Start-Stop Technology by using Micro-Hybrid Technology for Increasing Fuel Efficiency

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Abstract— To increase fuel efficiency and Reduce greenhouse gas (GHG) emissions by 5% each year for all new model mid-size cars, medium-duty cars, and light-duty Trucks is pushing automobile makers to convert their fleets to hybrid-electric and micro-hybrid vehicles. The national mandate set forth by the Environmental Protection Agency (EPA) implementing automated start/stop (SS) technology in a passenger vehicle is a cost effective way to improve fuel economy (FE) and to reduce Emissions without affecting consumer acceptance. In the urban areas, where much of the vehicle driving time is spentidling at Stop lights or on traffic jams, the engine can be shut down when the vehicle is stopped to save fuel. This research had been investigated the feasibility of using a micro-hybrid configuration to achieve efficient start Transients for SS technology. As the preliminary Simulation results which suggest that the traditional starter/battery combinations may be appropriate and a fuel savings of over 5% expected in regulatory urban driving cycles. The model as well as the selected component package will be used for development and control of a SS system in the test vehicle. Start-Stop vehicles, which shut off the engine at idle condition and restart the engine when the driver's release the brake pedal or presses clutch, it has been commercially available for several years and have achieved a recordable market penetration in Europe. However, they have only recently become available in the United States. Given different vehicle preferences, traffic conditions, regulatory environment and fuel prices in the U.S. market, there have been questions about the availability of Start-Stop vehicles in that market.

Key words: Start-Stop Technology, Micro-Hybrid Technology, Fuel Efficiency

I. INTRODUCTION

A ICE-electric technology is nothing but a micro-hybrid. Itmay Usually consists of an energy storage device and a strengthened starter-motor that can also act as a generator. The'stop-start' is the Main and important feature of a micro-Hybrid. According to various research & studies, in the urban areas the vehicles are at a standstill for one-third of the time. Stop-start Systems can help to reduce exhaust pipe emissions, & make cities quieter and Boosts fuel efficiency. A stopstart system operates by cutting the engine when the vehicle comes to a complete stop. The engine is automatically switch back on when the driver releases the brake pedal & presses the clutch pedal.

A first generation of alternator-based 'stop-start' system has been in serial production with Citroen, on the c4 since 2004 and on smart cars since 2007. This system performs the of stop-start that is transparent to the driver: the belt-driven Starter-alternator system shuts down the engine during idle phases and automatically restarts the engine when the driver wants to move off. As a Result, there is no fuel consumption, vibration or noise, gas emission at Standstill. By using this system in the European standard driving cycle, fuel Consumption is reduced by 6%; while in congested urban traffic, savings of up To 25% have been observed [1, 2]. However, disadvantages to this type of System can be the noticeable starting and stopping of the engine and the Inability to run major electrical. Loads such as air conditioning without the Engine restarting. When the stop/start system activated the engine is automatically turned off and goes to standby mode when the vehicle is brought to a stop at traffic Lights, stop signs and in traffic jams. The engine instantly restarts when the Brake pedal is released & the vehicle pulling away once the accelerator is Pressed. The 508 & 308 models, which will be on sale in late Octomber in Australia, will be the first mass-produced cars equipped with this innovative System. The system is combined with another leading-edge technology that already Commercially available – the electronically controlled manual gearbox (EGC).Thanks to precise metering and innovative computer control, repeatedly stop And start of the engine can reduce fuel consumption by 10 % as in city driving,6% & in a standard combined cycle and up to 15 % in heavy traffic. Co2 Emissions has thus reduced in similar proportion. And drivers to see the result in the dash board display showing total time spent with the engine is off. Start-stop vehicles, which shut off the engine at idle and restart the Engine when the driver's release the brake pedal or presses clutch, have been commercially available for several years and had achieved noticeable Market penetration in Europe. However, they have only very recently become in the United States. Given different vehicle preferences, traffic Conditions, regulatory environment and fuel prices in the U.S. market, there Have been questions about the viability of start-stop vehicles in that market.

II. GENERAL CONCEPT

As Many conventional vehicles, and the vehicles with non-hybrid power trains, are being equipped with SS. because adding SS technology to a vehicle is the lowest form of hybridization and these vehicles are classified as a micro hybrids. Companies that have SS systems on vehicles available in the U.S. market now a day's Include Audi, BMW, ford, gm, Honda, KIA, Mercedes-Benz, Porsche, Mahindra and others. Some of these systems will be reviewed here. The Ford has Introduced a SS system for their 2013 fusion vehicle that only costs $235 to Implement and has an a 18 month payback [3]. This system increases the fuel efficiency by3.5%. The only added cost comes from the addition of an upgraded starter Along with an electric hydraulic pump for maintaining the internal pressure of the Automatic transmission. The controls for the system had been closely regulating the Vehicles auxiliary loads to determine when the SSfunction is appropriate to the Use.

The controls are also use voltage blending to maintain driver acceptance When SS is enabled. The electrical system can be unmodified and uses a lead-acid12 absorbent glass mat (AGM) battery, which has become the industry Standard for the vehicles with small SS systems. To protect the battery from the advanced aging, Ford has strict controls on the battery depth of discharge (DOD) and Regulation of dynamic charge acceptance (DCA). DCA can directly affect the Amount of energy that the battery can accept during regenerative braking. BMW had implemented a SS system for its 3-series that uses the system to Perform auto start-stop function (ASSF) and regenerative braking [4]. This System can uses the traditional 12v AGM battery to gain a 3.5% increase in fuel efficiency. The electrical system that closely manages a partial battery state of charge (partial- BSOC) in order to maintain the battery life. The BSOC range is approximately 79-85%. The only additional components for the SS system is a battery sensor and a power management software module that controls the decision making Process for SS and regenerative braking. This system runs on manual Transmissions, here the engine startup and shutdown is controlled by the Driver by engaging and disengaging the clutch. The SS system along with the vehicle Road load reductions were shown to provide a 33% increase in fuel efficiency over the city drives cycle. Sophisticated control is needed for the fuel-efficient SS system that maintains consumer acceptance & offers enhance vehicle Drivability, meet emissions standards and avoid noise, vibration, and harshness (NVH) signatures due to engine start-up and shutdown. Control software mustManage regenerative braking, torque assist during vehicle launch (if used), Auxiliary load management, transmission operation, advanced start-up firing, Battery management, and SS logic algorithm.

III. LITERATURE REVIEW

In response of president obama's may 2010 directive to to reduce Greenhouse gas (GHG) emissions and fuel consumption (FE), the national Highway traffic safety administration (NHTSA) [3]. and the environmental Protection agency (EPA) are mandating an increase in fuel economy (FE) and Reduction of GHG emissions by the 5% each year for all new model mid-size cars, Medium-duty cars, and as well as light-duty trucks [3]. National mandates like this, Along with rising fuel prices, continue to push the automotive industry to improve its corporate average fuel economy (cafe). By 2025, the fleet-wide Average FE will by 54.5 miles per gallon (mpg). Midsize and medium-duty Cars will jump from 32 mpg as of 2012 to 62 mpg in 2025. The fe of light duty Trucks will go from 26 mpg in 2012 to 44 mpg by 2025. In order for new Vehicles to reach these standards, the average price of a vehicle in 2025 will increase by about $1800.

However, a family that purchases vehicle in 2025 will save $8200 in fuel costs compared to a similar automobile in 2010. Automakers are reaching out to find new ways to quickly and affordably Stretch the fuel economy of their vehicles to meet the new standards. Improvements are being made to the engines transmissions, and Auxiliary loads of conventional vehicles. Many manufacturers are beginning to produce hybridized vehicles where much of the power train architecture and Auxiliary loads of the vehicle are electrified. This increases the Vehicle efficiency because of the potential to recuperate energy that is Otherwise lost in a traditional vehicle structure. Precise control of electrified Components also minimizes losses during driving to improve overall vehicle Efficiency.[3]

Ma Xiamen developed a novel propulsion system design scheme for EVs requiring high power density. The theory analysis mathematical models of EV are first set up based on the vehicle dynamic characteristics, then the whole system is divided into seven function blocks according to power flow, the simulation models are formed in the MATLAB language. The simulation results are verified in a PDM AC-AC converter, which shows that the suggested method is suitable for EV [13].

Bauml and Simic (2008) discussed the importance of vehicle simulations in designing the hybrid electric vehicles. A series hybrid electric vehicle simulation with the simulation language Modelica was developed. They explained the simulation approach. They concluded with some of the simulation results emphasizing the simulation importance [14].

Andres Toledo, Rodrigo Felix 2017. Political and social trends in the automotive industry production and consumption have changed in the last decade, driving a demand for more efficient, low-fuel consuming, clean vehicles in most markets nowadays. Recently the demand for such vehicles has been increasing and emerging markets are no exception; automakers all around the world have invested heavily in developing new electrification technologies that would comply with the newer and stricter regulations and environmental policies, being Start-Stop systems one of the preferred approaches due to their lower complexity and cost compared to full and mild hybrids. Mexico stands out as a challenge for the implementation of this technology due to its wide range of altitudes, temperatures, traffic jams, and some other contributing factors that can hinder this type of application – especially in its bigger and more populated cities [15].

Zhongming Xu, Nengfa Tao, Ming lei Du, Tao Liang, Xiaojun Xia 2017.A coupled magnetic-thermal model is established to study the reason for the damage of the starter motor, which belongs to the idling start-stop system of a city bus. A finite element model of the real starter motor is built, and the internal magnetic flux density nephogram and magnetic line distribution chart of the motor are attained by simulation. Then a model in module Transient Thermal of ANSYS is established to calculate the stator and rotor loss, the winding loss and the mechanical loss. Three kinds of losses are coupled to the thermal field as heat sources in two different conditions. The thermal field and the components' temperature distribution in the starting process are obtained, which are finally compared with the already-burned motor of the city bus in reality to predict the damage. The analysis method proposed is verified to be accurate and reliable through comparing the actual structure with the simulation results [16].

IV. WORKING

A start-stop system used in automobiles can automatically shuts down and Restarts the internal combustion engine to reduce the amount of time of the Engine spends idling, therefore for improving fuel economy and reducing Emissions. In a typical situation the driver releases the accelerator pedal, Activates the brake paddle and the vehicle comes to a completely halt. The driver takes the Car out of the gear i.e. in neutral position.

The engine ECU can check the following conditions:

- Engine is in the idling condition and no gear is to be engaged.
- the wheel speed sensor is showing a zero speed on the display
- Electronic battery sensor is showing adequate battery charge for next start Operation of the vehicle.

When all these conditions are satisfied the engine will wait for some seconds and then switches off the engine automatically. The Starter pinion is engages in the ring gear 1 preparing for the next start cycle. This can causes the engine to be started quickly. (Ring gear is a medium carbon steel Ring with teeth, it transfer torque from the starter motor pinion to the flywheel to rotate the engine to begin the cycle.) As soon as the clutch is pressed the Starter will receives the signal to restart the engine. The engine is started quickly and quietly and is immediately ready for operation again [5]. The conditions in which the system will go to stop mode may differ with various customers

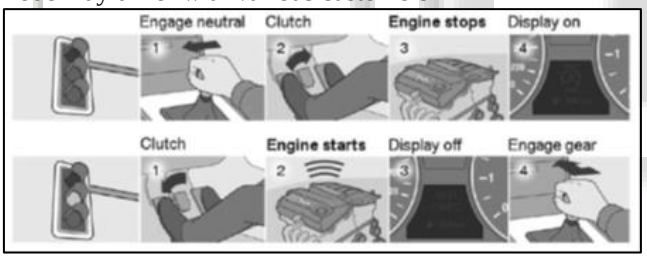

Fig. 1: Start/Stop Procedure of BMW's with Manual Transmissions

A. *Operating Details - Fuel Smart Start-Stop system*

When a vehicle is stationary and engine is at idling particularly at traffic Signals / traffic jams, considerable amount of fuel is consumed and emissions (CO2) are released to the atmosphere. With the help of stop start mechanism, the engine is automatically stopped to reduce the fuel consumption at the traffic signals / traffic Jam the engine will star tit automatically.

B. *Pre-Requisites*

- If the engine temperature at start of the ignition cycle is low, then the initial Warm up period will be around a 15 minutes. Otherwise, the warm period will be 1 minute.
- Stop-start feature is selected through selection of a switch.

C. *Condition for Stop the Of Engine*

- Engine speed is to be zero.
- Vehicle speed is to be zero.
- Gear box should be in a neutral.
- Bonnet should remains closed.

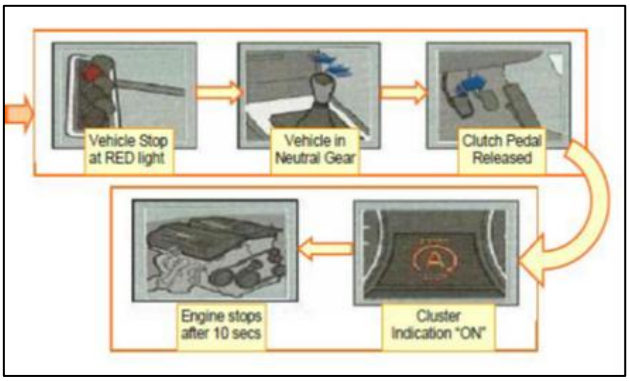

Fig. 2: Shows conditions for Auto Switch off Engine

D. *Condition for Starting the Engine*

The engine will start automatically, if all the following conditions are satisfied:

- Engine speed is to be zero.
- Vehicle speed should be zero.
- Gear box should be in neutral.
- Bonnet remains closed.
- Stop start feature is selected through selection of a switch.
- Vehicle stopped automatically due to auto stop.
- Clutch pedal is to be pressed fully.

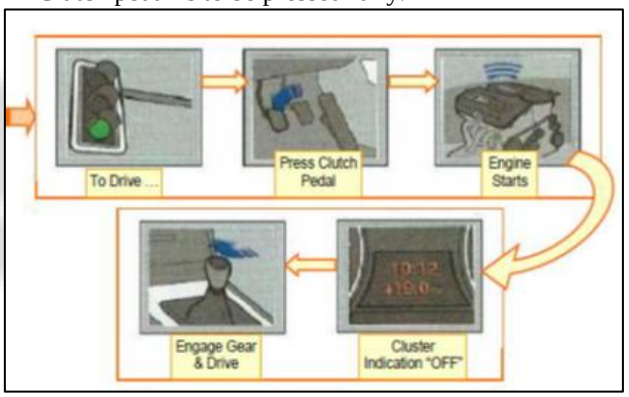

Fig. 3: Shows conditions for Auto Restart Engine

E. *Start/Stop System Components Description*

- Engine ECU - manages the start & stop system.
- CAS - car access system
- Start up motor - it is responsible for the starting of internal combustion Engine.
- Instruments panel - it can inform the driver about the status of the start & Stop system activated/deactivated.
- MSA centre console switching center
- Speed sensor –it can inform, normally through the ABS unit, of the vehicle's Speed.
- Battery sensor – it can informs the engine unit about the current entering and Leaving the battery in order to estimate the charge level.
- Bonnet switch - it can warn the engine unit of bonnet opening.
- Seat belt switch - it can indicates to the engine unit whether the seat belt is Fastened or not.
- Clutch pedal position sensor - it can Signals the pedal's position. If the leverIs slightly shifted (a hand isresting on it), the motor starts after pressing the pedal by 90%.

- Clutch pedal position sensor –it signals the pedal's position. If the gear Lever is in neutral position & the motor starts after pressing the pedal by10%.
- Brake servo vacuum sensor - it is located on the servo brake &sends a Signal proportional to the brake's vacuum.
- Neutral position sensor –it is located on the gearbox & signals the gear Lever position. After replacement, calibration needs to be carried out using diagnosis equipment.
- Automatic heat and a/c integrated climate control unit – requests Startup of the engine when it needs thermal units (a/c compressor) or calories (heating radiator) to reach the temperature selected by the Driver [6].

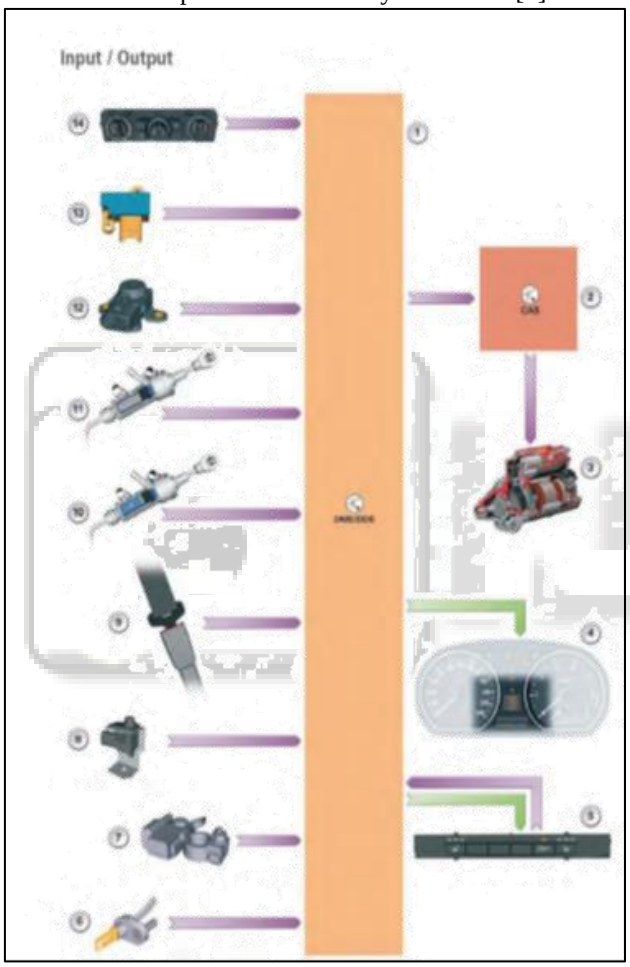

Fig. 4: Start/Stop System Component

F. Start/Stop Control

Sophisticated control is needed for a fuel-efficient SS system that can Maintains the consumer acceptance; & offers enhance vehicle drivability, it can also meet Emissions standards and avoid noise, vibration, as well as harshness (NVH) Signatures due to engine start-up and shutdown. Control software must manage regenerative braking, torque assist during vehicle launch (if used), Auxiliary load management, transmission operation, advanced start-up firing, Battery management, and ss logic algorithms

V. ADVANTAGES

- Fuel consumption is reduced up to 5% to10% in the city driving.
- CO2 emissions are reduced up to 5% to10% in city driving; and almost the same as the gain from fuel economy.
- The engine restarts within 350 milliseconds and in a complete silence.
- Eliminate engines noise and vibrations when the vehicle is at a Temporary standstill, which represents 35% of city driving time.
- Implementation cost is not very high (generally in range $300-$400)
- The engine can stops and restarts automatically

VI. LIMITATIONS

- Fuel saving is not as good as the fully hybrid.
- Some vehicle functions will not able to run when engine is off (Air Conditioner etc.) Even though the implementation is cheap,
- The vehicle manufacturer will charged huge amount for the vehicles with Start-stop systems.
- The Honda civic-hybrid has been using start-stop system since 2006.
- Volkswagen began using start-stop system with their Polo, golf & Passat_2007.
- BMW uses start-stop technology across many of its cars & mini line for 2008 there are many other vehicles which will implement the start stop in near future.

VII. FUTURE SCOPE

The Start-stop controllers are typically calibrated through an iterative Process of manually adjusting control gains until the control meets a defined Set of fuel economy, the performance and the drivability requirements. By applying Machine learning, it is possible to simultaneously optimize these factors and automatically generate a superior calibration using real data; we were able to improve the ford's existing policy 2988 by approximately 12%. This type of automated optimization is more time-efficient than a conventional manual Tuning approach. Since the policy search was conducted over the parameters that already present in ford's production start-stop controller, the updated Parameterization obtained by policy search can be directly and immediately incorporated into the start-stop controller calibration process.

The key challenge in implementing the adaptive start-stop Controller will be finding a reliable feed-forward indicator. In The future development a method for selecting one from a set of possible policies foruse online presents a more complicated path to deployment than using a single Optimized policy. The two or more policies are simply different sets of parameters that can be swapped out of in the ford's existing parameterized start-stop Controller, but determining the thresholds for switching between policies will need to be calibrated. For instance, a specialized policy might only be selected over a base policy if likehood that it will improve the performance that is greater than the 95%. & The start/stop function in automatic transmission vehicles

is straight Forward for the driver: pressings the brake pedal and once the vehicle has come to A complete standstill, the engine control unit will stop the engine, and then to restart the Engine brake pedal have to be released. as the time available for the System to restart the engine compared to a manual transmission, in which the Driver will press the clutch (declutch), engage gear and re-engage the clutch,Is a lot less. So in the essence Bosch engineers had to speed up the processes Responsible for restarting the engine.

VIII. CONCLUSION

Now a days the More than 50% of the newly registered vehicles can have start-stop as the Standard technology after 2013. Even though the technology is widely utilized for small / mid segment cars in Europe it also has high potential for compact and luxury car segments. It can be expected, that especially micro-hybrid Technology will gain increasing relevance in the coming years as technological Challenges are solved (high voltage electrical system, for e.g. 48v). The start-stop technology Is a key technology to be used in conjunction with other fuel saving Technologies to attain the stringent carbon norms of 2020.The work described in this paper included a program of qualitative Research, quantitative research and simulation modeling that all suggest that There will be significant demand for start-stop vehicles in the US.& the European experience to date has demonstrated that consumers are in general Satisfied with this type of a technology and are positively inclined toward re-purchase. The qualitative research showed that US. Consumers area almost universally did not Know about the start-stop vehicles. Markets, the quantitative research showed that many US. Consumers are willing to pay the expected additional cost of start-stop technology in Order to get the fuel savings that that technology can provide.

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