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Forced Idling Regime of Automobile Engines

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Abstract
This paper presents the factors affect the idling regime (mode) for the motor car engines, such factors include time of travel, gender of the driver, distance of travel and road conditions. Working conditions of the car engine in its compulsory free rotation is discussed too. This condition is occurred to the engine of the car when the foot released the fuel pedal and so the throttle status changed during engine work and also the connection of the movement between the engine and the wheels of the car is changed and still be in connection. Through the total movement of the vehicle during empty rotation (idling) of the engine which is frequently repeated during the driving, the car within cities as well as driving on mountain roads this condition may be existed. In this case the number of engine RPM is higher than that of the number RPM at the engine idling, then the reverse movement of the wheels of the car (relatively high speed of the car) is transmitted through the total transmission (complete transmission from the wheels to the engine) of low RPM, which is also called engine braking. This phenomenon will be studied and analyzed to ensure that there will be a reduction in fuel consumptions and low emissions. The study aimed to investigate the inability of reducing fuel consumptions of some automobiles during some travel routes by the presence of forced dealing regime or mode. In addition to executing many experimental tests on cars with different engine size, travel path, and with different drivers. And finally studying the factors affects fuel economy of the ICE. It was found that male are better in achieving forced idling conditions, urban areas and highways are better that mountain areas and finally the travel distance and mechanical status of the car may affect the percentage of forced idling regime of the car. The fuel consumptions and emissions in the case of forced idling are noticed to be increased.

Keywords: idle regime, engine, road conditions, fuel consumption, emissions.

Introduction
An internal combustion engine is one in which the fuel burns in a restricted space known as a combustion chamber. This exothermic interaction of the fuel with an oxidizer produces high-temperature, high-pressure gases that can expand. An internal combustion engine is distinguished by the fact that the expanding hot gases immediately create movement, which can take the form of pistons, rotors, or moving the entire engine [1].

Idling occurs whenever a vehicle's engine is running (i.e., the engine is on) but the vehicle is not moving. Drivers may idle because they want to pick up passengers, to run air conditioner or the heating, or to power other accessories. Idling speed of engine is designed that is produces just enough power to keep itself running but not enough to move the vehicle. For example, when the engine is ignited and the person's foot is away from the accelerator pedal, this is known as idling position [2-3].

In the United States (US), idling wastes more than one billion gallons of fuel in a year, contributes to air pollution, negatively impacts the health of the population, and wastes about four billion US dollar per year. Not in a technical sense, that Internal Combustion Engine (ICE) cars do and arguably, many ICE cars are not idling in the same way anymore . Internal combustion engines require gearboxes with multiple gears, including a neutral where no gears are engaged to transfer power to the drive shaft and wheels. This is required because as internal combustion engine must keep running if it is on, with gasoline injected into cylinders, sparks igniting it, the pistons are being pushed by the exploding gases and the crank rotating as a result. The gas and the power produced are wasted energy that is a by-product of the inefficient ICE engine .

Electric motors do not have the same requirement of power. They are simpler, when electricity is running into them, they turn (on). When no electricity is running into them, the motors do not turn on. No electricity current is exist if there is no need to keep them rotating when there is no necessity to be operated.

The concept of idling as opposed to the technical details of idling is that the engine is ready to be used. All electric cars have a state where the engine is ready to be used if the accelerator is pushed; the car will move. It has a state where if you press the accelerator, nothing will happen because the car in not “turned on”, although there are nuances there as given that Tesla’s are automatically “on” when you get into them, but not automatically in forward or reverse gear[2-3].

Many modern ICE cars have a feature which turns the engine off entirely at brief stops and automatically restarts it when the accelerator pedal is pressed, mimicking the electric car function although in a more complex way but significantly reducing wasted gas and excess emissions.

Idle Air Control Valve (IACV)

An automobile is pushed by way of an internal combustion engine having an air induction passage with an idle air manipulate valve function in a position via stepping motor in response to valve opening and closing pulses. A counter counts the pulses arithmetically to furnish an indication of valve function into accord, counter reset equipment is effective, when actuated , to generate a predetermined quantity of valve closing pulses ample to stall the stepping motor towards the stop, reset the counter to a predetermined reference matter and generate a predetermined range of valve opening pulses to return the idle at manage valve to a favored working function with the counter counting such pulses in the regular manner. The equipment is actuated upon the first incidence of an automobile pace larger than a predetermined velocity such as 30 mph following a counter reset signal, which sign is generated upon every engine begin and may additionally in addition be generated at any time a counter error is detected. The minimal required automobile pace ensures that the engine will now not stall for the duration of the duration of the reset operation [2].

Idle Stop (IS)

It is a technology that automatically turns off the engine when the vehicle comes to a halt at a light and then turns back on when the vehicle starts up again. Vehicle engines are frequently left running even when stopped, however a vehicle equipped with IS increases fuel economy by shutting off the engine. Vehicles equipped with IS systems can shut down the engine when the vehicle comes to a halt and restart it quickly when the vehicle is launched. This feature decreases fuel consumption and emissions while the engine is not used for propulsion or to power accessories. IS systems are a low cost, fast growing technology in the industry wide pursuit of increased vehicle efficiency, possibly becoming standard features in European vehicles in the near future.

Idling Stop System of Gasoline Direct Injection

The fuel injection engine (direct one) starts off evolved tons quicker than a well-known engine. At the equal time as the cranking start, gasoline can be fed into the cylinder throughout the compression stroke. The engine has its first combustion when the spark plug ignites the combination at the conclusion of the combustion stroke, which occurs inside 0.2 seconds of the engine starting. This awesome function of fast begin capability has resulted in the improvement of an idle end system, which lets in drivers to function the automobile in urban way [2].

In phrases of combustion technology, the most quintessential key phrase with the direct fuel-injection engine is "the flexibility of combination preparation," the place different combustion prerequisites are made available in the cylinder by using enhancing the injection time and keeping apart it into two phases. This favored science has been utilized for knock prevention as nicely as speedy catalyst light-off. Another integral time period for the Gasoline Direct Injection (GDI) engine is "engine administration freedom," specifically torque control.

To get a true acceptance, an idle-stop system wishes to execute a fast-start and -acceleration of the automobile below standstill mode, on the

other hand this is now no longer a straightforward thing. The wondering of Mitsubishi's idle-stop system, nevertheless, has originated from the thought that the GDI engine ought to possibly be commenced out in an immediately and generates the required torque immediately, if totally allow workable of control designed to the GDI engine is efficiently utilized in proper manner [2-3]

Significance of Idle Stopping

Normally, the engine keeps going for walks even when the vehicle is saved standstill, for the period of which the gas is saved consumed. The decent Japanese 10 & 15 Test Mode consists of about forty situations of the automobile stopping at the web site traffic warning signs in one-hour driving. The gasoline consumption at such stopping cash owed for about 15% of the entire fuel consumption in the direction of the whole test-mode operation. The GDI engine; however, consumes fully 10% beneath the equal scenario of the Japanese take seem at mode, thanks to this feature of greater fuel-economy at idle.

Needless to say, the engine halting at idle is a sensible capability of fuel-saving by turning off the engine routinely at each vehicle stop and re-starting the engine when the car is to be pushed again. As a result, the idle-stop architecture of a number of specialized schemes were introduced into the market; however, none of them were successful, and they all faded away over time. The main issue with such earlier arrangements was unintentional engine stall owing to delayed engine re-starting or additional device constraints to prevent possible engine stall. As a result of these conditions, the idle-stop device was no longer a challenge to enhance for broader market usage. Locations of Pistons during Engine Idle Stop Conditions: To fully comprehend the GDI engine's starting characteristics, it is necessary to pinpoint the location of a piston in the engine while it is in suspended operation at the compression stroke. Fuel Consumption Improvement of Vehicle with the aid of Idling Stop: Investigation has been carried out for the impact of the idling end for a brief time when stopping by means of the visitors signal. The quantity of the gasoline consumption via the idling end is formulated through the following equation [2, 3, 7, 9, and 10]:

$$F_s = I\,(T_{is}) - (S_2 + S_3) * (N_{is}) \quad (1)$$

Where: F_s: saved gasoline consumption (cc); I: gas consumption throughout idling (cc/s); T_{is}: length at some stage in the idling give up (s); S_2: extra gas consumption by way of restarting the engine (cc); S_3: power consumption at the battery for starting, in gas consumption equivalence (cc); N_{is}: frequency of idling stop.

In order to decrease the troubles associated to world warming, it is proposed to promote a coverage of creating and introducing a smooth electricity device to restrain emission of green-house gases by way of the usage of such electricity sources as wind power, photo voltaic cells, gas mobile and others. Because there are issues of no longer solely the world warming, however additionally brilliant consumption of fossil fuel, car manufacturing groups are attempting to enhance the engine diagram for lowering the gasoline consumption, to optimize the engine manipulate device to enhance the computerized transmission, to decrease weight of vehicles, and to limit the drag pressure of vehicles. Furthermore, they are making efforts to advance such low air pollution motors as herbal gasoline vehicle, hybrid vehicles, gas mobile vehicles, and electric powered vehicles. However, up to now, the bottle-neck has been that the fee for buying such automobiles is extraordinarily greater than that for traditional vehicles, and that there are solely few filling or charging stations. On the different hand, most of the customers of motors are doing nothing in spite of the reality that they renowned the environmental issues such as world warming. If all these vehicle customers who are doing nothing come to understand the significance of the environmental troubles and do something is equal to "to keep away from rapid acceleration, now not to fluctuate needless goods, to give up the usage of pointless air conditioner, to have upkeep regularly, and to keep away from pointless idling", as some distance as motors are worried [2-3].

The fuel consumption enhancement by way of the idling give up (IS) is studied by way of [2-3]. And the motion which any drivers can operate effortlessly and recognize the impact of the motion had been studied too. IS capability to quit

the engine whilst the automobile is no longer moving, IS used to be carried out when the automobile is no longer moving, IS used to be carried out when the automobile stays at the identical area for a lengthy time, for example, which items are loaded or unloaded from trucks. But lately the IS is going to increase to the case where automobiles end for a comparatively quick time, for example, whilst they give up and wait for a sign trade on the road. Furthermore, attachments to automobiles which allow handy operation of IS feature and additionally motors which are outfitted with the IS helping characteristic are already commercially handy in the market. [2-3].

Literature Review

There are many researches discussed this issue but little of them investigate and make experimental investigation. **Thitipatanapong et al. (2013)** a research on fuel usage in Bangkok traffic using a forced optimal system The data was analyzed by lowering the amount of gas used while the automobile was in a steady state. The vehicles in this research are conventional vehicles, not vehicles that have stopped operating. There were four degrees of congestion in the research, as well as three instances. The suggested system's results revealed that a spark ignition engine may improve fuel consumption by 40% in a severe scenario and traffic throughput by 10%. Furthermore, for compression ignition engines, the technology might reduce fuel consumption by 30%. Furthermore, the forced ideal system works to increase fuel efficiency in high-traffic areas while maintaining the same degree of flow [4].

Kumar et al. (2017) analyzed the idling fuel consumption of in-use cars, a total of 346 automobiles of various vintages and kinds were successfully tested under hot stabilized circumstances using a gasoline flow detector. The tests were conducted in Delhi, Bhopal, Chennai, Chandigarh, Pune, Vadodara, and Kolkata. The test findings demonstrate that fuel usage varies depending on vehicle technology as well as vehicle type. The average value of fuel consumption while idling for motorcycles was 0.14 l/h, while for three wheelers, cars, and buses it was 0.24 l/h, 0.6 l/h, and 0.9 l/h, respectively.. Analysis of data concludes that at idling the vehicle technology has a significant influence on fuel consumption [5].

Dardalis et al. (2021) defined the Diesel RLE prototype constructed from a Cummins 4BT, as properly as preliminary findings from first low load trying out For the masses examined (peak cylinder pressures on the order of a hundred bar) and up to round 10 bar BMEP, the foremost technical issue, namely the rotating liner face seal, seems to be running with little fuel leakage and inside the hydrodynamic lubrication regime (brake imply advantageous pressure). Preliminary checking out has proven that the metal-on-metal contact in the piston meeting has without a doubt dissipated, and a friction discount below idle stipulations of round 40% has passed off when extrapolated to the complete engine. It is predicted that as the pace increases, the friction discount share will diminish, however as the load increases, the friction discount will increase. The gasoline economic system advantage over the US Heavy-Duty using cycle will probably be of the order of 10% in contrast to a widespread engine [6].

In addition to providing a thorough overview of the fundamental control modules in the SI engine management system (EMS) in terms of their functions and control strategies, Ashok et al. (2016) consolidated an overview of the significant developments within the SI engine control system strategies and reviews about some of the basic control modules in the engine management system [8].

Methodology

As members working on this study, the car was driven and the data were collected with the help of different drivers the data in the schedule above in different areas including city, highway, and mountain roads using several types of vehicles. For example, we got to the vehicles and recorded the initial mileage on the dashboard and the time we started the trip on a worksheet, then we started driving to our destination and on the mobile phone with the help of a stopwatch we recorded every time the vehicle starts to force idle (the wheels are driving the vehicle not the internal combustion engine (ICE) which the engine is still running) neglecting the time while the vehicle is stopping but the engine is running such as waiting

for someone to pick up or on the traffic light. We used this criterion on different trips like driving to college or on transportation, driving to work or delivering orders at work, and driving with family and friends. Another example was when we used the transportation to go to the college, when we get into the bus, we recorded the trip initial time and calculated the journey's distance using the help of the GPS (Global Positioning System), then the recorded times were recorded using some suitable stopwatch.

Results And Discussion

Figure 1 shows the total travel time and its average and time of forced idling for 25 trials of the tested car in greater Amman areas, it can be noticed that the idling time represents a good percentage of the total time ranges from 3% to 30% as shown in Figure 2 depending on many factors like the area nature (inside the city, urban and highways roads).

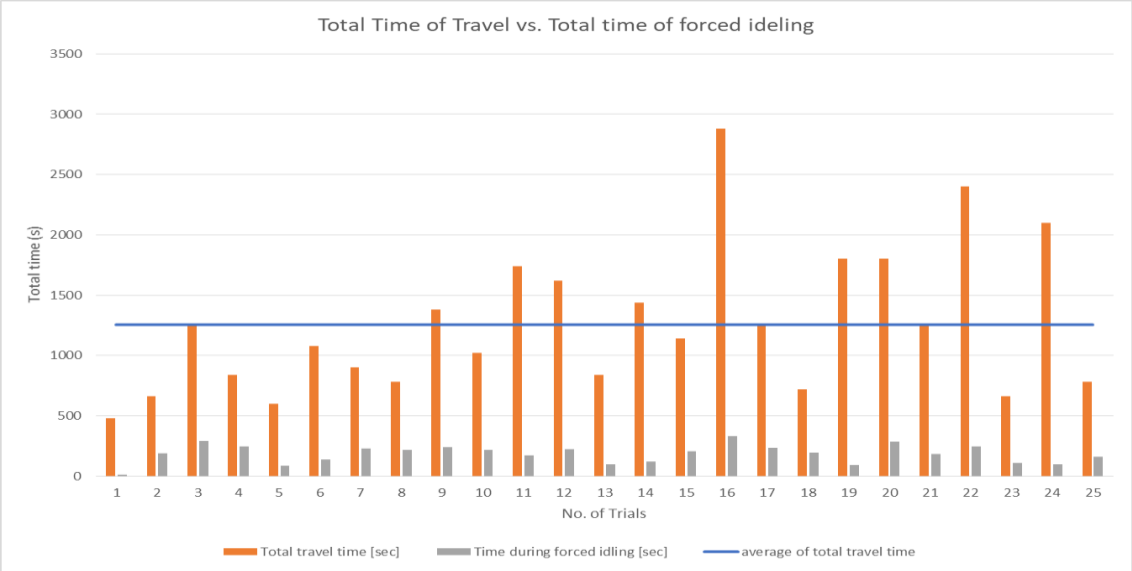

Figure 1. Total travel time vs. time of forced idling

Figure 2 shows the forced idling percentage time with an average of 16.308% of the total time of travel.

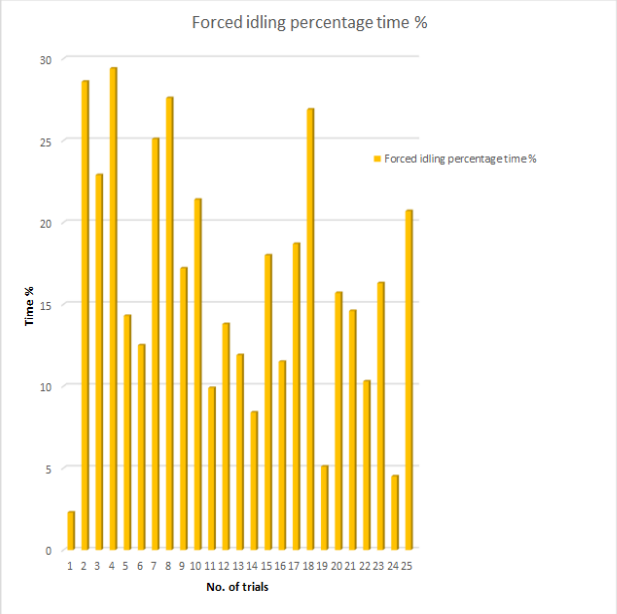

Figure 2. Time % **of** forced idling

Figure 3 shows a comparison between male and female drivers in the case of forced idling case for 9 trials, it can be noticed that in 7 trials of 9 trials the male are better in achieving idle driving.

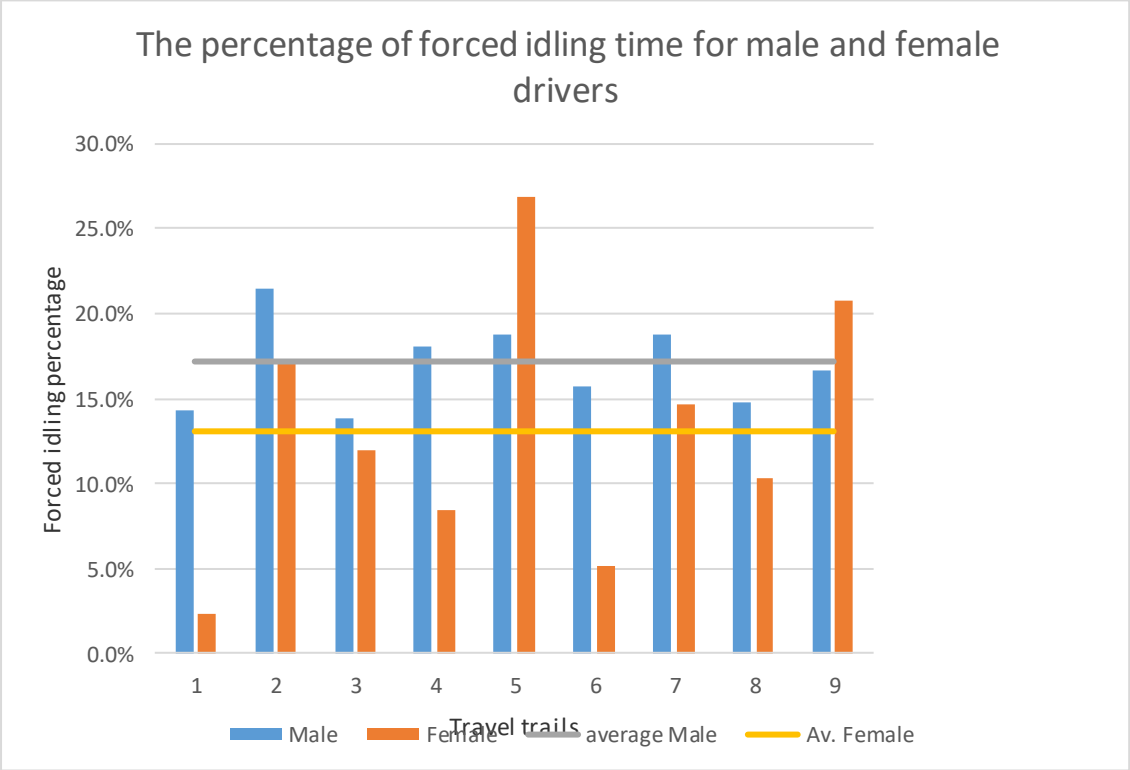

Figure 3 Comparison between male and female drivers during forced idling case

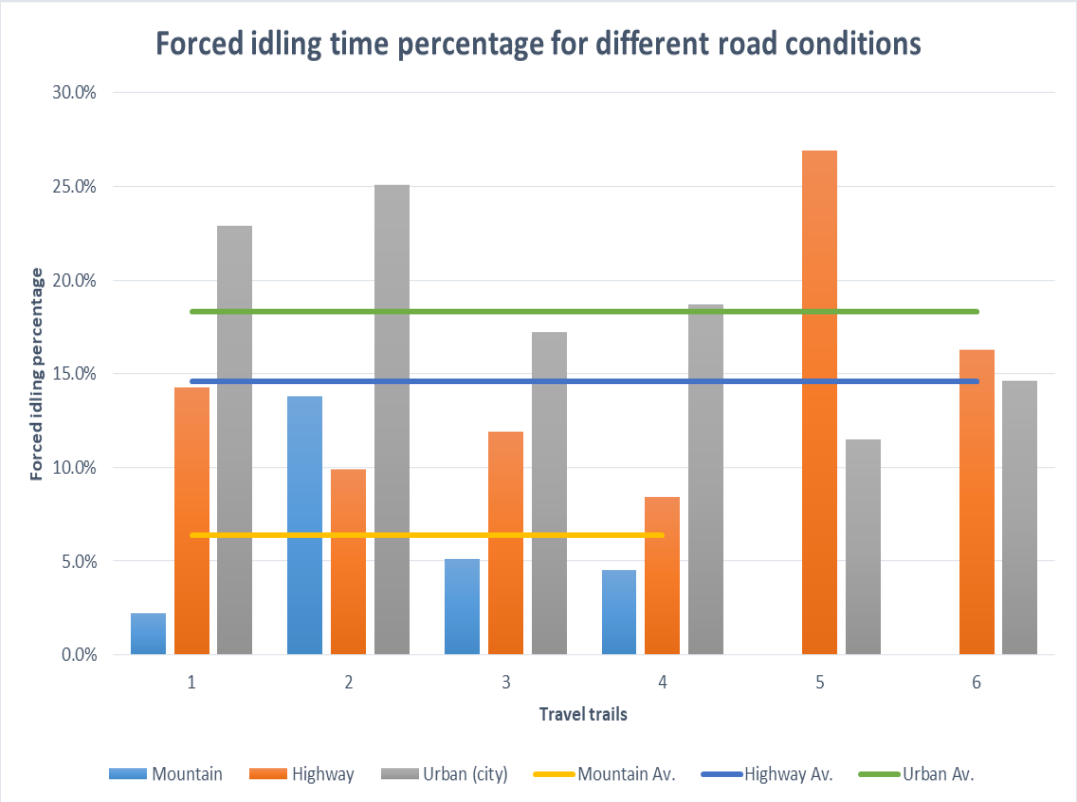

Figure 4. The effect of road nature on the forced idling percentages on Amman area

Figure 4 shows a comparison and the effect of road nature on the forced idling percentages on Amman area in 6 trials. It can be noticed that idling in urban areas has more percentages than that of mountains and highways (in 4 trials out of 6) and also, highways are better than mountains in most of trials.

Figure 5 shows the percentage of forced idling distance from the total distance of travel, it can be noticed that this percentages lies on the range of 3% to 30% of the total distance.

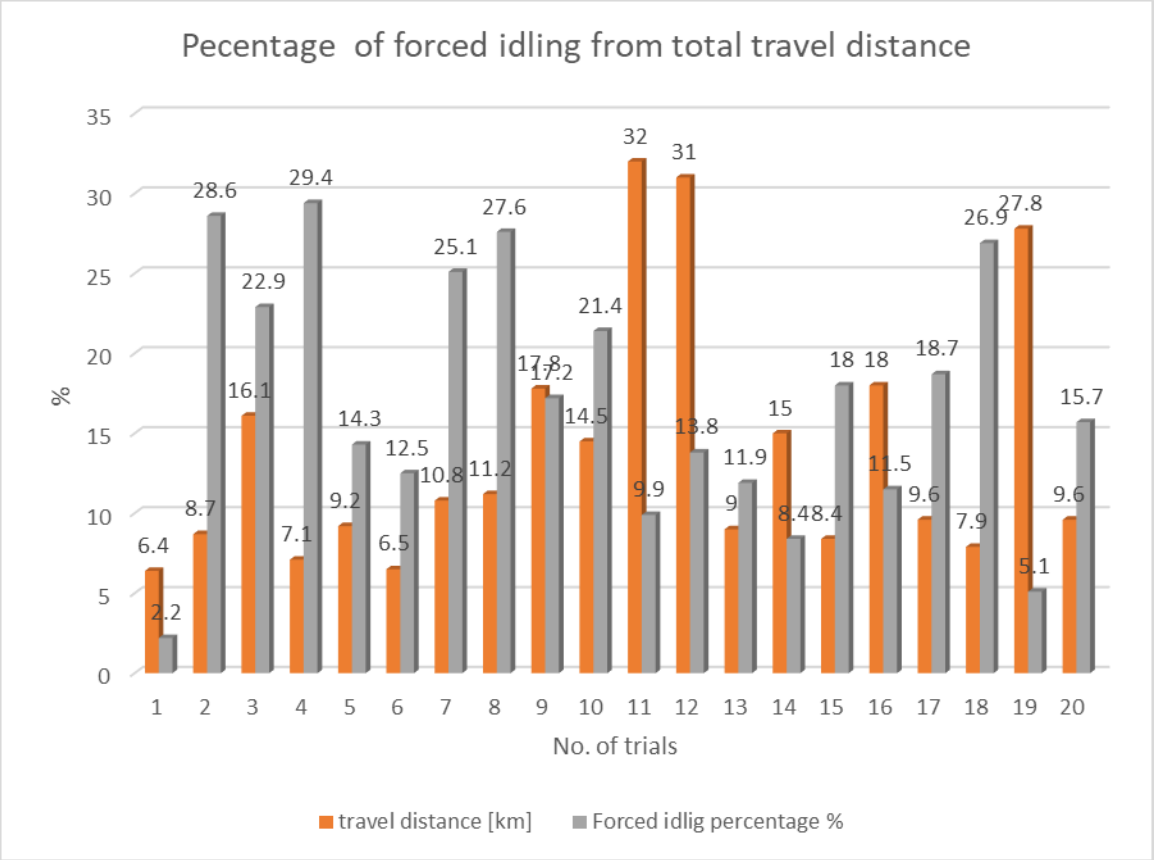

Figure 5. Percentages of forced idling from the total distance of travel

Fuel Consumption and CO/CO2 Reduction

In the case of (mode of operation), the forced empty rotation occurs, a clear increase in the car's fuel consumption occurs due to the high-vacuum that occurs in the intake duct of the car engine, which in turn works to get a greater amount of fuel and an increase in the proportion of carbon monoxide (CO) emitted with the exhaust gases coming out of the engine and the reason for this lies in the decrease in the amount of air flowing into the engine cylinders (the throttle is closed, which considered as a main condition for the car's work in the case of (forced idling).

Through the study, it was noticed that an increase in the carbon monoxide emitted by the car engine is occurred with an 8%, when the engine was running in the (mode) of forced idling condition, while the percentage of carbon monoxide when the engine was running in the other cases did not exceed 1.5%.

Also, if the engine is equipped with a forced empty rotation economizer, we are able to make the carbon monoxide emitted from the engine reach zero in the case of forced empty rotation regime.

Since the percentage of movement (travel) in the case of the forced idling rotation ranged between 5% to 27% of the total length of the journey, the percentage of fuel availability, in the case of installing the forced empty rotation economizer, would be between 15% to 20%.

Conclusion

Forced idling can achieve fuel consumption and then low emissions can be noticed, but it depends on many factors like driver skills (male, female),

road nature (mountain, highways, urban areas), and finally on travel distance.

It was found that male are better in achieving forced idling conditions, urban areas and highways are better that mountain areas and finally the travel distance and mechanical status of the car may affect the percentage of forced idling regime of the car.

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