LPG LEAKAGE DETECTION USING PREDICTION METHOD

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Increased using of LPG in wide variety of people's life makes is more comfortable gives its advantages, but the risk of its usage can not be put aside. The problem this paper is based on is related to the detecting of LPG leakage before dangerous level to occur. More of the solutions given by the moment are just to detect a dangerous level of LPG presence. In most of the cases is good idea to "catch" the leakage before it occurs, while in some of the cases presenting of dangerous level is not acceptable at all. This exactly is the purpose of the prediction method to be developed. It is based on statistic processing of a data that is to be analyzed. Then the method estimates if the data have to be considered as leakage or not.

Keywords: LPG, detection, prediction, measurement

1. INTRODUCTION

In present days the need of cheap and efficient source of energy draws the line of the new tendencies. The LPG usage takes bigger part as a source of fuel, producing heat, included in many different field of the human life. Wide usage of LPG however has its dangerous parts and hides many risk situations. The potential for fire poses critical safety hazard during the transportation, processing and the storage of the LPG, during the maintenance of related equipment, during underground construction, and during entry into confined spaces where flammable products may have accumulated. The development and implementation of safety measures to minimize the potential of fires are based on the principles of combustion. Combustion is defined as the process of burning. In order combustion to take place and be sustained, three elements must be present: oxygen, a source of ignition (source of high temperature), fuel. If one of them is missing the combustion can not take place.

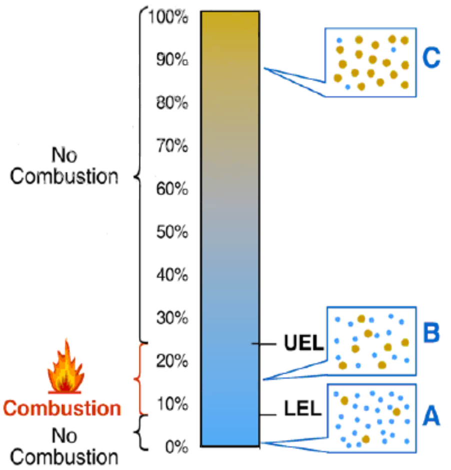

Fig.1

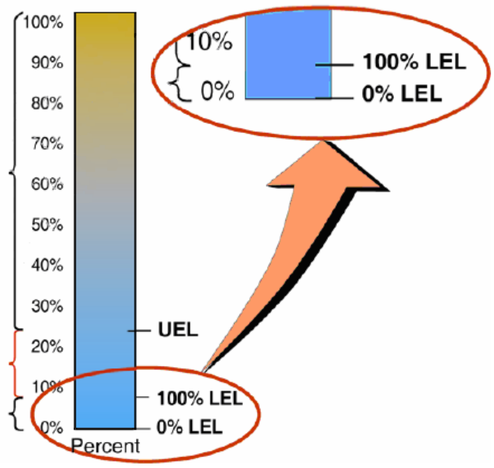

Fig.2

As might be seen on the Fig.1 keeping the LPG level out from the range of its Upper Explosive Level (UEL) and Lower Explosive Level (LEL) is the key of preventing from dangerous environment. Usually the first case is popular in places where the oxygen level is supposed to be kept at low rate. For the most often cases the places in which LPG level needs to be monitored are places where human beings live and work. This is why oxygen level can not be kept at low rates but the LPG. Fig.2 shows the way of LPG concentration safety limits presenting. The highest safety point is considered as 100%LEL and the lowest one respectively as 0%LEL. The LPG level between these two points is considered as safety zone. The concentration of the LPG molecules is too low combustion to occur or to be sustained.

Most of the manufactured devices measure the gas level at a point, while the others may have some threshold for early alert. But the gas leakage prediction as a feature of the devices seems to be neglected.

Basic scheme for measurement

The basic scheme used for measurement is based on a gas sensor and a source of energy Fig4. The energy is needed for the heating circuit that gets the sensor into its proper working mode. The voltage across the Load resistance gives related change of gas concentration. The output characteristics of the sensor are shown on Fig.3.

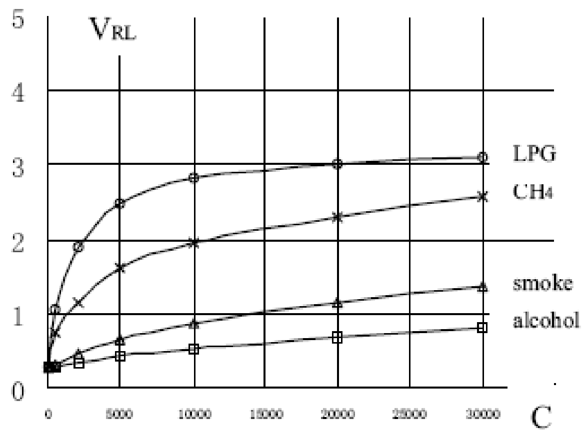

Fig.3

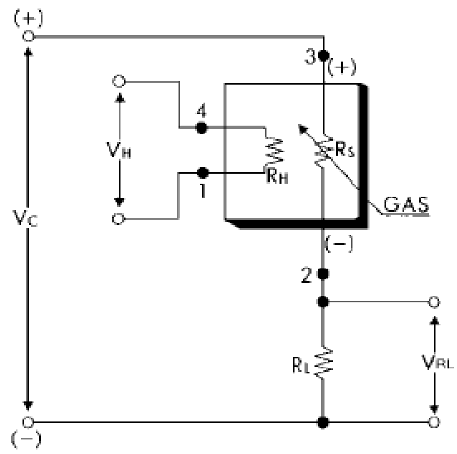

Fig.4

2. Description of the Problem

The problem of the LPG leakage detection is that most of the devices do nothing else but simply detecting. That means there is a threshold and if there is a level over it alert or other event occurs. However this means that dangerous level of concentration already presents. Hence what keeps the combustion still down is the lack of ignition source. The prediction method tries to analyze the environment and give the information about started leakage thereby dangerous situation can be prevented.

To predict LPG leakage we use the method that measures the difference between exact count measurements. The idea is that if leakage occurs there will be increasing level of LPG and approximate to linear relation between measured LPG level and stream of leakage. This way of thoughts takes the results between few consequent measured levels watches if the level is under LEL and for increasing to occur. If event occurs that means that leakage presents. The relation in the real case is not necessary to be line, because the difference between two adjacent measured levels may not be the same.

$$\Delta = \sum_{a=0}^{n} (m_{a+1} - m_a)\,, \tag{1}$$

Where Δ is the difference between two measurements; m is measured level of LPG.

In real conditions this may give some fake result. If the offset is zero or close to the result for Δ could be positive for next measurement that may cause alerting as for leakage event. Moreover recharging or other activity related to the work can produce controlled leaks for short period of time that can increase lightly the concentration of LPG, but further it can be dissipated. These situations can also produce fake results for the type of leakage. All of these disadvantages can be avoided by taking huge amount of results and then calculating the sum but unfortunately this is not working when try to predict leakage of LPG. Hence the method should take the results sequence of few measurements, estimate the relations between them and take the correct action.

3. Leakage Detection Method

This method tries to describe as close as possible the relation between the components the measured value is build of. At the beginning, before the measuring to proceed, the sensor needs to be put in the related environment for a while. Since the LPG sensor is sensible to other types of gases is natural to have detected a gas level different from zero. Monitoring the environment for long enough period of time by this sensor and one with already calibrated output will show the presence of other gases that can be considered as a constant part of the signal.

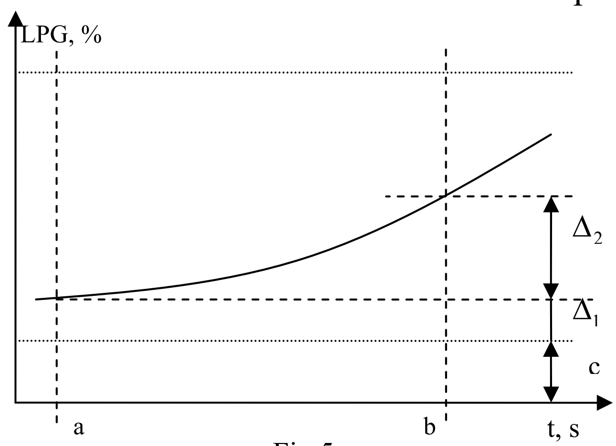

Fig.5

If the function that describes the relation of LPG and time is called L(t), the constant part of the function and the offset is described as:

$$\Delta_1 = L(a) - c\,. \tag{2}$$

The integral that gives increasing of the LPG level is:

$$\Delta_2 = \int_a^b L(t)dt = L(b) - L(a)\,. \tag{3}$$

Where a, b are the times of two adjacent measurement, c is the constant presence of gas environment, Δ_1 - gives the offset at the first measured value for the measurement cycle, Δ_2 - gives the level growth for a measurement cycle.

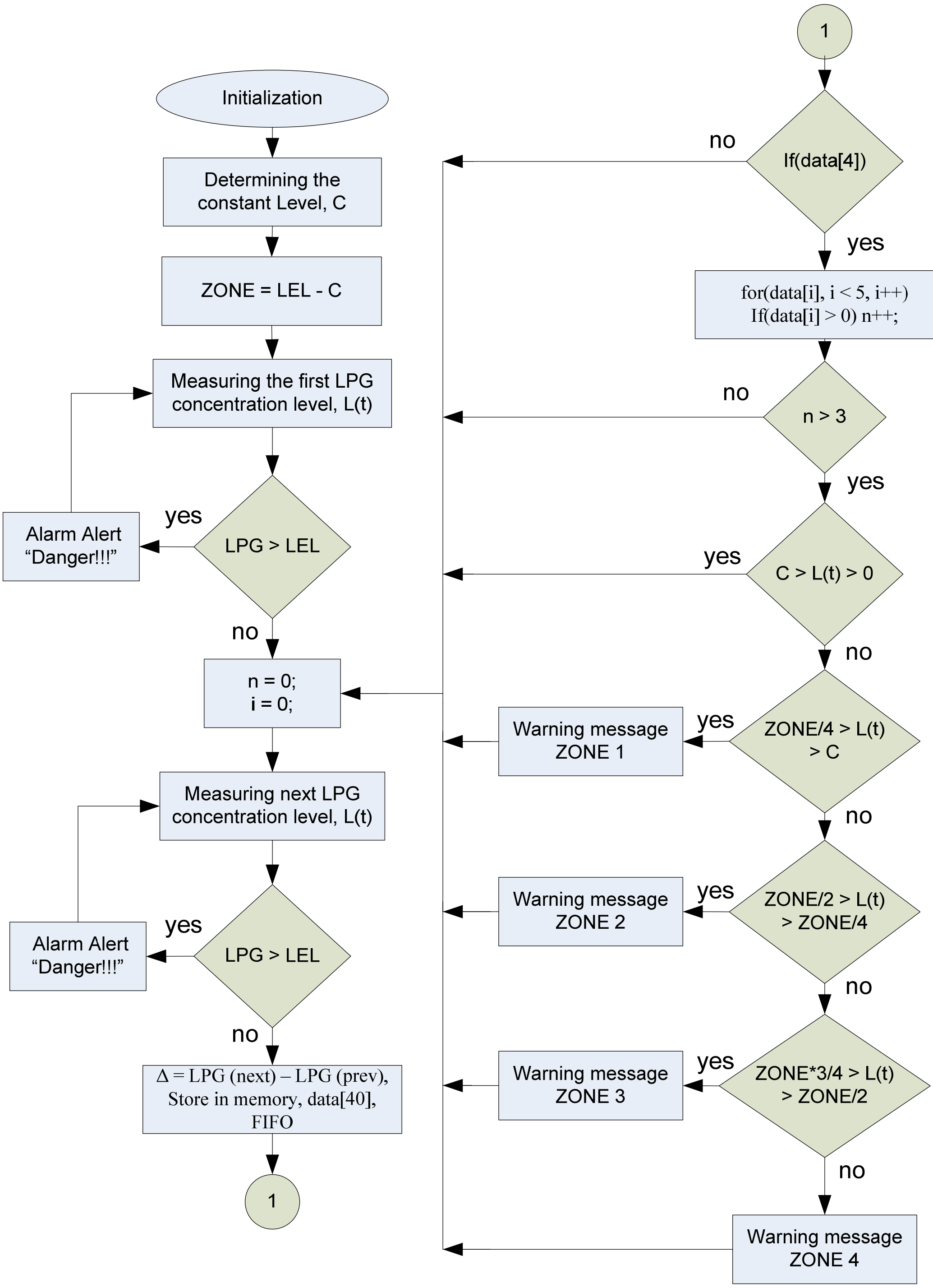

Fig.6

For every next measurement Δ_2 show the tendency of the leakage changing. If Δ_2 has positive value for more than 5 cycles, this absolutely means that leakage is presence and warning alert is given. For the same period if more than two cycles have flat characteristic means that leakage did not occur or the air is refreshing somehow or the gas level is as result of some activity. And if Δ_2 is negative this shows that gas concentration is dissipating. During the process L(a) shows if the gas level is still in safety borders.

How the method works? It actually uses one of the mentioned above Δ. After the constant concentration in the area is measured the zone between C and LEL is divided by four. This is how four different status zones are determined. Using of these zones help us to decide how dangerous is the increasing of the LPG concentration. Then the data for the measurements are stored in a FIFO organized memory.

After at least five measurements are stored the method starts working. Each interval of five measurements is checking whether the count of increasing is big enough and at the same time in which zone the concentration is. There are four different types of messages one for each zone that alerts for different threats. For example the messages might be chosen as follows: Zone 1 (lowest) – one beep when increasing occurs; Zone 2 – one beep each 10 seconds; Zone 3 – one beep each 3; Zone 4 (the highest one before LEL is reached) – one beep each half second. The time between two measurements may vary in depends of how big is the premises or other different considerations, but can not be below the time specified by the sensor producer.

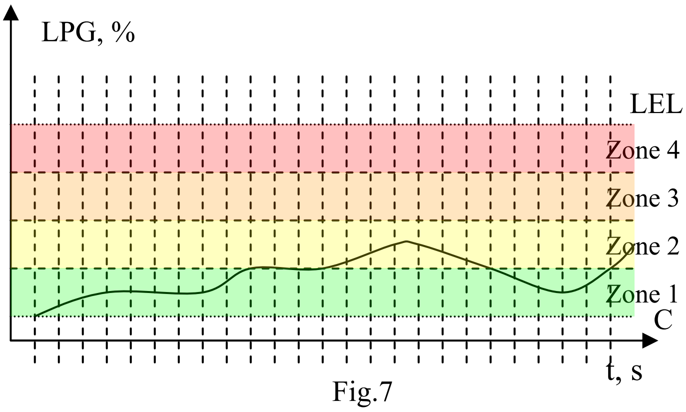

Fig.7

4. Conclusion

Using the leakage prediction method makes the work and home environment safer. Larger the place easier the estimation whether gas leakage presence.

As the target was laid so far the LPG concentration measurement is done by the estimating method. The purpose that was defined at the beginning, to predict leakage, is achieved. The relationship between the gas concentration and the difference between two measurements, described by the integral of LPG concentration by the time, is calculated with an exact enough approximation. The delay of time that can be mentioned between true leakage and measured results depends on what type of gas sensor had been used for the related measurement. As bigger the premises is as more accurate of the prediction method is to be achieved. This is true also for the size of the gas stream. Hence the method is not suited to small areas crossed by big pipes or other source of extremely huge stream. Accordingly with the first chapter environment saturated with gas is not dangerous, put in mind as not flammable, but however the situation probably would be out of control.

5. References

[1] Gases – Flammability. Gas detectors. I. HDC Human Development Consultants. TH9271.D48 2000 665.7'028'7 C00-900571-4

[2] www.winsensor.com

[3] www.coster.info