Available online at www.koozakar.com/journal/ajspim

Koozakar African Journal of Science Policy and Innovation Management
OPEN ACCESS | PEER REVIEWED
AJSPIM

Deployment of Alcohol Detection System in the Operations of Mechanical Systems

Babatunde V. Omidiji[1*], Oyetunde A. Adeaga[2] and James O. Ogunro[2]
[1]Obafemi Awolowo University, Ile-Ife, Nigeria
[2] First Technical University, Ibadan, Nigeria

*Corresponding author
Email: bomidiji@oaife.edu.ng

Article information

https://doi.org/10.69798/39702453

2756 – 4118

Published by Koozakar LLC. Norcross GA 30071, United States

A Journal of the African Institute for Science Policy and Innovation, AISPI, Obafemi Awolowo University, Ile-Ife. Reproduced with permission. A prior edition of the African Journal of Science Policy and Innovation Management Volume 3 Issue 1, was published by Obafemi Awolowo University Press, Ile-Ife, Nigeria.

ABSTRACT

The paper addressed the development of an alcohol detection device and its deployment in the operation of mechanical systems. The aim of the device is to prevent accidents caused by alcohol impairment of drivers/operators of the systems. The device was based on a micro-controller (ATmega328P) used to set a Blood Alcohol Content (BAC) limit authorized from the operators' breath. When this limit is reached by the input signal received from the MQ-3 alcohol sensor detected from the drivers' breath, a buzzer alarm would go off, and a Light Emitting Diode (LED) would start blinking. At this stage, the system will disable the installed Direct Current (DC) motor through a relay that received a signal from the micro-controller. A Liquid Crystal Display (LCD) integrated into the system will provide information about the driver's level of intoxication. The mechanical systems (the vehicle's engine and machinery power switch) were represented by the DC motor in this work. The LED stood for the vehicle's emergency light, which would warn oncoming traffic about the vehicle identified to be under the control of an alcohol-impaired driver. This was tested using various experiments put into practice using the created system, and evaluated. The results of each experiment done on the intended system demonstrated that the system was capable of detecting BAC of a driver of a mechanical system. It was shown that blowing air could increase the sensitivity of the MQ-3 sensor. The device was able to incapacitate the mechanical system from running at the detection of higher than normal BAC thus preventing any unexpected mishaps. It then means that rate of road crashes or accidents at shop floors caused by alcohol impairment maybe significantly reduced.

Keywords:
Mechanical Systems; Blood Alcohol Content (BAC); Drunk Drivers; Traffic; Experiments

INTRODUCTION

Accidents caused by intoxicated drivers while operating mechanical systems increase every year in society (Okeagwu and Taiwo, 2022). This is a universal problem that needs to be addressed. The operators of mechanical systems include people who drive vehicles or operate machinery or industrial equipment (Gbenga *et al.*, 2017). The most prevalent and pronounced form of accident occurs on roads, which is caused by vehicle drivers (Vagad, 2016).

A road accident involves the collision of two or more motor vehicles or at least one motor vehicle on a road open to public traffic in which at least one person is injured or killed (Okeagwu and Taiwo, 2022). Road users who drive under the influence of alcohol have a significantly higher risk of being involved in a motor accident (Vagad, 2016). Driving under the influence of alcohol, or drink-driving, contributes to 27% of all road injuries globally and drink-driving is a real public health problem that affects not only alcohol consumers but also, in most cases, innocent parties such as passengers and pedestrians (Niranjani *et al.*, 2019).

Misuse of liquor puts human beings in great danger and vulnerable to different forms of accidents (Weiye, 2018 and Gole *et al.*, 2022). Practically, all public action stakeholders are confronting mishaps due to drunk-driving that endangers everyone in the vehicle and the road users (Niranjani, *et al.*, 2019). Gbenga *et al.* (2017) established that 67.2% of commercial vehicle drivers in Nigeria admitted to drinking alcohol during working hours. It shows that most drivers such as commercial and heavy-duty truck drivers engage in drink-driving which makes them vulnerable to road accidents.

Gadekar *et al.* (2020) developed a system that can detect Blood Alcohol Content (BAC) of drivers and disable the vehicle being operated by such an individual. This system made use of Arduino Uno, MQ3 sensor, GPS, Buzzer, LED, SIM900A, and DC Motor. The location of the driver whenever an accident occurred was sent to preregistered relatives of the driver. Pranavan *et al.* (2021) developed an alcohol sensing alert with an engine locking system that is capable of preventing road accidents caused by drunk drivers. The system comprises of MQ-3 alcohol sensor, Nodemcu ESP8266 Board, DC motor, Liquid Crystal Display (LCD) and buzzer. The micro-controller sent live information about the status of the driver to a web page, which can be accessed by the individual's relatives. Xiuwei *et al.* (2018) and Nirosha *et al.* (2017) went in a similar way to develop detection systems using Arduino to effect the locking of engines of automobiles. Different strategies were created to address this issue, but none of them proved to be efficient or effective when put into practice. These included Breathalyzers to measure a driver's BAC, government legislation to prohibit drunk driving, and the creation of alcohol sensing alerts with engine lockout.

To prevent accidents caused by alcohol impaired drivers of mechanical systems, regardless of place, time, user or age, an automatic system to detect BAC of drivers of mechanical systems was developed in this study. This system is practically implementable and can be attached to any mechanical device. It is opined that if the problem of drunk-driving could be efficiently tackled, it would decrease the rate of road traffic accidents by at least 27%. Drink-driving is a major source of road injuries worldwide and accounts for 27% of all accidents.

MATERIALS AND METHODS

Materials

The materials used in the development of the alcohol detection system in drivers of mechanical systems are shown in Table 1.

Methods

Blood alcohol concentration (BAC) limit calculation

It is estimated that 1000mg/L of alcohol = 0.1% BAC. For every mg/L of alcohol in breath, there are 2100mg/L of alcohol in the blood.

A person with 0.1% BAC has 1000mg/L of alcohol in the breath (Xiuwei *et al.*, 2018). For this design, the limit of BAC value was taken to be 0.02% = 0.2g/L = 200mg/ L. Fisher *et al.* (1987) submitted that at 0.02% BAC, a person's judgement would begin to waver and experience a change of mood. It has also been established that at 0.02% BAC, a person would experience lack of judgment, increased relaxation, mood swings, decreased visual functionality and inability to multi-task.

Table 1: Materials Selection

S/N	Materials	Source	Uses
1	Arduino Uno R3 Board (ATmega328P)	Oke Padre market, Ibadan.	Used for controlling the system.
2	MQ-3 Alcohol Sensor	Oke Padre market, Ibadan.	Used to detect the presence of alcohol in driver’s breath.
3	LCD	Oke Padre market, Ibadan.	Used to display the level of alcohol detected.
4	Buzzer	Oke Padre market, Ibadan.	Used to alert the driver and passengers in a vehicle.
5	Relay	Oke Padre market, Ibadan.	Used as a killer switch.
6	DC motor	Oke Padre market, Ibadan.	Used to represent vehicle’s engine or machinery’s ignition switch.
7	Vero Board	Oke Padre market, Ibadan.	Used as a circuit board for the system.
8	5V USB Cable	Oke Padre market, Ibadan.	Used as a power supply cable from a 5V power source.

At 0.02% BAC, the threshold limit is

200mg/L / 2100mg/L = 0.095238 alcohol in breath.

Threshold value = 1024 X 0.095238
Threshold value = 97.5
Limit set = 100. (This set limit was input into the coding of the Arduino).

System prototype working principle

The Arduino board received an analogue input signal from the MQ-3. The threshold input signal was made to undergo processing. The micro-controller activated the DC motor by sending a high signal to the relay and a low signal to the LED and buzzer when the input threshold value went below the predetermined threshold limit. A high output signal given to the LED would start to flash along with a high output signal to the buzzer, which sounded and a low output signal to the relay, which de-energized the DC motor and stopped the impeller from turning if the threshold value input exceeded the threshold limit. The LED stood in for a vehicle’s emergency light, which would warn oncoming traffic to slow down in order to prevent a sudden collision with the vehicle whose driver was detected to have alcohol in his blood. The driver and other passengers in the vehicle would be alerted by the buzzer. The ignition supply switch for a machine or a vehicle's engine was represented by the DC motor.

Procedural implementation of the system in a vehicle

The system was installed in a vehicle powered with a 12V battery through the ignition switch. The voltage regulator LM7805 was used to step down the 12V from 9V to 5V, which the Arduino required. The heat sink was connected to the voltage regulator to prevent overheating of the system. MQ-3 alcohol sensor, LCD, and 5V Arduino board were connected to the circuit board. To detect the presence of alcohol on the driver's breath, the MQ-3 gas sensor was installed in the steering wheel. The LCD was situated close to the dashboard so that both the driver and passengers could see whether alcohol was present. In order to activate the emergency light once alcohol is detected and alert nearby motorists, an output signal was extracted from one of the digital pins of the Arduino and attached to the emergency switch. The car was equipped with a buzzer that would alert the driver whenever alcohol was detected. It was attached to one of the Arduino's digital pins. Upon the detection of alcohol, a 12V automotive relay acts as a kill switch to stop current from flowing to the fuel pump of the car. The automotive relay's pin 85 was attached to the circuit board's 12V supply. The relay signal pin (pin 30) was connected to one of the Arduino's digital pins. Pin 87 was used as the output kill switch and was connected to the fuel pump, and pin 86 was connected to the car's ground. When alcohol is detected, the relay would stop the supply of fuel by deactivating the fuel pump. The car gradually comes to a stop.

RESULTS AND DISCUSSION

To determine the viability of the system, three experiments were conducted. Distances were selected in the 0 to 50 cm range. The threshold values and the BAC levels were calculated based on the distances selected with the alcohol content of 37.5%. Table 2 and Figure 1 depict the results of Experiment 1, which measured the association between distance (cm) and BAC (%) with 37.5% alcohol by volume.

Table 2: Relationship between Distance (cm) and BAC level (%)

Distance (cm)	Analog Value (Threshold)	BAC level %
0	500	0.10
5	350	0.072
10	260	0.053
20	210	0.043
30	150	0.031
40	100	0.021
50	80	0.016

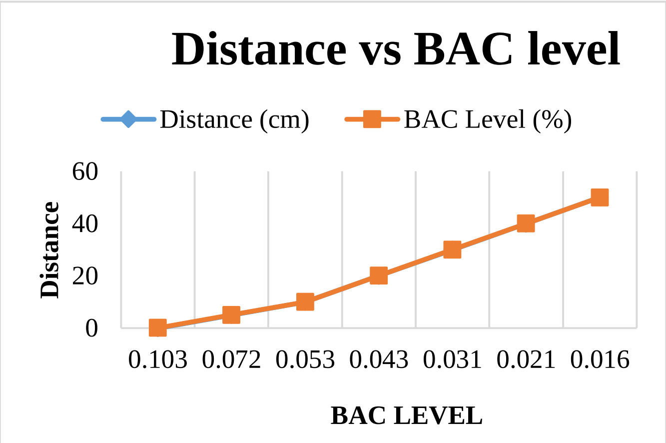

Figure 1: Graph of Distance (cm) vs BAC Level (%)

According to the results presented in Table 2 and also the distance plotted against BAC level in Figure 1, a driver's breath alcohol sensor detects a lower level of BAC the further they are from the sensor, because of the MQ-3 sensor's tiny surface area, the BAC level drops as distance increases.

The purpose of experiment two was to demonstrate the relationship between the alcohol content in volume of various alcoholic beverages and the BAC level measured by the alcohol sensor at a fixed distance (40 cm). The gathered information is displayed in Table 3 and is clearly depicted in Figure 2.

Table 3: Relationship between Percentage of Alcohol in Drinks and BAC Level

Alcohol Percentage %	Analog Value (Threshold)	BAC level %
43	135	0.028
40	122	0.025
37.5	100	0.021

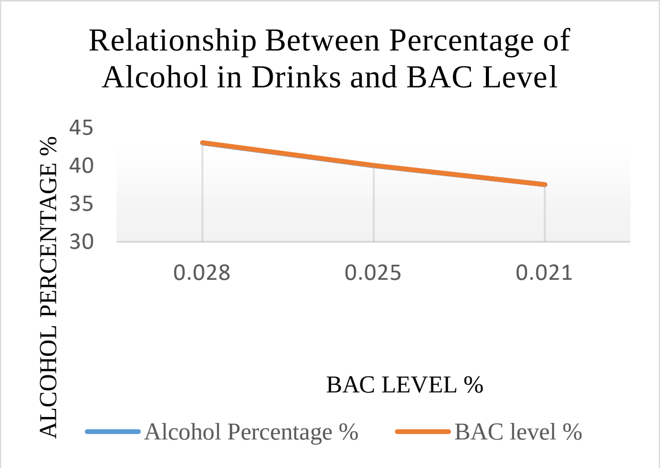

Figure 2: Graph of Alcohol Percentage vs BAC level

From the experiment, it can be seen that the alcohol percentage per volume and the driver's BAC are proportional. Thus, the higher the BAC level, the higher the alcohol present in the beverages.

The third experiment demonstrated how blowing air affected the MQ-3 alcohol sensor's sensitivity and the concentration of BAC levels in a driver's breath. The first one, which is depicted in Table 4 and Figure 3, and demonstrates how blowing air affected the MQ-3 alcohol sensor's sensitivity when alcohol was present.

Table 4: Sensitivity of Alcohol Sensor in the Presence of Blowing Air

Distance (cm)	Time Taken to Detect Alcohol Above the BAC Limit (sec)	Time Taken to Return to Below BAC Limit (sec)
30	3	900
35	5	780
40	7	600
45	10	480
50	14	420

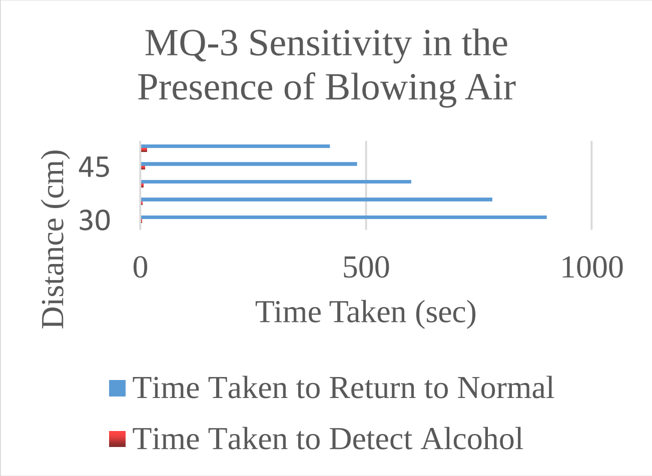

Figure 3: MQ-3 Alcohol Sensor Sensitivity in the Presence of Blowing Air

The second experiment demonstrated how the MQ-3 sensor's sensitivity to alcohol responded in the absence of airflow, as shown in Table 5 and Figures 4 and 5. These tests showed the impact of airflow from a moving vehicle on the sensitivity of the MQ-3 alcohol sensor.

Table 5: Sensitivity of Alcohol Sensor in the Absence of Blowing Air

Distance (cm)	Time Taken to Detect Alcohol Above the BAC Limit (sec)	Time Taken to Return to Below BAC Limit (sec)
30	30	7
35	80	9
40	120	12
45	180	14
50	360	16

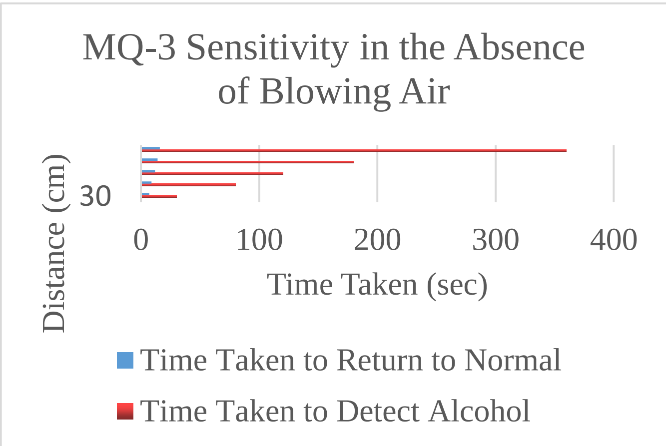

Figure 4: MQ-3 Alcohol Sensor Sensitivity in the Absence of Blowing Air

Figure 5: Alcohol Detection System Prototype

According to the results of these trials, blowing air boosts the MQ-3 alcohol sensor's sensitivity when alcohol is present. The system can be coupled to various types of machinery, such as lathes, milling machines, and others, in order to have direct interaction with the machine and to stop it whenever alcohol is detected in the operator's breath while operating that machinery.

CONCLUSION

Three experiments were conducted to test the functionality of the device. Experiment one showed that drivers of mechanical system should stay close to the sensor for optimum detection of alcohol in their breath. Experiment two demonstrated the relationship between the alcohol content in volume of some drinks and the BAC level measured by the alcohol sensor at a fixed distance of 40cm. It showed that the more the content of alcohol, the higher the BAC level. The third experiment revealed the relationship of the presence of air to the sensitivity of the sensor/BAC level in the driver’s breath. The trial results further verified that the system was implementable in either a closed or open mechanical system, and it could be utilized as an access pass to a workplace to monitor the intoxication level of the employees.

Reference

Fisher H.R., Simpson, R.I. and Kapur, B.M. (1987). Calculation of Blood Alcohol Concentration (BAC) by Sex, Weight, Number of Drinks and Time. Canadian Journal of Public Health. 78. 300-304.

Gadekar, P. P., Prashad, D. Sabale, R. Gagare, G. Jori, M. Dethe, P. (2020). Alcohol Detection System Using Arduino. *IJARIIE.* 6 (4).

Gbenga, D. E., Hamed, H. I., Lateef, A. A. and Opeyemi, A. E. (2017). Alcohol Detection of Drunk Drivers with Automatic Car Engine Locking System. *Nova Journal of Engineering and Applied Sciences.* 6 (1):1-15.

Gole, H., Ingle, S. and Salunkhe, R. (2022). Alcohol Detection Engine Locking System with Driver Hiring Service. *International Research Journal of Modernization in Engineering Technology and Science.* 4(4). 1312-1316.

Niranjani, V., Prabhu, C., Nithesh, P., Nithish, M. and Riyas, S. M. (2019). Drink and Drive Detection with Ignition Lock System. *International Journal of Research in Engineering, Science and Management.* 2(3). 2581-5792.

Nirosha, K., Priyanka, C. Kishore, K.A. (2017). Alcohol Detection in Vehicles. *International Research Journal of Engineering and Technology (IRJET).* 04(04). 2025-2030.

Okengwu, U. A. and Taiwo, A. A. (2022). Design and Implementation of In-Vehicle Alcohol Detection and Speed Control System. *EJECE, European Journal of Electrical Engineering and Computer Science*. 6(5). 10-16.

Pranavan S, Saravanan K., Ravi R. S. A. and Sudharsan V. (2021). Alcohol Detection Sensor- An Apprise. *International Journal for Innovative Research in Science & Technology*. 7(10). 1-4.

Vagad, A. (2016). Blood Alcohol Level Sensing Instrument for Car Drivers. *International Journal of Engineering Research & Technology (IJERT)*. 5(06). 607-610.

Weiye, H. (2018). Vehicle Alcohol Detection System Based on Internet of Things Technology. *IOP Conf. Series: Materials Science and Engineering*. 452. 042156. 1-6.

Xiuwei, F. Li, F. and Yifeng, W. (2018). Design of Alcohol Content Detector Based on Single Chip Microcomputer. *Advances in Engineering Research*, 162. 270-273.