Proceedings of the 3rd International Conference on Nonlinear Dynamics
ND-KhPI2010
September 21-24, 2010, Kharkov, Ukraine

INVESTIGATION OF FORCED VIBRATIONS OF TURBINE BLADES IN CONSIDERATION OF ROLLING CONTACT IN THE DETACHABLE SHROUD

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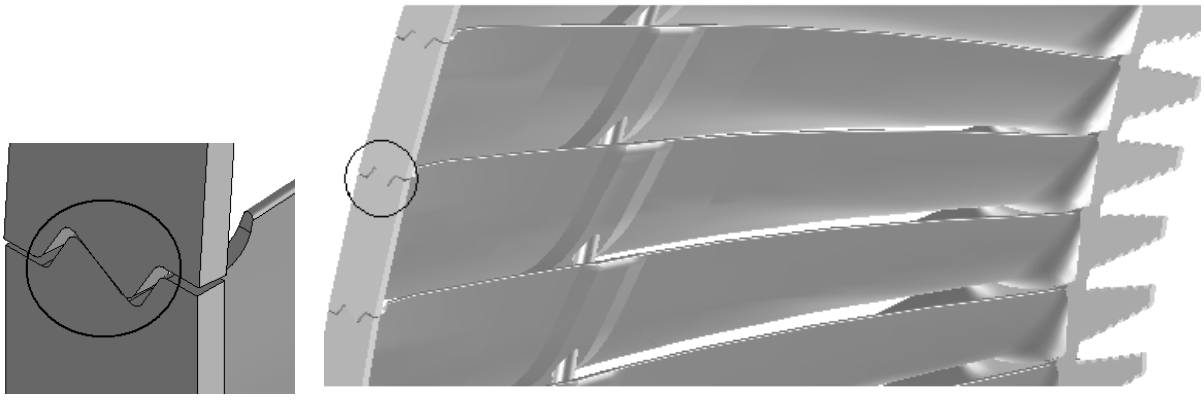
ABSTRACT

An original nonlinear discrete model of the 2 blade package which adequately describes kinematics of the dynamic contact interaction in the inter-blade detachable Z-like bandage is offered. The model via it small dimension could be efficiently used for detailed analysis its nonlinear behavior.

INTRODUCTION

An increase of the steam turbines power and demands of the magnification of their efficiency lead to the extension and complication of the turbines operating regimes on the one hand, and on the other hand lead to use new constructions of working bladings. First of all it is concerns with magnification of the length and the angle of pre-twisting of the blades of the last stages low-pressure cylinder.

The given work is devoted to the researching of the peculiarities of dynamic behaviour of the modern large length blades (Fig. 1). A shroud which has been represented as a detachable joint (Fig.1a) is used for securing the demanded strength and the technological characteristics.



a) *b)*

Fig. 1 Geometrical model of the blades

The initial mutual location of the contacted surfaces of the neighbour blades bandage parts has a capability of the dynamic modification due to bandage split character. This peculiarity brings into the system the structural nonlinearity which due to the smallness of studied vibrations could be also considered as the small one.

A direct numerical analysis of the nonlinear vibrations of the industrial scale bladed disk model concern with insurmountable computational difficulties. This defines a necessity of the construction an adequate small dimensional discrete model. The models of two levels are considered in the current work: detailed large dimension finite-element and small dimension discrete. Some numerical experiments have been carried out on the basis of the first model. The results are

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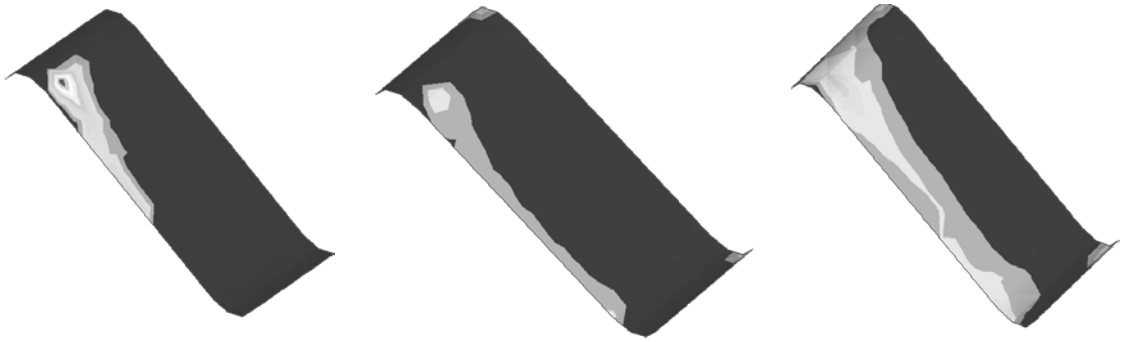
complicated in its understanding and are not enough for making any conclusions. But they let to define a type and character of nonlinearity of inter-blade conjunction (shroud). That gives a possibility to create correct but small dimension model which could be investigated via classical methods of nonlinear dynamics.

1. ANALISYS OF THE TYPE OF CONJUNCTION NONLINEARITY

The direct numerical experiments of blades vibrations for some turbine nominal operational regimes have been made on the basis of the first model [1,2]. The results of these researches have indirect confirmation at their comparison with natural experiment conducted by other authors on the similar type blades. The analysis of the blades dynamic behavior at numerical simulation has been shown, that the contact interaction has a rolling character alternately round of two positions (Fig. 2) [2].

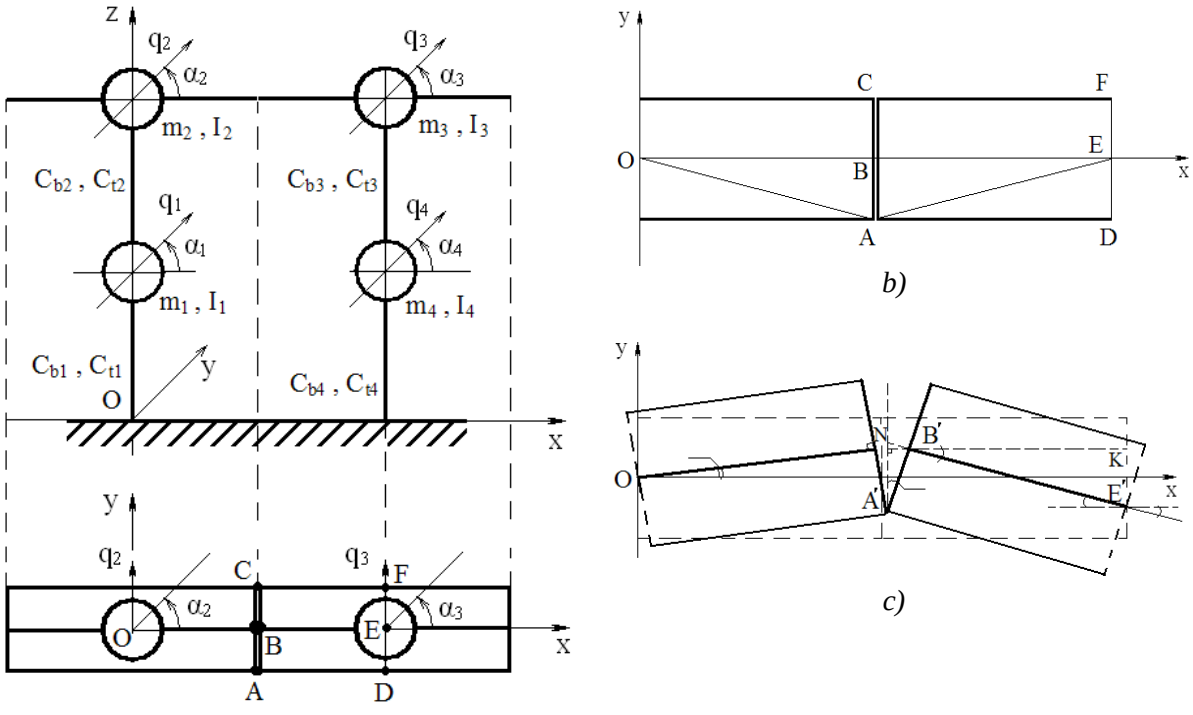


a) *b)* *c)*

Fig. 2 The type of contact interaction in the shroud

2. A CONSTRACTION OF THE DISCRETE MODEL

The second model which represents as a lumped parameters discrete model with the 8 degrees of freedom is developed for the analysis of the nonlinear dynamics of this system (Fig. 3a).



b)

c)

a)

Fig. 3 Discrete model of the 2 blades

The model contains a nonlinearity, which character is keeping with kinematics of the dynamic contact, defined on the first model in the bandage joint. In the fig.3b and fig.3c the kinematic of the dynamic inter-blade interaction is shown as a scheme.

Using the geometry of state fig.3b and deformed fig.3c relationships between displacement q_2, q_3 and angles α_2 and α_3:

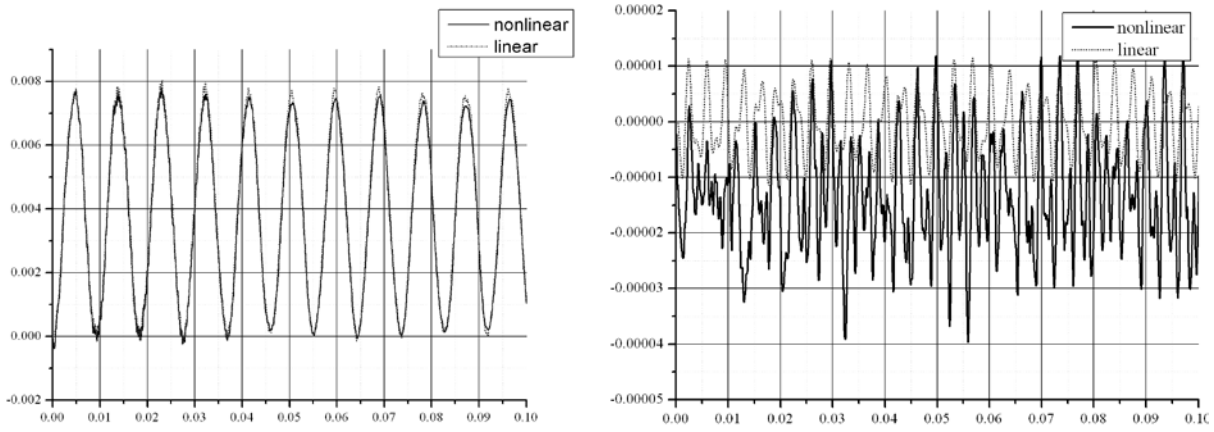
$$\Delta = q_2 - q_3,\ \Delta = d_1 - \alpha_2 \cdot l_1 + \sqrt{l_2^2 + d_1^2 - \left(d_1 \cdot \alpha_2 - l_2\right)^2}\ , \tag{1}$$

$$\alpha_3 = a_1 + \sqrt{1 + a_1^2 - \left(1 - a_1 \cdot \alpha_2\right)^2}\ ,\ \frac{d_1}{l_2} = a_1, \tag{2}$$

where *d* and *l* are half of bandage width and length.

Hereby the equations of motion of discrete nonlinear system consists from the two set of linear equations for 2-degrees-of-freedom banding and torsions vibrations which are got to be interrelated and nonlinear by the algebraic equations (1)-(2). So, the second model of the investigated system would be represented by the 6 coupled nonlinear equations.

Some results of the numerical solutions of this harmonically excited system are shown on the Fig.4. The results are very similar to results which were obtained in the work [3] on the base of precise FE 2-blade sector model. So, offered model could be efficiently used for detailed analysis.



a) *b)*

Fig. 4 Numerical calculations results

CONCLUSIONS

In the work it is offer and approved a new nonlinear discrete model of the 2 blade package which adequately describes kinematics of the dynamic contact interaction in the inter-blade detachable Z-like bandage. The model via it small dimension could be efficiently used for detailed analysis its nonlinear behavior.

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