Design and Fabrication of Fire Fighting Robotic Arm for Petrochemical Industries

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Abstract

Rapid industrialization and vast life situations caused the number of various hazardous and non-hazardous industries, high rise building, shops, storage facilities, oil and gas facilities etc. These are vulnerable sources of fire due to the presence of inflammable material. When a fire occurs in such situations, fire fighting is a difficult task to achieve successfully. If we use a fire truck to extinguish the fire it limits the access to the fire point and causes various life accidents of fire man. And also the long postures by holding the hoses and resisting the forces of back pressure due to water is a major issue faced by the fire-fighters. In this paper we are introducing a FIREMAN ROBOTIC ARM which enables better fire fighting features without the exposure of fire man. Here we use arduino based microcontroller and C programming methodology to function the robot. To establish the movement of the robot we use chain driven wheel which yields more stability. The robotic movement is based on the remote control. The water jet is provided both in horizontal and vertical direction to put out the fire. So this kind of new fire fighting methodology with proper controlling mechanism is effective than the current fire fighting systems.

Keywords: *Fire fighting robot, radio frequency, arduino*

I. INTRODUCTION

Today, fire fighting is a crucial task which is faced by the fire man. The fire man suffers difficulties in various types of fires especially fires involving in industries. Some of them are reaching the fire scenario accurately, put out fires by approaching the location and resulting various types of life threatening exposures to them. When we analyse this situation we can understand that majority of accidents are resulting to the fire man due to fire. The development in Robotics can be applied to such situation. It has a major role in the field of safety. In this paper we are introducing a fire fighting robotic arm which will work similar to fire man hand in fire fighting scenario. It can be used to increase the effectiveness of fire fighting and reduces the various exposures and difficulties faced by fire man. If multiple types of such Robotic arm can be used to put out complex fire efficiently.

II. METHODOLOGY

The fire fighting robotic arm is a remote controlled robot which can be used for fire fighting effectively. It consists of microcontroller, wheels for the drive, motor driver IC, DC motors, servo motors, power, zigbee communication device, a printed circuit board and an effective fire fighting media such as water. (Size 10 & Normal)An easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it.

The microcontroller which is ATMEGA 328 gives sufficient memory storage and known as the brain of the robot which controls the overall functions of the robot. The program is stored in the microcontroller. According to which the robot works. Wheels which are chain driven provide movement of the robot from one place to another. The wheel motion is controlled by a driver IC, which is L293 D. This diver IC provides independent rotation of the wheels in clock wise and anti-clock wise. The four DC motors are connected with four wheels so that it will rotate as the motor rotates. The servo motors which is used for the arm movement and provides support for the robot. The servo motor is capable of giving 180^0 rotation and we choose by 100 movement. For the working of the robot, suitable power source is required which is enabled with the battery support. Suitable means of communication is necessary for sending and receiving signals from remote and robot. In general any kind of extinguishing media can be used. The water is the cheapest and effective one. This kind of fire fighting technology is relevant considering todays advancements in various field of engineering and technology. This will reduce the effort and the exposures faced by the fire man. Considering the application of this system the consideration of cost can be neglected. And it comes in the affordable range.

I. TABLE I
COMPONENTS USED IN FABRICATION

Sl. No	Component description		
	Part Name	Quantity	Description
1	Arduino uno board	1	ATMEGA 328,14 digital input/output pins,6 analog pins, 16 MHz crystal oscillator, 5V, 40 MA, 32 kb memory
2	Motor driver IC	2	L293 D, 5 KHz, 16 pins, 4.5-36V
3	Voltage regulator	5	LM 317, 1.5A, 1.2-37V
4	DC Motor	4	10rpm, 12V, max ,450 MA Geared
5	Servo motor	2	5V parallax standard servo
6	Zigbee communication module	2	10 m range
7	Battery	2	12 V,9V
8	wheels	4	

III. DESIGN AND FABRICAT.ION

The main aim of the fire fighting robotic arm is to facilitate the function of fire man. The fire fighting robot is capable of providing forward and backward, left and right side motions when the operator presses the key via a zigbee communication system. And the jib also provides left, right, up and down motion to aim the water to the fire source to extinguish it. Its movement is also connected by remote control.

The support which resists the back pressure and provides stability for the robot system.

The following equations are used to find out the back pressure, effective height of jet of water, and water discharge rate.

The reaction force due to water hammer is given by

$$R = (1.57 \times P \times d^2)/10 \qquad (1)$$

Where P is the pressure in bar at the nozzle and d is the diameter of the nozzle in mm

The theoretical height of jet is find out by

$$H=V^2/2g \qquad (2)$$

Where H is Height in meters; V is velocity in m/s and g is the acceleration due to gravity

The effective height of jet of water is given by

$$H_e=2/3(H-0.113H^2/d) \qquad (3)$$

Where H_e is the effective jet in meter, d is diameter of nozzle in mm, and H is the theoretical height of water jet

The discharge rate is found out by

$$Q=2/3 \times d^2 \times (p)^{1/2} \qquad (4)$$

Where Q is the discharge in litre/minute; d is the diameter of nozzle in mm; p is the pressure in bar

The fire fighting robotic arm consist of 5mm diameter nozzle; and pressure of 2 bar
By substituting in equation (1)
Reaction force due to water hammer,
$R=(1.57 \times 2 \times 5^2)=7.85$ newton
The theoretical height of water jet is found by equation (2)
$H= 19.8^2/(2 \times 9.81)=20$ m
The effective height of water jet is found by equation (3)
$H_e=2/3(20-0.113 \times 20^2/5)=7.3$ m
The rate of discharge is found out by equation (4) as
$Q=2/3 \times 5^2 \times (2)^{1/2}=23.57$ litre/minute

Following are the steps in the fabrication

- ➢ Assembling the component of the structure of the robot as show in the figure
- ➢ Connection of components to the micro-controller (arduino ATMEGA 328).
- ➢ Checking the connection as per the given diagram.
- ➢ Using the diagram making the algorithm and the passing the coding to the arduino board.
- ➢ Converting the control using remote by RF signal
- ➢ Introducing of extinguishing media
- ➢ Verifying and trailing the robot by the continuous checking and running.
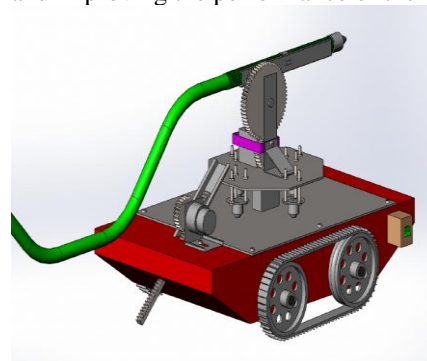- ➢ Finally obtaining the bugs, fixing the bugs and improving the performance of the robot.

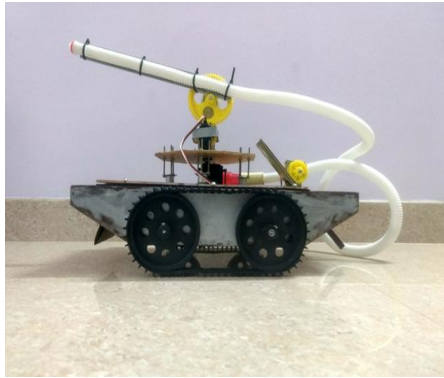**Fig.1 Isometric view of robotic body**

Fig.2 Final view of the fire fighting Robotic arm

IV. ADVANTAGES

Highly efficient method for fire fighting

➢ Reduces the direct exposure of fireman and his effort
➢ Extinguishing time can be reduced with the multiple number of similar number of robots
➢ Economical
➢ It is capable of fire fighting to the point of source
➢ The jet will have a greater range If we provide additional features like fire detection by sensors and using camera for recording the situation
➢ The robot will be highly effective Can be used for any kind of Fire extinguishing media
➢ It does not produces any adverse reactions

V. DISADVANTAGES

➢ To and fro motion to a same point is not possible
➢ Inability to fire fight automatically
➢ Need self-protection methods
➢ Cannot be used for indoor fire fighting

VI. RESULT

The development of the project was successful and the prototype will be able to extinguish the fire completely .The fire fighting robot can access the fire source directly and put out the fire in multiple directions using water as medium. It reduces the effort and exposure of the fireman in dangerous situations of fire. The robot can perform fire fighting more effectively than the current fire fighting systems with less damage. For our robot the jet reaction is obtained as 7.85 newton, the effective height of water jet is 7.3 m, and the water discharge rate is obtained as 23.57 litre/minute.

VII. CONCLUSION

Fire causes tremendous damage and loss of human life and property. Recently, in order to cope with such catastrophic accidents, research on Fire-fighting robots has been carried out in many countries. It is sometimes impossible for fire-fighting personnel to access the site of a fire because of explosive materials, smoke, and high temperatures. In such environments, fire-fighting robots can be useful for extinguishing a fire. These robots should be controlled by remote operators who are located far away from the fire site using remote communication systems. In order to control fire-fighting robots in dangerous places, robust radio communication systems are one of the important components of the robots.

In this paper we initially have done the completion of electronic part that is making connection with microcontrollers, installation of program etc. The next stage was to convert the control mechanism to a remote control using RF signal. Then we have done the fabrication of the robot body and attaching of chain driven wheel for movement of robot. Further we have provided a leg support to have more stability of robot. As the final stage we introduced a fire fighting system (water) to put out the fire by remote control.

Surely the Final product, this FIREFIGHTING ROBOTIC ARM will be good helpful for the current fire-fighting systems.

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