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CONTRIBUTIONS TO THE ASSESSMENT OF THE VIBRATION BEHAVIOUR OF THE FEED DRIVE ON THE CNC MILLING MACHINE MCV-300

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Rezumat. *Evaluarea comportării vibratorii a maşinilor de lucru şi a utilajelor tehnologice în regim static sau dinamic asigură prelungirea ciclului de viaţă al acestora. Monitorizarea vibraţiilor perturbatoare din lanţurile cinematice ale maşinilor de lucru ajută la prevenirea apariţiei de defecte la componentele acestora. Astfel, se poate stabili şi un program de mentenanţă predictiv pentru maşina studiată. Toate, cu scopul unei intervenţii eficiente, în caz de defecte, care ar influenţa buna funcţionare a maşinii, prin abateri de la parametrii iniţiali de funcţionare. [1], [2], [3], [4]*

Abstract. *The evaluation of vibration behaviour of machinery and technological equipment working in static or dynamics helps to extend their life cycle. Monitoring, vibration disturbing of the kinematic chains of the working machines contribute to prevent defects in their components. Thus, a predictive maintenance program studied of machinery may be established. All this in order to intervene effectively in the event of faults that might affect the proper functioning of the machine, the deviations from the initial operating parameters. [1],[2],[3],[4]*

Keywords: speed vibration, kinetics chain advance, predictive maintenance, defect.

1. Introduction

Assessing the vibration behaviour and the maintenance of machine tools is required to increase their processing accuracy. Monitoring the operation of the machines by predictive maintenance and by the assessment of the vibration behaviour and by the analysis of the vibrations present in the feed drive, respectively, proves to be efficient due to the information it provides in the decision-making process in case of failure. Thus, this research aims to study the vibrations that would result in deviations from the initial geometrical parameters of the feed drive for the FIRST MCV 300 processing centre. The geometrical parameters of the machine tool must be verified both when receiving the machine

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tool and periodically, during operation. Verifications during operation are required by the occurrence of vibrations, wear and tear and by the possibility for some control components to become loose. Parameters that define the geometrical accuracy of the machine tool include the linear and parallel alignment of the guide paths on various directions, the smoothness of the table, the radial beat of the main arbors, the coaxiality of the various operating parts, and the perpendicular alignment of the various operating parts.

2. Experiments, Equipment

This research aimed to identify the relationship between the feed speed and the vibration speed when the machine tool is set on the X axis in order to determine the operation state of the feed drive for the FIRST MCV 300 processing facility.

The following equipment was used:

- Three-axes accelerometer placed on the machine table (the signals issued by the accelerometer related to the X, Y and Z directions);
- The multi-channel DSA 550 Digitline equipment was used to gather data;
- The Fast View software was used;
- Reinshaw ML 10 laser interferometer system with mirrors and straightness reflectors;
- Equipment for balancing the working and the room temperature;
- PC used to run the data gathering software;

The experiment stand was set on the table of the First MCV300 – CNC cutting facility is presented in Figures 1, 2, 3, 4:

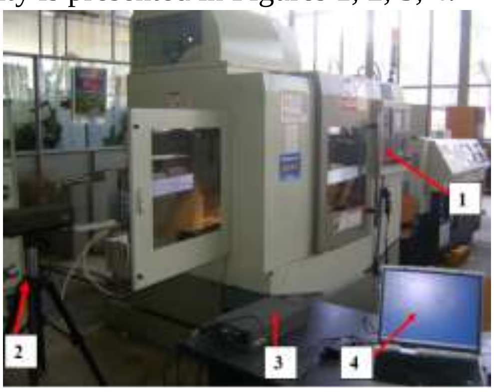


Fig. 1. The laser experiment facility, First MCV 300

1 - First MCV 300 cutting facility; 2 - ML - 10 laser; 3 – equipment for balancing the working and the room temperature; 4 – PC used to run the data gathering software

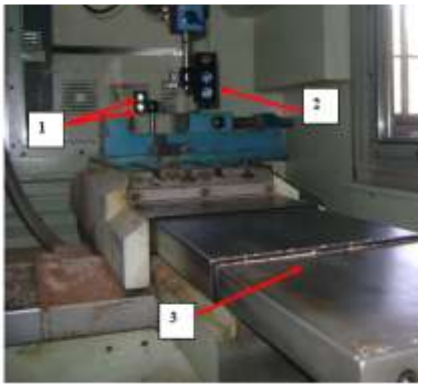


Fig. 2. Assembling the laser equipment

1 - straightness reflector; 2 – laser equipment with mirrors; 3 – machine table with pads

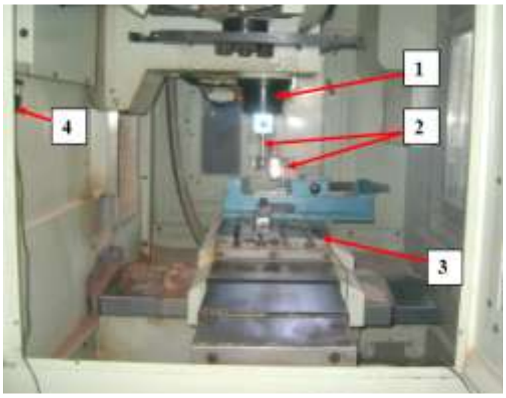


Fig. 3. Aligning the laser equipment
1 – main arbor; 2 – laser equipment with mirrors and straightness reflector; 3 – temperature sensor; 4 – room temperature sensor

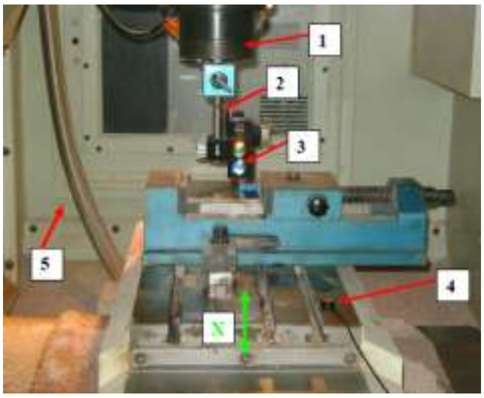
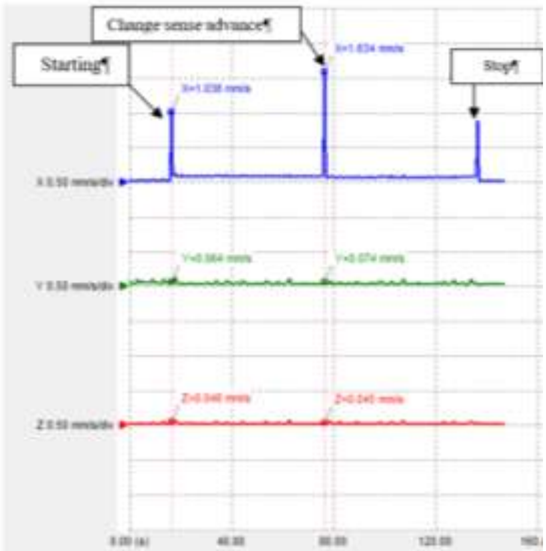


Fig. 4. Experiment laser stand – measuring vibrations
1- main arbor; 2- mirrors and straightness reflector assembly; 3 - straightness reflector; 4 – room temperature sensor; 5 - First MCV 300 processing facility; X – measurement direction

Table 1. Examples with recorded vibrations spectra

Feed speed values used v_a (mm/min)	**Spectrum of the measured vibration speed values v (mm/s)** - for different feed speed values, different strokes and for the change in the table feed direction
v_a = 500 mm/min	

v_a = 2000 mm/min

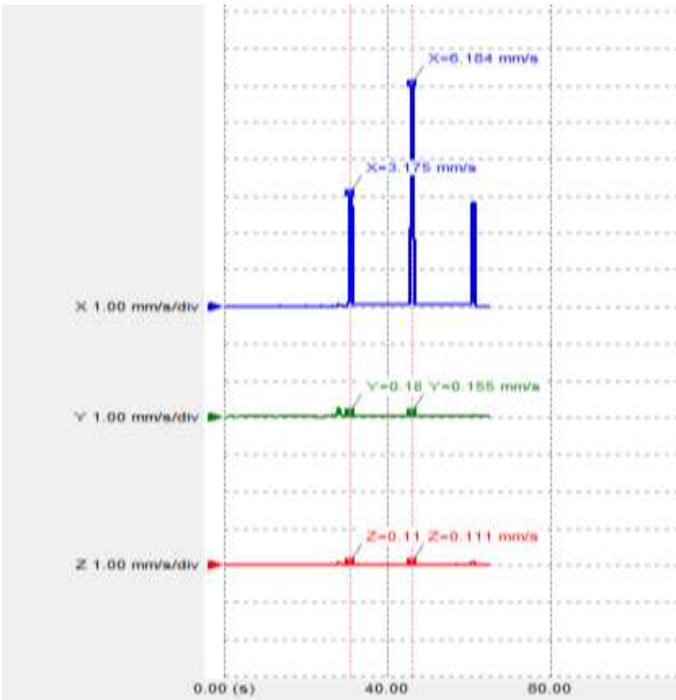


Table 2 Feed speed values and vibration speed values on the X table movement direction

Feed speed v_a [mm/min]	**Vibration speed**						
	v / Axis **X** [mm/s]		v/Axis **Y** [mm/s]		v/Axis **Z** [mm/s]		Time[s]
	Starting stop	Change sense advance	Starting stop	Change sense advance	Starting stop	Change sense advance	
v_a = 500	1.036		0.04		0.046		10
	1.01	1,634	0.034	0.074	0.040	0.045	70
v_a = 1000	0.049		0.021		0.013		30
	0.03	0,003	0.018	0,003	0.010	0.003	70
v_a = 1500	2.351		0.126		0.087		9
	2.20	3,682	0.012	1.02	0.07	0,067	20
v_a = 2000	3.175		0.18		0.11		30
	2.989	6.184	0.15	0.155	0.10	0.111	50
v_a **= 2500**	**4.185**		0		0.1		10
	4.01	**6.984**	0	0.171	0.09	0.123	20
v_a = 3000	5.655		0		0		10
	5.02	9,164	0	0.220	0	0.166	20
v_a = 3500	6.096		0		0		9
	5.987	10.507	0	0.234	0	0.167	20

v_a = 4000	5.950		0		0		8
	5.02	11.982	0	0.266	0	0.174	18
v_a = 4500	8.444		0		0		6
	8.001	13.050	0	0.276	0	0.205	16
v_a = 5000	8.523		0		0		8
	7.98	14.402	0	0.325	0	0.235	16

3. Experiment Results

3.1. Measurement diagram. Experiment device characteristics

In order to measure the vibrations on the X movement direction of the table in the MCV 300CNC processing centre, the following measurement diagram was used, as shown in Figure 5.

The equipment was mounted by placing the tripod on the ground, using the levelling indicator included with the tripod, in order to have the ground and the table aligned.

The mobile mirror was mounted on the machine table, and the following measurements were made on the three axes: X, Y and Z.

- DSA550 Digitline measurement and vibration analysis systems with 5 programmable inputs and 24-bit resolution were used.
- A 1 Hz to 20000 Hz sampling frequency range was used.
- Reinshaw ML 10 laser interferometer system has a ± 0.7μm accuracy, which remains constant within the operating range.
- Data was gathered at 250 values/second, at 100 mm nominal length, under an operating temperature of 0°C – 40°C.

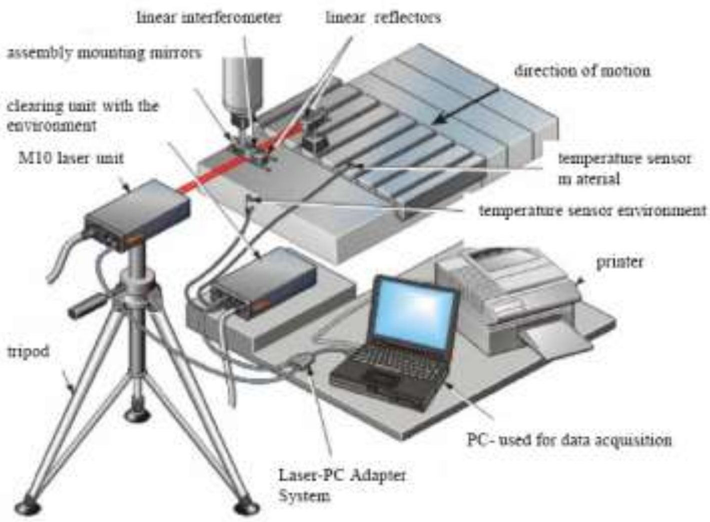


Fig. 5. Measurement diagram used [5]

3.2. Analysis of the measurement results

The feed drive of the table in the processing facility subject to the study consists of: a n_{max} = 8000 rpm and P = 11kV electric motor, bearing boxes, a 10 mm ball screw with nut, the machine table, and a flexible basis for the processing facility.

The table was moved in direction X (with the feed speed values listed in table, and a change in the feed direction), in relation to which we have measured the vibrations produced by the screw-nut coupling. The table movement stroke was of 500 mm. The results of the measurements of the vibration speed are also listed in Table 1. Thus, based on the vibration speed measurements, we have drawn the chart in Figure 6.

The analysis of the chart reveals the fact that there is a high increase in the vibration speed when the feed direction is changed and when the feed speed increases. In order to determine the operation state of the feed drive (from the point of view of a predictive maintenance program, which should be applied to the processing facility subject to the study), the vibrations recorded and the (feed drive) motor characteristics allow them to be classified and compared to the values in the ISO 10618-3 and ISO 2372 standards.

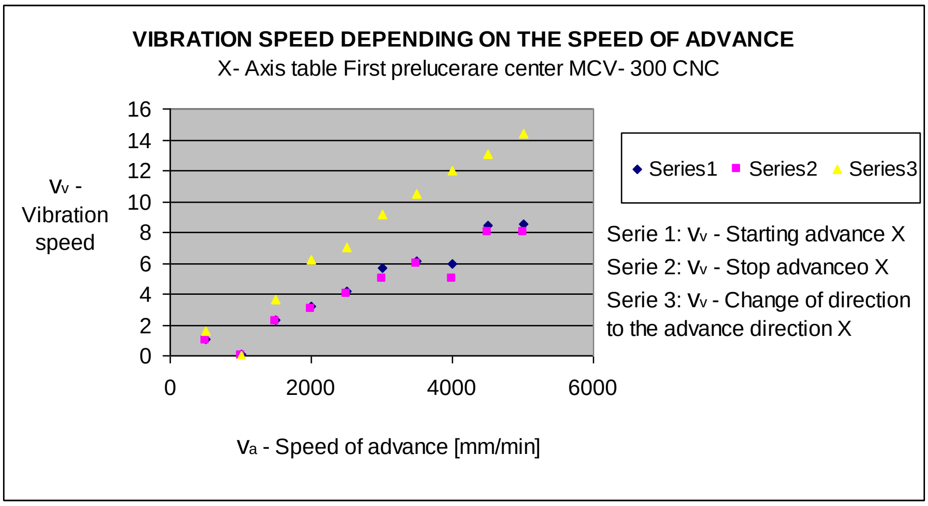


Fig. 6. Chart of the vibration speed values in relation to the feed speed used when moving the table on the X direction.

Thus, according to ISO 1018-3, based on the flexible basis of the centre and on the 11kW, n_{max} = 8000 rpm motor, the processing centre subject to the study falls under Group 3, Figure 7. And from the point of view of the maximum vibrations accepted during operation without user intervention, according to ISO 2732, it falls under Class 4 (with vibration speed values ranging from 4.5 mm/s to 7.1 mm/s, for group B of accepted operation).

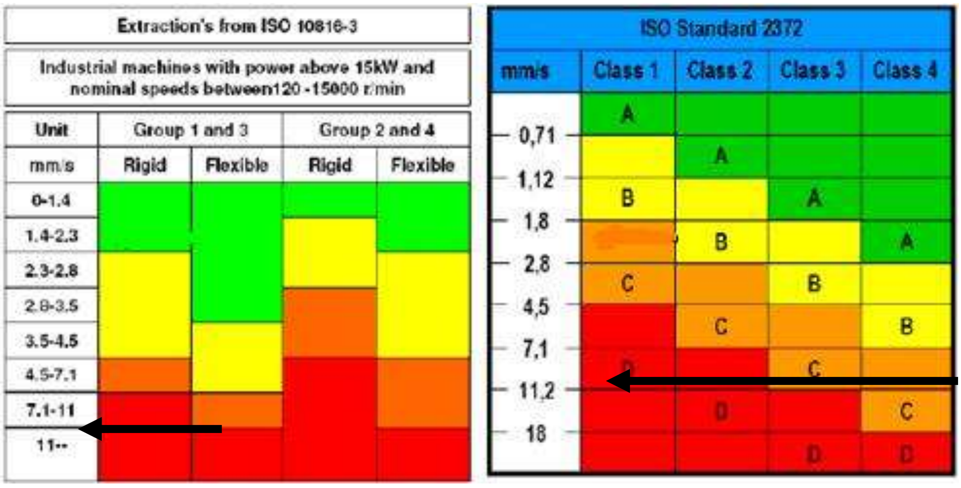


Fig.7. Charts determining the operation state of the feed drive subject to the study within the First MCV 300-CNC processing centre.

4. Conclusions

• As a result of the analysis of the feed and vibration speed in Table 1 and of the charts in Figure 7, the vibration speed accepted for the proper operation without user intervention is of 4.185 mm/s at start up and 6.984 mm/s when changing the feed direction, corresponding to a maximum feed speed of 2500 mm/min.

• If there is an increase in the feed speed, there is also an increase in the vibration speed, requiring the machine to be stopped for control and for removing the clearance occurring within the components of the feed drive subject to the study.

• The vibrations present on the X movement direction of the machine table indicate possible clearance on the X direction within the screw-nut coupling, the bearing boxes, wear and tear and the possibility for some control components to become loose.

• In conclusion, an increase in the vibrations on direction X results in a deviation from the initial geometrical parameters of the feed drive in the FIRST MCV 300 processing centre.

• The vibrations measured on the Y and Z directions are not significant for these measurements.

• The final conclusion is that periodical verifications of the vibrations and the integration of the First MCV300 - CNC processing centre in a predictive maintenance program are required.

Thus, according to ISO 1018-3, based on the flexible basis of the centre and on the 11kW, n_{max} = 8000 rpm motor, the processing centre subject to the study falls under Group 3, Figure 7. And from the point of view of the maximum vibrations accepted during operation without user intervention, according to ISO 2732, it falls under Class 4 (with vibration speed values ranging from 4.5 mm/s to 7.1 mm/s, for group B of accepted operation).

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