



BSc Automotive Engineering

Major Project

Stop and Start effect on Green House Gases

Stop and Start System

Lecturer: A Gibson

Supervisor: Kerry Tudor

Module Code: M6X02206

By

Ehab Barsoum

P149568

Abstract

Currently, we can see a lot of natural catastrophes because of changes in atmospheric conditions, the main source of which is an increase in CO₂ which results in an increase in global average temperatures. The most beneficial thing to manage this is the internet providing global communication and our developing the global economy. As the world becomes smaller, the amount of pressure by the media on the manufactures, means that they are working hard to renew the investments to provide good solutions to reduce CO₂. Manufacturers are looking at how to find new energy sources such as the sun, wind and waves.

Deforestation also contributes to higher levels of greenhouse gases (GHG) because it decreases oxygen production and reduces the absorption of CO₂ by trees. In addition pollution and greenhouse gas emissions can be increased through industrial activities such as using fossil fuels in energy production.

Vehicle manufacturers are discussing how to reduce CO₂ emissions that have an effect on climate change. The primary debate is about CO₂ reduction in the automobile industry, and a lot of evidence indicates that GHG emissions are, in large part, due to the automobile industry. The purpose of this project is firstly analysis and evaluation of the current processes to reduce the emissions, and then to create new processes with different strategies and techniques, such as reduction of emissions by emission systems like the stop start system, catalytic converters, exhaust gas recirculation (EGR), evaporative emission control system (EVAP) and air and fuel ratio. Ecological driving means a new style of driving focusing on saving fuel, reducing environmental contamination including acoustic contamination, and extra comfortable travel.

In this project we will focus at different strategy and different options for addressing emissions, find new technology such as stop and start technique, work with the engine size and capacity, design new styles of filters, dealing with car dynamics like Aerodynamic resistance and it is effecting on the engine performance which produces the emissions, Tyre pressure, the different temperature and effect in different pressures.

Modern exhaust emission control devices, Fuel, different sort of fuel, new energy like electricity in electric hybrid cars, lubricant materials and its impact on different loads creating friction forces (haynes.com, 2018).

Acknowledgment

It is my pleasure to express my gratitude to pro/A Gibson and Pro/ Kerry Tudor, who helped me with guidance and orientation while I am in this wonderful project topic, by all means, I am thankful for all.

Contents

Abstract	2
Acknowledgment.....	3
Contents.....	Error! Bookmark not defined.
List of Figures.....	6
List of Tables.....	8
1 Introduction	9
1.1 Aims	9
1.2 Objectives	9
2. Background to Vehicle Emissions	10
2.1. Greenhouse Gas Emissions	10
2.1.1 Greenhouse gas issues	11
2.1.2 Greenhouse gases Sources.....	11
2.2 UK Total GHG in 2017	11
2.3 Transportation percentages.....	12
2.4 Euro Emissions Standards.....	13
2.5 EU emission standard for passenger cars	14
3. Overview of Automobile Technology to reduce emission	15
3.1.1 Catalytic Converter	15
3.1.2 EVAP System	16
3.1.3 Stop and start.....	Error! Bookmark not defined.
3.2 How Stop and start works	17
3.2.1 Inertia starter & Pre-engaged starter.....	18
3.3 Vehicles in UK fitted with stop-start.....	19
4. Review of Stop-start systems.....	23
4.1 Reliability of stop- start system	23
4.2 Stop-start Advantages.....	23
4.3 Stop-start Disadvantages.....	24
5. Ece1504 Dyno vehicle test cycle.....	26
5.1 Ece 1504 Dyno.....	27
5.2 Test Methodology	27
5.3 Driving-Cycle Ece1504 Dyno	29
5.4 Ece1504 Dyno Test map.....	30

5.5 Ece1504 Dyno running time	31
5.6 Test Cycle target.....	31
6. Analysis CO, HC and CO ₂ Emissions.....	32
6.1 CO	32
6.2 Hydrocarbon (HC)	35
6.3 CO ₂	38
6.4 Total Running test without stop-start.....	41
7. Stop and Start Analysis	43
7.1 CO	43
7.2 HC.....	45
7.3 CO ₂	48
7.4 Running test with stop-start.....	50
8. Calculation processes	51
8.1 Gear multipliers.....	52
8.2 ICE Idling and stop start Data	53
8.3 RPM calculation	54
8.4 Stop and Start operates vs ICE.....	55
8.5 ICE running without stop and Start	58
9. Total summative HC over whole journey	66
9.1 Total HC values over whole the journey	67
9.2 Total summative CO ₂ over whole journey	69
9.3 Total CO ₂ Values	70
9.4 Total summative CO over whole journey	72
9.5 Total CO values	73
10. Comparison of ICE Idling versus Stop and Start	74
11. Stop and start Technique in Gasoline Engine	75
12. CO sensitive gas more than CO ₂ and HC	78
13. Discussions	80
14. Conclusion	81
15 Bibliography	82

List of Figures

Page

Figure (1) UK Total GHG in 2017.....	(11)
Figure (2) Percentage of GHG from transport in UK.....	(12)
Figure (3) Euro Emissions Standards.....	(13)
Figure (4) Catalytic Converter.....	(15)
Figure (5) EVAP System.....	(16)
Figure (6) Stop and start main component	(16)
Figure (7) How Stop and start works.....	(17)
Figure (8) Inertia starter	(18)
Figure (9) Pre-engaged starter	(18)
Figure (10) Vehicles in UK fitted with stop-start.	(19)
Figure (11) Acura RLX 2016 Sport Hybrid.	(19)
Figure (12) 2017 Cadillac XT5.	(20)
Figure (13) 2016 Jeep Grand Cherokee	(20)
Figure (14) 2016 Volvo XC60.....	(21)
Figure (15) TOYOTA V6 Highlander 2017	(22)
Figure (16) Ece1504 Dyno	(26)
Figure (17) Characteristics of Ece1504 Dyno	(27)
Figure (18) Test Methodology	(28)
Figure (19) Driving-Cycle Ece1504 Dyno.....	(29)
Figure (20) Ece1504 Dyno Test map	(30)
Figure (21) Ece1504 Dyno running time	(30)
Figure (22) CO / (Time from (0:60/sec)	(32)
Figure (23) CO / (Time from (60:120/sec)	(33)
Figure (24) CO / (Time from (120:180/sec)	(33)
Figure (25) CO / (Time from (180:210/sec).....	(34)
Figure (26) HC / (Time from (zero: 60/sec).....	(35)
Figure (27) HC / (Time from (60:120/sec)	(36)
Figure (28) HC / (Time from (120:180/sec)	(36)
Figure (29) HC / (Time from (180:210/sec).....	(37)

Figure (30) CO ₂ / (Time from (0:60/sec)	(38)
Figure (31) CO ₂ / (Time from (60:120/sec)	(39)
Figure (32) CO ₂ / (Time from (120:180/sec).....	(39)
Figure (33) CO ₂ / (Time from (180:210/sec).....	(40)
Figure (34) S&S CO / (Time from (zero:60/sec).....	(43)
Figure (35) S&S CO / (Time from (60:120/sec).....	(44)
Figure (36) S&S CO / (Time from (120:180/sec).....	(44)
Figure (37) S&S CO / (Time from (180:210/sec)).....	(45)
Figure (38) S&S HC / (Time from (0:60/sec).....	(45)
Figure (39) S&S HC / (Time from (60:120/sec).....	(46)
Figure (40) S&S HC / (Time from (120:180/sec).....	(47)
Figure (41) S&S HC / (Time from (180:210/sec).....	(47)
Figure (42) S&S CO ₂ / (Time from (0:60/sec).....	(48)
Figure (43) S&S CO ₂ / (Time from (60:120/sec)).....	(48)
Figure (44) S&S CO ₂ / (Time from (120:180/sec).....	(49)
Figure (45) S&S CO ₂ / (Time from (180:210/sec).....	(49)
Figure (46) Calculation processes.....	(51)
Figure (47) ICE running without S& S.....	(58)
Figure (48) Total Sum HC over whole journey.....	(66)
Figure (49) Total HC values over whole the journey.....	(67)
Figure (50) Total summative CO ₂ over whole journey.....	(69)
Figure (51) Total CO ₂ Values.....	(70)
Figure (52) Total summative CO over whole journey.....	(72)
Figure (53) Total CO values.....	(73)
Figure (54) Comparison of ICE Idling versus Stop and Start.....	(74)
Figure (55) Comparison of ICE Idling versus S&S explanation.....	(74)
Figure (56) Stop and start Technique in Gasoline Engine.....	(75)
Figure (57) illustrates the way to restart the engine.....	(75)
Figure (58) Engine stop and restart in Crank Angle Domain.....	(76)

Figure (59) Crankshaft position during the engine stops and starts..... (77)

List of Tables **Page**

Table (1) Greenhouse gases and their characteristics	(10)
Table (2) EU emission standard for passenger cars.....	(14)
Table (3) Total Running test without stop-start.....	(41)
Table (4) Running test with stop-start.....	(50)
Table (5) Gear multipliers.....	(52)
Table (6) ICE Idling and stop start Data.....	(53)
Table (7) RPM calculation.....	(54)
Table (8) Data Acquisition.....	(54)
Table (9) Stop and Start operates vs ICE.....	(55)
Table (10) Stop and start Data Acquisition.....	(56)
Table (11) Data Acquisition.....	(57)
Table (12) Summative CO, HC and CO ₂ data.....	(58)
Table (13) Data Acquisition.....	(59)
Table (14) Data Acquisition.....	(60)
Table (15) Data Acquisition.....	(61)
Table (16) Data Acquisition.....	(62)
Table (17) Data Acquisition.....	(63)
Table (18) Data Acquisition.....	(64)
Table (19) Data Acquisition.....	(65)
Table (20) Data Acquisition.....	(68)
Table (21) Data Acquisition.....	(71)

1 Introduction

Manufacturers' response to Green House Gas Emissions (GHG) is very important and due to rapid atmospheric change this response has increased over the last two decades. Until the 1990s, industry totally neglected environmental problems and emissions issues, although a few corporate oil firms and transportation firms did start to recognise the increasing scientific attention around this issue particularly in the mid-1990s (Houghton, 2009).

1.1 Aims

This project will look precisely at the emissions and its impact on a universal scale. As the world realizes the significance of the crisis that the world will face in the next two decades, it is important to look from the beginning of this investigation at the impacts. The primary aim of this project is to understand and concentrate on the current impact of automotive emissions and regulations that are used to govern and control it. The first step forward was to create a group known as the Global Climate Coalition (GCC) and the atmosphere council, in which their role was to stop negligence in regards to atmospheric pollution internationally and to control it, by enforcing caps on GHG emissions with connection to the Kyoto Protocol 2003 (Pinkse, 2008).

The second aim is to investigate and assess the use of stop and start systems through research, practical tests and analysis, which the manufacturers and automotive industry may apply to reduce the limit of emissions further (Dupont, 2000).

1.2 Objectives

The first goal and objective of this project is to establish the fundamentals of the next set of regulations which will be Euro 7 standards and procedures, in order to work more effectively on meeting the goals of the industry. Current processes used to manage the emissions in advanced countries are setting goals and firm legislation to let the industry work precisely and firmly to change its political response in preparation for a Nitrogen Oxide (NOx) and carbon neutral future, by creating different strategies and analysis of technologies with investigation to approach to low emission products.

The second objective is to evaluate the stop and start technique, focusing upon all of the current motor vehicles that use this system, which is aimed at diminishing the levels of emissions (GOV.UK, 2019).

2. Background to Vehicle Emissions

2.1. Greenhouse Gas Emissions

The greenhouse effect is a heat trap, the impact of which increases the heat retention of the planet, which has taken place over the last one hundred and fifty years. The first priority for governments and environment agencies has been to discuss the origin of the greenhouse gas. To gain a better understanding of such a large topic we will specifically look at the following compounds:

1. CO₂, carbon dioxide and carbon monoxide.
2. N₂O which is Nitrous Oxide.
3. CH₄ which refers to Methane.
4. Fluorinated gases.

Greenhouse gases and their characteristics

Table (1)

Greenhouse gas	How its provide	Life time average in the weather	100-years global warming potential
Carbon Dioxide	• Burning of fossil fuel. • Changes in land use. • Deforestation and soil degradation.	12.4 years	1
Methane	• Production and transport of oil and natural gas. • Livestock and agricultural practices. • Anaerobic decay of organic waste	12.4 years	28-36
Nitrous oxide	• Combustion of solid waste and fossil fuels. • Industrial and agricultural activities.	121 years	265-298
Fluorinated gases	• Come from different activities such as industrial processes, household uses and commercial. • Substitutes for ozone. • Chlorofluorocarbons (cfcs)	Thousands of years and a few weeks	varies

(GOV.UK, 2019)

UK government mentioned about increasing of GHG for maintaining the economy and to minimize emissions, The first source of Carbon dioxide is vehicles emissions which is creating standards for managing this problem in all UK (GOV.UK, 2019).

2.1.1 Greenhouse gas issues

Sectors of North American businesses which are related to increasing the CO₂ from burning fossil fuels have begun to take extra attention to atmospheric change, which means extra risk and threat causing a substantial increase of GHGs (Houghton, 2009).

2.1.2 Greenhouse gases Sources

These days, a lot of effort is being made to reduce the high percentages of GHGs the sources of which are:

1. Energy (Electricity)
 2. Transportation
 3. Industry
 4. Residential and commercial
 5. Agriculture
- (GOV.UK, 2019)

2.2 UK Total GHG in 2017

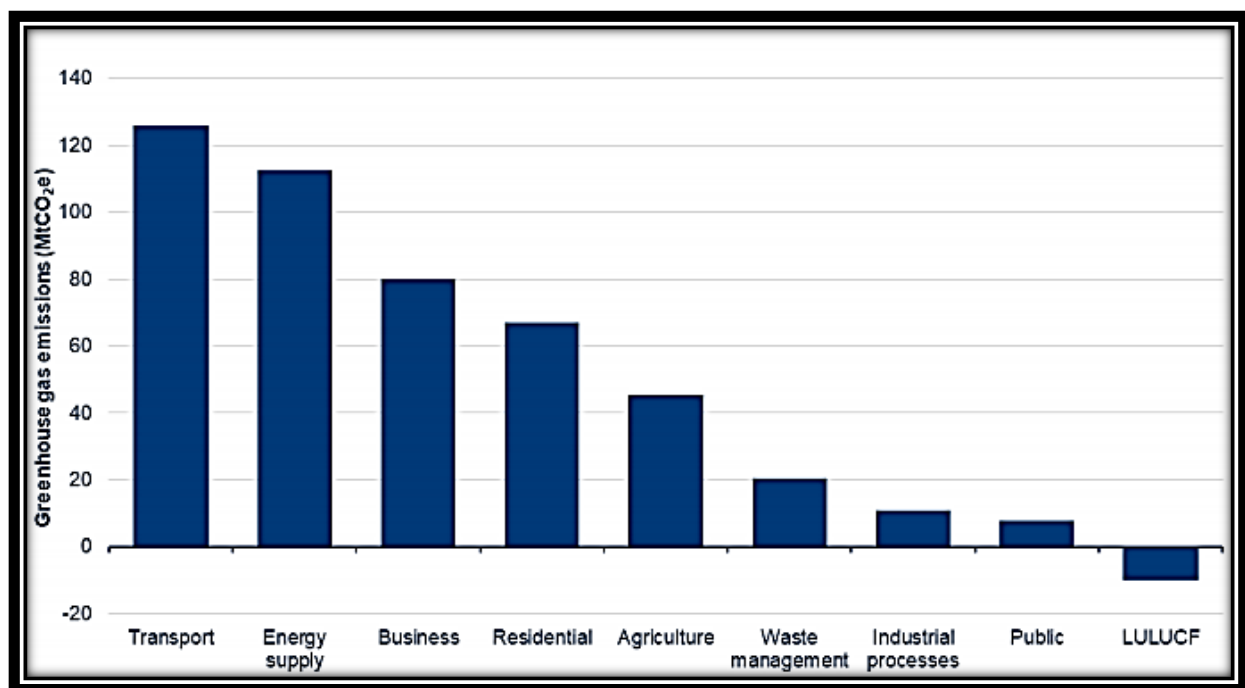


Figure (1)

(GOV.UK, 2019)

The figure shows the sources of GHG emission by source sector UK / 2017(Mt CO₂) the highest greenhouse gas emissions come from transportation 130 %, Electricity 110%, industry10%, Commercial & residential70% and Agriculture is 50 (GOV.UK, 2019)

2.3 Transportation percentages

In 2016, 91% GHG emissions came from transport which means it is very important to look how to reduce this problem.

Percentage of greenhouse gas emissions from transport in UK

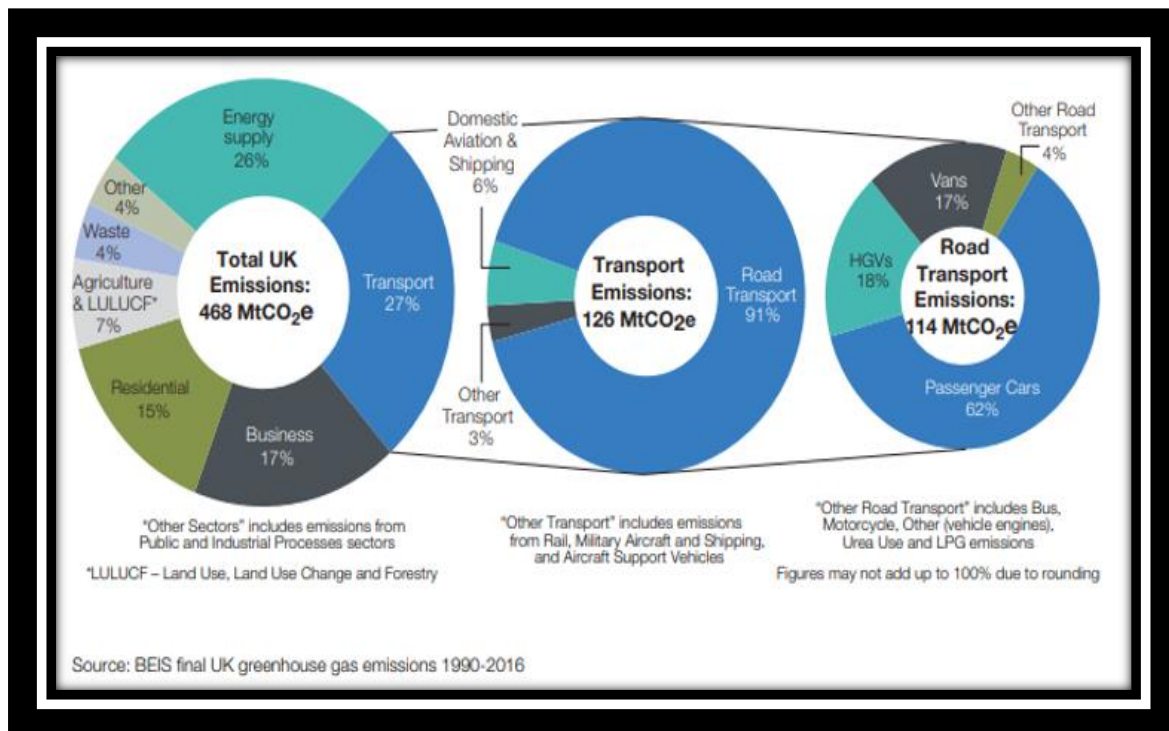


Figure (2)

(www.gov.uk, 2018)

The figure above shows the different source of emissions but the major air pollutants comes from transportation in UK, All the experts and scholars decided that the Transport has a huge impact on GHG emissions. The key air pollutants that come from road transport consist of : (CO) Carbon monoxide, (NOX) Nitrogen oxides, (HC) Hydrocarbons, (PM) Particulate matter, (NMVOC) Non Methane Volatile Organic Compounds (GOV.UK, 2019).

2.4 Euro Emissions Standards



Emissions standard	Applied to new passenger car approvals from:	Applied to most new registrations from:
Euro 1	1 July 1992	31 December 1992
Euro 2	1 January 1996	1 January 1997
Euro 3	1 January 2000	1 January 2001
Euro 4	1 January 2005	1 January 2006
Euro 5	1 September 2009	1 January 2011
Euro 6	1 September 2014	1 September 2015 - but see important note below

Figure (3)

(thesun.co.uk, 2018)

As the figure shows, according to the SMMT, which is the society of motor Manufacturers and Traders, the euro emissions standards have had significant impact and influences in decreasing the emissions percentages.

From 1993 the number for carbon monoxide percentages has been going down to 63% of original emissions in petrol cars engine and 82% for diesel. From 2001 particulate matter percentage has started to go down to 96 %, hydrocarbons in petrol engines is 50%, and nitrogen oxide has approached 84% also in petrol cars (thesun.co.uk, 2018).

2.5 EU emission standard for passenger cars

Table (2)

Stage	Date	CO	HC	HC+NOx	NOx	PM	PN
		g/km					#/km
Positive Ignition (Gasoline)							
Euro 1†	1992.07	2.72 (3.16)	-	0.97 (1.13)	-	-	-
Euro 2	1996.01	2.2	-	0.5	-	-	-
Euro 3	2000.01	2.30	0.20	-	0.15	-	-
Euro 4	2005.01	1.0	0.10	-	0.08	-	-
Euro 5	2009.09 ^b	1.0	0.10 ^d	-	0.06	0.005 ^{e,f}	-
Euro 6	2014.09	1.0	0.10 ^d	-	0.06	0.005 ^{e,f}	6.0×10 ¹¹ e,g
Compression Ignition (Diesel)							
Euro 1†	1992.07	2.72 (3.16)	-	0.97 (1.13)	-	0.14 (0.18)	-
Euro 2, IDI	1996.01	1.0	-	0.7	-	0.08	-
Euro 2, DI	1996.01 ^a	1.0	-	0.9	-	0.10	-
Euro 3	2000.01	0.64	-	0.56	0.50	0.05	-
Euro 4	2005.01	0.50	-	0.30	0.25	0.025	-
Euro 5a	2009.09 ^b	0.50	-	0.23	0.18	0.005 ^f	-
Euro 5b	2011.09 ^c	0.50	-	0.23	0.18	0.005 ^f	6.0×10 ¹¹
Euro 6	2014.09	0.50	-	0.17	0.08	0.005 ^f	6.0×10 ¹¹
* At the Euro 1-4 stages, passenger vehicles > 2,500 kg were type approved as Category N ₁ vehicles							
† Values in brackets are conformity of production (COP) limits							
a. until 1999.09.30 (after that date DI engines must meet the IDI limits)							
b. 2011.01 for all models							
c. 2013.01 for all models							
d. and NMHC = 0.068 g/km							
e. applicable only to vehicles using DI engines							
f. 0.0045 g/km using the PMP measurement procedure							
g. 6.0×10 ¹² 1/km within first three years from Euro 6 effective dates							

(swatchina.com, 2018)

Managing the vehicle emissions is a collaboration between governments and industry, which results in saving costs of maintenance and increases the vehicles safety while driving. Looking at GHG and their characteristics, the Euro emission specifications and Regulations from Euro1, 2, 3,4,5,6 and 7 in EU and UK, looking at the percentage of GHG emissions from transport, road to zero emissions, where the T charge located is always in centre cities like London and other capital cities around the world. EU emissions standards for passenger cars is assessing the diesel engine performance from Euro 1 until Euro 6 looking at CO₂ more precisely (swatchina.com, 2018).

3. Overview of Automobile Technology to reduce emission.

Current Emission Technologies

The current technology deals with the emissions by employing methods to manage and control the exhaust gases which the motor vehicles produce from different components when operational. For example in an internal combustion engine, there are three main sources that produce the by-products discussed previously, they are the engine exhaust, fuel tank, and crankcase. The gas emissions flowing inside the exhaust pipe, do not always fully combust depending on the conditions of the reaction, and this also can apply with different gases such as nitrogen, carbon monoxide, and different acids (Encyclopaedia Britannica.Inc, 2018).

In order to fix fundamental measures to manage the emissions, Portable Emissions Measurement System (PEMS), is used currently to test the emissions and will be developing onward European car Emissions roles and Legislation, which generally will focus on the expected benefits and principles of the Euro Standards. Common and best types of emission control devices are:

3.1.1 Catalytic Converter

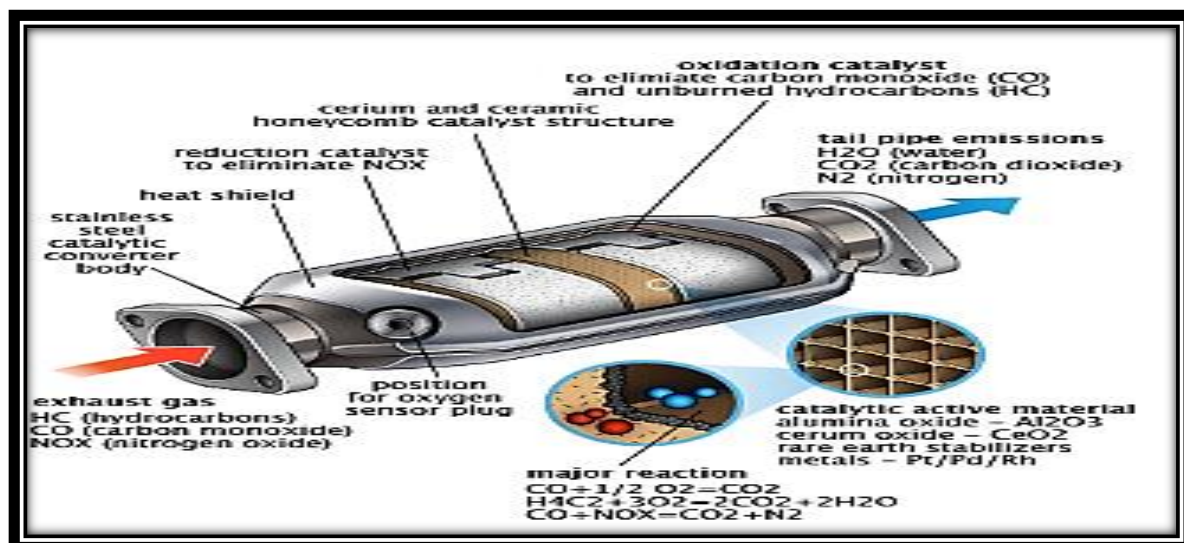


Figure (4)

(repairpal.com, 2018)

A catalytic converter is a common system used for reducing the gas emissions, the strategy of the catalytic converter is taking the harmful gases that come from the internal combustion engine and pass them through a structure designed to limit and control the by-products. A “catalyst” chemically supports the initial stage of a chemical reaction (WILEY, 2009).

Catalyst material must have the ability to deal with the chemical reaction, in order to help to reduce the gas emissions and to reduce their harmful effects (repairpal.com, 2018).

3.1.2 EVAP System

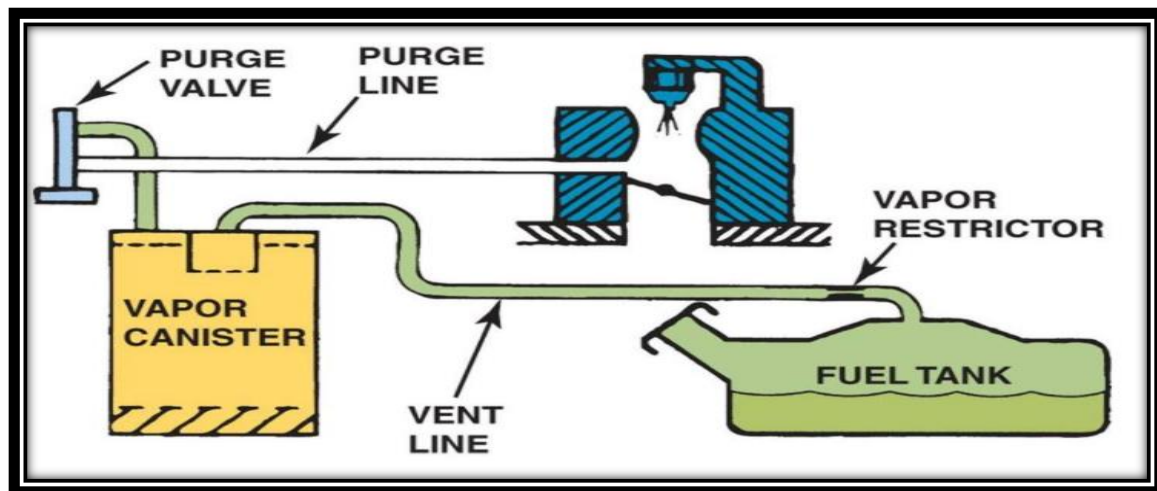


Figure (5)

(D.HALADERMAN, 2016)

EVAP emission system employed to trap and hold gasoline vapours, which is VOCs volatile organic compounds, EVAP function with charcoal canister, valves and pipes.

The vapours direction going throughout first charcoal canister then intake airflow, which this area is known as a combust area in the engine better than send it back to the ambient.

EVAP structure consists of vapour restrictor, vent line, vapour canister, purge valve and purge line (D.HALADERMAN, 2016).

3.1.3 Stop and start

Fuel prices are at record levels. It currently costs nearly £80 to fill up the average car; nearly 20% more than two years ago. The motor industry is looking to find fuel-saving technologies, and methods that keep improving performance and lowering fuel consumption. One of the technologies that has been most successful is stop and start technology. When the engine turns off it can't burn any fuel, which is why all the manufacturers in the rest of Europe use this system (The Truth About Cars, 2018).

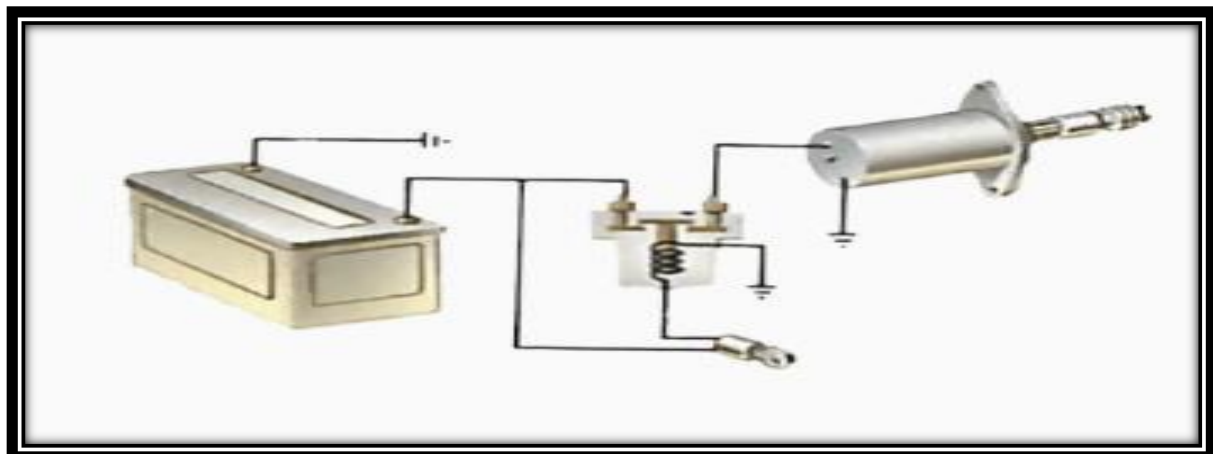


Figure (6)

(How a Car Works, 2019)

As the figure above shows the important parts the stop and start rely on, which consists of good make battery which helps with enough current, powerful electric starter motor for turning the engine, the rod of the starter motor carries a small gear wheel for the purpose to engages with the large gear ring around the rim of the flywheel, which gives quick action from the starter to the flywheel to function the engine.

Heavy electric current is needed to let the starter work correctly, need specific switch handle with high current from the battery, must turn on and off the switch very quickly to avoid damaging sparking or any dangerous at the solenoid, which function where a small switch works on an electromagnet to finish the circuit.

The starter switches on and off by the car ignition key to feed the electric current to solenoid, the ignition switch has a spring as you leave the key the springs back switch off the starter after it is run (How a Car Works, 2019).

3.2 How Stop and start works



Figure (7)

(.whichcar, 2017)

It works automatically when your car is coming to a halt in a specific position in traffic lights. The engine will shut off automatically, and then will restart on pressing the clutch. The starter motor will bring the engine back to life as it was, which avoids the idling engine still burning fuel and creating gas and noise emissions. This system will also improve Internal Combustion Engine (ICE) efficiency, for example, low emissions, low cost and high performance (Autocar, 2019).

Another stop and start system uses computer software to detect when the vehicle is out of gear or in the stationary position. Exactly at this point, the spark plugs stop igniting and the fuel pump stops the delivery of fuel, then when the clutch is pressed, there is a sensor on the clutch which sends a signal to the electric control unit (ECU) which in turn signals to the fuel injectors and spark ignitions to restart ignition. The vehicle then begins to move as the normal cycle of fuel injection resumes (Autocar, 2019).

3.2.1(A) Inertia starter.

Within the car or inboard which is the term of starter, the Bendix gear throws the pinion across to the motor, and vice versa outboard which means it moves by another way.

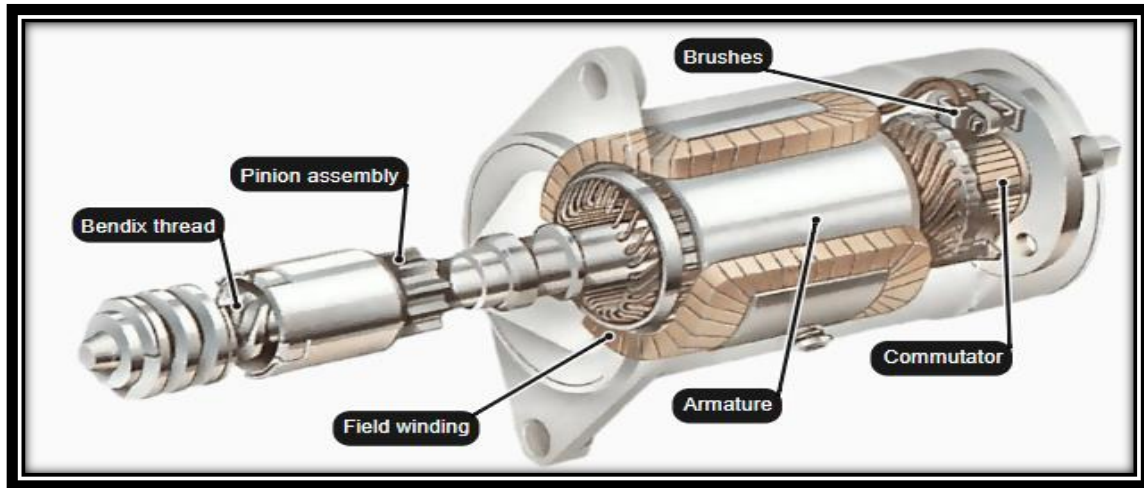


Figure (8)

(How a Car Works, 2019)

The figure shows the structure anatomy of starter which consists of brushes is of metal coil works towards commutator, Armature, Pinion assembly, Field winding and Bendix thread.

3.2.1(B) Pre-engaged starter.

The solenoid coil moves the pinion, there is an initial lap in which the motor slowly turns on to allow engagement, and it will work gently to prevent impacts on the teeth.

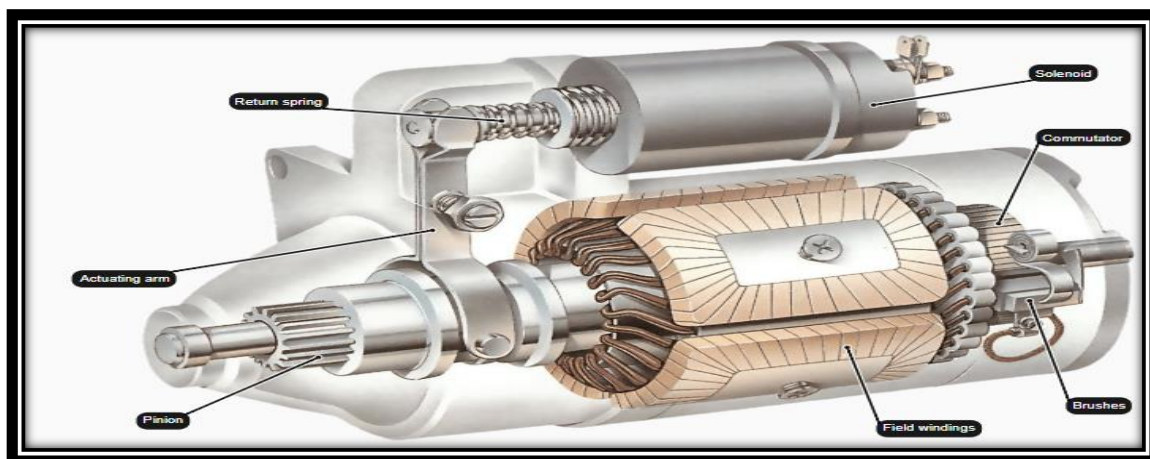


Figure (9)

(How a Car Works, 2019)

The starter circuit relies on battery which means all the components are earthed to the metal car structure just only one side of the wire is required to deliver the current to each stop and start parts (How a Car Works, 2019).

3.3 Vehicles in UK fitted with stop-start.

Recently fuel prices have dropped slightly, but fuel economy is still a necessary factor when anyone intends to buy a vehicle. Stop and start is one of the best automakers strategies to improve mileage and keep vehicles environmentally friendly, by reducing emission and saving fuel (Cars.com, 2019).

- 2016 Acura RLX Sport Hybrid. ...
- 2017 Cadillac XT5. ...
- 2016 Chevrolet Cruze. ...
- 2016 Chevrolet Malibu. ...
- 2016 Land Rover Range Rover, Range Rover Sport Diesel.
- 2016 Mercedes-Benz GLC-Class. ...
- 2016 Mercedes-Benz S-Class. ...
- 2016 Honda Pilot.

Figure (10)

(Cars.com, 2019)

Acura RLX 2016 Sport Hybrid



Figure (11)

(Cars.com, 2019)

Engine noise is an important matter in determining how the stop and start can function without being noticed. The Acura RLX 2016 Sport Hybrid (figure 5) is hybrid and because it has a quiet engine, there is no sudden difference when the engine is switched off because was always a silent engine during it is functioning. Stop and Start technology also includes sound insulation to add extra quietness to an engine (Cars.com, 2019).

2017 Cadillac XT5



Figure (12)

(Cars.com, 2019)

According to Cars.com (2019). The new SUV is particularly subtle because in this car the air conditioner is not affected by stop and start which in some cars it is (Cars.com, 2019).

2016 Jeep Grand Cherokee



Figure (13)

(Cars.com, 2019)

According to Assistant Managing Editor Patrick Olsen (Cars.com, 2019) Jeep always focuses on extra safety and efficiency, so their stop and start system provides this safety by creating only a half-second delay from the final dead stop, which produces a quick reaction turns in rush hour traffic (Cars.com, 2019)

2016 Volvo XC60



Figure (14)

(Cars.com, 2019)

Volvo's stop and start system works smoothly meaning there is very little vibration or noise, so the system not obvious and is not a nuisance. Many customers want luxury cars but if the manufacturers use modern technologies to constantly improve efficiency and quality, the manufacturers will improve their reputation (Cars.com, 2019)

TOYOTA

Fitting vehicles with stop-start, is done through brake energy recuperation technology and alternator energy management, which is one method car manufacturers have used to reduce the exhaust emission CO₂. In fact, one in every 7 vehicles on the UK currently have start-stop technique, which is around 5 million vehicles. To reduce CO₂ emissions and support these technologies for more development, a new batteries are needed, with high technology to satisfy all stop-start system requirements. (Parts Alliance Group , 2018)

TOYOTA V6 Highlander 2017



Figure (15)

(White River Toyota , 2019)

The ideology of Toyota is to keep you on the go even when your engine is at a stop. Toyota have improved drivetrain technology by producing and applying stop-start technology in its models. This works automatically by stopping and restarting the engine when the vehicle is in a stationary position, and making sure the vehicle is on standby to launch at any time required. The system works when the engine is shut down to zero miles per hour, and smoothly restarts when the brake paddle is released. Stop-start in Toyota is much easier to use because the dashboard information displays every stage for example when the engine is shut off, it shows that stop-start is activated automatically every time the brake paddle stops in crowded areas, and the system is suitable for all driving styles.

Toyota made this system for creating fuel economy and reducing emissions. Without stop-start a vehicle can burn around a gallon in just one mile in a crowded city. Toyota minimises this issue; when the engine is not running the vehicle does not produce any emissions when it is stops. Also there are not any vibrations or noises during the engine idling, which makes a peaceful car cabinet. It is possible to disable the stop-start system by pressing a button on the dashboard to the left of the steering wheel. An icon will appear showing that the system is not functioning, and to re-activate, press on the same button again which will make the stop start work again. Otherwise the engine can be shut off entirely, and the system will work automatically by using an ignition cycle to operate the engine (White River Toyota , 2019).

Toyota have managed to create a stop-start system that does not impact or drop the performance of any devices or accessories such as air conditioning or window screen heaters to prevent the windows fogging up if the engine is stopped. The idling style can be changed by choosing one of two options standard or extended. These procedures can be found in the vehicle settings button, the purpose of which is to stop the impact of the stop engine in idling time to keep the air conditioning and any other accessories the driver needs. The start-stop system is designed to monitor a wide range of input and to make sure all the operations function properly whenever possible, however, in certain cases such as front frost window light is illuminated, it might be necessary to check whether the owner log book is showing some guidance and instructions (White River Toyota , 2019).

4. Review of Stop-start systems

4.1 Reliability of stop- start system

A stop-start vehicle has more on and off cycles than a normal vehicle without it. While using this system it is expected for some components to wear out early and need replacing. Often the first part that that owners often complain about is the starter and battery which suffer wear and tear under the pressure of hard work, but regular maintenance can reduce costs and damage and create a longer life expectancy for the vehicle.

It can be predicted that a vehicle will go through 50 cycles of stop and start every single day, which is approximately 20,000 stop-start cycles annually. All modern vehicles use it which indicates it is not a bad system to use. The only the problem is that in cold countries, there is more wear and tear if the engine is cold and stop and start is not working due to lack of oil in specific internal parts. Certain components are very inefficient when not warmed up enough, those are factors of the stop-start system, the reason is no cold metal on metal contact or no huge fuel consumption when starting to warm up the engine. This issue is continually being improved.

The battery also works very hard; due to multiple charge cycles, batteries are charging continually in all engines functioning with a stop and start system, and discharge to let the engine start. This cycle repeats, charge and discharge works with the stop-start system, so stop-start relies heavily on the battery, meaning that the size and capacity of the battery is playing an important role. The common vehicle manufacturers using stop-start systems are VW and Ford, who state that their batteries have on average 28 % higher capacity than cars without a stop-start system (Advance Auto Parts, 2019).

4.2 Stop-start Advantages

Saving fuel

Vehicle owners looking at the advantages and disadvantages of any new systems such as stop-start, will want to know if it actually saves money for them. The advanced vehicles did not burn much fuel while idle, which keep the power of the spinning components moving and guides all the accessories , however, the Estimates Real-World (EPA), suggest that stop-start saves 3 to 10% range which is equal to \$2.87 per gallon, which is roughly \$10 monthly in petrol vehicles. Also, the technical website CNET declare that stop-start ads 4275 to manufacturer's suggested retail price (MSRP). It might take time to derive all the results from the owners, because the technology is new and not very much data is available yet (Merkisz, et al., 2011).

Many owners report the issue of lack of control when the engine stops automatically, or when the engine starts making some vibrations. Some systems can be restarted manually; EPA assume that 50% of the drivers turn off the feature, because they are not experienced in using this new system, but finally the manufacturers are happy with

EPA estimates test number and stop-start system is here to stay (Advance Auto Parts, 2019).

Premature wear

Modern engine cars are fitted with advanced auxiliary engine coolant, transmission pumps, and high quality of engine oil to maintain pressure and temperature, stop and start technology gives a long life for all these parts with regular oil changes which also makes crankshaft bearings avoiding premature wear (National Automotive Parts Association, 2019).

Increase battery capacity

Stop and start Technology relies on battery capacity, so the electrical system is usually enhanced with high-quality batteries which can carry dedicated super capacitors or starter batteries (National Automotive Parts Association, 2019).

More powerful

Stop and start increasing the power of the engines and more efficient when starter motors, the first type of motors is Hybrid like motor, motor controller and generators which allows engine recovery for more efficient and fast engine restarts (National Automotive Parts Association, 2019).

4.3 Stop-start Disadvantages

Mess orientation

Drivers accustomed to hearing the noise which comes from their engine running and pushing forward while its crowd. This it might be unsettling, when the engine is shut off, but once full understandable this technology will be simply enjoying it is benefits, the feeling of change during refuelling the car for fewer always (SAE, 2017).

Wrong adding

Adding stop and start technology in unsuitable cars it might be happed due to the design of engine size, which this causing premature wear perhaps be a concern, stop and start to demand specific handing with important parts such as battery capacity, restarter quality, and electric systems (National Automotive Parts Association, 2019).

Missing regular Maintenance

The designers created a stop and start system and gives recommendations that require regular maintenance from the vehicle's owners. However, missing the regular maintenance it might excessively wear the important parts such as restarter, battery or any connection components between each other's. The fact is that they want to always build reliable vehicles to increase their own reputation. However, it is a good idea to keep changing the oil of your vehicle on time and to use good quality oil to keep the engine in good condition. It is a bit hard to start a cold engine due to the engine bearings, so we have keep in mind that stop and start is not a big issue, since it works on warmed up engines only. Additionally, the manufacturers now use

polyamide material coating on the engine bearings to effectively reduce wear on the crankshaft and bearings (SAE, Fuel Consumption Evaluation of Stop/Start Systems.).

Battery maintenance is an important factor too, as all vehicle devices rely on it, but as you carry out proper maintenance on your engine, a lot of manufacturers prefer AGM batteries to always be used. Good routine under the hood combined with common sense, means that the stop and start systems are reliable for many years and save fuel (BestRide.com, 2019).

NVH

This Is a team that gives support and can provide any necessary help to determine the good specifications for the products using proven techniques. That is because a lot of specialist facilities are available and also for industry guiding data processing types of equipment. However, our target is doing smarter things and we are providing something that is going under a line of characterization of the products functions, the knowledge of noise vibration and harshness (NVH) issues, team skills can confidently deal with and tackle any challenges (Parts Alliance Group , 2018).

5. Ece1504 Dyno vehicle test cycle.

ECE which means European Cycle to test Emissions is known as MVEG cycle used for EU type which approval testing fuel consumption and emissions comes from light-duty vehicles. The test procedures are built on the chassis dynamometer. All the test cycle consists of four ECE segments repeated continually without interruption.

To get good results and success the test should allow the engine to soak for at least six hours at the temperature 20-30°C which test temperature and let the engine idling at least 40s (Dieselnet.com, 2019).

5.1 Ece1504 Dyno

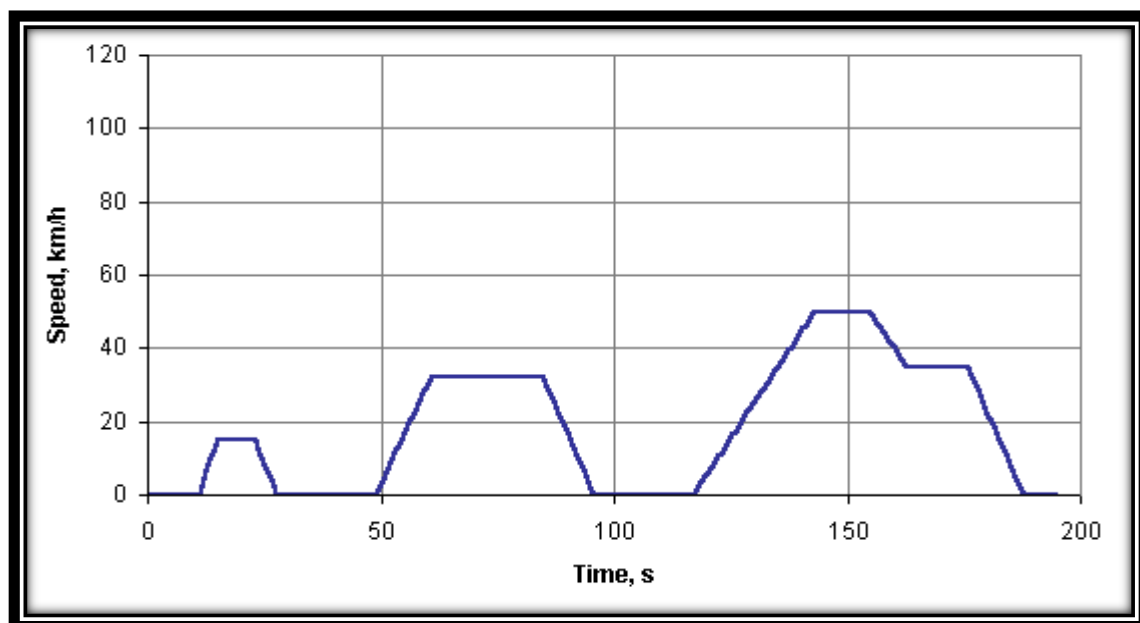


Figure (16)

(Dieselnet.com, 2019)

The figure shows Ece1504 Dyno test map, which is describing how to follow the test map between vehicle speeds versus the time. The time spent gradually increases with speed for three stages where it starts as the figure above with low speed and increase gradually as the first stage starts less than 20KMH then slows down to zero KMH. The second stage starts to build the speed up again and exceeds 20KMH then goes back down to zero KMH. The third stage is building the speed up higher than the first 2 stages and spends a longer time as well. The main purpose of this test is to check how the emissions values change for each stage of engine pressure throughout the gradually increasing the speed with short amount time and 1 gear selected in the 1st stage, 2nd stage increasing the speed with moderate amount of time spent and selected 2 gears and the 3rd stage with increased speed again and also the time spent increases with 3 gears used (Dieselnet.com, 2019).

Characteristics	Unit	ECE 15
Distance	km	0.9941
Total time	s	195
Idle (standing) time	s	57
Average speed (incl. stops)	km/h	18.35
Average driving speed (excl. stops)	km/h	25.93
Maximum speed	km/h	50
Average acceleration ¹	m/s ²	0.599
Maximum acceleration ¹	m/s ²	1.042

Figure (17)

(Dieselnet.com, 2019)

The characteristics of Ece1504 Dyno consist of the Distance, Total Time, Idle Time and different Averages such as Speed including stops. Average Driving Speed excluding stops, Maximum Speed, Average Acceleration and the Maximum Acceleration (Dieselnet.com, 2019).

Using this characteristics as a fundamental points to build the performance analysis of stop and start . (Dariusz & Mian, 2013).

5.2 Test Methodology



Figure (18)

This figure shows the instructions that must be followed to implement the Dyno Test. The instructions are as follows:

1. Make sure all the protection equipment is available before you start applying the test, such as ear plugs, overalls, and workshop shoes to keep health and safety procedures functioning.
2. Make sure the sight towards the Dyno screen is clear to practise the test correctly and effectively.
3. Put your left hand on the transmission standby to manage to select the gears on the correct gear in the correct time without any sort of delays.
4. Use the remote control to match the starting time between the dyno computer software and rolling rod to start launch the lopo car in the correct time.
5. Keep your feet on standby to press on the accelerator to enable you to change speed and gears properly (SAE, 2013).

5.3 Driving-Cycle Ece1504 Dyno

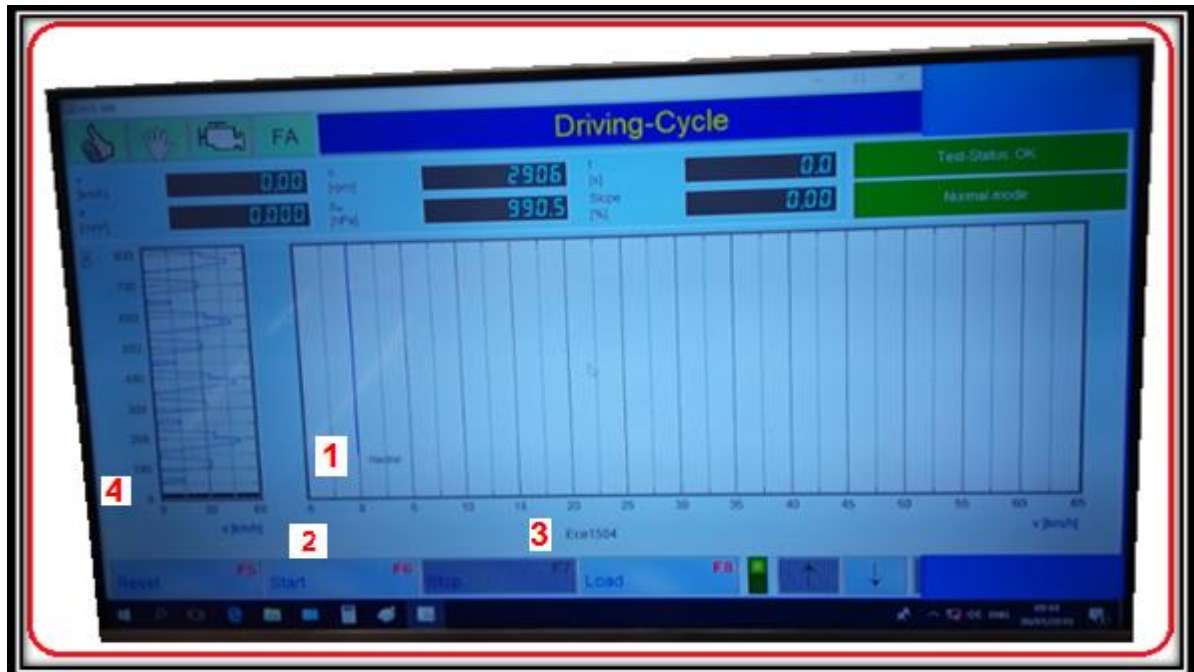


Figure (19)

To receive the correct data you have to follow the test plan successfully, because the primary steps are really important. It consists of the following:

1. Make sure your vehicle is in a neutral position and idling, to avoid the engine shutting off suddenly, keeping the engine running is good, to keep the engine temperature.
2. Make sure everything is working and fits properly before clicking on the start button to help you to finish another test stage.
3. If any mistakes happen during the test stages, you can cancel or switch off the test by clicking on the stop button if need be.
4. Keep your eyes on the test plan changing gears at the correct time to avoid increasing the tolerance between the vehicle and the test plan map line (Kim, 2013/2015).

To keep the tolerance between the vehicle and dyno test line, the guide must increase the engine revs for this purpose to keep balancing, which means not very high revs and not very low revs suitable to test plan guidelines (Dieselnet.com, 2019)

5.4 Ece1504 Dyno Test map

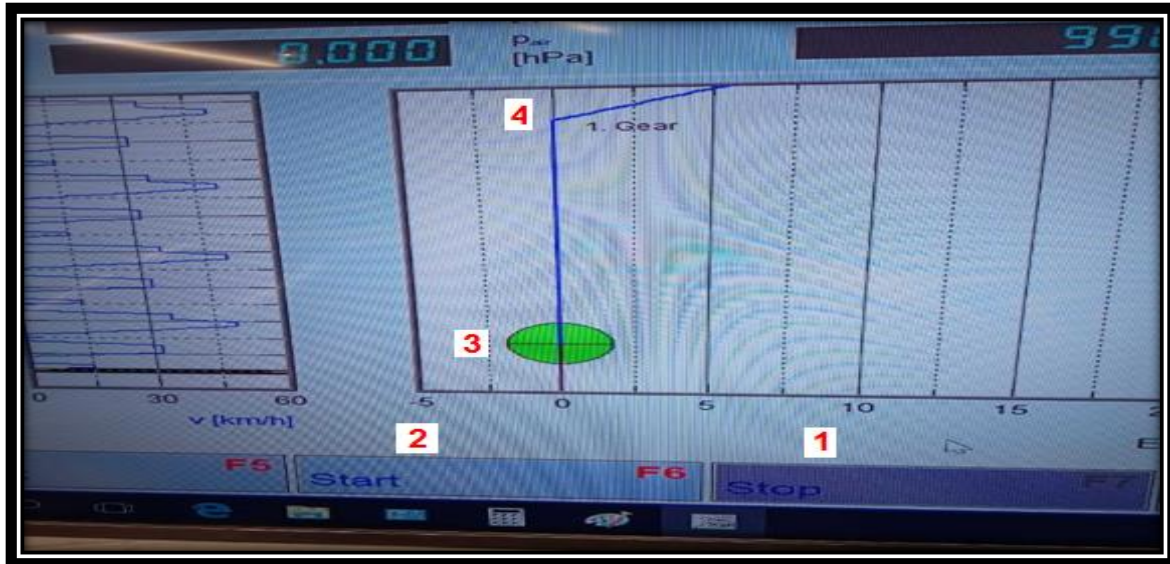


Figure (20)

As the figure shows different reading on the software screen, for example:

1. The stop button is on to start correct running match between feeding the fuel and the vehicle moving in the test direction.
2. Click on the start button and make sure that the transmission is in a neutral position and that the engine is idling.
3. The green circle is the driver cabinet area to drive and keep the circle moving on the blue line as straight as possible. Select the first gear as you achieve the end of neutral and idling line area (SAE, 2014).

5.5 Ece1504 Dyno running time



Figure (21)

During the test procedures you face some mistakes as normal so the strategy is to fix it. This is easy, for example:

1. Click the start button and keep going on the blue line.
2. If you get out of the test directly, try to go back by keeping the vehicle in the correct gear until to the end of the test. Either rushing or delaying to change the correct gears at the correct time might guide you to this common mistakes.
3. Select the transmission to neutral again slowly and keep the engine functioning.
4. Keep your eyes on the black line which shows the gears selection and stages of your test (Dieselnet.com, 2019).

5.6 Test Cycle target

The test relies on three devices, BOSCH 850, Dyno software and rolling rod. These systems are connected to each other and they transfer the data acquisition to each other during the test. For example, dyno and rolling rod and BOSCH are ready to run. The dyno software guide the vehicle on the rolling rod and also sends the data to BOSCH by drawing the cursor of three important gases, Co, Hc and CO₂. These three gases will focus on them while the Dyno test is functioning. The purpose of these gases is to give direct impact of GHGS which is changing the climate.

The cycle test plan is looking at these gases in a different style of engine, increasing the speed which increases the emissions, also looking at different gear transmissions. Our purpose is to check the difference between using or not using the stop-start technique. This will compare how the three gases change during not using stop-start and leaving the engine in a neutral position and idling style. The next step is going through the test cycle and using the stop-start technique in that previous period that the engine was idling and was in a neutral position. We will analyse all the three gases while the engine increases speed and gradually go in a crowded area and wait at traffic lights (Dieselnet.com, 2019).

6. Analysis CO, HC, CO₂

At this chapter will analysis at the three important gases which comes from Ece1504 Dyno test, this evaluation will works with the data comes from BOSCH Oscilloscope machine.

6.1 CO without stop and start

Carbon monoxide is a greenhouse gas which is tasteless, odourless and colourless. Its density is slightly less than air, and it is a toxic gas for animals and humans.

Through a dyno test, graphs were produced relating to CO emissions and these were interpreted and analysed by looking at cursor peak values (WILEY, 2002).



Figure (22)

(Time from (0:60/sec))

The graph shows the blue scale which is the CO volume value. The maximum CO is 4.6% of the total volume of other gases, so the blue vertical scale numbers on the left, show the first start value where the engine was idling and in neutral transmission position. At this point the CO was 0.4 part per million of the CO volume (ppmvol), and the horizontal scale shows the time per second, so the engine started at zero seconds, after 30sec the driver decided to select first gear and the CO increased to 1 ppmvol. The driver then changed back to neutral from 35 sec to 40 sec which decreased back to the usual limit which is 0.4ppmvol. This process was then repeated at 45 seconds when the driver once again selected first gear. The engine revs in the first gear at 137/rpm which will allow a calculation of speed during analysis (STRAUSS, 1972).



Figure (23)

(Time from(60:120/sec)

In this graph the engine is still running and the CO blue line is fluctuating from 60sec to 110 sec on the time scale. The maximum peak during this period was 0.8 ppmvol, which indicates that there were gear transmission and speed changes. The impact of this was increased engine revs: first gear is 137/rpm, and second 80rpm. It also affected the CO value which increased as the engine revs increased, i.e. burning a lot of fuel will produce a lot of CO (WILEY, 2002).



Figure (24)

(Time from(120:180/sec)

The previous figure shows the engine idling in neutral gear and producing a CO value of 0.3/ppmvol, until it approached 138/sec when the driver selected the first gear and then second gear which lifted up the CO value to 0.8/ppmvol. This appears on the cursor from 140/sec and 145/sec staying high until 150/sec. from 150/sec the CO blue line goes down back to its original value which is 0.3/ppmvol just for 3/sec, when the driver changed into first gear in accordance with the plan test guidance. The CO blue cursor then moves up to 0.8/ppmvol and continues until 170/sec with CO=0.6/ ppmvol (C.Ronneau, 1997).

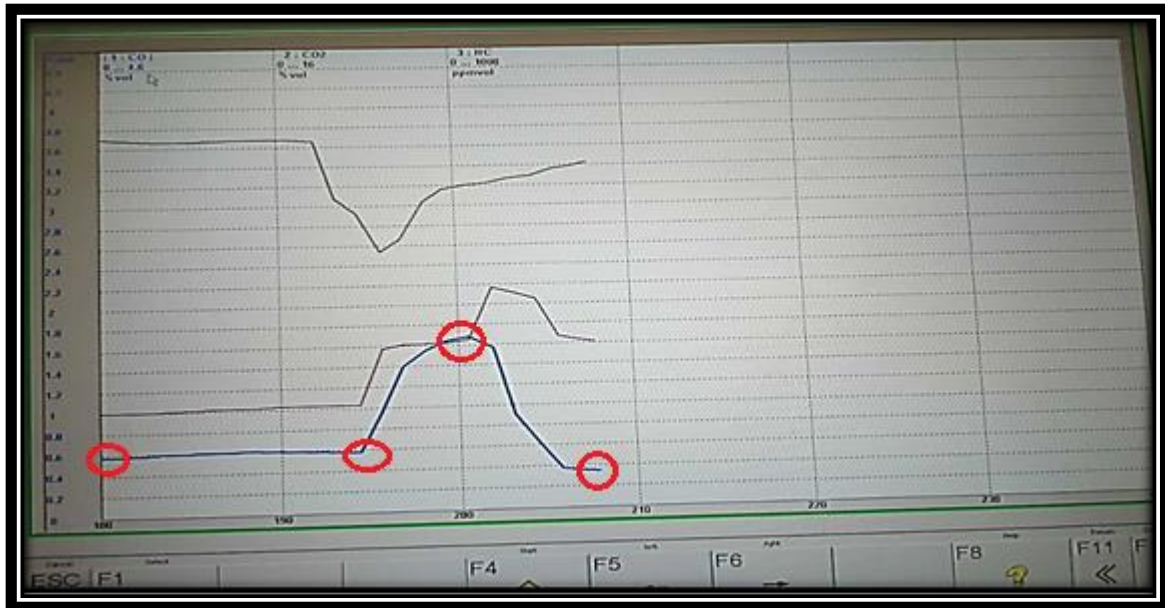


Figure (25)

(Time from (180:210/sec))

The last graph shows the engine is idling on neutral transmission position with the blue line showing CO=0.6 /ppmvol at 180/sec staying at the same level until 195/sec then the driver starts to speed up and select gears. The driver selects first, second and third continually, and the CO blue line is increased sharply from 0.6/ppmvol to 1.6/ppmvol. This has a huge impact on the CO value while the engine is running in high gears and a huge impact on emissions. The max CO value at time 205/sec is equal to 1.7/ppmvol which is at the third gear and then the driver selecting downshift gears from third to second to first gear and finally goes to neutral which leads the engine to idle again. From 205/sec the CO value starts gradually to go down until 208/sec when the CO is 0.3/ppmvol. The result of this test shows the impact of changing gears and neutral on CO values (SAE, 2017).

6.2 Hydrocarbon (HC) without stop and start

Hydrocarbon is a greenhouse gas and is a mixture of hydrogen and carbon monoxide which is toxic for humans and animals. A lot of gases consist of HC such as compounds of gases like hexane, propane, butane, and methane. Their chemical formulas are composed of hydrogen and carbon atoms only, with different chemical configurations and ratios (Vicente Díaz, 2009).



Figure (26)

(Time start (zero: 60/sec)

The graph above shows the engine running at neutral transmission and idling from zero/sec. HC is the middle red line which starts at HC=300/ppmvol at zero/sec while the engine is idling without selecting any gears or speeding up the engine. The total maximum HC is 1000ppmvol of emissions. Until the vehicle moves on the test plan map at 50/sec the engine is still idling, but the HC= 300/ppmvol drops to HC=220 between 35-47 seconds due to revving of the engine in order to warm it up. At this stage, the driver prepared to select the first gear but waited to finish the neutral and engine idling time to calculate the HC percentage correctly (SAE, 2017).



Figure (27)

(Time (60:120/sec))

In the graph above, the vehicle is following the test map guidelines from time 60/sec to 110/sec which is keeping at neutral transmission and idling. However, the engine still produces HC=300/ppmvol during normal engine running from 60/sec to 78/sec. To keep the dyno tolerance with the vehicle it might impact upon CO levels, additionally the peaks indicates that the HC produces more emissions than CO. HC values go up and down repetitively until 110/sec (SAE, 2014).



Figure (28)

(Time (120:180/sec))

During this test session, the driver makes the engine ready to follow the test map plan guidelines. The engine is idling from 120:133/sec. When the driver selects the first gear that increases HC from 300/ppmvol to 390/ppmvol. From 139/sec the driver goes back to neutral which guides the engine revs reduced and HC gradually from 390/ppmvol into 220/ppmvol, which is caused by reduced speed and the change in gear selection from first to neutral. The engine is then left idling again to give the driver the ability to go through another stage of testing HC (A.Roosa, 2009).

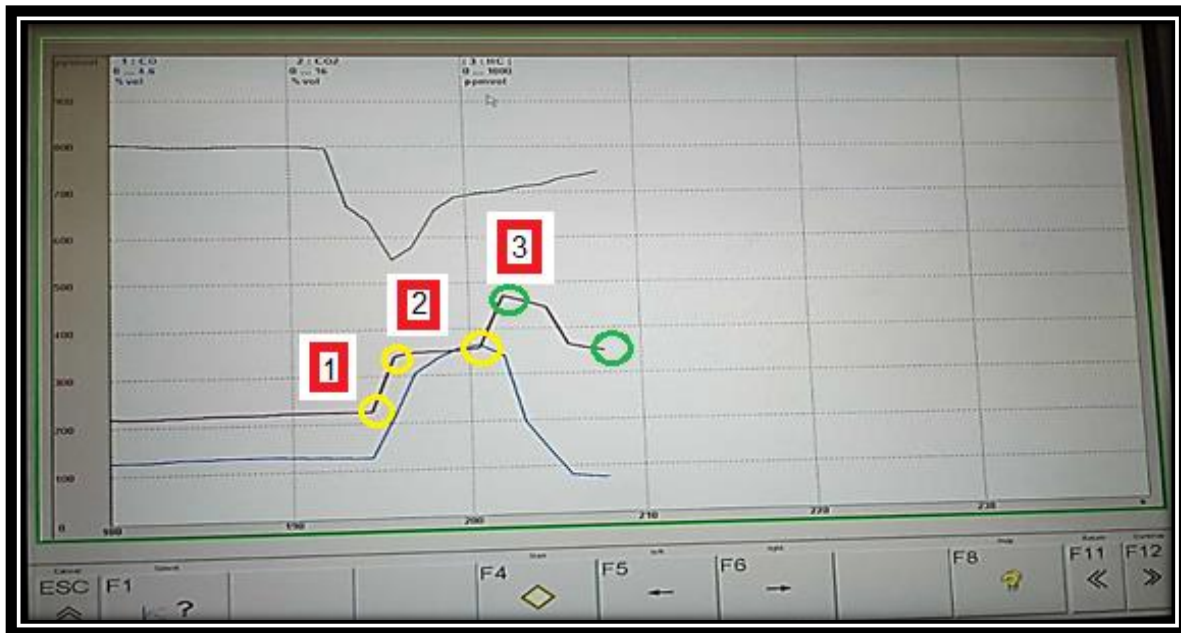


Figure (29)

(Time (180:210/sec))

In this graph the engine is idling from 180/sec with HC=220 /ppmvol limit until 195/sec when the driver selects the first, second and third gears continually, which always happens when driving in crowded areas at the rush hour. Analysis of the graph shows increased pressure in the engine because selecting gears produces a lot of emissions even if a car is not going as fast as it would on the motorway. So the impact of selecting three gears from 195 into 203/sec is that HC=480/ppmvol, which indicates the engine produces a large amount of emissions at this stage. The HC red line starts to reduce from 203/sec into 210/sec because the driver selects the transmission to neutral and lets the engine idle to finish the test plan, and at that time the HC reduced at 350/ppmvol, which indicates even when the engine is idling it still produces high hydrocarbons gas emissions (Encyclopaedia Britannica, Inc., 2019).

6.3 CO₂ without stop and start

CO₂ exists in the air at 0.037% normally, and is not harmful to humans or animals in low concentrations, but if the normal percentage is increased, it will become a toxic gas, however, it is essential for plants to grow.

The normal percentage is from 1000 to 2000/ppm (part per million of volume), but if this has been increased such as from 2000 to 5000/ppm it can cause problems like nausea, insomnia, and headaches. The air will be described as being contaminated from 5000/ppm. The level of CO₂ in the air rising above 2000ppm, will lead to a toxic climate poor in oxygen. Additionally, CO₂ is a greenhouse gas which if it continues to increase will affect the global warming and change the climate (Franchetti, 2013).

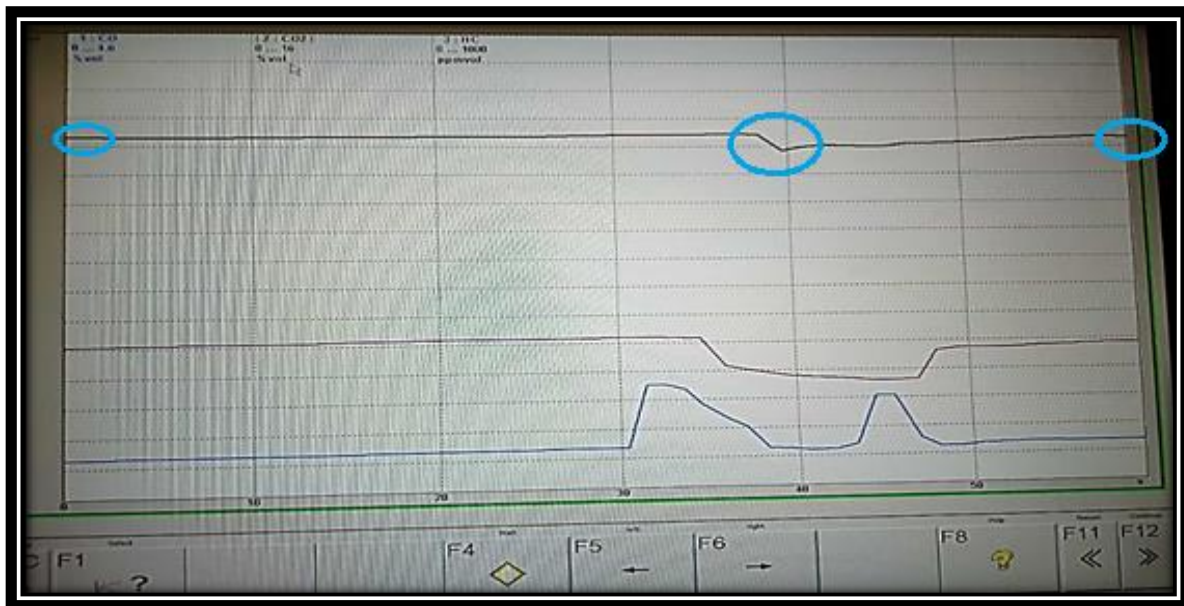


Figure (30)

(Time (0:60/sec))

The maximum general volume of CO₂ in this test is 16%vol of total gases, which is shown in the graph. The percentage of CO₂ at different stages might change due to speed and gear selection. From zero /sec when the engine is neutral, the CO₂ is 12.3%vol. This changes at 38/sec when the driver slows down and the engine revs ready to follow the test plan and keep the tolerance between the vehicle and test plan blue line. CO₂ reduces to 12% from 40/sec until 50/sec, then starts to increase (Franchetti, 2013).



Figure (31)

(Time (60:120/sec))

The previous figure shows CO₂ starts to increase from 75/sec due to the selection of first gear which finally achieved 13.5%vol until 99/sec. The driver kept the engine idling and CO₂ then dropped down to 11.5%vol. The transmission was then in neutral and the engine idling until the end of this session.



Figure (32)

(Time (120:180/sec))

Then the driver selected the first gear and the CO₂ started to increase from 12.3%vol to 13.8% from 120/sec into 170/sec due to selecting first gear and keeping the vehicle tolerance within the test map's blue guideline, which is why some increase happened in CO₂ value. If the engine is revved while stationary, the emissions from the engine will increase just as if the car was driving 15 miles an hour.



Figure (33)

(Time (180:210/sec))

The image above shows that CO₂ volume starts to decrease due to the neutral transmission position which the engine is idling at until at 195/sec CO₂ reaches 9%vol. The driver followed the test map and selected the first, second and third gear gradually. CO₂ then increased to 12%vol, and at the end of the test the cursor moved back to its original starting point.

6.4 Total Running test without stop-start

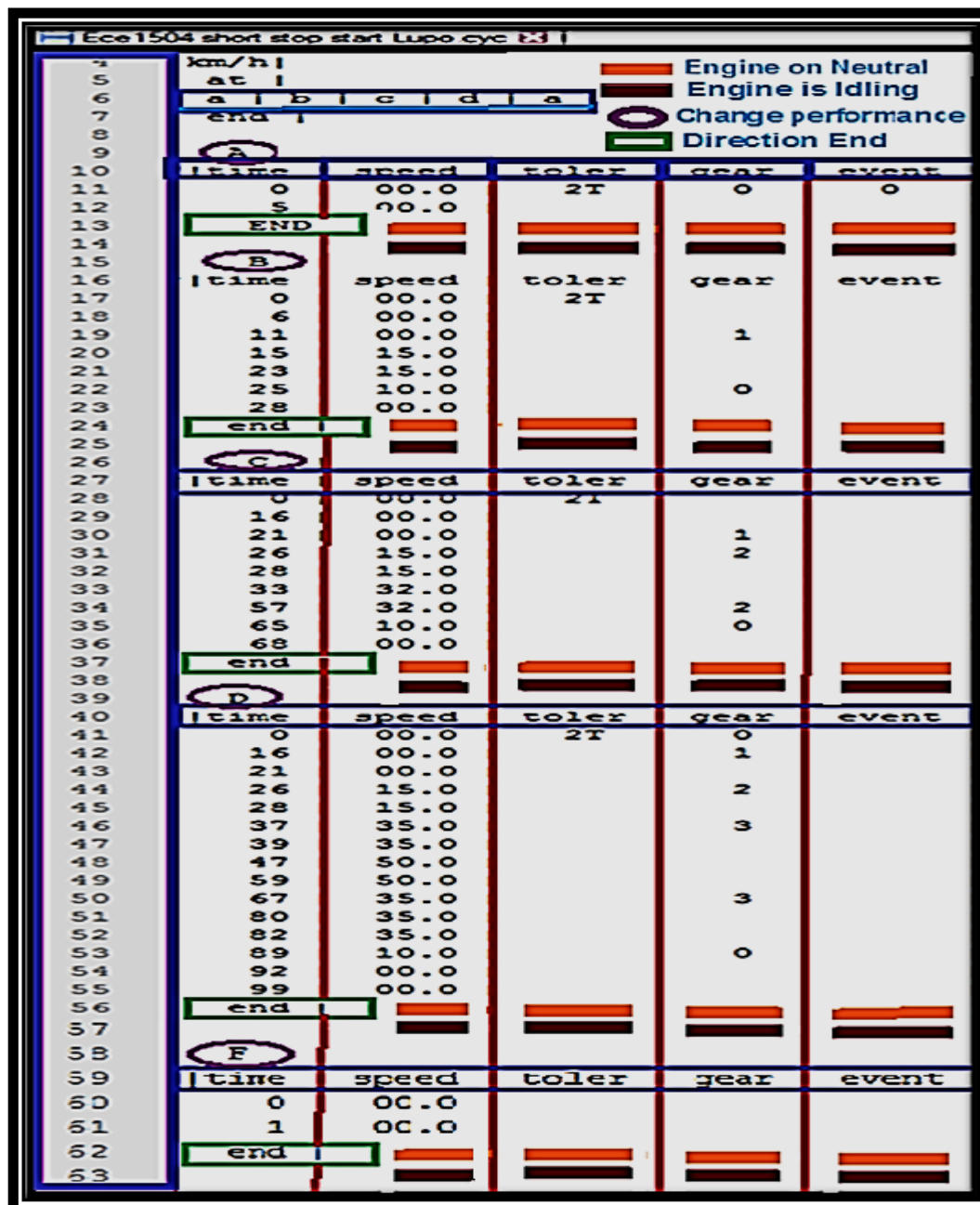


Table (3)

The table shows the areas where the engine is neutral and idling, changing performance from a stationary position to moving the vehicle into direction and end.

So the analysis here at the areas where the engine is idling to measure the emission gases such as CO, HC, and CO₂, the test map plan consists of 5 stages, comprising its time, engine speed, vehicle tolerance on the test blue line, gear selection and event if anything happens during the test plan. For the first stage, the engine is running and idling but in a neutral position, idling time for 5/sec to warm up the engine and make it standby for another stage. Between each stage, the engine is idling which is shown by the red and brown lines in the diagram (Franchetti, 2013).

At the second stage, the time at each stage starts from zero to be equal to the speed and gear selection. Obviously, from zero to 11/sec the vehicle is in neutral and idling. The driver then selects first gear and accelerates, which increases the speed to achieve 15/kMH the vehicle maintains this speed until 23/sec and starts gradually to decelerate to zero and the engine goes back to the idling position, which means that the car is in a crowded area and speeds up and slows down due to this event. The third stage involves the vehicle being in neutral until time 16/sec and the speed is zero, at time 21/sec the driver decides to select the first and second gears which accelerates and increases the speed to become 15/kmh. The speed maintained at this level until time 28/sec, the driver then speeds up the vehicle until 32/kmh, which indicates that the driver is on an open road not facing any traffic. The transmission is still in second gear with a speed of 32/kmh and slows down to 10/kmh until at 57/sec it makes the vehicle in neutral and idling, which slows down the speed to zero/kmh and time 68/sec. This sets the engine back to idling and standby for the next stage of the plan test (A.Roosa, 2009).

During the fourth stage the driver starts from time zero and selects first gear at 16/sec. Acceleration increases the speed from 26/sec and in this time the driver decides to select second gear, which will increase the speed to 15/kmh. During this stage, the driver selects the three gears gradually which will increase the vehicle's speed to 35/kmh and then to 50/kmh. After a while, the speed will slow down to 35/kmh and 10/kmh due to the driver putting the engine into a neutral position which makes the speed zero/kmh as appear at 92/sec and 99/sec. This leads to the engine running and idling and producing emissions as normal. The final stage involves engaging the engine at zero speed which keeps it idling and finally stops the engine and finishes the test plan map on the blue line (Dinh, et al., 2107).

7. Analysis of ICE works with Stop and Start

At this section of test cycle the stop and start technology will be applied, thus the analysis and evaluation procedures will be processed at each gas such as CO, HC and CO₂.

7.1 CO with stop and start



Figure (34)

(Time (zero:60/sec))

The figure shows the starting point which is zero time and at which the engine is running, CO = 0.4/ppmv until approached 10/sec. The driver follows the test map instructions to select the Stop and start technique, which will stop the engine running totally. While the engine is in stop and start mode CO value gas reduces to zero, equal to the time from 11/sec to 36/sec which is totally 25/sec and saves fuel and reduce emissions. The driver then pressed the clutch to get the engine running again, and the large spike on the graph is due to the first gear selection, where Co increased to 6.1/ppmv which is the highest number happen in time between 36/sec to 42/sec. CO gas emissions go down at this point to 0.6/ppmv, due to the change in engine performance to stop and start and that start from 53/sec to 59/sec (Franchetti, 2013).



Figure (35)

(Time (60:120/sec))

As the previous figure shows, the engine is under the influence of the stop and start technique from 60/sec to 74/sec, at which point the driver decides to select the first gear which is making another big spike from time 74/sec to 84/sec, the engine back to stop and start technique from 84/sec to 120/sec with CO average 0.6/ppmv continually until the end of this section (Vicente Díaz, 2009).



Figure (36)

(Time (120:180/sec))

In this section the stop and start technique is functioning and CO=0.3/ppm between the time 120/sec to 140/sec, the driver pressed the clutch which lead the restarter to run the engine again and select the first gear. The time from 140/sec to 155/sec creates a large CO spike in the graph, increasing it to 5.7/ppmv. The driver moved back to the stop and start technique which affected the CO to go to a low value, gradually to 0.6/ppmv from time 155/sec until 180/sec which also appears in the graph (Vicente Díaz, 2009).



Figure (37)

(Time (180:210/sec))

The previous figure shows the stop and start functioning and CO value at the beginning of time cursor is 0.3/ppmv. The driver turned the engine on by pressing the clutch which lead the restarter to run the engine again and select the three gears continually from time 180/sec to 280/sec. this manoeuvre increased CO=1.7/ppmv and this value stayed for 5/sec and then the CO level decreased to 0.8/ppmv from time 215/sec until the BOSCH 850 stopped reading the signal from the Dyno software. This ended at time 237/sec and CO=0.6/ppmv (part per million of volume).

7.2 HC with stop and start



Figure (38)

(Time (0:60/sec))

As the figure above show that the HC (hydrocarbons) in this section equal to 350/ppmmvol which the engine is running, the driver moves the engine to stop and start technique which reduces HC to 200/ppmmvol and this appears on the graph, the binging start from zero time to 10/sec the engine is running to warm up before using the stop and start mode then the driver transfer the engine from time 10/sec to 35/sec which drop HC to 200/ppmmvol, after that the drive restart the engine again and select the first gear from time 35/sec to 38/sec producing HC=700/ppmmvol, from 38/sec to 54/sec HC drop to 280/ppmmvol with time 54/sec. from 54/sec the driver select the second gear to increasing HC=410/ppmmvol then the driver change the vehicle performance to stop and start technique until time 60/sec (Encyclopaedia Britanica,Inc., 2019).



Figure (39)

(Time (60:120/sec))

In this section level of HC =205/ppmmvol which is accurate between the time of 60/sec to 73/sec, from 73/sec the driver decide to select the first gear which is creating the spike and increases HC to 595/ppmmvol, after this even the driver activates the stop and start technique which reduces the HC gradually to 215/ppmmvol between the time 75/sec to 120/sec as appears on the graph (Merkisz, et al., 2011).



Figure (40)

(Time (120:180/sec))

The previous figure shows HC the red line percentage which time start from 120/sec to 141/sec HC=100/ppmvol which show the engine is in stop and start technique and produces very low volume currently appears on the graph, from 141/sec the driver went back to running the engine and selects the first gear which it is impact is increases HC to 500/ppmvol which is in top yellow circle, from 145/sec the driver change again to stop and start technique which creates slop between the time of 145/sec to 150/sec, the red line the HC in decreased from 500/ppmvol to 220/ppmvol in time 180/sec which it appears at the end of the graph (Alexander, 1992).



Figure (41)

(Time (180:210/sec))

In this section the value of HC=220/ppmvol between the time 180/sec to 207/sec, the driver selects the first, second and third gear gradually which it impacts at HC is increased to 380/ppmvol which appears between the time 207/sec to 225/sec, then the driver decides to change to stop and start technique to finish the test which the actual finishing time is 220/sec but the red line stayed until 238/sec related to some delayed between the dyno software signals and oscilloscope BOSCH 850 receiver (Dinh, et al., 2107).

7.3 CO₂ with stop and start



Figure (42)

(Time (0:60/sec))

The maximum CO₂ in this test scale is 18% of total emission gases. In this section the driver starts the test plane with running stop and start technique which appears between the time zero/sec to 33/sec and CO₂=4.5/ppmvol which is low value in this section as the beginning of the test, then the driver change from stop and start by press the clutch to run the restarter again and selects the first gear which guide to increase CO₂ from 4.5/ppmvol to 13.3/ppmvol, this accurse between the time 33/sec to 50/sec. the driver follows the test plan and changes the engine to switch it off by using stop and start technique which drops CO₂ to 3.3/ppmvol between the time 50/sec to 60/sec which appears in the previous figure.



Figure (43)

(Time (60:120/sec))

the figure shows the driver selects the first gear start from time 60/sec and increases CO₂ percentage from 3/ppmvol to 14/ppmvol, this accurse between the time 60/sec to 88/sec and keeps CO₂ level to 122/sec, after that the driver decides to activate stop and start technique which starts to reduce CO₂ in this graph to 10.5/ppmvol at time of 120/sec.



Figure (44)

(Time (120:180/sec))

The previous graph shows CO₂ starts to decrease until achieved to 5/ppmvol from the time 120/sec to 140/sec, then the driver restarts the engine again and deactivate stop and start technique by selects the first, second and third gear which shown in the graph max CO₂ is 13.9/ppmvol between the time 150/sec to 180/sec.



Figure (45)

(Time (180:210/sec))

The figure shows the driver decides to downshift the gear from third to second and finally first between the time 180/sec to 216/sec which reduced CO₂ to 5/ppmvol, then the driver activates stop and start technique between the time 216/sec until the end of 230/sec last test time scale and CO₂ records 3/ppmvol.

7.4 Running test with stop-start

Table (4)

Ece1504 short stop start Lupo cyc 13					
5	km/h				Zero emission
6	at				Engine stop-start
7	a b c d e				Change performance
8	end				Direction end
9					
10	time	speed	toler	gear	event
11	0	00.0	2T	0	0
12	5	20.0			
13	END				
14					
15					
16	time	speed	toler	gear	event
17	0	00.0	2T		
18	6	00.0			
19	11	00.0		1	
20	15	15.0			
21	23	15.0		0	
22	25	10.0			
23	28	00.0			
24	end				
25					
26					
27	time	speed	toler	gear	event
28	0	00.0	2T		
29	16	00.0		1	
30	21	00.0		2	
31	26	15.0			
32	28	15.0		2	
33	33	32.0		0	
34	57	32.0			
35	65	10.0			
36	68	00.0			
37	end				
38					
39					
40	time	speed	toler	gear	event
41	0	00.0	2T	0	
42	16	00.0		1	
43	21	00.0		2	
44	26	15.0			
45	28	15.0		3	
46	37	35.0			
47	39	35.0		3	
48	47	50.0			
49	59	50.0		3	
50	67	35.0			
51	80	35.0		0	
52	82	35.0			
53	89	10.0			
54	92	00.0			
55	99	00.0			
56	end				
57					
58					
59	time	speed	toler	gear	event
60	0	00.0			
61	1	00.0			
62	end				
63					

The table above shows Ece 1504 stages stop and start applied on VW Lupo car cycle phases of stop and start function, the test is consists of 5 stages, during the stop and start applied the results showing in the table is time of each stage, vehicle speed during the test, the tolerance value between the vehicle and dyno test plan guide, the table shows also the selected gear number and finally the event happen if any changes it might accrue during the test periods.

Throughout the five stages of engine running rectangle named END which means the end of each stage, In this time it was in the past is the engine is idling but here while application stop and start system it will be Green rectangle as the table showing, the reason is the engine is totally not running. This experiment reviews how the stop and start reducing the emission to zero between each engine running periods (Dieselnet.com, 2019).

8. Calculation processes

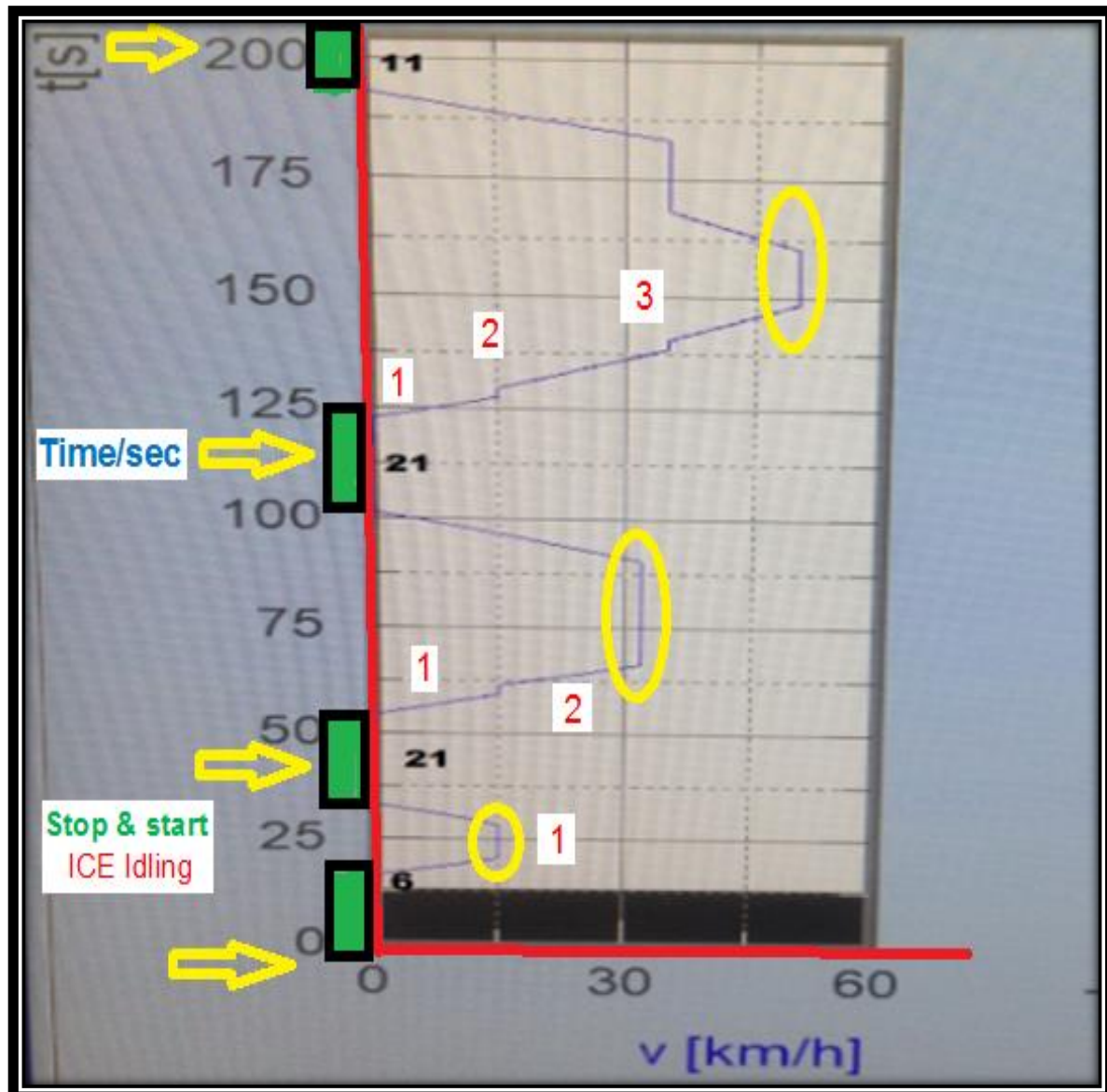


Figure (46)

The total engine functioning time is 210/sec as the BOSCH oscilloscope data acquisitions. But as on dyno software test cycle is 200 sec due to the warming up the engine also to keep the allowable tolerance between the engine revs and the test blue line guide, The total idling time is 59 sec which is also the time that the stop and start system will function though the test stages.

The green areas are when the stop and start system is applied and reduces the emissions to zero. At different speeds and transmission input, the highest gear selected is third gear and the maximum speed is 50kmh. The speed in the Ece1504 Dyno test cycle is in km/h which will need to be converted to m/s to calculate the required gases analysis processes (Merkisz, et al., 2011).

8.1 Gear multipliers

Table (5)

[illegible]

The table shows the first gear multiplier is that value 137 revolution per minute (rpm) when the engine starts to run and will decrease in second gear when it reaches 80 rpm and the third gear when it reaches 59 rpm. All of these values will be used as gear multiplier to find each rpm for each second when the driver decides to select any gear needed with specific speed during the stop and start test cycle (Zhao & Yu, 2018).

8.2 ICE Idling and stop start Data

Table (6)

	A	B	C	D	E	F	G	H
1	Time/sec	Speed/KMH	1 St Gear RPM	2nd Gear RPM	3rd Gear RPM	V/m/s	ICE Idling	Stop & start OPERATE
2	0	0	0	0	0	0.00	90	0
3	1	1	137	80	59	0.28	90	0
4	2	2	274	160	118	0.56	90	0
5	3	3	411	240	177	0.83	90	0
6	4	4	548	320	236	1.11	90	0
7	5	5	685	400	295	1.39	137	137
8	6	6	822	480	354	1.67	411	411
9	7	7	959	560	413	1.94	548	548
10	8	8	1096	640	472	2.22	822	822
11	9	9	1233	720	531	2.50	959	959
12	10	10	1370	800	590	2.78	1096	1096
13	11	11	1507	880	649	3.06	1370	1370
14	12	12	1644	960	708	3.33	1644	1644
15	13	13	1781	1040	767	3.61	1781	1781
16	14	14	1918	1120	826	3.89	1918	1918
17	15	15	2055	1200	885	4.17	2055	2055
18	16	16	2192	1280	944	4.44	2055	2055
19	17	17	2329	1360	1003	4.72	2055	2055
20	18	18	2466	1440	1062	5.00	2055	2055
21	19	19	2603	1520	1121	5.28	2055	2055
22	20	20	2740	1600	1180	5.56	2055	2055
23	21	21	2877	1680	1239	5.83	1918	1918
24	22	22	3014	1760	1298	6.11	1781	1781
25	23	23	3151	1840	1357	6.39	1644	1644
26	24	24	3288	1920	1416	6.67	1507	1507
27	25	25	3425	2000	1475	6.94	1370	1370
28	26	26	3562	2080	1534	7.22	1233	1233
29	27	27	3699	2160	1593	7.50	1096	1096
30	28	28	3836	2240	1652	7.78	959	959
31	29	29	3973	2320	1711	8.06	822	822
32	30	30	4110	2400	1770	8.33	685	685
33	31	31	4247	2480	1829	8.61	548	548
34	32	32	4384	2560	1888	8.89	411	411
35	33	33	4521	2640	1947	9.17	274	274
36	34	34	4658	2720	2006	9.44	137	137
37	35	35	4795	2800	2065	9.72	90	0
38	36	36	4932	2880	2124	10.00	90	0
39	37	37	5069	2960	2183	10.28	90	0
40	38	38	5206	3040	2242	10.56	90	0
41	39	39	5343	3120	2301	10.83	90	0
42	40	40	5480	3200	2360	11.11	90	0

The table above illustrates the time of the test, Speed / kmH, 1st gear RPM, 2nd gear RPM, 3rd gear RPM, transforms the speed from KMH to M/s divided by 3.6 which will produce Vm/s, ICE Idling or engine works without stop and start technology with fluctuations of rpm values up and down. Also, the figure shows ICE operates with stop and start technology and shows when the S&S operates the rpm become zero which the engine is stop to running totally (Zhang, 2015).

8.3 RPM calculation

Table (7)

	A	B	C	D	E	F
1	Time/sec	Speed/KMH	1St Gear RPM	2nd Gear RPM	3rd Gear RPM	V/m/s
2	0	0	=B2*X2	0	0	0.00
3	1	1	137	80	59	0.28
4	2	2	274	160	118	0.56
5	3	3	411	240	177	0.83
6	4	4	548	320	236	1.11
7	5	5	685	400	295	1.39
8	6	6	822	480	354	1.67
9	7	7	959	560	413	1.94
10	8	8	1096	640	472	2.22
11	9	9	1233	720	531	2.50

Ece1504 Dyno test cycle works with speed in KMH so in this case will calculate all the first, second and third RPM gears by using speed in KMH, also will calculate rpm for each gear by multiplying speed in each second times gear multiplier which in x2 spread sheet equal to=137 for first gear, second gear multiplier is 80 and third gear is 59 which are shows in the table (1) (Dieselnet.com, 2019).

Data Acquisition

Table (8)

	A	B	C	D	E	F	G	H
1	Time/sec	Speed/KMH	1 St Gear RPM	2nd Gear RPM	3rd Gear RPM	V/m/s	ICE Idling	Stop & start OPERATE
43	41	41	5617	3280	2419	11.39	90	0
44	42	42	5754	3360	2478	11.67	90	0
45	43	43	5891	3440	2537	11.94	90	0
46	44	44	6028	3520	2596	12.22	90	0
47	45	45	6165	3600	2655	12.50	90	0
48	46	46	6302	3680	2714	12.78	90	0
49	47	47	6439	3760	2773	13.06	90	0
50	48	48	6576	3840	2832	13.33	90	0
51	49	49	6713	3920	2891	13.61	90	0
52	50	50	6850	4000	2950	13.89	90	0
53	51	51	6987	4080	3009	14.17	90	0
54	52	52	7124	4160	3068	14.44	90	0
55	53	53	7261	4240	3127	14.72	90	0
56	54	54	7398	4320	3186	15.00	90	0
57	55	55	7535	4400	3245	15.28	137	137
58	56	56	7672	4480	3304	15.56	411	411
59	57	57	7809	4560	3363	15.83	685	685
60	58	58	7946	4640	3422	16.11	1096	1096
61	59	59	8083	4720	3481	16.39	1233	1233
62	60	60	8220	4800	3540	16.67	1781	1781
63	61	61	8357	4880	3599	16.94	2055	2055
64	62	62	8494	4960	3658	17.22	2055	2055
65	63	63	8631	5040	3717	17.50	2080	2080
66	64	64	8768	5120	3776	17.78	2160	2160
67	65	65	8905	5200	3835	18.06	2320	2320
68	66	66	9042	5280	3894	18.33	2480	2480
69	67	67	9179	5360	3953	18.61	2560	2560
70	68	68	9316	5440	4012	18.89	2640	2640
71	69	69	9453	5520	4071	19.17	2640	2640
72	70	70	9590	5600	4130	19.44	2640	2640
73	71	71	9727	5680	4189	19.72	2640	2640
74	72	72	9864	5760	4248	20.00	2640	2640
75	73	73	10001	5840	4307	20.28	2640	2640
76	74	74	10138	5920	4366	20.56	2640	2640
77	75	75	10275	6000	4425	20.83	2640	2640
78	76	76	10412	6080	4484	21.11	2640	2640
79	77	77	10549	6160	4543	21.39	2640	2640
80	78	78	10686	6240	4602	21.67	2640	2640
81	79	79	10823	6320	4661	21.94	2640	2640
82	80	80	10960	6400	4720	22.22	2640	2640
83	81	81	11097	6480	4779	22.50	2640	2640
84	82	82	11234	6560	4838	22.78	2560	2540
85	83	83	11371	6640	4897	23.06	2480	2480

The table shows in column G & H which the ICE internal combustion engine works without S&S (stop & start) which is ICE idling and column H which is stop and start

operations, as the numbers shows the differences during the ICE works with 90 rpm which is the engine is burning fuel and produce emissions just during it is idling and starts increases from first gear with 137 rpm and so on, comparing to stop and start operates, the ICE starts totally with zero RPM and zero emissions for first five seconds which the time on the Ece1504 Dyno test cycle at the figure(44).then repeats follows the test plane for other time. The total time 210 sec (Dariusz & Mian, 2013).

8.4 Stop and Start operates vs ICE

Table (9)

	A	B	C	D	E	F	G	H
1	Time/sec	Speed/KMH	1 St Gear RPM	2nd Gear RPM	3rd Gear RPM	V/m/s	ICE Idling	Stop & start OPERATE
85	84	84	11508	6720	4956	23.33	2400	2400
86	85	85	11645	6800	5015	23.61	2320	2320
87	86	86	11782	6880	5074	23.89	2240	2240
88	87	87	11919	6960	5133	24.17	2160	2160
89	88	88	12056	7040	5192	24.44	2080	2080
90	89	89	12193	7120	5251	24.72	2000	2000
91	90	90	12330	7200	5310	25.00	1920	1920
92	91	91	12467	7280	5369	25.28	1840	1840
93	92	92	12604	7360	5428	25.56	1760	1760
94	93	93	12741	7440	5487	25.83	1680	1680
95	94	94	12878	7520	5546	26.11	1507	1507
96	95	95	13015	7600	5605	26.39	1233	1233
97	96	96	13152	7680	5664	26.67	959	959
98	97	97	13289	7760	5723	26.94	685	685
99	98	98	13426	7840	5782	27.22	411	411
100	99	99	13563	7920	5841	27.50	274	274
101	100	100	13700	8000	5900	27.78	137	137
102	101	101	13837	8080	5959	28.06	90	0
103	102	102	13974	8160	6018	28.33	90	0
104	103	103	14111	8240	6077	28.61	90	0
105	104	104	14248	8320	6136	28.89	90	0
106	105	105	14385	8400	6195	29.17	90	0
107	106	106	14522	8480	6254	29.44	90	0
108	107	107	14659	8560	6313	29.72	90	0
109	108	108	14796	8640	6372	30.00	90	0
110	109	109	14933	8720	6431	30.28	90	0
111	110	110	15070	8800	6490	30.56	90	0
112	111	111	15207	8880	6549	30.83	90	0
113	112	112	15344	8960	6608	31.11	90	0
114	113	113	15481	9040	6667	31.39	90	0
115	114	114	15618	9120	6726	31.67	90	0
116	115	115	15755	9200	6785	31.94	90	0
117	116	116	15892	9280	6844	32.22	90	0
118	117	117	16029	9360	6903	32.50	90	0
119	118	118	16166	9440	6962	32.78	90	0
120	119	119	16303	9520	7021	33.06	90	0
121	120	120	16440	9600	7080	33.33	90	0
122	121	121	16577	9680	7139	33.61	90	0
123	122	122	16714	9760	7198	33.89	90	0
124	123	123	16851	9840	7257	34.17	90	0
125	124	124	16988	9920	7316	34.44	137	137
126	125	125	17125	10000	7375	34.72	411	411

S&S operates from first test as the table above shows the stop and starts when it is works will be zero RPM because in not working. However, when ICE is functioning it will produce the same rpm when the engine works without Stop and Start as the 84 sec roll shows, when the engine works without stop and start will make 2400 rpm the value of ICE idling this appears in the first roll (Midgley, et al., 2013).

Stop and start Data Acquisition

Table (10)

1	Time/sec	Speed/KMH	1 St Gear RPM	2nd Gear RPM	3rd Gear RPM	V/m/s	ICE Idling	Stop & start OPERATE
128	127	127	17399	10160	7493	35.28	1233	1233
129	128	128	17536	10240	7552	35.56	1507	1507
130	129	129	17673	10320	7611	35.83	1918	1918
131	130	130	17810	10400	7670	36.11	2055	2055
132	131	131	17947	10480	7729	36.39	2080	2080
133	132	132	18084	10560	7788	36.67	2160	2160
134	133	133	18221	10640	7847	36.94	2240	2240
135	134	134	18358	10720	7906	37.22	2320	2320
136	135	135	18495	10800	7965	37.50	2400	2400
137	136	136	18632	10880	8024	37.78	2480	2480
138	137	137	18769	10960	8083	38.06	2560	2560
139	138	138	18906	11040	8142	38.33	2640	2640
140	139	139	19043	11120	8201	38.61	2655	2655
141	140	140	19180	11200	8260	38.89	2714	2714
142	141	141	19317	11280	8319	39.17	2773	2773
143	142	142	19454	11360	8378	39.44	2832	2832
144	143	143	19591	11440	8437	39.72	2891	2891
145	144	144	19728	11520	8496	40.00	2950	2950
146	145	145	19865	11600	8555	40.28	3009	3009
147	146	146	20002	11680	8614	40.56	3068	3068
148	147	147	20139	11760	8673	40.83	3127	3127
149	148	148	20276	11840	8732	41.11	3127	3127
150	149	149	20413	11920	8791	41.39	3127	3127
151	150	150	20550	12000	8850	41.67	3127	3127
152	151	151	20687	12080	8909	41.94	3127	3127
153	152	152	20824	12160	8968	42.22	3127	3127
154	153	153	20961	12240	9027	42.50	3127	3127
155	154	154	21098	12320	9086	42.78	3127	3127
156	155	155	21235	12400	9145	43.06	2655	2655
157	156	156	21372	12480	9204	43.33	2596	2596
158	157	157	21509	12560	9263	43.61	2537	2537
159	158	158	21646	12640	9322	43.89	2478	2478
160	159	159	21783	12720	9381	44.17	2419	2419
161	160	160	21920	12800	9440	44.44	2301	2301
162	161	161	22057	12880	9499	44.72	2242	2242
163	162	162	22194	12960	9558	45.00	2183	2183
164	163	163	22331	13040	9617	45.28	2124	2124
165	164	164	22468	13120	9676	45.56	2065	2065
166	165	165	22605	13200	9735	45.83	2006	2006
167	166	166	22742	13280	9794	46.11	1947	1947
168	167	167	22879	13360	9853	46.39	1888	1888
169	168	168	23016	13440	9912	46.67	1829	1829

This schedule shows continuous data for ICE idling and S&S operates both sides the engine is works from 127 sec to 168 sec of journey time (Dieselnet.com, 2019).

Data Acquisition

Table (11)

Time/sec	Speed/KMH	1 St Gear RPM	2nd Gear RPM	3rd Gear RPM	V/m/s	ICE Idling	Stop & start OPERATE
169	169	23153	13520	9971	46.94	1770	1770
170	170	23290	13600	10030	47.22	1770	1770
171	171	23427	13680	10089	47.50	1770	1770
172	172	23564	13760	10148	47.78	1770	1770
173	173	23701	13840	10207	48.06	1770	1770
174	174	23838	13920	10266	48.33	1770	1770
175	175	23975	14000	10325	48.61	1770	1770
176	176	24112	14080	10384	48.89	1770	1770
177	177	24249	14160	10443	49.17	1770	1770
178	178	24386	14240	10502	49.44	1644	1644
179	179	24523	14320	10561	49.72	1507	1507
180	180	24660	14400	10620	50.00	1370	1370
181	181	24797	14480	10679	50.28	1233	1233
182	182	24934	14560	10738	50.56	1096	1096
183	183	25071	14640	10797	50.83	959	959
184	184	25208	14720	10856	51.11	822	822
185	185	25345	14800	10915	51.39	685	685
186	186	25482	14880	10974	51.67	548	548
187	187	25619	14960	11033	51.94	411	411
188	188	25756	15040	11092	52.22	274	274
189	189	25893	15120	11151	52.50	137	137
190	190	26030	15200	11210	52.78	90	0
191	191	26167	15280	11269	53.06	90	0
192	192	26304	15360	11328	53.33	90	0
193	193	26441	15440	11387	53.61	90	0
194	194	26578	15520	11446	53.89	90	0
195	195	26715	15600	11505	54.17	90	0
196	196	26852	15680	11564	54.44	90	0
197	197	26989	15760	11623	54.72	90	0
198	198	27126	15840	11682	55.00	90	0
199	199	27263	15920	11741	55.28	90	0
200	200	27400	16000	11800	55.56	90	0
201	201	27537	16080	11859	55.83	90	0
202	202	27674	16160	11918	56.11	90	0
203	203	27811	16240	11977	56.39	90	0
204	204	27948	16320	12036	56.67	90	0
205	205	28085	16400	12095	56.94	90	0
206	206	28222	16480	12154	57.22	90	0
207	207	28359	16560	12213	57.50	90	0
208	208	28496	16640	12272	57.78	90	0
209	209	28633	16720	12331	58.06	90	0
210	2010	275370	160800	118590	558.33	90	0

The table shows the cycle test time from 169 sec to 210 sec which is the end of the test. However, in 189 sec the driver decide to operate S&S which will be zero RPM from 189 sec to 210 which is appears in the table (Dieselnet.com, 2019).

8.5 ICE running without stop and Start

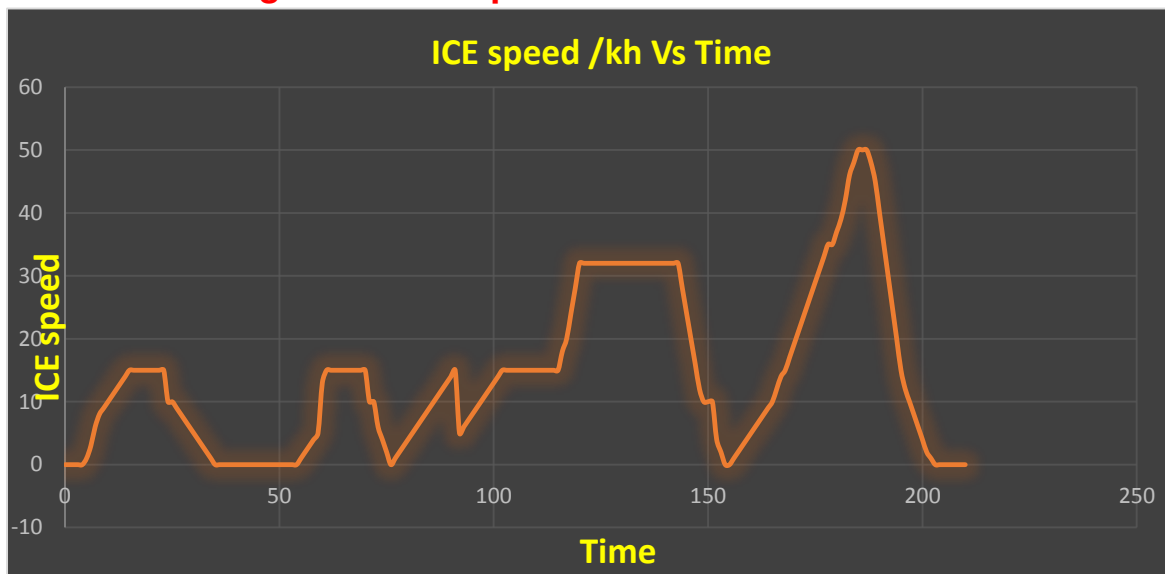


Figure (47)

This figure shows the ICE running from zero to 210 sec and between them there is a fluctuation in the speed, due to the Ece1504 Dyno test cycle. This cycle causes some increases and decreases of the speed as the figures illustrate.

Summative CO, HC and CO₂ data

Table (12)

	I	J	K	L	M	N	O
1	ICE speed /kh	CO WITHOUT S&S	Summative CO without S&S	Summative HC without S&S	HC WITHOUT S&S	CO ₂ WITHOUT S&S	Summative Co ₂ without S&S
2	0	0.1	0.1	2	2	1	1
3	0	0.1	0.2	6	4	2	3
4	0	0.1	0.3	14	8	3	6
5	0	0.1	0.4	24	10	4	10
6	0	0.1	0.5	44	20	5	15
7	1	0.1	0.6	74	30	6	21
8	3	0.2	0.8	114	40	7	28
9	6	0.2	1	164	50	8	36
10	8	0.2	1.2	224	60	10	46
11	9	0.2	1.4	294	70	12	58
12	10	0.3	1.7	374	80	12.5	70.5
13	11	0.3	2	464	90	12.5	83
14	12	0.3	2.3	564	100	12.5	95.5
15	13	0.3	2.6	684	120	12.5	108
16	14	0.3	2.9	824	140	12.5	120.5
17	15	0.4	3.3	984	160	12.5	133
18	15	0.4	3.7	1164	180	12.5	145.5
19	15	0.4	4.1	1364	200	12.5	158
20	15	0.4	4.5	1584	220	12.5	170.5
21	15	0.4	4.9	1824	240	12.5	183
22	15	0.4	5.3	2084	260	12.5	195.5
23	15	0.4	5.7	2364	280	12.5	208
24	15	0.4	6.1	2664	300	12.5	220.5
25	15	0.4	6.5	2964	300	12.5	233
26	10	0.4	6.9	3264	300	12.5	245.5
27	10	0.4	7.3	3584	320	12.5	258
28	9	0.4	7.7	3904	320	12.5	270.5
29	8	0.4	8.1	4224	320	12.5	283
30	7	0.4	8.5	4544	320	12	295
31	6	0.4	8.9	4864	320	12	307
32	5	0.5	9.4	5184	320	12	319
33	4	0.6	10	5504	320	11.9	330.9
34	3	0.7	10.7	5824	320	12	342.9
35	2	0.8	11.5	6144	320	12	354.9
36	1	0.9	12.4	6424	280	12	366.9
37	0	1	13.4	6704	280	12	378.9
38	0	0.9	14.3	6974	270	12	390.9
39	0	0.9	15.2	7224	250	12	402.9
40	0	0.7	15.9	7464	240	12	414.9
41	0	0.5	16.4	7704	240	12	426.9
42	0	0.4	16.8	7944	240	12	438.9

The table above shows the ICE speed in KMH, which is used in Ece1504 Dyno test cycle. The data which comes from this cycle will be transferred automatically to the

BOSCH Oscilloscope which we used here to calculate CO gas emission when the ICE works with stop and start technology and other algorithms will calculate the summative of CO. Summative of HC without S&S which is total summative of HC from the beginning of HC values without S&S, The same for the CO₂ gas will conclude the values of CO₂ without S&S as in the column N&O (National Automotive Parts Association, 2019).

Data Acquisition

Table (13)

1	ICE speed /kh	CO WITHOUT S&S	Summative CO without S&S	Summative HC without S&S	HC WITHOUT S&S	CO ₂ WITHOUT S&S	Summative Co ₂ without S&S
43	0	0.4	17.2	8184	240	12.4	451.3
44	0	0.4	17.6	8414	230	12.4	463.7
45	0	0.4	18	8644	230	12.4	476.1
46	0	0.4	18.4	8884	240	12.4	488.5
47	0	0.7	19.1	9134	250	12.4	500.9
48	0	0.9	20	9404	270	12.4	513.3
49	0	0.9	20.9	9684	280	12.4	525.7
50	0	0.7	21.6	9984	300	12.4	538.1
51	0	0.5	22.1	10284	300	12.4	550.5
52	0	0.4	22.5	10584	300	12.4	562.9
53	0	0.4	22.9	10884	300	12.4	575.3
54	0	0.4	23.3	11184	300	12.4	587.7
55	0	0.4	23.7	11484	300	12.4	600.1
56	0	0.4	24.1	11784	300	12.4	612.5
57	1	0.4	24.5	12084	300	12.4	624.9
58	2	0.4	24.9	12384	300	12.4	637.3
59	3	0.4	25.3	12684	300	12.4	649.7
60	4	0.4	25.7	12984	300	12.4	662.1
61	5	0.4	26.1	13284	300	12.4	674.5
62	13	0.4	26.5	13584	300	12.4	686.9
63	15	0.4	26.9	13884	300	12.5	699.4
64	15	0.5	27.4	14184	300	12.5	711.9
65	15	0.6	28	14484	300	12.5	724.4
66	15	0.7	28.7	14784	300	12.5	736.9
67	15	0.7	29.4	15084	300	12.5	749.4
68	15	0.5	29.9	15384	300	12.5	761.9
69	15	0.4	30.3	15684	300	12.5	774.4
70	15	0.5	30.8	15984	300	12.5	786.9
71	15	0.6	31.4	16284	300	12.5	799.4
72	10	0.6	32	16584	300	12.6	812
73	10	0.6	32.6	16884	300	12.7	824.7
74	6	0.6	33.2	17184	300	12.9	837.6
75	4	0.6	33.8	17484	300	12.9	850.5
76	2	0.6	34.4	17784	300	13	863.5
77	0	0.7	35.1	18074	290	13.3	876.8
78	1	0.7	35.8	18354	280	13.3	890.1
79	2	0.6	36.4	18624	270	13.4	903.5
80	3	0.5	36.9	18874	250	13.4	916.9
81	4	0.4	37.3	19124	250	13.4	930.3
82	5	0.5	37.8	19374	250	13.5	943.8
83	6	0.6	38.4	19624	250	13.5	957.3
84	7	0.6	39	19874	250	13.5	970.8

The Table shows the continuous data for summative HC & CO₂ without stop and start functioning (Encyclopaedia Britannica, Inc., 2019).

Data Acquisition

Table (14)

1	ICE speed /kh	CO WITHOUT S&S	Summative CO without S&S	Summative HC without S&S	HC WITHOUT S&S	CO2WITHOUT S&S	Summative Co2 without S&S
85	8	0.6	39.6	20124	250	13.5	984.3
86	9	0.6	40.2	20374	250	13.5	997.8
87	10	0.5	40.7	20624	250	13.5	1011.3
88	11	0.5	41.2	20874	250	13.5	1024.8
89	12	0.5	41.7	21124	250	13.5	1038.3
90	13	0.5	42.2	21374	250	13.5	1051.8
91	14	0.5	42.7	21624	250	13.5	1065.3
92	15	0.5	43.2	21874	250	13.5	1078.8
93	5	0.5	43.7	22124	250	13.5	1092.3
94	6	0.5	44.2	22374	250	13.5	1105.8
95	7	0.5	44.7	22614	240	13.5	1119.3
96	8	0.5	45.2	22854	240	13.5	1132.8
97	9	0.5	45.7	23094	240	13.4	1146.2
98	10	0.5	46.2	23334	240	13.3	1159.5
99	11	0.5	46.7	23574	240	13.2	1172.7
100	12	0.5	47.2	23814	240	13.1	1185.8
101	13	0.6	47.8	24054	240	13.1	1198.9
102	14	0.6	48.4	24294	240	13	1211.9
103	15	0.6	49	24494	200	12.9	1224.8
104	15	0.6	49.6	24694	200	12.7	1237.5
105	15	0.5	50.1	24894	200	12.5	1250
106	15	0.4	50.5	25104	210	12.4	1262.4
107	15	0.3	50.8	25314	210	12.3	1274.7
108	15	0.4	51.2	25534	220	11.5	1286.2
109	15	0.6	51.8	25754	220	11.7	1297.9
110	15	0.7	52.5	25974	220	12	1309.9
111	15	0.8	53.3	26204	230	12	1321.9
112	15	0.8	54.1	26444	240	12	1333.9
113	15	0.8	54.9	26684	240	12	1345.9
114	15	0.8	55.7	26924	240	12.1	1358
115	15	0.7	56.4	27174	250	12.1	1370.1
116	15	0.6	57	27424	250	12.2	1382.3
117	18	0.5	57.5	27684	260	12.3	1394.6
118	20	0.4	57.9	27964	280	12.3	1406.9
119	24	0.3	58.2	28254	290	12.3	1419.2
120	28	0.3	58.5	28554	300	12.3	1431.5
121	32	0.3	58.8	28854	300	12.4	1443.9
122	32	0.3	59.1	29154	300	12.4	1456.3
123	32	0.3	59.4	29454	300	12.4	1468.7
124	32	0.3	59.7	29754	300	12.4	1481.1
125	32	0.3	60	30054	300	12.4	1493.5
126	32	0.3	60.3	30354	300	12.4	1505.9

The data acquisition of HC and CO₂ without running stop and start from the time 85 sec to 126 sec (Dieselnet.com, 2019).

Data Acquisition

Table (15)

1	ICE speed /kh	CO WITHOUT S&S	Summative CO without S&S	Summative HC without S&S	HC WITHOUT S&S	CO2WITHOUT S&S	Summative Co2 without S&S
127	32	0.3	60.6	30654	300	12.4	1518.3
128	32	0.3	60.9	30954	300	12.4	1530.7
129	32	0.3	61.2	31254	300	12.4	1543.1
130	32	0.3	61.5	31554	300	12.4	1555.5
131	32	0.3	61.8	31854	300	12.4	1567.9
132	32	0.3	62.1	32154	300	12.4	1580.3
133	32	0.3	62.4	32454	300	12.4	1592.7
134	32	0.4	62.8	32774	320	12.4	1605.1
135	32	0.5	63.3	33114	340	12.4	1617.5
136	32	0.4	63.7	33464	350	12.4	1629.9
137	32	0.4	64.1	33814	350	12.6	1642.5
138	32	0.4	64.5	34184	370	12.7	1655.2
139	32	0.5	65	34534	350	12.8	1668
140	32	0.7	65.7	34874	340	12.9	1680.9
141	32	0.7	66.4	35184	310	13	1693.9
142	32	0.6	67	35484	300	13	1706.9
143	32	0.6	67.6	35784	300	13	1719.9
144	32	0.6	68.2	36084	300	13.1	1733
145	28	0.6	68.8	36384	300	13.1	1746.1
146	24	0.7	69.5	36684	300	13.1	1759.2
147	20	0.7	70.2	36964	280	13.1	1772.3
148	16	0.6	70.8	37224	260	13.1	1785.4
149	12	0.6	71.4	37474	250	13.1	1798.5
150	10	0.6	72	37714	240	13.1	1811.6
151	10	0.6	72.6	37954	240	13	1824.6
152	10	0.5	73.1	38204	250	13.3	1837.9
153	4	0.4	73.5	38454	250	13.3	1851.2
154	2	0.3	73.8	38704	250	13.3	1864.5
155	0	0.4	74.2	38954	250	13.3	1877.8
156	0	0.4	74.6	39204	250	13.3	1891.1
157	1	0.4	75	39454	250	13.6	1904.7
158	2	0.4	75.4	39704	250	13.7	1918.4
159	3	0.4	75.8	39964	260	13.9	1932.3
160	4	0.6	76.4	40224	260	13.9	1946.2
161	5	0.6	77	40484	260	13.9	1960.1
162	6	0.6	77.6	40754	270	13.9	1974
163	7	0.5	78.1	41024	270	13.9	1987.9
164	8	0.5	78.6	41294	270	13.9	2001.8
165	9	0.5	79.1	41564	270	13.9	2015.7
166	10	0.5	79.6	41814	250	13.9	2029.6
167	12	0.5	80.1	42054	240	13.9	2043.5
168	14	0.5	80.6	42274	220	13.9	2057.4

The table shows the data of summative of CO without running stop and start technology, Also show summative HC and CO₂ without functioning stop and start from time 127 sec to 168 sec (SAE, 2017).

Data Acquisition

Table (16)

1	ICE speed /kh	CO WITHOUT S&S	Summative CO without S&S	Summative HC without S&S	HC WITHOUT S&S	CO ₂ WITHOUT S&S	Summative Co ₂ without S&S
169	15	0.5	81.1	42484	210	13.9	2071.3
170	17	0.5	81.6	42694	210	13.9	2085.2
171	19	0.5	82.1	42904	210	13.9	2099.1
172	21	0.5	82.6	43114	210	13.8	2112.9
173	23	0.5	83.1	43329	215	13.8	2126.7
174	25	0.5	83.6	43544	215	13.8	2140.5
175	27	0.5	84.1	43759	215	13.8	2154.3
176	29	0.5	84.6	43974	215	13.8	2168.1
177	31	0.4	85	44189	215	13.8	2181.9
178	33	0.6	85.6	44404	215	13.8	2195.7
179	35	0.6	86.2	44619	215	13.6	2209.3
180	35	0.6	86.8	44834	215	13.1	2222.4
181	37	0.6	87.4	45049	215	13	2235.4
182	39	0.6	88	45259	210	12.9	2248.3
183	42	0.6	88.6	45469	210	12.9	2261.2
184	46	0.6	89.2	45689	220	12.9	2274.1
185	48	0.6	89.8	45908	220	12.9	2287
186	50	0.6	90.4	46129	220	12.9	2299.9
187	50	0.6	91	46349	220	12.9	2312.8
188	50	0.6	91.6	46574	225	12.9	2325.7
189	48	0.6	92.2	46799	225	12.9	2338.6
190	45	0.6	92.8	47024	225	12.9	2351.5
191	40	0.6	93.4	47249	225	12.9	2364.4
192	35	0.6	94	47474	225	12.9	2377.3
193	30	0.6	94.6	47699	225	12.9	2390.2
194	25	0.6	95.2	47924	225	11.9	2402.1
195	20	0.6	95.8	48194	270	10.9	2413
196	15	0.6	96.4	48494	300	9.8	2422.8
197	12	0.8	97.2	48844	350	9.1	2431.9
198	10	1	98.2	49194	350	9	2440.9
199	8	1.2	99.4	49544	350	9.7	2450.6
200	6	1.4	100.8	49894	350	10.9	2461.5
201	4	1.6	102.4	50264	370	11	2472.5
202	2	1.6	104	50664	400	11.1	2483.6
203	1	1.6	105.6	51104	440	11.2	2494.8
204	0	1.6	107.2	51574	470	11.3	2506.1
205	0	1.2	108.4	52054	480	11.4	2517.5
206	0	1.2	109.6	52534	480	11.5	2529
207	0	1	110.6	52994	460	11.6	2540.6
208	0	0.8	111.4	53454	460	11.7	2552.3
209	0	0.6	112	53884	430	11.8	2564.1
210	0	0.6	112.6	54244	360	11.9	2576
211	0	0.4	113	54594	350	12	2588
212		113	10558.8	5350970	54594	2588	265928.8

The table shows the data of summative of CO without running stop and start technology. It also shows summative HC and CO₂ without functioning stop and start from time 169 sec to 211 which is 210 due to large table which we cannot see the original time in lift side. Here there is an important piece of data which is the calculation of the CO without stop and start and the summative of CO, Also for HC and CO₂ (Goodall, 2007).

Total Data Acquisitions of:

Total CO without S&S = 133 ppmvol, CO summative without S&S = 10558.8ppmvol.

HC without S&S = 54594ppmvol, summative HC without S&S = 5350970ppmvol.

CO₂ without S&S = 2588ppmvol, summative CO₂ without S&S = 265928.8ppmvol.

Data Acquisition

Table (17)

P	Q	R	S	T	U
CO WITH S&S	summative CO with S&S	Summative HC with S&S	HC WITH S&S	CO2WITH S&S	Summative CO2 with S&S
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0.1	0.1	2	2	1	1
0.2	0.3	10	8	4	5
0.2	0.5	25	15	7	12
0.2	0.7	55	30	9	21
0.2	0.9	125	70	11	32
0.3	1.2	205	80	12	44
0.3	1.5	295	90	12.5	56.5
0.3	1.8	395	100	12.5	69
0.3	2.1	515	120	12.5	81.5
0.3	2.4	655	140	12.5	94
0.4	2.8	835	180	12.5	106.5
0.4	3.2	1015	180	12.5	119
0.4	3.6	1225	210	12.5	131.5
0.4	4	1445	220	12.5	144
0.4	4.4	1685	240	12.5	156.5
0.4	4.8	1945	260	12.5	169
0.4	5.2	2225	280	12.5	181.5
0.4	5.6	2525	300	12.5	194
0.4	6	2825	300	12.5	206.5
0.4	6.4	3145	320	12.5	219
0.4	6.8	3465	320	12.5	231.5
0.4	7.2	3785	320	12.5	244
0.4	7.6	4105	320	12.5	256.5
0.4	8	4425	320	12	268.5
0.4	8.4	4745	320	12	280.5
0.5	8.9	5065	320	12	292.5
0.6	9.5	5385	320	11.9	304.4
0.7	10.2	5705	320	12	316.4
0.8	11	6025	320	12	328.4
0.9	11.9	6305	280	12	340.4
0	11.9	6305	0	0	340.4
0	11.9	6305	0	0	340.4
0	11.9	6305	0	0	340.4
0	11.9	6305	0	0	340.4
0	11.9	6305	0	0	340.4
0	11.9	6305	0	0	340.4

The table shows ICE works with stop and start system which appears at all the areas with zero values on the above table, also shows the summative all gases such as CO, HC and CO₂ (Industrial Scientific, 2019).

Data Acquisition

Table (18)

CO WITH S&S	summative CO with S&S	Summative HC with S&S	HC WITH S&S	CO2WITH S&S	Summative CO2 with S&S
0	11.9	6305	0	0	340.4
0	11.9	6305	0	0	340.4
0	11.9	6305	0	0	340.4
0	11.9	6305	0	0	340.4
0	11.9	6305	0	0	340.4
0	11.9	6305	0	0	340.4
0	11.9	6305	0	0	340.4
0	11.9	6305	0	0	340.4
0	11.9	6305	0	0	340.4
0	11.9	6305	0	0	340.4
0	11.9	6305	0	0	340.4
0	11.9	6305	0	0	340.4
0	11.9	6305	0	0	340.4
0	11.9	6305	0	0	340.4
0.1	12	6315	10	1	341.4
0.2	12.2	6335	20	4	345.4
0.3	12.5	6375	40	6	351.4
0.4	12.9	6455	80	9	360.4
0.4	13.3	6575	120	11	371.4
0.4	13.7	6755	180	12	383.4
0.4	14.1	6975	220	12.5	395.9
0.5	14.6	7235	260	12.5	408.4
0.6	15.2	7525	290	12.5	420.9
0.7	15.9	7825	300	12.5	433.4
0.7	16.6	8125	300	12.5	445.9
0.5	17.1	8425	300	12.5	458.4
0.4	17.5	8725	300	12.5	470.9
0.5	18	9025	300	12.5	483.4
0.6	18.6	9325	300	12.5	495.9
0.6	19.2	9625	300	12.6	508.5
0.6	19.8	9925	300	12.7	521.2
0.6	20.4	10225	300	12.9	534.1
0.6	21	10525	300	12.9	547
0.6	21.6	10825	300	13	560
0.7	22.3	11115	290	13.3	573.3
0.7	23	11395	280	13.3	586.6
0.6	23.6	11665	270	13.4	600
0.5	24.1	11915	250	13.4	613.4
0.4	24.5	12165	250	13.4	626.8
0.5	25	12415	250	13.5	640.3
0.6	25.6	12665	250	13.5	653.8
0.6	26.2	12915	250	13.5	667.3

The table shows the continues data of CO, HC and CO₂ functioning with stop and start technology, Also the summative gases works with stop and start such as CO, HC and CO₂ (D.HALADERMAN, 2016).

Data Acquisition

Table (19)

CO WITH S&S	summative CO with S&S	Summative HC with S&S	HC WITH S&S	CO2WITH S&S	Summative CO2 with S&S
0.6	26.8	13165	250	13.5	680.8
0.6	27.4	13415	250	13.5	694.3
0.5	27.9	13665	250	13.5	707.8
0.5	28.4	13915	250	13.5	721.3
0.5	28.9	14165	250	13.5	734.8
0.5	29.4	14415	250	13.5	748.3
0.5	29.9	14665	250	13.5	761.8
0.5	30.4	14915	250	13.5	775.3
0.5	30.9	15165	250	13.5	788.8
0.5	31.4	15415	250	13.5	802.3
0.5	31.9	15655	240	13.5	815.8
0.5	32.4	15895	240	13.5	829.3
0.5	32.9	16135	240	13.4	842.7
0.5	33.4	16375	240	13.3	856
0.5	33.9	16615	240	13.2	869.2
0.5	34.4	16855	240	13.1	882.3
0.6	35	17095	240	13	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0	35	17095	0	0	895.3
0.2	35.2	17105	10	1	896.3
0.3	35.5	17125	20	5	901.3

The table above shows the continuous data of CO, HC and CO₂ functioning with stop and start technology. The important point when the engine under influences of stop and start the summative calculation keeps the last value before the engine back to function without stop and start which running normally for example CO summative with stop and start 34.4 ppmvol and keeps in 35 ppmvol when the engine has stopped and is not working, this occurs in summative of HC and CO₂ (SAE, 2013).

9. Total summative HC over whole journey

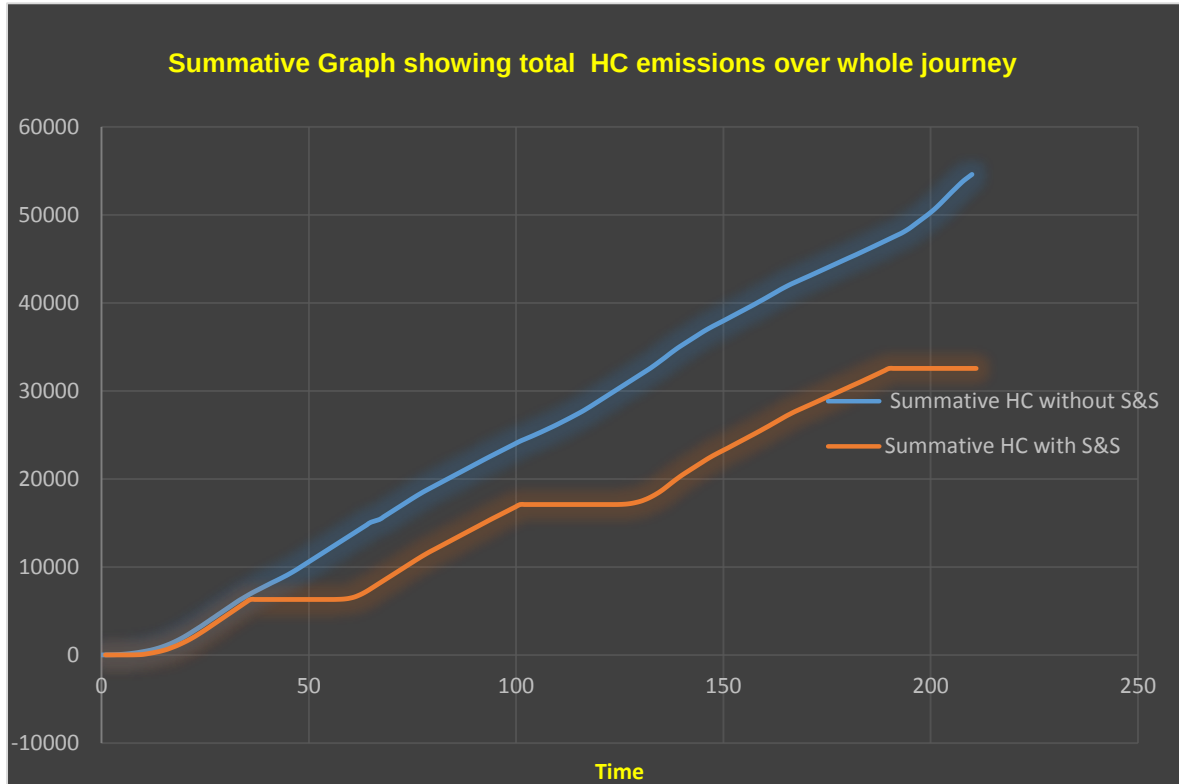


Figure (48)

The figure shows the blue line which is summative of HC emission and comes from the engine functioning without stop and start system and the orange colour is ICE works with stop and start system. The huge difference between each other's shows the stop and start technology is reducing the HC effectively which shows the difference values is about 1920093 ppmvol which comes from this calculation.

The difference of HC over whole journey= summative HC without S&S – summative HC with S&S.

The difference of HC over whole journey =5350970 -3430877 =1920093 ppmvol.

The difference is encouraging the manufactures to fit the stop and start technology which is useful to save the fuel and economy also friendly with the environment.

Note/ some delay it might be happens between the Ece1504 Dyno test cycle and BOSCH oscilloscope device writer which as an engineer's knows this fact (SAE, 2007).

9.1 Total HC values over whole the journey

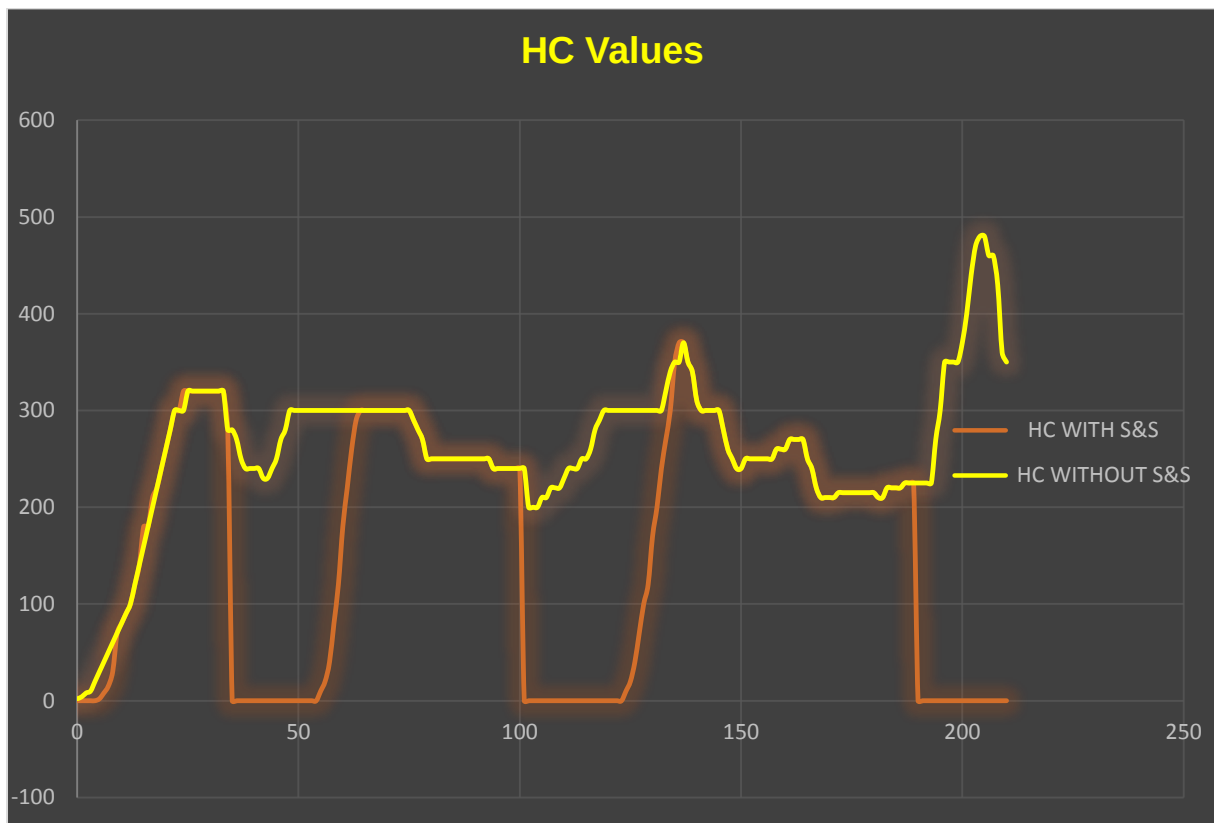


Figure (49)

As the figure shows HC hydrocarbons values when it is applying stop and start and without so will going towards the calculation operations first.

The difference of total values of HC over whole journey= HC without S&S – HC with S&S.

The difference of total values of HC over whole journey= 54594 – 32565 = 22029ppmvol.

The difference is good number showing the difference between the yellow line of HC without S&S and the orange line of HC with S&S technique. Look at the areas when the stop and start functioning reducing too much HC at four stages of the Ece1504 Dyno test cycle plan (Dinh, et al., 2107).

Data Acquisition

Table (20)

CO WITH S&S	summative CO with S&S	Summative HC with S&S	HC WITH S&S	CO2WITH S&S	Summative CO2 with S&S
0.3	36.1	17235	70	12	923.3
0.3	36.4	17335	100	12.4	935.7
0.3	36.7	17455	120	12.4	948.1
0.3	37	17625	170	12.4	960.5
0.3	37.3	17825	200	12.4	972.9
0.3	37.6	18065	240	12.4	985.3
0.4	38	18335	270	12.4	997.7
0.5	38.5	18635	300	12.4	1010.1
0.4	38.9	18985	350	12.4	1022.5
0.4	39.3	19355	370	12.6	1035.1
0.4	39.7	19725	370	12.7	1047.8
0.5	40.2	20075	350	12.8	1060.6
0.7	40.9	20415	340	12.9	1073.5
0.7	41.6	20725	310	13	1086.5
0.6	42.2	21025	300	13	1099.5
0.6	42.8	21325	300	13	1112.5
0.6	43.4	21625	300	13.1	1125.6
0.6	44	21925	300	13.1	1138.7
0.7	44.7	22225	300	13.1	1151.8
0.7	45.4	22505	280	13.1	1164.9
0.6	46	22765	260	13.1	1178
0.6	46.6	23015	250	13.1	1191.1
0.6	47.2	23255	240	13.1	1204.2
0.6	47.8	23495	240	13	1217.2
0.5	48.3	23745	250	13.3	1230.5
0.4	48.7	23995	250	13.3	1243.8
0.3	49	24245	250	13.3	1257.1
0.4	49.4	24495	250	13.3	1270.4
0.4	49.8	24745	250	13.3	1283.7
0.4	50.2	24995	250	13.6	1297.3
0.4	50.6	25245	250	13.7	1311
0.4	51	25505	260	13.9	1324.9
0.6	51.6	25765	260	13.9	1338.8
0.6	52.2	26025	260	13.9	1352.7
0.6	52.8	26295	270	13.9	1366.6
0.5	53.3	26565	270	13.9	1380.5
0.5	53.8	26835	270	13.9	1394.4
0.5	54.3	27105	270	13.9	1408.3
0.5	54.8	27355	250	13.9	1422.2
0.5	55.3	27595	240	13.9	1436.1
0.5	55.8	27815	220	13.9	1450
0.5	56.3	28025	210	13.9	1463.9

This table shows the CO gas values and it is summative which comes from stop and start functioning, Also the HC values and summative with stop and start functioning, CO₂ values and it is summative over whole journey (Dupont, 2000).

9.2 Total summative CO₂ over whole journey

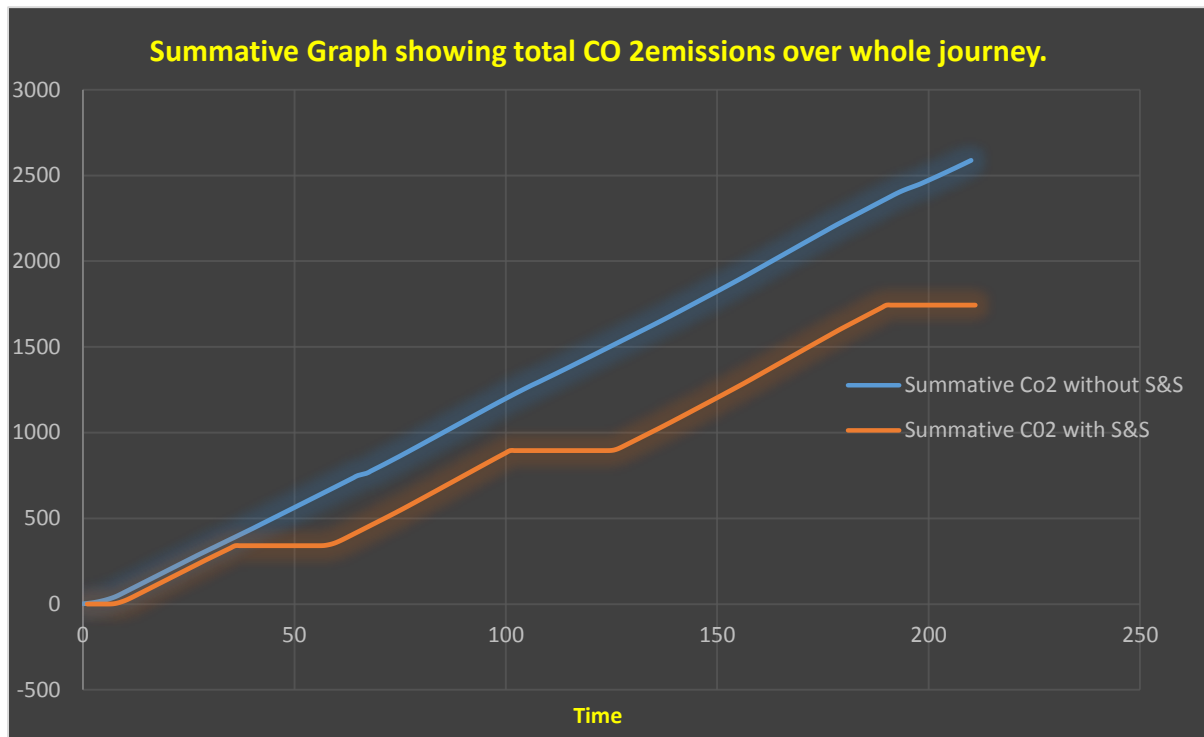


Figure (50)

The figure above shows the summative of CO₂ emissions over the whole journey by applying stop and start system and without stop and start. So the calculation to find the difference between using stop and start also to determine the benefits of applying this system in industry.

Difference of summative of CO₂ over whole journey= CO₂ without S&S – CO₂ with S&S.

Difference of total values of CO₂ over whole journey= 265928.8 – 182596.9 = 83331.9 ppmvol.

This value is working well if all the manufacturers using the stop and start technology for creating advanced engine (Saddington, 2014).

9.3 Total CO₂ Values

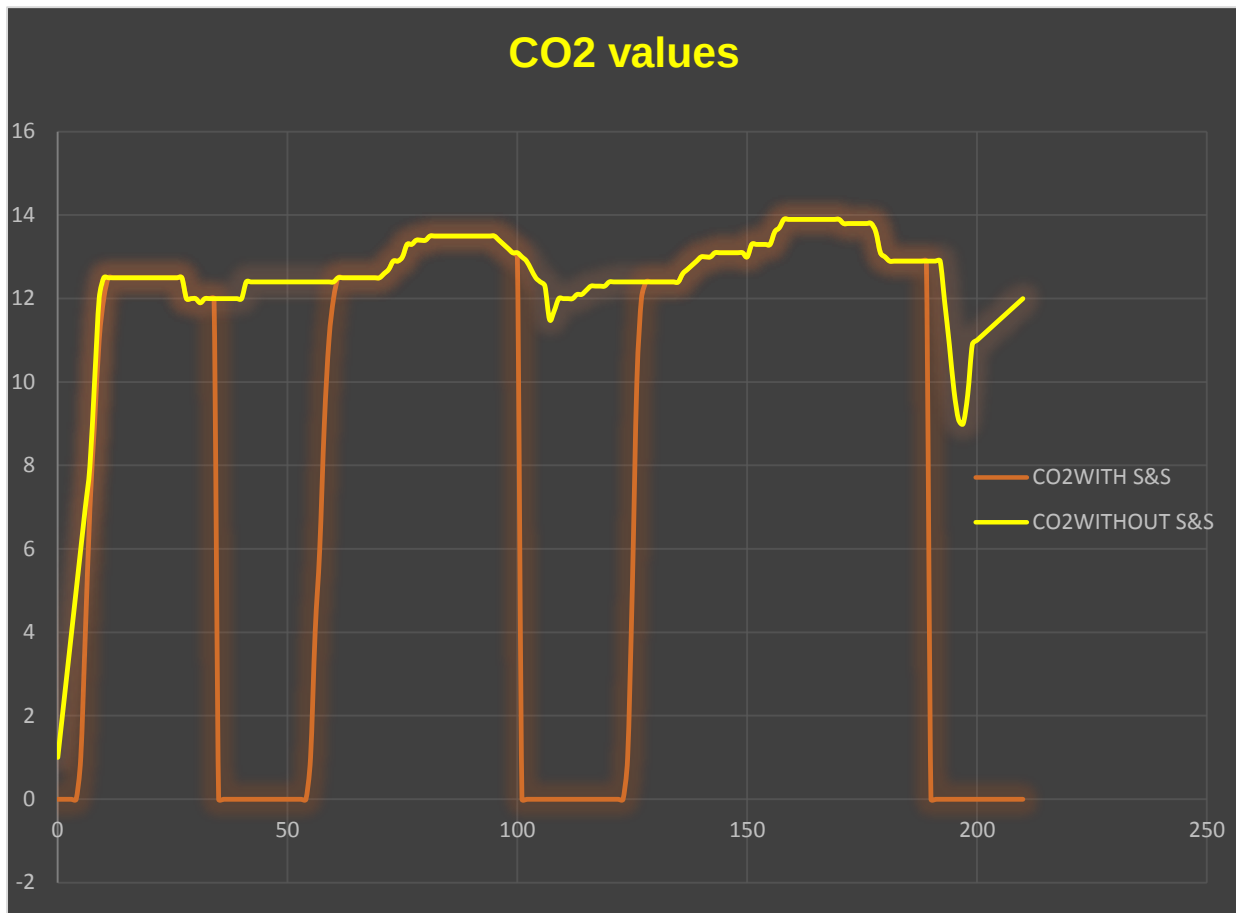


Figure (51)

CO₂ values during the engine functioning with stop and start and without, as the figure shows the huge difference for that impacts. The calculation operation will show that.

The difference of total values of CO₂ over whole journey= CO₂ without S&S – CO₂ with S&S.

The difference of total values of HC over whole journey= 2588 – 1744.1 = 843.9 ppmvol

This is an important difference to show the original CO₂ when it works with stop and start and without which gives the difference is 843.9ppmvol this test cycle. Thus, this cycle will be repeated automatically during the day drive so will gives more decreasing in the CO₂ emissions (Franchetti, 2013).

Data Acquisition

Table (21)

CO WITH S&S	summative CO with S&S	Summative HC with S&S	HC WITH S&S	CO2WITH S&S	Summative CO2 with S&S
0.5	56.8	28235	210	13.9	1477.8
0.5	57.3	28445	210	13.9	1491.7
0.5	57.8	28655	210	13.8	1505.5
0.5	58.3	28870	215	13.8	1519.3
0.5	58.8	29085	215	13.8	1533.1
0.5	59.3	29300	215	13.8	1546.9
0.5	59.8	29515	215	13.8	1560.7
0.4	60.2	29730	215	13.8	1574.5
0.6	60.8	29945	215	13.8	1588.3
0.6	61.4	30160	215	13.6	1601.9
0.6	62	30375	215	13.1	1615
0.6	62.6	30590	215	13	1628
0.6	63.2	30800	210	12.9	1640.9
0.6	63.8	31010	210	12.9	1653.8
0.6	64.4	31230	220	12.9	1666.7
0.6	65	31450	220	12.9	1679.6
0.6	65.6	31670	220	12.9	1692.5
0.6	66.2	31890	220	12.9	1705.4
0.6	66.8	32115	225	12.9	1718.3
0.6	67.4	32340	225	12.9	1731.2
0.6	68	32565	225	12.9	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
0	68	32565	0	0	1744.1
68	7001.3	3430877	32565	1744.1	182596.9

The table above showing the CO values and it is summative with functioning stop and start system, HC values and it is summative with functioning stop and start technology, CO₂ values with it is summative with functioning stop and start system (D.HALADERMAN, 2016).

9.4 Total summative CO over whole journey

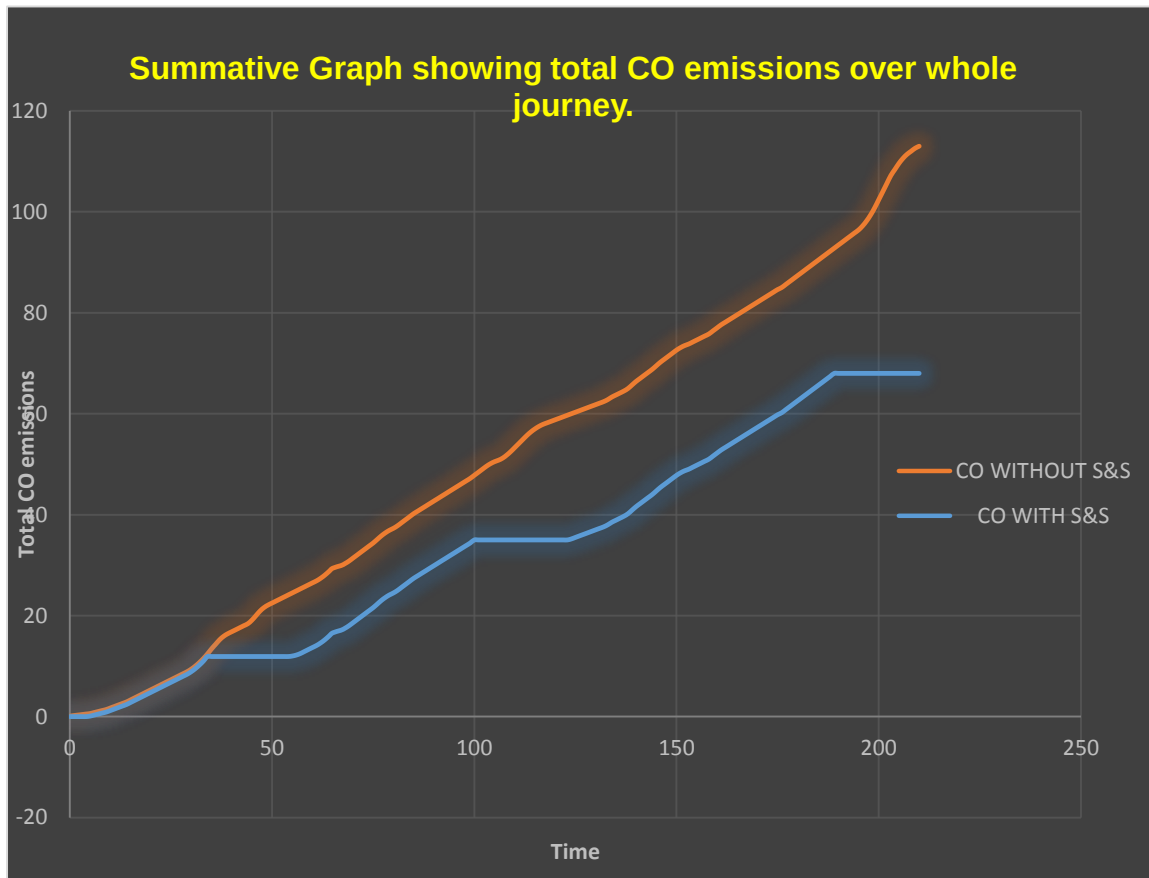


Figure (52)

The figure shows the summative of CO gas emission during functioning the stop and start system and without, to determine the difference values between the CO summative with stop and start and without over whole journey.

The difference of total summative of CO over whole journey= CO without S&S – CO with S&S.

The difference of total values of co over whole journey= 10558.8 – 7001.3 = 3557.5 ppmvol.

The results shows the difference of hydrocarbons for applying stop and start system and not. CO emissions are an important gas emission due to it is impacts on the human and environment, which is toxic gas, If the manufacturers achieved specific advance to manage and limiting this gas they can also the easy way to addressing other gases (A.Roosa, 2009).

9.5 Total CO values

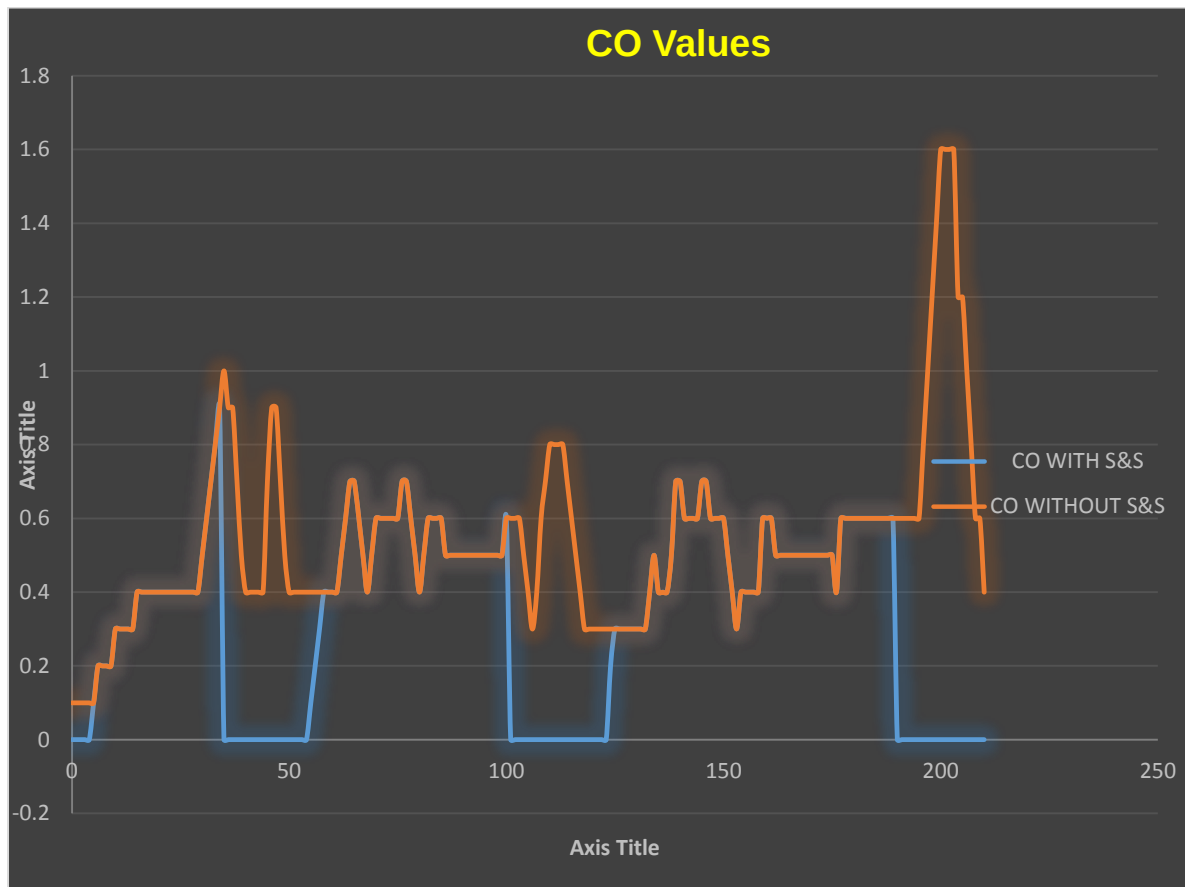


Figure (53)

CO carbon monoxide values during functioning the ICE with stop and start and without, CO is massive increasing when the engine increases the speed and rpm which is show massive values comparing the stop areas which is known as the crowded or waiting in traffic lights, this areas also will applying the stop and start system which will go to calculate the difference between the CO values without stop and start and with stop and start.

The difference of total values of CO over whole journey= CO without S&S – CO with S&S.

The difference of total values of HC over whole journey= $113 - 68 = 45$ ppmvol.

This result is closed to be half of the total number the ICE works without stop and start which is $113 / 2 = 56.5$ ppmvol, Also It is perfect result for the system works with stop and start which is more than half of $68 / 2 = 34$ ppmvol for each complete cycle (International, 2013).

10. Comparison of ICE Idling versus Stop and Start

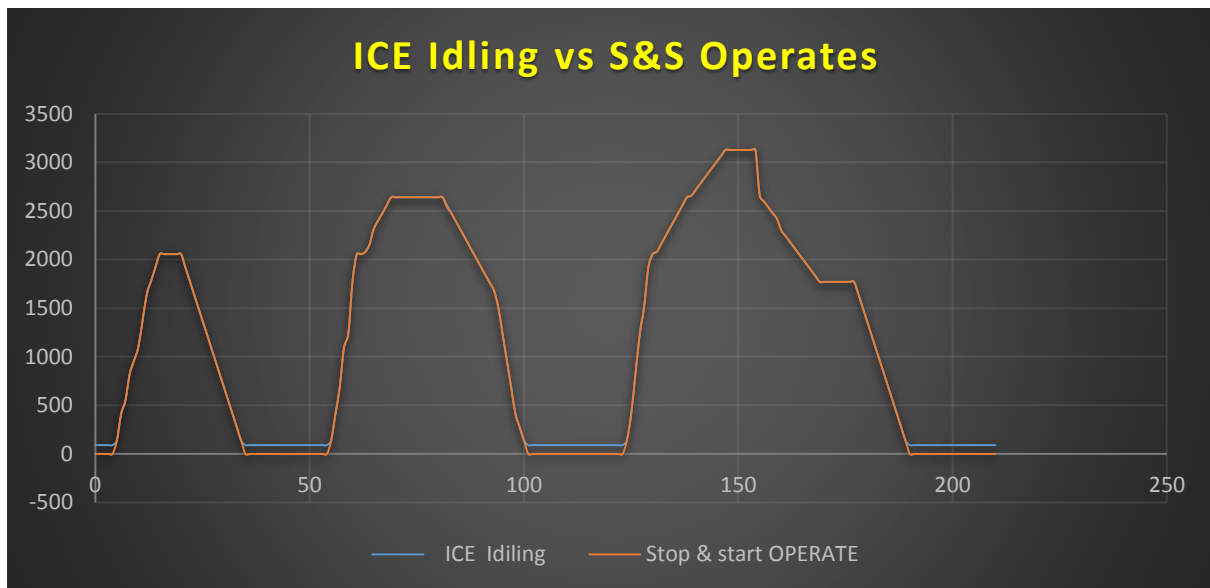


Figure (54)

The figure shows the ICE functioning without applying stop start system, In addition, during idling time, the emission value is relatively works with the rpm or vehicle speed, If the speed is increase will increase burning the fuel which producing a lot of emissions, the next will show the emission increasing and decreasing areas during the test cycle (Dariusz & Mian, 2013).

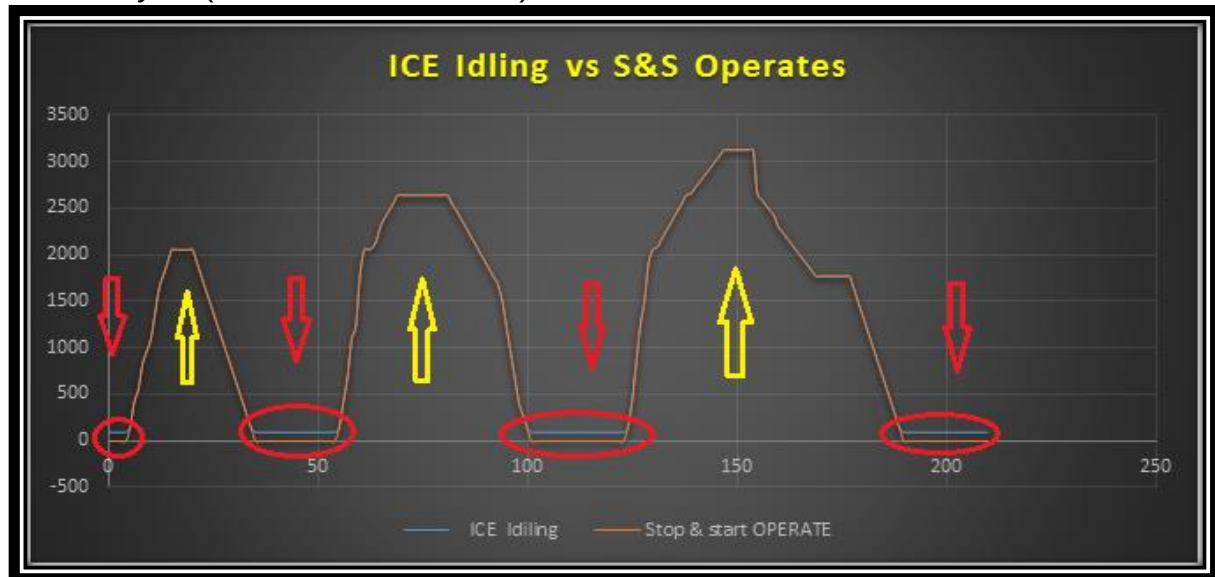


Figure (55)

The figure shows ICE works without stop and start system which the yellow arrows show the emission increases, and red arrows is the emission is decrease due to applying stop and start technology, the four red circles show the areas which shows the stop and start works and the engine idling when the vehicle is in stationary position. Orange line is to show stop and start functions during the red arrow is down (Dariusz & Mian, 2013).

11. Stop and start Technique in Gasoline Engine

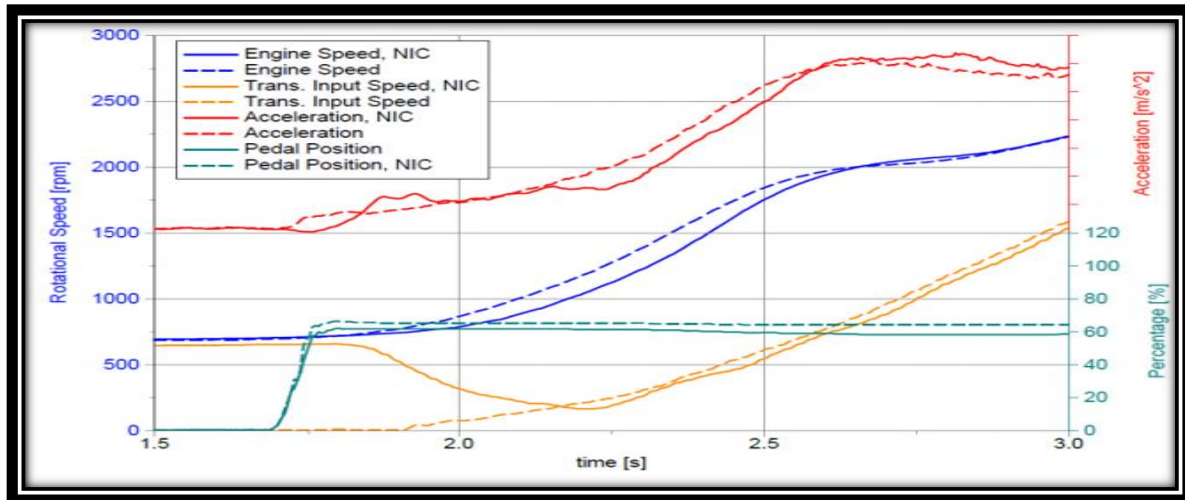


Figure (56)

(SAE, 2015)

The figure shows the impact of neutral idle control on acceleration and launch delay (Launch –W/o - Stop & start), and the impact of increasing speed and acceleration time compared to the pedal position which remains in 60%, thus providing a huge amount of emissions which increase as the vehicle is speeding up with increasing the transmission input further. In this case Stop and Start will make a huge difference in car performance and its emissions when it is applied correctly (SAE, 2015).

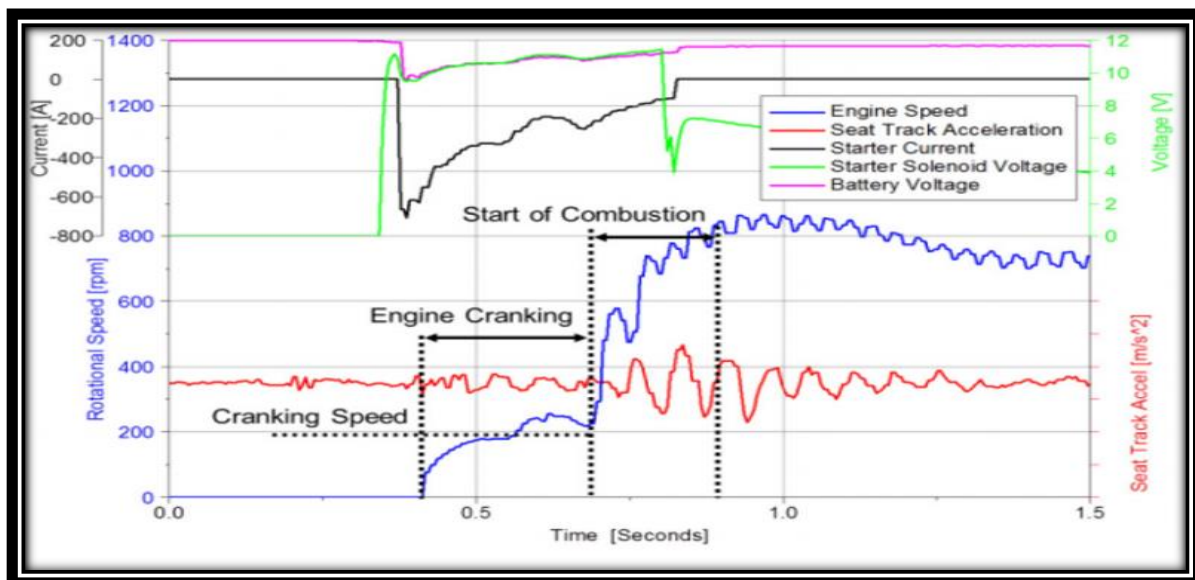


Figure (57) illustrates the way to restart the engine (SAE, 2015)

The figure shows the total test results for engine starts. The restarter system here is conventional ring gear. The pinion of the engine starter is engaged with the ring gear to let the engine start again, which is by the starter solenoid voltage, exactly when the pinion is engaged correctly the starter motor is running (SAE, 2015).

As the above figure shows, the top pink line refers to the volts which is the significant current for the time that the engine starts. When the engine starts, the speed increases automatically which can be divided into two distinct stages: first the engine cranking, and second the start of combustion. The starter accelerates the engine while the cranking stage works to a rotational speed that is sufficient to allow for a more stable engine start burning event, which increases the engine's torque (rotational speed). Once the combustion stroke starts processing, as the figure illustrates, there is a high starting speed which fluctuates but the overall combined speed of the engine increases (SAE, 2015).

Also the figure shows the engagement of the engine starter and the voltage limits which is dropped down at the starter battery, which occurs during the engine cranking. It falls down to 9.5V but a specific system is needed to assure the stability of the voltage during the restarter functioning of the engine (SAE, 2015).

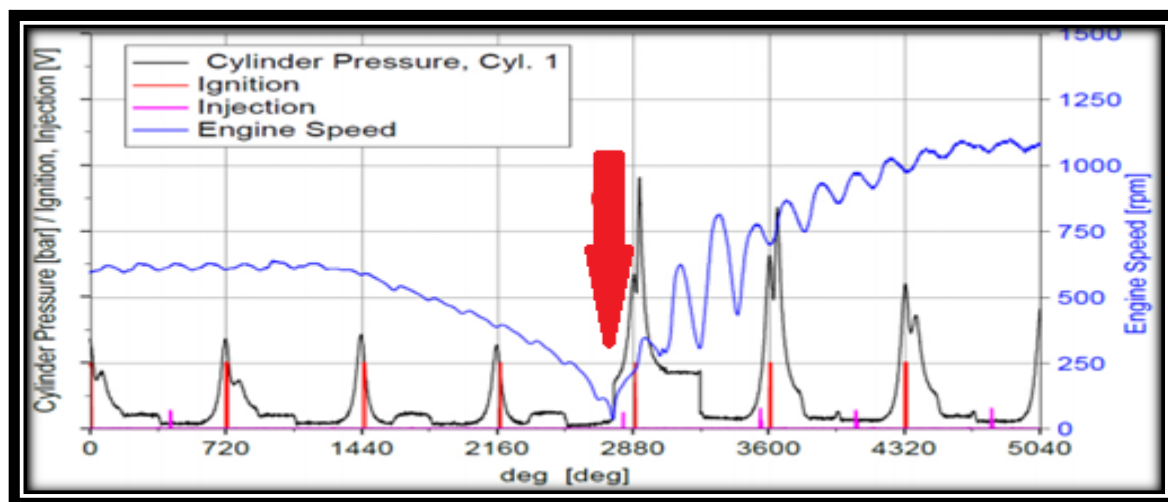


Figure (58) Engine stop and restart in Crank Angle Domain (SAE, 2015)

This figure illustrates the operation of an automatic gasoline four cylinder engine during a stop and start event. The analysis emphasises in this case one cylinder only, which works with direct injection style. At the beginning the engine cycle 0-720 degrees, is idling continuously and the engine speed is dropped down to 2880 degrees, due to the combustion cycle being shut off as the red arrow shows. The injector of the cylinder is stopped, but in this case the engine has fuel remaining and does two more cycles from idle speed before coming to a full stop. As the figure shows, the cylinder pressure of the engine is changeable while shut off (SAE, 2015).

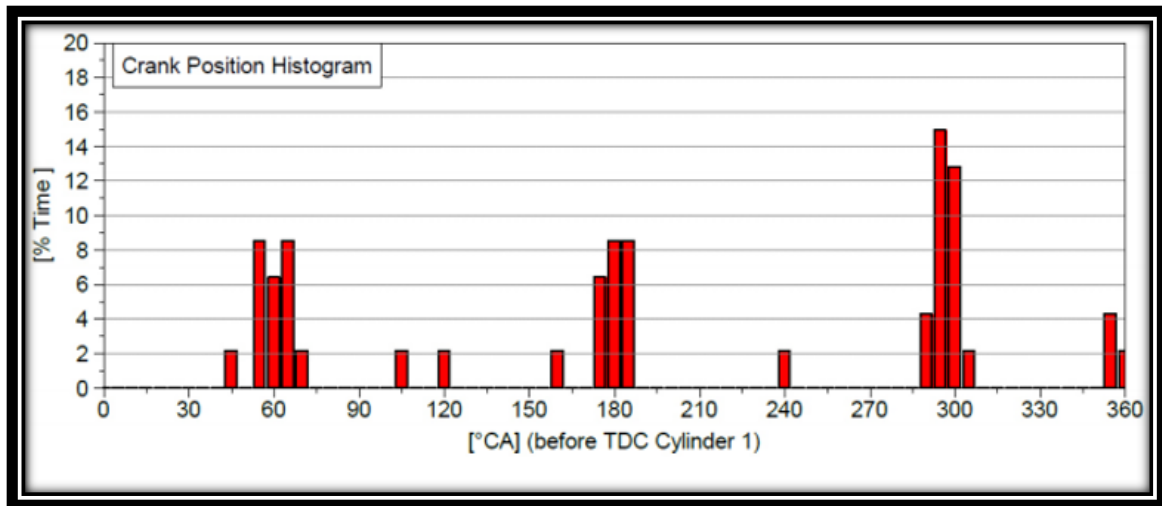


Figure (59) Crankshaft position during the engine stops and starts (SAE, 2015).

As the figure illustrates, the crank angle position randomly changes when the engine stops and restarts, which can occur while operating stop and start technology in vehicles. This is challenging for many reasons, such as with automatic transmissions. Due to oil pump operation during the engine stop phases, oil pressure needs to be built up again to continue at the same efficiency, which helps to transfer the required torque without hesitation or delay during the vehicle start up. If the oil pump does not function properly, this will affect the oil pressure of the transmission fluid pressure, the clutch will not function due to lack of transmission readiness, and this will produce a delay in the launch of the vehicle (SAE, 2015).

12. CO sensitive gas more than CO₂ and HC

The reason for CO is more sensitive is because its more harmful than other CO₂ and HC, (If creating quick comparison at the equality of their concentrations) CO is more compact than CO₂ plus haemoglobin, additionally this makes oxygen unavailable and deprives breathing enough oxygen, but CO₂ is not that much of a problem like CO, because it is managed via fuel consumption reduction. Carbon monoxide occurs in cases of incomplete combustion of specific gases or materials such as coal, natural gas and oil which are all known as environmental sources of carbon monoxide, in addition, if the engine is not burning any type of fuel (petrol or diesel) during the combustion process, it will produce carbon monoxide with higher values than other gas emissions. Which explains the reason that CO is more sensitive than CO₂ and HC (Goodall, 2007).

(CO₂) and carbon monoxide (CO) are two gases made from a combination of carbon and oxygen. People often confuse them. Once combustion of carbon is done, which needs plenty of oxygen, the result will be carbon dioxide.

For more understanding that fact of combustion operation refers to chemical substances with oxygen, which sometimes produces flames and fire when the carbon it is burned completely, Which occurs when the air suppliers in limited, Such as half as much of oxygen delivered to carbon (as assuming one atom of CO and Oxygen versus to two CO₂, oxygen atoms) and alternatively of carbon monoxide is formative (Industrial Scientific, 2019).

Carbon dioxide CO₂

The majority of carbon dioxide has come naturally from the atmosphere, these include human, animals, plant respiration, oceans, forest fires, and decomposition of organic matter and volcanic eruptions which produce a huge amount of emissions, unfortunately the human activity is a higher source of CO₂ emissions which is 87% comes from burning of fossil fuel such as coal, oil, natural gas. all this of the purpose of generating electricity or heat or power of different transportation methods, also industrial acts such as plastic and cement manufacturing.

CO₂ is non-reactive gas largely, and rapidly mixed throughout the climate when it is released (Franchetti, 2013).

Carbon monoxide CO

Is not like CO₂ comes from an incomplete burning fossil fuel like coal and not occurs naturally in the climate, but due to low temperatures and low levels of oxygen result in the creation of higher percentages of Carbon monoxide (CO) in the combustion mixture (Industrial Scientific, 2019).

CO₂ sensitive gas

Carbon dioxide is poison gas, which if become a concentration of it in a closed space it will be toxic, this occurs due to CO₂ takes extra space in the air alternative to normal oxygen which formatting dangerous environment for asphyxiation. The first of this impact on the human is dizziness, headaches, less concentration and hard to breathe normally (Franchetti, 2013).

Gas Detection

To fit the gas detector in the workplace it must be placed lower due to carbon dioxide is heavier than the air which must be close to the ground during the carbon monoxide is lighter than the air, At the carbon monoxide it can be changed to place higher up, the main target for using this tools is to understand and know the properties and the environment which consists of gases and the intent of each gas (Industrial Scientific, 2019).

Carbon Monoxide

Initially, this will bind chemically to all parts of your blood which supposed to carry and pick up oxygen molecules, which is prevent and blocks your system to have the oxygen, the concentration of CO your blood will achieve high level which guides to blocks a sufficient amount of oxygen from connecting to vital organs, this occurs due to CO is known as silent killer because is tasteless, colourless and non-irritating gas, and also hard to detect the poisoning from carbon monoxide gas.

National Conference of State Legislatures (NCSL).Refers to that more than 10.00 people have had asphyxiation and poisoned due carbon monoxide, which must have appropriate medical treatment for each year, unfortunately, this occurs only in USA 500 die annually from carbon monoxide poisoning, which CO is coming also from vehicles emissions (Industrial Scientific, 2019).

13. Discussions

According to James Hansen, if further global warming reaches 2 or 3 degrees Celsius, we will likely see changes that 'will make earth a different planet than the one we know' (Hansen, 2006, Ch1-p1). The last time it was that warm was in the middle of the Pliocene, about 3 million years ago, when sea levels were estimated to have been about 25 meters (80 feet) higher than today (Hansen, 2006).

It is a painful fact that there is successful monitoring of gradually increasing carbon emissions in the climate, which is a serious problem and needs a clear solution to be found, which limits the emissions generated by human activities. The concentration of carbon in fuels, which is released into the climate during the combustion processes, varies. One important way to reduce CO₂ emissions dependent on fuels with high levels of carbon content, is that all efforts must be orientated to replace such fuels with something that can produce less carbon or zero carbon such as EVs and HEVs (A.Roosa, 2009).

To manage the carbon produced by homes, which comes from fossil fuel to generate heat or electricity, new utility control technologies are a good method to reduce carbon, for example smart electric metering technologies can save and control sophisticated demand response capabilities (Goodall, 2007)

In addition in Germany, some manufacturers have already designed some vehicle models to be powered by biodiesel and Ethanol. For example, Elsbett have made huge modifications of diesel engines to work with vegetable oil which are high performing and efficient (Vicente Díaz, 2009).

.

14. Conclusion

Stop and start technology is designed to work automatically to shut a car's engine down at idle position when the car is stationary, to reduce the pollution, noise and carbon emission reduction targets, and also to improve fuel economy. This system works on vehicles with automatic transmission. Stop and Start activates and deactivates at different scenarios such as traffic lights, waiting in queue line at drive through fast food outlets, stopping in different circumstances when the transmission is still in drive. In this case, the engine will shut off showing that the stop and start is activated, and a light will appear on the instrument cluster to show that the system is functioning. When the driver releases the brake pedal to move forward, the engine will restart automatically. (Postmedia Network Inc., 2019).

According to John Houghton, global warming has become familiar to many people as one of the most important issues of our day, many opinions have been expressed regarding concerns about it.

The stop and start technology is a good solution for addressing harmful gases to the environment produced by the vehicle, which will reduce the emissions and its impact on the greenhouse gases which works directly to global warming. Global warming is a topic that is increasingly occupying the attention of the world.

Stop and start being installed in cars manufactured in the future, will enable the emissions to be lowered therefore, achieving the reduction in harmful gases which continues to cause speculation regarding the internal combustion engines future(Houghton, 2009).

15 Bibliography

A.Roosa, S., 2009. *Carbon Reduction Policies,Stratigies and Technologies*. USA: Fairmont Press,Inc.

Advance Auto Parts, 2019. *HOW START-STOP TECH WORKS*, USA:
<https://shop.advanceautoparts.com/r/advice/car-technology/how-start-stop-tech-works>.

Alexander, T., 1992. *How to Stop Fearing and Start Loving the Parallel Computer*, Washington: Superintendent of Documents, Mosaic National Science Foundation.

Autocar, 2019. *Stop-start technology: what's the long-term impact on my car's engine?*, UK: Haymarket Media Group.

BestRide.com, 2019. *DOES AUTO-STOP/START TECHNOLOGY WEAR OUT ENGINE COMPONENTS?*, s.l.: <http://bestride.com/research/buyers-guide/does-auto-stopstart-technology-wear-out-engine-components>.

C.Ronneau, 1997. *Biotechnology and Site Restoration..* Netherlands: Kluwer Academic Publishers.

Cars.com, 2019 . *Which Cars Have the Best Stop-Start Systems?*, unknown:
<https://www.cars.com/articles/which-cars-have-the-best-stop-start-systems-1420684556033/>.

D.HALADERMAN, J., 2016. *AUTOMOTIVE FUEL &EMISSIONS COLTROL SYSTEMS*. 4 ed. USA: Pearson Education.

Dariusz & Mian, 2013. *Experimental measurement and modelling of plain bearing wear in start-stop applications*, London UK: SAGE PUBLICATIONS, INC..

Dieselnet.com, 2019. *ECE 15 + EUDC / NEDC*, UK:
https://www.dieselnet.com/standards/cycles/ece_eudc.php.

Dinh, T. et al., 2107. *Powertrain modelling for engine stop-start dynamics and control of micro/mild hybrid construction machines*, London UK: SAGE PUBLICATIONS, INC..

Dupont, R., 2000. *Pollution Prevention*. USA: CRC Press LLC.

Encyclopaedia Britanica,Inc., 2019. *Hydrocarbon*, USA:
<https://www.britannica.com/science/hydrocarbon>.

Encyclopaedia Britannica.Inc, 2018. *Emission Cotrol Systems*, UK:
www.britannica.com.

Franchetti, M. J., 2013. *CARBON FOOTPRINT ANALYSIS*. USA: Taylor & Francis Group.

Goodall, C., 2007. *How to live alow-Carbon life*. UK: Chris Goodall.

GOV.UK, 2019. *Final UK greenhouse gas emissions national statistics: 1990-2017*, UK:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/776085/2017_Final_emissions_statistics_-_report.pdf.

GOV.UK, 2019. *Vehicle exhaust emission standards*, UK:
<https://www.gov.uk/government/publications/in-service-exhaust-emission-standards-for-road-vehicles>.

Hansen, J., 2006. *The important of reducing Carbon Emissions*. New York ,USA: NASA's Goddard institute for Space Studies.

haynes.com, 2018. *Stop-Start technology explained*, UK: haynes.com.

Houghton, J., 2009. *GLOBAL WARMING. FOURTH ed.* USA: Cambridge University Press.New York.

How a Car Works, 2019 . *How the starting system works*, unknow:
<https://www.howacarworks.com/basics/how-the-starting-system-works>.

Industrial Scientific, 2019. *Carbon Monoxide Vs. Carbon Dioxide: Let's Compare*, s.l.: <http://www.indsci.com/the-monitor-blog/carbon-monoxide-carbon-dioxide/>.

International, S., 2013. *Vehicle System Control for Start -Stop* , USA: SAE I.

Kim, K.-s., 2013/2015. *The implementation of start stop system with the OBD-II interface in the automotive smart key system*, New York , USA: Springer Science+Business Media New York .

Merkisz, J., Pielecha, I., Pielecha, J. & Brudnicki, K., 2011. *On-Road Exhaust Emissions from Passenger Cars Fitted with a Start-Stop System*, Poland: De Gruyter Poland.

Midgley, W., Cathcart, H. & Cebon, D., 2013. *Modelling of hydraulic regenerative braking systems for heavy vehicles*, London UK: SAGE PUBLICATIONS, INC..

National Automotive Parts Association, 2019. *STOP-START TECHNOLOGY — PROS AND CONS*, s.l.: <http://knowhow.napaonline.com/stop-start-technology-pros-and-cons/>.

Parts Alliance Group , 2018. *Replacing batteries on stop-start vehicles* , UK:
<https://www.thepartsalliance.com/replacing-batteries-on-stop-start-vehicles/>.

Pinkse, A. K. & J., 2008. Corporate Responses. *European Accounting Association*, unknown unknow, p. Routledge Journals.

Postmedia Network Inc., 2019. *Your Corner Wrench: What's the real benefit of stop-start systems?*, 365 Bloor St East, Toronto.Canda: <https://driving.ca/auto-news/news/your-corner-wrench-whats-the-benefit-of-stop-start-systems>.

repairpal.com, 2018. *Catalytic converter system*, uk: repairpal.com.

Saddington, D., 2014. *The Global Market for Stop-Start Systems.*, UK: Market Research Report.

- SAE, 2007. *Optimized Start Strategy for Stop/Start Operation of a μ -Hybrid Vehicle*, USA: SAE International.
- SAE, 2013. *Control Strategy Research of Engine Smart Start/Stop System For Micro Car*, USA: SAE International.
- SAE, 2013. *Integration of Engine Start/Stop System with Emphasis on NVH and Launch Behavior.*, USA: SAE International.
- SAE, 2014. *Development of Stop/Start Engine Combustion and Restart control for Gasoline Direct Injection Automatic Transmission Application*, USA: SAE International.
- SAE, 2015. *Influence of Automatic Engine Stop/start Systems*, USA: SAE.
- SAE, 2017. *Evaluation Between Engine Stop/Start and Cylinder Deactivation Technologies*, USA: SAE International.
- SAE, 2017. *Manage and Optimize Power System to Maximize Steering Assist and Stop/Start Availability.*, USA: SAE International.
- SAE, 2017. *Modeling and Validation of 12v lead -Acid Battery for Stop/Start Technology*, USA: SAE International.
- SAE, 2017. *Start /Stop Test Drive Cycle Design and Implementation in Challenging Markets.*, USA: SAE International.
- SAE, Fuel Consumption Evaluation of Stop/Start Systems.. *Off-Cycle* , USA: SAE International.
- STRAUSS, W., 1972. *AIR POLLUTION CONTROL*. 2nd part of AIR POLLUTION CONTROL. ed. USA: John Wiley and sons.
- swatchina.com, 2018. *EU EMISSION STANDARD*, UK: <http://www.swatchina.com/Articles/EURO.htm#accordion-1-slide-1>.
- The Truth About Cars, 2018. *The Shocking Truth About Start-Stop Systems*, UK: <https://www.thetruthaboutcars.com/2011/06/the-shocking-truth-about-start-stop-systems/>.
- thesun.co.uk, 2018. *T charge*, UK: www.thesun.co.uk/motors/4745037/euro-4-diesel-cars-emission-standard-how-to-check/.
- Vicente Díaz, S. S., 2009. *Reduction of carbon dioxide emissions*, Madrid: Carlos III University of Madrid.
- White River Toyota , 2019. *What is the Stop and Start Engine System in the 2017 Toyota Highlander?*, USA: <https://www.whiterivertoyota.com/blog/stop-and-start-engine-system-in-the-2017-toyota-highlander/>.
- .whichcar, 2017. *Stop-start systems: Pros and cons*, AU: Bauer Media Pty Limited/ <https://www.whichcar.com.au/car-advice/stop-start-systems-pros-and-cons>.

WILEY, 2002. *ENVIRONMENTAL ANALYSIS*. 2nd ed. England: John Wiley and sons.

WILEY, 2009. *CATALYTIC AIR POLLUTION CONTROL*. Third ed. CANADA: John Wiley and sons.

www.gov.uk, 2018. *Reducing emissions from road transport: Road to Zero Strategy*, www.gov.uk: www.gov.uk.

Zhang, J., 2015. *Technology evaluation of Chinese hybrid electric bus demonstration*, Netherlands, Dordrecht: Springer Science & Business Media.

Zhao, Y. & Yu, T., 2018. *Calculation and verification of Start/Stop optimum overlapping rate on metal DLF technology*, Netherlands, Heidelberg: The International Journal of Advanced Manufacturing Technology.