IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES
ISSN PRINT 2319 1775 Online 2320 7876
Research Paper © 2012 IJFANS. All Rights Reserved Journal UGC CARE Listed (Group-I) Volume 10 , Issue 01, 2021

A Real Time Exhaust Emission Sensing Device For Two-Wheeler

Shrikant M. Bante

Lecturer, Mechanical Engineering Department, Government Polytechnic, Sakoli
Shrikant.bante769@gmail.com

Abstract:-

Air pollution causes detrimental effects on human health and the atmosphere. The emissions associated with transport represent a major component of aerial pollution. In recent years, air pollution is becoming a very important issue in India and around the World. Conventionally, the most popular dynamometer testing has been widely used to measure vehicle exhaust emission and these measured emissions have been used as primary data for modeling transport related air quality impact. However, during such conventional emission testing, real driving conditions are not strictly considered. Nowadays, real-time vehicle emission measurement is mainly focused by the most of the researchers for analysis purposes. In the present paper, we discussed development of real time exhaust gas sensing system by using MG-811 sensor, MQ-7 sensor, MQ-3 sensor and MQ-135 for measurement of exhaust emission such as CO_2, CO, HC and NO respectively from two-wheeler in real driving condition. It is found that, the developed instrument has accuracy of 93.57% when compared with AVL gas analyser. The use of electronic sensors, IOT technology, Machine learning techniques for the development of exhaust gas emission system gives high accuracy. Along with this, due to compact in nature and low cost, the use of this developed device is preferable over existing devices.

Keywords: Air pollution, AVL gas analyser, IOT technology, sensor.

1. INTRODUCTION: -

Air pollution constitutes the foremost pressing environmental health risk facing our world population. It's calculable to contribute toward seven million premature deaths a year, whereas near about ninety-two percent of the world's population is estimated to breathe toxic air (WHO, 2016) [1]. In less-developed nations, 98 percent of

children under five breathe poisonous air. As a consequence, air pollution is the biggest cause of death for children under 15 years of age, killing 600,000 every year [1] [2]. The World Air Quality Report 2019 presents PM2.5 data made publicly accessible during 2019, data reported in this report are focused on real-time or roughly real-time

monitoring by government sources and independently controlled and validated non-governmental air quality monitors. This report concluded that according to region wise South Asia, Southeast Asia, and Western Asia bear the highest burden of fine particulate matter (PM2.5) emissions overall, with only 6 of 355 cities included meeting WHO annual goals in these areas collectively [2]. During 2019, the study highlights the world's top 30 most polluted cities, 21 in India, 27 in South Asia, and all the top 30 cities in Greater Asia [3]. In India day by day air pollution is becoming a serious problem from both the human perspective and environmental perspective [4]. Traffic-related emissions constitute a major component of airborne pollution [5], and it is largely responsible for climate change [6]. Transport emissions,

Research Paper © 2012 IJFANS. All Rights Reserved

primarily road transport, contribute significantly to the number of greenhouse gases in the environment, so the amount of exhaust gas emissions produced by motor vehicles needs to be accurately measured [7]. In urban areas the high inflow of vehicles decreasing air quality and causing more air pollution that leads to serve health diseases [8]. After decades of study and laboratory studies on livestock, the US Environmental Protection Agency (EPA) report concluded that the contaminants are carcinogenic and thus contribute significantly to the production of lung cancer; carmakers treat the issue of exhaust pollution with priority [9]. Measuring the emissions of exhaust pollutants from car engines is very important because of their adverse environmental impact [10]. Studies on automotive exhaust emissions under real operating conditions have clearly demonstrated that the level of natural vehicle emissions is higher than the level of laboratory test emissions [11] [12]. The Real Driving Emission (RDE) test concluded that the emission of nitrogen oxides is greater than that obtained in the laboratory test [13]. They, therefore, suggest using the test results of the RDE (Real Driving Emission) to develop the engine control system. Emissions from diesel vehicles are responsible for more air pollution related death worldwide [14] [15]. The national clean air programme (NCAP Ministry of Environment, Forest & climate change, Government of India 2019) report 2019 [16] concluded that there is a need to develop techniques and methods for measuring harmful emissions in real time due to the extreme risk posed to human health and the environment. Emissions from automobiles have traditionally been studied in laboratories using chassis or engine dynamometers. These tests are carried out utilizing standardized driving cycles that are supposed to simulate real-world vehicle operation. But emission result of vehicles in real driving conditions are not same as laboratory test result. (Pathak et.al ,2016). To measure the vehicular emissions from automobile in real time there are various portable emission measurement systems (PEMS) are available like AVL, Horriba, Semtech DS analyzer etc. Despite the fact that PEMS is labelled as "portable," it normally weighs more than 100 kg due to the presence of gas cylinders for calibration and batteries this weight has an impact on the driving conditions of vehicles on the road [16]. but the cost of such portable emission measurement systems in lakhs of rupees. So, we decided to design and developed the low-cost real-time exhaust gas sensing system which can be easily sense exhaust emission from two-wheeler in real time with the use of various gas sensors namely MQ-7, MQ-2 and MG-811.Thus, the objective of this paper is to quantify the emissions of CO, HC and CO_2 from two-wheeler in real time using exhaust gas sensing system. can easily monitor and measure air pollution through the transport sector.

2. Factors affecting vehicular emissions:

Fuel intake and exhaust emission rates are closely related to engine load and vehicle speed [17]. Factors that directly affect engine load are vehicle acceleration, engine friction, wind resistance, roadway efficiency, tire-roadway friction and accessories such as air conditioning. In turn, these engine load sources are calculated by a combination of vehicle characteristics such as motor displacement, vehicle mass, transmission performance, etc. and operating conditions of vehicles. Operating conditions include vehicle speed and acceleration are influenced by traffic congestion, driver attitude, traffic signals, posted speed limits, etc. [18]. In the summer of 2016, researchers (Granié, M.A. et.al. 2011; Holmén, B.A.et.al.1998) performed an on-road emissions measurement experiment in the city of Logan, UT, USA to

Research Paper © 2012 IJFANS. All Rights Reserved

determine the effects of driver experience and gender and driving behaviour on vehicle emissions, where the driving of the same vehicle along the same route was measured in four different driver groups: Experienced versus Inexperienced, female versus male. The results revealed that experienced drivers and male drivers released more HC and NOx than the control driver, which was not the case with both young and female drivers [19] [20].

Jawad H. Al-rifai et.al. [21], found in his research that road grades, speed and type of vehicle had a substantial effect on gas emissions rates. Since there is no uncertainty about the fact that heavy traffic on road is more responsible for generating more pollution hence significant attention is needed to evaluate and quantify the factors which are responsible for these emissions. The following listed factors are directly or indirectly affect the emission level [22].

Type of vehicle: Vehicles in this category can be categorized into the following categories, such as vehicle brand, vehicle model, engine size, vehicle era, vehicle technology, vehicle maintenance and categories of exhaust systems, vehicle tire pressure.

Type of Fuel: Exhaust emission emitted from vehicles depends upon grade, type of fuel such as CNG, biodiesel, petrol, diesel.

External Conditions: External conditions mainly include environmental conditions such as pressure, temperature, and humidity.

Driving activity: Driving activity includes normal driving, aggressive driving, cruising, idling, accelerating, and decelerating.

The vehicular emissions also rely upon proper contact between driver and vehicle. The vehicular emissions can be minimized by identifying user optimal behavior while driving and intimate the drivers about the problems associated with the inefficient style of driving, as well as informing them about its possible solutions.

3. Implementation of Emission Norms in India

In India, as proposed by the Auto Fuel Policy and the productive development of new technologies, the Indian automotive industry is primarily working towards regulatory emissions. As Indian safety requirements are compliant with Global Technical Regulations (GTR) and UN Regulations, vehicle technology in India is now on par with international benchmarks [23]. The first concept of emission standards in India was introduced for petrol engines in 1991 and diesel engines in 1992. From April 1995, in the four metro cities Delhi, Kolkata, Chennai, and Mumbai, new petrol passenger cars with the mandatory fitting of catalytic converters were launched along with the availability of unleaded petrol [24]. The Bharat Stage-I (BS-I) emission standards for passenger cars and commercial vehicles were implemented in India in 2000 to meet the Euro I standard. In Delhi, Mumbai, Chennai and Kolkata, further Euro II equivalent Bharat Stage II standards were in place from 2001 onwards. In August 2002, the first auto fuel policy was implemented, in which four-wheeled vehicles have followed the BS III norm. In April 2010, Bharat Stage IV was introduced for 13 metro cities, and the rest of the country switched to Bharat Stage III. The criteria for Bharat Stage IV were expanded to an additional 20 cities in October 2014. India's National Capital Region (NCR) was in extreme condition due to a massive rise in levels of air pollution. This drastic situation has led the Indian Government to take the strongest decision

Research Paper © 2012 IJFANS. All Rights Reserved

to bypass the BS V emission standard, which was introduced in 2020, and to advance the introduction of the BS-VI emission standard from 2020[25].

Table.1: Bharat Stage Norms for Two-Wheeler Emission (gm/Km)

Sr. No.	Year	BS Stage	CO	NO_x	HC+NO_x	PM
1	1996	BS	4.5	-	3.60	-
2	2000	BS-I	2.00	-	2.00	-
3	2005	BS-II	1.5	-	1.5	-
4	2010	BS-III	1.0	-	1.0	-
5	2017	BS-IV	1.403	0.39	0.79	
			CO	NO_x	HC	PM
6	2020	BS-VI	1.0	0.06	0.1	0.0045

4.Population of Motorcycle in Maharashtra

India is the world's third largest emitter of greenhouse gases, behind China and the United States (GHGs) [26]. The transportation sector in India is expected to expand significantly as the country's population and economic growth rise [27]. Due to their cost, simplicity, and ease of operation, Many Asian countries, including India, use motorcycles as a mode of personal transportation [28-30]. As a result, two-wheeler sales in India have grown at an exponential rate[31-32]. According to statistics from the Ministry of Statistics and Program Implementation of the Government of India, the number of registered two wheeler in India went from 92 million in 2010 to 169 million in 2016 [33-35]. Maharashtra ranked third in two-wheeler registrations, according to data published by the Federation of Automobile Dealers Associations. Both the number of road cars and transportation related carbon dioxide emissions might treble by 2030, according to projections from an Indian government policy think group (Rocky Mountain Institute and NITI Aayog, 2017a) [36]. As per the data published by Society of Indian Automobile Manufacturers (SIAM), the total productions of passenger vehicles which includes commercial vehicles, passenger vehicles, three-wheeler quarterly, two-wheeler, performance was 4,583,510 units out of which two-wheeler sales was 2,403,591 i.e., 52.4 % as compared to 14 % for passenger vehicles, 2.3% for commercial vehicles and 0.5 % for three-wheeler. All of these two wheeler runs on a gasoline, their emissions will have a significant influence on air quality [37,38].

5. Effect of vehicular pollutant on human health and environment

Automotive vehicles emit several pollutants depending upon the quality of the fuel they consume and engine efficiency. The major pollutants released as vehicle/fuel emissions are, carbon monoxide (CO), nitrogen oxides (NOx), photochemical oxidants, air toxics, namely benzene (C_6H_6), aldehydes, 1,3 butadiene (C_4H_6), lead (Pb), particulate matter (PM), hydrocarbon (HC), oxides of Sulphur (SO_2) and polycyclic aromatic hydrocarbons (PAHs). While the predominant pollutants in petrol/gasoline driven vehicles are hydrocarbons and carbon monoxide, the predominant pollutants from the diesel-based vehicles are Oxides of nitrogen and particulates [39].

5.1 Carbon Monoxide (CO)

CO is produced when the fuel does not burn completely, the carbon in the fuel will be converted to CO. Emissions of CO decreases with increasing of engine speed. This odorless,

Research Paper © 2012 IJFANS. All Rights Reserved

colorless gas is formed by the combustion of fossil fuels such as gasoline When inhaled, CO blocks the transport of oxygen to the brain, heart, and other vital organs in the human body. Newborn children and people with chronic illnesses are especially susceptible to the effects of CO.

5.2 Carbon dioxides (CO_2)

CO_2 is produced when the fuel does burn completely, the carbon in the fuel will be converted into CO_2. When increases engine speed so the CO_2 emissions follow a minor increase. Carbon dioxide in the atmosphere warms the planet, causing climate change. Symptoms of mild CO_2 exposure may include headache and drowsiness. At higher levels, rapid breathing, confusion, increased cardiac output, elevated blood pressure.

5.3 Nitrogen Oxides (NO_x)

Increase in fuel consumption as load increases, which lead to increase in temperature during combustion process thus increase NOx. These vehicular pollutants can cause lung irritation and weaken the body's defenses against respiratory infections such as pneumonia and influenza. In addition, they assist in the formation of ozone and particulate matter

5.4 Hydrocarbon (HC)

The presence of hydrocarbon in the exhaust gases indicates that the fuel was not completely burned. It was found that the hydrocarbon decreases with increase of engine speed. The main causes of complete combustion failure and hydrocarbon formation are Lack in the oxygen, the temperature is low, and mixture heterogeneity. Hydrocarbon has low surface tension and a low viscosity, therefore it penetrates deep into the lungs. This leads to a severe necrotizing pneumonia.

6. Related Work

6.1 Literature Survey Based on RFID technology

Various emission control systems have been explored in various kinds of literature over the year. Chi-man vong et.al.2014 [40] , in the present paper author mainly focused on the emission control system for developing countries is discussed. The systems are made up of RFID tags to which the lambda sensor is attached with an analogue to digital converter. The lambda sensor mounted at the exhaust pipe of the vehicle for calculating air ratio. If the air ratio is less than one then the emission of carbon monoxide and the hydrocarbons will be increased and when the air ratio more than one nitrogen oxide will be emitted. The RFID reader is used to read the value. This RFID tag passes data to the Second RFID device. The second RFID device is attached to the 3G card from which data is sent to the database server where all information is successfully modified and saved. If the actual data does not match with the standard data, then the message is generated and sent to the vehicle owner.

Anita Kulkarni et.al.2015 [41], the onboard vehicle (OBU) device is installed, which is used to collect vehicle exhaust data and send it to the roadside unit (RSU) installed at the traffic signal point. Received data along with traffic threshold transfer to the server side unit (SSU). The author concluded that using this method would minimise CO (carbon monoxide) exhaust emission. This system stops the vehicle and generates the message and sends it to the

Research Paper © 2012 IJFANS. All Rights Reserved

unique contact number stored in the GSM module if vehicle emission crosses pre-set standards.

Ramgiri R. et.al.[42], in this proposed system author, used a wireless sensor along with active RFID monitor vehicular pollution based on IoT. IoT plays a vital role in the proposed system to address vehicular pollution in real-time applications. Given a system equipped with a CO_2 gas sensor and SOx gas sensor to monitor the pollutants continuously to maintain the quality of the air. The RFID reader, wireless gas sensors are integrated along with the microcontroller at the monitor location. The given proposed system is placed on either side of the road. The proposed system of the given paper can identify the vehicle which is attached with RFID tags passes through the sensor node. The sensor measures the exhaust emission emitted by the vehicle and the RFID reader displayed the information in the monitoring system. The real-time data detected is further sent to the microcontroller to verify the concentration of pollutants from the vehicle. The microcontroller verifies the levels of the emissions pollutant of the air emitted by the vehicle. If the amount of pollutants is greater than the threshold, the vehicle sends an alert warning message to the owner of the vehicle. The information about the RFID of the vehicle and time and date of the vehicle, the levels of CO_2 and SOx, vehicle number send to authorized agencies. This data get stored in the server database for future analysis. The microcontroller monitors the levels of emission pollutants released by the vehicle. If the amount of pollutants is greater than the threshold, the vehicle sends an alert message to the owner of the vehicle.

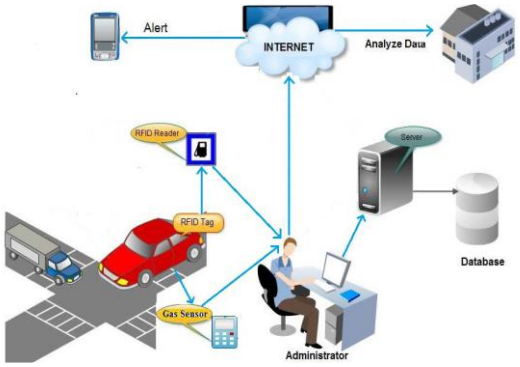

Figure 1: Proposed Emissions Control Method Using RFID technology (Source [42]: Ramgiri R. et.al.IEEE, 2015)

6.2 Literature Survey Based on Gas Sensor Technology

G.Arun Francis et.al [43], In this system, the hydrocarbon, carbon monoxide, and nitrogen oxide amounts emitted from the exhaust are monitored by MQ2, MQ7, MQ135 sensors mounted at the vehicle exhaust. The analogue value obtained from the sensors is analyzed by the Internet-connected Wi-Fi controller. The value of the sensors is displayed on LCD and cloud on an ongoing basis. When the value obtained from the sensor exceeds the threshold limit, the controller alerts the user via the vehicle owner's LCD and database. Io T allows the computer to change the value of the cloud.

P Arun Mozhi et.al. [44], the proposed system used in this paper consists of a

Research Paper © 2012 IJFANS. All Rights Reserved

microcontroller and a sensor to measure vehicle emissions in order to alert the government to monitor the AQI and to communicate emission related information through GSM. The proposed prototype system for monitoring and detecting the level of emissions of the individual vehicle and sending information to the Central pollution control board and RTO if the vehicle crosses the threshold limit. The present system capable of detecting nitrogen oxide (NO) and carbon monoxide (CO), Carbon oxide (Cox) by using gas sensors. Due to heat dissipation from exhaust emission, the sensors may be malfunctioned during working so that they placed it in the thermal Isolation Clip. The real-time data get collected in PIC microcontroller and data analyzed using C coding. While comparing data any deviation occurs then with the help of GSM and Information regarding GPS modules is transmitted to the nearest control station also to the driver with the help of LCD display.

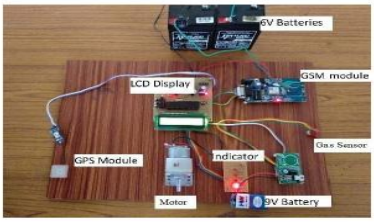

Figure 2: Real-time emission sensing system Using gas sensor (Source: P Arun Mozhi et.al[44])

6.3 Literature Survey Based on PEMS (Portable emission measurement system) Technology

Jerzy Merkisz et.al. [45], in the present paper author emphasis on real driving emission test for the light- duty vehicle (LDV), heavy-duty vehicle (HDV). The actual driving emissions test was carried out under real traffic conditions with portable emission measurement system (PEMS) equipment. PEMS such as SEMTECH DS is used to measure CO, CO_2, No, NO_2 emission from the exhaust of the vehicle. To measure the PM [mg / m3] concentration, PEMS AVL MSS (Micro Soot Sensor) is used. TSI 3090 EEPS™ determines the size distribution of PM [nm] is used during the test. The paper discussed the problem of measurement of CO, HC, NOx, PM emissions, and related methodologies. After the completion of the test, it was reported that the main problem is the emission of NOx and PM, which is normally higher than the level of emission, which also indicates that the actual driving emission method is very complex, but is the only way to obtain information on the actual emissions of road exhaust that cannot be obtained in the laboratory test.

Barouch Giechaskie et.al. [46], The RDE procedure has been described in this paper. This paper focuses on the test technique used by Portable Emissions Measurement Systems (PEMS) to check emissions of gaseous pollutants and particle numbers during a wide variety of typical road operating conditions. Total RDE test procedures are divided into the following steps such as Vehicle selection, 2 vehicle preparation, trip design, trip execution, trip verification, and calculation of emissions. Out of these mentioned steps, vehicle preparation and trip execution are described in a better way in this paper.

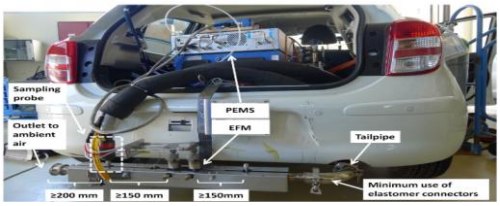

Figure 3: PEMS Installation (Source: Barouch Giechaskie et.al. [46])

7. Proposed Emission sensing device

The present exhaust gas sensing system consist of Arduino, various gas sensors namely MG-811, MQ-2, MQ-7 and MQ-135, Wi-Fi module. Arduino is used for controlling overall system architecture. As a Motorcycle emission having various pollutants such as Carbon monoxide (CO), Nitrogen oxide (NO), hydrocarbon (HC) and Carbon dioxide (CO_2) these pollutants are sensed by the gas sensors. During real world driving conditions, the sensed information in the form of analog value received from the sensor is continuously processed by the Controller. The value obtained from the various gas sensors is continuously updated on mobile screen by crating one application on mobile. The motorcycle emission data get stored continuously on cloud. Updated data record time, CO, NOx, HC, CO_2, longitude and latitude, current location of Motorcycle.

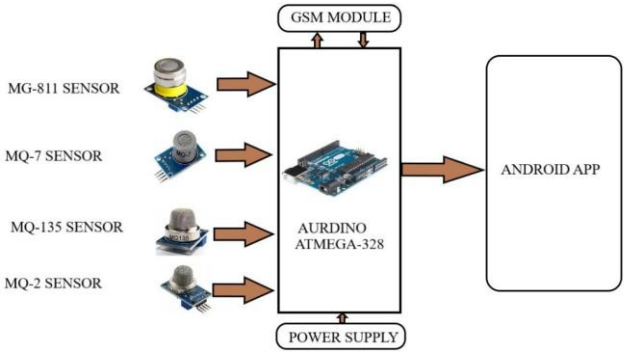

Figure 4: Block diagram of exhaust gas sensing system

With the aid of the Bluetooth device and the Arduino Mega 328 kit, both the gathering of data as well as its transmission was successfully performed. An Android application has to be developed in order for the data to be shown on mobile devices in real time. The cell phone and the recently developed device were able to communicate with one another thanks to Bluetooth technology. Both the Arduino kit and the mobile application were programmed in Java. Figures 3.9 and 3.10 respectively depict the finished product, which is a gadget, as well as the application. Figure 3.11 provides a visual representation of the attachment of the device to the motorcycle.

Research Paper © 2012 IJFANS. All Rights Reserved

Figure 5: Real time exhaust gas sensing device

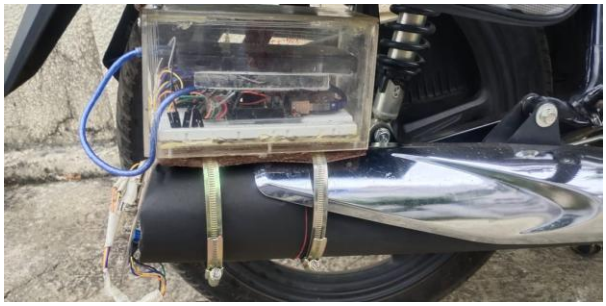

Figure 6: Mounting of exhaust emission sensing device on two-wheeler tailpipe .

7.1 Android application of proposed system

We chose the Android mobile platform because of its popularity and productivity in order to make the data collection process more convenient. An Android application using the Android APK was created to collect data from the device to the phone. The application will run on Android phones that meet the operating system's basic requirements. The Application functions by making the user pair the phone with the physical exhaust emission sensing device via Bluetooth. The user is prompted to load the data to their phone after establishing a connection successfully. The data from exhaust emission sensing device is transferred to the Android phone using Bluetooth. The information can then be stored to the phone's physical memory or SD Card.

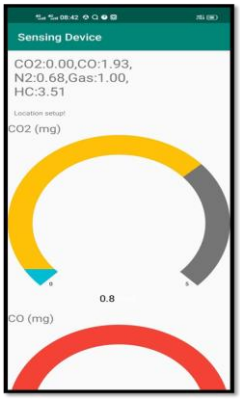

Figure 7: Android App for Sensor based

real time exhaust emission sensing device.

Research Paper © 2012 IJFANS. All Rights Reserved

7.2 Calibration of exhaust gas sensing device

In order to use proposed system to measure on road motorcycle emission there is need to calibrate the system with standard gas analyzer. Thus, each sensor namely MQ-2, MQ-7 and MQ-135 is calibrated by using 5- Gas analyzer. It is found that, the developed instrument has accuracy of 93.57% when compared with gas analyser. The use of electronic sensors, IOT technology, Machine learning techniques for the development of exhaust gas emission system gives high accuracy. Along with this, due to compact in nature and low cost, the use of this developed device is preferable over existing devices.

Conclusion

A real-time emission measurement system is needed to control air pollution caused by the transport sector. Real-time emission monitoring technologies are important research tools, as various factors affecting the exhaust emission of the vehicle are significantly considered while measurement. In the Real Driving Emissions (RDE) test, real-time sensing systems are used to measure pollutants such as CO_2,HC, and CO emitted by two wheeler when driving on the road. Several studies have attempted to measure emissions from cars, buses, and trucks using laboratory-based or real-world emission tests. However, real-world emissions from motorcycles (or motorized two-wheelers) have not received adequate attention. In India, there is very few real time exhaust emission monitoring systems are available for four wheeler only which are costly like AVL gas Analyzer (PEMS-Portable emission measurement system).

Poor vehicle maintenance and ignition defect increase the pollution. Urbanization has increased relative number of land vehicles which have led to the decline of the air quality. Emission standards were made more stringent and different inspection and maintenance (I/M) programs have been introduced. This program requires the inspection of different vehicle parameters to maintain the standards of emission. In the present paper, various technologies used for real-time exhaust emission measurements have been discussed. Many researchers are giving a decent contribution to the development of new technologies using different methods for measuring vehicular emission in real-time. The present paper has given information about new developed real time exhaust emission sensing device which can be easily use to measure on road two wheeler emission emitted by motorcycle in real driving conditions. Researchers could study the effect of different biodiesel & speed on vehicular emission in real driving condition. In future real time recorded data measured by emission sensing device can be display on two-wheeler dashboard like speed.

REFERENCES:-

1. Who. (2016, September 27). Who Releases “Country Estimates On Air Pollution Exposure And Health Impact”. Retrieved February 17, 2020, From Https://Www.Who.Int/News-Room/Detail/27-09-2016-Who-Releases-Country-Estimates-On-Air-Pollution-Exposure-And-Health-Impact.
2. Who. (2018, October 29). More Than 90% Of The World’s Children Breathe Toxic Air Every Day. Retrieved February 17, 2020, From Https:// Www.Who.Int/News-Room/Detail/29-10-2018-More-Than-90-Of The World%E2%80%99s-Children-Breathe-Toxic-Air-Every-Day.

Research Paper © 2012 IJFANS. All Rights Reserved

3. Iqair Report (2019), "2019 World Air Quality Report Region & City Pm2.5 Ranking" [Accessed: 1- Sept- 2020].
4. Central Pollution Control Board, Monitoring Network,2019 Http://Cpcb.Nic.In/Monitoring-Network-3/ [Accessed: 1- Aug- 2020].
5. Karl Ropkins, Joe Beebe, Hu Li, Basil Daham, James Tate, Margaret Bell & Gordon Andrews (2009) Real-World Vehicle Exhaust Emissions Monitoring: Review And Critical Discussion, Critical Reviews In Environmental Science And Technology,39:2, 79-152, Doi: 10.1080/10643380701413377.
6. Report On National Clean Air Programme (NCAP), 2019 [Accessed: 1- Sept- 2020]
7. Jaworski, A., Mądziel, M., Lejda, K., 2019. Creating An Emission Model Based On Portable Emission Measurement System For The Purpose Of A Roundabout. Environmental Science And Pollution Research 26(21), 21641-21654.
8. Merkisz J., Lijewski P., Fuc P., Siedlecki M., Ziolkowski A., 2016, Development Of The Methodology Of Exhaust Emissions Measurement Under Rde (Real Driving Emissions) Conditions For Non-Road Mobile Machinery (Nrmm) Vehicles, Iop Conference Series: Materials Science And Engineering, Vol. 148, No. 1.
9. Environmental Protection Agency. Health Assessment Document For Diesel Engine Exhaust. 2002. Online Document: Http://Ofmpub.Epa.Gov/Eims/Eimscomm.Getfile?P_Download_Id=36319. [Accessed: 2-Aug-2020]
10. Artur Jaworski ,Maksymilian Mądziel1 & Kazimierz Lejda1 (2019),Creating An Emission Model Based On Portable Emission Measurement System For The Purpose Of A Roundabout Environmental Science And Pollution Research (2019)26:21641–1654
11. Pielecha, J., Kurtyka, K., Skobiej, K. The Impact Of Vehicle Dynamic Parameters On The Exhaust Emission In Rde Tests. Combustion Engines. 2018, 175(4).
12. Merkisz, J., Pielecha, J. Selected Remarks About Rde Test. Combustion Engines. 2016, 166(3), 54-61.
13. May J, Favre C, Bosteels D. (2013), Emissions From Euro 3 To Euro 6 Light-Duty Vehicles Equipped With A Range Of Emissions Control Technologies. London: Association For Emissions Control By Catalyst; 2013.
14. Reşitoğlu, İ. A., Altinişik, K., & Keskin, A. (2014). The Pollutant Emissions From Diesel-Engine Vehicles And Exhaust After Treatment Systems. Clean Technologies And Environmental Policy, 17(1), 15–27. Doi: 10.1007/S10098-014-0793-9.
15. Anderson P (2008) Scr Catalysts For Low-Emitting Diesels. In: Us Dept. Of Energy Diesel Engine Emissions And Energy Reductions Conference (Deer), Detroit.
16. Report Of National Clean Air Programme (Ncap) Ministry Of Environment, Forest & Climate Change Government Of India, (2019) Indira Paryavaran Bhawan, Jor Bagh Road New Delhi-110 003, India.

Research Paper © 2012 IJFANS. All Rights Reserved

17. Kean, A.J., R.A. Harley, And G.R. Kendall 2003 Effects Of Vehicle Speed And Engine Load On Motor Vehicle Emissions. Environ. Sci. Technol. 37(17), 3739-3746

18. Khader, Abdelhaleem, And Martin, Randal 2019 On The Road Testing Of The Effects Of Driver's Experience, Gender, Speed, And Road Grade On Car Emissions. Journal Of The Air & Waste Management Association Pp.1-35.

19. Granié, M. A., And E. Papafava. 2011. Gender Stereotypes Associated With Vehicle Driving Among French Preadolescents And Adolescents. Transportation Research Part F: Traffic Psychology And Behaviour, 14(5), 341–353. Https://Doi.Org/10.1016/J.Trf.2011.04.002

20. Holmén, B.A. And D.A. Niemeier. 1998. Characterizing The Effects Of Driver Variability On Real-World Vehicle Emissions, Transpn Res-Part D, 3:2, 117-128.

21. Al-Rifai, J.H. Correlation Analysis Of Driving Conditions And On-Road Emissions Trends For Vehicles. J. Urban Environ. Eng. 2017, 63–72.

22. Zhang, K., Yao, L. & Li, G. 2013. Factors Affecting Vehicular Emissions And Emission Models.

23. Society Of Indian Automobile Manufacturers Http://Www.Siamindia.Com/Technical-Regulation

24. Sharma S, Jain S, Goel A, Mahtta R , Kumar R, Datt D, Kundu S, Aggarwal P, And Sharma P, 2014 Advancement Of Fuel Quality And Vehicle Emissions Norms To Improve Urban Air Quality In India. *The Energy Resource Institute. Policy Brief.*

25. Sharma P, Yadav M, Yadav D And Vashist D 2018 A Comparative Study And Analysis Of Emission Norms Adopted By Developed And Developing Nations. *International Journal Of Engineering Technology Science And Research Volume 5, Issue 1.*

26. J. Timperley, The Carbon Brief Profile: India, *Accessed On. 14 (2019).*

27. D. Chen, Y. Bhatt, The Impacts Of Industrialization On Freight Movement In China, King Abdullah Pet. Stud. Res. Center, Riyadh, Saudi Arab. (2019).

28. S. Mahesh, G. Ramadurai, S.M. Shiva Nagendra, Real-World Emissions Of Gaseous Pollutants From Motorcycles On Indian Urban Arterials, *Transp. Res. Part D Transp. Environ. 76 (2019) 72–84. Https://Doi.Org/Https://Doi.Org/10.1016/J.Trd.2019.09.010.*

29. M.S. Alam, A. Khan, To Minimize Vehicular Emissions Of Nagpur, India, (N.D.).

30. D. Malik, Assesment Of Impact Of Vehicular Pollution On Ambient Air Quality: A Case Study Of Gurgaon City, (2014).

31. S.S. Chandrasekaran, S. Muthukumar, S. Rajendran, Automated Control System For Air Pollution Detection In Vehicles, In: *2013 4th Int. Conf. Intell. Syst. Model. Simul., Ieee, 2013: Pp. 49–51.*

32. C.-M. Vong, P.-K. Wong, Z.-Q. Ma, K.-I. Wong, Application Of Rfid Technology And The Maximum Spanning Tree Algorithm For Solving Vehicle Emissions In Cities On Internet Of Things, In: *2014 Ieee World Forum Internet Things, Ieee, 2014: Pp. 347–352.*

33. P.A.M. Devan, F.A. Hussin, R. Ibrahim, K. Bingi, M. Nagarajapandian, Iot Based Vehicle Emission Monitoring And Alerting System, In: *2019 Ieee Student Conf. Res. Dev., Ieee, 2019: Pp. 161–165.*

34. N. Aayog, India Leaps Ahead: Transformative Mobility Solutions For All, Natl. Inst. *Transform. India, New Delhi. (2017).*

35. R.S. Bharj, R. Kumar, G.N. Singh, On-Board Post-Combustion Emission Control Strategies For Diesel Engine In India To Meet Bharat Stage Vi Norms, In: *Adv. Engine Diagnostics, Springer, 2019: Pp. 105–125.*

36. B.R. Gurjar, K. Ravindra, A.S. Nagpure, Air Pollution Trends Over Indian Megacities And Their Local-To-Global Implications, Atmos. *Environ. 142 (2016) 475–495.*

37. Chetana Khandar And Sharda Kosankar "A Review Of Vehicular Pollution In Urban India And Its Effects On Human Health" *Journal Of Advanced Laboratory Research In Biology E-Issn: 0976-7614 Volume 5, Issue 3, July 2014 Pp 54-61.*

38. Md Shahjada Alam Et.Al.(2020),The Impact Study Of Vehicular Pollution On Environment ,*Ijsart Volume 6 Issue 12 –December 2020 Issn [Online]: 2395-105.*

39. Vong C,Wong P, Ma Z And Wong Application Of Rfid Technology And The Maximum Spanning Tree Algorithm For Solving Vehicle Emissions In Cities On Internet Of Things, *Ieee World Forum On Internet Of Things (Wf-Iot), Seoul, Korea (South), 2014, Pp. 347-352.*

40. Vong C,Wong P, Ma Z and Wong Application of RFID technology and the maximum spanning tree algorithm for solving vehicle emissions in cities on Internet of Things, *IEEE World Forum on Internet of Things (WF-IoT), Seoul, Korea (South), 2014, pp. 347-352*

41. Anita Kulkarni1, T. Ravi Teja 2014 Automated System For Air Pollution Detection And Control In Vehicles. *Ijareeie2014.0309061.*

42. Ramagiri R, Reddy C M And Reddy S 2015 Development Of Iot Based Vehicular Pollution Monitoring System. *Ieee, 978-1-4673-7910-6/15.*

43. Francis G A, Dhinesh M,Lijo J A ,Hariprasad P, Balasubramanian K 2019 Iot Based Vehicle Emission Monitoring System. International Journal Of Innovative Technology And Exploring Engineering (Ijitee). *Issn: 2278-3075, Volume-8 Issue-5s March, 2019.*

44. Devan P A M, Hussin F A, Ibrahim R, Bingi K And Nagarajapandian M 2019 Iot Based Vehicle Emission Monitoring And Alerting System. *In Proceedings Of The 2019 Ieee Student Conference On Research And Development (Scored), Bandar Seri Iskandar, Malaysia, 15–17 October 2019; Pp. 161–165.*

45. Merkisz J, Lijewski P, Fuc P, Rymaniak L And Ziolkowski A 2018 Measurement Of Exhaust Emissions Under Actual Operating Conditions With The Use Of Pems: Review Of Selected Vehicles. Improvement Trends For Internal Combustion Engines.

46. Giechaskiel B, Vlachos T, Riccobono F, Forni F, Colombo R, Montigny F Weiss M 2016 Implementation Of Portable Emissions Measurement Systems (PEMS) For The Real-

ISSN PRINT 2319 1775 Online 2320 7876
Research Paper © 2012 IJFANS. All Rights Reserved Journal UGC CARE Listed (Group-I) Volume 10 , Issue 01, 2021

Driving Emissions(RDE) Regulation In Europe. *Journal Of Visualized Experiments.2016. 10.3791/54753.*