STUDYING THE WORKING CONDITIONS OF WORKERS IN COTTON TEXTILE PRODUCTION

ИЗУЧЕНИЕ УСЛОВИЯ ТРУДА РАБОЧИХ ХЛОПКО-ТЕКСТИЛЬНОГО ПРОИЗВОДСТВА

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Аннотация. Внедрением хлопко-текстильного производство вопросы охраны труда и техники безопасности приобретает все большее значение в научном и практическом решении. Обеспечение работа способности рабочего персонала хлопко-текстильного производство зависит во многом от факторов как, условия труда, квалификации рабочего персонала, спецодежды и др.

Abstrct. With the introduction of cotton textile production, occupational health and safety issues are becoming increasingly important in scientific and practical solutions. Ensuring the work ability of working personnel in cotton-textile production depends largely on factors such as working conditions, qualifications of working personnel, workwear, etc.

Ключевые слова: Производство, тепло, влажность, условия труда, квалификация рабочего персонала, спецодежда, охрана труда, меры безопасности.

Keywords: Labor protection, safety measures, production, heat, moisture, working conditions, qualifications of working personnel, overalls.

With the introduction of cotton textile production, issues of occupational health and safety at work are becoming increasingly important in scientific and practical solutions. The preservation of the ability of cotton textile production workers to depend on factors such as working conditions, worker qualifications, work clothes, etc. [1-4].

The paper considers the issue of the influence of the totality of these factors on the worker engaged in physical labor. In this case, you can provide that, the body of the worker includes the skin, muscles and solid bone. To resolve the issue of heat and moisture from the body of the worker and penetration into workwear, Darcy's law describes as a heterogeneous material [5-14] Fig. 1.

The equation of motion of such a system can be written in the form (1).

$$G_n \frac{\partial 2\, u}{\partial x2} = \rho_n \frac{\partial^2}{\partial t^2} \qquad (n=1,2,3\ldots) \qquad (1)$$

where, $G_n = \lambda_n + 2\mu_n$

$\lambda_1 = \lambda_b$, $\mu_1 = \mu_b$ – Lame's working body parameters,

$\lambda_2 = \lambda_c$, $\mu_2 = \mu_c$ – Lame workwear options,

$\rho_1 = \rho_b$, $\rho_2 = \rho_c$ – the specific gravity of the body of the worker and workwear.

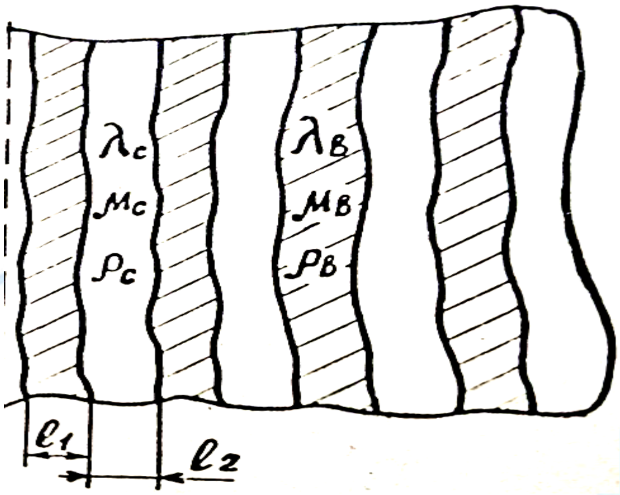

Fig. 1. A model for calculating the release of a gas-liquid medium from a worker's body and penetration into clothing.

The condition for the periodicity of movements and stresses:

$$U_1(x,t)\,/_{\,x=l1} = U_2(x,t)\,/_{\,x=-l2}, \qquad (2)$$

$$G_1(x,t)\,/_{\,x=l1} = G_2(x,t)\,/_{\,x=-l2},$$

The continuity of Ui and G at X = 0 gives

$$U_1(x,t)\,/_{\,x=0} = U_2(x,t)\,/_{\,x=0}, \qquad (3)$$

$$G_1(x,t)\,/_{\,x=0} = G_2(x,t)\,/_{\,x=0},$$

The solution to problem (1) and (2) can be written as:

$$U(x,t) = U_n(x)\exp[\,i(\omega t) + k x)], \qquad (4)$$

where, ω is the circular frequency, k is the wave number.

The wave number can be expressed from the following relationships:

$$\cos(\omega l/c) = \cos\lambda_{1-x}\sin\lambda_1\sin\lambda_2, \qquad (5)$$

where, $\lambda_i = \frac{w \cdot \ln}{C_n}$, $x = \frac{P_1 G_1 + P_2 G_2}{\sqrt[2]{P_1 \cdot P_2 \cdot G_1 \cdot G_2}}$ (6)

Substituting the value of λ in the dependence (5) we obtain:

$$\mathrm{Cos}\, kl = \cos\frac{wl_1}{C_1}\cos\frac{wl_2}{C_2} - x\sin\frac{wl_1}{C_1}\, \sin\frac{wl_2}{C_2}\,, \qquad (7)$$

where, $C_1 = C_B$, $C_2 = C_C$, - the speed of propagation of waves in the body of the worker and overalls.

Thus, the relationship between the speed of the wave through the body of the worker and overalls is established. From equation (7) it follows that X≥ 1.

Now we consider the case when the direction of movement of the heat wave is the body of the worker and work clothes, i.e. parallel to the location of the layer. The coordinate system for this case is shown in Fig. 2.

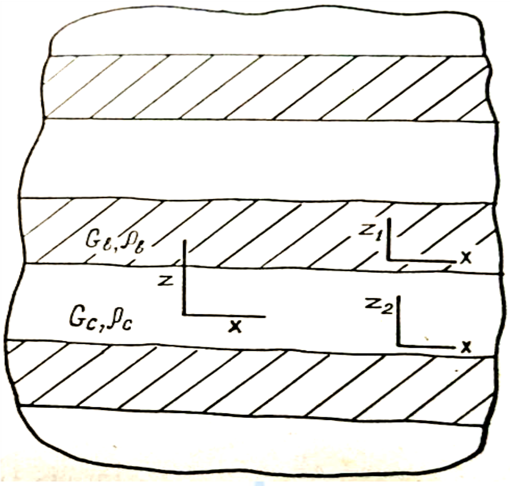

Fig. 2. A model for calculating heat release from a worker’s body and movement through clothing.

We use the Helmholtz decomposition to move a wave in a medium

$$U = \nabla U + \nabla \mathrm{x} \varphi \qquad (8)$$

where, ∇ is the gradient operator.

We write the equations of motion of the heat wave in three versions:

1.Horizontally moving the wave,

2.Vertically moving the wave,

3.Longitudinal wave movement.

For all cases, the equations of motion of the wave must be satisfied if the scalar and vector potentials obey the condition:

$$\nabla^2\varphi = \rho/(\lambda+2\mu)\varphi \qquad (9)$$

$$\nabla^2 \varphi=\rho/\mu\ \varphi$$

Now consider horizontally polarized shear waves. Let Uy be the only nonzero component of displacement.

Then Uy = Uy (x, z, t) and we assume that φ = 0 in equation (9) φz is the only nonzero component.

$$\nabla^2 U_y = \frac{\rho}{\mu} \cdot U_y \qquad (10)$$

The solution of equation (10) looks like this:

$$U_y^{(n)} = [A_n \cdot sin\text{ђ}_n \cdot z_n + B_n cos\text{ђ}_n \cdot z_n] \exp[i\ k\ (x + v \cdot t) \qquad (11)$$

where, $\text{ђ}_n^2 = k_n^2 - k^2$; n=1,2…;

$$k_n = \omega/v_n$$

In the case of symmetric motion, the requirement of periodicity is heat mixing

$$\frac{U_y^1}{z_1} = l_{\frac{1}{2}} = \frac{U_y^2}{z_2} = -l_{2/2} \qquad (12)$$

Then equation (11) for the symmetric movement of heat into the body of the worker and overalls looks like:

$$\mu_1\left(\frac{k_1^2}{k^2} - 1\right)^{1/2} tg\,\frac{\text{ђ}_1 \cdot l_1}{2} + \mu_2\left(\frac{k_2^2}{k^2} - 1\right)^{1/2} tg\,\frac{\text{ђ}_2 \cdot l_2}{2} = 0 \qquad (13)$$

Similarly, for antisymmetric terms, it was found that

$$\mu_2\left(\frac{k_1^2}{k^2} - 1\right)^{1/2} tg\,\frac{\text{ђ}_1 \cdot l_1}{2} + \mu_1\left(\frac{k_1^2}{k^2} - 1\right)^{1/2} tg\,\frac{\text{ђ}_2 \cdot l_2}{2} = 0 \qquad (14)$$

Using the relation ω = k · υ from equations (13) and (14), we can find the rate of heat generation from the frequency of the work of the worker.

Now we turn to the consideration of longitudinally and vertically polarized heat shifts.

We write the components of the displacement in the form:

$$U_x = U_x(x;z;t); U_y = 0, U_z = U_z(x;z;t) \tag{15}$$

The scalar potential φ (x; z) in equations (8) has the components Ux and Uz, and the vector component φ_y (x; z) in φ.

From the first expression according to equation (9) it follows that

$$\nabla^2 U_x = \frac{\rho}{2\mu+\lambda} U_x; \quad \nabla^2 U_z = \frac{\rho}{2\mu+\lambda} U_x; \tag{16}$$

From the first expression according to equation (9) it follows that

$$\nabla^2 U_x = \frac{\rho}{\mu} U_x; \ \nabla^2 U_z = \frac{\rho}{\mu} U_z; \tag{17}$$

The equation of heat motion in a two-phase layer, in this case, the body of the worker and overalls look like this:

$$U_{1z} = [C_1 \cdot \cos\beta_1 \left(z - \frac{l_1}{2}\right) + D_1 \sin\beta_1 (z - \frac{l_1}{2})]\exp[ik(x + \vartheta t)] \tag{18}$$

$$U_{2z} = [C_2 \cdot \cos\beta_2 \left(z + \frac{l_1}{2}\right) + D_2 \sin\beta_2 (z + \frac{l_2}{2})]\exp[ik(x + \vartheta t)]$$

where, $\beta_n^2 = \omega^2/(\mu\ n/p) - k^2$ (19)

$$U_{1x} = [A; \cdot \cos\mathfrak{h}_1 \left(z - \frac{l_1}{2}\right) + B_1 \sin\mathfrak{h}_1 (z - \frac{l_1}{2})] \exp[ik(x + \vartheta t)]$$

$$U_{2x} = [A_x \cdot \cos\mathfrak{h}_2 \left(z + \frac{l_2}{2}\right) + B_2 \sin\mathfrak{h}_2 (z + \frac{l_2}{2})]\exp[ik(x + \vartheta t)] \tag{20}$$

where, $\mathfrak{h}_n^2 = \left[\frac{w^2}{\frac{\lambda_n + 2\mu_n}{\mathcal{P}}}\right] - k^2$ (21)

U_{1z} and U_{2z} are determined in two layers of the form of the equation under study

$$\frac{\partial \cup x}{\partial \times} + \frac{\partial \cup z}{\partial z} = 0 \qquad (22)$$

Combine the results obtained for the two types of waves.

The unknown amplitudes of the total wave motion are eight constants A_1, A_2, B_1, B_2, C_1, C_2, D_1, D_2.

The conditions from the boundary have the form at Z = 0

$$\cup_{1x} = \cup_{2x}\ ;\ \cup_{1z} = \cup_{2z}\ ;\ \sigma_{1x} = \sigma_{2x}\ ;\ \sigma_{1zx} = \sigma_{2zx} \qquad (23)$$

The frequency of heat transfer across the body of the worker and work clothes is expressed as

$$U_{1x}/_{z=l_1} = U_{2x}/_{z=-l_2};\ U_{1z}/_{z=l_1} = U_{2z}/_{z=-l_2}$$

$$(24)$$

$$\sigma_{1x}/_{z=l_1} = \sigma_{2x}/_{z=-l_2};\ U_{1zx}/_{z=l_1} = U_{2zx}/_{z=-l_2}$$

Conditions (23) and (24) together form a system of eight homogeneous equations with respect to eight unknown constants. This system is naturally divided into two systems associated with the longitudinal movement of heat through the body of the worker and workwear. For example, to write the equation of motion of a longitudinal wave, $B_1 = B_2 = C_1 = C_2 = 0$.

Consider the terms stored in the equations in the form:

$$U_{1x} \longrightarrow D_1 \sin\left(z - \frac{l_1}{2}\right)$$

Then the final equation of motion through the layer of the body of the worker and work clothes in the longitudinal direction is:

$$4(\mu_1 - \mu_2)K_1 \cdot K_2 + \omega^2 P_1 \left[\frac{\omega^2 P_1}{k^2} - 4(\mu_1 - \mu_2)\right] \cdot K_2 t_g \frac{\beta_1 l_1}{2} + \omega^2 P_2 \left[\frac{\omega^2 P_2}{k^2} + 4(\mu_1 - \mu_2)\right] \cdot K_1 t_g \frac{\beta_2 l_2}{2} - \frac{\omega^4 P_1 \cdot P_2}{k^2} x [L_1 t_g \frac{\beta_2 l_2}{2} + L_2 t_g \frac{\beta_1 l_1}{2}] = 0, \qquad (25)$$

where, $K_1 = k^2 t_g \frac{\beta_1 l_1}{2} + \mathfrak{h}_1 \beta_1 t_g \frac{h_1 \cdot l_1}{2};$

$$K_2 = k^2 t_g \frac{\beta_2 l_2}{2} + \mathfrak{h}_2 \beta_2 t_g \frac{h_2 \cdot l_2}{2};$$

$$L_1 = k^2 t_g \frac{\beta_1 l_1}{2} + \mathfrak{h}_1 \beta_1 t_g \frac{h_1 \cdot l_1}{2};$$

$$L_2 = k^2 t_g \frac{\beta_2 l_2}{2} + \mathfrak{h}_2 \beta_2 t_g \frac{h_2 \cdot l_2}{2}; \qquad (26)$$

For transversal heat transfer

$$А_1 = А_2 = Д_1 = Д_2 = 0$$

Then the final equation for the motion of heat looks like this:

$$\frac{\mu_2-\beta_2}{\mu_1-\beta_1}\left(tg^2\frac{\beta_1-l_1}{2} + tg^2\frac{\beta_2-l_2}{2}\right) + \left[1 + \frac{\mu_2-\beta_2}{\mu_1-\beta_2}\right] tg\frac{\beta_1-l_1}{2} \cdot tg\frac{\beta_2-l_2}{2} = 0 \quad (27)$$

An analysis of various cases of the release of a heat wave through the body of a worker and the penetration of workwear shows that there is a close relationship between speed and wavelength and frequency.

For example, as can be seen from equation (12), a decrease in the wave velocity through the layer of the body of the worker and overalls occurs with an increase in the frequency in the low-frequency region. This means that in order to intensify the propagation of the heat wave into the body of the worker and penetration into work clothes, cyclic loads in a certain frequency value are necessary.

The solution of the frequency equation (4) on a computer showed that with dimensionless materialized data l_1=0,5; l_2=0,5; C_1=1,0; C_2=2,0; ρ_1=1,0; ρ_2=2,0; G_1=1,0; G_2=20,0; and the smallest attenuation of oscillations is achieved at a frequency range of ω = 2.99 and 8.99, 26.99 s^{-1}.

The results obtained are of interest from the point of view of the need for the release of heat and a liquid medium from the body of the worker and penetration into work clothes. However, the system under consideration implies a physical change in the pore volume in the body of the worker with the cyclical nature of his work.

The source of wave movements can be: air flow, the cyclical movement of the worker, clothing fluctuations, etc. Therefore, the conservation of energy to perform certain work is obvious, it is possible the release of heat and moisture from the body of the worker and penetration into overalls.

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