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THE RESEARCH AND APPLICATION OF HYDRAULICS AND PNEUMATICS IN HUAZHONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

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ABSTRACT

The Pneumatic Center in Huazhong University of Science and Technology (HUST) is one of the most active research center in fluid power transmission and control in China. The main fields of Pneumatic Center in HUST are component development and control technology of fluid power. Hydraulics research is the most important part of fluid power in the Pneumatic Center in HUST. Based on several decades of the research on the hydraulics in HUST, the further research and new application in this field are made, include underwater motion platform, automatic buoyancy regulation technology and new type hydraulic valve, etc.. From 1996, the Pneumatic Center in HUST focuses on the combination of electronics, computer technology and pneumatics, and the research achievement play a very important role in some state key engineering projects successively. The pneumatic research and applications have been developed, such as the gas temperature control technology, pressure and vacuum servo control technology, leak-testing technology, pneumatic muscle platform and the high pressure pneumatic valve, etc.. In this paper the main research and application of hydraulics and pneumatic in Pneumatic Center in HUST are introduced. Also some practical examples research projects and subjects in above fields are presented.

KEY WORDS

Pneumatic, Vacuum and Pressure, High Pressure, Hydraulic, Underwater

INTRODUCTION FOR PNEUMATIC CENTER AND RESEARCH FIELD

The Pneumatic Center in Huazhong University of Science and Technology is one of the most active research center in fluid power transmission and control in China. The main fields of Pneumatic Center in HUST are component development and control technology of fluid power.

Hydraulics research is the most important part of fluid power in the Pneumatic Center in HUST. Based on several decades of the research on the hydraulics in

HUST, the further research and new application in this field are made, include underwater motion platform, automatic buoyancy regulation technology and new type hydraulic valve, etc..

From 1996, the Pneumatic Center in HUST focuses on the combination of electronics, computer technology and pneumatics, and the research achievement play a very important role in some state key engineering projects successively. The research field pneumatic center includes:

- Study of new type hydraulic and pneumatic component and system

- Electronic hydraulic proportion/servo control technology, including position and force control system
- Electronic pneumatic proportion/servo control technology, including pressure, vacuum, position and force servo control system
- High-pressure pneumatic technology
- Mechanic and electronic integration, computer testing technology
- Study of special equipment applied to the semi-physical simulation system, including air environment simulation technology, load simulator, underwater motion platform etc..



Figure 1 The pneumatic center in Huazhong University of Science and Technology (HUST)

PNEUMATIC TECHNOLOGY RESEARCH AND APPLICATION

Vacuum and Pressure Continuous Control

Research in this sector is aimed to implement semi-physical flight height simulation technology of flight of aircraft. The technology is researched to master the flight condition and characteristics to avoid danger and ensure stable control of flight. In the research, the pressure and vacuum continuous control system is studied, which can implement continuous control of pressure and vacuum with high accuracy and fast response.

Initially, an idea is presented^[1-2] to solve the problems mentioned above, that is, making use of pneumatic servo technology to control vacuum, the vacuum servo control system is founded with servo valve and vacuum generator. The research solves the key problem of developing vacuum servo control system with high accuracy and fast response.

The further advances have been made in studies^[3-5] the pressure and vacuum continuous control system, which is shown in the Figure 2. The system adopted compressor and vacuum pump as pressure and vacuum source respectively. The research results demonstrated that the system behaved with desirable static and dynamic

characteristics. When absolute pressure in closed chamber declines from 100 kPa to 20 kPa, the transition time is 1.4 s and static error is less than 30 Pa. When system traces sin wave signal (frequency is 1 Hz and amplitude is 0.2 kPa), amplitude frequency error and phase frequency error are 0.37% and 4.939 3° respectively.

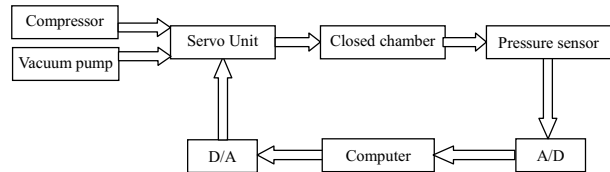


Figure 2 The sketch of the pressure and vacuum continuous control system based on vacuum pump

Based on a decade of theory research, several kinds of simulators for flight height and Mach number are developed with high accuracy and fast response, which are well applied to semi-physical flight height simulation system for aircraft and UAV.

Gas Temperature Control

The growing uses of simulator for total temperature have encouraged research to explore key technology of gas temperature control. For the gas temperature control system being a time-varying, big inertia and non-linear system, it's hard to control the gas temperature accurately, especially gas temperature control of a flowing open system with high degree of accuracy and fast-response signal of gas temperature.

By way of example, Figure 3 describes a principle of high and low temperature control system^[6]. The research results show that the system can control gas temperature among the range between 233 K and 393 K. The static error is not more than 0.4 K. The maximal temperature varies rate is 1 K/s.

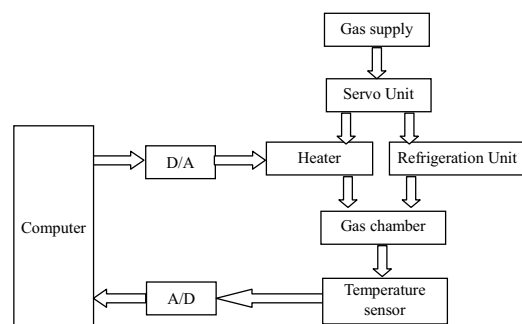


Figure 3 Principle of the temperature control system

Recently, the research in this filed to acquire further development. For the system^[7,8] showed in Figure 4, the temperature range been controlled is 293~753 K, the maximal static error is 2 K and The temperature

varies rate can achieve 80 K/s.

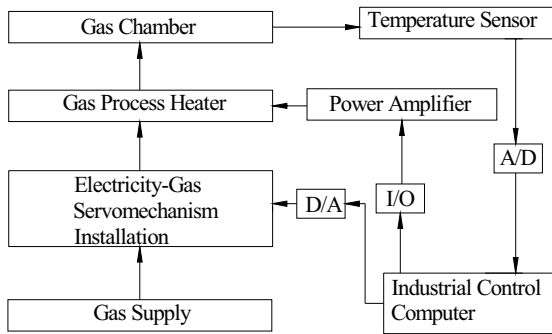


Figure 4 Operating principle of the system

Leak Test

The leak test is another research field of Pneumatic Center. The leak test system^[9], which serviced to important device is shown in the Figure 5. When setting pressure in the closed chamber in the system to 50 kPa and 200 kPa respectively, the variety value of pressure is no more than from 20 kPa to 30 kPa.



Figure 5 The leak test system

High Pressure Technology

The research on the high pressure technology firstly focus on simulation of high pressure gas flow. The pressure and flow characterize of high pressure is studied by means of computational fluid dynamics. The simulation result is of benefit to further optimal design of high pressure pneumatic component.

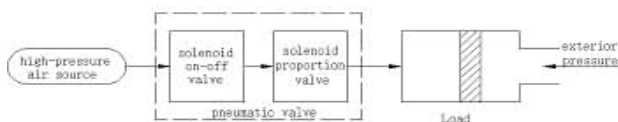


Figure 6 Sketch of high-pressure pneumatic system

Based on theory research, high pressure Pneumatic valves are researched. As shown in the Figure 6, a new type high-pressure Pneumatic solenoid on-off valve^[10] is developed, which has the advantages of high work

pressure and large output flow-rate.

HYDRAULIC PRESSURE TECHNOLOGY RESEARCH AND APPLICATION

Hydraulic System

The underwater-simulated device^[11] has pure rotational degrees of freedom with rotational range of $\pm 30^\circ$ with respect to x and y axes and rotational range of $\pm 180^\circ$ about z axis. It is necessary to design a spatial 3-DOF manipulator according to the requirements of the simulated device. Its architecture is shown in Figure 7. The device consists of a 2-DOF parallel manipulator driven by hydraulic cylinders and a creeper gear with one degree of freedom driven by servo motor. Hence, the kinematic characteristics of the creeper gear are independent of the rotations of parallel manipulator. The characteristics and control of the creeper gear driven by servo motor are simple relative to the parallel manipulator in this project.

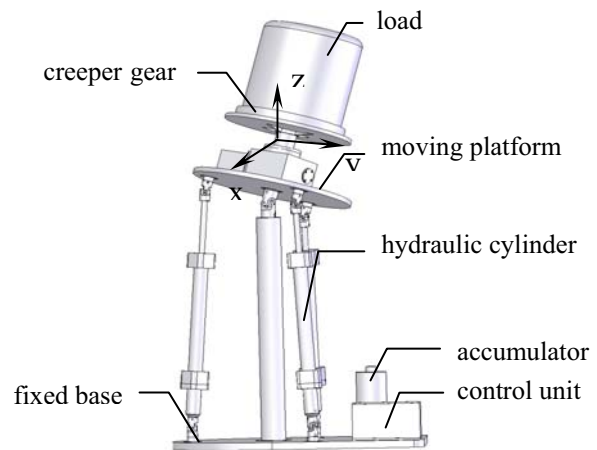


Figure 7 The sketch of the underwater-simulated device

More and More importance is attached to the operating security and reliability of important equipment to which hydraulic system used in such important equipment, fluid flow rate limiting device is developed^[12]. Purpose of researching the fluid flow rate limiting device is to improve operating security and reliability of hydraulic system in important equipment.

Hydraulic System for Ocean research

With the development of ocean research, the collection and supervision of observations describing the ocean states are becoming more important. Ocean vertical section plane survey plat roof is a system facing the high technical research plan, which can meet with this demanding in our country. The flotage adjustor^[13] exploited is developed to meet with the actual demanding of ocean section plane survey plat roof to realize the purpose of automatic raising or lowering from

100m to 150m under the water for the survey platform. It is a product with more consideration of light weight, smart volume, low power consumption and high reliability.

Hydraulic Components

With the development of hydraulic technology, hydraulics has been applied widely in many industry fields as an automatic control means. The various valves are also studied with the development of hydraulics. In order to satisfy some special industry requirements, the new types of valves are studied and applied with new material, new structures and new functions. The watering valve presented in this paper is researched for the water supplement of lead-acid batteries^[14]. The valve is one kind of autocontrol components, which has sensitive response, accurate control and steady function.

CONCLUSION

Research in the Pneumatic Center in Huazhong University of Science and Technology covers a very wide range. In most research filed in the center, the theory research achievements have been developed to production, which is applied in some important technology area in China. And as the development of center, more complex systems and more precision components in the pneumatic and hydraulic field will be researched to meet demand of important domestic research institution. For Ocean research is the development focus in China in during the next decade, the center will stress pneumatic and hydraulic research which service to ocean technology.

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