RESEARCH ARTICLE

Control scheme of thermal insulating door based on area linkage control structure

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Abstract: Taking the thermal insulating door as an example in which door blocks are driven by electric push rod, the area linkage control structure of block-groups has been established based on door blocks area linkage division. And multi-block control under different working conditions is realized. By employing PI controller to regulate single block to open and close, system controllability has been improved and control energy consumption has been reduced. The simulation results show that the proposed control scheme can relieve the heavy dependence of thermal insulating door control on manual operation to some extent.

Keywords: Control science and engineering; thermal insulating door control; block-area linkage control

Introduction

Thermal insulation door is one of the important components of the heat preservation chamber, ensuring the tightness of the heat preservation chamber at various temperatures. Therefore, by improving the working mode of the existing thermal insulation door, a thermal insulation door system capable of automatically opening and closing is formed to automatically control the improvement of thermal insulation door. The degree and control precision are very important.

Taking the structure of the thermal insulation door system described in document[1] as an example, as shown in **Figure 1**, the thermal insulation door system consists of several gate blocks, wherein a few door blocks are located on the vertical wall surface of the heat preservation chamber, and most door blocks are located on the inclined wall surface of the heat preservation chamber. Each door block can be pushed to move along the thermal insulation door guide rail by a driving force actuator located at the left end of the door block, and the actuator can adopt an electric push rod or a electric hydraulic draw stem. Each actuator is numbered as Act_0-Act_13, where Act_0-Act_3 is used to drive the vertical wall door block. Act_4-Act_13 is used to drive inclined wall door blocks.

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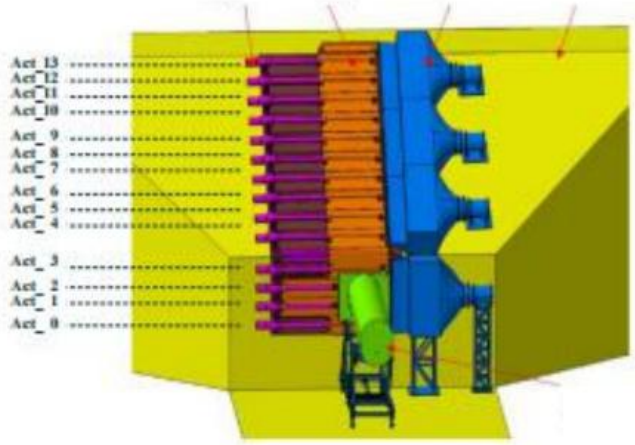

Figure 1. The overall layout of thermal insulating door system[1].

1. Door block area linkage control structure

1.1 Gate block grouping

From the overall analysis of the thermal insulation door system: according to the position characteristics of the electric push rod in **Figure 1**, the thermal insulation door electric push rod system can be divided into two action areas: vertical wall area and inclined wall area, each area including several electric push rod control paths. When opening the thermal insulation door, the vertical wall surface area starts the electric push rod to pull the door block outwards in the direction of Act_3 to Act_0 as required, and the inclined wall surface area is along the direction of Act_4. From to Act_13, the electric push rod is started in turn to pull the door block outward; When the thermal insulation door is closed, the starting sequence of the electric push rod is opposite to that when the electric push rod is opened to complete the pushing of the door block.

1.2 Linkage control logic

Considering the starting sequence of the electric push rods in the vertical wall surface area and the inclined wall surface area, the linkage control structure of each working group is established, as shown in **Figure 2.** the logic variables listed in table 1 are introduced. The generating expression of each group's starting signal is shown in formula (1). The linkage logic block diagram is shown in **Figure 3**.The switch structure is characterized in that there is only one switch at the current moment is on, and the other switches are off.

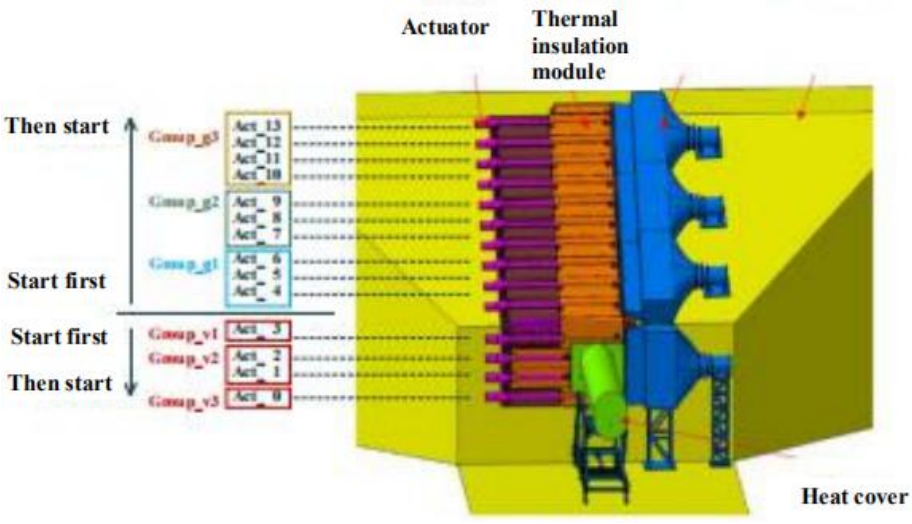

Figure 2. Activation sequence of electric push rods distributed in both vertical wall and inclined wall.

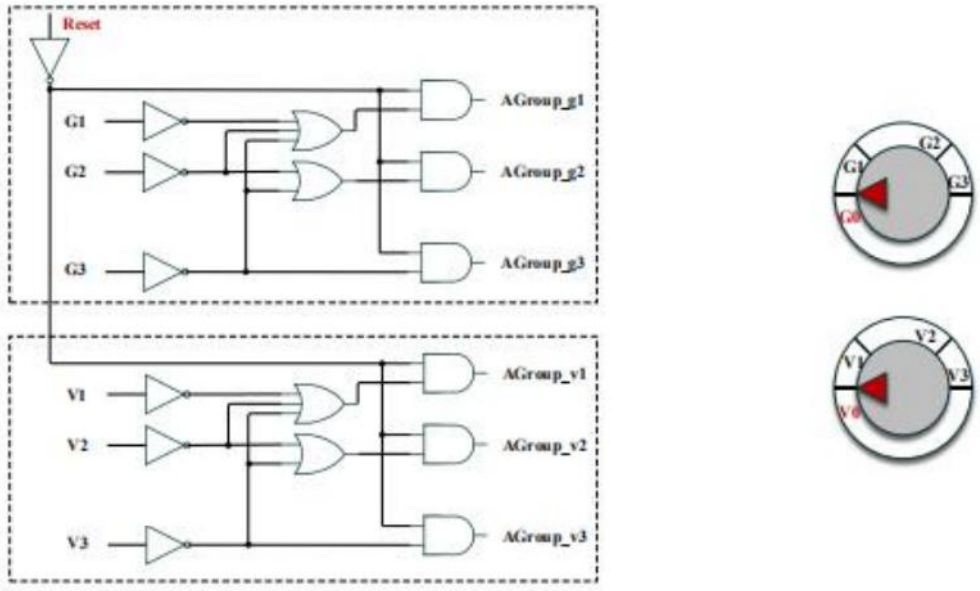

Figure 3. Linkage control logic block diagram.

2. Closed-loop control structure for opening and closing door block

From the perspective of the working conditions of each door block in the thermal insulation door system, the state of the single electric push rod is divided into static state and moving state, and the moving state is determined according to the setting opening, electric push rod drives door block to realize displacement follow-up output. The control of the electric push rod is divided into starting control and motion control according to the state characteristics. In the startup controller, each is designed to start. The set opening values w and s are used as the given positioning displacement input of the electric push rod displacement control system, thus the difference x between the set displacement and the real-time stroke can be calculated.

3. Simulation analysis

3.1 Gate block area linkage control simulation

The hardware description language is used to virtually implement the gate block area linkage control logic[2] and perform functional simulation, setting the simulation time as 80 ns. The Reset signal RESET is invalidated at the first 60 ns with a value of 0, which is reflected as a low level in the waveform diagram. The G1-G3 and V1-V3 are respectively set to be valid at different time periods with a value of 0 and a low level.

3.2 Single electric push rod displacement control simulation

The controller of the single electric push rod displacement closed-loop control loop adopts the PI control algorithm [3-5] which is relatively mature in industrial control applications. When the output approaches the set opening, there is slight overshoot, which shows that the door block opening will slightly exceed the set value and the error will be eliminated. In the physical system, when the opening degree is set to full open of the door block, 115 means that the opening degree is set to W and S = W. The electric push rod driving the door block will be limited by the maximum stroke, and the overshoot will not affect the door block opening and closing.

4. Conclusion

Taking a thermal insulation door driven by an electric push rod as an example, this paper discusses how to improve the automation degree of the thermal insulation door control system by setting the state of each door block and the opening degree of the door block. The multi-gate block control under different working conditions is realized by

grouping the multi-gate blocks, establishing a grouping area linkage control structure and designing control logic. Through the PI control of a single gate block control circuit, the controllability of the system is improved and the control energy consumption is reduced. The simulation results show that although the system does not automatically adjust the linkage control and opening setting of the door block according to the working conditions, the proposed control scheme can alleviate the heavy dependence of the current thermal insulation door control on manual operation to a certain extent.

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