the machine tool.

The present study will be continued with a future deep analysing of the sources and path of vibrations associated with the noise.

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