Innovations in Modern Automobile Vehicles: A Challenge for Diagnosing and Troubleshooting of Faults by Craftsmen and Master Craftsmen in Nigeria

By

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Abstract

The curriculum for the technical college programmes that train the craftsmen and master craftsmen for maintaining vehicles has however remained rigid. As a result, it has been removed from the recent technological innovation in automobiles. The gaps created between the curriculum and the new technological innovations have made the needed skills for effective maintenance of these new breed automobiles to continue to elude the craftsmen and master craftsmen who were the products of technical college programmes. The study highlights the challenges facing craftsmen and master craftsmen in the maintenance of modern automobile vehicles. The modern trend with respect to automobile vehicles is equipping the vehicles with on-board diagnostic (OBD) system. Therefore, this paper highlighted the objectives of OBD II system and some of the diagnostic and troubleshooting techniques needed in handling modern automobile vehicles. Conclusion was drawn and recommendations made amongst which are that the National Board for Technical Education should ensure that the curriculum of Motor Vehicle Mechanics programme be reviewed to conform to the recent technological development in automobile technology and government should ensure that institutions of learning are adequately equipped with the state-of-the art facilities in Motor Vehicle Mechanics Works programme

Keywords: Modern Automobile Vehicles, Diagnosing and Troubleshooting, Craftsmen and Master Craftsmen, On-Board Diagnostics II

Introduction

The use of automobile vehicles on our roads plays a key role in road transportation system. In Nigeria where land transport is largely in use compared to water transportation and other modes of transportation, the use of automobile vehicles, either diesel or petrol driven is predominant. Therefore, the automobile has now become an indispensable means of transportation in modern societies. At the early stage of development, there were several experimental cars but the work of Karl Benz, a German Mechanic in 1885 was regarded as the first practical and reliable automobile (Wilkins, 1971; Clarke, 1978). According to Wilkins (1971) as well as Egbuchulam (2000), the Benz car and many other early automobiles were however, simple, not very reliable, limited in speed and distance of travel and less comfortable. Technological dynamism coupled with the emergence of new technologies has however, influenced the modern automobiles. There have being a continual evolution in design intended to achieve faster, more reliable, more streamlined, cleaner and safer vehicles with enhanced comfort, fuel economy and longevity (Odigiri & Ede, 2010). Harnessing new technologies into the vehicles have made the modern automobiles an assemblage of a group of sophisticated technologies (Schwaller, 1993). The introduction of electronic controls has particularly brought even greater changes in designs and operations of many of their sub-systems.

In addition, the high level of usage of vehicles for both private and commercial activities coupled with the inflow of second hand vehicles popularly called "Tokunbo" brought about the need for very efficient and effective maintenance. Often times, the garages where the automobile craftsmen and master craftsmen carry out their maintenance are of low capital base and are makeshift establishments either located on slippery terrains, under tree sheds, canopy made of banana or palm fronds, and so on. No effective maintenance can take place in such environment. Similarly, a close look at the equipment being used reveals the level of poverty of these automobile craft-men and master craft-men. In most places, service pits are not available and where available, there is no reinforcement at the sides to hold loose sands in place. No accuracy of either wheel balancing or alignment could be obtained. New vehicles were the result of technological development, which calls for literate hands to carry out its maintenance and repairs in order to prolong the life span of the vehicles which is normally carried out by automobile craftsmen and master craftsmen who are trained in technical colleges in Nigeria.

In Nigerian school system, the programmes for the education and training of craftsmen and master craftsmen for the maintenance of all types of motor vehicles are carried out in technical colleges at the National Technical Certificate (NTC) and Advanced National Technical Certificate (ANTC) levels respectively (National Board for Technical Education - NBTE, 2001).

However, several studies conducted revealed that the products of these programmes lacked the basic skills needed for gainful employment in today's automobile industry (Jimoh, 1997; Elobuike, 1999; Agbata, 2000). The curriculum was blamed for not being adequate and relevant to offer enough of the skills needed to meet the challenges that are involved in the maintenance of modern automobiles on Nigerian roads. The incorporation of new technologies with new subsystems and system components into modern automobiles have changed their configurations and made their maintenance a more complex task, even though some of the new systems make them easier to maintain (Schwaller, 1993; Nice, 2001). The curriculum for the technical college programmes that train the service personnel for maintaining these vehicles has however remained rigid, thus far removed from the recent technological innovation in automobiles (NBTE, 2001).

However, the gaps created between the curriculum and the new technological innovations have made the needed skills for effective maintenance of these new breed automobiles to continue to elude the products of these programmes. The result has being that, the graduates of these programmes are often unemployable or underemployed while most automobiles with these new innovations either suffer disrepair or have the new systems replaced by the classical substitute systems that the new ones were meant to improve upon. Yet some are even completely grounded just barely into their expected service lives because of lack of competent personnel for their effective maintenance. As measures to keep education and training in tune with the knowledge and skills needed in the world of work, school courses and curricula must be reviewed, enriched and updated regularly in line with changes that are taking place in the industries. Thus, it was imperative to investigate the new technological innovations in automobiles with the view to identifying those that posed new challenges to the maintenance personnel in Nigeria.

2.0 Challenges Facing Craftsmen and Master Craftsmen

Automobile technology like other discipline experiences a very high level of technological development, which; to this new area of specialization is called Automotive Mechatronics. Rapid technological changes in the automotive service industry demands automotive service industry must cope with the ongoing innovative and technological changes that require it to continually upgrade the existing skills of its craft-men and master craft-men. The industry must find a way of equipping and attracting new qualified workers to the currently shrinking pool of skilled automotive craftsmen and master craftsmen (Kolo, 2006). With these advancements the mechanics job has evolved from purely mechanical to include electronics technology. Modern vehicles today possess complex computer and electronic system, for this reason automotive craftsmen and master craftsmen need to have a broader base knowledge than in the past. Fading quickly is the day of the roadside mechanics (craft-men and master craft-men), which need little knowledge of today's computerized system (Stan, 2011). There has been tremendous change in modern vehicles technology, they use sophisticated computer technology, advanced wiring, intricate circuitry and complex engineering. The automobile industry is equipped with computer system that has more intelligence than the United State National Aeronautic and Space Administration (NASA) spacecraft that was sent to the moon (Malone, 2006). From 1985 to 1995 vehicles were equipped with first and second generation on-board diagnostic (OBD I & OBD II) systems. The development went further from mild hybrid to strong hybrid vehicles (New York State Automobile Dealers Association NYSADA, 2006). Another powerful invention was Extra Sensory Perception (ESP), it is recommended by many lawmakers and car makers to be a standard features in all vehicles sold in the European Union (EU). The ESP recognized dangerous situation and correct the drivers input for a short moment to stabilize the car. Fully self- directed vehicles also known as robotics cars or driverless cars already exist in prototype and are expected to be commercially available by 2020.

For Nigeria to attain the set objectives of vision 2020, and be enlisted among the top industrialized nations in the world, the condition of its automotive industries and training institutions needs to be given much importance and priority. In essence, there is need to deliberately domesticate the technology needed through the utilization of modern tools and equipment by the industries and institutions. The country has to learn from the experience of some of the newly industrialized nations of Asia that were at the same level of development with Nigeria in the early sixties such as Malaysia, and the Republic of Korea. For instance, Korea produces the globally competitive KIA motors with 100 percent local content (Momoh, 2008). Among the major challenges facing Nigeria's automobile service industries are discuss below:

a. The Need for Re-training of Automotive Mechanics Craftsmen and Master Craftsmen

The automotive mechanic craftsmen and master craftsmen of today must be able to do well and be specifically trained and equipped for an on-board diagnostic technology, if at all they want to remain in the profession (Malone, 2006). For the automotive craftsmen and master craftsmen to effectively service and repair modern cars, they must have undergone training and experience in a diverse range of subject, which includes mechanical engineering, electrical engineering, electronics, chemistry, physics and many more. The NYSADA (2006) stated that, automotive craftsmen and master craftsmen must be knowledgeable in mechanical, electrical and computer technology and their knowledge in these areas must be updated to keep up with the rapid changes in modern automobile vehicles. In essence, they must have a well-rounded education that will adequately prepare him to repair contemporary automobiles, as well as adapt to future changes in the industry. They must understand not only the parts, nomenclature and operation, but also understand the diagnostic and service procedure for each system in the vehicle. The high technological nature of today's vehicles mandates the need for regular training of the automotive craftsmen and master craftsmen. As such Nigerian craft-men needs to be re-trained to enable them cope with high level of technological advancement particularly in the field of automobile technology.

b. Meeting-up with new Developments in Automobile Vehicles

Automotive craftsmen and master craftsmen (roadside mechanics) in Nigeria have been finding it quite challenging in meeting up with new developments in automobile vehicles. Jalal, (2009), stressed that majority of Nigerian roadside mechanics may be rendered unemployed as a result of the influx of new vehicles into the country. He further explained that it is because these types of vehicles the mechanics that are trained to fix vehicles in Nigeria are getting out of job. The wide range of fanciful vehicles imported into the country by individuals, firms and various government organizations, most mechanics are not conversant with them in terms of maintenance and repairs. In a country, where mechanics are illiterates or semi illiterates, the high sophisticated combination of mechanical and electrical parts put them at a disadvantage. Their knowledge of most new system in modern vehicles is generally low, while their inability to read and interpret electronics circuit diagrams is also a big problem. Jalal (2009), also added that our mechanics cannot repair many of the vehicles plying the Nigerian roads today.

c. Environmental Protection

Emissions from automobiles can harm the environment, as well as our health. These emissions are sometimes referred to as pollutants or volatile organic compounds (VOCs), to the atmosphere. The VOCs may be fuel or oil vapors emitted from the fuel tank, fuel lines engine crankcase, or tailpipe. The pollutants include: carbon monoxide (CO), hydrocarbons (HCs) particulate matters (PM), carbon dioxide (CO2), sulfur dioxide (SO2) and oxide of nitrogen which consist of nitric oxide (NO) and nitrogen dioxide (NO2). Oxides of nitrogen react with hydrocarbons to create ground level ozone, which is considered a health hazard to children, elderly people and those with respiratory problems. The need for these to be monitored and kept in check cannot be overemphasized. It was on this basis the United States Congress passed Federal Emission Regulations, starting with Clean Air Act in 1963. Pollutants are monitored and controlled by efficient on-board systems using state-of-the-art electronics, (CDX Automotive, 2013).

Therefore, it was based on some of the above challenges facing the automotive craftsmen and master craftsmen in automotive service industries and training institutions in the country that this paper considered it to be timely and needed to dwells on the ways of handling on-board- diagnosis (OBD) vehicles as they affect maintenance of newly imported vehicles and environment in Nigeria.

3.0 On-Board Diagnostic (OBD) Vehicles

During the 1980s, most manufacturers began equipping their vehicles with full- function control systems capable of alerting the driver of a malfunction and of allowing the technician to retrieve codes that identify circuit faults. This system in the automotive industry is called on-board diagnostics (OBDs). According to Santini (2011), OBD refers to a system of self –diagnostic and reporting capability on modern vehicles. Prior to 1996 it was primarily an engine management system. After 1996 it became an emission testing strategy.

The OBD systems use powerful on-board computers to pinpoint problems in vehicle systems and components. OBD Generation I (OBD I) applies to all vehicles sold in California beginning with the 1988 model year. The following requirements are needed for the system:

i. An instrument panel warning lamp able to alert the driver of certain control system failures, now called a malfunction indicator lamp (MIL).
ii. The system's ability to record and transmit the diagnostic transmission codes (DTCs) for emission-related failures.
iii. Electronic system monitoring of the HO2S, EGR valve, and evaporative purge solenoid. Although not only in U.S.A the European Protection Agency (EPA) required that during this time most manufacturers also equipped vehicles sold outside of California with OBD I.

By failing to monitor the catalytic converter, the evaporative system for leaks, and the presence of engine misfire, OBD I did not do enough to lower automotive emissions. This led the California Air Resource Board (CARB) and the EPA to develop OBD Generation II (OBD II), (Halderman, 2014).

3.1 Objectives of OBD-II

The OBD II stands for on-board diagnostics, second generation vehicles. Starting with the 1996 model year, all vehicles sold in the United States must use the same type of 16-pin Data Link Connector (DLC) and must monitor emission-related components (Carley, 2008). CARB defines an OBD-II-equipped vehicle by its ability to do the following:

(i) Detect component degradation or a faulty emission-related system that prevents compliance with federal emission standards.

(ii) Alert the driver of needed emission-related repair or maintenance.

(iii) Use standardized Diagnostic Trouble Codes (DTCs) and accepts a generic scan tool.

Primarily the system detects conditions that may cause a vehicle's emissions to increase. It was designed to detect emission problems as they develop. An OBD II equipped vehicle turn on the Check Engine warning light (also called the Malfunction Indicator Lamp or "MIL") and log a Diagnostic Trouble Code (DTC) hydrocarbon (HC), carbon monoxide (CO), oxides of nitrogen (NO_X) or even evaporative emissions exceed 1.5 times the Federal Emission Limit. In other words, the Check Engine Light should come on any time there is emission problem and where there is also a drivability problem or not. Detecting (and correcting) emission problems early on means less pollution, less reliance on smog checks to catch emission violations, and less risk of minor problems causing additional harm. Ignition misfire, for example, passes unburned fuel into the exhaust which can cause catalytic converter to overheat and suffer damage.

3.2 How OBD II System Works

The OBD II is an active computer analysis system because it actually tests the operation of the oxygen sensors, exhaust gas recirculation system, and so forth whenever conditions permit. It is the purpose and function of the Power-train Control Module (PCM) to monitor these components and perform various active tests. OBD II constantly monitors engine performance as well as other emission functions as the vehicle is being driven. Instead of waiting for a hard fault to occur to set a Diagnostic Trouble Code (DTC) and illuminate the Check Engine lamp, the OBD II system actively tests various components under different operating conditions to make sure everything is functioning within accepted limits. These include monitoring:

(i) The operating efficiency of the catalytic converter

(ii) Ignition misfires

(iii) Evaporative emissions from the fuel tank and canister purge

(iv) Exhaust gas recirculation (EGR)

(v) Plus all onboard sensors that affect the operation of the ignition and fuel delivery systems.

3.3 OBD II Monitoring System

A monitor is an organized method of testing a specific part of the system. Monitors are simply tests that the computer performs to evaluate components and systems. If a component or system failure is detected while a monitor is running, a DTC will be stored and the MIL illuminated by the second trip. The OBD II monitoring system checks out all monitored systems at least once each time the vehicle is driven for emission faults through various cycles which include, a drive cycle, a warm-up cycle and a trip cycle.

a. **Drive Cycle –** the "drive cycle" represent the starting the engine and driving the vehicle until it goes into closed loop.
b. **Warm-Up Cycle -** the "warm-up" cycle occurs when engine coolant temperature rises at least 40 degrees Fahrenheit and reaches at least 160 degrees Fahrenheit.
c. **Trip Cycle -** the "trip" results when the warm-up cycle and drive cycle occur, and the vehicle is driven long enough to enable the different diagnostic checks which vary depending on the application and system being monitored.

3.4 Emission Faults (Misfires)

Emission faults are faults that are common in modern vehicles. Halderman (2014) observed that if the system noticed any "emission faults" that is, any problem which makes hydrocarbon (HC), carbon monoxide (CO) or oxides of nitrogen (NO_X) emissions to exceed federal limits by 50% or causes the deterioration of any monitored system that could potentially lead to an increase in emissions. The check engine light may come on immediately with some faults, but may not come on with others unless a failure has occurred on two or three consecutive trips. The light generally remain on until there are three consecutive trips without the fault reoccurring. The OBD II system monitors engine performance for misfire which was tricky and occurs under a wide variety of circumstances. This is caused by ignition, fuel or compression problems for these misfires by monitoring the speed of the crankshaft. These misfires are classified based on their severity. These include, the Type A, Type B or Type C misfires.

Type A Misfire - This is a constant and the worst kind of engine misfire that causes the greatest increase in emissions. It is also more likely to overheat and damage the converter. A steady misfire could cause the Check Engine lamp to come on as it is occurring. At the same time, the OBD II system will set a code and capture "snapshot" or "freeze frame" data on other engine operating conditions (such as rpm, throttle position, load, temperature, etc.) to assist in diagnosing the problem.

Type B or Type C - This is an intermittent misfires which depend on their frequency. This type of misfire must exceed a certain limit at least once on two consecutive trips before the Check Engine lamp will come on. If an intermittent misfire fault occurs during one trip but does not repeat during the next, the code will not "mature" and the light remains off. But if the misfire repeats, the Check Engine lamps come on and a code and snapshot data is stored.

3.5 Retrieving and Understanding OBD II Codes

3.5.1 Plugged-in the Scan Tool into the Standardized Data Link Connector (DLC)

Diagnosis of OBD II vehicles usually requires a scan tool or code reader that cans and access codes through vehicle's onboard computer. To access the codes, the tool was plugged into the standardized Data Link Connector (DLC), which was usually located under the instrument panel near the steering column.

3.5.2 Reading the Codes

All OBD II codes are a 5-character alphanumeric code. The first letter identified the general type of code "P" is for power train codes (which include all the emission, sensor and electronic codes as well as transmission codes), "B" is for body codes, and "C" is for chassis codes. The second number in each code will either be a "0" indicating that it is "generic" code (common to all makes of vehicles), or a "1" indicating it is vehicle specific code unique to the vehicle manufacturer. Both types are covered in the vehicle code sections. The third character in the code tells the system where the fault occurred. Number 1 and 2 are for fuel or air metering problems, number 3 is for ignition problems or engines misfire, number 4 is for auxiliary emission controls, number 5 relates to idle speed control problems, number 6 is for computer or output circuit faults, and numbers 7 and 8 relate to transmission problems.

4.0 Troubleshooting Using Diagnostic Trouble Codes

Once an OBD II trouble code has been identified with scan tool the procedure is essentially same as with earlier onboard diagnostic system. You refer to the appropriate diagnostic chart in a service manual and follow the step by step test procedure using a digital volt and break out box (if needed) to isolate the fault. Then you replace the faulty component and verify that the problem has been eliminated. OBD II also provide "snap shot" of "freeze frame" data, which help to identify and diagnose intermittent problems. When a fault occurs, the OBD II system logs a DTC and records all related sensor value at that moment. This data can be later retrieved and compared to the "real time" data to help identify the nature of the problem. Some systems allow snap shop data to be captured via a scan tool while test driving a vehicle for later analysis.

4.1 Methods of Clearing Diagnostic Trouble Codes

There are three methods that can be used to clear stored diagnostic trouble codes. These methods are discussed as follows;

a. **Clearing Codes - Method 1 -** The preferred method of clearing codes is by using a scan tool. This is the method recommended by most vehicle manufacturers if the procedure can be performed on the vehicle. The computer of some vehicles cannot be cleared with a scan tool.
b. **Clearing codes - Method 2 -** If a scan tool is not available or a scan tool cannot be used on the vehicle being serviced, the power to the computer can be disconnected.
    i. Disconnect the fusible link (if so equipped) that feeds the computer.
    ii. Disconnect the fuse or fuses that feed the computer.
c. **Clearing codes - Method 3 -** If the other two methods cannot be used, the negative (-) battery cable can be disconnected to clear stored diagnostic trouble codes.

5.0 Servicing OBD II Vehicles

The OBD II systems do not actually need any tune-up or servicing but all what they need is preventive maintenance or, if their check Engine light is on, what needs to be done is to connect a diagnostic scan to determine the causes of the fault, (Carley, 2008). Servicing or tune-up involves replacing the spark plugs and performing other adjustments to maintain or restore like-new engine performance. As OBD II systems are equipped with computerized engine controls, ignition timing, idle speed and the fuel mixture can be taken care of by the computer. Though base timing can be checked with a scan tool, but cannot be adjusted on most engines. The same goes for idle speed and various emission functions. A scan tool can reveal if the systems are functioning normally, but in most cases no adjustments are possible because the adjustments are programmed into the computer. A simple maintenance type tune-up means using new set of plugs to improve fuel economy and engine performance. Any problem other than this may be a waste of time and money. The engine needs to be diagnosed to find out what is wrong. As such the engine should be check-up first with a scan tool for any current, pending or past fault codes.

6.0 Diagnostic Procedure

Halderman (2014), summarized and suggested steps to be followed as a way of diagnosing faults in OBD II vehicles. These eight steps diagnosing procedures is highlighted below:

a. Step 1: Verify the Problem (Concern)

i. If the problem cannot be verified, it cannot be solved or tested to verify that the repair was complete.

ii. The driver of the vehicle knows much about the vehicle and how it is driven.

iii. A sample form that customers could fill out with details of the problem.

b. Step 2: Perform a Thorough Visual Inspection and Basic Tests

i. Check for obvious problems (basics).

ii. Check the air cleaner and air duct for dirty.

iii. Check everything that does and does not work.

iv. Look for evidence of previous repairs.

v. Any vacuum leaks will be spotted by observing smoke coming out of the leak.\

vi. Check coolant level and condition.

vii. Use the paper test.

viii. Ensure adequate fuel level.

ix. Ensure gas cap is properly tightened after refueling.\

x. Ensure that there is no water in the gas or even variation in an additive package.

xi. Check the battery voltage.\

xii. Check the spark plug using a spark tester.

xiii. Check the fuel-pump pressure.

c. Step 3: Retrieve the Diagnostic Trouble Codes (DTCs)

If a diagnostic trouble code (DTC) is present in the computer memory, it may be signaled by illuminating a malfunction indicator lamp (MIL), commonly labeled “check engine” or “service engine soon.”

d. Step 4: Check for Technical Service Bulletins (TSBs)

Studies performed by automobile manufacturers indicated that about 30% of vehicles can be repaired following the information, suggestions, or replacement parts found in a service bulletin.

e. Step 5: **Look Carefully at Scan Tool Data**

Vehicle manufacturers have been given the technician more and more data on a scan tool connected to the data link connector (DLC).

f. Step 6: Narrow the Problem to a System or Cylinder

g. Step 7: Repair the Problem and Determine the Root Cause

e. Step 8: Verify the Repair and Clear Any Stored DTCs

7.0 Conclusion

The automotive industry in Nigeria and the entire world is generally being recognized as an engine of growth in any economy because of the important roles it plays in the execution of various activities. But, it is unfortunate to notice that some of the automotive industries in Nigeria are virtually on the edge of a precipice, and waiting for their eventual fall. These rapid technological changes in the automotive service industry demands that automotive service industry must cope-up with ongoing innovative and technological changes that require it to continually upgrade the existing skills of its technicians. This paper focused on some of the means of overcoming some of the problems associated with environmental degradation as in other countries and the need for automotive mechanics to up-date their knowledge in order to catch-up with some of the challenges being thrown by rapid technological advancement on automobiles.

8.0 Recommendations

Based on the findings of the study, the following recommendations were proffered.

i. The National Board for Technical Education should ensure that the curriculum of Motor Vehicle Mechanics prograamme be reviewed to conform to the recent technological development in automobile technology

ii. Government should ensure that institutions of learning be provided and properly equipped with the state-of-the art facilities in automobile technology departments or programs.

iii. Government should make training available to lecturers and technical teachers on auto-mechatronics to update their skills and knowledge.

iv. The government in partnership with automobile industries should provide training on diagnosing and troubleshooting OBD II vehicles to all categories of automotive mechanics in Nigeria and make available the OBD II equipment to the mechanics.

v. Government should ensure that all vehicles operating in Nigeria to conform to the regulation on emission control.

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