MODERN AUTOMOBILE ENGINE MAINTENANCE MANAGEMENT: NEED FOR CONVENTIONAL AUTO-MECHANIC RE-ENGINEERING

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Abstract

Automobile mechanics in this part of the globe have little or no knowledge of engine management systems in modern electronic-controlled unit (ECU) vehicles nor how the engine management system works. Automobile maintenance is a life involving activity in the sense that in the event of failure, accident could be catastrophic resulting in damage to the vehicle or to loss of life. In the light of this, this paper highlights the result of a study on modern automobile maintenance practice requirements, modern automobile engine management system and pollutant reductions. The study reveals that in Nigeria, Auchi in particular, that automobile mechanics do not have a structured maintenance management programme in place; and most of which lack complete knowledge of how engine management system, electronic-controlled unit (ECU) in modern vehicle works.

The transmission of power by mechanical and electrical devices has long been in use in automobile industry. Today, with the advancement in engineering and technology, electronic devices are now taking the place of mechanical and electrical devices or electro-mechanical devices.

A lot of vehicles are parked-up at homes, and a visit to a place like the “mechanic village”, where automobiles are serviced or repaired, will reveal the rate at which automobile users, individuals or companies, visit their auto-mechanic for maintenance (Akele, Okoh, Ejiofor and Alimasunya, 2011).

The first fuel electronic system was introduced by Bendix in the USA in 1950. Seventeen years later a similar unit was made by Bosch and was fitted to a Volkswagen model. Today, it is necessary to fit electronic petrol injection systems to comply with emission regulations. The major differences, according to Hillier (2004), in the existing electronic injection systems today are in the method of metering or measuring the amount of air entering the cylinder, as this determines the amount of fuel required for combustion. These variants are

- Indirect – pressure/vacuum sensing systems (PSS)
- Direct – Airflow or air-mass sensing systems (ASS)

PS system uses a manifold absolute pressure (MAP) sensor to measure the manifold depression. Signals from the MAP sensor are passed to the ECU and, after taking into account the information received from the other sensors, the ECU provides a control signal for the injector to open for a set period of time proportional to the mass of air that the engine is receiving (e.g. the Bosch D-Jetronic System).

The AS system petrol injection system measures the volume or mass of air flowing into the engine by either an air-flow meter (vane or flap type) or an air mass meter (hot wire type). Both of these sensors produce an output signal voltage, which changes as the volume of airflow increases. The signal voltage is then passed to the ECU where it is used, in conjunction with other sensor information, to determine the period of time that the injectors should remain open. In all, to allow for optimal combustion taking place, the ignition spark with sufficient energy has to occur at precisely the right time in the engine cycle to ignite the correct amount of air-fuel mixture.

Developments in vehicle technology have produced an electronic ignition system that can increase the electrical energy over the conventional contact ignition system, as well as providing low maintenance ignition system. The electronic ignition system was succeeded by a ‘maintenance-free’ computer-controlled ignition system, which provided a system that continually adjusts the ignition timing to suit the engine conditions. At the end of the 1980s, the requirement for cleaner emissions...
meant that the carburetor fuel system needed to be replaced by an electronically controlled fuel system. (Hillier and Coombes, 2004). The term ‘petrol injection’ is used to describe any system in which pressurized fuel is injected out of a nozzle in an atomized state to mix with a supply of air.

Modern systems are controlled electronically because this form of control enables the fuel quantity to be accurately set to suit the engine operating conditions. Strict emission control regulations have demanded precise metering of the fuel, and although petrol injection systems are more expensive than carburetor fuel systems, they are now used to control the fuelling on all engines. Most of these petrol injection systems are integrated with the ignition system into what is known as “engine management system”.

A petrol injection system that delivers the correct quantity of highly atomized fuel gives the following, in comparison to carburetor engine:
1. Lower exhaust pollution
2. Lower fuel consumption
3. Higher power output
4. Smoother engine operation due to even power output from each cylinder.

These electronic devices, simple or complex, are used to better serve Man by improving on his environment (pollution control) and drivability.

Emission regulations or control, worldwide, is becoming increasingly strict such that the automobile industry has had to continually research and develop designs of components (especially the inlet and exhaust systems) that will give optimal combustion of air-fuel mixture. This advanced engine management system technology is to aid in monitoring and controlling other engine components as well as those that have a direct effect on emission levels. Side by side this emission regulation requirement is the users’ expectation for higher engine performance at preferably lower fuel consumption which works in direct opposition in trying to reduce emission from vehicle. It is a well known fact that emissions from vehicles damage human health, plant life and the environment. (Donkundwar, 2007) This problem is particularly severe in areas where the geographic and climatic conditions create an atmospheric envelope which traps the pollutants.

Auto-maintenance Management

Maintenance is the act of ensuring that physical assets (machines, automobiles, plants etc) continue to do what they are expected (or designed) to do in their present operating context. (Moulbray, 1991). In other words, it is an activity that is applied to natural and artificial systems to cause the system to remain unaltered or unimpaired in its ability to perform its function(s). (Okah-Avae, 1995). Therefore, automobile maintenance has to do with the day-to-day up-keeping of an automobile in order to avoid or remedy failure problems.

However, to most users of automobile, maintenance only comes to mind when their automobile fail; while others see maintenance solely as when repair is required. As a result of this, many vehicles end up broken down on the high way or abandoned in the auto-workshops all around the cities. This explicitly supports the fact that Nigerians, most registered engineers inclusive, lack maintenance culture. For the auto-mechanics, it requires serious re-engineering and training to bring them to align with modern trends in automobile maintenance. For an automobile, it requires a simple periodic or routine preventive maintenance practice as specified by the manufacturer to keep the automobile up and running.

Auto-maintenance Requirements

Automobile maintenance method, over the years, has changed greatly. This is as a result of the fact that,

i. varieties of automobiles are available
ii. modern automobiles are a bit complex and sophisticated- involving the use of electronic-control unit (ECU)
Modern Automobile Engine Maintenance Management: Need for Conventional Auto-mechanic Re-engineering

As a result of these, present day auto-maintenance personnels are faced with the challenges of how to overcome these aforementioned facts. According to Moulbray (1991), some key challenges that maintenance personnels encounter in an attempt to solve maintenance problems are:

i. Ability to select the best maintenance techniques
ii. How to deal with each type of failure processes encountered
iii. How to fulfill the expectations of the customers of the automobiles and
iv. How to carry out auto-maintenance in the most cost effective enduring manner.

The automobile industry is one of the largest industries in Nigeria; under the umbrella of which is one of the largest informal sector (auto dealers, auto-mechanic, auto-electrician, auto-body works mechanics or panel beaters, and vulcanizers) that is a major job provider within Nigeria (Akele, 2011). Auto-mechanics are usually products of apprenticeship training programmes with little or no formal education and mainly sponsored by parent or guardians (Ogwo, 2004). Therefore, for the conventional automobile mechanics to be able to carry out proper and complete maintenance or repairs, he has to be properly re-educated in the working principles of modern vehicle systems. This of course, will re-engineered him to be a better auto-mechanic with high quality of workmanship.

According to King (2000), diagnosing problem on modern vehicles fitted with complicated electronic systems takes a little different approach than many automotive technicians are used to. Service manual is expected to be consulted with the procedures there-in carefully followed. It is very useful to spend some time familiarizing oneself with the diagnostic guides and charts that manufacturers present in the service manual. So, any mechanic who has previously acquired formal education will have little or no problem dealing with modern ECU vehicles as this ability will make it easy for him to be able to read service manual and use the computerized equipment (e.g. scanners, monitors etc) usually used to diagnose and solve problems. Therefore, education and training in ICT are important requirements needed by every automobile mechanic.

Necessity of Maintenance Management Programme
Every auto-garage has to be re-educated into having a good maintenance management programme in place. This should contain questions that will enable easy or systematic repairs to be carried out. Moulbray (1991) suggested that before maintenance task could be performed a maintenance technician should have ready answers to questions such as,

1. What are the functions and associated performance standards of the automobile at the fail state?
2. In what ways does the automobile fail to fulfill its function(s)?
3. What causes the functional failure?
4. In what ways does the failure matter or affect the automobile user?
5. What can be done to predict or prevent this failure from occurring in future?

This systematic approach to maintenance task if applied by the road-side mechanic, will have re-engineered our conventional auto-mechanic to abandon the costly and dangerous trial and error method they are used to. Any maintenance personnel who will consider providing answers to these questions before maintenance is carried out in a vehicle, would have carried out not less than 50% of the maintenance task as the answers will act as guide to carrying out the task.

Maintenance Management Programme Success
It is not enough to have a maintenance management programme but ensuring that every aspect of the programme is strictly adhered to and implemented. The success of any maintenance management programme depends on proper planning and scheduling of maintenance task, the mechanic’s understanding of how the automobile systems and sub-systems work and how components are interrelated, proper documentation of data and information on maintenance procedures, plans, inventory, cost implications and safety sheets; availability of equipment and tools
as well as spare-parts; education, seminar and workshop attendance to enable familiarization with
trends in modern automobile technology.

Why Automobiles Fail

Failures do not just occur in automobiles. Certain factors are always attributed to why
automobiles do fail. According to Akele (2009), deterioration due to friction and wear, thermal
degradation, internal reaction and corrosion, design flaws and material selection during design stage,
operating the automobile beyond its operating limits or severe conditions, and quality or degree of
technical-know-how of the automobile mechanic can be attributed to why automobiles do fail.

Without fatigue, stress (mechanical or thermal), friction or wear in automobile systems or
components maintenance will not be necessary and automobile will be expected to operate
perpetually. The moment our automobile is put to use, deterioration will start to set in gradually such
that with time, poor operation, efficiency, high vibration and noise, lubricant leaks and fuel spills
will be observed. At this moment, visits to the maintenance workshop become more frequent due to
frequent failures (Akele, 2009).

Engine Management System

According to Hillier and Coombes (2004), electronic petrol injection provides precise fuel
delivery and therefore cleaner emissions that are accompanied by an increase in engine load and fuel
economy. To monitor the engine’s operating conditions, these electronically controlled ignition and
fuel systems use very similar sensor information systems, although each system is completely
independent. Therefore, the ignition ECU used a programme stored in its memory to control the
ignition timing, and the fuel injection ECU used a programme stored in its memory to control the
timing of the injection point and the quantity of fuel delivered. Although the ignition system adapts
itself slightly with changes in engine performance (i.e. with the use of knock sensors), the fuel
injection system maintains a fixed fuel delivery based on its own sensor information. Integrating these
two control systems into one engine management system and therefore, one ECU allows the sharing
of information provided by all of the sensors. Such integration also allows the ignition and fuel
injection programmes to interact with each other and therefore provide the optimum control signals
for both ignition and fuel throughout all engine operating conditions. The requirement for lower
emissions has led to the fitment of the exhaust catalyst, which reduces to function efficiently; the
content of the exhaust gas entering the catalyst has to be precisely controlled. The engine management
system has to therefore, control the ignition and fuelling systems accurately, to control the content of
the exhaust gases entering the catalyst. The system also provides accurate control of engine idle
speed. The engine management system can also adapt itself to the changing conditions of the engine
components, thereby providing a low level of emission throughout the vehicle’s life. Integrated into
the system is a self-diagnostic facility that constantly monitors the sensor and actuator signals. If a
fault is detected, the system registers it and usually signals to the driver.

Electronically-controlled systems generally make use of various sensors and actuators. Sensors provide information to the computer electronic control unit (ECU). The computer then uses
the information to calculate what actions to take by the actuator. In modern vehicle, a number of such
as sensors are positioned around the engine to monitor operating conditions such engine temperature,
load, speed, and detonation; around the gearbox, road wheels and so on. Signal information is passed
from these sensors to the computer.
Figure 1 below shows typical sensor input signal information necessary for the ECU to calculate the correct output signals used to control the various actuators, the ignition, injectors and idle speed control.

**Conclusion**

In this era of fast-track engineering technology advancement, conventional auto-mechanics have to be re-educated and re-engineered through computer training so as to avoid the present continual damage to modern electronically controlled unit vehicles. The era of trial and error is over. Modern ECU vehicles systems are 80% electronically connected leaving little or no chance for the usual trial and error practice. Education, computer-literacy and good maintenance management programme are all that are required.

**Recommendation**

- Conventional auto-mechanics should be encouraged to get formal education where this is lacking.
- With average education, auto-mechanic will be able to map out a workable maintenance management programme for their workshops.
- Mobile training systems should be set-up to reach out to the various mechanic villages Nigeria to organize workshops on how ECU vehicles work and how to use scanner and so on to diagnose and repair vehicles.

**References**


