

# Introduction of Electronically Managed Vehicle Systems and the Operations of Local Automobile Garages in Ghana: A case study in the Ho Municipality

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**Abstract**— This research was carried out to assess the knowledge level of mechanics on the use of on-board diagnostic (OBD) equipment/tools for carrying out routine maintenance and repair work on electronically managed vehicle systems and the extent to which indigenous repair garages were equipped with diagnostic tools/equipment and reference manuals. The main data collection methods used included interpersonal interviews, direct observation and the use of questionnaire distributed to eighty-five (85) mechanics working in the randomly sampled automobile garages. Results from the study revealed that a majority (91%) of the mechanics lacked knowledge regarding the use of OBD equipment for the diagnosis and appropriate repair of vehicles equipped with electronically managed systems. The study also revealed that only a few (5%) of the mechanics referred to manufacturer's manuals for carrying out diagnosis, maintenance and repair. Furthermore, it was evident that most of the garages lacked basic tools/equipment required for carrying out proper diagnosis with only about 6.7% of the garages possessing an automotive stethoscope, for example. It was concluded that the local automobile garages did not have a majority of the needed diagnostic tools and equipment with the mechanics lacking knowledge regarding the use of such tools and equipment. In order to help local garage mechanics cope with the changing trends in automotive maintenance and repair technology, local garages could take advantage of the World Bank and DANIDA sponsored Skills Development Fund (SDF) in Ghana for training mechanics and resourcing the various garages.

**Index Terms**— Ghana, local garages, maintenance, OBD equipment

## I. INTRODUCTION

Maintenance can be referred to as a practice where an automobile is serviced on a regular basis to prevent breakdown. The actual schedule of car maintenance varies depending on the make and model of a car, its driving conditions and driver behavior. The purpose of maintaining a vehicle is to preserve its value [1]. According to Higgins [2], maintenance is simply a frenetic rush to repair a broken

machine part although this can sometimes be a dominant maintenance activity.

According to [3], most mechanics do visual maintenance and also use their knowledge of vehicle behavior and experience to diagnose and solve problems on vehicles. Sometimes, the solved problem on a vehicle introduces additional problems leading to a difficulty on the part of mechanics to repair the vehicle. The on-board diagnostic (OBD) system was introduced to make fault diagnosis on motor vehicles easy as well as ensuring that emissions are kept within the stipulated limits.

On-board diagnostics (OBD) is an automotive term referring to a vehicle's self-diagnostic and reporting capability. OBD systems give the vehicle owner or repair technician access to the status of the various vehicle sub-systems. The amount of diagnostic information available via OBD has varied widely since its introduction in the early 1980s versions of on-board vehicle computers. Early versions of OBD would simply illuminate a malfunction indicator light (idiot light) if a problem was detected but it would not provide any information regarding the nature of the problem [4].

Modern OBD implementations use a standardized series of diagnostic trouble codes (DTCs) which allow one to rapidly identify and remedy malfunctions within the vehicles [5]. In the work of James [6], it was stated that motor vehicles have been fitted with an increasing range of electronics and computer controls since the late 1960s. Electronic controls (or computer controls) have become increasingly necessary in motor vehicles. For example, electronic control of vehicle systems (primarily the engine management and emission control systems) has led to a significant reduction in emissions from engines. Legislators in various countries around the world seek a continued reduction in emissions and vehicle manufacturers have been able to achieve tremendous results. Without the use of electronics it would not have been possible to reduce emissions to anywhere close to the current low levels.

After using computerized control to achieve low level emissions, it was necessary for some kind of diagnostic system that will monitor the various sensor circuits and various emission control devices for correct operation. The modern trend, however, is to monitor other powertrain and vehicle systems for correct operation in order keep vehicle emissions within the required limits [7], [8]. On-board

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# Introduction of Electronically Managed Vehicle Systems and the Operations of Local Automobile Garages in Ghana: A case study in the Ho Municipality

diagnostic (OBD) systems were developed to help technicians diagnose and repair the computerized engine systems of modern vehicles. The OBD II system, regardless of the vehicle type, now monitors standard components, use similar computer “language” and has similar criteria for evaluating the systems and indicating problems to the driver and the repair technician. When the OBD II computer detects a problem, it sets and stores a Diagnostic Trouble Code (DTC) or Fault Code. When a car is taken in for diagnosis, the repair technician retrieves any set DTCs or fault codes from a vehicle’s computer using the code reader or scan tool. There are now over 400 possible trouble codes that can be stored in the OBD II system [9]. Cope [10], stated that the OBDII systems have been designed to reduce in-use vehicle emissions by monitoring for failure and/or deterioration of the powertrain and its emission-control systems on an essentially continuous basis. It can usually detect a malfunction or deterioration of these components before the driver becomes aware of the problem. The Environmental Protection Agency (EPA) in certain countries also define OBDII as a system of vehicle component and condition monitors, controlled by a central on-board computer running software designed to signal the motorist when conditions exist and which could lead to a vehicle exceeding its emission standards by 1.5 times the standard [11].

According to Ribbens [12], an OBD test is quicker and more effective than the basic emission test. It can lower repair costs if there is a malfunction because the test is more specific about the problem and saves troubleshooting time. The OBD test consists of a scan tool or code reader that plugs directly into the vehicle’s computer, giving an instant reading on the screen. When the OBD system determines that a problem exists in the motor vehicle, a corresponding “Diagnostic Trouble Code” is stored in the computer memory. The computer also illuminates a dashboard light indicating “service engine soon” or “check engine”.

The absence of adequate and appropriate tools and equipment could adversely affect effective and proper maintenance and as a result, mechanics could find it difficult to maintain vehicles as required by the manufacturer [13]. To this end, it is worth mentioning that the introduction of electronic vehicle management systems may result in serious challenges to local automobile garage mechanics in the area of vehicle diagnostics and repair work. This research was therefore carried out to ascertain how disposed the local garages are to effectively deal with the diagnostic and repair requirements of modern electronic vehicle management systems. The study focused on assessing the knowledge level of mechanics as well as the availability of diagnostic equipment and other required resource materials.

## II. METHODOLOGY

### A. Case study area

The Ho Municipal District is one of the twenty five (25) districts in the Volta Region of Ghana. The Ho Municipality is the administrative capital of the people of the Volta Region. The Municipality lies between latitudes 6° 20'7N and 6° 55' N and longitude 0° 12'7 E and 0° 53' E and covers an area of 2.660 sq km. The Municipality shares boundaries with the Republic

of Togo to the east, to the west with Ho West District, to the north with the Hohoe Municipality and to the south with Agotime–Ziope. Ho is one of the fast developing regional capitals in the country and it is near to the republic of Togo which has a free port and imports sophisticated electronic vehicles which are then bought and imported into Ghana by interested persons.

### B. Research instruments and data collection procedure

The research involved the distribution of questionnaires to eighty-five (85) mechanics in the garages sampled. The questionnaire contained closed and open-ended questions aimed at measuring knowledge levels of mechanics regarding diagnostics as well as their general attitude towards the use of diagnostic equipment for vehicle maintenance and repair work. An observation study was also conducted for taking stock of equipment and reference materials available in each garage. Interviews were also conducted to solicit additional information from the respondents. The questionnaires administered were pre-tested on mechanics working in local automobile garages outside the study area with the aim of validating the questions and avoiding ambiguity in the structure of questions used.

## III. RESULTS AND DISCUSSION

### A. Demographic characteristics

The demographic characteristics showing the distribution of business ownership type, staff strength, gender and educational background of mechanics is shown in table 1. Results from this revealed that a majority of the respondents (95.3%) were males. This result is similar to that of a recent study [14] in which it was stated that the automotive repair business is a male dominated one, hence the few number of females found engaged in the business. Furthermore, most (47.1%) of the respondents were between the ages of 34 and 41 years implying that the automotive repair business has operatives that are fairly matured for the job.

It was also revealed that a good number (69.4%) of the respondents had a Middle School or Junior High School (JHS) qualification. This majority group of respondents may be trained in the area general repair and diagnostics and probably the use of reference manuals; however, the respondents who hold Diplomas (3.5%) or Degrees (1.3%) may better appreciate the need for diagnostic procedures and the use of reference manuals. These groups of respondents were rather in the minority.

While a majority (86.7%) of the automotive repair businesses was owned by sole proprietors, a few of them (13.3%) were owned by partners with a large number (66.7%) of these business ventures having staff strength of between 1 and 10. As a majority of the businesses are owned by individuals it would be difficult to engage many operatives as remuneration could be difficult with an increased number of workers.

Table 1 Demographic characteristics

Gender	Frequency	Percentage
Male	81	95.3
Female	4	4.7
<b>Age (Years)</b>		
18-25	11	12.9
26-33	22	25.9
34-41	40	47.1
>41	12	14.1
<b>Educational background</b>		
Middle school/J.H.S	59	69.4
S.H.S	15	17.6
Diploma	3	3.5
Degree	1	1.3
Technical	7	8.2
<b>Business ownership type</b>		
Sole proprietorship	13	86.7
Partnership	2	13.3
<b>Staff strength in garages</b>		
1-10	10	66.7
11-20	3	20
21-30	2	13.3
>31	0	0

*B. Illumination of the check engine light, knowledge in diagnostics and diagnostic challenges*

Table 2 shows the frequency distribution of responses for selected questions. A check engine lamp forms an integral part of on-board diagnostic (OBD) systems. This lamp should be illuminated when the ignition key is on and go off a few seconds after the engine has been started. If the lamp remains illuminated after the engine has been started, it implies that there must be a problem with the engine management system, emission control devices and even other powertrain system components. For example, it is possible for the check engine light to be illuminated when the catalytic converter, used for emission control, has its conversion efficiency reduced by 50%. Diagnostic trouble codes stored in the memory of the computer could be retrieved by using a code reader or an OBD scan tool. While it is important to consult the vehicle manufacturer's manual for interpretation of the stored trouble codes, it is equally important to use a scan tool in place of a code reader because the scan tool would not only give the diagnostic trouble code but also give the mechanic or technician an idea of what is happening in a particular system or to a component through additional information including sensor voltage and resistance values [7], [8], [13].

The results from this study indicated that a majority (62.4%) did not have an idea about the behavior of the check engine light. Similarly, a majority (89.6%) of the respondents had no idea regarding how to go about diagnosing faults on vehicles equipped with electronically managed systems. This result is similar to those obtained in a survey [15], conducted in Nigeria. The survey revealed that local artisans expressed the need for government's support in the acquisition of the requisite knowledge and skills in order to help deal with the challenges posed by the influx of exotic vehicles with electronically managed systems. One of the respondents of the survey [15] said '*...the lack of knowledge and skills among artisans was a major obstacle to our work...We do repair old generation cars using simple technologies. In rare cases, we go to auto firms in Kano or Lagos for the repair of such exotic cars built with brain box and remote sensor*'.

*C. Knowledge of respondents and availability of reference manuals*

Reference manuals are a vital resource as far as the diagnosis of electronically managed vehicle systems is concerned and should be handy in every garage at all times. Apart from containing general information regarding routine maintenance of a vehicle, reference manuals also contain information regarding the various system diagnostic trouble codes and their interpretation. These manuals may also contain information in the form of diagnostic flow charts that could be very useful in the diagnostic process. However, the study revealed that most (97.7%) respondents said that they had no reference manuals in their various garages and this might affect the quality of diagnosis and subsequent repair work that is done by the mechanics and technicians.

**Introduction of Electronically Managed Vehicle Systems and the Operations of Local Automobile Garages in Ghana: A case study in the Ho Municipality**

Table 2 Responses to selected questions

Questions	Response	Frequency	Percentage
<b>Knowledge regarding the illumination of the check engine lamp</b>	Yes	32	37.6
	No	53	62.4
<b>Knowledge about vehicle diagnostics</b>	Yes	8	9.4
	No	77	89.6
<b>Any difficulties in carrying out diagnostics</b>	Yes	4	4.7
	No	81	94.3
<b>Any reference manuals available</b>	Yes	2	2.3
	No	83	97.7
<b>Training or no training regarding the use of OBD</b>	Yes	4	4.7
	No	81	94.3
<b>Opinion on the relevance of diagnostic tools in automobile repair and maintenance</b>	Yes	31	36.5
	No	54	63.5

Table 3 Availability of diagnostic equipment/tools in garages

Diagnostic equipment and reference materials	Number of garages having serviceable diagnostic equipment/tool	Average number of diagnostic equipment and tools available in all the garages	Percentage of garages having serviceable diagnostic equipment/tool
<b>Digital multimeter</b>	6	1	40
<b>Automotive stethoscope</b>	1	1	0.07
<b>Oscilloscope</b>	5	1	33
<b>Code reader</b>	1	1	0.07
<b>OBD scanner</b>	7	1.14	47
<b>Logic probe</b>	1	1	0.07
<b>Manufacturer's manual</b>	4	1	27
<b>List of OBD codes/interpretation</b>	4	1	27

*D. Availability of diagnostic equipment/tools and manuals*

Digital multimeters, automotive stethoscopes, oscilloscope, logic probes and manufacturer's reference manuals are essential resources for carrying out effective diagnosis, proper maintenance and repair of electronically managed vehicle systems. Certain wave forms given by an oscilloscope connected to the ignition system of an engine may give an idea regarding which component in the ignition system is responsible for an engine misfire, for example. Similarly, engine management sensor voltage or resistance values measured using a multimeter may also give an indication of the serviceability or otherwise of a particular sensor. The results from this study shows that even though the number of garages having certain diagnostic tools was fairly high the average number of tools for all the garages, in the case of all the diagnostic equipment and diagnostic

resources, was one (1) except in the case of the OBD scanner which had an average of 1.14. The results showed clearly that even though a majority of the garages had certain tools like the digital multimeter, the number may not exceed one (1) because of the indicated average.

IV. CONCLUSIONS AND OUTLOOK

This study was aimed at assessing the knowledge and attitude on the part of mechanics in the area of diagnostics and repair of vehicles equipped with electronically managed systems. The study was also aimed at ascertaining how disposed mechanics are for carrying out diagnostics with regards to the availability of diagnostic tools/equipment and other vital resources. To this end, it is worth mentioning that the results of the study revealed a very low knowledge level of mechanics regarding how to carry out diagnosis. It was also evident that the various garages were poorly resourced with



the appropriate diagnostic equipment and tools that would facilitate proper diagnosis, maintenance and repair activities.

In the future, local automobile garages, through their workers' union in Ghana, could take advantage of the World Bank and DANIDA sponsored Skills Development Fund (SDF) currently being implemented by Council for Technical and Vocational Education and Training (COTVET) for the purpose of training mechanics and resourcing the various garages with the appropriate diagnostic equipment and tools. Training of mechanics and resourcing the various garages would be a possibility in the future because the SDF aims at upgrading the skills of employees with regards to the adoption of new technologies as well as upgrading the skills of master crafts-persons and graduate apprentices who are self-employed, and this includes local automobile garage mechanics and apprentices. The only challenge the local garages might face is how to put together comprehensive proposals that would attract the needed support from the Skills Development Fund.

#### REFERENCES

- [1] B. S. Dhillon, "Maintainability, Maintenance, and Reliability for Engineers", CRC Press, 2006, ISBN 0-8493-7243-7, ISBN 978-0-8493-7243-8.
- [2] L. R. Higgins, "Maintenance Engineering Handbook" (4<sup>th</sup> Ed), 1988
- [3] Denton, "Advanced Automotive Fault Diagnosis" (2<sup>nd</sup> Ed). Burlington: Elsevier Ltd, 2006.
- [4] E. Gardetto, "Analysis of On-Board Diagnostics for use in I/M", Presented at the OBD conference 2000, 17 May 2000.
- [5] Oregon, (April 2003). "On-Board Diagnostics, fact sheet of the Oregon Department of Environmental Quality" [Online]. Available: [www.deq.state.or.us](http://www.deq.state.or.us)
- [6] C. James, (2001) "Engine Management Systems" [Online]. Available: [www.formulafordzetec.co.uk](http://www.formulafordzetec.co.uk)
- [7] B. Henderson, and J. H. Haynes, "OBD II & Electronic Engine Management Systems". USA: Haynes Publishing, 2006.
- [8] D. H. King, "Computerized Engine Controls". U.S.A.: Delmar Publishers, 1995
- [9] J. W. Flemings, "Overview of Automobile Sensors". *IEEE sensors journal*. Vol. 1 p. 297, 2001.
- [10] D. Cope, (2004). "On – Board Diagnostic II and Light Duty Vehicle Emission Related Inspection and Maintenance Programme" [Online]. Available: [www.ccme.ca/assets/pdf/jia-trsprtobd-e.pdf](http://www.ccme.ca/assets/pdf/jia-trsprtobd-e.pdf)
- [11] A. Santini, "Automobile Electricity and Electronics" (2<sup>nd</sup> Ed). Canada: Nelson Canada Publisher, 1992, p. 34.
- [12] W. B. Ribbens, "Understanding Automotive Electronics" (6<sup>th</sup> Ed). U.S.A.: Elsevier science, 2003, p.119.
- [13] V. A. W. Hillier, "Fundamentals of Automotive Electronics" (2<sup>nd</sup> Ed). Cheltenham, UK: Stanley Thornes, 1996.
- [14] M. S. Akple, R. F. Turkson., C. I., Ezugwu, R. K Biscoff, C. K. Bosrotsi, "An empirical investigation into the relationship between workshop operations and accidents in local automobile garages in Ghana". *J. Adv Environ Health Res*, 2014.
- [15] Vanguard (2013, October 16). Auto mechanics seek computer training to repair modern vehicles – Survey [Online]. Available: <http://www.vanguardngr.com/2013/10/auto-mechanics-see-computer-training-repair-modern-vehicles-survey/#sthash.lbDF71C7.dpuf>

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