

DEVELOPMENT OF A REMOTELY CONTROLLED CAR SPEED LIMITER ON HIGHWAY

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Abstract

This study modifies a Car Speed Limiting Device based on a pre-existing design with a view to avoiding car over speeding and reduces possible accident on highway. The speed limiter was modified by incorporating a carrier chip into the device using an Arduino Nano to coordinate the activities of the carrier chip and the speed limiter. The function of the carrier chip is to send and receive notification message from owner's phone number. Two different cars were used and tested on a highway. The result obtained for the two vehicles showed the same responses. When the speed of the car exceeds the designed speed limit of the device, the speed limiter came into action and restricted the car from going beyond the pre-set speed by actuating the relay to reduce the current flowing through the fuel line and reduced the rate of flow of fuel into the combustion chamber which reduces the power output of the engine. Warning signal in the form of alarm was activated, and the receiver sent a message to the owner through the carrier chip. The study concluded that the modified speed governor design is better, safer and remotely controlled compared to the existing design.

Keywords: Car, Speed Limiter, Carrier chip, Relay, Speed.

1. Introduction

Road accidents have become something normal due to its consistent happening and ubiquitousness. Even in our present world, we believe any mechanical device could fail or show sign of misbehaviour, especially if not properly manage. Every minute someone is killed or seriously injured on the major roads because of terrible accidents (Ahmed *et al.*, 2015). A report by the International Road Federation (IRF) shows that about 2.4 million people have died in road accidents across the world with over 1.3 million road death every year and daily record of 3, 000 deaths (IRFAR, 2017). This is a worldwide pestilence practically identical to Malaria or Tuberculosis, which go after the youthful, poor people

and the defenceless (Varshith, 2016). The primary explanation behind these mischances is the fast and careless driving of motorist. The World Health Organisation raised an alarm on this figure and believes that it may increase to 1.9 million if deliberate and solid action is not taken (Tribune, 2019). Safety has become principal focus of government agencies and private organizations concerned with transportation. In Nigeria, the Federal Road Safety Commission (FRSC) is the government agency with statutory responsibilities for road safety administration. Nigeria is the most populous country in Africa with a total land area of 910,771 km² and human population of about 167 million and a high number of vehicles estimated at over 7.6 million, the country has suffered severe loss of manpower and economy to fatal car accidents (Sumaila, 2013). Undoubtedly, this population create immense pressure that contributes to the high road traffic accidents in the country (FRSC, 2017).

The factors that induce fatal car accidents in Nigeria have been classified into human, mechanical and environmental factors. Human factor accounts for up to 90% of accidents while the mechanical and environmental factors sum-up to 10 % (Assum, 2018). Human factors include visual acuteness, driver fatigue, poor knowledge of road signs and regulations, illiteracy, health problems, excessive speeding, drug abuse and over-confidence while on the steering. Mechanical factors include poor vehicle maintenance, tyre blowouts, poor lights, and broken-down vehicles on the road without adequate warning. The environmental factors are summed up into heavy rainfall, harmattan, sun reflection, heavy wind, pot holes and un-tarred roads. These factors have independently and/or collective contributed to the high prevalence rate of fatal car accidents in Nigeria (Ukoji, 2017). With the deadly crashes encountered everywhere throughout the world, vehicle safety has been set up to check them. One of the approaches to lessen such vehicle crashes is to avoid over speeding in streets and expressways. The automobile is likewise one of the primary methods for transportation, and individuals make broad utilization of it for the duration of their lives. This reason, among others, justifies the need of use of the advances in sensors, instrumentation and control in vehicles with the goal of enhancing road safety. The problem of automotive speed limiter/speed governor was considered by many investigators and researchers. Most research work concentrated on the impact of the speed limitation on the reduction of accidents and casualties (Han *et al.*, 2017). Few articles are available that concern the technical aspect of the speed limiting system. Some of the articles or publications handled the technical perspectives of the automotive speed governor system in the recent years. Croitoru *et al.*, (2014) introduced an order of speed limiting device demonstrating the advantages and disadvantages each type. He found that appropriately design ISA can be exceedingly successful in urging drivers to obey speed limits and ought to be supported by governments. Pérez *et al.*, (2018) exhibited another Infrastructure to Vehicles communication and control system for intelligent speed control, which depends on Radio Frequency Identification (RFID) technology for identification of traffic signals on the road. Their outcomes recommended that an automatic intelligent control system can be used to keep any sudden activity conditions and enhance the safety of the occupants of the vehicle.

Burje *et al.*, (2017) presented a design to control the speed of the automobiles at remote places for fixed time. Their proposed model used a microcontroller unit that gets the pedal position and after that exchanges appropriate signal to the Electronic Control Unit (ECU) that thus controls the cars' throttle position. They expressed that their theoretical study needs further extension to more than one vehicle. The objective of this work is to modify a speed governor by adding a speed notifier and SMS controller into it and evaluate a prototype of the device through experiments.

2. Types of Road Speed Limiter

2.1 Based on the Functionality (Ahmed *et al.*, 2015)

(1) Top-speed limiting

It prevents the vehicle from exceeding a set speed. Most modern vehicle engine-management systems have a top speed setting but it is usually well in-excess of maximum national speed limits and could not be regarded as a safety device.

(2) Speed alarm and speed limit set by the driver

It alerts the driver if a selected speed is exceeded. Some vehicles have this feature. It also prevents the vehicle from going beyond the pre-set speed, except for temporary over-ride situations. These are also known as "Adjustable Speed Limitation Function (ASLF)".

(3) Intelligent speed alarm and speed limiter

The system "knows" through an application like goggle map, the speed limit of the section of road and direction of travel and alerts the driver if that speed is exceeded by an audible alarm, a visual signal or a vibrating throttle pedal or a combination of these. It also prevents the vehicle from being accelerated beyond this speed.

2.2 Based on the Control Technique (Ahmed *et al.*, 2015).

(1) Throttle Control: The throttle control is a type of technique used in limiting the speed of a vehicle through throttle body of the engine. A throttle body is the intake system component in fuel-injected engines that the drivers control with the accelerator. The throttle regulates or limits the amount of air that enters the combustion chamber with the fuel delivered from the injector.

(2) Direct Fuel Control: The direct fuel control is the most type technique used to regulate the speed of a vehicle. Also, the fuel control is the most effective of all types. In this type of method, the fuel is the source of control. The speed is limited by reducing the amount of fuel that is released into the combustion chamber for combustion.

(3) Electronic Speed Governor: In this type, electric signal is utilized by using a magnetic pick up sensor. The magnetic pick up sensor is installed alongside a drive shaft gear made of material that responds to a magnetic field. As each gearing tooth passes the sensor, the gear interrupts the sensors magnetic field. This, thus, creates an Alternating Current signal, which compares to the speed of the shaft. The signal is sent to the electronic control

module to build up the measure of fuel that ought to be infused to the combustion chamber of the engine.

2.3 Basic Vehicle speed measurement System

The basic measurement system consists mainly of three blocks: Sensing element, Signal conditioning element and signal processing element. An electronic speed limiter/governor contains three key components in particular the vehicle speed sensor, Electronic Control Unit (ECU) and a fuel flow control valve. The speed sensor creates electronic pulses in relation to the vehicle speed and transmits the same to the ECU. In this examination, the sensing component converts the non-electrical signal (mechanical rotational motion) into electrical signal (voltage pulses). The reason for the signal conditioning component is to convert the variety of electrical signal into a voltage level suitable for additionally preparing. This is accomplished using amplifier circuit and digital logic circuit. The following stage is the signal condition component which is a microcontroller which takes the output of the signal conditioning component and converts it into a shape appropriate for presentation and different uses (display, recording and feedback control). Based on the installed algorithm, the electronic control unit processes the speed of the vehicle also, persistently monitors the same. At whatever point the vehicle accomplishes the most extreme set speed, the electronic control unit enacts the actuator which directs the fuel stream and henceforth the vehicle speed is constrained.

3. Methodology

Materials used are speed limiting device, relay, connecting cables, GPS antenna while tools used are cutting plier, testing lamp, razor blade and black tape

Description of Major Components

Speed Limiting Device: Speed limiter is an Electronic / Electro-Mechanical device fitted on a vehicle with the purpose of regulating the maximum speed of a vehicle to a set limit. A Speed Limiter is shown in Figure 1. The speed limiter used in this work was pre-set to 95km/h and programmed with the receiver phone number. Speed Limiters are of different types based on the vehicle category on which it is used. The two most important types are the Drive by Wire System (RDPS) and the Fuel Type System. The Fuel type system was used in this project. The speed limiter was built to have a port for the GPS antenna and the GSM antenna for receive signal. It also has another cable port for the connection of the wire that would be connected to the vehicle system.



Figure1: Speed limiter

Connection Cables: The connection cables were used to connect the speed limiter to the relay and to the vehicle. The connection cable had different cables with different colours on it, namely: blue, white, black, red, brown and yellow. The connection cables are as shown in Figure 2.



Figure2: Connection Cables

Relay: Relay is a switch that opens and closes circuit electromechanically or electronically. The relay used controls one electrical circuit by opening and closing contact in another circuit. The relay came with four (4) wires, two (2) thick green wires, a red wire and black wire. The Relay is shown in Figure 3.



Figure 3: Relay

GPS Antenna: The Global Positioning System is a worldwide radio-navigation system formed from a constellation of 24 satellites that continuously orbit the earth. All GPS receivers use an antenna to receive these signals. The GPS Antenna is shown in Figure 4.



Figure4: GPS Antenna

GSM Antenna: is an antenna to receive GSM signal to the device. It is as shown in Figure 5.



Figure 5: GSM Antenna

The specifications of cars used in this research are shown in Table 2 and 3. First thing done was to identify the fuel line cable (yellow cable with green stripes) using a Tester which is a device used to test for the flow of current in a wire or circuit. The fuel line cable was cut into two, making the wires one carrying current from the source and the other without any current in it. The divided wires were then connected to the relay. Connection of the relay to the fuel line was carried out by connecting the two thick green wires from the relay to the two ends of the fuel line cables. One of the thick green cables was connected to the fuel line cable from the power source and the other green cable to the second wire of the fuel line. The black wire from the relay to the black wire of the connection cable was joined together because the black wire is the grand wire. Both black wires were connected to any other grand in the vehicle. The red wire from the relay was connected to the brown cable from the connection cable. At the end the connection cable is plugged into the speed limiter. The red and white wire from the connection cable is connected to the thick green cable of the relay (the current source). The GPS and GSM antennas were connected to the speed limiter.

Table 2: Engine Specification (HONDA ACCORD, 2003)

Parameters	Value
Fuel tank capacity	17.1 Gal
EPA mileage estimates Highway	26 city/ 34
Base engine size	2.4 litres
Base engine type	I-4
Horsepower	160 Hp
Horsepower rpm	5,500
Torque	161 Lb.Ft
Torque rpm	4,500
Maximum Towing capacity	1,000Lbs
Drive type	Front wheel

*EPA- Environmental Protection Agency

Table 3: Engine Specification (TOYOTA COROLLA, 2019)

Parameter	Value
Fuel tank capacity	17.1 Gal
EPA mileage estimates	26 city/ 34 Highway
Base engine size	1.8 Litres
Base engine type	I-4
Horse power	132 Hp
Horsepower rpm	6,000
Torque	128Lb-Ft
Torque rpm	4,400
Maximum Towing capacity	950Lbs

*EPA- Environmental Protection Agency

4. Result and Discussion

Honda Accord and Toyota Corolla Response

Table 4 and Table 5 show the interrelation between the car speed, engine speed, speed limiter, alarm and the receiver for Honda Accord and Toyota Corolla, respectively. They basically show the response of each component as the car speed changes. The engine speed in the case of Toyota Corolla was quite different from Honda Accord due to some factors like engine capacity, vehicle weight, and material selection.

Table 4: Interrelation between car speed and components for Honda Accord

Car Engine Speed (km/h)	Speed (Rev/min)	Alarm	Receiver
01000	On (NA)	No	No
201600	On (NA)	No	No
401500	On (NA)	No	No
602000	On (NA)	No	No
802500	On (NA)	No	No
953000	On (NA)	Yes	Yes (Msg)

- NA-Not Active, Msg- Message

Table 5: Interrelation between car speed and components for Toyota Corolla

Car Engine Speed (km/h)	Speed (Rev/min)	Alarm	Receiver
01100	On (NA)	No	No
201300	On (NA)	No	No

401500	On (NA)	No	No
602100	On (NA)	No	No
802400	On (NA)	No	No
952800	On (NA)	Yes	Yes (Msg)

*NA-Not Active, Msg- Message

The two vehicles showed similar response to the speed limiter, alarm and receiver. Figure 6 shows the histogram of car speed against speed limiter for Honda Accord and Toyota Corolla.

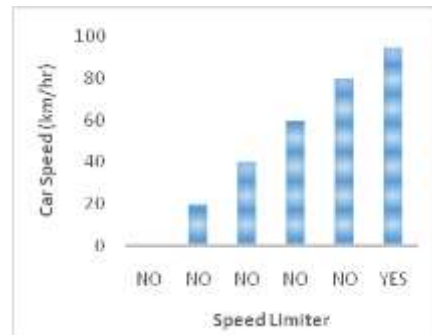


Figure 6: Histogram of Car Speed against Speed Limiter for Honda Accord and Toyota Corolla.

At 0 km/h, the engine was idle. There was no load on the engine yet. Speed limiter was on but was not active. Because the speed has not been accomplished at which it will be active. At 20 km/h, Engines of the two vehicles started running at speed higher than 0 km/h because load has been applied to it (Transmission was on drive). At 20 km/h, the speed limiter was on but was not active. Tracker was able to get signal and vehicles were able to be tracked at this speed. At 40 km/h, vehicle was moving at the constant speed while the speed limiter was not active but on. Tracker from the speed limiter was on and was able to track vehicle at that speed. At 60 km/h, no activity from the speed limiter aside the tracker been able to locate the exact location of vehicle at that point. At 80km/hr, vehicle approaches maximum speed limit and speed limiter still not responsive while it is on. At 95 km/h, Engine of each car running at higher speeds, the speed limiter became active immediately it sensed the pre-set speed, reduced the current in the flow line circuit leading to reduction in the flow rate of the fuel being supplied to the combustion chamber making the mixture a lean mixture and limits the speed of the vehicle at 95 km/h. The tracker was able to track the vehicles location as well. When trying to exceed the pre-set car speed, the car refuses to exceed the speed because of the shortage in current of the flow line.

Figure 7 shows the effect of car speed on the receiver for the two vehicles. As the speed of the car increases and approaches the maximum speed pre-set already in the speed limiter, the receiver responded variably. At 0 km/h when the vehicle is idle, the receiver

is on but not responsive at 0 km/hr. At 20 km/h, the engine was under load and vehicle was moving and yet the receiver is still not responded. At 40 km/h, the vehicle was still being driven and no output from the receiver from the speed limiter. At 60 km/h, receiver was on but no output from it. At 80 km/h, the vehicle was approaching the maximum speed limit and receiver was yet to respond to the speed at which the vehicle was been driven at. At 95 km/h, receiver is fully functional and responsive. The speed limiter stored the data to its history and when the network was restored, the speed limiter sent the message through the carrier component to the owner's phone as a text message as shown in Figure 8 and at that time the message was seen from the owner's phone. The vehicle was shut down by sending a code "<SABO*STP>" and a confirmation message saying "lock car successful" was received as shown in Figure 9, then vehicle shut down immediately. The vehicle started again as the owner restores the vehicle by sending "<SABO*RES>" and the owner (person sending the message receives a message too saying "unlocked successfully" as shown in Figure 10, then the vehicle will start again.

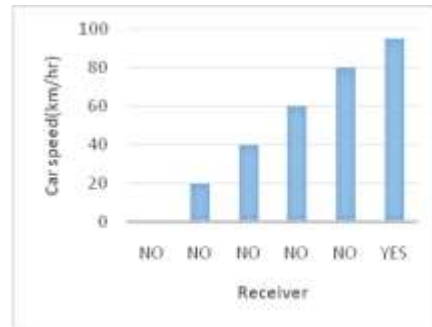


Figure 7: Histogram of Car Speed against Receiver for Honda Accord and Toyota Corolla.

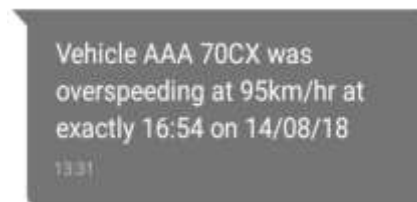


Figure 8: Message from the Receiver

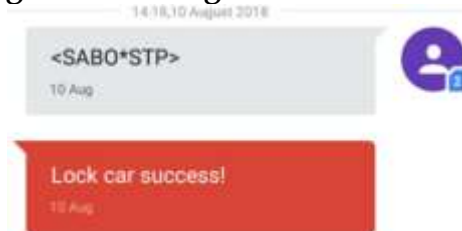


Figure 9: Message from the Speed Limiter after Sending the STOP Code



Figure 10: Message gotten after sending restore code

Figure 11 shows the response of the alarm at different car speed for the two vehicles. The alarm is the sound notifier that alerts the driver when the vehicle approaches or reaches the maximum pre-set speed on the speed limiter. At 0 km/h, car was on and running but alarm wasn't ringing. At 20 km/h, vehicle was moving and alarm wasn't responsive. At 40 km/h, still running the car and the speed limiter was still not responsive. At 60 km/h, vehicle was still working and running but the alarm was not working. At 80 km/h, vehicle approached maximum speed and the alarm was yet to respond. The alarm started working when speed exceeded 80 km/h and above. The sound became more pronounced when the speed got closer to the maximum speed. At 95 km/h, the car was at its maximum speed and the alarm was beeping continuously till the speed drops below the pre-set speed. When the speed drops below the maximum speed, the alarm reduced gradually. Between the speeds of 0-80 km/h, the alarm is inactive.

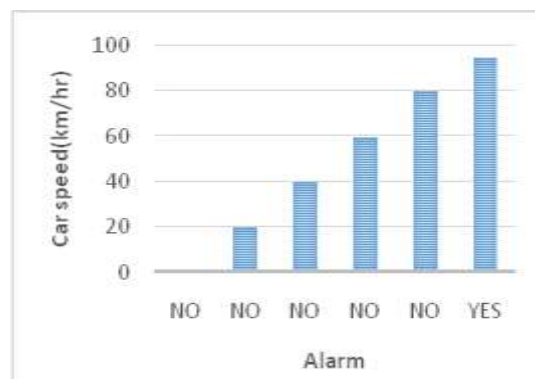


Figure 11: Histogram of car speed against alarm for Honda Accord and Toyota Corolla

5. Conclusion

This project has improved an existing speed limiting system by adding a notifier and SMS controller. The prototype programmed to limit speed at Federal Road Safety maximum speed at highway to be 95 km/h was able to limit vehicle speed at its maximum speed (95 km/h). The transmitted alarm sounds when the vehicle approaches 95 km/hr and the receiver also gives or sends a text message when the car gets to its maximum speed, alerting the owner the speed activity of the vehicle. The relay, showed that once the speed

drops below 95 km/h the engine picks up again. The improvement basically provided an economic solution to deadly car crashes, save vehicle fuel consumption and also monitors the activities of the driver. The project was focused more on limiting the speed of the vehicle and informing the owner about vehicle over-speeding activities. The project can further be improved by considering the system with google map road speed limits to know areas with their speed limits.

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