Stick-Slip Oscillation of Hydraulic Telescopic Boom

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In many dynamic systems, unwanted vibrations which may arise during operation of machines are costly in terms of reduction of performance and service life. Sometimes these risky oscillations endanger equipment and personnel. When hydraulic telescopic booms taken large mass are driven at slow speeds between the two pads, unstable oscillations occur through the stick-slip at the sliding parts and become more severe and saw-toothed.

This paper supposes few models for the telescopic boom in the multi-degree of freedom system, and attempts a theoretical approach for the numerical analysis in its stick-slip condition. It was verified that this theoretical approach has an effect on estimate of stick-slip in the one-degree as well as multi-degree of freedom system.

Keywords : Telescopic Booms, Stick-slip, Oscillation, Multi-degree of Freedom System

. INTRODUCTION

The relative motion on surfaces may cause some problems with heat, vibration, noise, and so on. Unwanted vibrations by friction, which may arise during the operation of machines, are costly in terms of reduction of performance and service life. Such vibrations are encountered, for instance, by the squealing of brakes, the creaking of hinges and the ringing of wine glasses. When a large mass is driven at slow speeds, these phenomena which may occur along slideways involve stick-slip.

Studies of stick-slip have progressed by many researchers such as Van De Velde, Takano, and so on, but all experiments to be carried out are only reached the level of basic model test. So, it is difficult to apply to the practical condition for developing machinery.

This paper supposes few models for the telescopic boom in the multi-degree of freedom system, and attempts a theoretical approach for the numerical analysis in its stick-slip condition.

2. STICK-SLIP ON AERIAL WORKING PLATFORM

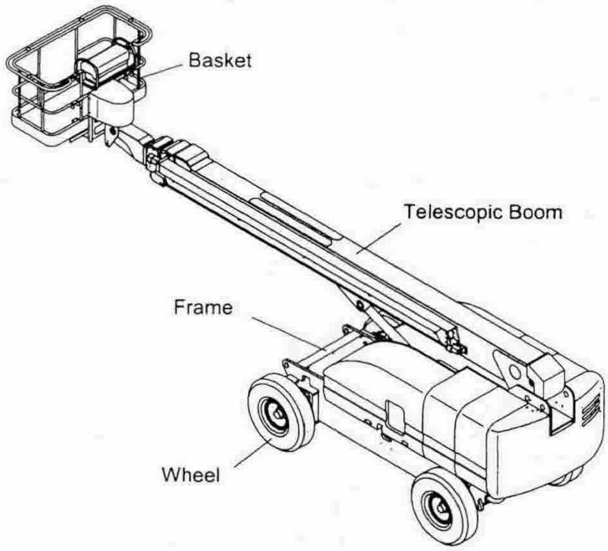

Fig. 1 Aerial working platform of telescopic type

The aerial working platform is shown in Fig.1. It has three motion axes, that is, telescoping, elevation and slewing, which are driven by electro-hydraulic actuators.

Generally the operation of the aerial working platform is difficult because of nonlinear characteristics of hydraulic actuators and its complicated mechanical structures.

Especially the telescopic boom operations involve stick-slip oscillations like slideways. Unwanted stick-slip oscillations on telescopic boom operations cannot achieve smooth sliding and many developers of that machine make a lot of effort to remove or reduce it.

The telescopic boom of Fig.2 consists of four booms with pads which reduces friction force in relative sliding motion. In this model, 2nd boom is driven by the electro-hydraulic cylinder. The chain connected by the roller and rods on each booms is extended 3rd and 4th boom

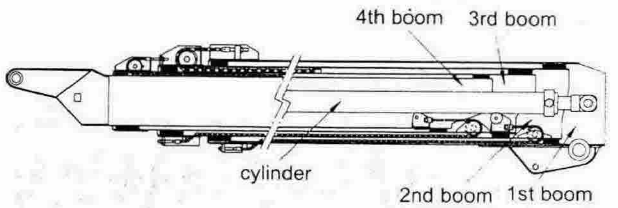

Fig. 2 Telescopic boom

3. NUMERICAL ANALYSIS

The system with stick-slip is said to be in a state of self-exited oscillation. In self-exited oscillations, the frequency is greatly influenced by the parameters of the system itself.

To solve this stick-slip oscillation it is appropriate that many systems ate non-linear and are represented by non-linear equations. Non-linear systems are often difficult to analyze and understand because of the absence of the superposition property.

The purpose of this study is to derive the numerical model of the telescopic boom in its stick-slip condition in the multi-degree of freedom system and to analyze the model used to 5th Runge-Kutta method.

3. THEORICAL RESULTS

In the stick-slip condition, the pressure variations and displacements of booms with time are shown Fig. 3. In here, Q is flow rate, μ_k is kinetic friction coefficient at start to moving, and β is stiffness of chain/stiffness of steel.

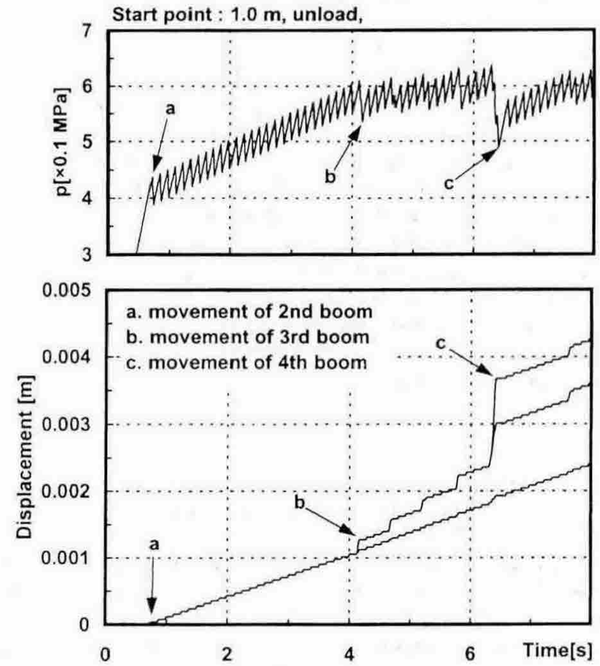

Fig. 3 Pressure variation and displacement of each boom during stick-slip
(Q=0.2 l/min, μ_k=0.28, β=0.05)

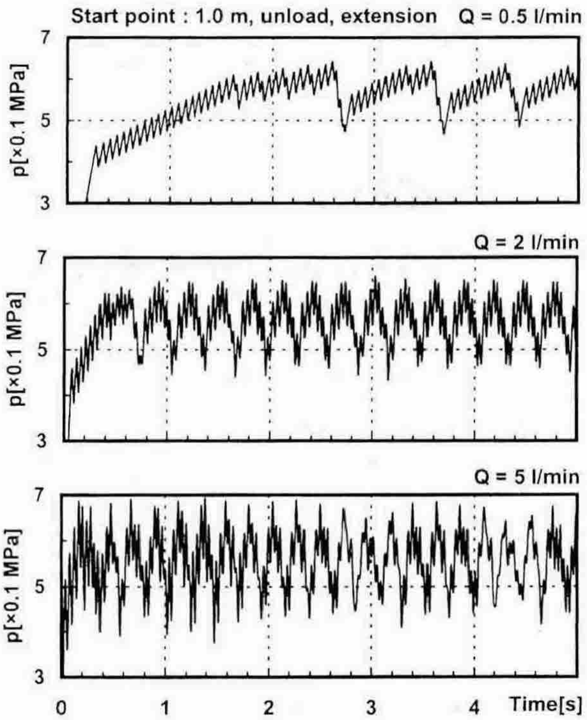

Fig. 4 Pressure variation for incensement of flow rate
(μ_k=0.28, β=0.05)

As the telescopic boom is operated and the time passes, each boom are extended orderly from (a) to (c) and the stick-slip oscillation with the saw-toothed wave is concurrently occurred. It is caused by the low speed of boom, the low flow rate, the friction of sliding parts, stiffness of material, etc.

Fig. 4 shows the pressure variations for the incensement of flow rate. The stick-slip is obviously found at Q=0.5 l/min and as the flow rate is on the increase, the stick-slip is gradually faded and the wave is changed sinusoidal.

The pressure variations as the stiffness ratio β is risen at Q =1.0 l/min is shown in Fig. 5. This non-linear oscillation shows the stick-slip phenomena at β=0.02. However, as the booms are extended, the shapes of wave become from the saw-tooth to the sin curve.

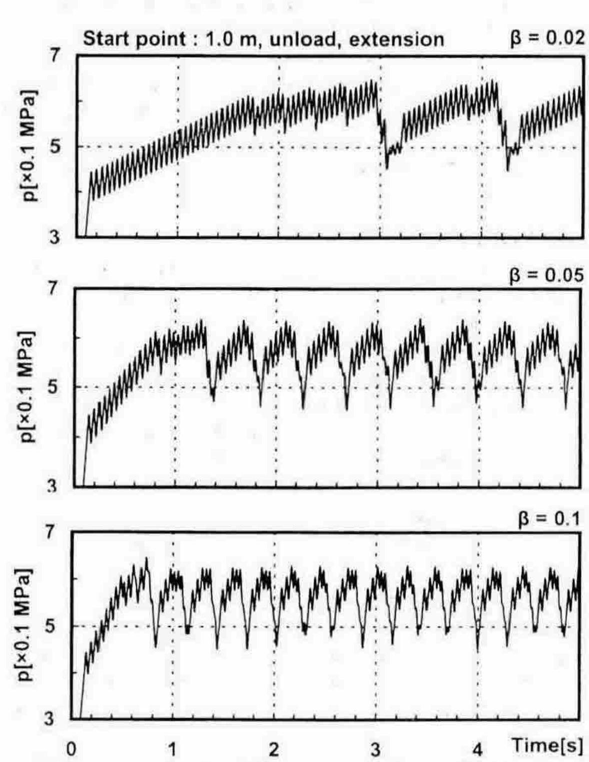

Fig. 5 Pressure variation for incensement of stiffness ratio
(Q=1.0 l/min, μ_k=0.28)

4. CONCLUSIONS

The following results were obtained:

1. In the low flow rate, the telescopic booms are orderly extended from 2nd boom to 4th boom and accompanied with the stick-slip oscillation.
2. The stick-slip oscillation is occurred to the pressure variation for the low flow rate region, and disappeared as the flow rate is increased.
3. As the stiffness ratio is increased, the stick-slip is disappeared in the low flow rate.

6. REFERENCES

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