THE INFLUENCE OF WOOD STRUCTURE UPON THE DINAMIC STABILITY OF HSM CNC WOODWORKING MACHINE

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Abstract

In the present study performs the working manner regarding the experiments on a HSM CNC machine which we determined the influence of wood structure upon the dynamic stability.

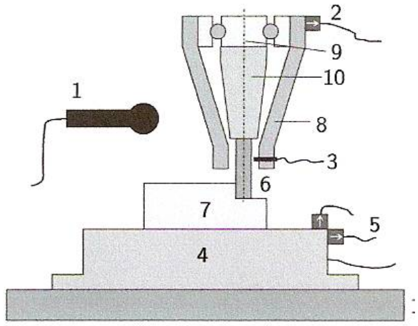
Key words: wood structure, dynamic stability, HSM, CNC woodworking machine.

INTRODUCTION

The experiment's purpose is to test the method of detection of vibrations. We use the experimental stand presented in image 1, using sensor type acceleration. In image 2 a and image 2 b we present the assembling of test stand. The following types of sensors are used: a digital decibelmeter type Center 322, an earthquake transducer Metra MMF: KS48B, Sensitivity: 1000mV/g-IPC and connecter Binder 713-BNC, assembled on the work shaft housing.

Image 1. Measurement and control stand. Assembling and distribution of measurement equipment DELPHIN.(S.C. MOBIL S.A.Tileagd). General view.

The mill used is HSK-F63-A-76,5 RH/Dx V26 with diameter of 10cm, with two cutters, and the material is from beech, oak tree and fir lumber.



a.) Photo (S.C. MOBIL Tileagd S.A.) b.) reprezentare schematica

Image 2. Assembling of test stand. 1-microphone; 2-accelerometer; 4-electric power sensors; 5-accelerometers, 6-tool; 7-piece; 8-housing ; 9-work axle;10- STT system.

MATERIAL AND METHODS

Mechanic vibrations measurements with registration of acceleration signal were performed on the HSM ROVER machine, with the help of a measurement system made up of: **DELPHIN** (**hard**: Measurement Data Acquisition System Top Message – GBDT type and **soft**: Vibrolab Module), at S.C. MOBIL Tileagd S.A.

The registrations done were performed in order to process various types of wood essences, as well as at backlash for various speeds of processing system axle, the results being stored in ASCII files (<name file.asc>), as mentioned in Table 1.

Table 1.

speed n [rot/min]	BACKLASH	BEECH	FIR	OAK TREE
9960	gol1a.asc	f1a.asc	r1a.asc	s1a.asc
10920	gol2a.asc	f2a.asc	r2a.asc	s2a.asc
11880	gol3a.asc	f3a.asc	r3a.asc	s3a.asc
13020	gol4a.asc	f4a.asc	r4a.asc	s4a.asc
14100	gol5a.asc	f5a.asc	r5a.asc	s5a.asc
15000	gol6a.asc	f6a.asc	r6a.asc	s6a.asc

The files ASCII were then decoded and transformed into **data files** specific to the programming environment MATLAB® (<name file.mat>), maintaining the initial name given to the file, and the correspondence is presented in table 2.

Table 2.

Name file.asc	Name file.mat	Name file.asc	Name file.mat
gol1a.asc	gol1a.mat	r1a.asc	r1a.mat
gol2a.asc	gol2a.mat	r2a.asc	r2a.mat
gol3a.asc	gol3a.mat	r3a.asc	r3a.mat
gol4a.asc	gol4a.mat	r4a.asc	r4a.mat
gol5a.asc	gol5a.mat	r5a.asc	r5a.mat
gol6a.asc	gol6a.mat	r6a.asc	r6a.mat
f1a.asc	f1a.mat	s1a.asc	s1a.mat
f2a.asc	f2a.mat	s2a.asc	s2a.mat
f3a.asc	f3a.mat	s3a.asc	s3a.mat
f4a.asc	f4a.mat	s4a.asc	s4a.mat
f5a.asc	f5a.mat	s5a.asc	s5a.mat
f6a.asc	f6a.mat	s6a.asc	s6a.mat

The decoding of ASCII files was done with the help of a decoding program <decod_amdtv.m> especially created for this operation in the MATLAB® programming environment.

Thus, the tracing of acquisitioned curves was performed, through measurements, as results from the images below.

The data files obtained were used for subsequent processing with the help of another file function <amdtv_fft.m> with which the visualization of the most important part of signals acquisitioned is done (signals processed accompanied by their spectrum).

For each type of processing and speed n on spectrum the most significant frequencies may be read, especially those corresponding to the entry of tool into the piece at all wood essences, but especially at oak tree wood, of strong essence.

For each signal processing, the values "peak to peak" and RMS (Root Mean Square**)** were calculated. We notice that the processing of pieces becomes more stable at the same time with the increase of speed.

The peak-to-peak amplitude of a waveform is the amplitude between the maximum positive value and the maximum negative value. The **peak** value is the maximum **positive** amplitude**.**

For a sinusoidal wave, the **relation** between **RMS** and the **peak-to-peak amplitude** is**:**

$$\text{peak to peak} = 2\sqrt{2} \times \text{RMS} \approx 2.8 \times \text{RMS}$$

In mathematics, RMS represents a statistical measurement of the amplitude of a variable quantity.

RMS for a set of *n* values $\{x_1, \quad x_2, \quad x_3, \dots \quad x_n\}$ is:

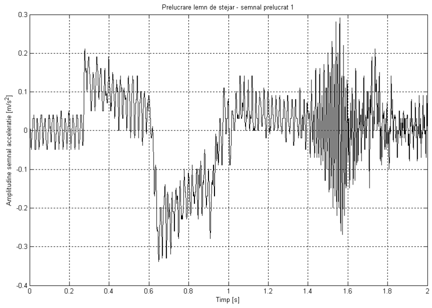
$$x_{rms} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2} = \sqrt{\frac{x_1^2 + x_2^2 + x_3^2 + \dots + x_n^2}{n}} \qquad (1)$$

The correspondent formula for a continuous function $f(t)$ defined on an interval $T_1 \le t \le T_2$ is:

$$f_{rms} = \sqrt{\frac{1}{T_2 - T_1}\int_{T_1}^{T_2} [f(t)]^2 \, dt} \qquad (2)$$

The *RMS* of a periodical function is equal to the **RMS** of a period of the same function. The *RMS* of a continuous function or of a signal may be approximated taking into account the *RMS* of equally distributed samples.

At backlash, we emphasize the free vibrations of HSM. We notice that HSM is well balanced, due to improved constructive solutions adopted. Their influence is overwhelming in ensuring the dynamic stability at high speeds of HSM, for obtaining a competitive output, in the conditions of a special processing quality.



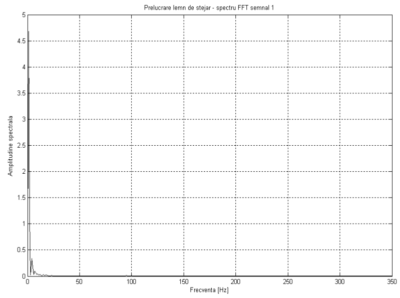
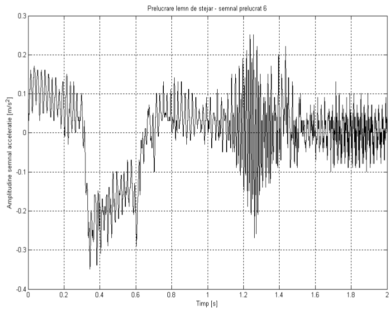


Image 3a –Signal acceleration oak tree at the speed

n = 9960 rot/min.

Image 3b – Spectrum signal acceleration oak tree at speed
n = 9960 rot/min.



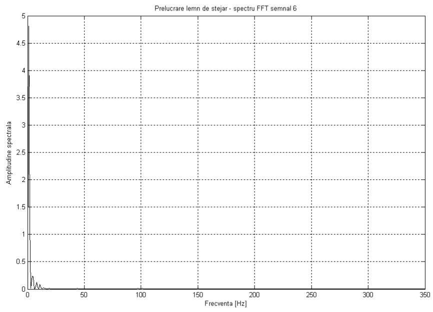
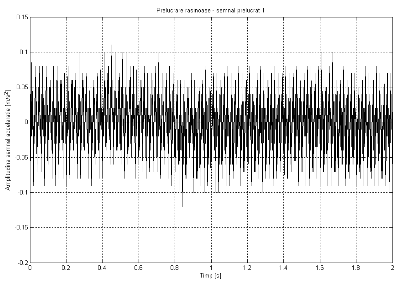


Image 4a–Signal acceleration oak tree at speed

n = 15000 rot/min

Image 4b–Spectrum signal acceleration oak tree at speed
n = 15000 rot/min.



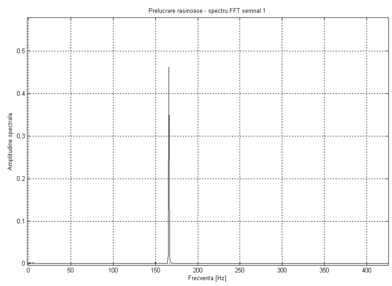


Image 5a–Signal acceleration fir at speed
fir at speed
n = 9960 rot/min.

Image 5b–Spectrum signal acceleration
n = 9960 rot/min.

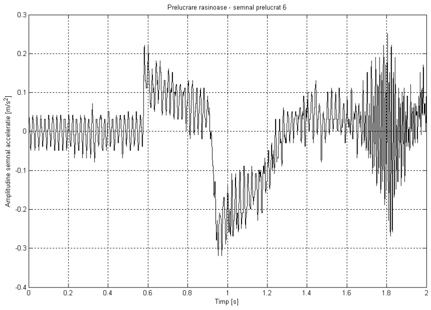


Image 6a–Signal acceleration fir at speed
n = 15000 rot/min.

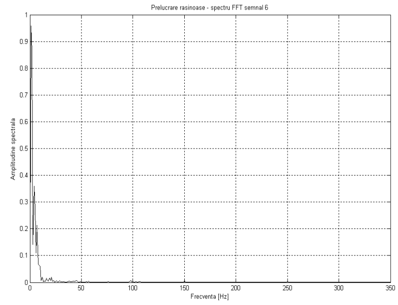


Image 6b–Spectrum signal fir at speed n
n = 15000 rot/min.

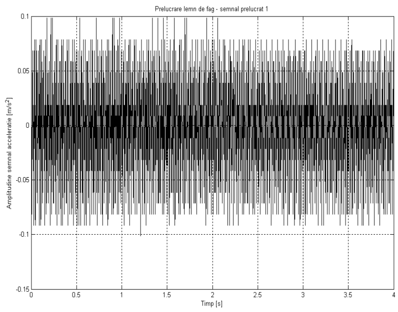


Image 7a–Signal acceleration beech at speed
n = 9960 rot/min.

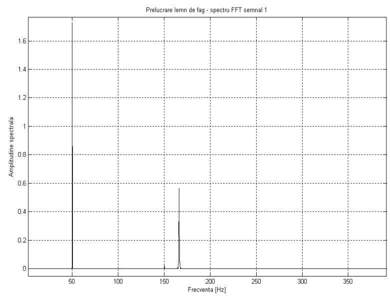


Image 7b–Spectrum signal acceleration beech at speed
n = 9960 rot/min.

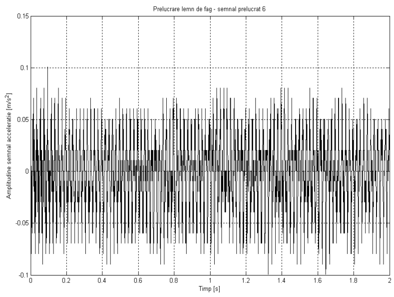


Image 8a–Signal acceleration beech at speed
n = 15000 rot/min.

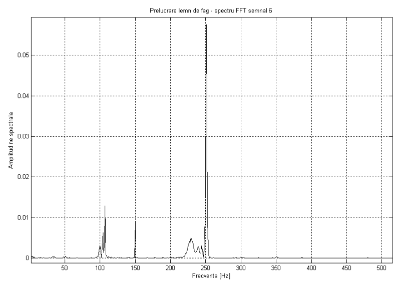
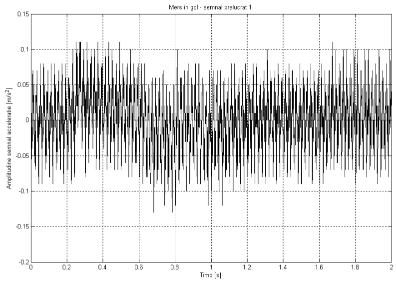


Image 8b–Spectrum signal acceleration beech at speed
n = 15000 rot/min



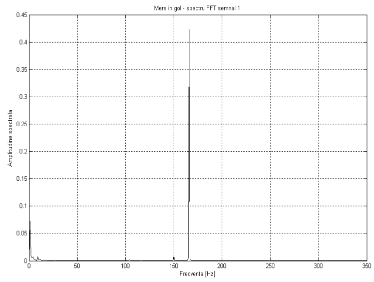
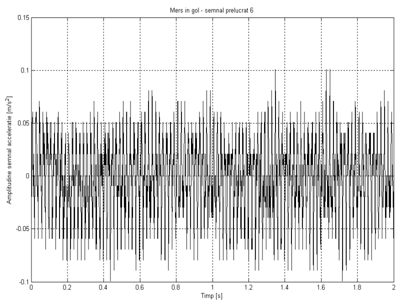


Image 9a–Signal acceleration at backlash   Image 9b–Spectrum signal acceleration at backlash
speed n = 9960 rot/min.   speed n = 9960 rot/min.



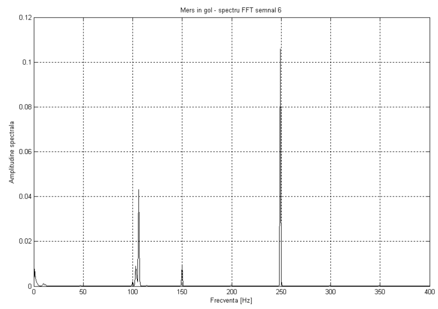
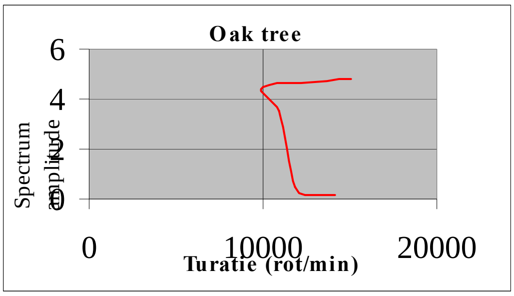


Image 10a–Signal acceleration processed at backlash   Image 10–Spectrum signal acceleration at backlash
at speed n = 15000 rot/min.   at speed n = 15000 rot/min.

RESULTS AND DISCUSSION

- The experiments performed emphasized the stable behavior of processing centre, at work speeds ranging between 9000 - 15000 rot/min, for three different kinds of wood: oak tree, beech and fir, and at 23000 rot/min the stability reserve of processing centre studied was reached;
- We notice a dependence of occurrence of vibrations on the types of processed wood. Thus, in images 4a and b, for the oak tree wood type, the optimum speed ranges between 12000 – 15000 rot/min. At smaller or larger speeds in comparison to this interval, the spectrum amplitude significantly increases due to the anisotropic structure of the wood caused by the presence of late and early wood, of the higher density of oak tree wood and its hardness;
- The corresponding peaks of frequencies occurred at various steps of speed do not exceed the critical frequency leading to the cessation of HSM;



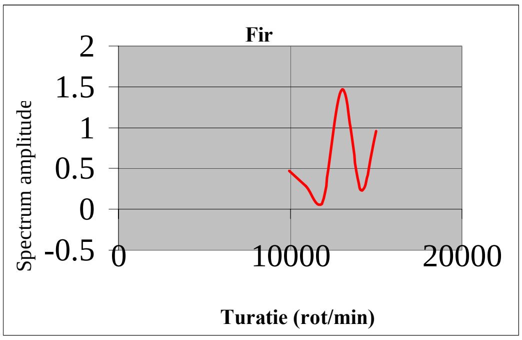
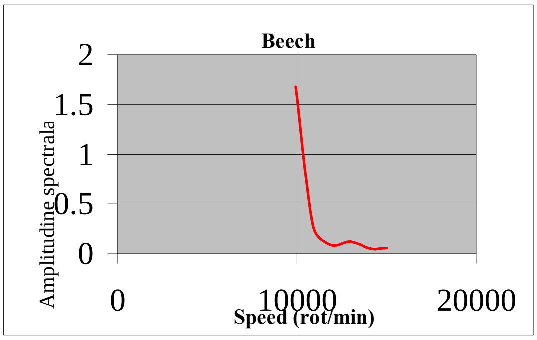


Image 11. Stability diagram at wood processing of fir wood
Image 12. Stability diagram at wood processing of oak tree.



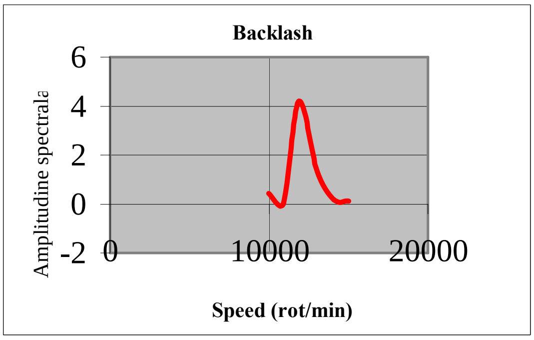


Image 13. Stability diagram at wood processing
Image 14. Stability diagram at backlash of beech wood

CONCLUSIONS

- From the experiment presented we may conclude that, by attaching an accelerometer on the fixed support of a work shaft, assembled close to the ball bearing of foregoing portion of the axle, the best results regarding the accuracy and applicability, in order to accurately detect the vibrations;
- Also, we notice the enhanced variation of amplitude of acceleration signal and exit of piece from the processed tool at wood species of oak tree, respectively fir, due to the presence of late wood and early wood at these types (image 4.a, 6a);
- At processing of beech type, variation of amplitude of acceleration signal is constant due to homogeneity of this type of wood (image 8a);
- At backlash, the variation of amplitude of acceleration signal presents an increase an speeds close to 15000 rot/min, due to regenerative vibrations of ball bearings, bushings, dilatations of ball bearing rings and not of the work shaft itself (image 9a-10a);
- Improvement of work shaft bearings may be performed in two steps, in the first step we replace the ball bearings of work shaft with ball bearings with steel balls type FAG with oil anointment – mist in duplex system for speeds of up to 20000 rot/min but more expensive, in the second step we replace the usual ball bearings with ceramic balls with vaseline type anointment special for speeds of 19000 rot/min, cheaper and more reliable.

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