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CALCULATION OF SHAFTS BENDING VIBRATIONS

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ABSTRACT

This article deals with the problem of calculating the vibration of the details of high-speed non-woven fabric making machines. ***Methods:*** *The brushes of the needle mechanisms of weaving machines provide direct needle movement. In the current machines, the needle rods are fixed to the beam. The brushes, in turn, are mounted on the shaft, which leads to the mechanism.* ***Conclusion:*** *When designing textile, light and cotton industrial machines, the dimensions of the parts and the materials for their manufacture should be chosen in such a way that the parts do not wear out and residual deformation under the influence of maximum stresses under normal operating conditions.*

KEYWORDS: *Nonwoven Fabric, Machine, Strength, Stiffness, Shaft, Bending, Krylov's Function, Deformation, Boundary Conditions, Shear Force, Bending Moment, Resonance, Frequency.*

INTRODUCTION

Modern nonwovens are evolving at a high speed. This, in turn, takes into account not only the strength of machine parts, but also the deformation and stresses caused by vibration.

The inherent danger of vibratory loads is that they can cause sudden wear failure even without significant plastic deformation of the part, which is known to be able to detect and prevent hazards based on plastic deformation.

If the design of the mechanism or part is designed without vibration, their resonant event will occur due to an increase in the amplitude of vibrations, as their specific frequency will overlap with the frequency of the external variable force. As a result, parts or mechanisms of the machine break, causing the technological process to stop. One of the most important details of virginity indicators is the variety of shafts. The required height of the shafts is determined by the operating conditions of the gears, pulleys and bearings connected to it. In this case, the limit slope and slope angles of the shaft are determined by such parameters as the allowable slope angles in the bearings, the degree of uneven distribution of loads on the gear teeth, the magnitude of lateral radial cracks in the gear joints.

Methods

The brushes of the needle mechanisms of weaving machines provide direct needle movement. In the current machines, the needle rods are fixed to the beam. The brushes, in turn, are mounted on the shaft, which leads to the mechanism.

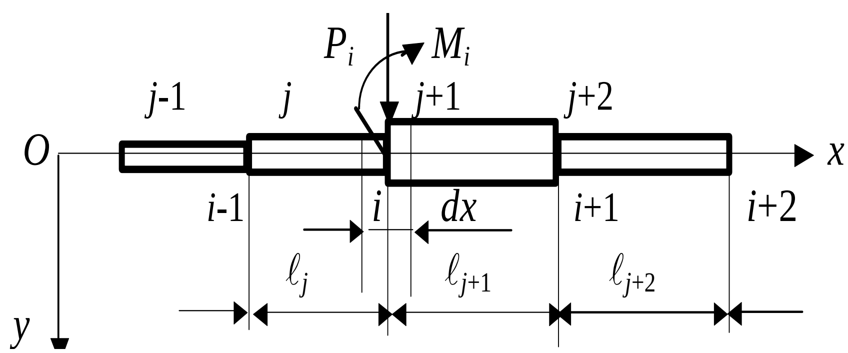

Figure 1

Let us consider the equilibrium of the infinitesimal element dx of the shaft. We enter characters:

EI - is the bending stiffness of the shaft section;

q - is the longitudinal mass of the shaft;

η - shaft section sliding.

here: Q - is the shear force;

M - is the bending moment;

$qdx\frac{\partial^2 \eta}{\partial t^2}$ - inertial force of the element. 62 / 5000

We get the sum of the projections of the forces on the vertical axis:

$$\frac{\partial Q}{\partial x} + q\frac{\partial^2 \eta}{\partial t^2} = 0 \qquad (1).$$

The sum of the moments of these forces is:

$$\frac{\partial M}{\partial x} - Q = 0 \qquad (2).$$

In Equation (2) we take the product of x and enter $\frac{\partial M}{\partial x}$ from Equation (1):

$$\frac{\partial^2 M}{\partial x^2} + q\frac{\partial^2 \eta}{\partial t^2} = 0 \qquad (3).$$

As you know

$$M = EI\frac{\partial^2 \eta}{\partial x^2} \qquad (4).$$

We obtain the product of (4) twice for x:

$$\frac{\partial^2 M}{\partial x^2} = \frac{\partial^2}{\partial x^2}(EI\frac{\partial^2 \eta}{\partial x^2}) \qquad (5).$$

Now let's add (5) to (3):

$$\frac{\partial^2}{\partial x^2}(EI\frac{\partial^2 \eta}{\partial x^2}) + q\frac{\partial^2 \eta}{\partial t^2} = 0 \qquad (6).$$

If the cross section of the shaft does not change:

$$EI\frac{\partial^2 \eta}{\partial x^2} + q\frac{\partial^2 \eta}{\partial t^2} = 0 \qquad (7).$$

We accept the solution of equation (7) as follows:

$$\eta = V\sin(pt + \alpha) \qquad (8),$$

Where: V - vibration amplitude;

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r - is the specific oscillation frequency of the shaft. Now if we add (8) to (7) we come to a simple differential equation:

$$EI\frac{\partial^2 V}{\partial x^2} - p^2 qV = 0 \qquad (9).$$

We enter the symbol:

$$\alpha^4 = P^2\frac{q}{EI} \qquad (10).$$

In this case, Equation (9) is represented by:

$$\frac{\partial^2 V}{\partial x^2} - \alpha^4 V = 0 \qquad (11).$$

(7.11) General solution of equation:

$$V = AS(\alpha x) + BT(\alpha x) + CU(\alpha x) + D\upsilon(\alpha x) \qquad (12),$$

where: A, B, C, D are constant coefficients; are determined from the boundary conditions:

$$\left.\begin{aligned} S(\alpha x) &= \frac{1}{2}(ch\,\alpha x + \cos\alpha x) \\ T(\alpha x) &= \frac{1}{2}(sh\,\alpha x + \sin\alpha x) \\ U(\alpha x) &= \frac{1}{2}(ch\,\alpha x - \cos\alpha x) \\ \upsilon(\alpha x) &= \frac{1}{2}(sh\,\alpha x - \sin\alpha x) \end{aligned}\right\} \qquad (13)$$

where: $S(\alpha x), T(\alpha x), U(\alpha x), \upsilon(\alpha x) -$ Functions of AN Krylov.

Derivatives of Krylov functions:

$$\left.\begin{aligned} &S'(\alpha x) = \alpha\upsilon(\alpha x); S''(\alpha x) = \alpha^2 U(\alpha x); S''' = \alpha^3 T(\alpha x) \\ &T'(\alpha x) = \alpha S(\alpha x); T''(\alpha x) = \alpha^2 \upsilon(\alpha x); T'''(\alpha x) = \alpha^3 U(\alpha x) \\ &U'(\alpha x) = \alpha T(\alpha x); U''(\alpha x) = \alpha^2 S(\alpha x); U'''(\alpha x) = \alpha^3 \upsilon(\alpha x) \\ &\upsilon'(\alpha x) = \alpha U(\alpha x); \upsilon''(\alpha x) = \alpha^2 T(\alpha x); \upsilon''' = \alpha^3 S(\alpha x) \end{aligned}\right\} \quad (14).$$

If x = 0 then S (0) = 1; T(0) = U(0) = υ (0) = 0.

There are constant coefficients:

$$V_x = 0 = A; \left(\frac{dV}{dx}\right)_{x=0} = \alpha B; \left(\frac{d^2V}{dx^2}\right)_{x=0} = \alpha^2 C; \left(\frac{d^3V}{dx^3}\right)_{x=0} = \alpha^3 D \quad (15).$$

Boundary conditions

$$V_x = 0; \left(\frac{dV}{dx}\right)_{x=0} = 0; \left(\frac{d^2V}{dx^2}\right)_{x=0} = 0; \left(\frac{d^3V}{dx^3}\right)_{x=0} = 0$$

From the conditions x = 0 A = V = 0

$$V = CU(\alpha x) + D\upsilon(\alpha x),$$

conditions $x = \ell$

$$\left.\begin{aligned} &C\alpha^2 S(\alpha\ell) + D\alpha^2 T(\alpha\ell) = 0 \\ &C\alpha^3 \upsilon(\alpha\ell) + D\alpha^3 S(\alpha\ell) = 0 \end{aligned}\right\} \quad (16).$$

(16) so that the solution is not ambiguous

$$\begin{vmatrix} S(\alpha\ell) & T(\alpha\ell) \\ \upsilon(\alpha\ell) & S(\alpha\ell) \end{vmatrix} = 0 \quad (17)$$

or

$$S^2(\alpha\ell) - T(\alpha\ell)\upsilon(\alpha\ell) = 0 \quad (18).$$

By entering S, T, and functions (18): $\cos\alpha\ell = -\dfrac{1}{ch\alpha\ell}$ (19).

Equation (19) is the transcendental equation. The solution is obtained graphically.

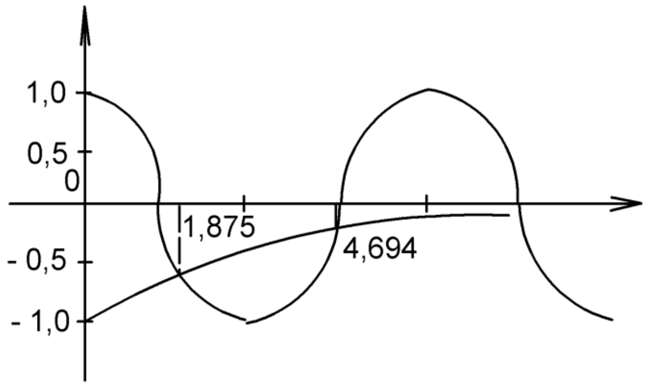

Figure 2

That is $(\alpha\ell)_1 = 1{,}875;\ (\alpha\ell)_2 = 4{,}694$

and n > 2 $(\alpha\ell)_n \cong \dfrac{2n-1}{2}\pi$

$$P = (\alpha\ell)^2 \sqrt{\frac{EI}{q\ell^4}}$$

$$P_1 = 3{,}52\sqrt{\frac{EI}{q\ell^4}};\ P_2 = 22{,}0\sqrt{\frac{EI}{q\ell^4}}$$

And n > 2 $P_n = \dfrac{(2n-1)^2}{4}\pi^2\sqrt{\dfrac{EI}{q\ell^4}}$

$$V_n = C\left[U(\alpha_n\ell) - \frac{S(\alpha_n\ell)}{T(\alpha_n\ell)}\upsilon(\alpha_n\ell)\right]$$

CONCLUSION

When designing textile, light and cotton industrial machines, the dimensions of the parts and the materials for their manufacture should be chosen in such a way that the parts do not wear out and residual deformation under the influence of maximum stresses under normal operating conditions. To do this, the designer must determine by calculating the stress in the main parts of the machine, or at least in the parts that operate under the maximum load.

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