Product design methodology applied in developing a liquid petroleum gas level indicator using android technology

Vishwas Mahesh[1,*], Vinyas Mahesh[2], Ishwarkumar Teggi[1], Arpit Bansal[1], Manjesh S.[1]

1. *Department of IEM, Siddaganga Institute of Technology, Tumakuru, Karnataka 572102, India*

2. *Department of Mechanical Engineering, Nitte Meenakshi Institute of Technology, Bengaluru, Karnataka 560064, India*

vishwasm@sit.ac.in

ABSTRACT. This paper deals with the systematic product design methodology and development of liquid petroleum gas (LPG) level indicator using open source software Android. Domestic Cooking gas cylinders contain LPG which is used for cooking. Sometimes consumer feels cheated with regard to the amount of gas filled by the dealer. Using LPG gas indicator with the assistance of android, one can easily know the amount of gas present in the cylinder. Also it is loaded with many new applications like gas leakage alarm, indicator to refill the cylinder. This device will come with the weighing sensors attached just below the cylinder; these sensors will sense the weight of the cylinder. The level of the gas will be shown on the smart phone screen with the assistance of android. The smart phone will be connected through Bluetooth to the sensors.

RÉSUMÉ. Ce document traite de la méthodologie systématique de conception de produits et du développement d'un indicateur de niveau de gaz de pétrole liquéfié (GPL) à l'aide d'un logiciel open source Android. Les bouteilles de gaz pour la cuisson domestique contiennent du GPL utilisé pour la cuisson. Parfois, le consommateur se sent trompé en ce qui concerne la quantité d'essence remplie par le revendeur. En utilisant l'indicateur de gaz GPL avec l'aide d'Android, on peut facilement connaître la quantité de gaz présente dans la bouteille. En outre, il est chargé avec de nombreuses nouvelles applications telles que l'alarme de fuite de gaz, indicateur pour remplir le cylindre. Cet appareil viendra avec les capteurs de pesage fixés juste en dessous du cylindre; ces capteurs détecteront le poids du cylindre. Le niveau de gaz sera affiché sur l'écran du smartphone avec l'aide d'Android. Le smartphone sera connecté via Bluetooth aux capteurs.

KEYWORDS: cylindre GPL, conception produit, android.

MOTS-CLÉS: cylindre GPL, conception produit, android.

DOI:10.3166/ISI.23.5.175-184

1. Introduction

Using natural resources in plenty results in their extinction. Hence its use has to be limited. In this regard, for cooking liquid petroleum gas (LPG) is popularly used. Due to the advantages LPG offers, it is used as domestic fuel and industrial fuel and thus there is an exponential demand for the LPG cylinder. At the same time, there are few concerns associated with its usage.

On the verge of the cylinder becoming empty, consumer has to call local gas agencies book the cylinder. It further takes many days to deliver the cylinder. The customer doesn't know the amount of left put LPG in cylinder so that he can plan in advance. There are many incidents that happen across the globe like cylinder bursts, gas leakages etc. and as a result many lives have come to an end. Hence it is essential to develop a technique to monitor the level of LPG in the cylinder.

The study carried out by Fraiwan *et al.* (2011) provided wireless safety device for such leakages. Soundarya *et al.* (2014) studied the detection, monitoring and control of LPG leakage where they used DC motor to automatically control the stove knob. Archana *et al.* (2016) developed a material for gas sensing application based on nano structure. Chen-ching Ting *et al.* (2013) proposed a technique for detecting a LPG leakage based on schlieren technique. Syed *et al.* (2015) made use of fyzzy fault tree analysis for analysing the risk of leakage of oil in abandoned gas wells. Umesh *et al.* (2017) developed a film for the purpose of detecting the leakage of gases. Ashit *et al.* (2015) fabricated a material towards the development of LPG sensor. Bremer *et al.* (2014) amde use of fiber optic system for detecting the leakage in sewerage tunnel. Kotresh *et al.* (2017) developed a spin cast processed LPG sensor. Maniram *et al.* (2018) concentrated on LPG dispensing station and made use of fuzzy technique to prioritise the risk. Nilambar *et al.* (2016) carried out a case study on disaster that took place in Kannur, in the state of Kerala of Indian country due to explosion of LPG while transportation. Morteza *et al.* (2016) studied on leakage detection in pipeline using multi-layer perceptron neural network. Dorota *et al.* (2017) performed numerical and experimental investigation on LPG release during parking of cars and their impact. Tirmizi *et al.* (2018) carried out GIS based risk assessment of oil spill and gas leakage vulnerable zones in Pakistan. Arya *et al.* (2016) discussed about the importance of LPG as a domestic fuel in India. Arash *et al.* (2018) put forth a view that designing a proper system leads to enhanced flexibility and efficiency in the product. This can be achieved by following a product design methodology proposed by Ulrich *et al.* (2008).

Though available literature fouses on avoiding and detecting gas leakage, an online, effective and low cost system using android technology in not addressed. Thus, in the present paper a technique has been proposed so that the gas level inside the cylinder can be monitored by the android handheld device. Whenever the gas will reach a certain low level, the order of the cylinder will automatically get placed by the android application. The present work aims at developing system based on microcontroller containing features to measure level of gas inside the cylinder which is displayed on the screen of android device. This work is aimed at developing a device which is cost effective, highly portable based on GSM techniques that can be easily installed on every cylinder while it is being delivered.

2. Methodology

The entire development process is systematically carried out using the methodology provided by Ulrich *et al.* (2008). The entire development process goes through six phases of product development namely:

Phase 0: Planning

Phase 1: Concept development

Phase 2: System level design

Phase 3: Detail design

Phase 4: Testing and refinement

Phase 5: Production ramp up

2.1. Planning

It is planned to use a weight sensor which will be positioned beneath the stand on which LPG cylinder will be placed. The input to the microcontroller will be the output of weight sensor which will be continuously monitored and sent to android based smart phone and with the assistance of ANDROID application, it is notified to the user. Alarm is provided in stand when any leakage of gas takes place. Wheels are provided integrated with stand for portability of cylinder and the working principle is represented in the block diagram shown in Figure 1.

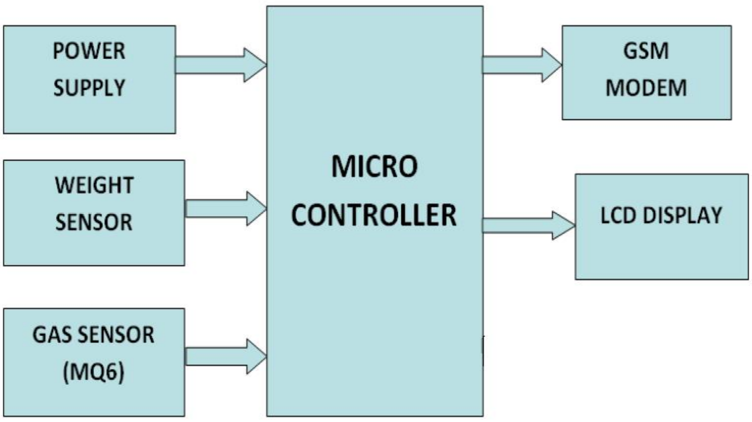


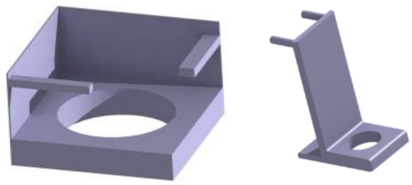
Figure 1. Block diagram showing the working principle

2.2. Concept development

2.2.1. Concept generation

In this phase, based on the brainstorming of the authors, five different concepts are generated as shown in Figure 2.

Concept A *Concept B* *Concept B*



Concept D *Concept E*

Figure 2. Concepts generated

Concept A: This is the simple concept based on the idea to reduce the human effort while lifting the filled cylinder from ground level to stand; we thought of opening the half part of the cylinder stand which is hinged to the base stand and close it after cylinder is placed. The problem with this is the hinged part of cylinder side plate is not flat so it's even harder to place cylinder on stand.

Concept B: This is the concept based on the mechanism which helps in easy lifting of the cylinder and easy moving of stand. The stand is portable, easy to handle, easy to manufacture.

Concept C: This is the concept based on the easy portability, easy to handle, economical, easy to manufacture, easy to use, less effort. It is the square based Cylinder stand and the Slant plate is hinged to the front portion of the base. The customer can easily roll the cylinder through the slant part to place the cylinder and then close the plate.

Concept D: This is the concept based on the simple idea of placing cylinder and moving through sliding actions and cylinder is grappled by the pair of belts.

Concept E: This is the concept based on easy handling and easy usage of the cylinder stand. During screening and scoring process of the concepts, this concept has got the good responses in some categories, but failed to fulfil the characteristics like easy to handle, less space. And also it needs effort to port cylinder from place to place.

2.2.2. Concept Selection

In this stage, the multiple concepts generated are evaluated in a systematic way using Pugh matrix and the winning concept is selected. It contains two steps namely concept screening and concept scoring.

Based on the Table 1 concept screening a concept is selected and the selection procedure is as follows:

- Prepare the selection matrix.
- Rate the concepts.
- Rank the concept.
- Select one or more concepts.

Based on the Table 2 outcome of the selection matrix, concept C is choosen as the final concept.

Table 1. Concept screening

Selection Criteria	A	B	C	D	E
Effort	−	+	+	−	0
Space occupied	+	−	0	+	0
Economical	+	−	0	−	−
Easy to Manufacture	+	−	+	0	0
Portability	0	-	0	−	0
Easy to handle	0	+	+	−	-
Easy to Use	−	+	+	0	+
Sum'+ve'	3	3	3	1	1
Sum'-ve'	2	4	0	4	2
Sum '0'	1	1	3	2	5
Net total	1	-1	3	-3	-1
Continue	Yes	No	Yes	No	No

Table 2. Concept scoring

Selection criteria	Weightage in (%)	A		C	
		Rating	Weighted score	Rating	Weighted score
Effort	20	3	0.6	3	0.6
Space	10	3	0.3	2	0.2
Economical	5	2	0.1	3	0.15
Easy to Manufacture	5	3	0.15	4	0.2
Portability	20	3	0.6	3	0.6
Easy to Handle	20	4	0.8	5	1
Easy to use	20	4	0.8	4	0.8
	Total Sum	3.35		3.55	
	Rank	2		1	
	Continue?	No		Develop	

2.3. System level design and detailed design

In this stage, the product architecture is defined and the product is decomposed into sub components.

The various components used in the system are

- ATMEGA8 Microcontroller
- RPS-7805
- Load cell
- MQ-6 LPG sensor
- GSM modem(SIM 900)
- 2X16 LCD display

To book a LPG refill , we should know ahead of time of measure of gas in the chamber, and for this reason the level of gas exhibit in the barrel must be observed constantly. The load cell having required weight limit with regards to local barrel is utilized and for adjustment reason the weight sensor module is utilized alongside the load cell. Signal conditioning unit manipulate the input analog signal to our specified requirements of further use. It usually consist of sensor, instrumentation amplifier and analog to digital converter.

The gas sensor MQ6 as shown in Figure 3 senses the gas. When the concentration is above the danger level it will send an interrupt to the microcontroller and the end user will receive a caution message which will be displayed on LCD. For further preventive action the regulator will switch off automatically.

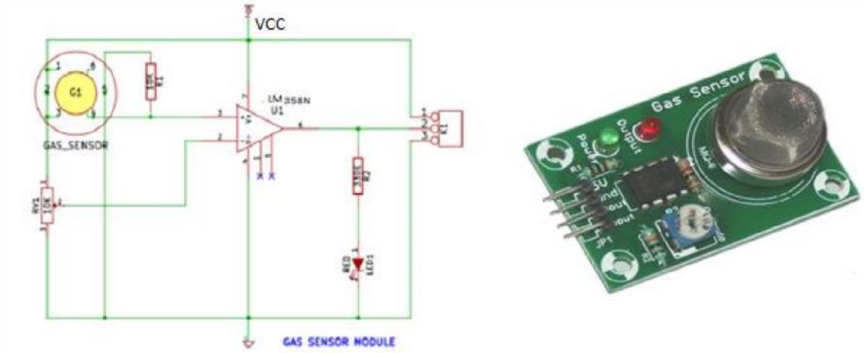


Figure 3. Gas sensor module

For the sensor to work appropriately the sensor should be warmed for particular measure of time called the preheat time. The sensor works with 5 volt control supply. The favoured wiring is to associate both 'A' pins together and both 'B' sticks together. It is more secure and it is expected that is has more dependable yield.

At the point when the objective ignitable gas exists in the environment, the sensor conductivity expands opposition of sensor changes with the convergence of flammable gases. Straightforward electronic circuit can be utilized to change over the adjustment in protection from change as far as centralization of LPG gases. Minimal effort and long life are the upsides of utilizing this sensor.

The prominent standard used for mobile phones is GSM. It needs a SIM card to operate. Here we use SIM 900 which is a GSM modem and powerful terminal. This has standard connector interfaces and has an integral SIM card reader.

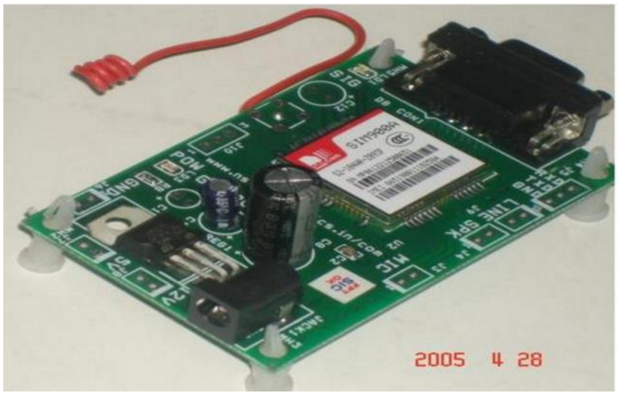


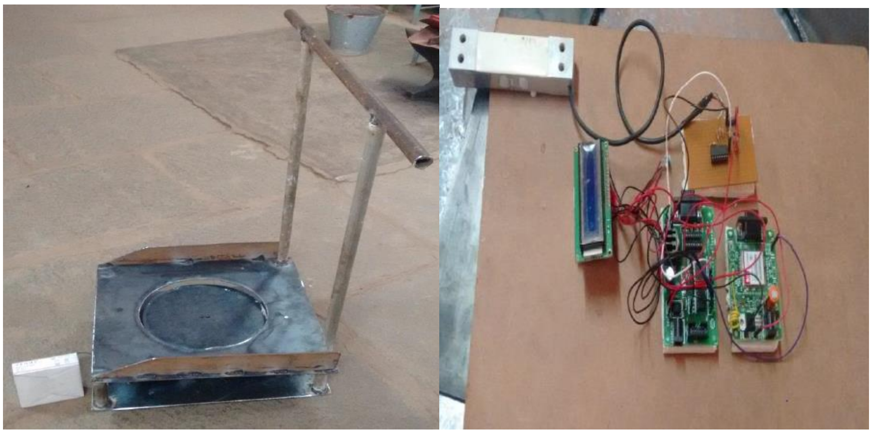
Figure 4. GSM module

LCD display will display the current status of the gas content. Warning message during gas leakage and message about gas booking will be displayed also.

The LCD module makes use of basic and simple 16x2 LCD display. These are preferred over others with the reason being low cost, ease of programming etc. Its name indicates that it is capable of displaying 16 characters per line and two such lines. A 16X2 LCD means it can display 16 characters per line and there are 2 such lines.

2.4. Testing, refinement and production rampup

Initially android application is installed on any android device, and initially assuming the cylinder weight is 29.5 Kg (Empty Weight of cylinder + Gas Weight) is feed into the application settings. Now it suppose to show 100% in UI. Now it can be tested by sending one sample SMS 14.75 KG now it should suppose to show 50%. Now it confirmed that if gas reduces in weight, application also synchronizes in real time and shows the gas level of the cylinder. Similarly now you can check for leak detection by sending SMS keyword as 'leak'. Now Application should recognize that keyword and starts siren and also gives the information about safety measures. Once testing completed it can be integrated to real time GSM Module. The working model and the components used in circuit are shown in Figure 5.



(a) *(b)*

Figure 5. (a) Working model and (b) components used in circuit

3. Conclusions

The systematic product design methodology has been adopted to develop a LPG level indicator. The LPG indicator developed provides information when any leakage happens and also it constantly monitors the amount of gas left over and thus helping the consumer decide when to order for refill. A cost effective gas level indicator is designed and implemented in the present work. This framework gives a completely robotized approach towards the gas booking. Continuous estimation of the gas and its show on LCD and on the screen of android device makes it an efficient home security.

References

Arya P. K., Tupkari S., Satish K., Thakre G. D., Shukla B. M. (2016). DME blended LPG as a cooking fuel option for Indian household: A review. *Renewable and Sustainable Energy Reviews*, Vol. 53, pp. 1591-1601. https://doi.org/10.1016/j.rser.2015.09.007

Bariha N., Mishra I. M., Srivastava V. C. (2016). Fire and explosion hazard analysis during surface transport of liquefied petroleum gas (LPG): A case study of LPG truck tanker accident in Kannur, Kerala, India. *Journal of Loss Prevention in the Process Industries*, Vol. 40, pp. 449–460. https://doi.org/10.1016/j.jlp.2016.01.020

Bremer K., Meinhardt-Wollweber M., Thiel T., Werner G., Sun T., Grattan K. T. V., Roth B. (2014). Sewerage tunnel leakage detection using a fibre optic moisture-detecting sensor system. *Sensors and Actuators, A: Physical*, Vol. 220, pp. 62-68. https://doi.org/10.1016/j.sna.2014.09.018

Brzezinska D., Markowski A. S. (2017). Experimental investigation and CFD modelling of the internal car park environment in case of accidental LPG release. *Process Safety and Environmental Protection*, Vol. 110, pp. 5-14. https://doi.org/10.1016/j.psep.2016.12.001

Fraiwan L., Lweesy K., Bani-Salma Mani A. N. (2011). A wireless home safety gas leakage detection system. *Proceedings of 1st Middle East Conference on Biomedical Engineering*, pp. 11-14. http://dx.doi.org/10.1109/MECBME.2011.5752053

Hashemoghli A., Mahdavi I., Tajdin A. (2018). A novel possibilistic cellular manufacturing model considering worker skill and product quality. *Scientia Iranica*, pp. 1-33. https://doi.org/10.24200/sci.2018.4948.1002

Jaiswal A. K., Singh S., Singh A., Yadav R. R., Tandon P., Yadav B. C. (2015). Fabrication of Cu/Pd bimetallic nanostructures with high gas sorption ability towards development of LPG sensor. *Materials Chemistry and Physics*, Vol. 154, pp. 16-21. https://doi.org/10.1016/j.matchemphys.2015.01.031

Kotresh S., Ravikiran Y. T., Vijaya Kumari S. C., Ramana C. V. V., Batoo K. M. (2017). Solution based–spin cast processed LPG sensor at room temperature. *Sensors and Actuators, A: Physical*, Vol. 263, pp. 687-692. https://doi.org/10.1016/j.sna.2017.07.026

Lavasani S. M., Ramzali N., Sabzalipour F., Akyuz E. (2015). Utilisation of Fuzzy Fault Tree Analysis (FFTA) for quantified risk analysis of leakage in abandoned oil and natural-gas wells. *Ocean Engineering*, Vol. 108, pp. 729-737. https://doi.org/10.1016/j.oceaneng.2015.09.008

Maniram Kumar A., Rajakarunakaran S., Pitchipoo P., Vimalesan R. (2018). Fuzzy based risk prioritisation in an auto LPG dispensing station. *Safety Science*, Vol. 101, pp. 231-247. https://doi.org/10.1016/j.ssci.2017.09.011

Nakate U. T., Patil P., Ghule B. G., Ekar S., Al-Osta A., Jadhav V. V., O'Dwyer C. (2017). Gold sensitized sprayed SnO_2 nanostructured film for enhanced LPG sensing. *Journal of*

Analytical and Applied Pyrolysis, Vol. 124, pp. 362-368. https://doi.org/10.1016/j.jaap.2016.12.029

Singh A., Singh A., Singh S., Tandon P. (2016). Nickel antimony oxide (NiSb2O6): A fascinating nanostructured material for gas sensing application. *Chemical Physics Letters*, Vol. 646, pp. 41-46. https://doi.org/10.1016/j.cplett.2016.01.005

Soundarya, T., Anchitaalagammai J. V., Deepa Priya G., Karthick kumar S. S. (2014). C-leakage: Cylinder LPG gas leakage detection for home safety. *IOSR Journal of Electronics and Communication Engineering,* Vol. 9, No. 1, pp. 53-58. http://dx.doi.org/10.9790/2834-09165358

Ting C. C., Chen C. C. (2013). Detection of gas leakage using microcolor schlieren technique. *Measurement: Journal of the International Measurement Confederation*, Vol. 46, No. 8, pp. 2467-2472. https://doi.org/10.1016/j.measurement.2013.04.073

Tirmizi S. T., Tirmizi S. R. U. H. (2018). GIS based risk assessment of oil spill and gas leakage vulnerable zones in Pakistan. *Mathematical Modelling of Engineering Problems,* Vol. 5, No. 3, pp. 190-196. https://doi.org/10.18280/mmep.050309.

Ulrich K. T., Eppinger S. D. (2008). Product design and development. *4th Edition, McGrawHill Education, USA.*

Zadkarami M., Shahbazian M., Salahshoor K. (2016). Pipeline leakage detection and isolation: An integrated approach of statistical and wavelet feature extraction with multi-layer perceptron neural network (MLPNN). *Journal of Loss Prevention in the Process Industries,* Vol. 43, pp. 479-487. https://doi.org/10.1016/j.jlp.2016.06.018