International Journal of Research and Engineering
ISSN: 2348-7860 (O) | 2348-7852 (P) | Vol. 5 No. 4 | April 2018 | PP. 360-363
Digital Object Identifier DOI® http://dx.doi.org/10.21276/ijre.2018.5.4.4

Design and Manufacturing of Pole Climbing Unmanned Fire Extinguisher

Author(s): [1]Neeraj Dhakephalkar, [1*]Anirudha Kharote, [1]Amrutsingh. J. Patil

Affiliation(s): [1]Department of Mechanical Engineering, Smt. Kashibai Navale College of Engineering, Pune, India
Corresponding author: anirudhaskharote@gmail.com

ORIGINAL ARTICLE

Abstract: May it is the destruction of Jerusalem temple in 587BC or the infamous disaster in a mall in the Philippines in December 2017, a fire was the major culprit. Fire is one of the most severe and frequent disasters faced by the mankind especially in the machine age. Our project focuses on extinguishing such city fires with the help of a specially designed robot. The proposed robot would climb up a pole which can easily be constructed with minimal expenditures and efforts during or after the construction of the building. The robot being able to climb pole, would be able to traverse upwards, no matter at what height the fire is set. This versatility would eliminate the problems posed due to insufficiently long ladders (100 feet maximum) with the firefighting department. The robot is also equipped with a motor controlled nuzzling arrangement which will allow spraying the water jet in all possible directions. Such use of technology also safeguards the lives of firefighters which in conventional methods are put in danger. The robot will be equipped with a camera at the top which would enable the controller to judge the intensity and severity of the fire. The robot can be wirelessly controlled using radio controlled device which can control the locomotion of robot, direction control of water jet and an LCD which can display the camera sight.

Keywords: *Firefighting robot, LCD, Pole climbing, Radio controlled*

I. INTRODUCTION

Fire is one of the major disasters faced by the mankind especially in the the machine age. According to a modern survey fire is one of the major reasons for death of people on large scale after terrible natural disasters like tsunamis and earthquakes. In order to extinguish urban fires, the Government of India provides firefighting services in city areas. Various methods are employed to extinguish different types of fires: Domestic, Industrial, Chemical, and electric short-circuit etc. However, the fire fighters face tremendous amount of difficulty while extinguishing fires set on high rise buildings- Skyscrapers. The longest of the ladders on fire engines measure approximately 100 feet i.e. they are sufficient only up to the tenth floor. Apart from this, in many cases of raging fire, the fire fighters are not able to reach intricate places because of extremely high temperatures. Fire fighters have to risk their life when working 100 feet from the ground performing their duty. Our proposal tries to find a solution for this problem.

The proposed robot will perform the task of a firefighter and can easily extinguish fire set at any height from the ground. The robot comprises of two parts mainly-

- Pole climbing arrangement
- The hose and nozzle directing arrangement

The pole climbing arrangement consists of wheel and pulley arrangements to provide proper grip over the pole. High torque motors are provided which ensures that the robot is able to transverse in upward direction along the pole with all the self-weight and other loads acting on the robot if any. The pulleys are firmly gripped to the pole using a mechanical arrangement which provides both compactness and required gripping force. The design of the robot is such that the reaction forces provide the required grip and hence slipping conditions are avoided even over wet surfaces.

An arrangement is provided on the robot to properly hold/house the spraying end of the nozzle of the robot. This housing is mounted on a hollow shaft attached to a high torque motor. Bushes are provided to avoid direct loading on the shaft of the motor. The bushing arrangement would also bear the reaction force of the water jet gushing out of the nozzle. The direction of the water jet through the nozzle can be easily controlled by controlling the angle of the motor about the horizontal axis. This provides the required flexibility while extinguishing rampant fires.

II. TYPES OF FIRE AND EXTINGUISHING METHOS (CITY):

Logo	Description	Type	Suitable suppression
	Combustible materials (wood, paper, fabric, refuse)	Class A	Mainly water and suppressing agents like carbon dioxide
	Flammable liquids	Class B	Inhibiting chemical chain reaction, such as dry chemical or Halon
	Flammable gases	Class C	Inhibiting chemical chain reaction, such as dry chemical or Halon
	Flammable metals	Class D	Specialist suppression required
	Electrical fire	Class E	As ordinary combustibles, but conductive agents like water not to be used
	Cooking oils and fats	Class F	Suppression by removal of oxygen or water mist

Table 1: Types of Fires

(A) City fires

These comprise of the fires set to simple households like wood, plastics, cloth, domestic articles, etc. This type of fire is commonly set due to leakage in gas cylinders, fire crackers etc. Extinguishing of Class A fires is mainly carried out with the use of simple fire extinguishing techniques which involve water spray and spraying CO2.

Water jet helps breaking the supply of oxygen and thus extinguishes the fire. Wetting of the surface by water prevents spreading of fire and also causes a drop in the temperature. Water being available in plenty amount is preferably used by the firefighting department in order to extinguish such city fires. (Class A, Class B, Class F).

However, water cannot be used to extinguish fires set due to electric failures and short-circuits. Water breaks downs into its constituent elements viz- Oxygen and hydrogen and both of them help spread fire. Water being a good conductor of electricity also acts as a medium for the flow of current which may worsen the situation.

(1)

$$2H_2O \xrightarrow{\text{Electric current}} 2H_2 + O_2$$

(Water) (Hydrogen) (Oxygen)

Such fires set up because of electric short circuits are extinguished by class C fire extinguishers which contains CO_2 foam, ABS powder or dry chemicals.

III. CONSTRUCTION OF ROBOT

(A) Main Frame

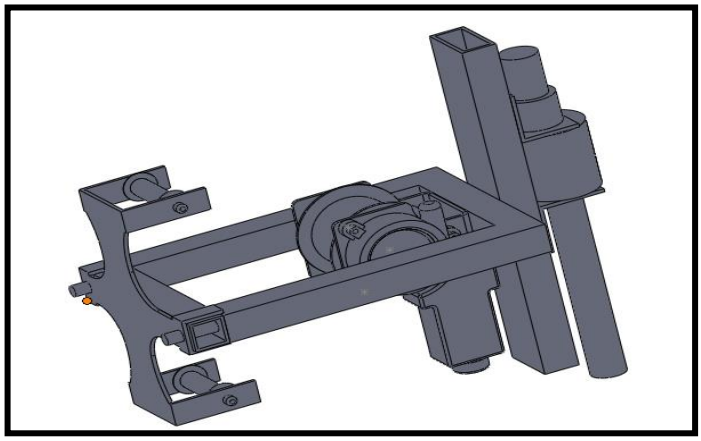

Figure 1: Schematic of final design

The proposed robot consists of two frames which hold the robot around the standard dimension square pole. The main frame is a C-shaped frame which will surround the pole from three sides. The second frame will be used to lock the main frame onto the pole. Locking is being done with the help of a mechanical nut-bolt arrangement. The two frames will be constructed separately and joint on site during the application. The frames will be constructed using stainless steel. Four stainless steel pipes (1”×1”) will be used to form the two frames. Cutting and welding operation will be used to manufacture the two frames.

The proposed robot has a simple construction. The skeleton of the robot prototype is made up of stainless steel to make it light weight and durable. However the actual robot needs

to be constructed out of mild steel to be fire resistant. Chassis has been constructed using a combination of welding and cutting processes. The bracket of the C-clamp arrangement is manufactured using laser cutting and bending. Archimedean screw arrangement is being used for locking the robot on the pole. Nozzle dimensions will be according to the specifications provided by the fire department.

The main frame consists of a C-clamp arrangement. This forms housing for the high torque motor. A wheel pulley drive is attached on the shaft of the motor. This is the driving pulley which enables the wheel to climb up the pole. The second frame consists of another C-clamp arrangement on which two dummy wheel pulley arrangements have been mounted. These dummy wheels provide support to the driving wheel while traversing up as well as down on the pole.

(B) Nozzle Assembly

Nozzle assembly is being used for the purpose of spraying water via the pipes provided on the fire extinguishers on to the fire. The customized device is mounted on a stainless steel hollow shaft connected between two bushes on the chassis. High torque low rpm motor will be used to control the movement of the nozzle assembly about the shaft. Shaft will be mounted between two bushes mounted lengthwise along the robot.

The mechanism will be attached on the shaft with the help of a flange coupling. The flange will be attached on the top surface of the mechanism with the help of M4 fasteners. Hollow shaft will be inserted inside the neck of the flange. These will be held together with the help of a laterally inserted M3 bolt.

Nozzle can move freely around the horizontal axis. The nozzle will be modified to suit the high pressure application. Venturi losses are encountered in nozzles which lead to a decrease in velocity of the water which restricts the range of the nozzle. A hole will be drilled at an angle of 45˚in the nozzle which will change the orientation of the nozzle with respect to the horizontal axis. Water coming out of the nozzle will move in a projectile direction and losses due to vena-contracta formation will be reduced to least minimum.

IV. WORKING OF ROBOT

The robot will be manually mounted on the pole which would be installed during the construction of the building. A mechanical gripping system will then enable the robot to grip firmly to the pole. There are two forces facilitating this gripping action on the pole viz-

- Clamping Force
- Friction Force

The main frame will be locked onto the pole with the help of the second frame. This extends the wheel pulley arrangement towards the pole. A high clamping force will be exerted on the pole by the wheel pulley arrangement. As the robot is now gripped firmly on the pole, it will tend to descend in the downward direction due to self-weight. The wheel material is so selected that it will be able to sustain this downward motion. A frictional force will act in the upward direction and cancel out the downward force.

The operator will then actuate the motor after the robot has firmly gripped the pole. The wheel pulley arrangement coupled to the motor enables the robot to traverse along the pole. Two supporting rollers on the second frame will help the robot to remain stable while traversing on the pole. The robot will then reach the required height on the pole.

The operator will be able to view through the window with the help of the camera attached on the robot which allows the operator to observe the site. The device attached to the robot will enable to position the nozzle accurately with respect to the fire affected area. The fire fighters reservoir is connected to the nozzle via the pipe.

Consequently, water or foam based fire extinguisher will be sprayed on the affected area via the nozzle attached to the pipe. Nozzle can be provided free motion about the horizontal axis. This combined with the vertical traverse of the robot enables the robot to cover the entire range of the window and thus extinguishing fires efficiently. The robot will return to its starting position after completely dousing the fires on the affected floors. The working wheel will be powered using the power window motor to perform the same. The motors will be powered using 18V battery which will be mounted on the chassis of the robot using mechanical screwing arrangements. The robot will be dissembled following its application by unscrewing the locking frame from the main frame. As a result, not only is the robot compact in size but also saves crucial time during emergency

V. CONCLUSION

Thus, we manufactured a robot that will be able to extinguish fires in sky-scrapers and vertical high rise buildings. Our robot will solve the various problems involved in extinguishing fires in high buildings. It will provide an effective mean for the water or fire extinguishing foam to reach the affected area at any altitude possible. It successfully provides us with an option to douse fire without any human interference which not only saves human life but also does the job in less time and more efficiently as

compared to humanized fire extinguishers. Thus, the unmanned fire extinguisher is the solution to the aforementioned problems.

VI. FUTURE SCOPE

The proposed robot is a working prototype of an unmanned robotic fire extinguisher. The robot can be used to extinguish class A type of fires through the window of the high rise buildings. The range of the water-jet will depend on the pressure generated by the pump. Higher range can be obtained by increasing the pressure of the pump. The design and construction of the chassis will have to be done accordingly. Reaction forces acting on the chassis of the body can lead to mechanical failure of the chassis. It will have to be designed accordingly to sustain the large amount of force.

The proposed robot is able to douse fire through the window of the buildings. It will not be able to counter the internal fires. We propose that in order to extinguish internal fires, a second automated sister robot will be launched through the window. The robot will enter through the window and will be able to douse the fire. This robot will be an autonomous compact machine which will be able to detect as well as extinguish fire by moving in the interior of the affected areas. The robot will be able to detect the fire using infrared sensors installed on the body. Thus the combination of two robots will successfully be able to douse any type of fires autonomously.

The proposed robot is effective only in extinguishing type A fires. Foam based extinguisher can be used to counter rest of the types by changing the type of dispenser. A foam dispenser will have to be attached to the robot in place of a water dispenser. If the above mentioned foam dispenser can be provided by the fire extinguishing team, the proposed robot will be able to eliminate electric fires as well.

The proposed robot is used to extinguish fires in vertical high rise buildings. Horizontal traverse can also be made possible by inducing slight modifications in the design of the robot. This can be used in extinguishing fires over a workshop floor or assembly floors in large industries. Just by changing the orientation of the pole on which the robot will be able to move, the proposed robot will be able to traverse about the horizontal axis by inducing no changes in the fire extinguishing mechanism.

The pole climbing mechanism in our robot can be used for applications other than fire extinguishing as well. The robot is able to scale any vertical height easily and in less time with less accident risks as compared to a human climber. This mechanism can be used in applications like cleaning the windows of high rise buildings, changing the light bulbs of high towers, plucking coconuts from coconut trees more efficiently and without any risks.

VII. DECLARATION

As stated above we have developed the working prototype of the fire extinguishing robot. But to integrate it with another sister robot as discussed we need funding as well as technical assistance from experts. We are keen to witness this robot in actual use as it would guarantee safety of fire fighters.

REFERENCE

[1] Jianglong Guo, Laura Justham, Michael Jackson, Robert Parkin," A Concept Selection Method for Designing Climbing Robots", Key Engineering Materials Vol. 649 (2015) pp 22-39.

[2] Akshay Prasad Dubeya, Santosh Mohan Pattnaikb, Arunava Banerjeec, Rajasree Sarkard, Dr. SaravanaKumar R," Autonomous control and implementation of coconut tree climbing and harvesting robot", Procedia Computer Science 85 (2016 755-766).

[3] M. Nili Ahmadabadi, Senior Member, IEEE, H. Moradi, Member, IEEE, A. Sadeghi, A. Madani, and M. Farahnak," The Evolution of UT Pole Climbing Robots", 1st International Conference on Applied Robotics for the Power Industry 2010 IEEE.

[4] Kyeong Ho Cho, Young Hoon Jin, Ho Moon Kim, Hyungpil Moon, Member, IEEE, Ja Choon Koo, Member, IEEE, and Hyouk Ryeol Choi, Member, IEEE," Caterpillar-based Cable Climbing Robot for Inspection of Suspension Bridge Hanger Rope", IEEE International Conference on Automation Science and Engineering2013 IEEE 1059-1062.

[5] Frank E. Schneider and Dennis Wildermuth," Using Robots for Firefighters and First Responders", 2017 IEEE 216-221.

[6] AlHaza Ta, Alsadoon Aa, Alhusinan Za, Jarwali Ma , Alsaif K," New Concept for Indoor Fire Fighting Robot", ,Procedia - Social and Behavioral Sciences 2015 2343-2352.