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# ONLINE MEASUREMENT OF VENEER LATHE CHECKS

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## ABSTRACT

The present work deals with online lathe checks measurement. It is one of the most critical defects of veneer (leading to handling difficulties, excess of glue consumption, poor veneer surface quality, etc.). It could be characterized by lathe checks depth or frequency but these indicators require tedious measurements of the veneers.

The objective of this work is to get an estimation of veneer lathe check indicators from vibratory and acoustical measurements. This approach is inspired by operators who are able to adapt the lathe settings “at the noise”.

Acoustic and vibratory measurements during the peeling process were performed. Several signal processing techniques giving a spectral representation of sensors measurements are compared. Finally, an analysis of spectrum is proposed to measure the average lathe check frequency of the veneer during the process.

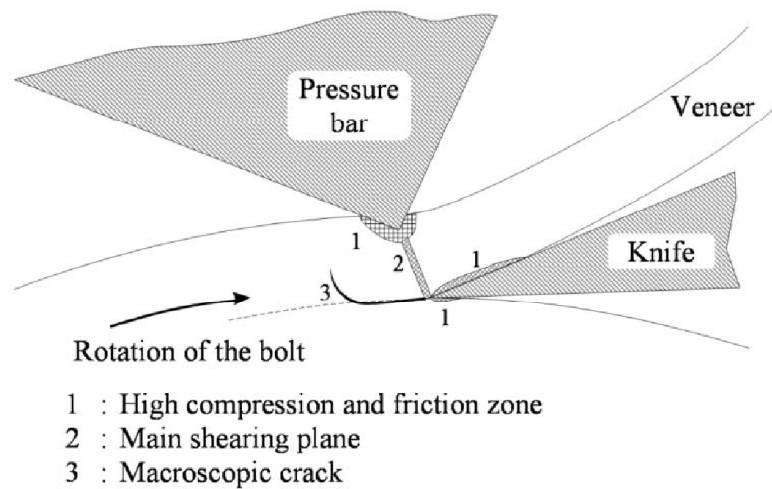
**Keywords:** lathe check, acoustic, vibration, online.

## INTRODUCTION

Peeling is a wood process largely used for plywood, LVL (Laminated Veneer Lumber) and packaging production. However, the commercialization of these products is totally different since the most important criteria of the product could be either the visual quality for cheese box or mechanical characteristics for LVL panels. The production objectives and the way to control them will be also different.

LVL production could be a relevant way to cope with secondary quality resources and fast growing trees. Indeed, this supply can present interesting intrinsic mechanical properties but it is unusable for structural application. For example, douglas fir in Bourgogne presents a relatively fast growing rate but the large size of knots make them often rejected by sawmills. Anyway, the large proportion of final wood in douglas ensures high intrinsic mechanical properties. Peeling process could be a pertinent way to use this “low quality” resources from the aesthetic point of view to produce LVL for structural application. To limit glue consumption and to simplify the process, the most natural approach is to produce relatively thick veneers (thickness  $\geq 3$  mm) as for *Kerto*<sup>®</sup> (Metsä Wood) or *BauBuche*<sup>®</sup> (Pollmeier). For these cutting conditions, the peeling process induces lathe checks in the veneers (1-3). Thibaut and Beauchene (4) proposed a simplistic cutting force model able to describe chip formation and lathe check generation (Figure 1). Depending on several parameters as veneer thickness, wood density and wood temperature, the energy required to produce the veneer during cutting can be lower by splitting than by shearing. Indeed, the cutting geometry generates a tensile stress field which favours check opening (see Figure 1). For given cutting conditions and homogenous woods as poplar, beech or birch, lathe check phenomenon could be almost periodical (3-6). The thicker the veneers, the larger the check depth and the interval between checks (6-8). Lathe checks depth can be limited

thanks to a pressure bar (1-3, 9 and 10). This system compresses wood just ahead the cutting edge (see Figure 1), so that lathe check formation is limited.



**Figure 1:** Main mechanical phenomenon during the peeling process (inspired by Thibaut and Beauchene (4)).

Lathe check could be penalizing for LVL production if they become excessively deep (8, 10). For thick veneers, the pressure bar settings adjustment could be particularly challenging since its effect is extremely sensitive to the wood density. Indeed, the compressive stress field area is limited and for thick veneers, the pressure could be not adequate to avoid checks opening. Extending this area up to the cutting zone requires an increase of the pressure exerted by the pressure bar which can create other critical defaults as veneer thickness variation (4). The steaming step induces a strong modification of wood properties and can make this adjustment necessary for each log.

Most of the time, experienced operators are able to adapt the setting of the lathe when hearing the sound created during the cutting process. Nevertheless, this skill requires time to be mastered and a help decision system could be a great help to perform the fine tune adjustment of the bar.

A first attempt was proposed in (6) to measure online lathe check frequency for homogeneous species. Several signal processing techniques giving a spectral representation of sensors measurements are compared. Finally, an original procedure based on Power Spectral Density ratio was proposed to measure the average lathe check frequency of the veneer during the process. But this approach was performed on a laboratory lathe on wood disc with no background noise (manufacturing ambiance). The present paper proposes to test this approach on a complete industrial peeling line (clipper, treadmills, fan heater, high speed air cylinder,...).

## MATERIALS AND METHODS

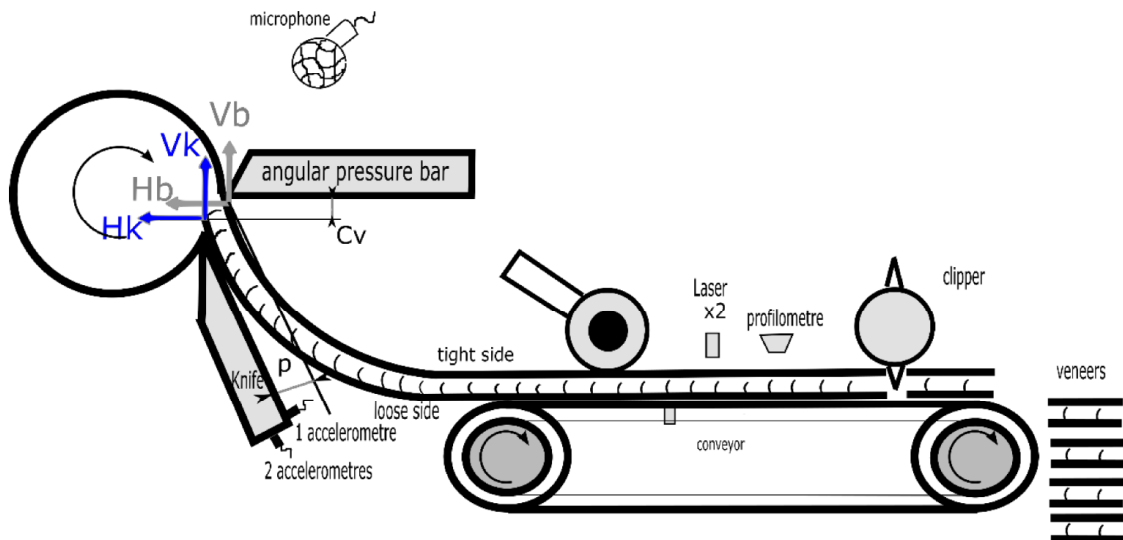
### Peeling line

The Arts et Metiers ParisTech LABOMAP has a complete instrumented peeling line (figure 2). First, a boiler allows heating logs with a controlled temperature. This parameter is extremely influent on the lathe check mechanism (1-3, 7). After boiling, logs are loaded using a hoist. The peeling lathe is equipped with a static pressure nose bar and a motored back roll. The knife and the nose bar are mounted on a sliding carriage which allows fine setting of the clearance angle.



**Figure 2:** Instrumented peeling line of the LABOMAP.

The peeling lathe is equipped with piezoelectric sensors. Two couple of gauges are in used. A first one is screwed between the knife and the carriage to measure forces exerted by the knife on the wood (horizontal  $H_k$  and vertical  $V_k$  shown on figure 3). The second couple of sensors measures forces exerted by the system knife plus pressure bar on the log. The pressure bar force components (horizontal  $H_b$  and vertical  $V_b$  shown on figure 3) are calculated by difference of the two previous signals. This part of the measurement will not be presented in this paper.



**Figure 3:** Principle scheme of LABOMAP peeling line. Notice that both laser and profilometer system were not in use for this experimental campaign.

To get information from the process cutting, sound and vibrations were measured. The knife was equipped with 3 piezo-electric accelerometers ( $\pm 0.25$  dB between 8 Hz and 12.5 kHz): two attached under the blade (Acc 1&2) and the last one perpendicularly (Acc3) as it is represented on Figure3. Finally, a capacitor microphone ( $\pm 1$  dB between 8 Hz and 12.5 kHz) was in use near the peeling cockpit to get the sound heard by operator. The positions chosen for each sensor were inspired from (6) and (6). Sensors were connected to a multi-analyser system (PULSE of Brüel & Kjær). It is an acquisition and treatment system able to make real-time analysis. The sampling

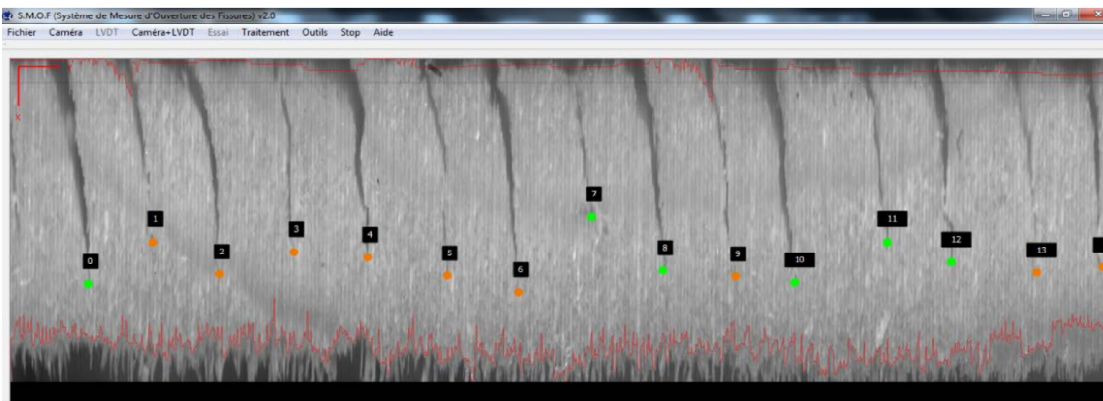
frequency was set to 65,536 Hz to allow the treating of the signal for frequencies up to 25.6 kHz according to the Shannon criteria and the real filter capabilities.

To facilitate the computation and the analysis, the time window selected was kept constant (1s) which correspond to one veneer meter, which is more than one turn of the lathe taking into account the logs diameter. This gives a spectral resolution of 1 Hz. The window number of points was 3200 which limits the analysis to 3200 Hz (more than enough to measure lathe check phenomenon, a few hundred of Hz). The average was chosen linear and maximum (>10 for each measurements). Power Spectrum Density was performed for each sensors to get a normalized measurement of the signals.

The ribbon is cut into veneers by a clipper. The veneers are stacked. A band of the veneers was sawn to be analysed using the SMOF (Optical Measuring Checks System). The apparatus was designed and realized by Pałubicki (7).

### Veneer Characterization

The SMOF principle consists in bending veneer over a pulley to visualize checks exposed to a laser light. A camera automatically takes pictures of the veneer thickness enabling a continuous recording of the veneer cross-section (Figure 4).



**Figure 4:** Picture and treatment of beech veneer with the SMOF (Software Version 2.0).

The SMOF hardware was kept unchanged since 2010 but the software part was completely rebuild for this study. The new processing of the SMOF is divided in four steps:

- The first step pre-processes the image to make it binary, to clean it and to extract the top and bottom border of the wood.
- The second step extracts blobs in the image between top and bottom border and keeps only valid blobs with the help of a filtering condition defined by the user. This condition can use parameters like the area, the position, the bounding rect, etc... of the blob
- The third step connects blobs between them with the help of a mathematical condition defined by the user. For example, a blob is linked with another if the distance between the bottom of the first and the top of the second is less than 0.1mm.
- The last step detects automatically cracks (a crack is a list of blobs linked previously) and the user can apply a filter to keep only valid ones with the help of a mathematical condition.

The checks end are then use to get statistical data as mean/standard deviation distance between two consecutive checks or depth average/standard deviation of the checks.

## Experimental design

The objective of this study was to verify the possibility of using accelerometer or microphone to get online interesting data from lathe checks. So, an experimental design was built to produce characteristics situation regarding lathe check phenomenon.

Beech was selected for its great ability for peeling process. Indeed, it is considered as a homogenous wood species. Five logs were sawn (60 cm length) from a well conformed tree (Table 1). According to literature, veneer thickness was chosen equal to 3.5 mm. This thickness is consistent with the background of LVL production. Moreover, it allows processing at the same time veneer without any checks or hardly checked veneers depending on peeling process conditions.

To really create distinctive situations according to the lathe check phenomenon, only the pressure rate of the pressure bar and the heating temperature were varying (Table 1). For a 0% pressure value,  $p$  is equal to veneer thickness (3.5mm). For 20%,  $p$  is adjusted to 2.8mm. The more the number of the log is, the less favourable the conditions for lathe checks are.

**Table 3:** Experimental design.

Log number	Temperature (C°)	Pressure p (%)
B1	25	0
B2	50	0
B3	50	5
B4	50	10
B5	75	20

The other cutting parameters were kept constant and adapted according to literature (1-4). A classical knife blade (20° angle) and angular pressure bar were in used. The linear cutting speed was constant and adjust to 60m/min, the clearance angle was linearly varying from 0,5 to 0°. The  $C_v$  (Figure 3) was kept constant (1 mm). The veneer length was 500mm and the cut was performed by the clipper.

## RESULTS AND DISCUSSION

### SMOF results

Table 2 presents the statistical data extracted from the analysis performed on the veneers with the SMOF. The last trial was not characterized with the SMOF since no check could be observed.

**Table 2:** Lathe check measurements: average (standard deviation).

Log number [T° p]	Frequency in Hz or Nb of checks/meter	Check depth in % of thickness	Number of Checks
B1 [25_0]	267 (18.27)	81 (13.50)	378
B2 [50_0]	261 (13.67)	72 (11.74)	360
B3 [50_5]	337 (29.20)	62 (14.13)	542
B4 [50_10]	397 (29.20)	44 (14.33)	2019
B5 [75_20]	No check	No check	No check

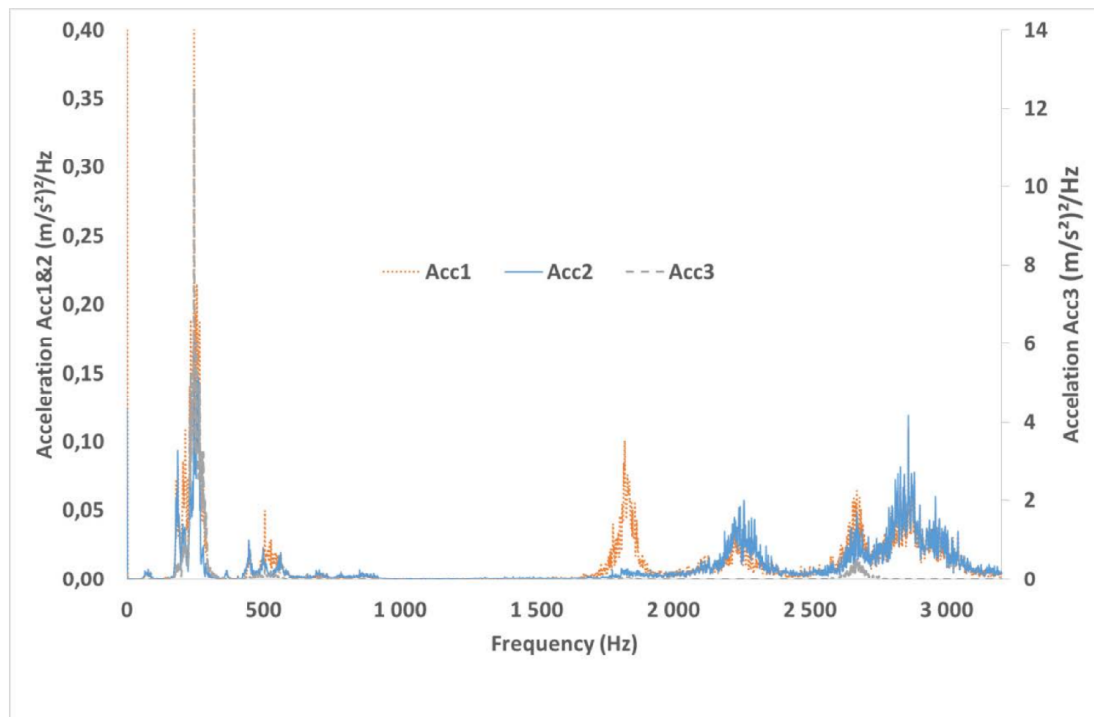
First, it is interesting to notice that the general trend observed by many authors is confirmed (3, 8, 9 and 11): the shallower the checks are, the more numerous they are until the lathe check phenomenon becomes not periodical. Nevertheless, there is no significant difference between

B1&2 in terms of check frequency but the temperature seems to reduce mean check depth as observed by (8) and (9). At the end, four different “levels” of checked veneer were created from B1&2 (very bad) up to B5 (no check).

### Spectral analysis

First, Figure 5 shows the Autospectrum (Power Spectrum Density) of the 3 accelerometers for the first trial (B1). It is the most favourable to lathe checks and indeed, the 3 spectrums show a large peak between about 220 and 290 Hz which is the signature of the lathe check phenomenon (measured at 267 with a SD of 18.27). Indeed, this peak disappears for the last trial (B5) were the cutting conditions avoid lathe check formation (Figure 6). It is not a real thin peak but more a relatively large band since the lathe check phenomenon is not perfectly periodical.

The 3 accelerometer signals are similar in the area of interest regarding lathe check. Since Acc3 is clearly the most sensitive one, it will be chosen for the following analysis.

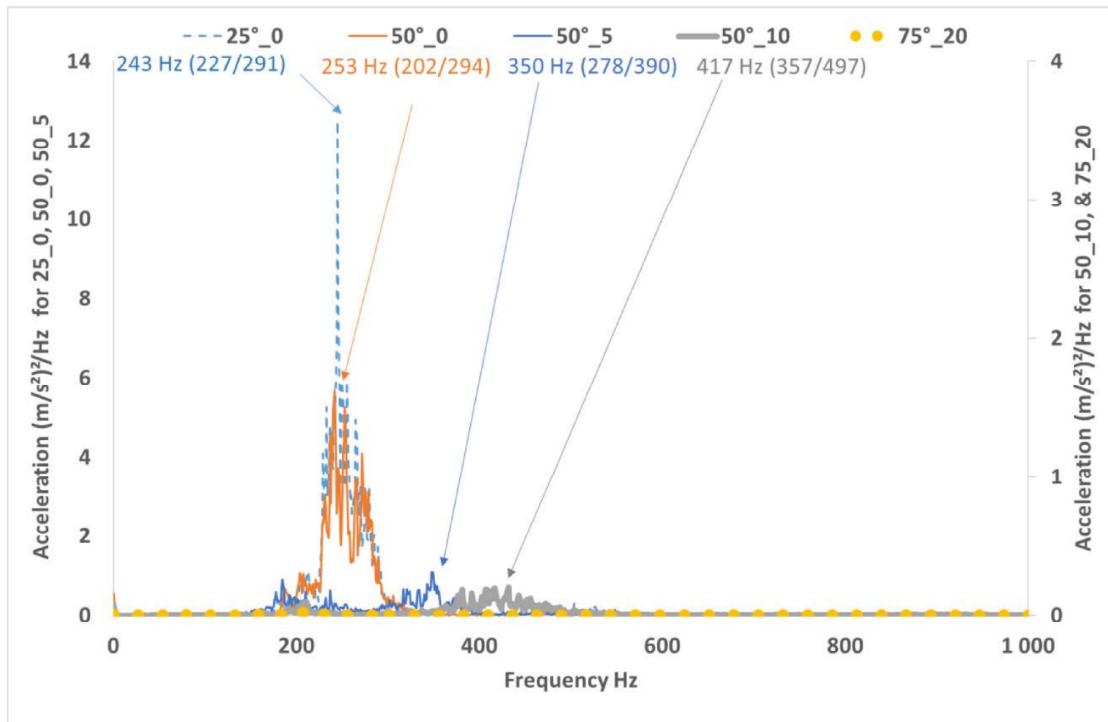


**Figure 5:** Comparison of Autospectrum (PSD) analysis of the 3 accelerometers.

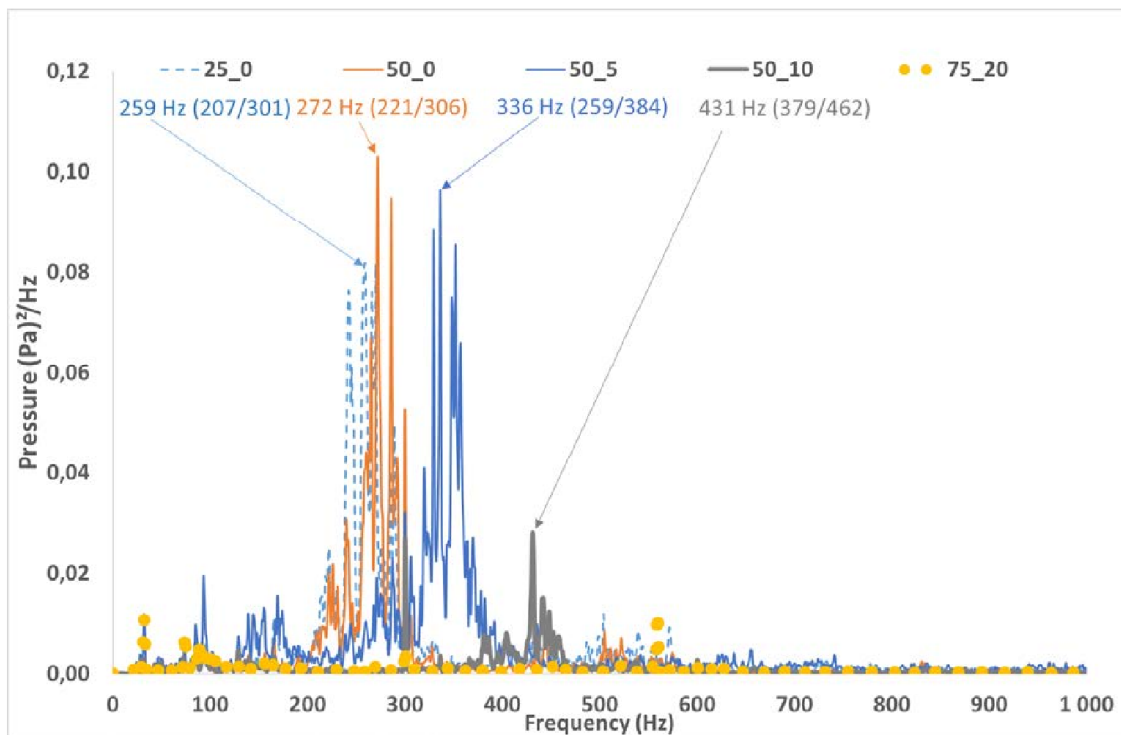
The Figure 6 shows that it is possible to identify an area of excitation for each trial corresponding to SMOF measurements. The band pointed out on figure 6 for each trial was obtained by using a threshold equal to 10% of the maximum amplitude for each signal.

Notice that the amplitude of the signals is decreasing with the average depth of check. A larger experimental design with different logs from different trees must be performed to verify if this trend is confirmed. Indeed, it could be an interesting way to estimate mean check depth.

No specific signal treatment seems necessary if the checks are deep. For shallow checks (<30% of veneer thickness) a work on signal to noise ratio must be performed and the method called PSD ratio proposed in (6) could be employed.



**Figure 6:** Evolution of the accelerometer 3 PSD for the 5 different cutting conditions. (band of frequency obtained with a threshold=10% of maximum amplitude par signal)



**Figure 7:** Evolution of the microphone PSD for the 5 different cutting conditions (band of frequency obtained with a threshold=10% of maximum amplitude par signal)



Figure 7 show the PSD obtained from the microphone for all trials. The same conclusions as for accelerometers could be made excepted concerning the amplitude. Indeed, it is possible to observe the signature of lathe check phenomenon via a large band corresponding to SMOF measurements. Nevertheless, the magnitude of the signals are not clearly decreasing with the depth of the checks.

Moreover, the analysis of the signal in a larger band of frequency (0-3.2kHz) shows a very flat signal for the microphone. This point is particularly interesting to cope with mechanical behaviour of the lathe which could make the checks detection more difficult for accelerometers.

## CONCLUSIONS

An experimental design was performed using the fully instrumented peeling line of the LABOMAP. Some important results from the literature were confirmed concerning lathe checks. The lathe check phenomenon is almost periodical for homogeneous species and the checks depth decreases when the number of checks increases for a given heating temperature.

The objective of this work was to verify if it was possible to use acoustic or vibration methods to detect lathe checks on an industrial lathe. This was a success since lathe checks band of frequency is visible on both spectrums (accelerometer and microphone) for each trial where checks were produced. It is important to point out that the peeling process was performed using a peeling line near to industrial ones (clipper, treadmills, fan heater, high speed air cylinder,...).

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