DETECTION AND IDENTIFICATION OF CHEMICAL AGENT USING ATOMIC ABSORPTION SPECTROPHOTOMETER

Saradhi Nimmagadda[1], Asa Jyothi[2]

[1]M.Tech, [2]Associate Professor, ECM Department, KL University, Vijayawada, Andhra Pradesh, India
saradhi.nimmagadda@hotmail.com

Abstract

The problem comprises the automatic detection and identification of a vapour state chemical agent. Chemical agent in vapour state is being complicated in comparison with the agent in solid and liquid state. Actually the agent in vapor state being a mixture with the other agents like dust, water molecules and the other chemicals or gases in air .There are many techniques existing for the chemical agent detection but each has got its own parameters sensitivity ,calibration, accuracy etc. In this work atomic absorption Flame Spectrophotometer for detection is used due to its advantages with the sensitivity and calibration. 8051 microcontroller is used for the controlling and processing of system.

Keywords: *chemical agent detection, atomic absorption spectrophotometer*

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1. INTRODUCTION

Any toxic chemical intended for use in toxicating the environment by reacting with other chemicals along with water, air etc. CA is the term used to signify the toxic component of a chemical weapon and can include in chemical warfare agents. Examples: Ethyl Sarin, Sulfur Mustard, Nitrogen Mustard.

The chemical agents are classified accordingly their affect on human .it include nerve, blister, blood and choking agents. Incapacitating and riot control agents can also be included in this category. These agents are aptly named based on their mode of action (i.e. route of penetration and their effect on the body) and sometimes according to their intended use. They are Nerve Agents, Blister Agents, Blood Agents, and Choking Agents.

Major emission of these toxic chemical agents occur in chemical industries like pharmaceuticals etc, even there happens to be an intentional release of the toxic chemical agents can also occur by many anti-social activists or in a war fields during wars etc where a large amount of life loss occur. The required equipment must be designed to address the need for a local alarm, enabling the alert for the humans around the chemical agent affected area.

2. CHEMICAL AGENT DETECTION

All the chemical agent detectors have been the reactive rather than the proactive most detectors are tend to reactive rather warn. The chemical agent detection is the method used for detecting and monitoring chemical agent providing early warning of danger or threat.

The early warning or proactive detector makes the commanders in case of warfare or people around case of other situations would be more helpful as the time available to take necessary reactions such as usage of gas masks or some individual protective equipment or gear10.

The protective equipment involves two ways the individual protection or zone protection. The prior one is the individual protection such as individual gas masks or wearing a full protective clothing etc. The second indicates the gaseous neutralization etc which would be more effective but a complicated process10.

3. ATOMIC ABSORPTION PROCESS:

The quantity of interest in atomic absorption measurements is the amount of light at the resonant wavelength which is absorbed as the light passes through a cloud of atoms. As the number of atoms in the light path increases, the amount of light absorbed increases in a predictable way. By measuring the amount of light absorbed, a quantitative determination of the amount of analytic element present can be made. The use of special light sources and careful selection of wavelength allow the specific quantitative determination of individual elements in the presence of others1, 3.

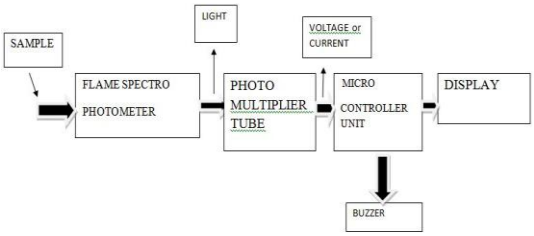
The atom cloud required for atomic absorption measurements is produced by supplying enough thermal energy to the sample to dissociate the chemical compounds to free atoms. Aspirating a solution of the sample into a flame aligned in the light beam serves the purpose2,4. Under the proper flame conditions, most of the atoms will remain in the ground state form and are capable of absorbing light at the analytical wavelength from a source lamp. The ease and speed at which precise and accurate

determinations can be made with this technique have made atomic absorption one of the most popular methods1, 3.

4. ATOMIC ABSORPTION SPECTROPHOTOMETER

The system is a electro-optical-mechanical instrument used for detection and identification of the toxic chemicals present in the given air sample.

The total system basically consists of two units. Spectrophotometer Unit, Micro-controller Unit.



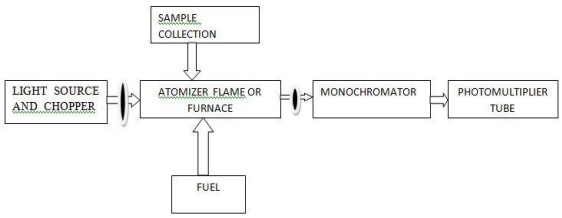
BLOCK DIAGRAM

Figure1: BLOCK DIAGRAM

Every spectrophotometer must confined with three basic requirements they are a light source , sample cell and specific light measurement. The following units illustrate the above basic requirements along with the other key units of the system.

4.1. Spectrophotometer Unit

The spectrophotometer unit is the optical-mechanical part of the system which comprises certain parts for the sample atomization, light source, sample collection etc. Following diagram gives the schematic of the spectrophotometer unit.



SPECTOPHOTOMETER UNIT

Figure2: Schematic of Spectrophotometer Unit

4.1.1 Light source and chopper

The light source is a radiation lamp which consists of certain wavelength limits .Selection of the lamp is based on chemical agents required to be detected and operational wavelength. Example for the light source is Hollow Cathode lamp. Each light source got their own wavelength limits it also got its association with monochromator for isolating a particular wavelength1, 3.

Chopper is used to take reference wavelength it alters the reference light falling on the photo multiplier tube and light through flame chamber where the sample atomization takes place.

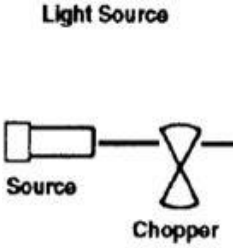


Figure3: Light Source and Chopper

4.1.2 Sample collection

The sample collection process is done through a wind pipe .wind pipe is consists of a horizontal and vertical pipe connected at 90 degrees each other with a open slit connecting them. The air sample is initially collected at the top of the vertical pipe , a blower set near to slit in horizontal pipe to suck the air inside which collects the sample nearly a 30 percent of air sucked is collected for detection and the rest is left out of the other open end down the pipe.

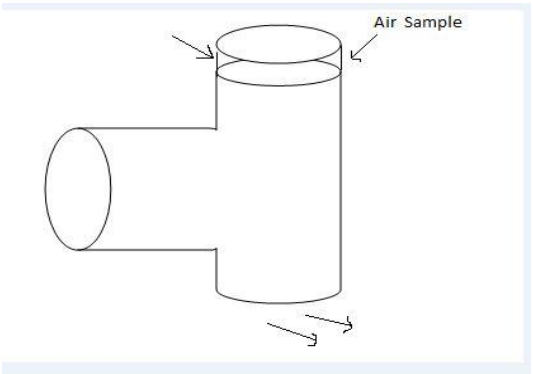


Figure4: sample collection

Above figure visualizes the sample collection procedure. Open lid on the top of the vertical pipe avoid the dust particles etc entering in to the wind pipe.

4.1.3 Atomizer flame or furnace

Atomizer flame or furnace collects the sample from the sample collector and atomizes the sample for further procedure. It mainly consists of Automatic gas control unit, Burner

Adjustment Assembly, Burners, Burner Sensing, and Auto Flame Controls.

4.1.4 Monochromator

The job of a monochromator is to produce a single spectral line from a broadband (multi-wavelength) source. In spectrometers, this can be used to collect light from an atomic emission source, like the atomic emission detector, and allow only a specific line to exit. It can also be used to isolate a single line from a light source such as a hollow cathode lamp. Monochromator consists of the following parts

Entrance and Exit slits: The purpose of the two slits in this monochromator is to control the size and "position" of the beam of light passing through the slit. On the way in, the entrance slit makes sure that only a small area of the input beam passes into the monochromator and that the light waves are relatively parallel coming from the source1, 3.

Grating is dispersion element in this monochromator is a grating. Its job is to take parallel light incoming from the entrance slit, light that contains multiple different wavelengths, and to disperse the wavelengths in space such that they are no longer parallel but instead leave the grating at slightly different angles, angles dependent upon the wavelength. The movement of the grating is further controlled by stepper motor connected to microcontroller unit1, 3.

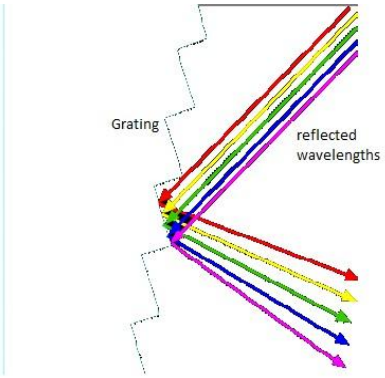


Figure5: Grating and Reflected Wavelengths

Selecting Wavelengths: All that is required to isolate a wavelength of choice and get it out of the monochromator is to adjust the position of the grating so that a desired wavelength passes through the slit. The fine adjustment on which wavelength falls on exit slit is achieved by little continuous adjustment of the grating using motor controlled by the microcontroller unit.

4.1.5.Photo Multiplier Tube

The most commonly used detector in spectrophotometer is photo multiplier tube. They have an internal amplification that gives them great sensitivity and wide spectral range. Light causes emission of electrons from a photo cathode which accelerates past a series of dynodes maintained at progressively increasing potentials1, 3.

Electrons striking the first dynode release a secondary emission that is stronger than original beam and so on through the dynode chain to produce a cascade effect. The electron density released by the final dynode to the anode can be many orders of magnitude greater than that from the cathode, but it still remains proportional to the intensity of incident radiation1, 3, 5, 6.

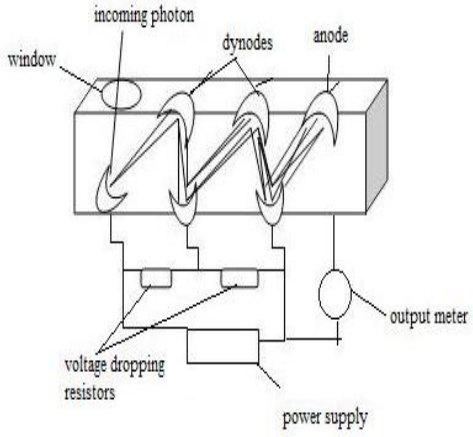


Figure6: Photo Multiplier Tube

4.2 Microcontroller Unit

The main part of the microcontroller unit is 8051 controller which is used to execute multiple task as accordingly programmed. A Microcontroller is a computer-on-a-chip. It is embedded inside a device so that it can control the features or actions of that device.

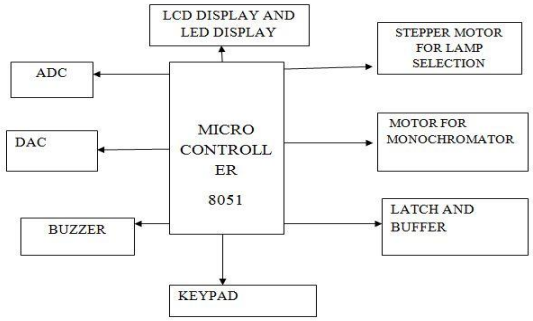


Figure7: Schematic of Micro Controller Unit

The above block diagram illustrates the interfacing of the each block with microcontroller .Each block connected with microcontroller got its own function acting parallelely along

with the spectrophotometer unit, Microcontroller is programmed accordingly related with each function with each block.

4.2.1 Interfacing Stepper motor for selection of lamp

The control of lamp turret in which the variety of lamps are fixed around a wheel is done by stepper motor which is interfaced with the microcontroller. The rotation of the motor results in the rotation of lamp turret wheel which makes the selected lamp to set in a row.

4.2.2 Interfacing motor for adjusting grating in monochromator

The adjustment of the grating in the monochromator is significant for the reflection of each individual wavelength which is used for isolating a particular wavelength.

4.2.3 Interfacing of ADC and DAC

The signal from the photomultiplier tube which is an analog signal is given to the Analog to Digital converter for conversion. Microcontroller interfacing with ADC converts the signal and uses it for further processing. The DAC is used for interfacing with the LED display .

4.2.4 Interfacing with latch and buffer

The interfacing with latch and buffer is used to save the information regarding the wavelengths and the signal level taken from the photo multiplier.

Interfacing with keypad, buzzer and LCD display:
The keypad is used for the selection of lamp and for ON, OFF,reset of the system. The buzzer for alarming and LCD display for displaying identified chemical agent.

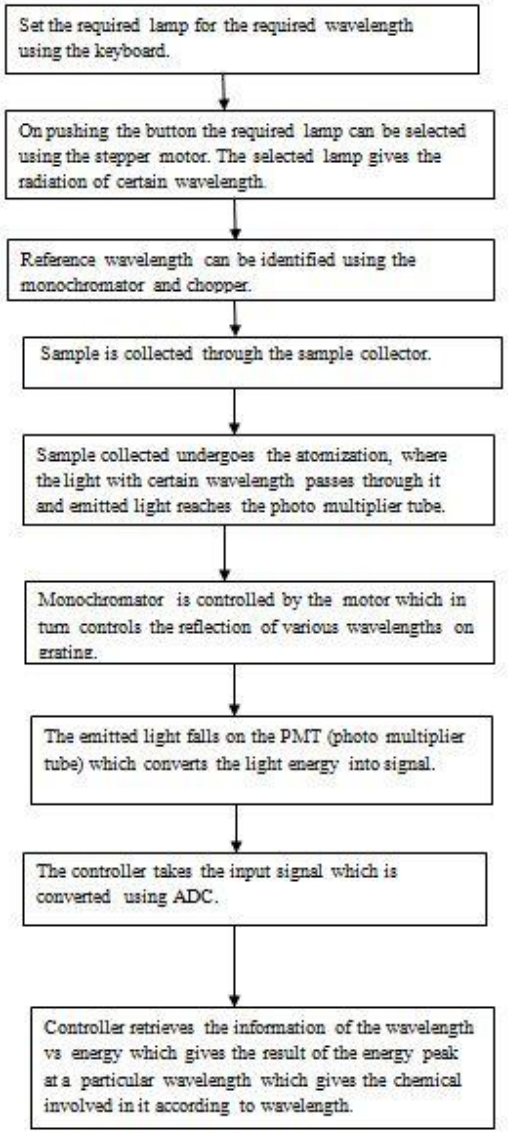


Figure8: Execution Flow

CONCLUSIONS

The method of choice in most laboratories, warfare, chemical production companies concerned with the detection of intentional or accidental presence of toxic chemicals in the air. The early detection avoids threat to the life loss. Compared to PC based Atomic Absorption Spectrophotometer instrument, the Microcontroller based Atomic Absorption Spectrophotometer instrument is easy to operate ,portable, cost effective, easy to transport from one location to other location because of not using the PC. It is mainly designed for low budget users.

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