DYNAMIC ANALYSIS AND VIBRATION CONTROL OF THE PLANAR BEAMS MOVING ALONG THE AXIAL DIRECTION

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Summary In this paper, a dynamic simulation method and vibration control technique are proposed for a flexible body moving along the axial direction, such as the plates or the wire rods in the mill. At first, a dynamic simulation model of the planar beams moving along the axial direction using FEM formulation is proposed. Next, a vibration control method using optimal damper-spring support system is proposed and the effect of this control is investigated by this simulation.

INTRODUCTION

Recently, for the purpose of investigating the vibration problem of wire or plate in a mill, dynamic analysis of flexible materials moving along the axial direction is required.

In the former studies, the strict solution of the moving beams under the fixed-fixed boundary condition was investigated[1][2]. Moreover, Stylianou[3] proposed the linear FEM method of moving beams. However, the beams are treated as a linear model in this study, so it has the problem of linearizing error or neglecting the stiffness change by the tension. Sugiyama[4] proposed a method in which the beam is treated as the connection of many small rigid bodies and springs. However, it has a problem in that the number of small bodies must be large to obtain the precise result.

Therefore, the nonlinear FEM method is adapted to the analysis of beams moving along the axial direction in this study. The flexible materials are treated as planar beams and the effect of movement along the axial direction and the effect of geometric nonlinearity are taken into account. The precision of the analysis is investigated by comparing this method and the strict solution. This calculation result indicates that the unstable phenomenon by divergence occurs when the moving velocity becomes large.

Next, a vibration control method is proposed for this vibration phenomenon. Stability of the system is examined for the damper-spring property at the beam support point, and the optimal damper-spring properties for stabilizing the system are obtained. Furthermore, it is shown that the outstanding vibration reduction effect is obtained by conducting the dynamic simulation proposed above.

DYNAMIC ANALYSIS OF THE PLANAR BEAMS MOVING ALONG THE AXIAL DIRCTION USING FINITE ELEMENT FORMULATION

This research examines the vibration of a flexible body moving along the axial direciton by modeling as a 2-dimensional beam moving along the axial direction using a finite element method shown in fig.1. In this method, the displacement vectors of the arbitrary point along the element are obtained in the local coordinates and transformed into the global coordinates. By differentiating this displacement vectors, the velocity vectors in the global coordinates are obtained, considering the effect of the movement along the axial direciton. Next, substituting this velocity vectors into the Lagrange's equation of motion, the equation of motion is obtained.

The calculation result shows that the cantilever beams are pulled into the fixed area with vibration and the cycle of vibration becomes shorter as the time increases, as shown in fig.2. For the purpose of investigating the accuracy of the analysis, the calculation result is compared with the result using the large displacement beam element in the former study. This result shows that this method can analyze the vibration problem of the beam pulled into the fixed area accurately and more effectively than the method of former study.

VIBRATION CONTROL METHOD FOR THE MOVING BEAM

Relation between the damper-spring property at the support point and the system stability

The vibration control technique for the cantilever beam moving along the axial direction is examined in this section.

In order to examine the effect of vibration control by the damper-spring at the support point of the cantilever beam, the system stability evaluation is carried out by the complex eigenvalue analysis. The non-dimensional parameters are employed to express the damper-spring property at the support point. The eigenvalue analyses are conducted using these parameters under the condition that the length of the cantilever beam is changed. The optimal parameters which make the damping ratios maximum are obtained from these analyses.

Evaluation of the vibration control method by using the finite element model

In this section the vibration control method for the cantilever moving beam is examined considering the results obtained in the previous section. The proposed vibration control system is shown in fig.3. From the examination in the previous section, the vibration control method proposed for the system to be stable requires that the damper- spring property at the support point is varied in proportion to the cantilever beam length.The vibration control effect is verified by using the finite element model proposed above. It is shown that the vibration control is conducted fairly and the beam is drawn without the vibration because the vibration energy is absorbed by the damper at the support point shown in fig.4.

CONCLUSION

In this paper, dynamic simulation method and vibration control technique are proposed for flexible body moving along the axial direction, such as the plates and the wire rods in the mill. In consequence the following conclusions are obtained.

(1) An FEM beam model that takes account of the movement of the axial direction and geometric nonlinearity is proposed.
(2) The optimal damper-spring property for controlling the cantilever beam vibration is obtained by examining the relation between damper-spring property at the support point and the system stability.
(3) A vibration control method is proposed and the effect of the control is verified by numerical simulation using the finite element model. Finally, it is verified that the vibration of the beam is reduced by the proposed vibration control method.

References

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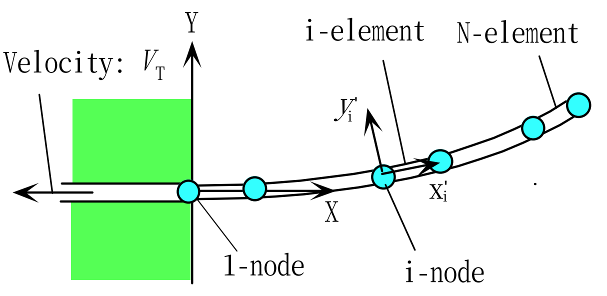

Fig.1 Plannar beam model moving along the axial direction using FEM formulation

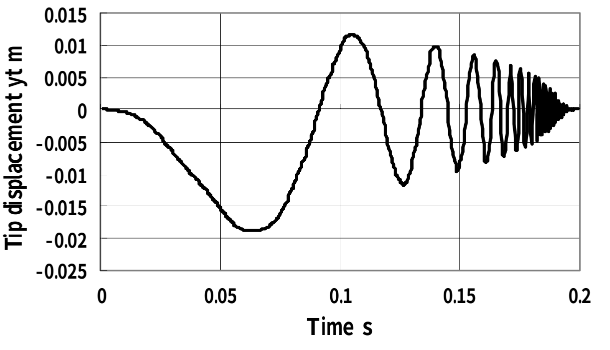

Fig.2 The tip displacement response of the moving beam

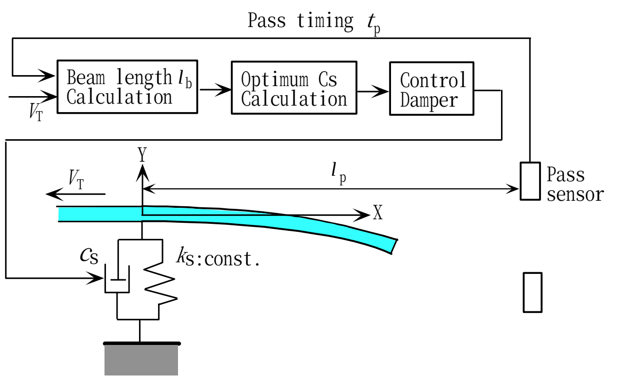

Fig.3 Vibration control system of the moving beam

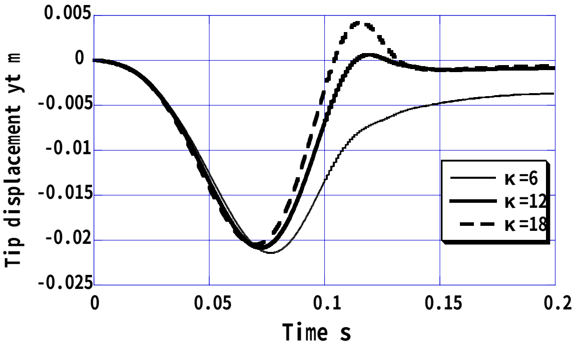

Fig.4 The tip displacement response of the moving beam with the vibration control