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Fire Detection Sensor Technologies

Introduction

In America, an average of seven people die every day in home fires, 57% of which involve homes with missing or non-functional fire detection systems[1]. Fire can be a devastating force when allowed to develop in an uncontrolled in-home environment, growing exponentially and engulfing almost anything in its path. The most common detection systems are simple, battery powered, non-interconnected smoke alarms due to their relatively early detection times and cheap cost at less than $10 for the cheapest models. However, with the abundance of other fire detection technologies available, consumers may soon find better devices becoming more readily available, affordable, and prevalent in U.S. homes. This technical review briefly summarizes some of the reliable fire detection technologies and early warning systems that may be further developed into more advanced life-saving devices.

Commercial Applications of Fire Detection Devices

Smoke detectors are currently the most commonly used device for fire detection. They contain only a smoke sensor, audible alarm, and a battery housing and these smoke sensors operate by either ionization or photoelectric methods[2]. Current market price for smoke alarms that contain ionization sensors are typically about half the price of those that contain photoelectric sensors, costing about $8 and $16 respectively. Due to their prevalence, these detectors are manufactured by a very large variety of companies such as First Alert and Kidde[3].

Heat detectors are another type of fire detection method which employs melting eutectic alloys to detect excessive heat sources. These heat detectors are more expensive than smoke detectors, costing about $29 which manufactured by Kidde[4]. Given that there must be either a large accumulation of heat or direct heat on the sensor in order to melt the alloy, it often takes a significant amount of time to trigger such a fire detection device. While this may be a negative feature of the sensor, it does result in a very low false positive detection rate.

Another common fire detection device uses infrared(IR) sensors to detect flames. These sensors are often used in specialized fire-fighting thermal imaging cameras (TIC) and were originally developed as a surveillance tool and a night-vision tool for the US military. These cameras can have a very wide array of uses as they can capture the infrared radiation emitted by all objects with a temperature above absolute zero[5]. Unfortunately, infrared sensors are significantly more expensive than other fire detection methods but they are much more versatile and can collect much more information than traditional fire detection sensors. As research continues and manufacturing and adoption of the sensor increases, the price of the sensors has been steadily dropping. A handheld infrared thermal imaging camera could cost as little as $200 and are manufactured by companies such as FLIR and PerfectPrime.

Underlying Fire Detection Technologies

The two major types of fire detection methods that detect smoke are ionization sensors and photoelectric sensors. In ionization sensors, there are two electrically charged plates with radioactive material between them. As smoke enters the sensor and disrupts the flow of ions between two electrically charged plates, the result is reduced current flow which triggers the sensor[6]. The more recent and more responsive photoelectric sensors emit a light beam within the device. When smoke enters the device, the light is refracted and the quantity of light that reaches the sensor changes and a threshold determines whether a positive signal is transmitted[7]. Due to the nature of Photoelectric sensors, they have a larger false positive alarm rate. The functional difference between ionization sensors and photoelectric sensors is that ionization sensors are better at detecting fires with large flames, while photoelectric is better at detecting smoldering fires that produce more smoke.

Heat detection as a fire detection method rely on melting properties of eutectic metal alloys which are mixtures of metals which result in a lower melting point than the melting point of each of the alloy's component metals. The eutectic temperature at which the alloy melts typically lie between the range of 117 and 281 degrees Fahrenheit[8].

Every object also emits an invisible infrared radiation of wavelength between 700 nanometers and 1 millimeter. As the object heats up, more infrared radiation is released by the object. This radiation can be detected and measured using infrared sensors which are simply infrared photodiodes that are sensitive to the particular infrared wavelength. The infrared light changes the resistance of the photodiode and thus, the voltage through the sensor can be measured in proportion to the amount of infrared radiation being detected[9].

Implementing Fire-Detection Technology

The specific type of sensor to be implemented in a project is inherently completely deterministic of the requirements of the project. Each type of sensor has its pros and cons, and each must be considered in order to ensure sufficient information collection, but also as to not break the bank because the cost of each system can vary greatly. Does the project need to simply detect the presence of a flame? If so, a cheaper option such as smoke detection may be used. If the device needs to be able to not only reliably detect but to also locate the source of a fire, then more expensive IR sensors may be required. However, the good news is that once the sensor breakout is obtained, each sensor requires no further additional equipment to function before being integrated into the full circuit system. With this information, a product development team must decide the most efficient and applicable fire sensor that fits into their product.

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