Journal of Information Technology and Application in Education Vol. 3 Iss. 3, September 2014 www.jitae.org
doi: 10.14355/jitae.2014.0303.05

Improving JCCD-II Experimental Platform Design Based on Innovative Experiment Course

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Abstract

This paper introduced the composition and principle of the original JCCD-II mechanical experimental platform. Based on the innovative experiments of undergraduate students, we analysed the problems and deficiencies in the JCCD-II experimental platform, then added and improved the corresponding institutions to make it better. Performance before and after the improvement are compared. We verified the feasibility of our scheme by using Pro/E and ADAMS to simulate the Single-crank-and-double-rockers mechanism which is one of our schemes.

Keywords

JCCD-II Experimental Platform; Innovative Experiment Course; API; Simulation and Analysis

Introduction

With the need for technical talents and advances in design technology, undergraduate students not only need to have broader knowledge and more experience in solving practical problems. It is highly desirable that even for research universities to pay more attention to strengthening the students' open mind thinking, to the cultivation of practical problem solving skills, and to the explorative and innovative spirit. Experiment is a key step to combine the theory learning in the class with practice (Xiaoyi JIN, Ping LI and Dongke NIU, 2013). Many universities and enterprises have used experimental platform to fully develop the creativity and intuition of the students. These experiments can also improve students' comprehension and stimulating students' curiosity, while enriching and strengthening the theoretical knowledge (Diansheng CHEN, Xiyu LI, Zhen LI and Tianmiao WANG, 2012).

The design of the original JCCD-II type experimental platform for mechanical system innovative lap and motion test is based on the above thinking. Shanghai university of Engineering Science acquired the platform in 2012, and set up an innovative experiment course based on the platform. We found some drawbacks, and some place for improvements when we taught the innovation experiment lessons. We made many improvements the existing problems. These problems encountered in practice showed the necessity of the improved design.

Analysis of the Experimental Platform

The Composition of the Experimental Platform

The main function of the device is to provide students a platform that they can have opportunities to assemble a typical and commonly seen mechanical system manually, and analyse the state of the motion parameters to learn the kinematics characteristics of different systems, using different sensors installed in the system, in conjunction with the data-processing software configured (Tianxiang LIU, Yunwen ZHANG and Wenjun WEI, 2005).

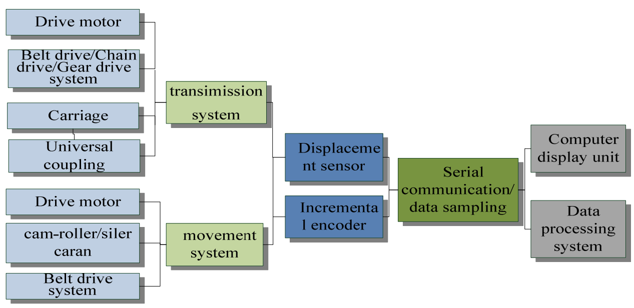

FIG. 1 THE SYSTEM OF THE EXPERIMENT PLATFORM

Fig. 1 is the block diagram of the experimental platform.

The Principle of the Experiment Platform

The mechanical part mainly includes mechanical transmission system and movement system (He, Kexiang, 2007).

The power of the system is provided by an electric motor, and is transmitted from a gear to another axis so that the speed can be measured. Then the power is transmitted from a gear, which can be replaced with different gear to obtain adjustable gear ratio, a belt drives or chain drive and double universal coupling in turn to the end. There is another sensor to measure the speed at the last place (Niu, Dongke, Xiaoyi JIN, Xiangwei ZHANG and Yang XU, 2013).

The part of movement system is powered by the same motor. It is transmitted from belt drive to another axis which can drive a cam mechanism to put the slider rocker mechanism in motion. We can analyse different effects of different configurations and factors and compare with measured data various sensors in the movement system. The real experiment photos and simulation diagram are shown in Fig. 2 to Fig. 6.

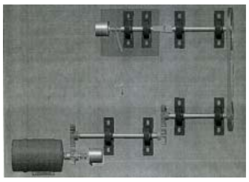

FIG. 2 THE SIMULATION DIAGRAM TO ORIGINAL TRANSMISSION SYSTEM

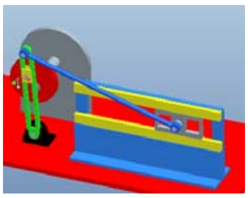

FIG. 3 THE SIMULATION DIAGRAM TO SILER CARAN PART OF ORIGINAL MOVEMENT SYSTEM

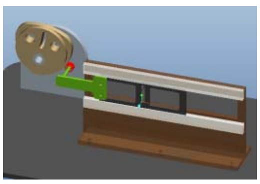

FIG. 4 THE SIMULATION DIAGRAM TO CAM-ROLLER OF ORIGINAL MOVEMENT SYSTEM

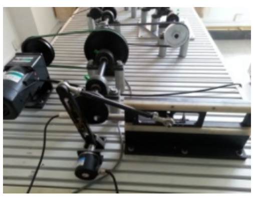

FIG. 5 THE TRANSMISSION SYSTEM PHOTOS OF THE ORIGINAL REAL EXPERIMENT PLATFORM

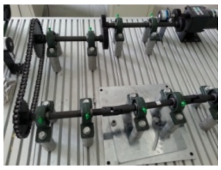

FIG. 6 THE MOVEMENT SYSTEM PHOTOS OF THE ORIGINAL REAL EXPERIMENT PLATFORM

Several Problems Found

Several Parts the Platform can be Improved

We found some parts of the platform that can be improved after the undergraduate course is established based on the platform.

(1) Lack helical gearing. It would reduce the scheme that student can choose. (2) There is no loading device. The original mechanism does not have any loading device, that we cannot get data under different loading on follower. (3) There is no device to measure force and moment, which can increase the kind of data we can measure. (4) The test on the roller-cam cannot repeat in case that will reduce the accuracy of the data tested. (5) The software interface which process data is not well-organized.

Several Problems Met in the Undergraduate Course

(1) The schemes are limited, which reduce the initiative of students. (2) The scope of data relatively narrow. (3)The system lack capacity to handle data. (4) The initial tension of belt and chain drives cannot be measured easily. The center distance of belt is different from the chain.

Improved Design to the Mechanical Part of the Platform

(1) Add the single-crank-and-double-rocker mechanism (Dong, Erbao, Min Xu, Yongxin LI, and Jie YANG, 2010) to the end of the transmission system. Because this mechanism is one of the bionics flapping Gerocraft's drive mechanism, the change can enrich the experimental scheme, and also let students know what bionic flapping wing system is. (2) Adding torque sensor to the crank-rocker system (Wang, Zhijun, Zhanxian LI, He JING, Jiantao YAO, and Yongsheng ZHAO, 2013; Saurabh, Gupta and Pal Molian, 2011) to enrich the kinds of data that can be measured. (3) Adding MPB (magnetic particle brake) (Liu, Jingliang, Ying SONG, Fei LIU, et a1, 2013) which can load steadily, to the rotation axis of the two rockers of the crank-rocker system. (4) Add two pairs of helical gears which have different transmission ratio to the

transmission system which will add some comparison of different kind gears. (5) Redesign roller-gear cam mechanism to realize a force closure mechanism, which can make the analysis to the roller-gear cam mechanism become more completion. (6) Adding several pairs of cam which known the cam profile. Let students learn cam properties by observing the different output data, and make difficult knowledge of cam to be the change of visual data.

The Virtues after Improved Design of Platform

(1) Quantity of the experimental scheme has significantly increased and almost doubled. (2) More varieties and precise data can be tested, improved the precision obviously. (3) Enriched the constitution of the platform. We have added the single-crank and double-rocker which is one of the biomics flapping Gyrocraft's drive mechanisms. Added load to the output shaft to simulate air drag when the gyro craft is flying. The changes let students learn more mechanism knowledge of applications and stimulate students' initiative. (4) Contraposing the progress laboratory course, we can add some simulation content to let students learn some simulation software like Pro/e and ADAMS (Luo, Jianguo, Maoyan HE, Zhen LU and Zhen HUANG, 2009). Then we can have some comparison between the data from simulation and experiment, let students learn more useful knowledge from the platform.

Simulation of the Single Crank Double Rocker Mechanism by ADAMS

We drew the accurate three-dimensional models of the single-crank and double-rocker mechanism by Pro/E, and imported the three-dimensional model into ADAMS by the data interface between the two software (Hroncová, Darina, Michal Binda, Patrik Šarga, František Kičák, 2012), then added revolute pair to the models in the ADAMS. Then we set the material as steel, and the crank as the mechanism's drive shaft whose speed was 30 rad/s. The Mechanism simulation diagram of ADAMS is shown in Fig. 7.

Added force to the model. We used the MPB to add different forces to the crank-rocker mechanism in the improvement design. We added corresponding moment to the revolute pair of the mechanism for replacing the braking effort we added. The Schematic diagram of the crank and rocker mechanism can be seen in Fig. 8.

We then analyzed the results of simulation to verify feasibility of the design. The results would show the relation among angular velocity, angular acceleration, force and moment of the input and output shaft.

Through detailed analysis, the mechanism can work on correctly only when it satisfies the following condition:

$$\sqrt{L_0^2 + L_1^2 + 2L_0L_1\cos(\phi/2)} - L_3 \le L_2 \le \sqrt{L_0^2 + L_1^2 - 2L_0L_1\cos(\phi/2)} + L_3$$

According to calculation, L=200, L_0=160, L_1=25.56, L_2=102.22, L_3=90

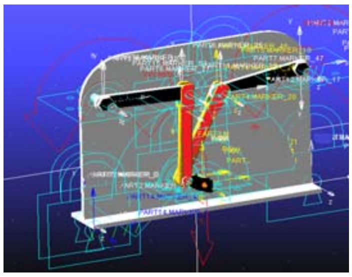

FIG. 7 MECHANISM SIMULATION DIAGRAM OF ADAMS

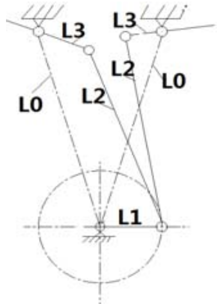

FIG. 8 SCHEMATIC DIAGRAM OF THE CRANK AND ROCKER MECHANISM

When the force we added to the two rockers is 0N, the output result is shown in Fig. 9-12.

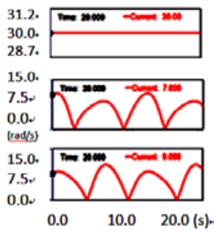

FIG. 9 COMPARISON CHART OF ANGULAR VELOCITY OF INPUT AND OUTPUT SHAFT

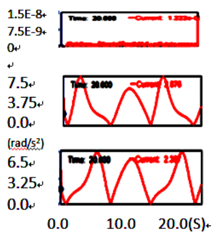

FIG. 10 COMPARISON CHART OF ANGULAR ACCELERATION OF INPUT AND OUTPUT SHAFT

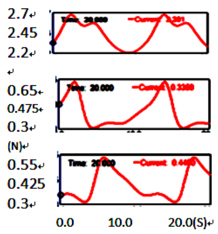

FIG. 11 FORCE DIAGRAM OF INPUT AND OUTPUT SHAFT

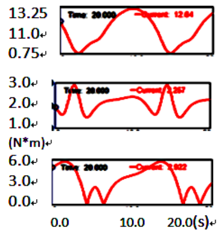

FIG. 12 MOMENT DIAGRAM OF INPUT AND OUTPUT SHAFT

When the force we added to the two rockers is 100 N, the output results are shown in Fig.13-16.

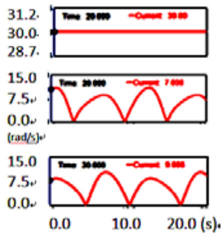

FIG. 13 COMPARISON CHART OF ANGULAR VELOCITY OF INPUT AND OUTPUT SHAFT

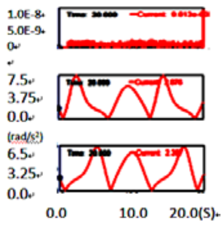

FIG. 14 COMPARISON CHART OF ANGULAR ACCELERATION OF INPUT AND OUTPUT SHAFT

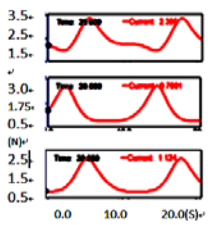

FIG. 15 FORCE DIAGRAM OF INPUT AND OUTPUT SHAFT

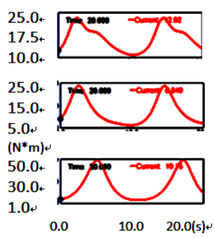

FIG. 16 MOMENT DIAGRAM OF INPUT AND OUTPUT SHAFT

Analyzing Fig.9-16, we can find the influence to the force and moment of input shaft is major, but to the angular velocity and angular acceleration of output shaft has less affected, when we change the loading moment and keep the angular velocity and acceleration of input shaft. The mechanism would not appear dead point or points where have extremely high forces, so it is feasibility to add a single-crank and double-rocker mechanism.

We can understand the system of the mechanism theoretically by simulation, and learn those mechanisms more profound by the contrast between theory and practice.

Conclusions

The paper has discussed those practical problems encountered in the experiment course, and designed improvement hardware. Newly designed hardware is checked by using software to verify the feasibility. The main purpose of the JCCD-II type experiment table is to study the characteristic of movement and transmission. It would export data and corresponding curve by change the scheme to analyze the features of many commonly used mechanisms. The experiment platform improved would add many types of schemes that can be studied. We added the flapping-wing aircraft mechanism to the platform, which would raise students' learning interest immensely. The experimental data would be more accurate added the dynamic loading of modules. Students can learn more and intuitively about cam mechanism.

ACKNOWLEDGMENTS

Authors would like to thank teachers and students who helped developing and teaching the new experimental course, and who made valuable suggestions to improving the manuscripts of this paper.

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