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Calculation of loads during operation of tower cranes

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ABSTRACT

In order to simplify calculations of structures under dynamic loads in operation, a diagram is given according to which the rest of all elements of the mechanism are brought to its first element (engine). This allows you to greatly simplify the equation for solving and determine the values of the elasticity or stiffness factors of the elements.

Keywords: crane, mechanism, indicator, element, load, moment.

1. INTRODUCTION

Loading and unloading works are an integral part of the technological process of construction. Cranes of different types are mainly used to perform these works [1 - 3].

Tower cranes are the most used among construction cranes that solve the issue of mechanization of loading and unloading operations in construction. But their accidents account for 40% of the total number of accidents of boom cranes.

The fall of tower cranes occurs both in our country and abroad, even with all the rules of operation and safety requirements. The development and further improvement of domestic tower cranes in our time is impossible without studying the loads that act on the crane during dynamic loads.

To ensure trouble-free operation and increase the reliability of cranes in the calculations of structures and components of their working equipment, it is important to take into account dynamic loads that are several times higher than static loads. Elements of dynamic loads in the crane suspension are its elastic components (flexible traction organs) - ropes.

Cranes as lifting machines are widely used in construction for the movement of goods and installation of structures.

The scientific and technological progress taking place in all countries of the world strongly requires an increase in productivity, load lifting and an increase in the working speeds of lifting machines, which leads to a reduction in transients, that is, to a decrease in the time of acceleration and braking of machines.

All this leads to an increase in the intensity of the load-lifting machine, causes additional forces on all elements of the machine, received in the technique the name – external dynamic loads [4].

On the other hand, any machine has structural features of its kinematics, deformability of flexible elements - all this in the process of the machine causes oscillatory processes in the suspension of the load and refers to the phenomena - the internal dynamics of the machine.

2. RELEVANCE OF RESEARCH

For safe operation of cranes, it is important to take into account the value of all types of dynamic loads operating when calculating their structures and selecting component elements [5, 6].

Therefore, at present, the actual problem is the development of a technique for determining dynamic loads in the mechanism of lifting the cargo of cranes in case of lack of movement in order to simplify complex calculations.

3. PRESENTATION OF THE MAIN MATERIAL

For calculations of dynamic loads, general dependencies are given in the literature to determine inertial loads on crane structural elements, which do not take into account the deviation of the load under the action of centrifugal forces and the influence of the position of the resultant inertia forces on the boom axis, which does not coincide with the center of mass of the boom. Taking into account these factors makes it possible to more accurately determine the inertial loads on the boom and make calculations for the strength of the boom elements and the constituent mechanisms of its drive.

The impact of inertial loads of the load and its deviation on the crane boom has already been considered, but the features of determining inertial loads on the elements of the crane lifting mechanism under dynamic loads have not been considered.

To determine the inertia forces acting on the crane boom, it is necessary to draw up its design load scheme. Usually, in calculations, the design scheme is taken in the form of a rectangular beam with a distributed load on its surface, and the total inertia force is calculated through the integral of the elementary inertia force. But this does not take into account the position of the resultant forces of inertia on the axis of the boom, which does not coincide with the center of mass of the boom.

When computer simulations of loads in the metal structures of a long flexible boom, it is possible to detect an uneven distribution of force factors in the processes of boom movement, which can be explained by the inaccurate determination of the inertial components of the boom.

Elements of dynamic loads of the crane load lifting mechanism are its elastic components – ropes and shafts, which are deformed under the influence of loads. The value of this deformation of the elements is taken into account by the coefficients of elasticity or compliance with linear and steep or their inverse value – stiffness coefficients. These coefficients depend respectively on linear or angular strains.

Due to the fact that the lifting mechanism consists of a large number of elastic elements, the assembly and solution of equations for determining these coefficients is difficult. In order to simplify the equations and these calculations, the given calculation scheme according to which the remaining elements of the mechanism are brought to its first element (engine) is recommended. This allows you to greatly simplify the equation for solving and determine the values of the elasticity factors or stiffness of the elements of the dynamic loads of the crane lifting mechanism.

Therefore, it is necessary to develop a methodology for determining dynamic loads in the mechanism of lifting the crane load in case of non-stop movement with the use of the given design schemes in order to simplify complex calculations.

Any mechanism or any machine has elements or assemblies of massive or rigid bodies, which in the course of the transition process move as a whole. Such elements can be considered absolutely rigid bodies, and their entire mass can be concentrated at a point coinciding with the center of weight of this element or node.

Thus, the mechanism or machine consists of "point masses" which include: transported cargo, rotating parts of the engine, brake pulley, drum, gear wheels, etc. [7].

These "point masses" are connected by elastic elements – shafts, ropes and other elements that determine, mainly, the deformation of the mechanism. These elastic elements have a relatively small mass, compared to "point masses," so they can, in the first approximation, be considered massless or absolutely elastic elements.

The elastic elements of the machine under its load are appropriately deformed. The amount of this deformation of the element is taken into account by the coefficient of elasticity or compliance.

The coefficient of elasticity or compliance is defined as the ratio of the value of linear deformation or the angle of twist of this element to the value of the force or torque acting on it [8].

In practice, more often use the value of the inverse coefficient of elasticity, which is called the stiffness coefficient.

Thus, the design scheme can be represented by a number of "point masses" connected by weightless absolutely elastic bonds.

To illustrate the dynamic action of individual masses, depending on the task, they are led to some one elastic link located on one elastic link. Due to the fact that each mechanism has both rotating and progressively moving masses, two design drive schemes are possible.

If the drive is made to some shaft of the mechanism, then the given scheme of rotational motion is applied.

For such a scheme, external loads (torques), inertial forces (moments of inertia or flywheels), elasticity of kinematic elements (coefficients of torsion stiffness), backlash or clearances are specified.

If brought to the translational moving elastic element - rope, chain, rod, then the given scheme of translational stroke is applied.

For such a scheme, external loads (starting or moving forces of the engine, brake forces, supports of motion), inertial properties (masses), elastic kinematic elements (rigidity factors), backlash (linear gaps) are specified.

4. CONCLUSIONS

It follows from the analysis of data of calculation schemes that if we take into account all the elements of the machine in the design scheme, then the scheme is very difficult, and the definition of dynamic loads is an intractable task. Therefore, in order to study dynamic processes in a mechanism or machine, it is advisable to use the so-called given calculation schemes that reflect the actual operation of the mechanism or machine and allow non-difficult decisions to obtain and analyze dynamic loads.

In the future, it is necessary to develop programs to perform these calculations using computers.

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