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STUDY OF EXPERIMENTAL IDENTIFICATION AND VALIDATION OF THE MODEL AT HSM WOOD WORKING MACHINE

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Abstract: In the present study I present the working manner regarding the experiments carried out at SC Mobil SA Tileagd and SC ELVILA SA Beius on a high performance HSM machine (state-of-the-art), with modern constructive solutions applied to the holding system of the STT tool, of the spindle, of the control system and through which we determined the best working regime, at high revolution within the limits of the stability threshold.

The strategy adopted at the experimental testing takes into account the modelling of nonlinear cutting forces. The experiments were done on a splinter of maximum thickness and they aimed at the experimental description of the behaviour of the tool holding system (STT) and the spindle, the improved variants.

The aim of the experiment is to test the method of detecting the vibrations. [3], [8]

The experiments were carried out in a centre of wood processing type ROVER-346, with a HSK-F63A tool holding system that allows the development of the tool's rotation speed between 15000 rpm and 45000 rpm. The parts processed are essences of oak wood, resinous wood and beech. The tools are of type HSK-F63-A-76, 5 RH/Dx V26 with a diameter of 10 cm and length of 20 cm and their variants. The tools are cutters with two edges. (Fig 1), (Fig 2), (Fig 3) [3]

Fig. 1 The oak timber piece after processing. It can be noticed an absence of the effects of the regenerative vibrations (SC MOBIL SA Tileagd)

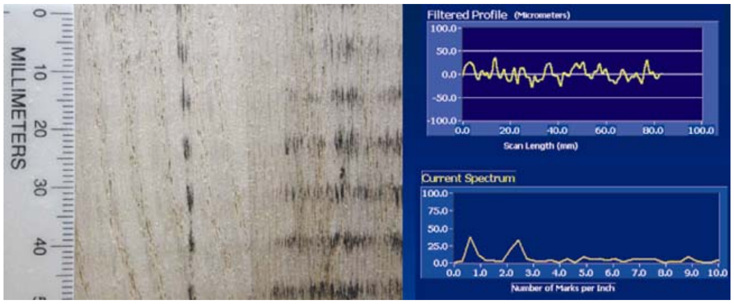


Fig. 2 The “imprint” of the regenerative vibrations on the processed surface in case of vibrations occurrence

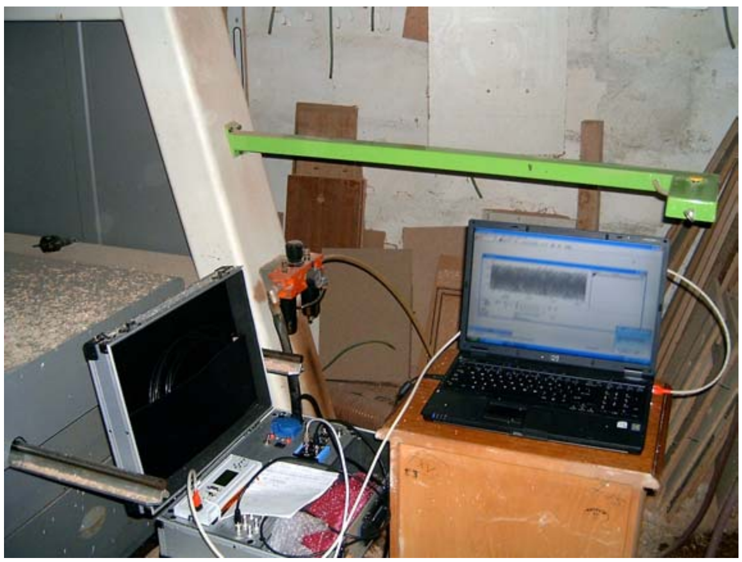
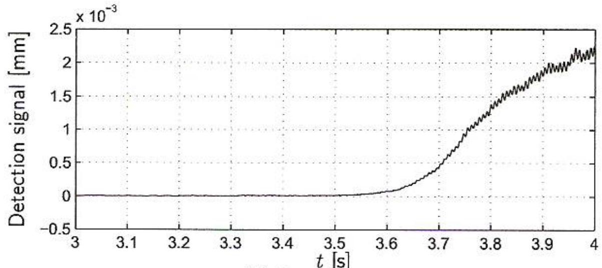


Fig. 3 The stand of measuring and control of the vibrations. Mounting and displaying the apparatus. (SC MOBIL SA Tileagd)

The measuring and control machine is Delphin-Hard-Delphin AMDM V2.0 and SOFT-mhouse Software V3.6.6 type. The sensor is an accelerometer Bruel&Kjaer. [3], [8]

In practice, you cannot establish in advance which harmonic gives the best information concerning the HSM dynamic. Choosing the frequency can be done after several trying. During the first processing phase no vibrations occur, from where it results a low value of the detected signal. When vibrations occur (about t=0,6 s) the amplitude of the vibrations frequency increases, thus the values of the detected signal increase rapidly (fig. 4). On the stable part of the cutting process, the noise represents the lowest level. If the stability threshold is closer to the maximum value of the signal from the first part of the cutting process, the vibrations are detected with 0,005s earlier than the accelerating sensors signal (fig. 5). The maximum value of the moving depends on the splinter’s thickness, even in the established conditions (fig. 4), (fig 5). [3]



(b) Detection.

Fig. 4 Simulating the detection of vibrations at increasing the cutting depth

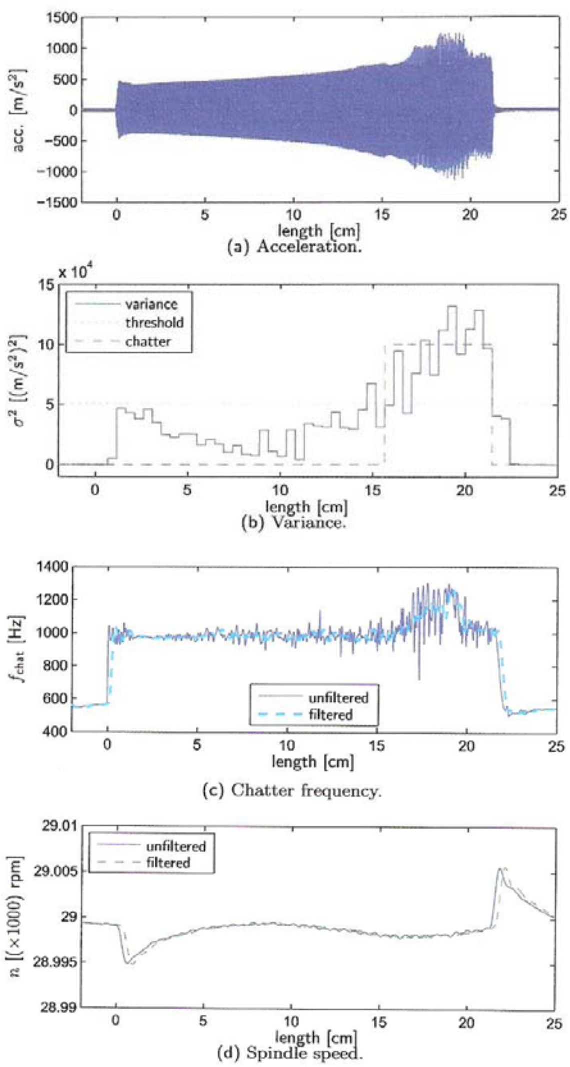
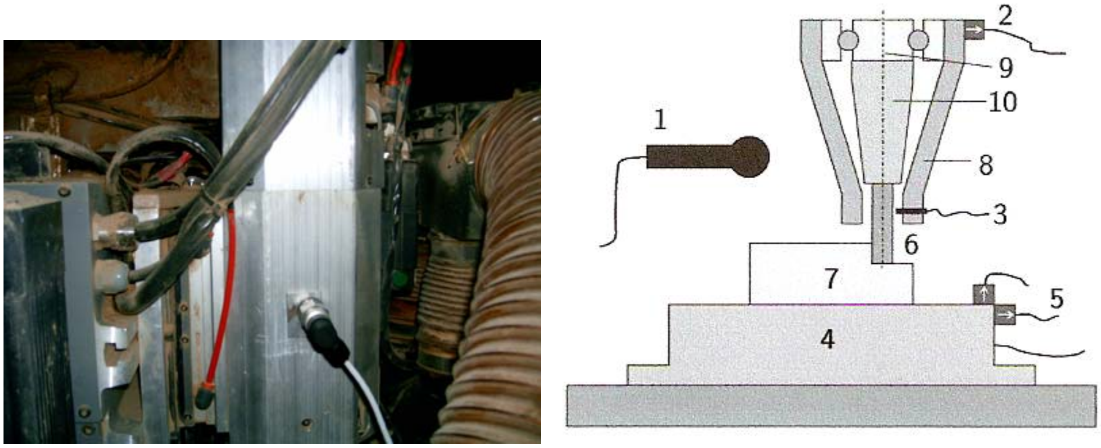


Fig. 5 The experimental results at 29000rpm, with ap that increases from 4.0 to 6.0 mm. [36], [76]

In order to detect the vibrations occurrence in real time, we used an accelerometer set close to the bearing in the anterior part of the shaft (Fig 6). In fig. 5 the results of a cutting process are shown, at a maximum depth of 2mm, and the tool's axial movement increases linearly from 4mm to 6mm. From fig. 5 it results that the stability threshold is chosen in such a way to be close to the variation of the $y_{ch}^{\wedge}(t)$ resulted at the first contact between the cutter and part (fig. 6). [1],[3]



a) Photo (SC MOBIL SA Tileagd) b) Scheme representation

Fig. 6 Mounting the testing stand. 1-microphone, 2-accelerometer, 4-energy sensors, 5-accelerometers, 6-tool, 7-part, 8-frame, 9-spindle, 10-STT system, 11-bearings [36], [76]

The initial increase of $y_{ch}^{\wedge}(t)$ variant at the cutter's entering into the material has two causes. First, the amplitude of acceleration, reported to the frequency of the shaft's vibrations, increases suddenly, due to the intensifying of the forces as they enter into the material. Secondly, because of these forces, the revolution decreases a little. This revolution is measured by the control system of HSM. Using the method of demodulating the signal, the error of measuring the revolution has negligible consequences on detecting the vibrations. An accurate estimation of the frequency of vibrations is necessary for the control system, in order to be able to calculate and fix a new revolution. Fixing the revolution is a relatively slow process in comparison with the algorithm of the detection process, due to the shaft's inertia. [1], [2], [3]

In fig. 7,8,9 there are shown all the acceleration signals processed with MHouse Software V.3.6.6 of the Delphin machine, for different wood species: oak, resinous trees and beech.

It can be noticed an initial increase of the amplitude at the cutter's entering into the part, at different times, respectively 0.4s at oak, 1s at resinous trees, due to the characteristic of wood essences. The amplitude of vibrations does not exceed the stability limit. [3]

The experiments were carried out on a HSM tool with improved solutions applied to the tool holding system (STT) in HSK system (fig. 11), with tools specific for high revolutions (fig. 10), with HSK holding system, having spindles with radial-axial bearings with ceramic balls and an oil-mist system of cooling-oiling (fig. 12). All these improvements allow working conditions at high revolutions with an increased dynamic stability. [3]

The system of operating and controlling the HSM allows the adjusting and simulation of working regimes; respectively the revolutions and the advance speed within the limits of the stability threshold, as well as the programming of the parameters for cutting processing (fig. 13).

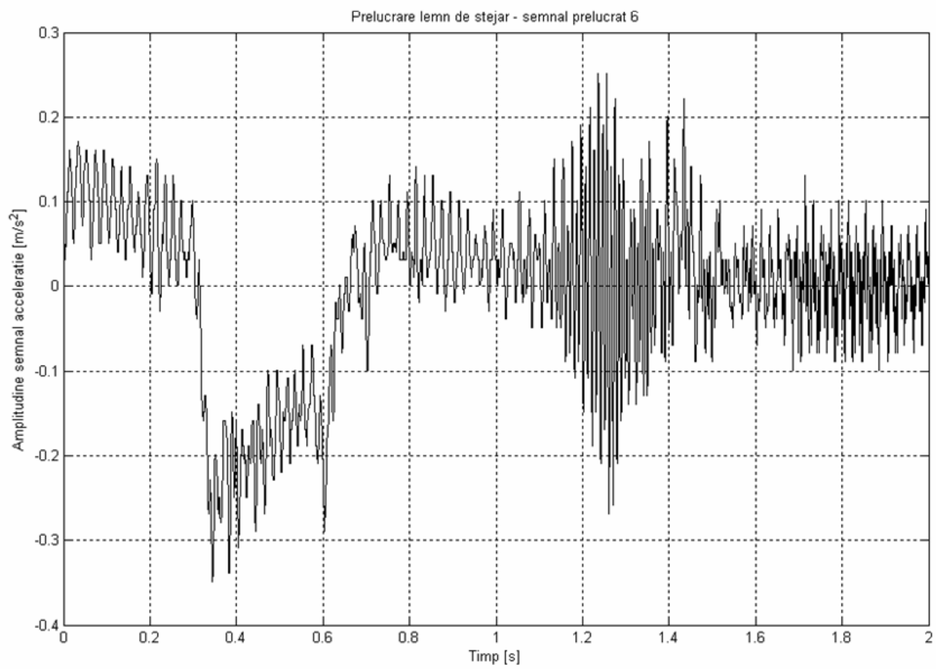


Fig. 7 Acceleration signal for oak wood processing at a revolution n=15000rpm

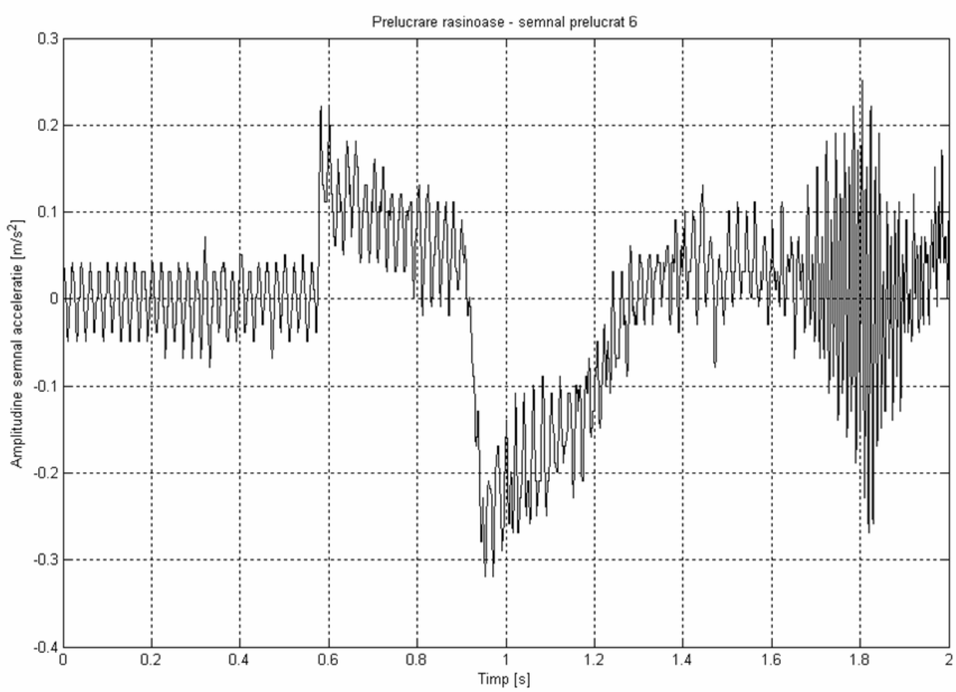


Fig. 8 Acceleration signal for resinous wood processing at a revolution n=15000rpm [76]

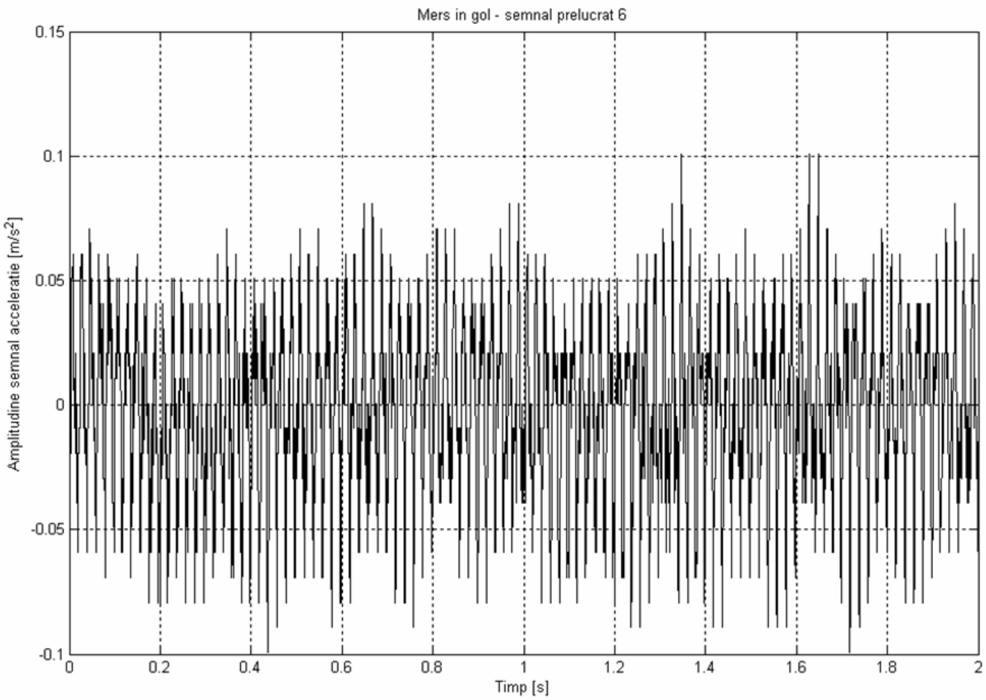


Fig. 9 Acceleration signal for beech wood processing at a revolution n=15000rpm

Conclusions

We obtained in our experiments the validation of the best parameters (revolution, advance speed) so that the loading of the splinter on the tool’s tooth to remain constant.

We calculated the extending function of the shaft’s revolution and advance speed, parameters that are sent to the fixing system of HSM. The internal fixing and controlling system modifies the revolution and the advance speed towards these parameters, fact that was shown in the solutions of improving the spindles.

Fig. 10 High performance tools for HSM with a HSK holding system. (SC MOBIL SA Tileagd)

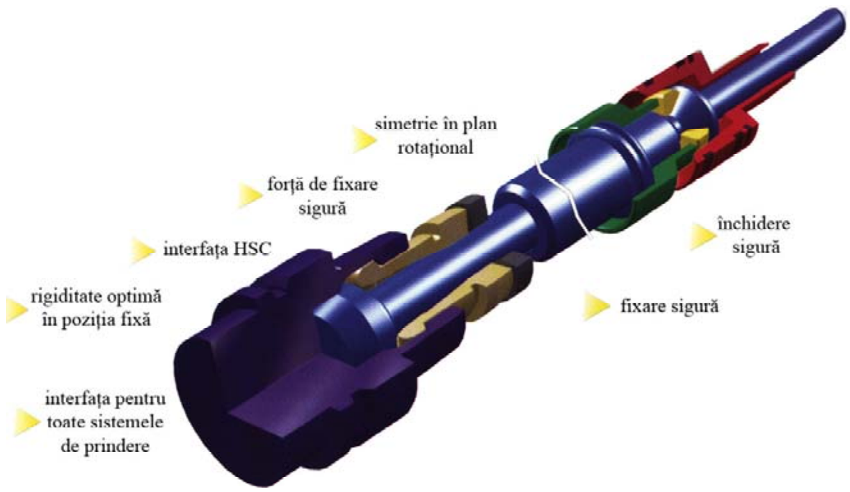


Fig. 11 Holding system [3], [7]

We emphasized a certain dependence of the cutting process on the wooden species: density, homogeneity, the presence of the late and early wood. Due to the robustness of HSM, this influence is maintained in the limits of the stability threshold, but it must be taken into account when calculating the dynamic stability.

We made an experimental method that follows the tool's behaviour at the graded increase of cutting depth for an advance detecting of the vibrations occurrence.

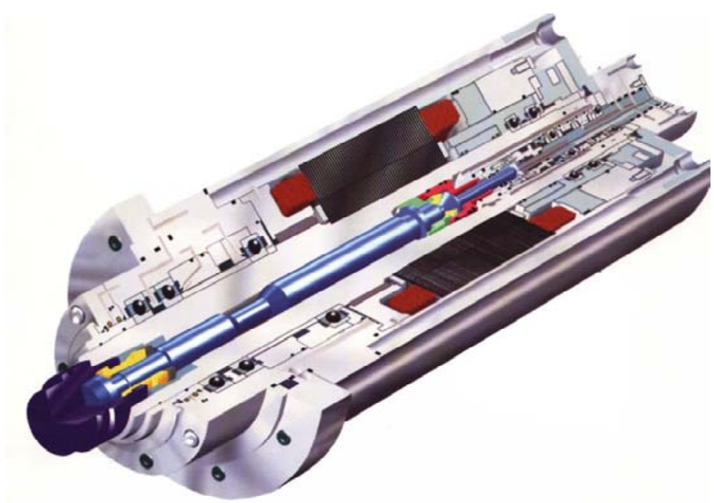


Fig. 12 Spindle – rotor system [3],[7]

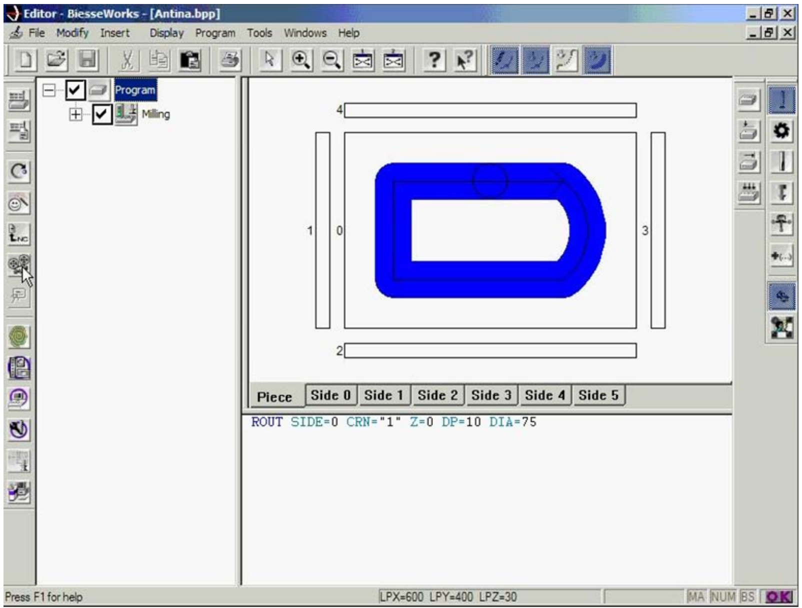


Fig. 13 Programming the processing parameters by cutting with the BiesseWorks program.[3]

We made an experimental method that follows the tool's behaviour at the graded increase of cutting depth for an advance detecting of the vibrations occurrence.

We obtained a very short time interval from the vibrations occurrence to their detection and the fixing of revolution by the control loop.

By the increased bearing and spindles solutions you can get significant results in predicting, controlling and processing the wood in the limits of the dynamic stability at high revolutions. The best results are obtained by mixing the aspects reflected in the adopted technical solutions regarding the mechanic tools with those referring to the operation and control systems, the electric, hydraulic and pneumatic systems.

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