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論文 / 著書情報
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題目(和文)	柔軟旋回クレーンの動力学解析モデルと振動制御法の開発
Title(English)	Development of Dynamic Model and Vibration Control of Flexible Rotary Cranes
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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

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（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	Mechanical Engineering	系 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of (Engineering)
学生氏名： Student's Name	Chalermpong Kolawach		指導教員（主）： Academic Supervisor(main)	Yamaura Hiroshi
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

The vibration of the carrying object during the transporting operation is one of the major problems in the crane operation. To approach this problem, this thesis developed the dynamic model and the vibration control strategy of the rotary crane with flexible boom. The dynamic model was developed in order to efficiently simulate the motion of the crane to study the behavior of the mechanism. The vibration control strategy was developed to suppress the vibration of the hoisted load during the transporting operation of the crane.

The development of the dynamic model of the flexible rotary crane aimed to tackle the problem of the long calculation time. In the first section, the modeling of the hoisted rope was focused. The comparison between the modeling of the rope as the massless rigid component, the massless flexible component and the inertia included rope model was studied in order to find the optimal criteria for the rope's model. The inertia included rope model was developed, and its bending deformation during the crane's motion was investigated. The numerical simulation showed that the inertia included rope model illustrated the bending deformation of the rope during the crane operation. The magnitude of the bending deformation increased with the length of the rope. It was found that as the rope length increased, its natural frequency of the bending deformation modes decreased. Thus, the vibration from the other components in the crane structure could excite the bending vibration of the rope. However, this bending vibration was not strong enough to create the different trajectory of the hoisted load when comparing to the massless rope models under the chosen rope length. Additionally, the massless rigid rope and massless flexible rope also showed very similar trajectory of the hoisted load. Therefore, the rigid rope's model was considered as the optimal choice for the crane's dynamic model.

From the selected modeling criteria, the efficient dynamic model was then formulated. The relative coordinates system was chosen as the main formulation. Since the boom was modeled as a flexible body and the hoisted load was modeled as a point-mass, there was not enough coordinates to map between two bodies via constrain joint in the relative coordinates formulation. Therefore, the modeling of the flexible boom and the point-mass hoisted load by considering the hoisted load as the additional particle of the boom was proposed. Then, the short calculation time dynamic model was developed by applying the system-level model reduction of the adaptive modal integration (AMI). This development was aimed to solve the problem of the numerical stiffness in the dynamic model of the flexible structure, and the calculation cost of the inverse of inertia matrix. The AMI crane model was developed such that an arbitrary motion can be used. This was achieved by using the few numbers of the low frequency mode shapes at static condition to form the modal reduction matrix. When the modal matrix was formed from the static mode shape, it became the function of the crane's configuration, thus, the arbitrary driving velocity and acceleration can be used. Then, the calculation cost of the inverse inertia matrix was reduced by precalculate this matrix before the simulation and interpolated it during the simulation. In this thesis, the bilinear interpolation and the radial basis function were used for comparison. The efficiency of this reduced model was shown by comparing with the nonlinear model via numerical simulation. The comparison showed that the reduced model was able to give an accurate simulated motion under shorter calculation than the nonlinear model. In addition, the reduced model with the bilinear interpolation was the fastest model.

Then, the vibration control strategy for the rotary crane with the flexible boom was developed. This research proposed the vibration control model with the explicit consideration of the flexible boom. The vibration control model was designed by modeling the vibration of the boom tip as a simple mass-spring system. The vibrationless trajectory was designed by applying the optimal control theory on the proposed control model, where the optimal condition was determined via the trial calculation on the prior developed dynamic model. In this designed trajectory, the motion was divided into three periods: the acceleration period, the constant velocity period and, the deceleration period. The designed trajectory only calculated the acceleration function during the acceleration and deceleration periods. These functions were required to be calculated once. In this trajectory, the crane was moved during the constant velocity period with constant slewing velocity. Thus, the target angle of the slewing operation was adjustable by simply adjusting the duration of the constant velocity period without redesigning the acceleration. This was the advantage of this trajectory.

The performance of the proposed vibration control model was investigated by 1) conducting the numerical simulation on the crane model with the specification that mimics the real-size crane, 2) conducting the numerical simulation and experiment on the laboratory-size flexible crane. The effectiveness of the proposed flexible control model was shown by comparing its trajectory with the reference control model that did not consider the flexibility of the boom. The numerical simulation and the experiment showed that the effectiveness between the flexible control model and the rigid control model had similar performance when the crane was driven with low acceleration or long acceleration period. When the driving acceleration was increased due to the shorter acceleration time or increasing of the designated velocity, the proposed flexible control model showed smaller vibration amplitude of both boom tip and the hoisted load. These results have shown that the proposed vibration control model has the effective over the rigid boom control model because the proposed control model gave the crane potential to operate at higher acceleration which could improve the work efficiency.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
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