MULTI-BODY DYNAMIC MODELING AND ANALYSIS
OF LIFE-UP FIRE ENGINE

Feng Zengming
College of Mechanical Science and Engineering
Jilin University
Changchun, Jilin, 130025, China
Email: fengzm@jlu.edu.cn

Li Junlong
Yabing Cheng(corresponding author)
Zhang Lei
College of Mechanical Science and Engineering
Jilin University
Changchun, Jilin, 130025, China
Email: chengyb@jlu.edu.cn

In this paper, focus on the new products development of 88 meter aerial platform fire engine, a virtual prototype model of aerial platform fire engine is established based on the multi-body dynamic software RecurDyn. The luffing mechanism, telescope mechanism, rotation mechanism and working platform leveling mechanism of the aerial platform fire engine system are simulated and analyzed using multi-body dynamic method. The operating radius and the trajectories of the key points of the aerial platform fire engine is analyzed. Load-bearing characteristics of each mechanism hinges are checked, and the mechanism-control coupling dynamics simulation model of the working platform leveler with the PID control is established, which provides important design foundation for the design of each mechanism’s drive device—hydraulic cylinder.

The research results provide important design basis and scientific evaluation index for the design of new aerial platform fire engine.
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ABSTRACT
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1. INTRODUCTION
Fire hydraulic platform occupy a very important position in the field of fire engine, and is widely used. Because of it has some characteristics such as its wide range of applications, a large working area, complete safety limit protection measures and emergency operating system, maneuvering flexible, transition convenient. In recent years, with the rapid development of high-level, high-rise buildings, a higher requirement for the lifting height of fire hydraulic platform has been proposed. In order to achieve new product development of fire hydraulic platform, we must rely on multi-body dynamics technology, control technology and hydraulic simulation technology and so on.

Now, there are many multi-body dynamics simulation software, like ADAMS, DADS, Simpack, Virtual Lab Motion, RecurDyn etc. However, most of software don’t have control module, if we want to do simulation about model’s control, we have to do a joint simulation with a third-party software. The RecurDyn has built-in control module, such as CoLink, users can build body control integrated simulation model based on RecurDyn.

In this paper, multi-body dynamic simulation and solver for the luffing mechanism, telescope mechanism, rotation mechanism and working platform leveling mechanism of the 88 meter aerial platform fire engine system, which is the highest, is done using RecurDyn.

2. AERIAL PLATFORM FIRE ENGINE’S DYNAMIC MODEL
Because RecurDyn is software that more for multi-body dynamic simulation, in this paper, we establish the models of every agency on aerial platform fire engine using Pro/E firstly, then import them into RecurDyn to carry out the research work.

Figure 1 shows the model of the whole aerial platform fire engine. It’s consisted of two major parts: top and bottom. As study of bottom is very mature now, in this paper, the main research focus on the top of aerial platform fire engine. We make the research of the luffing mechanism, telescope mechanism, and rotation mechanism and...
working platform leveling mechanism of the aerial platform fire engine. Telescope mechanism is consisted of the arm at the composition of the 1st arm which has five sections and the 2nd arm which has three sections.

![Figure 2: THE LUFFING AND TELESCOPE MECHANISM](image)

The luffing method of luffing mechanism on aerial platform fire engine is arm swing amplitude, it changes the elevation of boom through swing around rear point in the vertical plane. The working platform lifts through the swing of each section and the luffing of luffing mechanism, and sends firefighters to assignment height.

![Figure 3: ROTATION MECHANISM](image)

The function of rotation mechanism is to support the turntable and the upper device.

![Figure 4: LEVELING MECHANISM](image)

Working platform leveling mechanism connected with platform directly. As the platform need to carry firefighters and necessary fire-fighting tools, so leveling mechanism must always control the platform maintain horizontal, and the adjustment process should be as smooth as possible.

The above figures show the models of each institution we study in this paper. They are established by Pro/E, and then imported to RecurDyn. After that we add a series of rotational revolution joints and translation joints that are required, and add appropriate motion to each cylinder, to make each agencies moving as design requirements. For leveling mechanism, this paper establishes PID control model using CoLink module within RecurDyn, by adjusting the parameters to raise platform more smoothly.

![Figure 5: LEVELING MECHANISM'S CONTROL MODEL](image)

First we establish two parametric points at platform and leveling mechanism respectively, if we want the platform to move in horizon continuously, we only need to ensure that the distance between the two parametric points in vertical direction remains unchanged. Based on this principle, make the distance between the two parametric points as the amount in charged. We establish PID control model using Co Link module within RecurDyn, and find a group of optimal dates making platform to rise smoothly by adjusting parameters of the PID model.

3. DYNAMIC SIMULATION

![Figure 6: FAR-RADIUS](image)
Figure 6 shows the far-radius curve of aerial platform fire engine. From this figure, we can see that in the initial stage, the far-radius almost unchanged. Because the extension direction of the 1st arm is different with the radius increase direction, while the elevation of boom is small. When the boom reaches a certain elevation angle, the impact on far-radius from the extension of the 1st arm become small, then the far-radius began to increase at a fast rate.

![Figure 7](image)

**Figure 7 THE TRAJECTORY OF EACH KEY POINTS**

In this paper, the trajectory of a few key points on leveling mechanism and platform has been studied. First fix other agencies of fire engine, only apply driver to leveling mechanism, therefore, what shows in figure 7 is the trajectory relative to the 2nd arm of each key points.

![Figure 8](image)

**Figure 8 THE SUPPORTING FORCE OF THREE JOINTS ON THE 1st ARM**

The above three figures (fig.8, fig.9, fig.10) show the load-bearing curve of each key joints on the 1st arm and the 2nd arm as well as the total torque of forces on each joints to the rotary centre.

4. CONCLUSION

Based on a comprehensive understanding and knowledge of current development status and trends of aerial platform fire engine abroad, we complete the multi-body dynamic simulation of important institutions in aerial platform fire engine due to the multi-body dynamic software RecurDyn. This paper not only studied forcing characteristics, but also established the mechanism-control coupling dynamics simulation model of the working platform leveler with the PID control. The research results provide important design basis and scientific evaluation index for the design of new aerial platform fire engine.

ACKNOWLEDGMENT

This paper was supported by a grant from the Special
REFERENCES


4. RecurDyn/Help/Manual/Tutorials