

## Research on Embedded Retractable Fire Rescue Equipment for High-Rise Building

Jianguo Luo<sup>\*,1</sup>, Jianyou Han<sup>2</sup>

<sup>1</sup>College of Mechanical & Electrical Engineering, North China Institute of Science & Technology, Beijing, 101601, China

<sup>2</sup>Beijing University of Science & Technology, School of Mechanical Engineering, Beijing, 100083, China

**Abstract** — Fire rescue of high-rise building is a worldwide problem, rescue method mainly divided into two types currently, includes he saved methods and self-help methods, due to the limited working height of these equipment, effectively rescue can not realized. In this work, a new type of embedded retractable fire rescue equipment based on system thinking presented, system includes three subsystem, the retractable guide rail, the fire extinguishing system, the ground remote central control system, corresponding function defined respectively, its constitutes designed and as well. by making use of the fire refuge floor of high-rise buildings jointly, install a certain number of these equipment in refuge floor according to scientific rules. Complete operating process of simulating the fire rescue of high-rise building obtained from the workflow of embedded retractable high-rise building fire rescue equipment. widely application of this technology and equipment in future, it will solve the difficult problem which has plagued human for a long time, also make a epoch-making significant contribution to world high-rise building fire rescue.

**Keywords** - High-rise building, Fire, Embedded, Retractable, Rescue equipment

### I. INTRODUCTION

With the development of the city, most of buildings are developing into space, which become even higher than 100m, the number of high-rise buildings are more and more, it is often seen that the fire accidents of high-rise building[1]. High-rise building fire accidents based on indoor sprinkler system, if insufficient of indoor fire water and pressure is not enough, still with the fire fighting equipment out of service, large area of fire can not be effectively rescued from outdoor water of fire engines, this is the key why the high-rise building fire emergency rescue has become worldwide problem[2]. Currently, fighting ability of fire ladder among fire equipment for building more than 15 layers will be greatly reduced, even incapable of action. The highest fire ladders in the world manufactured in Finland just 101m, it can work up to 33 layers, but only 6 in use, the Chinese Chongqing and Dalian each have one set[3]. Tank fire sprinkler of existing fire extinguishing equipment in China can reach the height about 8 layers, the highest fire engines equipped with a lift high device for city can only reach to a height of about 15 layers. For those high-rise buildings more than 15 layers, the existing fire fighting equipment still beyond its power. Both the height of fire ladder and water gun are limited, it is difficult to keep up with the step of building growth. To solve the problem of high-rise building fire rescue will provide reliable guarantee and support to the safety production and development of human being.

### II. DEVELOPMENT AND TREND

Two ways existed for the fire rescue, one type rely on automatic fire extinguishing system in building for fire fighting, another type rely on passive fire fighting equipment out of buildings for fire fighting. Among high-rise buildings, the common active fire rescue facilities includes fire hydrant system and automatic fire alarm system and automatic sprinkler system and so on. Foreign passive fire rescue equipment from outside of building includes fire helicopter and fire-fighting robot and fire extinguishing gun except fire engines.

#### A. Research In Developed Countries

At present, fire rescue departments of many large and medium cities in the United States and France and Russia and Britain and other developed countries make use of fire helicopter frequently, as well as urban air fire rescue team established then[6]. although there are many outstanding advantages for fire helicopter, but it is not equal to anything, due to the complexity of urban high-rise building fire, the role of fire helicopter can play is limited by many factors, such as street width and effective space is far less than the helicopter safety control standards, interference of high temperature hot air flow and smoke, glass wall of high-rise building is very difficult to break directly, the amount of water loaded on fire helicopter is very limited[7], all those factors will affect rescue, high-rise building fire rescue by fire helicopter is still plagued by these difficult factors.

A high altitude fire fighting and rescue robot belongs to the fire fighting robot, it is mainly for high-rise and super high-rise buildings. Study carried out abroad early on fire

fighting robot, earlier study done by the Soviet Union and USA, after then, there are many countries join the research of this technique, such as Japan and France and the UK and Germany and so on. Various types of fire fighting robot developed in Japan, which can complete functions such as straight walking and obstacle crossing and climbing and so forth, in addition, it is also equipped with a larger flow of fire extinguishing gun, these robots generally controlled by cable or wireless. Italy fire engineers invented a fire robot model[8], it can quickly enter the key position of the fire and finish the task of scene detection and extinguishing, make use of its own camera, find the fires very accurate, firefighters can find the fire point through wireless remote control, control the robot with its high pressure water gun to fight fire. America Fuguniya College of science and Engineering help American navy designed a fire robot [9], the navy plans to use this robot as the autonomous firefighting robot on the ship.

In recent years, foreign research on fire extinguishing gun gained some achievements, GAZ-5903 developed by Russian used for forest fire fighting, as well as tanks and other occasions. Air fire extinguishing gun put into use in 2005 by Italy[10], the maximum shot range up to 200 to 400 meters, which have been widely used in the petrochemical enterprises, wells, warehouse, airport and the port terminal. The mobile fire extinguishing gun made by America depend on the pressure of water supply[11], its working height more than 300 meters, single shot not less than 60 cubic meters, its disadvantage is not regulated of initial velocity of extinguishing bullet, security is not easy to guarantee by using gunpowder to launch. Hungarian engineers invented large caliber fire extinguishing gun[12], its characteristics is long shot distance and large capacity and good maneuverability, which has achieved good results in the oil fire environment during the Gulf War, its disadvantages include huge size and large energy consumption and slow activity.

#### *B. Research In Developing Countries*

In the high-rise building in China, the active fire rescue facilities include indoor and outdoor fire hydrant system, automatic fire alarm system, automatic sprinkler system and fire extinguishing gun. Research on fire fighting robot and fire extinguishing gun and so on have got some attention. In 2014, Jiang [13] from China University of Science & Technology proposed a suspension type fire-fighting and rescue robot system, the robot is transported to high-rise buildings above by helicopters connected with cable, bear the relief task in its periphery. Northwestern Polytechnical University[14] developed a high-rise building fire fighting robot, which can climb, break glass, detect fire and feedback, but its speed and fire rescue equipment carried is limited, due to

close mobile on the fire floor, there will have a very high requirement on its thermal properties and preparation of materials. Bracket type pneumatic fire extinguisher PZ120 developed by a company in Taiyuan, the fire extinguishing gun mainly use high-pressure gas as power source[15], fire extinguishing bomb sent directly into the fire site, so as to achieve the purpose of fire extinguishing. Which mainly used in long distance fire fighting such as forest, grassland, high-rise buildings, dangerous goods and special dead angle, its shooting accuracy is not very high, shot range is limited, application in high-rise building fire fighting is not ideal. CSIC No. 710 Research Institute and the Yichang Forestry Bureau and other departments developed a remote fire extinguishing gun system jointly[16], its efficiency used for building fire fighting is not high, one reason is the window of the high-rise building block the hydraulic cover of fire extinguishing gun, the second reason is the insufficient head of fire extinguishing gun. 2012, the second Institute of China Aerospace Science and industry and trade group developed a high-rise building vehicle mounted multiple pump fire extinguishing system[17], the fire extinguishing bomb launch to high-rise building wall or into the building in the form of rocket. The disadvantage is the initial velocity obtained at the muzzle can not be controlled with gunpowder as the emission power source for fire extinguishing bomb. 2012, Liu from Harbin Engineering University use pneumatic emission high-rise building fire extinguishing gun equipped with dry powder fire extinguishing agent, this fire extinguishing bomb can be sent to site from far distance with dispersed type for fire extinguishing[18], the system can also be used for the long-distance fire fighting work in forest, airports, warehouses, petrochemical enterprises, storage tank area, ports and docks and so on.

From the above research status of high-rise building fire rescue equipment, we can see the future developing trend of high-rise building fire rescue technology and equipment mainly focus on the following aspects, the first aspect is the research on the linkage system of fire alarm and automatic sprinkler system, in order to realize the all-weather automatic fire-fighting and rescue without missing. The second aspect is the study of new fire safety evacuation system, in order to ensure timely and effective and convenient emergency escape for building. The third aspect is the development of new fire rescue equipment, in order to overcome the disadvantages such as limited height of existing rescue equipment and discontinuous fire fighting and non precision fire fighting and limited operating space and other issues, the developing trend in the future is to find fire rescue equipment avoid these defect.

III. NEW EQUIPMENT BASED ON SYSTEM THINKING

Based on the current situation and trend of high-rise building fire rescue equipment, a new kind of embedded retractable fire rescue equipment put forward based on system thinking. Combined with the high-rise building fire refuge floor, the scientific installation of a certain amount of this equipment in the refuge floor, full coverage and high efficiency and remote control fire rescue can be achieved from outside the building.

A. Constitutes of Equipment

The embedded retractable fire rescue equipment includes three parts, the first part is the retractable guide rail, as shown in Fig. (1), the second part is the fire extinguishing system, as shown in Fig. (2), the third part is the ground remote central control system, as shown in Fig. (3).

The retractable guide rail is installed in the refuge floor of a high-rise building flatly, which is fitted with a retractable fire extinguishing medium transmission pipeline, as shown in Fig. (1), among them, 1 denote the retractable guide rail, 2 denote the fire extinguishing system, 3 denote the retractable fire extinguishing medium transmission pipeline.

The fire extinguishing system consists of 6 parts, as shown in Fig. (2), among them, 1 denote the fire monitoring device, 2 denote the spray gun control system, 3 denote the fire monitoring and transmission system, 4 denote the inherent power, 5 denote the retractable guide rail, 6 denote the fireproof control room, 7 denote the fire extinguishing gun.

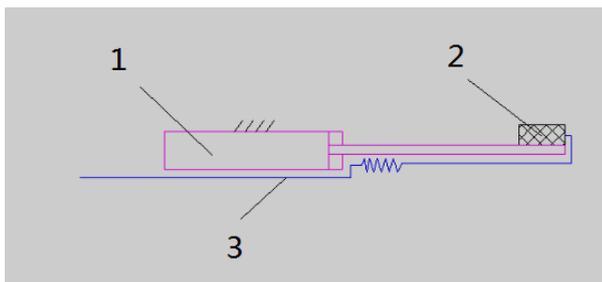


Fig.1 Retractable guide rail

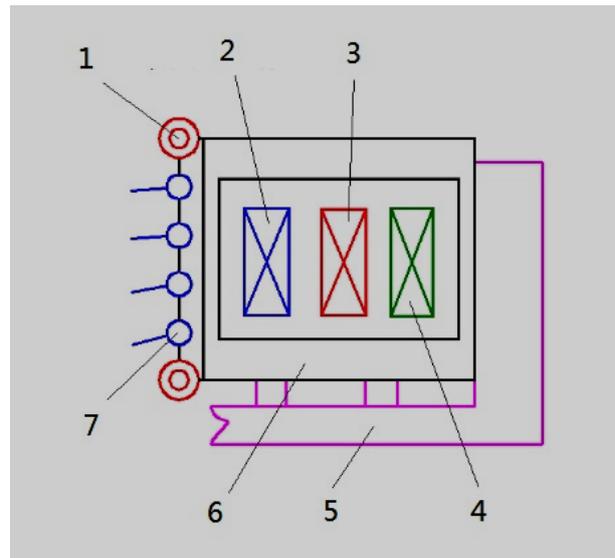


Fig.2 Fire extinguishing system

The ground remote central control system consists of four parts, include 4 to 7, as shown in Fig. (3), among them, 1 denote the fire extinguishing range of spray gun, 2 denote the high-rise building, 3 denote the refuge floor, 4 denote the ground remote central control room, 5 denote the fire extinguishing media transmission control system, 6 denote the spray gun remote control system, 7 denote the real time fire information display system.

B. Working Principle And Workflow

When the fire occurs, the equipment can be extended out of the building from inside of the building by means of manual or automatic way. The fire extinguishing system is fixed installed at the end of the retractable guide rail. Under normal circumstances, which located in the building.

Three-dimensional reorientation can be realized in fire monitoring device, both with the function of lighting and information gathering, and the information will be transmitted to the ground station of the central control room wireless through the fire monitoring transmission system, command sent to the spray gun control system wireless by control room according to the fire condition, adjust the direction of the fire fighting gun by spray gun control system, so as to achieve accurate fire fighting. The inherent power in fire extinguishing system provides power security for gun control system and fire monitoring and transmission system, high efficient rechargeable batteries adopted as the inherent power.

The working range of a single fire extinguishing gun depends on the power of the fire fighting medium transmission control system and the type of fire extinguishing media and so on, the vertical working range of a single gun at least cover half the distance of the adjacent two refuge floor, the horizontal working range of

a single gun is the same as the vertical working range of a single gun, the working range of multiple gun is also determined by the size of the horizontal frame and the number and length of the spray gun.

In view of the facts that the high-rise building is a large object, a single set of embedded retractable high-rise building fire rescue equipment can not meet the requirement of the whole building fire rescue, as shown in Fig. (3), we need to consider the building surface area and rescue area of single set of rescue equipment, multiple sets of rescue equipment installed on refuge floor according to certain

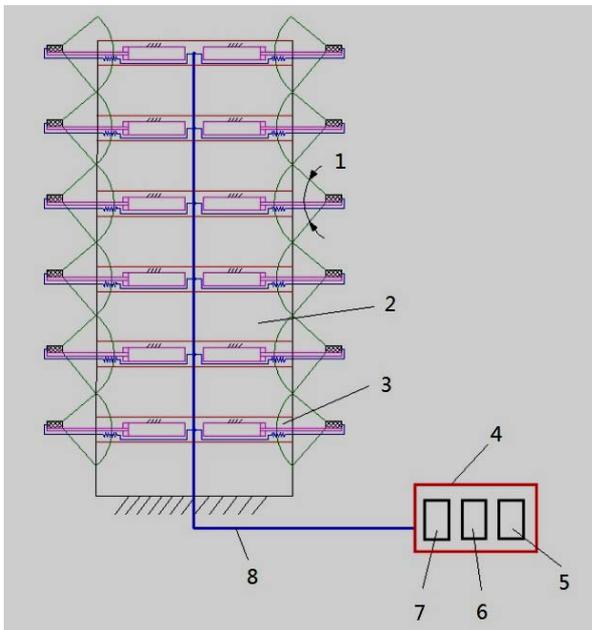


Fig.3 Ground remote central control system

requirements, as shown in Fig. (4) and Fig. (5), full coverage fire rescue of high-rise building obtained then.

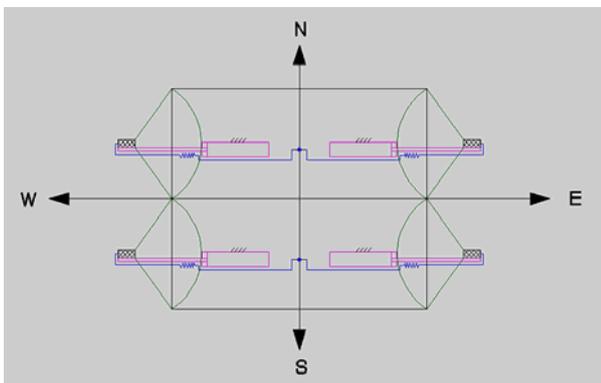


Fig. 4 Equipment installed flatly along direction of east and west

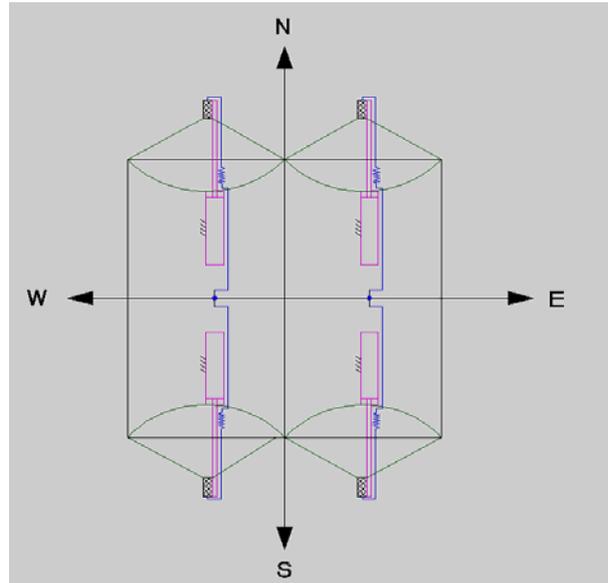


Fig. 5 Equipment installed flatly along direction of south and north

The workflow of the equipment as shown in Fig. (6), when the fire occurred, automatic fire alarm system in high rise building started, which combined with the ground remote central control room and control system installed inside the refuge floor, retractable guide rail equipment nearly corresponding to the fire site started then, the fire monitoring system to start lighting based on visibility, which collect the fire information and transmit to the ground remote central control system, and display the real-time information, instructions for gun control system issued by the ground control personnel according to the fire information, adjust the direction of the spray gun to the proper position, and start the fire extinguishing media transmission and control system then, accurate fire fighting of high-rise building realized, until the fire eliminated completely, fire extinguishing gun stop working, ground remote central control system sends out the instruction, the guide rail retracted, the whole equipment stop working.

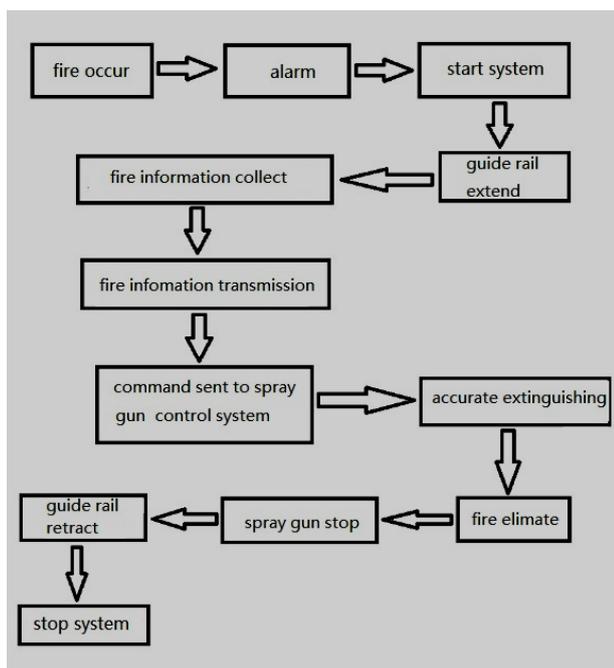


Fig.6 Workflow of embedded retractable high-rise Building fire rescue equipment

#### IV. CONCLUSION

A new type of embedded retractable high-rise building fire rescue equipment presented in this work, analysis and design carried out on the structure and working principle and workflow, this equipment overcome the disadvantages of limited height of existing rescue equipment and discontinuous fire fighting and non precision fire fighting and limited operating space and other issues, research and application of it will solve the worldwide problem in high-rise building fire rescue, it will make up the defects when the automatic sprinkler system can not work effectively, when the external rescue equipment can not be used effectively, thus provide reliable fire rescue means for high-rise buildings, it will play an important role in human building development and production and life, great benefits will be brought to social development.

#### CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

#### ACKNOWLEDGEMENT

This work is supported by the Fundamental Research Funds for the Central Universities (No. 3142015023),

research fund on science and technology of Hebei province (No. Z2015072), National Natural Science Foundation (No. 50975024).

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