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DESIGN AND RESEARCH OF A NEW TYPE OF ANTI-VIBRATION GLOVES WITH THE USE OF DISTANCE KNITTED FABRICS

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ABSTRACT

The paper presents tests of vibration damping in anti-vibration gloves with knitted spacers. The research was carried out at the Lodz University of Technology, Faculty of Materials Technology and Textile Design. Measurements of the anti-vibration properties of the gloves were made on two types of vibration generating devices - a hammer drill and an orbital sander.

Two gloves with spacer knitted inserts with different physico-mechanical parameters and one standard available on the market were tested. The conducted research shows that all gloves have vibro-insulating properties to a different degree.

KEYWORDS

Vibrations, spacer, anti-vibration glove, OSH.

EFFECT OF VIBRATIONS ON THE HUMAN BODY

Mechanical vibrations are defined as low-frequency vibrations spreading in solid media and transmitted to the human body through a specific part of the human body in direct contact with the vibrating medium [1].

The long-term effect of vibrations on humans may have multiple consequences, even in the form of an occupational disease called vibration disease, which causes a number of extensive changes in the body. Symptoms accompanying exposure to vibrations include increased motor reaction time, increased visual reaction time, disturbances in coordination of movements, excessive fatigue and insomnia [2]. In a person exposed to vibration, mechanical injuries (damage to the flexible connections of organs) can occur in individual organs or parts of the body. When the vibration damping capacity of organs, muscles and other tissues, peritoneal fluid, and the air and gases in the organs is insufficient to ultimately suppress resonant vibrations in internal organs, mechanical injuries occur [3–5]. Examples of the frequency of bastards and the corresponding disease entities for selected occupational activities are presented in Table 1 [6].

The human body is often exposed to vibrations from power tools and industrial machinery, and from vehicles such as trains and cars. Such vibrations are transferred to the human body during direct contact with the machine [7].

Table 1. The type of disease depends on the frequency of vibrations.

Activity	Disease	Frequency[Hz]
Operator of a manual mechanical tool, e.g. a hammer drill	Osteoarticular changes	10 – 130
Operator of the machine for whipping the ground	Abnormalities in the circulatory system	above 30
Operator of an orbital sander	Disorders in the muscular system	50
Air hammer operator	Paroxysmal finger skin whitening	above 30
Helicopter pilot	Weakness of vision, blurred	18
Machine operator for excavation and drilling	Angioneurotic problems Raynaud syndrome Keratosis of the skin Sensation problem	40 – 300

There are vibrations that are transmitted:

- through the lower limbs, back or pelvis - called general vibrations,
- through the upper limbs - called local vibrations.

The effects of whole-body vibration can cause back pain, sciatica, digestive disorders, urogenital problems, and hearing damage. Long-term exposure to hand-transmitted vibrations creates the risk of hand vibration syndrome, a well-known example of which is the white vibrating finger. Therefore, it is very important to measure and reduce vibrations at the workplace. Mechanical vibrations are common in various areas of human activity, especially professional, and are classified as harmful physical factors of the work environment. Most of all, drivers, tram drivers, train drivers, operators of soil compaction machines, construction and road machines are exposed to mechanical vibrations with a general effect on the body.

MATERIALS AND METHODS

Vibrations should be prevented, first of all, by constructing and using such tools, which do not generate vibrations with parameters exceeding the permissible standards, or by equipping the manual handles of these machines with shock-absorbing elements [4,8]. Currently, anti-vibration seat cushions and gloves made of damping materials such as polymer foams, rubbers, gels and air bubbles are used to reduce exposure to vibration. However, these materials, despite their advantages, cause problems with recycling [9]. Therefore, it is desirable to develop breathable and recyclable materials with good vibration isolation. An alternative to the typical upholstery materials used for seats can be 3D distance knitted fabrics (Fig. 1), as vibro-isolating inserts.

A spacer knitted fabric made in accordance with the guidelines was used [10]. The knitted fabric structure is shown in Figure 1, and the basic physical parameters of the component yarns are shown in Table 2.

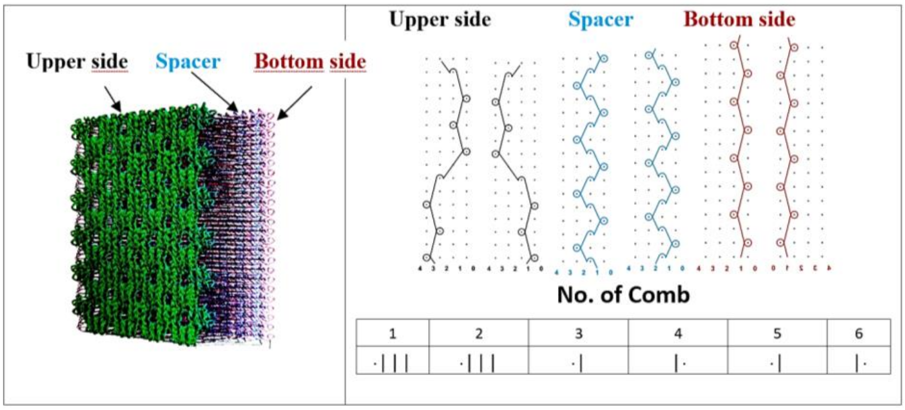

Figure 1. Scheme of the structure of 3D knitted fabric; upper outer layer of spacer knit; fasteners; bottom layer of spacer knit.

Table 2. The linear mass of component monofilaments yarns of spacer knitted fabrics corresponding with Figure 3.

Yarn no.	Yarn 1	Yarn 2	Yarn 3	Yarn 4	Yarn 5	Yarn 6
linear mass	tex	tex	tex	tex	tex	tex
	111	111	50	50	111	111

Gloves prototypes were made. The diagram of the arrangement of individual layers is shown in Fig. 2.

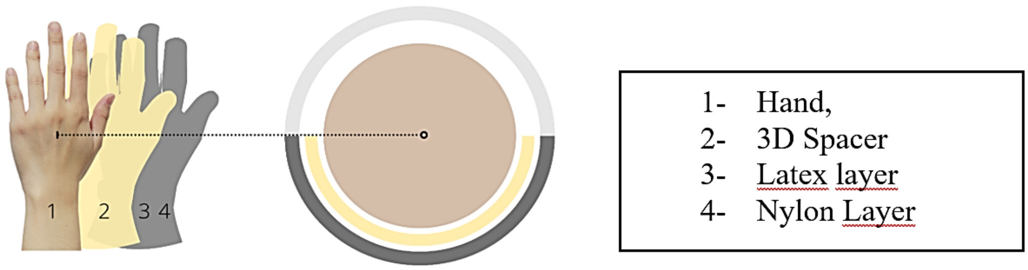

Figure 2. The layout diagram in the prototype of an anti-vibration glove with a spacer knitted fabric insert.

METHODOLOGY AND CONDUCTED RESEARCH

For the tests, a laboratory stand was constructed (Fig. 3) by simulating the work of an operator of a manual mechanical tool, with the use of a Metabo KHE 2444 hammer drill, a Metabo FSR 200 Intec orbital sander and a VM-54 Rion meter with a PV 62 Rion vibration sensor, which enables the measurement of vibration acceleration in three axes.

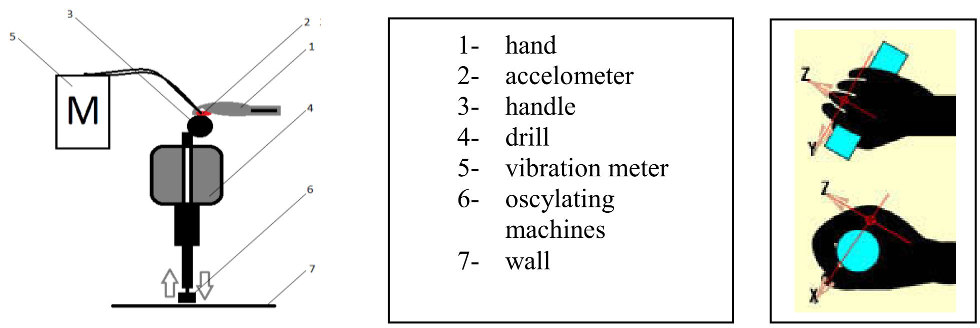

Figure 3. Scheme of the measuring stand; Coordinate systems used to measure hand vibration (ISO 5348).

The tests were carried out for prototype gloves with a knitted vibro-insulating insert and commercial antivibration gloves in accordance with the [11] standard, where the RMS values of vibration acceleration of the sensor on the handle of the tool were measured in three different axes.

Four people participated in the tests, taking 3 measurements for each variant within 1 minute. Measurements were also made using an anti-vibration glove available on the market. All variants of measurements are described below:

- Measurement without the use of an anti-vibration glove;
- Measured using a standard commercially available anti-vibration glove;
- Measurement using a prototype anti-vibration glove with spacer knit materials.

RESULTS AND DISCUSSION

The measurement results of acceleration in three directions x,y,z, are presented in Table 3.

Table 3. Measurement acceleration in three directions x,y,z.

	X RMS , m/s^2	Y RMS , m/s^2	Z RMS , m/s^2
Without anti-vibration gloves	0.263	0.111	0.324
Comercial anti-vibration gloves	0.258	0.084	0.336
Prototype anti-vibration gloves	0.291	0.086	0.308

To assess the damping quality, a dimensionless SEAT index (Seat Effective Amplitude Transmissibility) was proposed and defined as the ratio of the weighted vibration acceleration determined at the station (without damping inserts) to the weighted vibration acceleration determined at the station with the use of knitted damping inserts (Table 4).

SEAT = ARMS/ ARMS, D [1]

where: SEAT - effectiveness of protection indicator, ARMS - the effective value of weighted vibration acceleration without the suppression (damping inserts), ARMS, D - the effective value of weighted vibration acceleration with the suppressing (damping inserts) characteristic.

Table 4. Calculated Seat coefficient in three directions x,y,z.

	SEAT, x	SEAT, y	SEAT, z
Commercial anti-vibration gloves	1.020	1.317	0.962
Prototype anti-vibration gloves	0.905	1.293	1.049

CONCLUSION

The paper presents the research and construction of prototype anti-vibration gloves. The selected material for the construction of the damping system is a spacer 3D material. A very important factor, from the structure of the ant vibration gloves point of view, is the choice of a proper knitted material with the best possible damping properties. The selected material had a very good SEAT vibration damping coefficient of 2.3. Connectors in the 3D material play the role of flat springs with a linear characteristic (dependence of the elastic force on the deflection of the spring and the equilibrium position).The authors analyzed the the SEAT vibroinsulation coefficient measurement in three axes x,y,z for prototype antivibation gloves and commercial one. The test was done according to the ISO standard. Damping vibration properties in all x, y and z directions is similar, which confirms the possibility of using 3D inserts in the construction of anti-vibration gloves. The condition is that the appropriate 3D material is selected.

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