TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 68, Issue III, September, 2025

STUDY BY MEASUREMENTS OF THE ACTION OF MECHANICAL VIBRATIONS PRODUCED BY A FANUC MACHINE TOOL ON A HUMAN "MALE" OPERATOR

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Abstract: *The paper is a natural continuation of the study of the action of vibrations on an operator servicing a FANUC machine tool when idling. In the work, measurements are made on the operator when transmitting the vibrations from the machine tool through the feet of the 'male' operator, to the abdomen, which summarize the vibrations transmitted through both legs. Measurements are made with the SVAN 958 vibrometer that transmits vibrations through a triaxial accelerometer having the three main directions of the body. Through these measurements, it is sought to prove that the health of the "male" operator is affected by exposure to the vibrations produced by the machine tool.*
Keywords: *vibration measurement, male operator, interpretation of results, comparative study with the literature.*

1. INTRODUCTION

An operator, servicing a machine tool FANUC with numerical control, it is subject to vibrations produced by it during the production process. In order to establish the amount of vibrations required by the operator's body, this paper presents the vibration measurements made on a "male" operator, when the car is idling. The measurements are provided so that the vibrational state of the body can be evaluated, which precedes the machining process when running under load of the machine tools.

The study corresponding to this doctoral thesis refers to the vertical transmission of vibrations through the operator, from the soles of the feet, through both feet, to the abdomen, which is the part that sums up / cumulates the vibrations transmitted through both feet [1], [2]. The body segments referred to in this study are: the foot, ankle, calf, knee joint, femur, hip joint, abdomen – which together with the upper body form an assembly assimilated to a rigid solid.

The study will be carried out on “male” human operators, of medium age, who have experience in servicing machine tools with numerical control. He has a 46-year-old, weighing 83 kg and 187cm tall.

The operator was informed about the measurements that will be carried out on him. He said that he accepts the investigations that will be carried out and that he is physically and mentally healthy.

2. MEASUREMENT CONDITIONS

A human operator is positioned on both legs, and the vibration is transmitted evenly through them, the body is assimilated to a rigid solid [3], [4], [5]. Vibration measurements are correlated with those found in the literature [6]. [7].

The operator is positioned in front of the machine tool inspection door, as can be seen in figure 1 of [8], which corresponds to the possibilities of supervising the production process of the machine tool [NET**_24_a], [NET**_24_b].

The position of the "male" operator is highlighted by a pad [NET**_24_c], which is an integral part of the measuring system of the SVAN 958 vibrometer, together with the triaxial accelerometers of the [NET**_24_d] device. An accelerometer is fixed with elastic bands to the measurement site, and the vibrational impulse is transmitted to the device, which is stored in a data file.

3. ACCELEROMETER POSITIONING SEQUENCE

On the "male" operator, the first measurement is made on the PAD, in two distinct situations, with the bare foot placed directly on the pad and with the foot shod with socks. The operator is in an upright position, and the vibration is transmitted through both legs.

The triaxial accelerometer transmits the vibrations in its three directions, and in the vibrometer they are materialized through the three channels, for each one the numerical data is stored in files. Compared to the position of the accelerometer on the investigated subject, the direction of the transmission axis to the operator's body will be specified at each image.

Fig. 1. The measurements on the "male" operator on the pad, with: Ch1- axis y; Ch2- axis x; Ch3- axis z

Fig. 2. The measurements on the "male" operator left foot, below the ankle, without textile, with: Ch1- axis z; Ch2- axis x; Ch3- axis y

Fig. 3. The measurements on the "male" operator left foot, above the ankle, without textile, with: Ch1- axis z; Ch2- axis x; Ch3- axis y

Fig. 4. The measurements on the "male" operator left foot, above the ankle, with textile, and: Ch1- axis z; Ch2- axis x; Ch3- axis y

Fig. 5. The measurements on the "male" operator left foot, below the knee, without textile, and: Ch1- axis z; Ch2- axis x; Ch3- axis y

Fig. 6. The measurements on the "male" operator left foot, above the knee, without textile, and: Ch1- axis z; Ch2- axis x; Ch3- axis y

Fig. 7. The measurements on the "male" operator left foot, on the thigh, with textile, and: Ch1- axis z; Ch2- axis x; Ch3- axis y

Fig. 8. The measurements on the "male" operator, on the abdomen, with textile, and:
Ch1- axis z; Ch2- axis x; Ch3- axis y

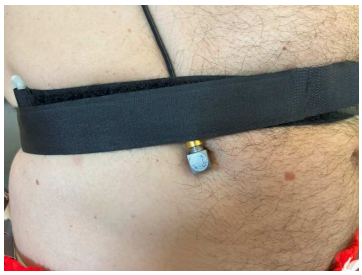

Fig. 9. The measurements on the "male" operator, on the abdomen, without textile, and:
Ch1- axis z; Ch2- axis x; Ch3- axis y

Fig. 10. The measurements on the "male" operator right foot, on the thigh, with textile, and:
Ch1- axis z; Ch2- axis x; Ch3- axis y

Fig. 11. The measurements on the "male" operator right foot, above the knee, without textile, and:
Ch1- axis z; Ch2- axis x; Ch3- axis y

Fig. 12. The measurements on the "male" operator right foot, below the knee, without textile, and:
Ch1- axis z; Ch2- axis x; Ch3- axis y

Fig. 13. The measurements on the "male" operator right foot, above the ankle, with textile, and:
Ch1- axis z; Ch2- axis x; Ch3- axis y

Fig. 14. The measurements on the "male" operator right foot, above the ankle, without textile, and:
Ch1- axis z; Ch2- axis x; Ch3- axis y

Fig. 15. The measurements on the "male" operator right foot, below the ankle, with textile, and:
Ch1- axis z; Ch2- axis x; Ch3- axis y

Fig. 16. The measurements on the "male" operator right foot, below the ankle, with textile, and:
Ch1- axis z; Ch2- axis x; Ch3out- axis y

4. GRAPHICAL REPRESENTATION OF VIBRATION MEASUREMENTS ACTING ON THE "MALE" OPERATOR

Figures 1 – 16 show the images of the accelerometer being fixed on the body parts of the "male" operator during measurements on the SVAN 958 vibrometer. From the images it is possible to identify the directions of the accelerometer axes, which correspond to the data recording channels in the vibrometer files.

From the orientation of the accelerometer axes without the direction of the axes related to the human body – the vertical ascending "z" axis, the horizontal "y" axis directed from right to left, and the horizontal "x" axis directed from back to front, the data recorded by the vibrometer can be interpreted.

The documentation for the use of the SVAN 958 vibrometer specifies the meaning of the acceleration quantities, which it records and stores in the data files.

The meaning of the notations in the table:

- ✓ **PEAK** – peak size or amplitude,
- ✓ **P-P** – Peak to peak – double amplitude, or the distance between the extremities of the recording,
- ✓ **Max** – the maximum value recorded for each measurement,
- ✓ **RMS** – Root Means Square – is a crucial metric that represents the effective value of a fluctuating signal, like vibration, over a period of time. It essentially provides a single value that indicates the overall magnitude and energy content of the vibration, making it useful for assessing the severity and health of machinery,
- ✓ **VDV**– Vibration Dose Value - It's a metric used to quantify human exposure to vibration, particularly in situations involving intermittent or impulsive vibrations,
- ✓ **CRF** – Crest value of Frequency - contact resonance frequency.

In the figures that follow, the graphic representations of the data files corresponding to the images shown in figures 1-16 are given.

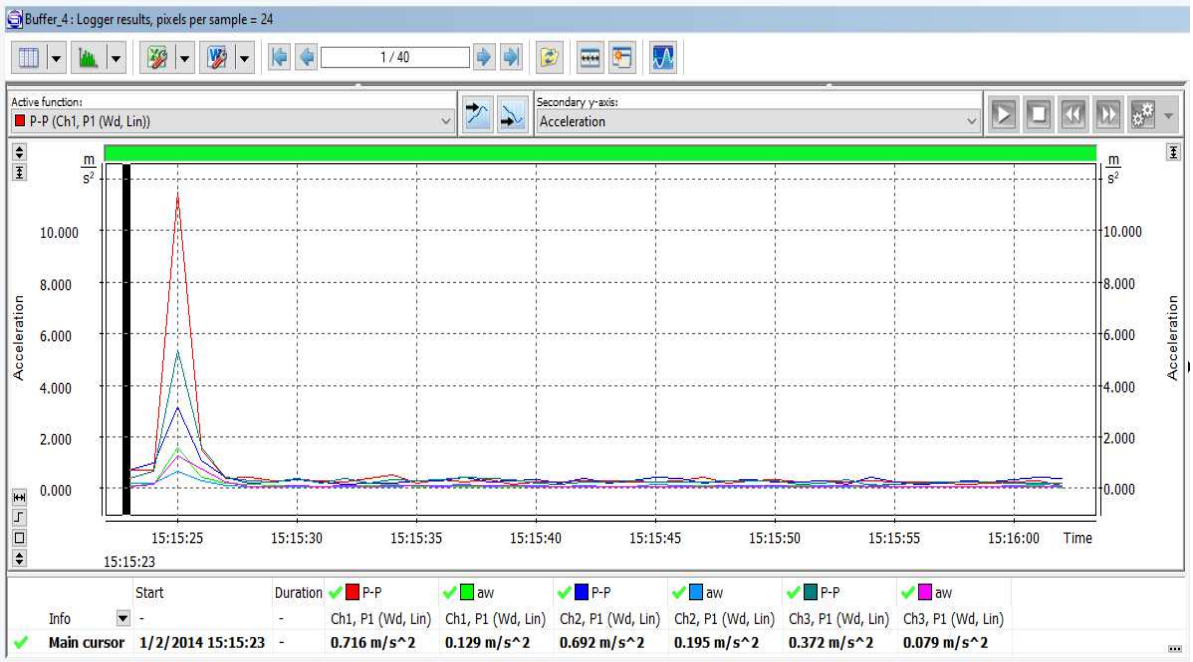

Fig. 17. The representation of the measurements on the "male" operator on the pad, with: Ch1- axis y; Ch2- axis x; Ch3- axis z

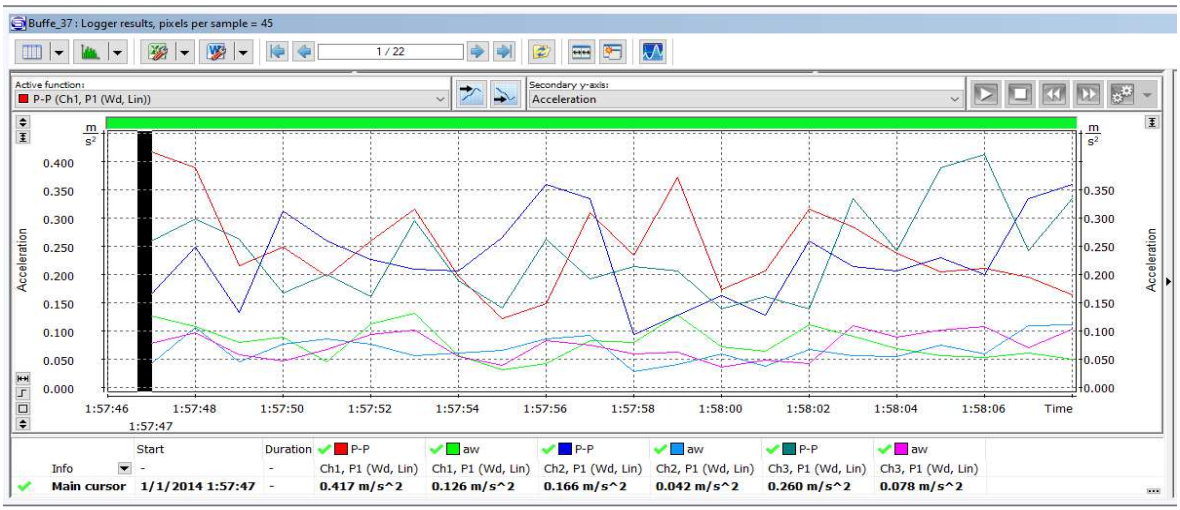

Fig. 18. The representation of the measurement on the "male" operator left foot, below the ankle, without textile, with: Ch1- axis z; Ch2- axis x; Ch3- axis y

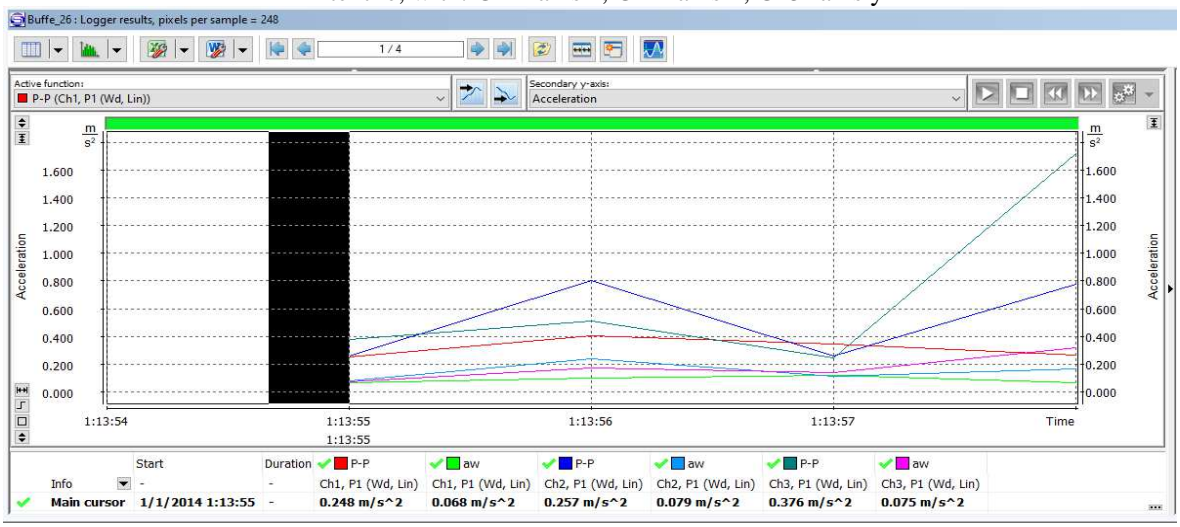

Fig. 19. The representation of the measurement on the "male" operator left foot, above the ankle, without textile, with: Ch1- axis z; Ch2- axis x; Ch3- axis y

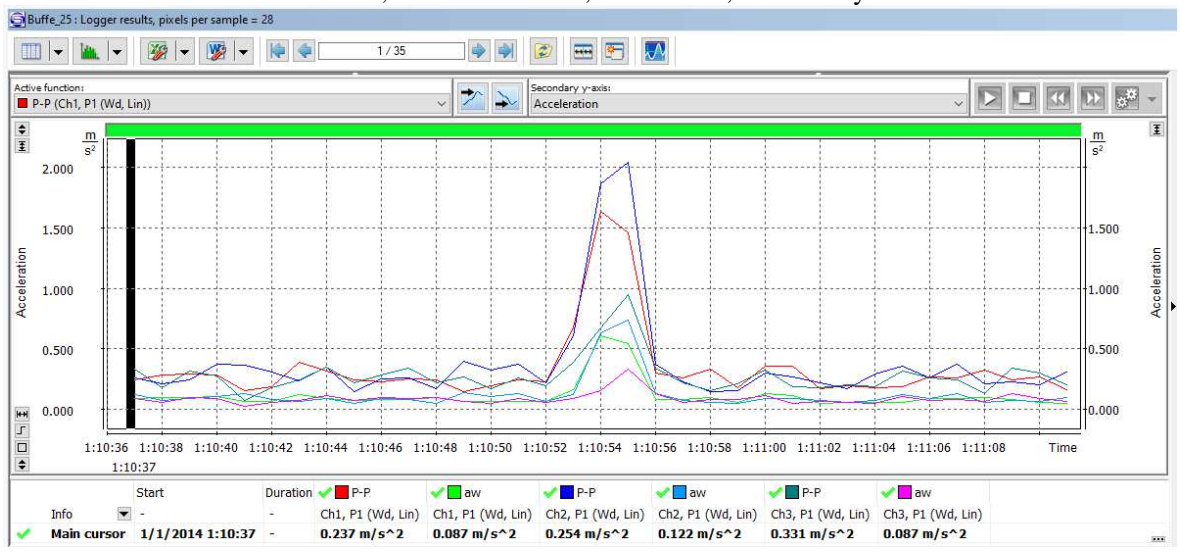

Fig. 20. The representation of the measurement on the "male" operator left foot, above the ankle, with textile, and: Ch1- axis z; Ch2- axis x; Ch3- axis y

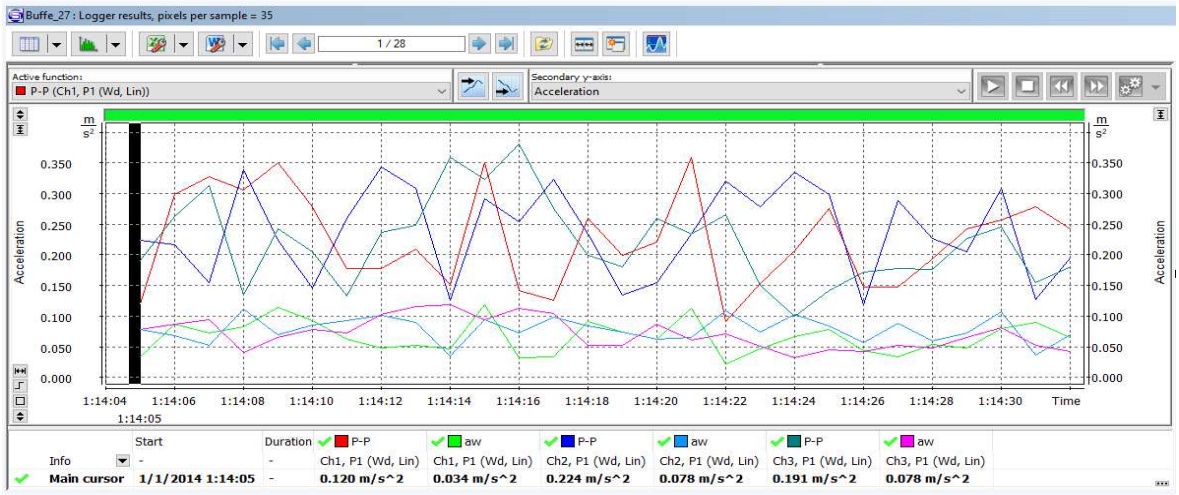

Fig. 21. The representation of the measurement on the "male" operator left/right foot, below the knee, without textile, with: Ch1- axis z; Ch2- axis x; Ch3- axis y

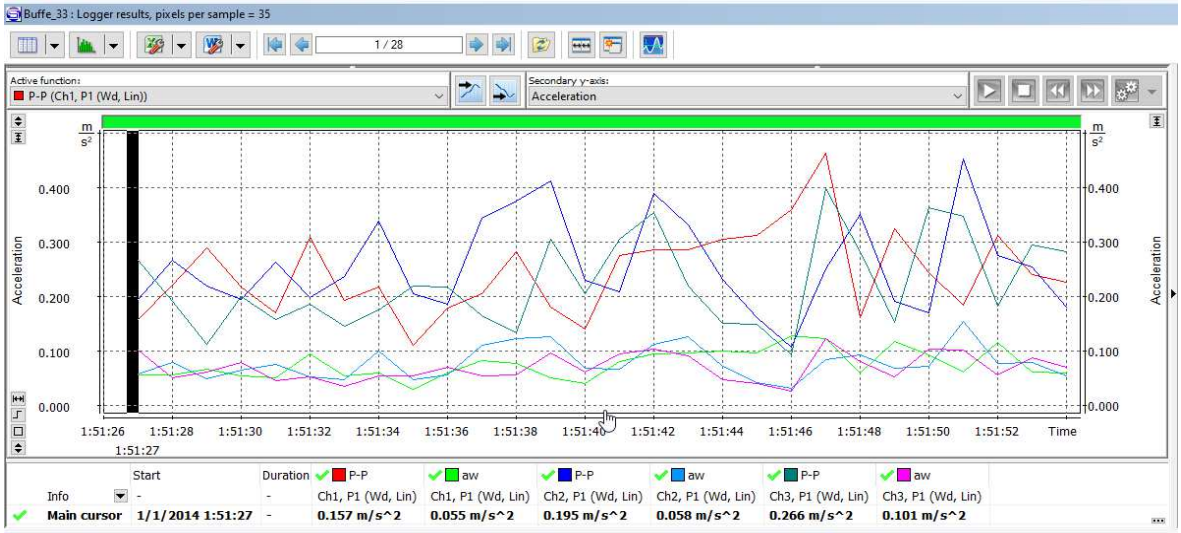

Fig. 22. The representation of the measurement on the "male" operator left/right foot, above the knee, without textile, with: Ch1- axis z; Ch2- axis x; Ch3- axis y

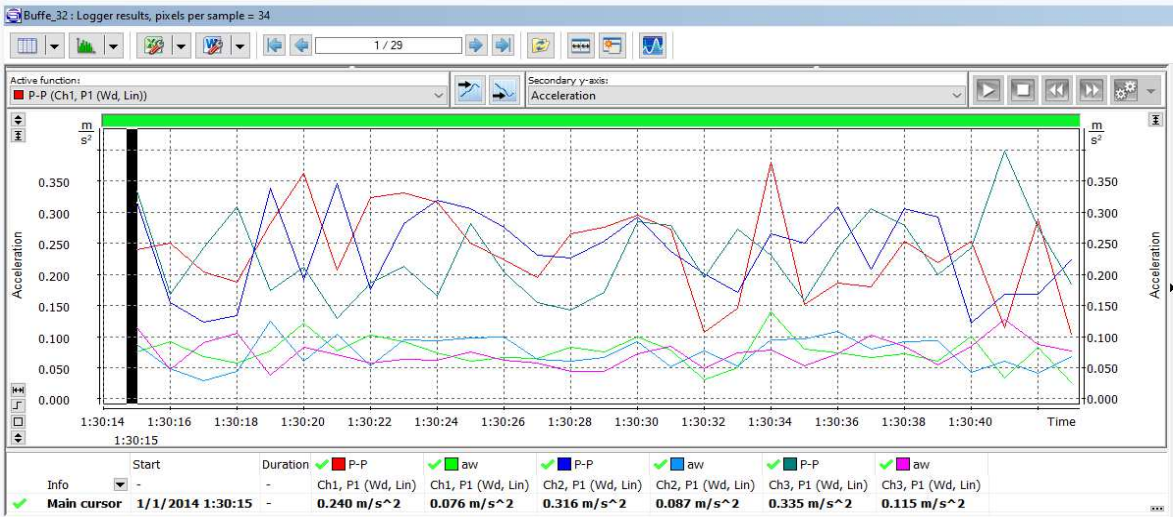

Fig. 23. The representation of the measurement on the "male" operator left/right foot, on the thigh, with textile, with: Ch1- axis z; Ch2- axis x; Ch3- axis y

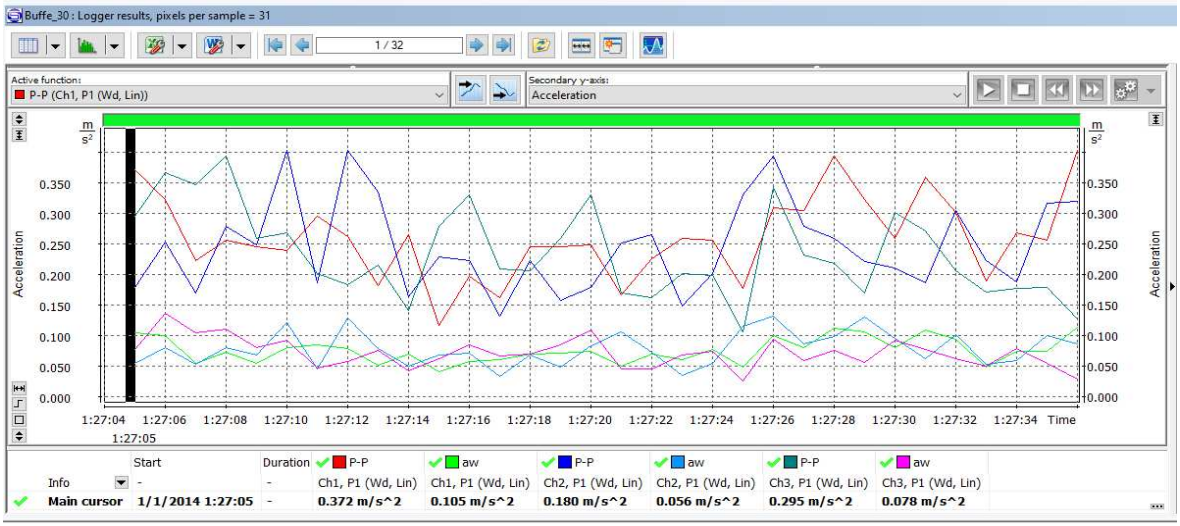

Fig. 24. The representation of the measurement on the "male" operator, on the abdomen, with textile, with: Ch1- axis z; Ch2- axis x; Ch3- axis y

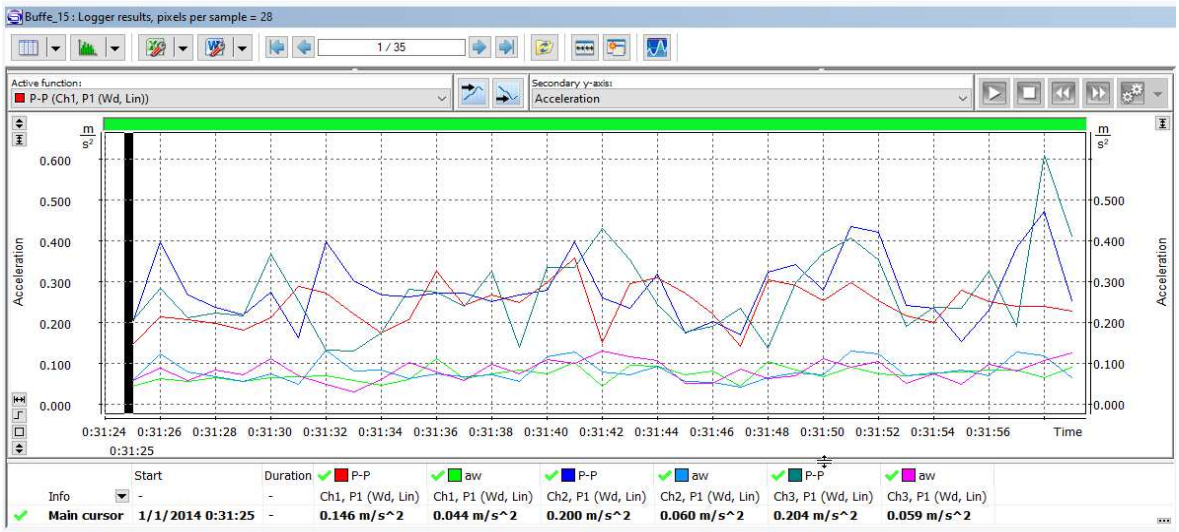

Fig. 25. The representation of the measurement on the "male" operator, on the abdomen, without textile, with: Ch1- axis z; Ch2- axis x; Ch3- axis y

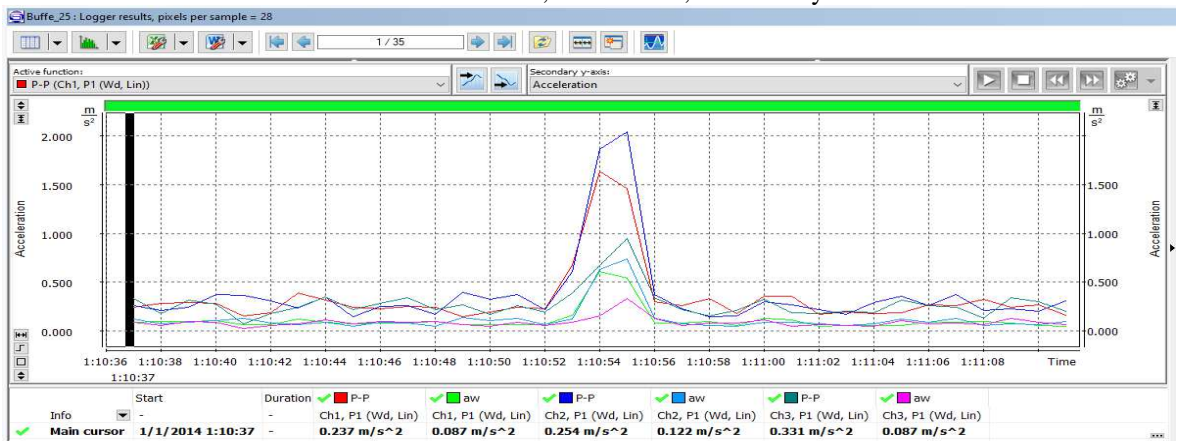

Fig. 26. The representation of the measurement on the "male" operator
right foot, above the ankle, with textile, and: Ch1- axis z; Ch2- axis x; Ch3- axis y

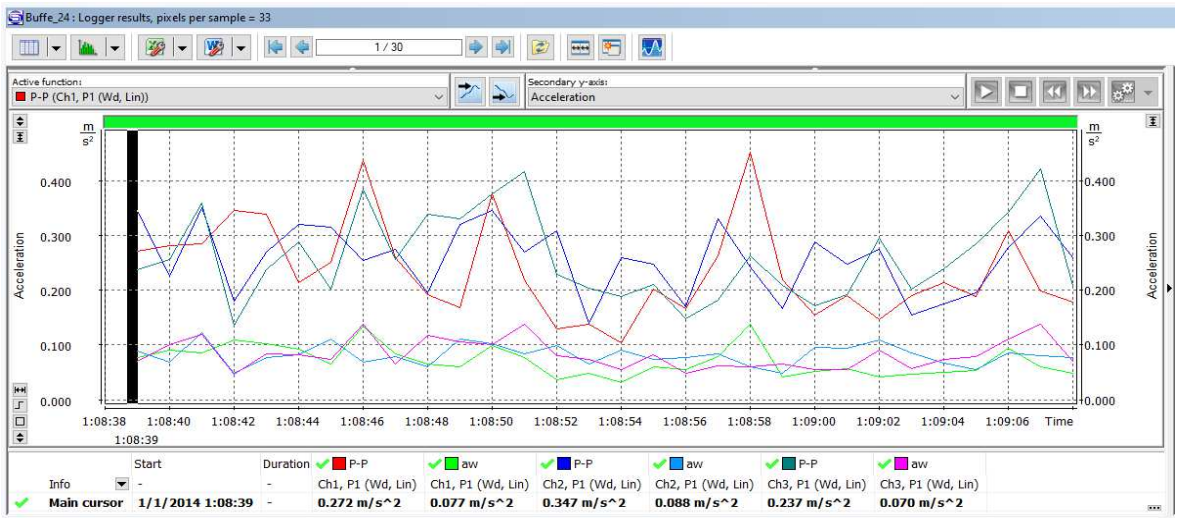

Fig. 27. The representation of the measurement on the "male" operator right foot, above the ankle, without textile, and: Ch1- axis z; Ch2- axis x; Ch3- axis y

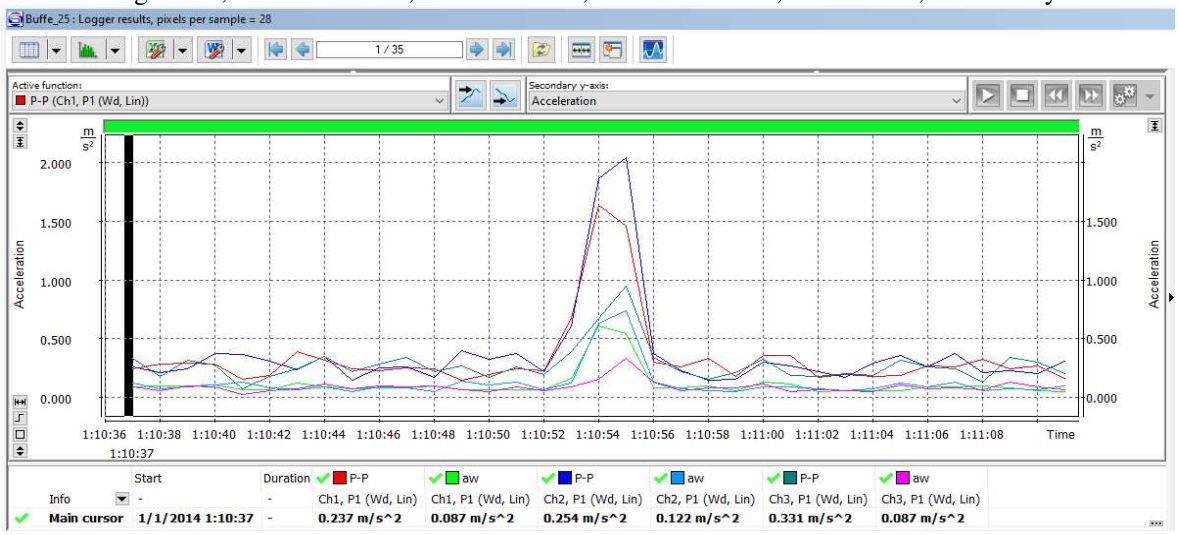

Fig. 28. The representation of the measurement on the "male" operator right foot, below the ankle, with textile, and: Ch1- axis z; Ch2- axis x; Ch3- axis y

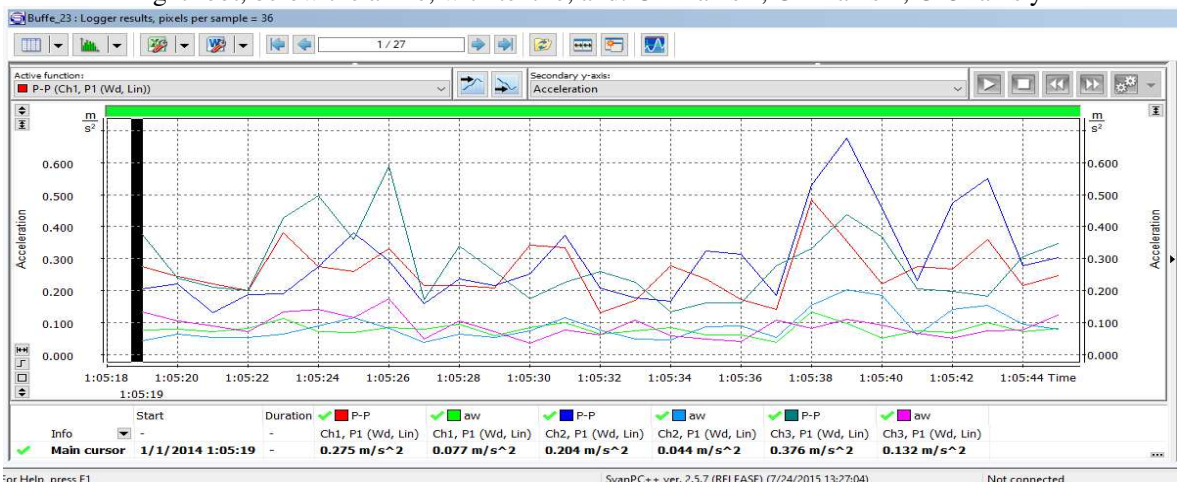

Fig. 29. The representation of the measurement on the "male" operator right foot, below the ankle, without textile, and: Ch1- axis z; Ch2- axis x; Ch3- axis y

The study corresponding to this work refers to the vertical transmission of vibrations through the operator, from the soles of the feet, through both feet, to the abdomen, which is the part that sums up / cumulates the vibrations transmitted through both feet. The "male" operator is considered right-handed, so the mechanical characteristics are different for the left leg than for the right leg.

5. CONCLUSIONS

This paper studies the action of vibrations, which act on the “male” operator, who serves a machine tool, with numerical control during the production process.

The study is carried out in several stages:

1. The mechanical vibrations, produced by the machine-tool, with numerical control, act on the "male" operator through both legs, when he is in front of the machine's inspection door and supervises the production process.
2. The study, through vibration measurements on the material system assimilated to the operator's feet, which serves the machine tool, is drawn up in sequence: foot, ankle, calf, knee, femur, hip.
3. The upper part of the body sums up the vibrations transmitted through the legs; the entrance being made in the abdomen.
4. The abdomen together with the upper part of the body is considered to form a rigid solid, which reacts to the vibrations transmitted.
5. The vibrations measured on the abdomen are higher if the accelerometer is positioned directly on the skin, compared to the situation in which the accelerometer is fixed on a textile tissue on the abdomen. So, the operator must be able to use protective equipment when supervising the machine tool.
6. The accelerations recorded sequentially on the different parts of the legs of the "male" operator have values recorded in the order of 10^{-1} m/s^2 on any of the axes of orientation per operator.
7. On the same side of the legs (body) the accelerometer placed directly on the skin recorded higher values than when it is portioned in the same place, but with intermediate fabric. Therefore, the 'male' operator must be able to wear a protective suit and operate the machine tool in shoes.
8. There were no different values of the accelerations transmitted on the two legs, so some graphic representations specify the position of the recorded part, on both legs: left / right.
9. The paper contributes to the study of vibrations acting on the operator, who serves a numerically controlled machine tool, without causing health damage to the human body during processing.

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Studiu prin masuratori ale actiunii vibrațiilor mecanice produse de o mașină-unealtă FANUC asupra unui operator uman “barbat”

Rezumat*: Lucrarea este continuarea fireasca a studierii actiunii vibratiilor asupra unui operator, ce deserveste o masina-unelta FANUC la mersul in gol. In lucrare se efectueaza masuratori asupra operatorului la transmiterii vibratiilor de la masina-unealta prin picioarele operatorului ‘barbat”, pana la abdomen ce insumeaza vibratiile transmise prin ambele picioare. Se fac masuratori cu vibrometrul SVAN 958 ce transmite printr-un accelerometru triaxial vibratiile pe cele trei directii principale ale corpului. Prin aceste masuratori se cauta sa se dovedeasca faptul ca starea de sanatae a operatorului “barbat” un este afectata de expunerea la vibratiile produce masina-unealta.*
Cuvinte cheie: *masurarea vibratiilor, operator barbat, interpretarea rezultatelor, studiu comparativ cu literatura de specialitate.*

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