Realization of the helicopter test management system Based on Fuzzy Control automatic balancing technology

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Abstract：According to the shortcoming of present helicopter wind tunnel test by manual operation , an automatic control technology based on network communication was developed for the helicopter winder tunnel experiment. It includes the test standard process and different pipelines between command communication and data communication. Combined with information collection, show and safety judgment, the helicopter test automatic trimming technique based on fuzzy control technology is developed to ensure the experiment safety and accurate data. The applied results have shown that the network communication technology for winder tunnel test is of high efficiency, low labor intensity and high automatic and intelligent level.

Introduction

Helicopter winder tunnel(W.T) test plays a key role in providing aerodynamic data for the helicopter model design, exploring new aerodynamic shape, and revealing the mechanism of flow. During the wind tunnel test, the rotor and the test rig is an elastic system of periodic vibration under the effect of aerodynamic force, inertia force and centrifugal force. So, the helicopter winder tunnel test is of difficulty, complex technology, high risk and long preparation time.

The helicopter test rig includes power system, operation control system, velocity pressure control system, collecting and monitoring system and many other systems At the same time, it is of high speed dynamic test. So, there are many shortcomings, such as high labor intensity, much more operators, low efficiency and poor data quality in the helicopter test, at the same time, it often causes bigger loss originated from delay fault treatment.

In order to overcome the defects of artificial control , improve the automation level and safety of the helicopter W.T test, the helicopter test management system Based on Tt&c LAN has been built. The management system connects all the other system together. On this basis ,the automatic balancing technology based on fuzzy control theory was developed. With the management system, the intelligent level, the efficiency, the security and the data quality of the helicopter test are greatly improved. At present the system has been successfully applied to many period in wind tunnel test, has obtained the good economic and social value

Overall scheme

Combined with helicopter W.T test characteristics, the distributing control system(DCS) is applied by traditional DCS pattern, which is shown in figure 1.

. The DCS network focused on test management system, which is C/S network server. The sub system runs independently, and it is C/S network client.

. The test running information system collects trial operation information of each system, and provides the

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safety information for the test management system, according to the test safety standards. The comprehensive display system mainly display test personnel concerned information, such as test data information, image information and test curves.

The network information of the helicopter test includes test operation instruction and data information. It is high real-time. So the system needs the different communication pipeline. The Winsock communications mechanism is used to transmit the test operation instructions, and the Data socket controls is utilized to transfer the test data. In the transmission of the orders, the test management system creates the Winsock server applications, and the other subsystems build Winsock client application. In the transmission of the data information, the subsystem as the Data Socket server releases its own main operating information, the test management system and the other related system real-time access the information that it core about as the Data socket client.

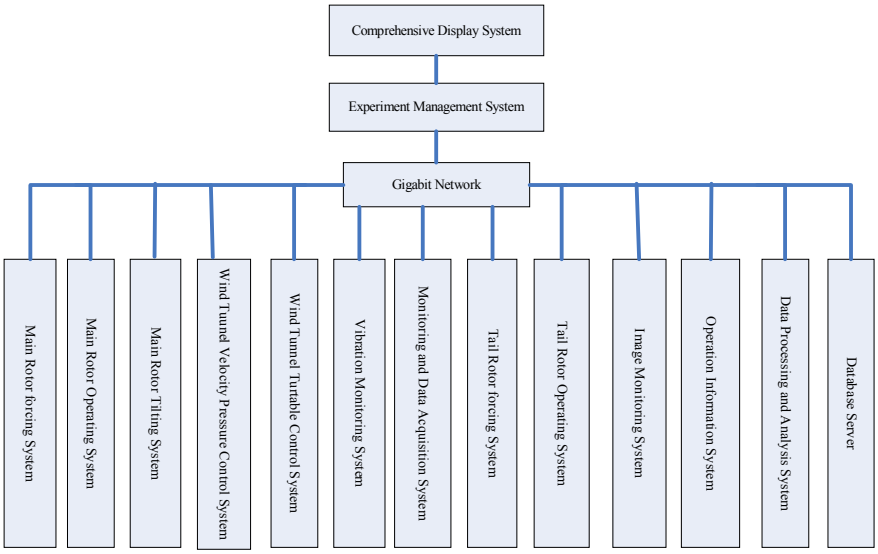

Fig .1Overall structure diagram of helicopter W.T test

Key techniques and implementation

In our designed system, some key techniques are developed as follows:

3.1 Real-time interaction technology

In Helicopter W.T Test, monitoring balance load and velocity pressure are needed to be known in real time. At the same time, each system operation needs related information support from the other system. So, during the Helicopter W.T test, we require interaction information that includes order information and a large number of subsystems operating information, and the effective real-time interaction of test information is the foundation of the whole system implementation. The system runs command and tests data respectively in different ways. The operating instruction includes the character and data, emphasized sent off and accept it. In the operation instruction design, the system uses TCP/IP communication based of WinSock control. The system issues instructions, after receiving the response of corresponding system to transmit the next instruction, which means the system focuses on reliability other than real time. On the other hand, operation information consists of only running data and often adopts a one-to-many way to transmit data, which emphasizes the real time and high speed. The design uses NI company's DataSocket control to transmit an array of data, or a single data. Practically, the transmission rate in a 10M network can reach 640 kps which can fully satisfy real time requirements for Helicopter W.T Test. Based on the characteristics mentioned above, each subsystem adopts the DataSocket server to release its own

key operation information. And all other subsystem as the client can real time acquire test information to participate in the control of this system and ensure the safe operation of the test.

3.2 Operating information collection and security judgment Technology

Because of the complexity of the flow field of the helicopter, the test operators must conduct comprehensive grasp of running situations of each system for Helicopter W.T Test, and therefore decide to the test process. Consequently, each system not only saves all the operational information of the system, but also adds the information system of equipment operation, in which all key operational information are displayed in a central way. Meanwhile, according to running limitation parameters of each sub-system set by security requirements, we set the display information background to blue (security), yellow (caution) and red (danger) to give the operators real time prompt information, and send the relevant information to the test management system. On this basis, the test management system judges the test process by the safety operation standard.

In addition, this system records the entire test operation information and stores the typical operating information (such as the normal operation of all system information, failure operation information of a system) to the Test Information Database which can be used to build data accumulation for system fault analysis and construction of expert systems.

3.3 Automatic trimming technology based on fuzzy control for Helicopter Test

Helicopter trimming process is a multi-input & multi-output complex system, which involves in data acquisition system, operation control system and spindle tilt control system and so on. It is very difficult to be modeled by accurate mathematical way. In traditional the helicopter trimming test has always had a way to test by manual operation, low efficiency of manual operation test due to various reasons, data quality is not stable, labor intensity and other issues.

In order to improve the intelligence level of the Helicopter W.T Tests trimming, typical control mechanisms usually use neural network method to trim and debug in hover trials. Since neural networks need to learn, the learning result will affect the late data quality which leads to unstable control results. Based on the fuzzy control principle: simulating human approximate reasoning and comprehensive decision-making process, which makes the controllability, the adaptability and the reasonable of the control algorithm to increase. We put forward the helicopter test automatic balancing based on fuzzy control technology. The automatic trimming technique based on fuzzy control is classified into such a process:

1) Get difference between current model state and trimming goal as input : $\{\Delta Cw、\Delta Ch、\Delta Mz、\Delta Mx\}$.
2) Membership functions are used to fuzz the input data：$\{m_{Cw}、m_{Ch}、m_{Mz}、m_{Mx}\}$.
3) Fuzzy output data are inferred according to the rules：$\{m_{q7}、m_{qs}、m_{qc}、m_{a}\}$.
4) Get operational output value by the anti-fuzz：$\{\Delta q7、\Delta qs、\Delta qc、\Delta a\}$.
5) Repeat the process until the trimming goals are met.

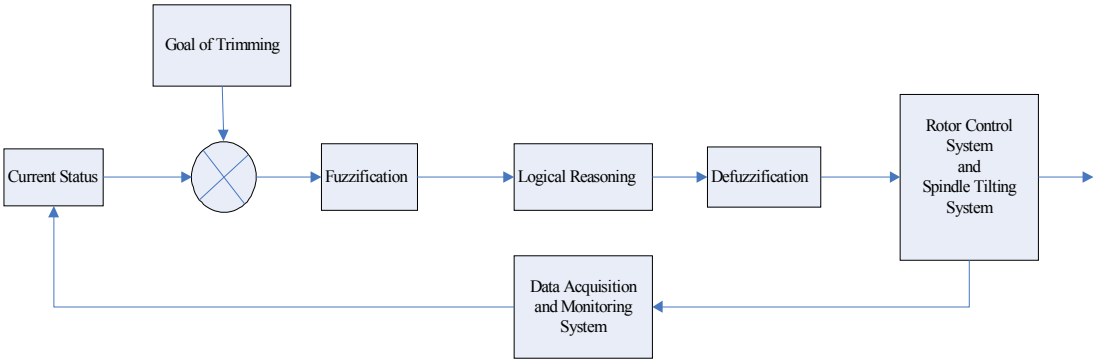

Fig. 2 Fuzzy automatic trimming structure diagram

Application results

4.1 Data quality

In the wind tunnel test of some type of the helicopter, we record the data before and after the implementation of Automatic balancing technology, as shown in table 1

Tab 1 Data comparison before and after the implementation of Automatic balancing technology

Serial number	Number	Planned		measured				Time
		Cw (Ct)	Ch	Cw(Ct	Ch	Mx	Mz	
1	KC0019	0.0119	/	0.011921	/	2.10836	20.37343	Before control system improvement
2	KC0020	0.0119	/	0.01184	/	-12.4551	13.31352	
3	KC0021	0.0119	/	0.011767	/	-9.08612	-12.1539	
4	QCW110	0.015	0.0000406	0.015076	0.0000028	-1.8637	1.51996	After the modification of the control system and before the main shaft system to improve the former
5	QCH110	0.015	-0.0000889	0.014998	0.000015	-0.02582	0.86971	
6	QCW215	0.0116	-0.00000757	0.011642	-0.0000067	0.435	1.2785	
7	QCH115	0.015	-0.0000889	0.015029	-0.000084	-4.182	8.783	
8	DCW110	0.008578	0.000113	0.008591	0.000108	1.708835	-1.26502	After the improved control system and the main shaft system
9	DCW115	0.008578	0.000113	0.00858	0.000109	0.84852	-3.34458	
10	DCW210	0.006862	0.000113	0.006877	0.000114	4.749898	1.213209	
11	DCW215	0.006862	0.000113	0.006851	0.000108	4.679442	-2.76682	
12	DH1210	0.008578	0.000104	0.008581	0.000096	0.974862	1.151756	
13	DH1215	0.008578	0.000092	0.008561	0.000104	4.872893	1.394861	

Can be seen from the chart, on the basis of the test management system developed by the application of the helicopter automatic balancing technology, the balancing precision of lift coefficient is better than 0.3%, the error of the resistance coefficient is better than 0.000005, the moment is better than 3 n. m. At the same time, data quality stability is very good.

4.2 Test efficiency

As a result of the test management system building, through the experiment instruction and key

data sharing, the helicopter test volunteers together the equipment, reduce the operating personnel, speed up the information communication between each system. At the same time, the realization of the automatic balancing technology makes the balancing time reduce to 27 seconds since 87 on average, so that the test points increased from 10 points to 30 points every time during blowing (helicopter test bench work 30 minutes must stop check model). And during the process of wind speed change the automatic balancing technology ensures that moment in the 100 n. m, which improves the test security and Reduce s the proficiency and strength requirements to test personnel.

Conclusion

The test management system based on network communication for Helicopter W.T test runs stably from March 2014 and the controlling result is satisfying. Up to now, it has already performed many helicopter W.T tests. The results of applications in the test show that the technology significantly improves test efficiency and data quality, at the same time, reduces labor intensity, and improves the security of the test, but also. These show that the proposed technology has characters as follow: reasonable design, desirable reliability, easy operation. It can completely take helicopter wind tunnel test with the properties of “three highs”.

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