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EXPERIMENTAL STUDY OF VIBRATIONS IN FACE MILLING CUTTING

GABRIEL VASILE ONIŢĂ
Faculty of Engineering/Department of Industrial Engineering and Management, University Lucian Blaga of Sibiu, Romania, gabriel.onita@yahoo.com

Abstract: *The present paper consists in a comparison of vibrations measured during face milling cutting with two constructive variants of milling cutters (one with classic insert clamping and other with a quick insert adjustment mechanism). The goal of the study is to determine if the new clamping mechanism of the inserts has a similar behaviour with the classic one and can withstand milling conditions without introducing additional vibrations in the system.*

Key words: milling cutter, vibration, insert clamping, modular design

Introduction

Milling process has a leading role in metal cutting because of the multitude of shapes and dimensions that can be obtained by it. Because of this, it is necessary to constantly improve the process. It is imperative to find new constructive solutions to satisfy the new needs for a highly productive milling process, more complex surface geometry and a more precise surface finish. To this end, a new modular face milling cutter was designed and analyzed by finite element method in previous paper.

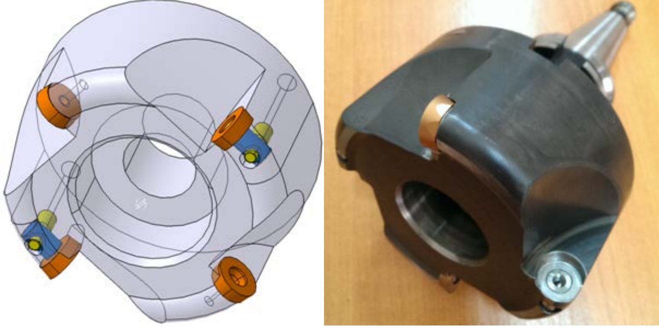
The goal of this paper is to take a step forward in testing the new milling cutter, by conducting an experimental research to verify the vibration behaviour of the cutter, compared to the classic one.

Cutting tool design

The central roles in designing the new face milling cutter are represented by creative methods of modelling, evaluation, and simulation. Current milling cutters with round inserts are difficult to adjust when the inserts are worn out due to their compact design. The cutter must be released from the spindle and each insert must be rotated manually, with a certain degree, in order to bring a new cutting edge in the milling zone. In this way, the auxiliary time is very high. We proposed in our previous paper the model of a new face-milling cutter based on a new design of insert clamping, which significantly improves the auxiliary time while being able to maintain the high static and dynamic stability.

For this study we need two milling cutters of the same construction dimensions and number of inserts to obtain relevant data. To this end we constructed a combined face milling tool with four inserts, two diametrically opposed, with classic clamping of the insert with central screw and another two with the new mechanism for insert clamping. The geometry of the tool is presented in figure 1. The experiments were conducted by milling successively with the two kinds of insert clamping.

Figure 1: Cutting tool design



Experiment

The experiment was conducted on a three axis DMC 635 V machine tool and consisted of a number of 8 face milling trials for each type of insert clamping, of a solid block made of S355 steel. The monitoring system consisted of an acquisition board from National Instruments (NI PCI 4462), two Monitran MTN/1100C accelerometers, which monitored the accelerations from two directions X and Y of the machine tool, connected to a PC with LabView 8.5 software.

In order to have valid comparative data, both constructive variants were subjected to the same milling process conditions. The process parameters were calculated in respect to the relations from Sandvik general catalogue for the specified material and tool dimensions.

The milling parameters are presented in Table 1.

Table 1: Milling parameters

No.	Depth of cut a_p [mm]	Feed/tooth f_z [mm/tooth]	Spindle [rpm]
1	**0.5**	**0.3**	**400**
2	0.5	0.3	500
3	**0.5**	**0.2**	**400**
4	0.5	0.2	500
5	**1**	**0.3**	**400**
6	1	0.3	500
7	1	0.2	400
8	**1**	**0.2**	**500**

The signals recorded for the two directions X and Y were processed using LabView software. Two virtual instruments were created in order to compare the results for the different insert clamping.
The block diagrams are presented in figure 2 for displacement analysis and figure 3 for spectral analysis.

Figure 2: Displacement analysis

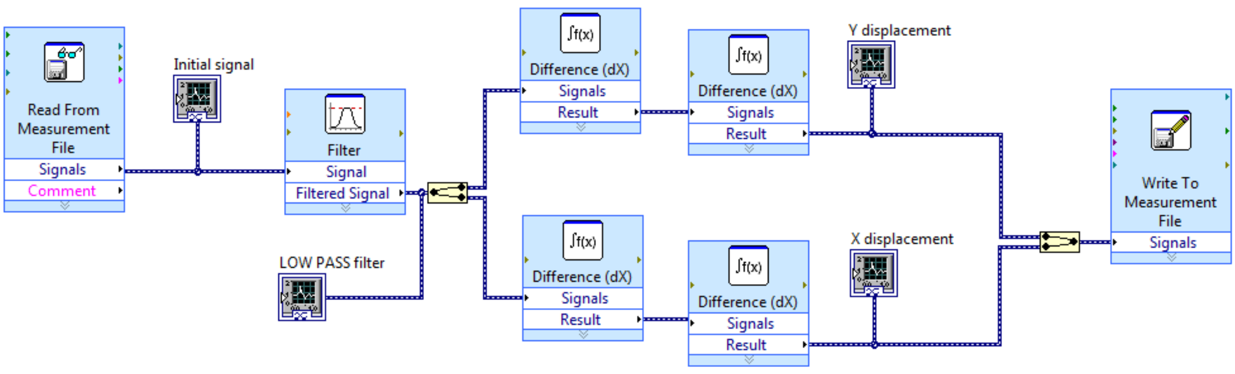
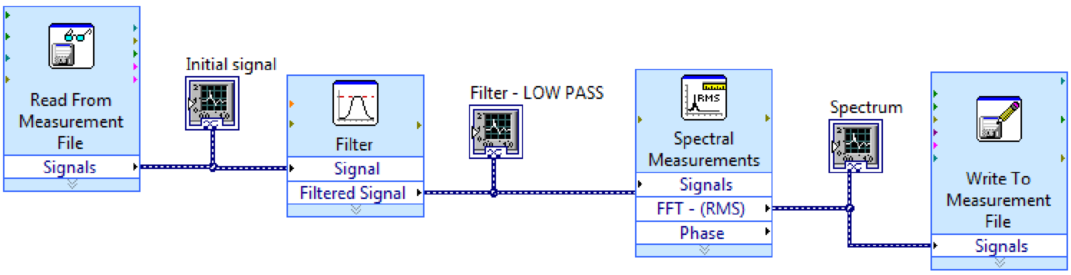


Figure 3: Spectral analysis



For both comparative analyses a low pass filter, with cut-off frequency of 1kHz was used, in order to eliminate the high frequencies from the signal, due to environment noises. The signals obtained are presented in figures 4,5,6,7. We observed that the displacement values are comparable and very close to each other, thus the new insert clamping has a similar behaviour regarding vibrations for all cutting trials.

Figure 4: Displacement for experiment no.1, a - classic clamping b - new clamping
(a) (b)

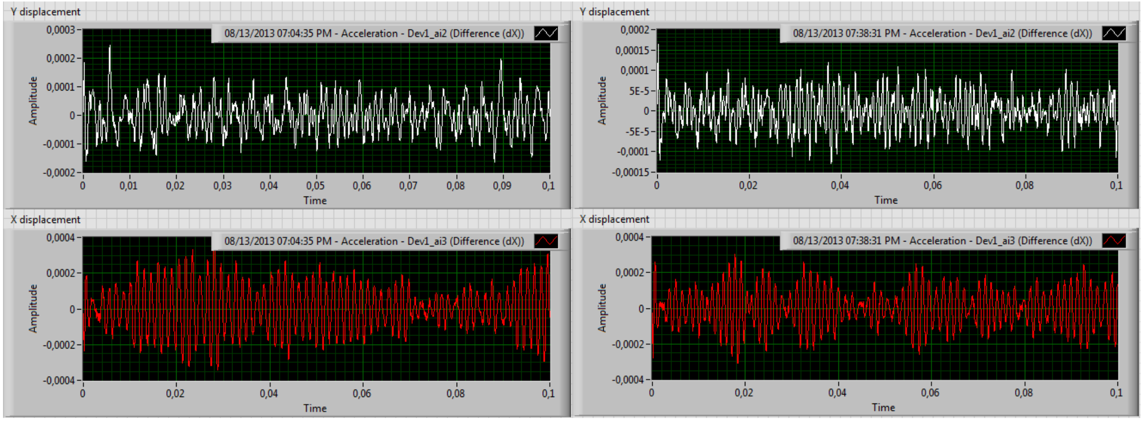


Figure 5: Displacement for experiment no.3, a - classic clamping b - new clamping
(a) (b)

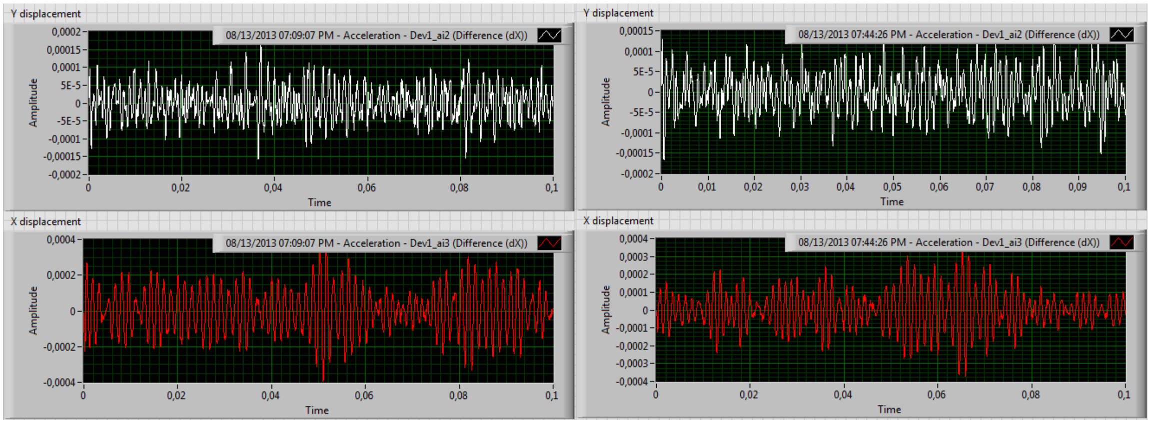


Figure 6: Displacement for experiment no.5, a - classic clamping b - new clamping
(a) (b)

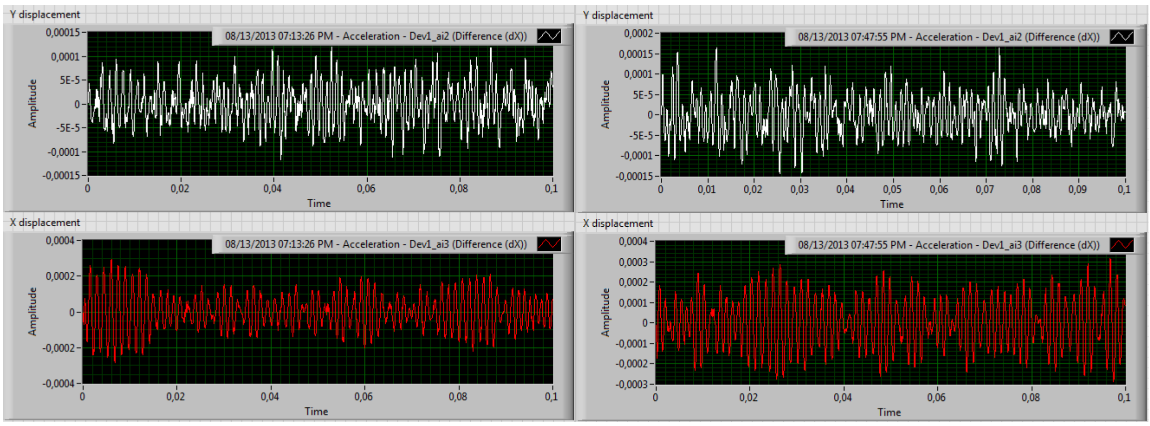
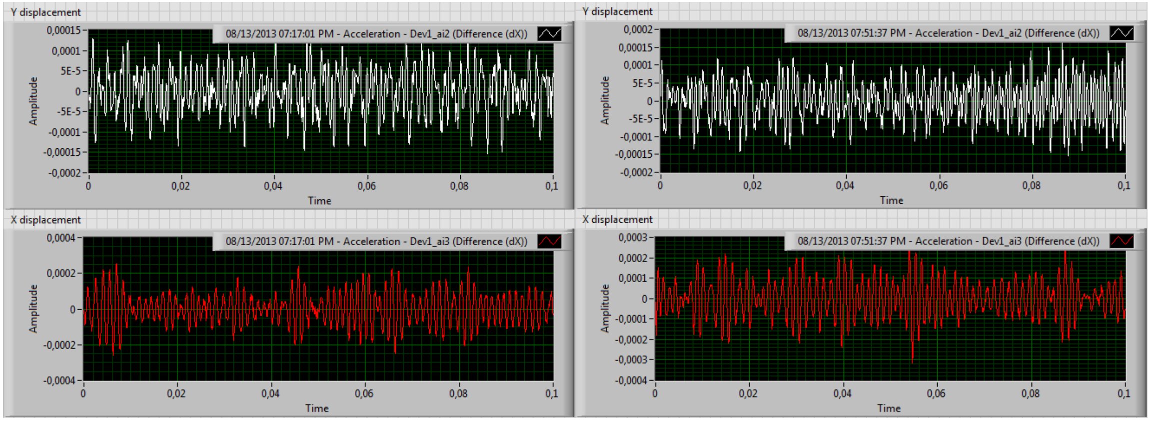


Figure 7: Displacement for experiment no.8, a - classic clamping b - new clamping
(a) (b)



For the comparative spectral analyses we observed that around 250Hz and 650Hz, in both cases there are maximum peaks which suggests that around these values the systems start to resonate. The results are presented in figures 8, 9, 10 and 11.

Figure 8: Spectral analysis for experiment no.1, a - classic clamping b - new clamping
(a) (b)

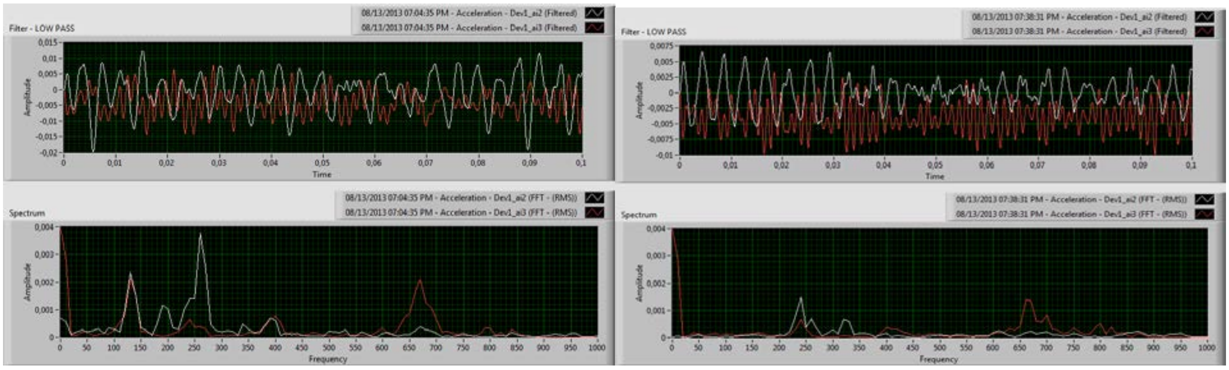


Figure 9: Spectral analysis for experiment no.3, a - classic clamping b - new clamping
(a) (b)

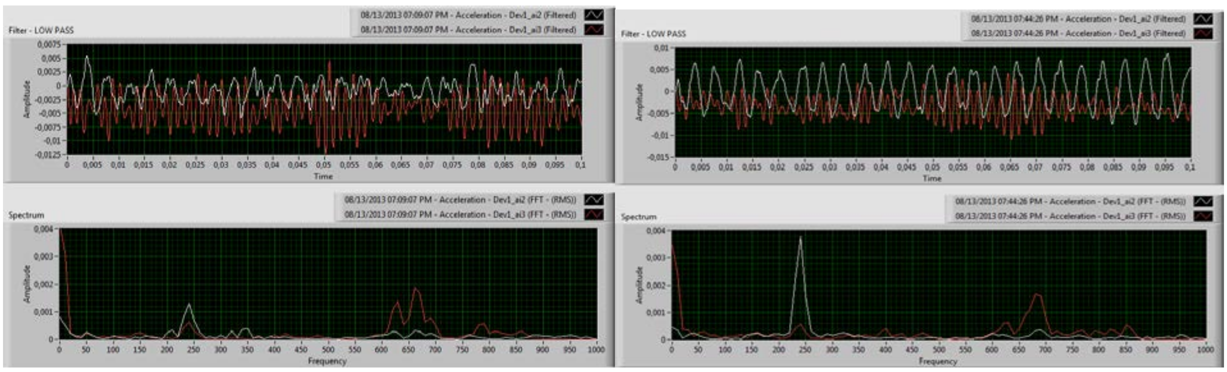


Figure 10: Spectral analysis for experiment no.5, a - classic clamping b - new clamping
(a) (b)

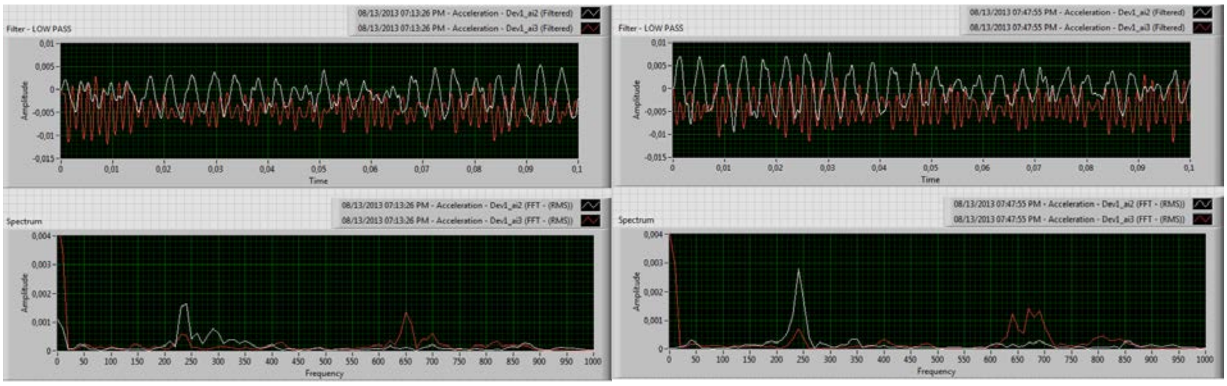
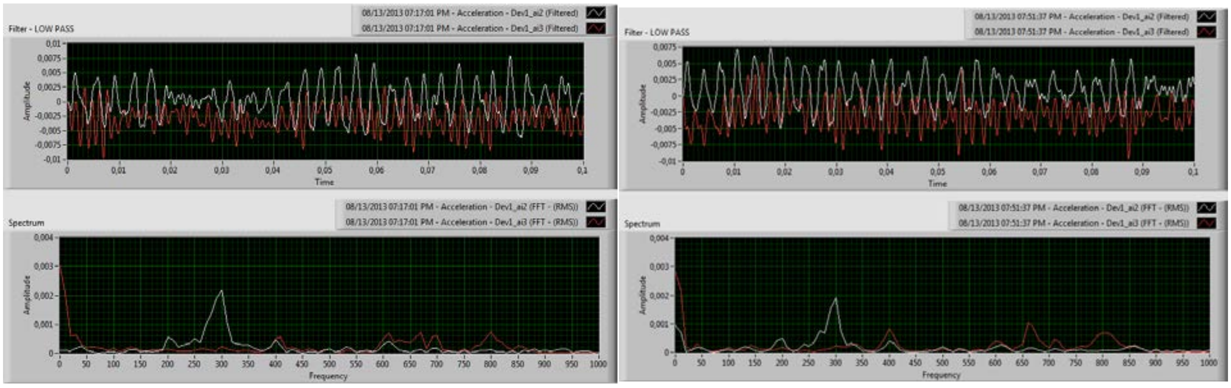


Figure 11: Spectral analysis for experiment no.8, a - classic clamping b - new clamping

(a) **(b)**



Conclusions

From the presented results, we demonstrated that both constructive variants for insert clamping have a similar behaviour regarding vibrations during milling, which makes the new variant a real candidate for face milling because of the advantages it offers.

The main advantage of this construction consists in the possibility to quickly adjust the inserts to compensate for cutting edge wear, which means that the auxiliary time is drastically reduced.

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***Sandvik Rotating Tools Catalogue (2013) http://www.coroguide.com/