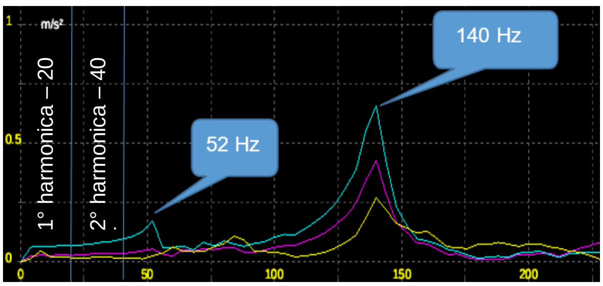
Chattering

Identification of vibrations during
the initial processing phase.

The Power of Knowledge Engineering

DEEP HOLE DRILLING TEST

Spindle RPM: 1200 / 20 Hz
Number of tool cutting edges: 2
Tool frequency response:

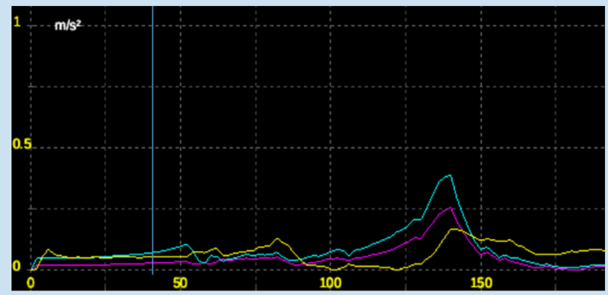


Obtained through BUMP TESTING and FASTTRACER sensor, with stationary spindle, and sensor positioned on tool-spindle trigger.

The TOOL - SPINDLE system has two resonances at 52 and 140 Hz.
The second harmonic (No. of revolutions x N) where N is the number of cutting edges is rather close to the first resonance of the tool. Situation to avoid, if possible.

POCKET REALIZATION

Spindle RPM: 1400 / 23.3 Hz
Number of tool cutting edges: 6
Tool frequency response:



Obtained through BUMP TESTING and FASTTRACER sensor, with stationary spindle, and sensor positioned on tool-spindle trigger.

In this case with six cutting edges you arrive very close to the second resonance peak at 140 Hz.
It's an unhealthy situation that can cause instability phenomena.

ANALYSIS

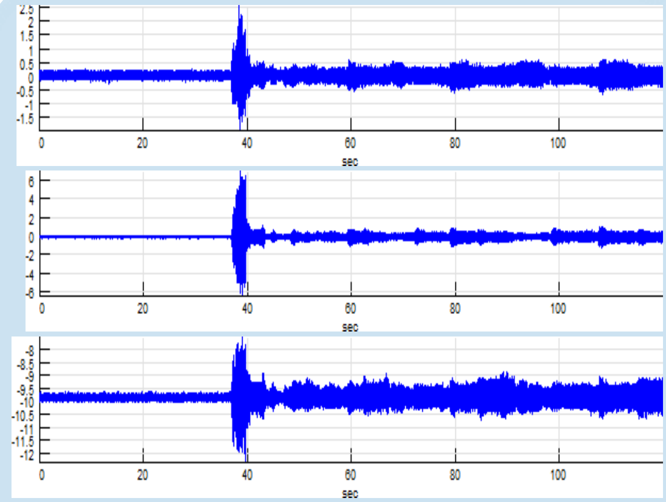
As far as deep drilling is concerned, a filter setting of 10 Hz (high pass) and 20 Hz (low pass) is sufficient to exclude phenomena of resonance and/or dynamic instability. A pre-alarm threshold can be set around 15 m/s^2, while the alarm around 20 m/s^2.

It is more complicated to set thresholds for the construction of the pocket.

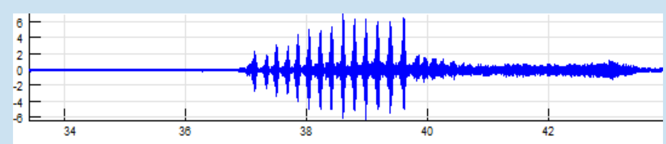
- With the 6-edged tool, we are really going to work in resonance with respect to the Tool/Spindle system.
- The first two graphs with 10-20 Hz filters (which also exclude the resonant part of the system) show an extreme sensitivity to the depth of the cut. In fact, we go from a value of 9 m/s^2 for 1 tenth of a cut to almost double 16 m/s^2 for 2 tenths of a cut.
- Considering that machining with 2 tenths of a second is the heaviest, you can still use the threshold settings used for deep machining.
- Setting high pass and low pass filters centered on the resonance shows that the value reached increases significantly, reaching a maximum of 81 m/s^2. (verification test).

A more in-depth dynamic analysis should probably be carried out than in the initial phase of the machining, as it seems that the system shortly enters a condition of dynamic chatter/instability.

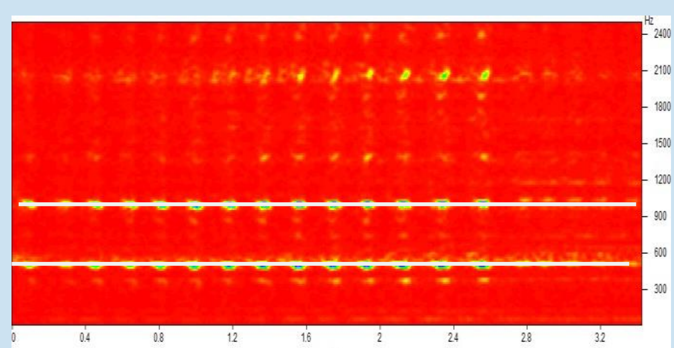
This is quite evident from the acquisition of the accelerometric signals taken with our FastTracer system on the workpiece support during pocket machining with 2 tenths of a second removal:



Going to see what happens in the initial transitory:

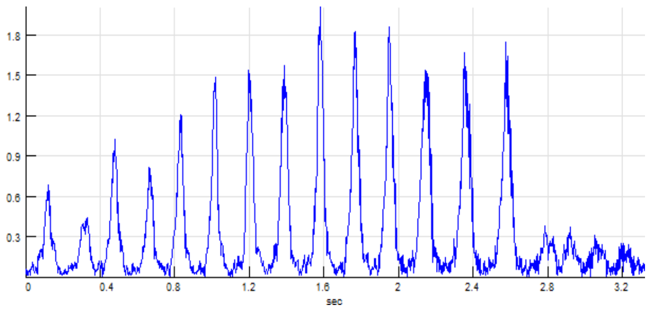


You can clearly see a series of real "bumps", and the signal, zooming in further, looks like a frequency modulation (see appendix A) and we can use "demodulation" techniques to understand what happens:

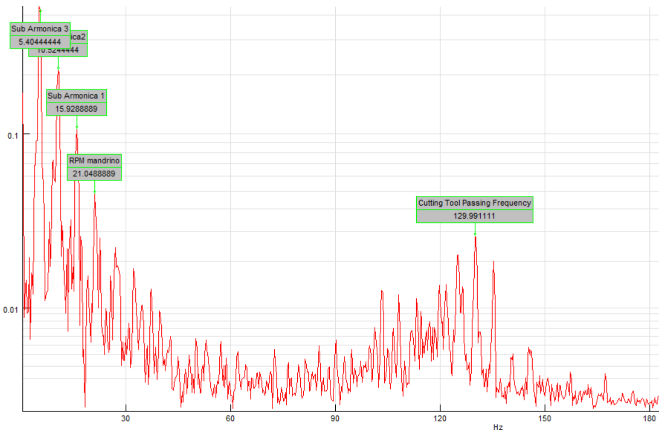


In the TIME - FFT Analysis graph you can see during the transient of the frequency lines where during the shocks the amplitude rises. Particularly in the 500 Hz and 1000 Hz zones. I believe that these are resonance frequencies of the workpiece support.

We extract a slice at 500 Hz:



You can clearly see the course of the collisions. Let's do an FFT of this signal to understand the carrier (500 Hz) from which frequencies is modulated (Envelope Spectrum).



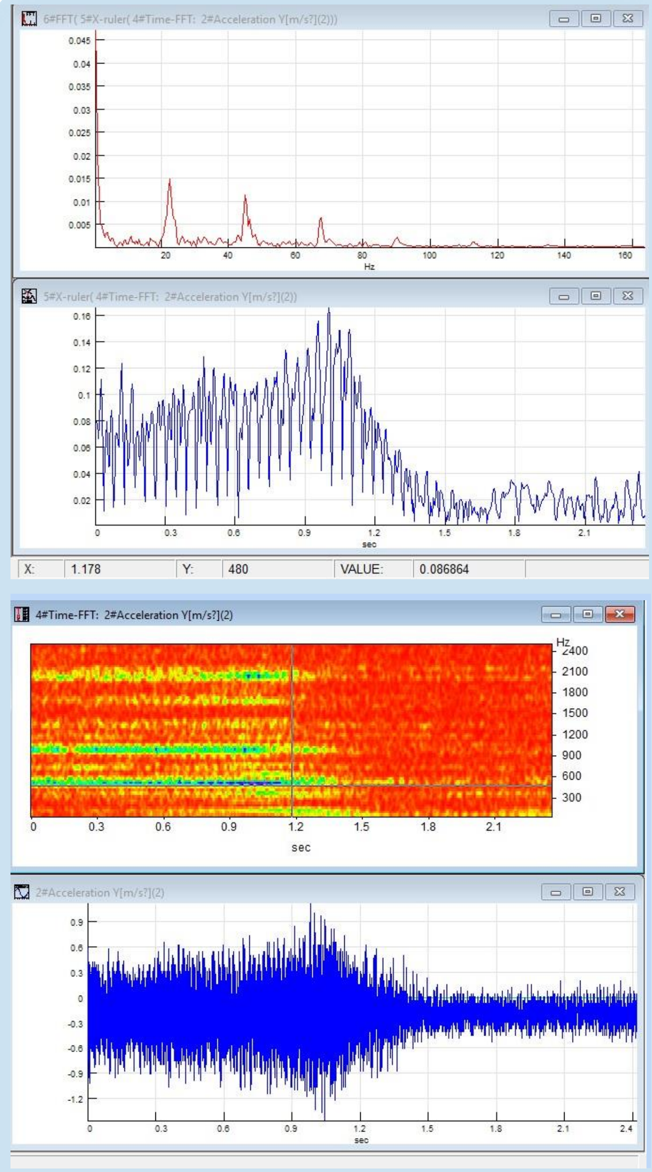
They can be clearly seen:

- RPM spindle (about 21,5 Hz) which means that the spindle is probably turning around 1300 RPM

- Cutting edge frequencies (6 x 21.5 = 129 Hz)

- And dangerous sub-harmonics (about 15, 10 and 5 Hz) as they indicate strong instability during tool/spindle rotation - 5 Hz is the main modulation one.

Analyzing with the same method a part of the signal after the initial transient:



It should be noted that

- There is always a modulation of the structure's own frequencies

- It is mainly due to the first harmonica and its multiples (2/3/4/5/6) and not to sub-harmonics.

- Among other things, the first harmonic is at 22.58 Hz - 1355 RPM, i.e. much closer to the nominal RPM (1400) of the spindle for the machining in question.

Smart Solutions for Vibration Monitoring