Application of Simulators for Aerial Machinist Training

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Abstract. Aerial mechanists play an important role in flight and maintenance of large helicopters and transports. Based on the author's experience in the development of simulators and training of aerial mechanists for many years, this paper discusses the working principle and key technologies of the simulators and their applications in order to improve such capabilities of aerial mechanists as maintenance, troubleshooting and emergency disposal through simulators instead of real equipment. The simulators applied to the daily training of aerial mechanists can open up a new way of training aerial mechanists, which has a certain promoting significance.

Keywords: Aerial mechanists; Simulators; Teaching and training.

1. Introduction

Transports and large helicopters need aerial mechanists, because of their operational complexity, long endurance, and various tasks far from the base. Aerial mechanists are required to provide timely, accurate and effective technical services and support in case of equipment failure in flight, special situations in the air or temporary requirement of takeoff and landing in other airports.

Aerial mechanist training on real equipment poses many difficulties, while employing simulators mainly has four advantages: First, improving the training efficiency. The environment has little impact on the simulators. Training time can be extended and training organization become easier; Second, significantly reducing training costs. It can save a lot of funds and cost for equipment, fuel, and support personnel; Third, improving safety. Simulators contribute to less safety accidents, and less threat to the trainers and equipment and better psychological quality; Fourth, conducting more courses. Simulating fault situations and high-risk emergencies enable aerial mechanists to carry out more challenging exercises.

2. Constitution and Working Principle of Simulator

2.1 Constitution

The Simulator is a comprehensive simulation training system. It is mainly composed of six parts: simulated cockpit system, sound system, computer measurement and control system, power and network communication system, simple visual system, instructor console.

The simulated cockpit is located in the front of the main body frame, and its internal layout and space size are consistent with the real model, creating a realistic training environment for aerial mechanists. Instruments, indicator lights, integrated display, control panel and manual lever are complete in the cockpit. The control and instructions are simulated by computer, and their working relationship and working status are the same as that of the real airplanes.

There are one data acquisition and processing of measurement and control computer, two virtual instrument generating computers, one simple visual computer displaying the environment of the airport and flight, and sound system generating sound effects (shared with virtual display computer) in the simulated cockpit. All the computers are located in the two machine cabinets in the middle of the main framework. Together with the simulated cockpit, it constitutes the main part of the simulator.

The instructor console located at the rear of the main frame includes the master computer, high-resolution display, simulated cockpit power control box, and emergency power-off switch. It can help teachers command and monitor trainees and intervene simulation system, for example, the

personnel operation and the status of simulation system, recording data, setting up special situation, and conducting command according to the trainees' training situation.

2.2 Working Principle

The simulating mission coverage is more than 85%. Real cockpit environment, complete instruments, switches, buttons, indicator lights, warning lights, displays, power distribution systems are main simulating contents. The interior layout of the cockpit is the same as the real model. The main equipment in the cockpit is processed or purchased in reference to the real equipment. The main instruments and integrated displays on the instrument panel of simulated cockpit are realized through virtual instrument technology and other instruments are realized by refitting voltmeter or electrometer.

The working principle of the simulator is shown in figure 1. The trainees' operation in the simulated cockpit is collected by the PLC host through the PLC input terminal, packaged and sent to the measurement and control computer, which processes the data and transmits it to the master computer through Ethernet. The data transmitted to the master computer is solved by the corresponding professional simulation model, and the simulation results reflecting the working state of the equipment are obtained. Then, the result data are sent to measurement and control computer, virtual display computer (including sound computer) by the master control computer. After that, indicator lights, warning light, and modified instrument are driven by the measurement and control computer through the PLC system, graphics and images of the corresponding instrument and the display are generated by the virtual display computer to simulate the real instrument, and the sound effect is produced by the sound computer when the equipment is working. As a result, a complete working condition is simulated. The master computer reflects the switch position, alarm light status and instrument indication in the cockpit with a list, which provides an effective way for the instructor to understand the trainees' operation and equipment working status in the cockpit.

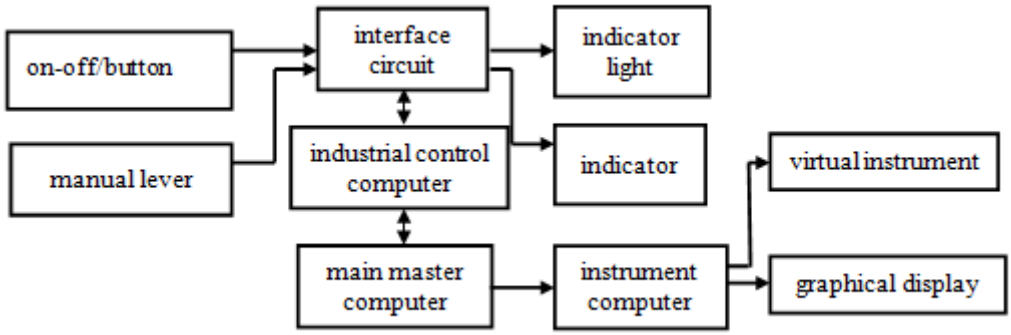

Fig. 1 Working principle of simulator

The simulator mainly has five functions: First, it can simulate the whole process of starting and test, and train the mechanists to familiar with the control method and working procedure of ground test; Second, it can simulate the typical faults, mainly performance faults, and train mechanists to judge and identify the typical faults; Third, the typical special situation is reproduced through the change of instrument, light, signal and sound to train machinists to recognize and deal with various special situations; Fourth, it can record the flight parameters and trainees' operation process to provide accurate basis for performance evaluation; Fifth, it can do the self-test for the its hardware and software to improve the reliability and maintainability of the system,.

3. Key Technology for Simulator Development and Application Value

3.1 Key Technology

The development and application of computer simulation, virtual instrument display, multi-channel sound synthesis, programmable logic controller (PLC), network communication, visual provide reliable technical support for the development of the simulators.

Computer simulation technology is a comprehensive technology based on the similarity principle, control theory, computer technology, information technology and other professional technologies in the application field. It employs computer and physical effect equipment as tools to conduct dynamic test and research on actual or imagined system through system model. In the development of the simulator, a dynamic mathematical model is established according to the simulation object, and the working state of the simulation equipment is solved by computer. The dynamic equations of helicopter and engine are very mature, but the solving equation is a tedious lengthy process. In order to realize the real-time training, first of all, in the process of simulating, the dynamic equations are linearized, and then the correction can be done through actual work data from real equipment modification. As a result, the solving process is greatly simplified, and the simulation accuracy is greatly improved.

The virtual instrument display technology employs the real-time computer graphics to replace the real instrument to reduce the simulation instrument cost, make installation, usage and maintenance easier. The virtual instrument can be consistent with real instrument in appearance, function and dynamic and static performance. Besides its economic and practical features, its layout can be arbitrary, and it can be zoomed in and out, and various pages of the multi-function display can be shown, and it is convenient to reuse and replicate the instrument. The development of virtual instrument generally adopts the OpenGL graphics and GL Studio. The OpenGL has the incomparable superiority in the interactive 3D graphics modeling and programming. It can flexibly realize senior 2D and 3D graphics. It can help to obtain such effect as modeling, transformation, light processing, color processing, animation and texture mapping, object motion blur, and atomization. GL Studio, developed by DISTI company as a rapid graphic instrument developing tool based on OpenGL is employed to create real-time, three-dimensional, photo level interactive graphic interface. The generated source code such as C++ and OpenGL™ can be run separately or embedded in other programs.

DirectSound of DirectX package, a multi-channel sound synthesis technology, is adopted because in the simulator the engine and all kinds of airborne equipment would produce sound, and sometimes many kinds of equipment would make sound at the same time. Its details about bypassing device-independent sound is specified clearly to get the best possible performance. DirectSound not only provides multi-channel low delay synthesis, hardware acceleration, and direct access to sound devices, but also enables the development of 3D sound effects, and 3D sound positioning and synthesis, which help the users obtain immersive sound effects.

Programmable logic controller (PLC), a new type of industrial control device with microprocessor as the core, is of high reliability and strong anti-interference ability. Also, it is easy to install and maintain. For different signals, there are corresponding I/O module for AC or DC, switching value or analog quantity, voltage or current, pulse or potential, high voltage or low voltage. Connecting the I/O terminal of PLC to corresponding devices can put the device into operation. In addition, PLC has a variety of communication network interface module, which can make PLC and PLC, PLC and the upper computer carry out the information exchange. Therefore, a unified whole is formed to complete the data collection, analysis and processing. Moreover, many technologies such as network communication, visual simulation are also very mature and widely applied in the development of simulators.

3.2 Application Value

At present, adopting the mature production technology of ground training simulator and the latest computer technology at home and abroad, our research group has founded three aircraft

training simulators for transports and helicopters with high reliability, maintainability and expandability. These simulators can complete more than 80% of the tasks of the training of aerial mechanists.

If calculated according to 6 hours of daily under the condition that training effect is consistent, the time ratio between the prevailing simulation training and flight training is 3:1, which means only 2 hours of flight training every day. The annual training amount of the simulator is equivalent to 400 hours of flight training if calculated according to 200 days of annual training. As for the fuel and equipment wastage, the simulators can produce lots of annual economic benefits.

4. Summary

The developed simulators basically have met the training requirements. It can also help to do professional modification training for the ground staff of machinery and special instrument professionals as well as teaching training in academies. The simulators can help the trainers to improve the technical level of aerial mechanists, cultivate their abilities to deal with special situations and enhance their psychological quality. The simulated training can replace most of the flight training, and has great promoting significance.

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