Mechanism and Machine Theory 82 (2014) 1–16

Contents lists available at ScienceDirect

Mechanism and Machine Theory

journal homepage: www.elsevier.com/locate/mechmt

Spatial deformations in the transmissions of certain classes of woodworking machines

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ARTICLE INFO

Article history:
Received 24 March 2014
Received in revised form 17 June 2014
Accepted 22 July 2014
Available online 14 August 2014

Keywords:
Shaft
Support
Reaction
Deformation
Elastic line

ABSTRACT

In this paper the spatial deformations in the transmissions of big band saw machines are analyzed. These deformations are caused by static and dynamic loads that arise during the working process. The influence of the static loads is studied as a result of expressions describing the differential equations of the elastic lines. These equations are used in order to determine the deformations of the main shaft. The paper also contains diagrams showing the type of the elastic lines in two mutually perpendicular planes. The influence of the dynamic loads is also analyzed. The transverse vibrations of the shaft are studied allowing expressions that describe the deformations of the shaft in two mutually perpendicular planes to be obtained. Expressions describing the deformations depending on two parameters are received. These expressions would allow solving various optimization problems that are associated with the safe and reliable operation of the machines.

1. Introduction

The band saws form certain classes of woodworking machines, which are widely used in the woodworking industry. They can be classified into different groups. The big band saw machines cause particular interest. They are used for cutting logs, prisms, beams, planks, etc. The cutting process is performed by a band-saw blade and two leading wheels. These wheels are very large. Their diameters can reach up to 3200 mm. They are usually manufactured with inaccuracies. The centre of mass of the disk is displaced from the axis of rotation of the distance e (eccentricity) and the axis of the disk makes an angle α with the axis of rotation. Static and dynamic loads arise during the operating mode. These loads give rise to static and dynamic reactions at the supports. The main shaft of the band saw machine is deformed as a result of these forces and moments. The static deformations are caused by external loads that act in two mutually perpendicular planes. The purpose of this study is analyzing these deformations. We want to get the equations of the elastic lines for the different parts of the shaft. These lines should be continuous in themselves. We can plot the diagrams that show the static deformations of the shaft in the two planes. These diagrams show the cross sections where the deformations are the greatest. These deformations should be less than the admissible deformations.

Another objective of this study is analyzing the deformations of the shaft caused by the dynamic loads. These deformations depend on the mass and the kinematic characteristics of the rotating disk, as well as by the inaccuracies in its manufacture (the eccentricity e and the angle α). We can draw the diagrams showing the deformations of the shaft for different cross-sections. They depend on the time t and change according to harmonic laws. We also can draw the surfaces showing the deformations of the main shaft in two mutually perpendicular planes. These deformations are a function of two parameters, the time t and the coordinate z, which takes into account the length of the shaft. Obtained analytical expressions and diagrams allow an optimal choice of the operating parameters. Thus the normal operation of the band saw machines can be guaranteed.

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http://dx.doi.org/10.1016/j.mechmachtheory.2014.07.010
0094-114X/

2. Expose

2.1. Principle scheme of the band saw machine

The scheme of the band saw machine is shown in Fig. 1 [1–6]. The following symbols are defined: 1, 2, 5, 6 — belt pulleys, E — electric motor, 3 and 4 — leading wheels, A — band-saw blade, and 7 and 8 — chain-wheels.

2.2. Transmission dynamic model

The dynamic model is shown in Fig. 2 [7,8]. This model is used to solve the problems.

We choose the following coordinate systems [7,8]: Fixed coordinate system O_3xyz, moving coordinate system $O_3x_1y_1z_1$, which moves along with the driving wheel. In the initial moment ($\varphi = 0$) the axes of the two coordinate systems coincide. Coordinate system $C_3x'y'z'$, beginning at the centre of mass C_3. Its axes are parallel to the axes of the moving coordinate system. We use a fourth coordinate system $C_3\xi\eta\varsigma$. The axes of this coordinate system are principal axes of inertia of the disk. The centre of mass C_3 of the driving wheel 3 is displaced from the axis of rotation $AB \equiv z \equiv z_1$ of an eccentricity $e = O_3C_3$ and describes a circle with a radius $\rho_{C3} = e\cos\alpha$ around this axis. The axis $C_3\varsigma$ of the disk makes an angle α with the axis of rotation. The driving wheel 3 and the belt pulleys 2 and 5 perform rotation with constant angular velocity ω about an axis AB and describe an angle $\varphi = \omega t$.

2.3. Main shaft — static and dynamic loads

The overall reactions in the main shaft bearings are sums of static and dynamic components caused by external loads and the kinematic and mass characteristics of the rotating body. Expressions for the overall reactions, as well as the static and dynamic forces and moments are obtained by the author [7,8]. They can be written in the following form:

$$\begin{aligned} A_x &= A_x^{st} + A_x^d, \quad A_y = A_y^{st} + A_y^d, \\ B_x &= B_x^{st} + B_x^d, \quad B_y = B_y^{st} + B_y^d. \end{aligned} \tag{1}$$

2.4. Deformation of the main shaft due to static loads

We consider the static loads on main shaft in two mutually perpendicular planes — O_{3xz} and O_{3yz}. These loads are shown in Fig. 3.

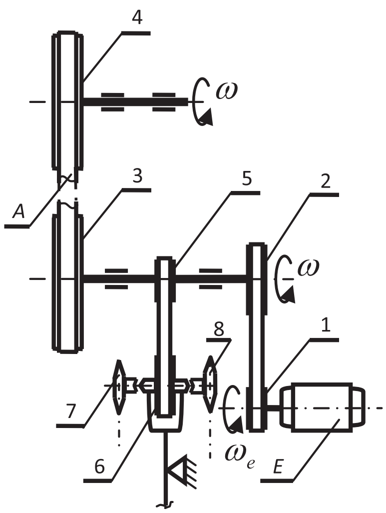

Fig. 1. Principle scheme of band saw.