OXYGEN EXTRACTOR FIRE DETECTION SYSTEM: AN EFFECTIVE APPROACH TO EXTINGUISH FIRE OUTBREAK

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ABSTRACT

In society at large, fire outbreak has become a major concern. Nigeria Fire service and the mandated fire extinguisher, which expires after a short while have never sorted out the problem that's why we went into this research. Oxygen Extractor Fire Detection System aimed at tackling the problem of fire destruction in our society that causes loss of life and properties by first alerting human occupants through the alarm system within sixty seconds to leave the area. Secondly, after sixty seconds there will be automatic lock down, the next the system will introduce hydrogen or nitrogen to displace the atmospheric oxygen to another compound thereby inactivating fire in the area because without oxygen no fire, within this time limit, oxygen mask (supplemental oxygen) drop down will be introduced into the enclosed partitions (rooms, cars). Presently, this system is at prototype level with Visual BASIC 6.0. We believe that soonest the design will go into an active simulator like Proteus VSM professional to physical prototype via microcontroller or field programmable gate array (FPGA).

Keynotes:—oxygen extractor, alarm system, system lock down, oxygen, temperature detection,

INTRODUCTION

Since the earliest days of mankind, fire has been both a friend and a foe. Fire is defined as 'the destructive burning of something in which something such as a building or an area of land is destroyed or damaged by burning [3]. Fire requires fuel, oxygen and heat to burn, so the elimination of any of these elements will extinguish any fire risk no matter how intense**.** It is every man's wish for himself and his loved ones to be secure and safe at every point in time. As time goes by, the world becomes even more unsafe, with hazards such as natural disasters, fire disasters, pollution and theft threatening the existence of mankind, man devised a means of raising an alarm to alert people about these disasters before they either occur or they must have occurred [1].

STATEMENT OF THE PROBLEM

Fire since its invention has being doing good and bad to mankind. Humans have being struggling to fight fire through many means. We noticed that in every disaster and accident, humans are panicked to the extent that they will never remember the right things to do to save the situation and save themselves and their properties.

In Nigeria, we are aware of the fire extinguisher which many people don't even remember to use, even if they remember due to panic, most people cannot remember the operations of the system.

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.Again, we noticed that some people are not even bothered to know how to use the fire extinguisher, so when there is fire outbreak, it will be impossible for them to administer the extinguisher.

Thirdly, is the third world factor where most stored –pressure fire extinguishers imported into the country (Nigeria) are expired or of low quality which can never work in case of fire.

Finally, in Nigeria we have problems of nonchalant attitude, even with the access to the good quality fire extinguisher; no one has the time for checking the expiry date or the functionality of the fire extinguisher.

OBJECTIVES OF STUDY

The objectives of research work are:

1. To produce, locally, an oxygen extractor fire detection system in Nigeria for Nigerians.
2. To able to produce fire extinguisher that can solve all the problems mentioned in section II.
3. To develop a system that can automatically detect fire and quench fire.
4. To develop an automated fire extinguisher that uses automatic lockdown.
5. To develop an automated fire extinguisher with oxygen mask control.
6. To develop a fire detection system that can automatically trigger alarm for people to evacuate the fire infected area.

HISTORICAL BACKGROUND

Two hundred years ago, Americans early fire alarms were pragmatic. Communities announced fires by blowing whistles, ringing church bells, or even shooting guns into the air. In the 21st century, multi-functional community fire reporting method through wireless transmitters were introduced [3].

In the early times, gongs, bells, drums and even humans (guards) were also used to alert people when any mishap like fire was perceived, of course there measures were not efficient enough therefore new measures began to emerge.

The earliest American fire alarm came in 1658, when New York's first fire department employed eight men. Nightly the 'firemen' walked the streets checking for fires. This was adopted by American communities, shortly after its invention by Australians in the 1850s. The hand-shaken wooden rattle alarm woke people from impending harm.

Using the telegraph technology of 1852, William F. Channing and Moses Farmer designed two fire boxes with each containing a telegraphic key. When reporting a neighborhood fire, the person cranks the attached handle on the box releasing the key to send out a message of the box number to a central alarm station. Upon receiving the message, the telegrapher at the central headquarters sends the corresponding address of the box location to the fire department response team.[3]

Commercially, new construction and mobile home manufacturers embraced the first AC battery powered smoke detectors during the 1970s. Smoke alarm brought new companies into the industry. An estimated 92 percent of all American homes had smoke detectors by 1993.

RELATED LITERATURE

Once a fire breaks out, it can envelop a room within minutes, temperature in the room may exceed 600 degrees Celsius (1100 degree Fahrenheit), while this heat alone would be deadly,

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the toxic gas in the smoke cause majority of deaths and injuries. Destructive fires can occur wherever fuel and oxygen are available including office buildings, homes, vehicles and forests. The 21st century offer new technologies for the fire alarm systems working without wires [1]. Digital communicator systems, private radio systems and cellular transmitters are operable from the location of the user. In 2009, Dr David Albert, a research scientist and biomedical engineer as well as medical doctor released his invention to assist people unable to awaken from the standard chirping or light based residential smoke and fire alarms. The new system listens for the sound of the regular fire alarm then sends its own signal to the bed [1]. Sleepers feel forceful intermittent vibrations throughout the bed from part of the device. The target groups benefiting from this alarm system include hearing impaired, older adults, heavy sleepers and those who use sleep medication.

Fire Triangle

The fire triangles or combustion triangles are simple models for understanding the necessary ingredients for most fires [4]. The triangle as shown in fig.1, illustrates the three elements a fire needs to ignite: heat, fuel, and an oxidizing agent (usually oxygen). A fire naturally occurs when the elements are present and combined in the right mixture, meaning that fire is actually an event rather than a thing. A fire can be prevented or extinguished by removing any one of the elements in the fire triangle. For example, covering a fire with a fire blanket removes the oxygen part of the triangle and can extinguish a fire.

Figure 1: The fire triangle [4]

The fire tetrahedron as shown in fig. 2 represents the addition of a component, [4]the chemical chain reaction, to the three already present in the fire triangle. Once a fire has started, the resulting exothermic chain reaction sustains the fire and allows it to continue until or unless at least one of the elements of the fire is blocked. Foam can be used to deny the fire the oxygen it needs. Water can be used to lower the temperature of the fuel below the ignition point or to remove or disperse the fuel. Halon can be used to remove free radicals and create a barrier of inert gas in a direct attack on the chemical reaction responsible for the fire.

[4]Combustion is the chemical reaction that feeds a fire more heat and allows it to continue. When the fire involves burning metals like lithium, magnesium, titanium, etc. (known as a class-D fire), it becomes even more important to consider the energy release. The metals react faster with water than with oxygen and thereby more energy is released. Putting water on such a fire results in the fire getting hotter or even help it to explode. Carbon dioxide extinguishers are ineffective against certain metals such as titanium. Therefore, inert agents (e.g. dry sand) must be used to break the chain reaction of metallic combustion.

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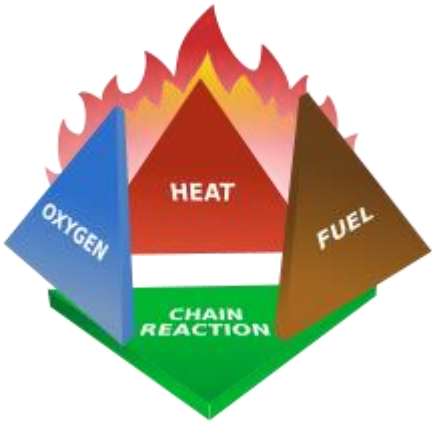

Figure 2: The fire tetrahedron [4]

In the same way, as soon as one of the four elements of the tetrahedron is removed, combustion stops.

The Oxidizer

The oxidizer is the other reactant of the chemical reaction [8]. In most cases, it is the ambient air, and in particular one of its components, oxygen (O_2). By depriving a fire of air, it can be extinguished; for example, when covering the flame of a small candle with an empty glass, fire stops; to the contrary, if air is blown over a wood fire with bellows, the fire is activated by the introduction of more air. In certain torches, gaseous oxygen is introduced to improve combustion.

Some chemicals, such as fluorine gas, perchlorate salts such as ammonium perchlorate, or chlorine trifluoride, act as oxidizers, sometimes more powerful ones than oxygen itself [9]. A fire based on a reaction with these oxidizers can be very difficult to put out until the oxidizer is exhausted; that leg of the fire triangle cannot be broken by normal means (i.e., depriving it of air will not smother it).

In certain cases such as some explosives, the oxidizer and combustible are the same [8] (e.g., nitroglycerin, an unstable molecule that has oxidizing parts in the same molecule as the oxidize able parts).

Reaction is initiated by an activating energy, in most cases, it is heat [9]. Several examples include friction, as in case of matches, heating an electrical wire, a flame (propagation of fire), or a spark (from a lighter or from any starting electrical device). There are also many other ways to bring sufficient activation energy including electricity, radiation, and pressure, all of which will lead to a temperature rise. In most cases, heat production enables self-sustainability of the reaction, and enables a chain reaction to grow. The temperature at which a liquid produces sufficient vapor to get a flammable mix with self-sustainable combustion is called its flash-point.

Extinction of Fire

To stop a combustion reaction, one of the three elements of the fire-triangle has to be removed [10]. Without sufficient heat, a fire cannot begin, and it cannot continue. Heat can be removed by the application of a substance which reduces the amount of heat available to the fire reaction. This is often water, which requires heat for phase change from water to steam. Introducing sufficient quantities and types of powder or gas in the flame reduces the amount of heat available for the fire reaction in the same manner. Scraping embers from a burning structure also removes the heat source. Turning off the electricity in an electrical fire removes the ignition source.

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Without fuel, a fire will stop. Fuel can be removed naturally, as where the fire has consumed all the burnable fuel, or manually, by mechanically or chemically removing the fuel from the fire[4]. Fuel separation is an important factor in wild land fire suppression, and is the basis for most major tactics, such as controlled burns. The fire stops because a lower concentration of fuel vapor in the flame leads to a decrease in energy release and a lower temperature. Removing the fuel thereby decreases the heat.

Without sufficient oxygen, a fire cannot begin, and it cannot continue [10]. With a decreased oxygen concentration, the combustion process slows. Oxygen can be denied to a fire using a carbon dioxide fire extinguisher, afire blanket or water.

Hypoxic air technology for fire prevention

Hypoxic air technology for fire prevention, also known as oxygen reduction system, is an active fire protection technique based on a permanent reduction of the oxygen concentration in the protected rooms [14]. Unlike traditional fire suppression systems that usually extinguish fire after it is detected, hypoxic air is able to prevent fire. It is a technology based on the usage of air with reduced oxygen content that is injected to the protected spaces continuously to lower the oxygen concentration until the desired oxygen concentration is reached. Then, because of air, the oxygen concentration inside the protected volumes rises: when it exceeds a certain threshold, low-oxygen air is again injected to the protected volumes until the desired oxygen concentration is reached. Oxygen sensors are installed in the protected volumes to monitor continuously the oxygen concentration.

Working principles of Hypoxic air technology

In a volume protected by hypoxic air, a normobaric hypoxic atmosphere is continuously retained: hypoxic means that the partial pressure of the oxygen is lower than at the sea level, normobaric means that the barometric pressure is equal to the barometric pressure at the sea level [12]. Usually 5%/10% of oxygen contained in the air is replaced by the same amount of nitrogen: as a consequence a hypoxic atmosphere containing around 15 Vol% of oxygen and 85 Vol% of nitrogen is created. In a normobaric hypoxic environment, common materials cannot ignite or burn. Thus, considering the fire triangle in fig. 1, a fire cannot occur because of the lack of sufficient oxygen.

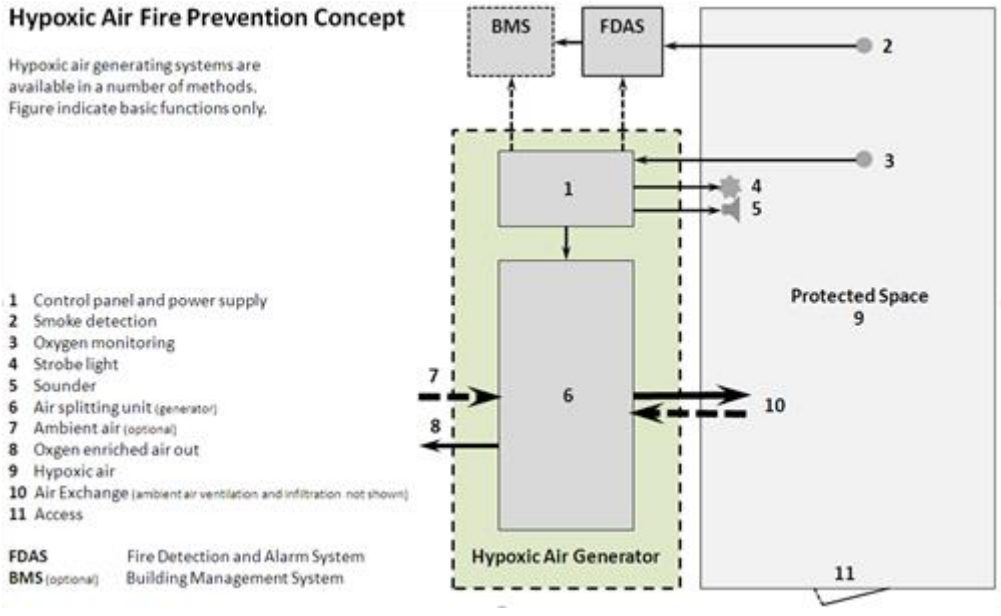

Figure 3: Hypoxic air fire prevention [14]

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"However, at 15% oxygen level, risk for fire still exists, and the system cannot be seen as an alternative to extinguishing systems.". The exact oxygen level to retain in the protected volumes is determined after a careful and accurate assessment of materials, configurations and hazards. Alternatively the ignition-limiting threshold is determined as shown in fig. 3 by performing a proper ignition test described in BSI PAS 95:2011 - Hypoxic air fire prevention systems specification [13]. Smoke detectors are installed in protected volumes because, similar to gas suppression systems, hypoxic air does not prevent smoldering and pyrolyzing processes. Air with low oxygen concentration is produced by hypoxic air generators, also known as air splitting units. Hypoxic air generators can be located inside or outside the protected rooms. Hypoxic air systems can be integrated with the building management system and can include systems to recover the heat generated by the hypoxic air generator that, otherwise, would be wasted.

METHODOLOGY

The first existing system which we analyzed is the conventional fire extinguisher that the Nigeria Road safety corp. normally forces all motorists to carry always and kept in some houses. In Nigeria, if there's a fire outbreak, and there is no fire extinguisher around, before the occupants of the building can reach the fire emergency department, the fire must have damaged most of their properties and even some lives. This system proved futile because not everybody can use it, at times when you buy from Nigeria market you found some empty or expired, there is no alarm and temperature detection system to even indicate or sense the fire. Fire can start without the occupants of the building being aware of it. Oxygen in the atmosphere makes fire to spread, in this system fires cannot be put out due to the presence of oxygen in the environment. It can only put off a limited size of fire, therefore not suitable for huge fire outbreaks.

The second existing system was reviewed in section D. We found out that the system must continuously generate and reduce oxygen from the protected space [11], this system might not work in any 3rd world country like Nigeria due to the cost of maintenance. This system uses smoking detecting system instead of temperature detecting system. This system poses health hazard to human occupants due to reduction of oxygen content to less than 15%.

A. The Proposed System

The new system will regulates change in room temperature, when the temperature of the room which is supposed to be about 25°c increases to about 40°c, this system sets off a warning alarm, this warning alarm enables the occupants of the house or building to know that something is wrong and they can check for the cause of the increase in temperature. When the room temperature increases to about 70°c which indicates that there's fire somewhere, the system sets up danger alarm to beep continuously, it beeps for 60secs then there will be automatic lock down. After the automatic lockdown, oxygen mask is released into the room, the occupants of the room that were not able to escape the room before the shutdown makes use of the oxygen mask. As they are using the oxygen mask, the system releases Nitrogen (N_2) into the building, this nitrogen reacts with atmospheric oxygen to produce Nitrous oxide (N_2O) which is also known as laughing gas, this gas is a nonflammable gas and its not harmful to human health if inhaled in a little quantity. Since fire needs oxygen to spread and the oxygen in the building has been extracted by the nitrogen, the fire does not spread and all this reaction happens within 30secs. When the fire dies down, the doors are opened and oxygen returns to the room, lives and properties are saved. This is illustrated more in fig. 4 and fig. 6 below.

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B. Advantages of The Proposed System

C. There are a lot of advantages of the new system as emphasized in the objectives.

1. It's a fast method and means of preventing fire outbreaks from occurring. It also regulates the temperature in a room to detect temperature change (i.e. to know when the room is getting hotter). Oxygen is extracted from the room, this will stop the spread of fire.
2. There is no need to call fire service or use the conventional fire extinguisher in an emergency like fire outbreak.
3. This system does not involve water to extinguish fire which is not advisable for data centers, document storages and chemical storages
4. The system goes to action only when there is fire outbreak thereby cutting cost quite unlike the hypoxic air fire prevention system that works continuously.
5. This system uses temperature detecting system that triggers above room temperature quite unlike system that uses smoke detecting mechanisms that triggers when there is already fire.
6. The most important advantage is that it does not have any health hazard like fire-prevention systems which result in the oxygen content being less than 19.5%. they are not permitted for occupied spaces by federal regulation (OSHA) in the United States [5] though medical researches carried out on this issue proved that hypoxic air is safe to breathe for most people.[6]. Angerer and Novak's conclusion is that "*working environments with low oxygen concentrations to a minimum of 13% and normal barometric pressure do not impose a health hazard, provided that precautions are observed, comprising medical examinations and limitation of exposure time*".[7]

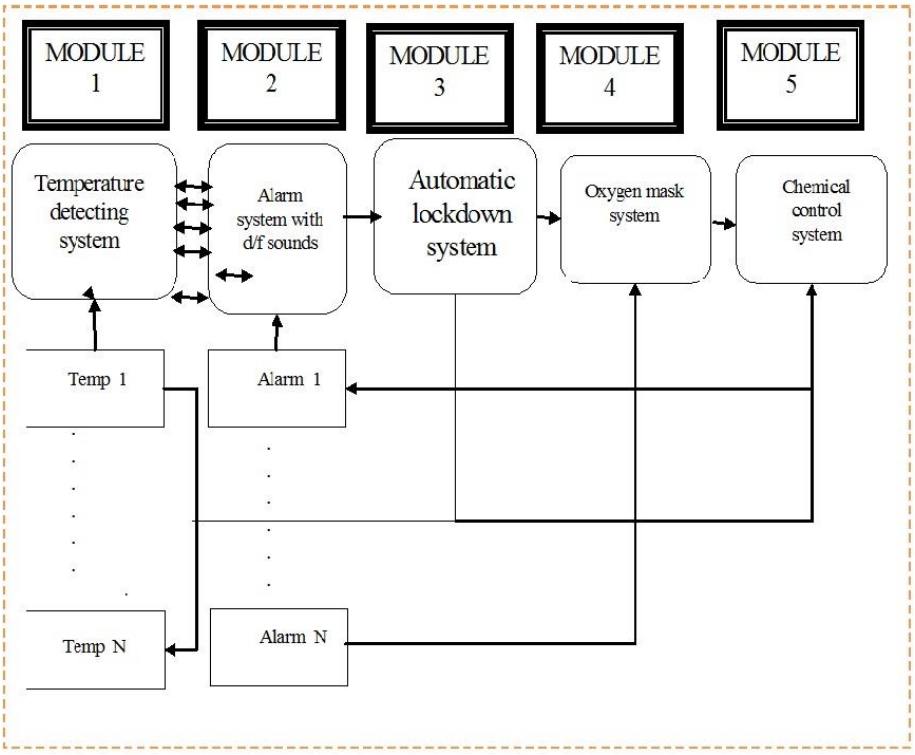

Figure 4: The System Layout

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SYSTEM WORKING PRINCIPLE

Oxygen extractor fire detection system is designed to detect the unwanted presence of fire by monitoring environmental temperature changes, as the environmental temperature increase above normal the system triggers different alarm sounds to the maximum which indicates danger of fire outbreak. The system is made up of five sub-systems

1. Different sounds alarm system
2. Automatic lock down control system
3. Chemical control system
4. Oxygen mask control system
5. Temperature detecting system

This Oxygen extractor anti-fire system with other sub systems is meant to notify people to evacuate in the area of fire outbreak within sixty seconds, after that there will be automatic lockdown. The oxygen mask will drop in case there is any human in the environment who couldn't go out within sixty second. After ten seconds, the chemical (nitrogen) that will remove the atmospheric oxygen will be introduced. Normally, fire doesn't survive without oxygen and it is assumed that after ten second fire is extinguished, then the safe alarm sounds for human to reenter the environment.

SYSTEM DESIGN

The System design is at the stage of simulation and coding with Visual Basic 6.0 to show case what we have in mind to do in the future. The system is simulated to work at different temperature levels

Case 1: In this case, the Anti-fire alarm is disabled and the simulation begins, as soon as the temperature gets to 70^0, the presence of excess oxygen causes the room to flame up.

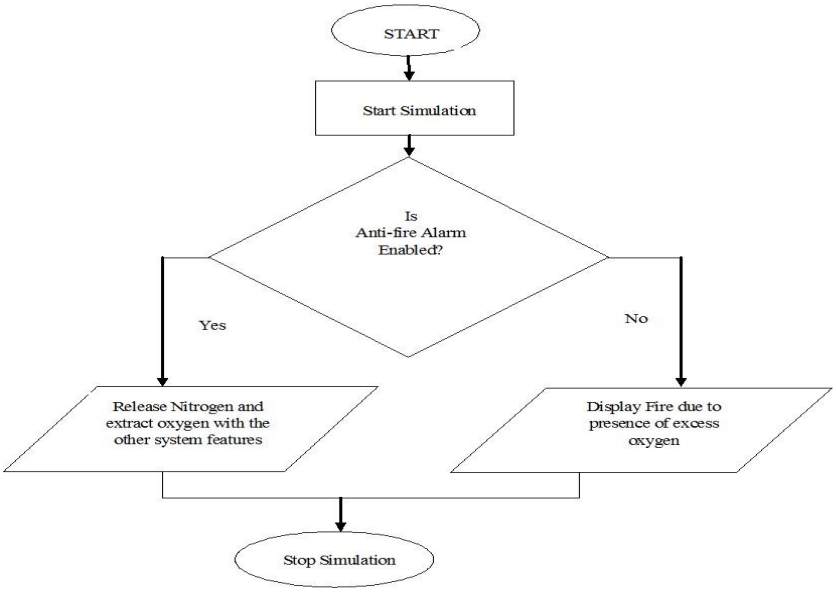

Fig. 5. The System Flow Chart

Case 2: where the Anti-fire alarm system is enabled and the simulation starts, there is a warning (beep) when the room temperature becomes 40^0. When the temperature gets to 70^0, the alarm starts beeping continuously. There is also a release of Nitrogen molecule through the Nitrogen dispenser. The Nitrogen gas reacts with the oxygen in the room to form

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Nitroxide. Also, before the reaction takes place, oxygen mask is released to the people in the room. This process is simulated within seconds showing the effects of Anti-fire alarm system. The design flow chart and system design view are shown in fig. 5 and fig. 6.

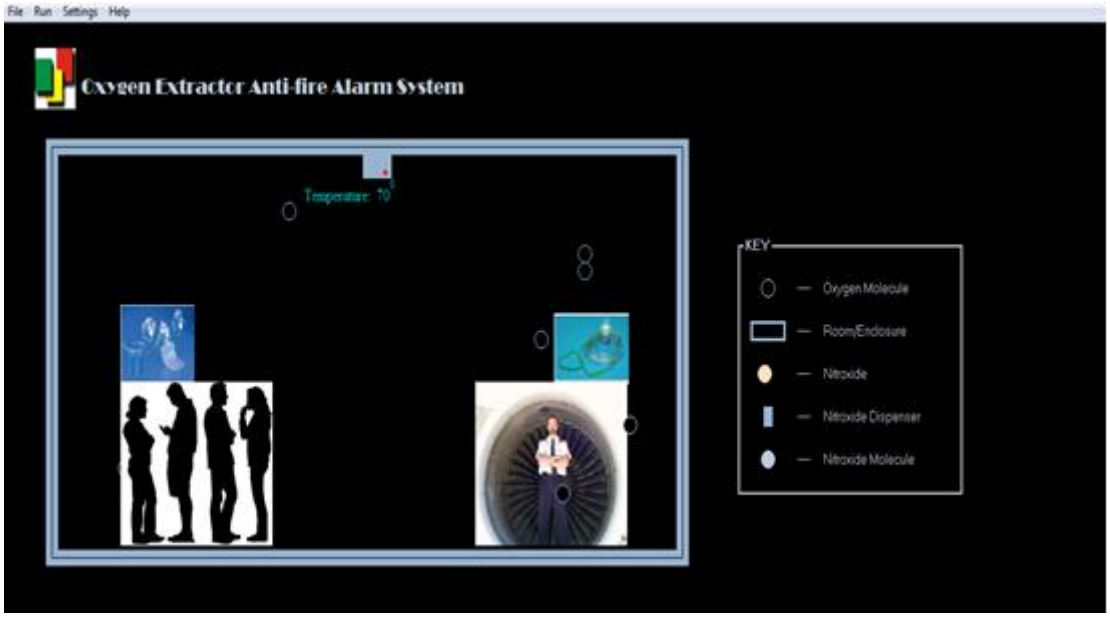

Fig. 6. System Design View in VB 6.0

DISCUSSIONS

In our society today, the question of total safety in our homes and offices in terms of fire outbreak has the most uncertain answers. The use of an object oriented program to design a brilliant system such as an oxygen extractor fire detection system shows that it is possible for us to achieve the construction of the system as embedded systems with the use of microcontrollers, programmable integrated circuit (PIC), programmable logic device (PLD) and field programmable gate arrays (FPGA).

CONCLUSION

This system if achieved is necessary to be used in data centers, ICT facilities. Storages with high valued items, large warehouses, utilities, in homes, offices, banks, companies, industries, churches, schools and other organizations, in order to reduce loss of lives and valuable properties through fire. We recommend that computer scientists, programmers, researchers and IT students should further their research into this area. If this system is achieved it will aid and facilitate the work of the Nigeria fire Service and Road Safety Commission.

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REFRENCES

[1] Abba, J. (2009). *Fire alarm system*. Enugu: Gitzelle Press.

[2] Angerer, P. N. (2003). Working in permanent hypoxia for fire protection-impact on health. *International archives of occupational and environmental health, 76* (2), 87–102.

[3] Burtscher, M., Mairer, K., Wille, M., Gatterer, H., Ruedl, G., Faulhaber, M., & Sumann, G. (2005). Short-term exposure to hypoxia for work and leisure activities in health and disease: Which level of hypoxia is safe? USA: Authors.

[4] Connelly, N.G., & Geiger, W. E. (1996). Chemical redox agents for organometallic chemistry. Chemical Reviews, *96* (2), 877– 910.

[5] Ekhomu, O. (2009). *Consequences of fire outbreak*. Retrieve from www.ieee.org/organisation/history_centre/fire_alarm.html.

[6] Makeri, J. (2010). History of fire systems. Nigeria: Debsa Printing and Publishing Inc.

[7] Martin, N., & Patrick, H. (2014). Advantages and challenges with using hypoxic air venting as fire protection. *Fire and Materials, 38* (5), 559-575.

[8] Redmond, W.A., & Jonathan, B. (2009). *Fire*. Retrieved from www.its- home-security.co.uk/monitored_html.

[9] Smith, M. B. (2007). Advanced *organic chemistry*: *Reactions*, *mechanisms*, *and structure (6th Ed.)*. New York: Wiley-Interscience.

[10] Stefano, C. (2011). a pilot study on hypoxic air performance at the interface of fire prevention and fire suppression (PDF). USA: The Science of Suppression.

[11] United States Access Board, (2003). *Benefits of fire alarm systems in the home*. Retrieved from www.firealarms.co.uk/monitored.html.

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