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Simulation and Testing of Urea Tank Level Detection in Diesel Engine Vehicles

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Abstract: One of the biggest issues now is reducing exhaust emissions from internal combustion engines. It may result in headaches, corroded teeth, permanently diminished lung function, eye irritation, and breathing issues. Indirectly, it can have an impact on people by harming the terrestrial and aquatic ecosystems that people depend on. Either combustion or the temperature of the exhaust stream can be treated to reduce emissions in internal combustion engines. The latter is easier in comparison because there is minimal, or no engine modification required. The goal of this project is to improve driveability by modifying the existing engine control unit to decrease exhaust emissions. Additionally, automated testing is performed, and the functional component of the exhaust system's existing design is improved to address customer concerns. ASCET, ECU Worx, Continuous Integration Dashboard, and TPT software packages simulate, diagnose, and test urea tanks used in diesel engine vehicles under particular needed conditions. The urea sprays, a degraded cause in SCR technology, have been used effectively to the fullest extent. It is only used in ships' mobile and fixed diesel engines. This technique significantly lowers emissions while also increasing efficiency.

Keywords: Selective Catalytic Reduction, Urea, Diesel Exhaust Fluid, NOx Reduction, Diagnosis.

I. INTRODUCTION

Nitrogen oxides are referred to as NOx. Although the majority also includes nitrous oxide (N2O) in this description, purists would argue that it only refers to nitric oxide (NO) and nitrogen dioxide (NO2). There are several other variations, but their atmospheric concentrations are insufficient. NOx emissions are caused by a) High temperature fuel combustion, which occurs when a fuel is burned at a temperature hot enough (above approximately 1300°C/2370°F) to oxidize some of the nitrogen in the air to NOx fumes. Burning hydrogen falls under this category since it burns at a high temperature; burning plant matter also produces nitrogen oxides because all plants contain nitrogen; and using nitric acid, nitrates, or nitrites in industrial or chemical processes will also produce NOx.

NOx gases are dangerous because; a) Nitrous oxide (N_2O) is defined as being 298 times as bad as CO_2 because of its radiative effect, and the time taken to break it down. For people who are lacking, the reaction with vitamin B12 could be problematic. It degrades in the stratospheric layer and aids in the ozone's decomposition rays must be absorbed by ozone in the upper atmosphere because they are dangerous if they reach the earth's surface; b) nitric oxide (NO), which easily oxidizes in the atmosphere to nitrogen dioxide and is non-toxic in small amounts; and c) nitrogen dioxide (NO2), a major pollutant and a main ingredient in smog. It produces nitric acid when it combines with water, which is why it irritates the respiratory system and eyes so badly.

Today, there is no question that air pollution poses a serious threat to everyone's health.
Nearly every nation is struggling with this issue. Over time, several nations modified technology and crisis management tactics in response to the threat posed by decreasing air quality. Environmental change as a result of a rise in global temperature has demonstrated the severity of the problem. In the United States, Europe, China, and many other places, problems with ozone and nitrogen oxides in the air are of great concern.

There is a need of some technique to cut back emission of pollutant in diesel engines. By introducing Selective Catalytic Reduction (SCR) technique it will be provided higher efficiency and reduced emissions. A sophisticated active emissions management device called selective catalytic reduction (SCR) injects a liquid reductant into a diesel's exhaust stream via a unique catalyst. Diesel exhaust fluid, often known as automotive-grade urea, is occasionally used as the reducer supply (DEF). The DEF ignites a chemical reaction that transforms nitrogen oxides into nitrogen, water, and trace amounts of carbon dioxide (CO2), which are then ejected through the vehicle pipage.

Today most of the transport vehicles in countries like India where value effective is that the predominant criteria utilize diesel engines instead of the gasoline engines. However, it's some disadvantage conjointly, like because of hot temperature in combustion chamber ends up in formation of NOx and material that is harmful to human likewise as atmosphere.

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An air and fuel mixture is fed into the combustion chamber of an internal combustion engine. Spark plug, an electrical gadget, is then used to compress and ignite this. In a diesel engine, air is pumped into the cylinder and compressed by roughly twice as much as it would be in a gasoline or extremely petrol engine. Once the fuel is injected, the heat produced by this compression causes it to spontaneously burn. Diesel fuel generates a lot of energy from a given volume despite having a lower calorific value than gasoline or other fuels.

II. EXHAUST SYSTEM

The exhaust system was initially designed as a simple duct system with the intention to safe route the toxic exhaust gas emissions from our car into harmless gases to the environment at the same time providing attenuation of noise made by the engine during combustion. Today, over the years the responsibility of exhaust system has grown. Modern exhaust systems are an integral part of combustion and pollution control thereby reducing noise, minimize harmful emissions and even give assistance in increasing fuel economy, power and hence the overall drivability. The main parts of the exhaust system cooperate to remove emissions, lessen noise, and promote smoother operation of the moving parts. Although the emission control systems may vary based on the manufacturers and the vehicles, they all are designed to meet the same goal and they work on the same principle.

The primary design consideration of an exhaust system includes:

- Minimizing the gas flow resistance and confine it to specified range depending on the engine model to achieve maximum efficiency.
- Suppressing the exhaust noise to meet the automobile regulations and requirements.
- Providing sufficient clearance between exhaust system components and engine components so as to minimize the impact of high exhaust temperature.
- Ensuring that the system does not overstress engine components with excess weight as overstressing can shorten the component life.
- Ensuring that the exhaust components are able to reject heat energy as intended.

The following elements make up the exhaust system typically:

• After-treatment tools to reduce the pollutants released, like particulate filters and catalytic converters.

• Mufflers to reduce noise.

• Components that serve as a decoupling link between the exhaust manifold and the rest of the exhaust system.

• Hangers and piping

The "hot end" of the exhaust system is the after-treatment equipment and its piping, while the "cold end" is made up of the muffler and tailpipes. The "down pipe" or "front pipe" that joins the exhaust manifold with the catalytic converter, as well as the pipework between the catalyst and the particle filter, may be included in the hot end pipe. The "middle pipe" joins the muffler and the after-treatment system. The exposure to requirements and chemical exposure affects the material choice for the exhaust system.

The exhaust manifold often thought to be a part of engine is the key component of exhaust system that collects all the exhaust gases from the combustion chamber to the exhaust pipe. The design of exhaust manifold has a major influence on the torque and performance characteristics of the engine. The flexible joint follows, which minimizes engine movement transmission to the exhaust system. It typically sits between the catalytic converter and manifold. Hence it must withstand high temperature and it should be durable and strong.

The catalytic converter is another important component in the exhaust system that is installed between the manifold and muffler in the exhaust line. It makes use of chemicals that act as a catalyst. Prior to exiting the exhaust system, a catalytic converter causes a chemical interaction between the pollutants in the exhaust, without causing any damage to the pollutants themselves.

The IC engines usually make a whole lot of noise while operating. This noise reduction is achieved through well designed mufflers. Mufflers make use of the principle of reactive silencing which is an application of wave cancellation technique to tune out certain frequencies that are hash to our ear. By choosing appropriate design parameter we can achieve tuning for a specific range of frequencies. Since a muffler can't reduce the engine noise by itself add-on features such as resonator is included in the exhaust system. A typical resonator is a hollow steel cylindrical tube attached to the muffler. They both work together to decrease the exhaust noise. Finally comes the tail pipe that is designed to serve as an enclosed route for the exhaust emissions to exit the system.

With the emission reductions strategies being more stringent, major technologies are deployed to reduce emissions. Some of them include:

2.1 OXIDATION CATALYST

The oxidation catalyst sown in Fig 1, can cut CO and HC emissions by more than 90% and harmful HC emissions by more than 70%. Toxic by-products are created when there is not enough oxygen present in an internal combustion engine to oxidize carbon fuel into carbon dioxide and water. The redox conversion of toxic fuel by-products into less dangerous compounds takes place in catalytic converters. It is made up of a steel housing, a ceramic or monolith honeycomb interior, and a metallic substrate. Platinum (Pt), palladium (Pd), and rhodium are combined to form the honeycomb structure, which maximizes the surface area for greater reaction to occur (Rh).

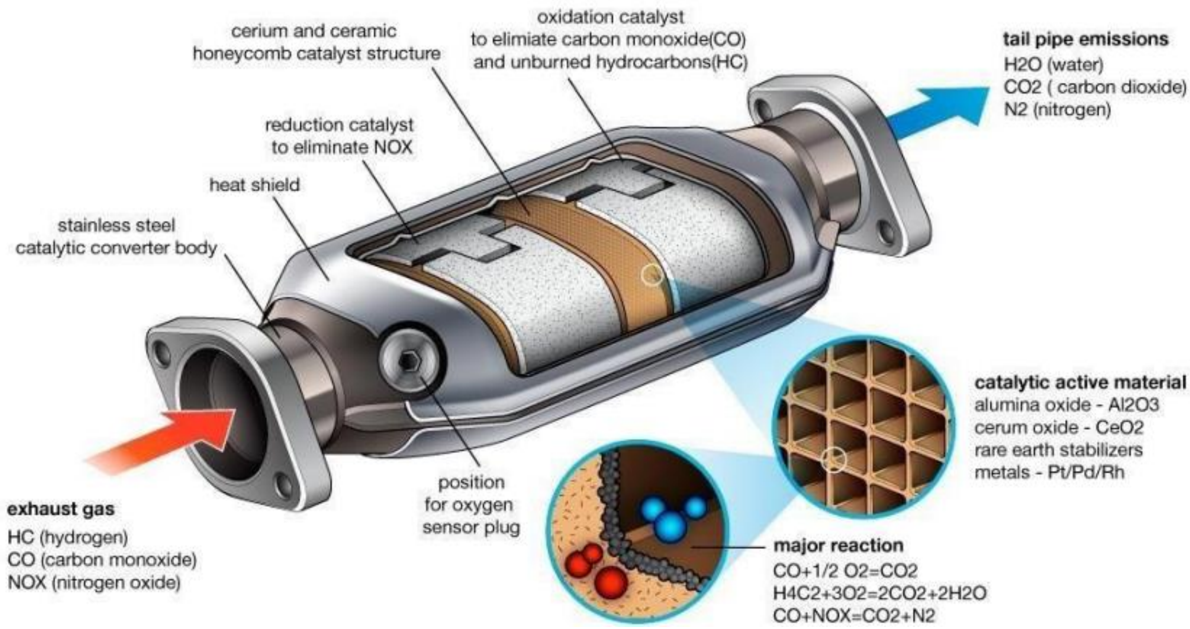


Fig – 1: Oxidation Catalyst.

The catalyst initially starts a reduction reaction to reduce nitrous oxide. The nitrogen atom in nitrous oxide is eliminated as it passes through the Pt and Rh catalyst, allowing free oxygen to produce oxygen gas O_2. The nitrogen atom then interacts with other nitrogen atoms linked to the catalyst to produce nitrogen gas N_2. In the second stage, an oxidative catalyst made of Pt and Pd is used to regulate carbon monoxide (CO) and unburned hydrocarbons (HC). Carbon dioxide (CO_2) is created when carbon monoxide (CO) combines with oxygen in the air, and water is produced when hydrocarbons are oxidized (H_2O). Water is formed when hydrocarbons are oxidized, and carbon dioxide (CO_2) is made when carbon monoxide (CO) and oxygen in the air combine (H_2O). When it comes to decreasing emissions from gasoline engines, catalytic converters are dependable and effective.

When coupled with diesel engines, which operate more coolly than gasoline engines, they are less effective. Higher temperatures are ideal for catalytic converter operation. Particles like soot will also be produced by diesel engines. Thus, combining a particulate filter and a catalyst can cut down on ultra-fine particle emissions by up to 99 percent.

2.1 PARTICULATE FILTERS

To comply with particulate matter emission restrictions, the particulate filters in Fig 2, are fitted (PM). Particulate filters eliminate particles smaller than 100 nm that are made up of carbon, ash, and unburned hydrocarbons. Since the filter's capacity is limited, the trapped soot increases flow resistance, necessitating its emptying or burning off in order to replenish the DPF. The extra soot particles that gathered in the filter after about 800 to 2000 kilometers of driving are thoroughly burned during the regeneration process. At temperatures above 600 °C, the deposited soot is then burned off together with the exhaust fumes. Since this temperature is typically not attained during routine driving, the exhaust temperature is raised through post-injection, delayed main injection, and throttle valve air mass reduction. The exhaust outlet valve's temperature then rises as a result. The temperature is also raised by the exothermic reaction of unburned hydrocarbons in the oxidation catalytic converter. The particle filter is often placed close to the exhaust manifold and frequently used in conjunction with an oxidation catalyst in order to prevent significant heat loss.

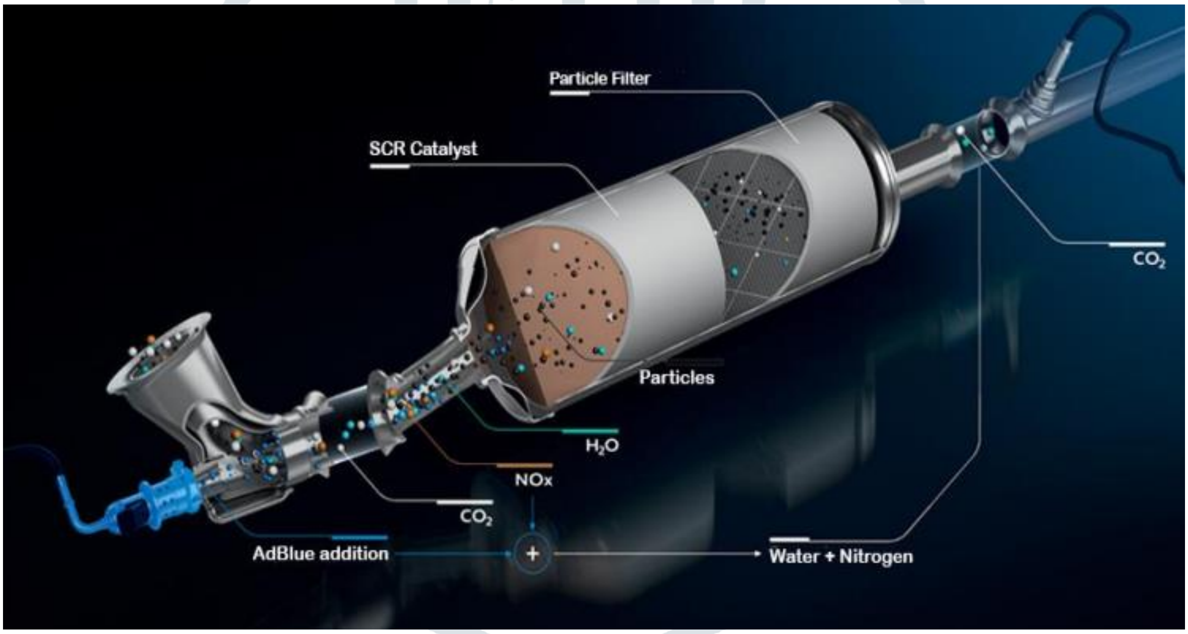


Fig - 2: Particulate Filter.

2.3 EXHAUST GAS RECIRCULATION

Exhaust gas recirculation (EGR), which reduces the oxygen content in the combustion chamber and absorbs heat, is an efficient method for reducing NOx emissions. By using the inlet system, it is a technique for returning some of the exhaust gas to the combustion chamber. By providing inert gases to the combustion process and limiting the amount of oxygen present in the incoming air stream, this lowers the peak in-cylinder temperatures. Fig 3 is a schematic illustration of an EGR system. When air oxygen and nitrogen are combined at high temperatures in the combustion chamber, which typically happens at peak cylinder temperature, NOx is formed. The composition of the gas introduced into the cylinder during the engine cycle will change as a result of the mixing of exhaust gas with intake air. Significantly less oxygen will be present, but more CO2 and water from burning will be produced. A drop in the peak temperature of the diesel combustion flame is the main factor causing EGR's NOx reduction impact.

The exhaust gas added to the oxygen, fuel and combustion products will increase the specific heat capacity of the cylinder which lowers the adiabatic flame temperature. A properly operating EGR can increase the engine efficiency. Automotive exhaust system is one of the inevitable parts of combustion and emission control system that is designed to perform one or more of the following functions: remove solid materials from the exhaust gas, muffle the exhaust noise, quench sparks and furnish energy to a turbine-driven supercharger. Thus, keeping our exhaust system in better working condition is vital for fuel consumption, safety and environment. The durability of the exhaust is crucial.

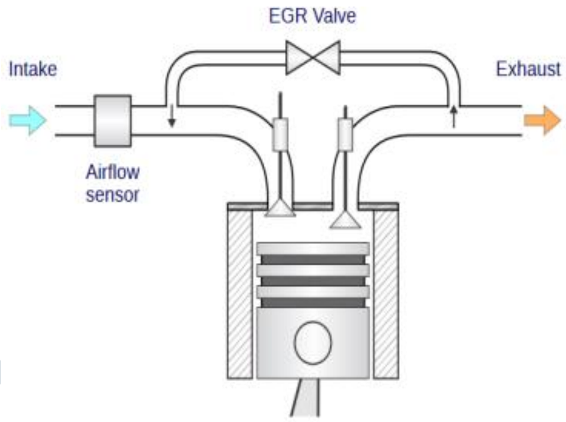


Fig – 3: Exhaust Gas Recirculation.

III. ENGINE ECU

Before the automotive industry adopted electronics, cars were thought of as mechanical machines. Through the principle of mechanics, every component in a vehicle, from the engine to the window, brake, and steering, was mechanically driven on gears. However, the inherent limitations and poor accuracy of these mechanical systems led to undiscovered failures and a high risk of harm to the users. These restrictions made it possible for the car industry to innovate more effectively. This finally resulted in the use of electronics in vehicles.

Since its introduction to the automotive industry in 1970, automotive electronic control units (ECUs) have grown to be a significant part. It has been crucial to the evolution of the automobile from a wholly mechanical to an electronic-dominant machine. To control and regulate the functionality, modern cars feature around one hundred embedded or fitted ECUs.

The electronic control unit (ECU) seen in Fig 4, is a computer with inbuilt programmable and pre-programmed chips that uses microprocessors and sensor data that may be processed to conduct real-time control of a number of actuators. For the gearbox, traction control or ABS, body functions, lighting control, AC, engine, air bags, and other sections of the car, there are numerous distinct Ecosite power train, body control, and chassis system are the three main units for which an automotive ECU can be used. The ECU, which is a component of the Power-train Control Module (PCM), is in charge of controlling the combustion process, including opening and closing the inlet or outlet valve in response to input from the accelerator pedal.

The ECU regulates the timing of the fuel injection rate and spark ignition. Thus, compared to vehicles with mechanical controls, ECUs produce accurate synchronisation and increase power, efficiency, and functionality. Sensors have a significant impact on how an ECU function. Instead of sending numerous wires from the sensor to various ECUs, the ECU will share information with other ECUs over communication network lines for control operations. Most vehicles include an OBD connector that the ECU uses to transmit all diagnostic data to all other ECU modules.

Fig – 4: Engine ECU

Government regulatory bodies have imposed strict restrictions on the emission levels from automobiles hence OEMs are responsible for implementing emission controls in automobiles. Implementing such restrictions would have been a mission impossible without the use of ECUs and software algorithms. With automation the regulatory bodies are able to respond to emergency situations in a better way. Also, with the advancement in mobile phones, car manufactures had slowly transformed car with the explosion of electronics to introduce web connectivity, smart devices and navigation control.

Astonishing amounts of data are processed by an ECU. To obtain maximum performance, a number of operations must be carried out simultaneously. With the aid of sensors, the ECU enables the processing of all the data that the engine receives. The automakers can configure the ECU in such a way that some car models have very smooth rides while others have a more racing-inspired feel. ECU thus enables us to have these two unique traits in a single car. To accommodate greater and better performance, ECUs are periodically reset. Thus, the performance provided by the ECU makes driving more enjoyable than difficult.

IV. DIESEL AND GASOLINE SYSTEM

The development of the gasoline engine marks the beginning of the diesel saga. The four-stroke combustion principle known as the "Otto cycle" was created by Nikolaus August Otto, who also received a patent for the idea. In the beginning, gasoline engines weren't very efficient because only 10% of the fuel they used actually moved the car. The remainder was transformed into waste heat. After learning about the inefficiency of gasoline engines, Rudolf Diesel was motivated to develop an engine with improved efficiency. He spent a significant amount of effort developing a "combustion power engine. "Diesel was able to patent a diesel engine by 1892 as a result.

Diesel and gasoline engines are conceptually pretty similar. They are IC engines made to transform fuel's chemical energy into mechanical energy. The pistons inside the cylinders are then moved up and down, creating a linear motion, using this mechanical energy. To turn the wheel forward, a rotary motion is produced by a crankshaft that is coupled to the pistons. A gasoline and diesel engine's explosion process is depicted in Fig 5. Both diesel and gasoline engines use a sequence of explosions or combustions to transform fuel into mechanical energy. But how these explosions happen makes a significant difference. Fuel and air are combined in gasoline, which is then compressed by pistons and ignited by sparks from spark plugs. In a diesel engine, the fuel is injected after the air has been compressed. Compression warms the air, which causes the fuel to ignite.

The following is how an explosion happens in a gasoline engine:

1) Intake stroke – Here, gasoline and air are combined.

2) Compression stroke — Piston rises, compressing the air-fuel mixture.

3) The air-fuel mixture is ignited by a spark plug during the ignition stroke.

4) The piston rises and pushes the exhaust out the exhaust valve during the exhaust stroke.

The following is how an explosion happens in a diesel engine:

1) The intake valve opens and fills with air during the intake stroke.

2) Air is compressed during the piston's upstroke during the compression stroke.

3) The air-fuel mixture is ignited once fuel is introduced into the engine.

4) The piston rises and pushes the exhaust out the exhaust valve during the exhaust stroke.

Spark plugs are not used in diesel engines. To produce the high temperatures required for fuel ignition, they require high compression ratios. Of comparison to a gasoline engine with a ratio of 8:1 to 12:1, the compression in a diesel engine with a ratio of 14:1 to 25:1 is significantly higher. Higher thermal efficiencies and improved fuel economies are produced by higher compression ratios. The engine's compression ratio is constrained by the compression of the air-fuel mixture. The air-fuel mixture ignites spontaneously and creates knocking, which might harm the system, if there is more air compression.

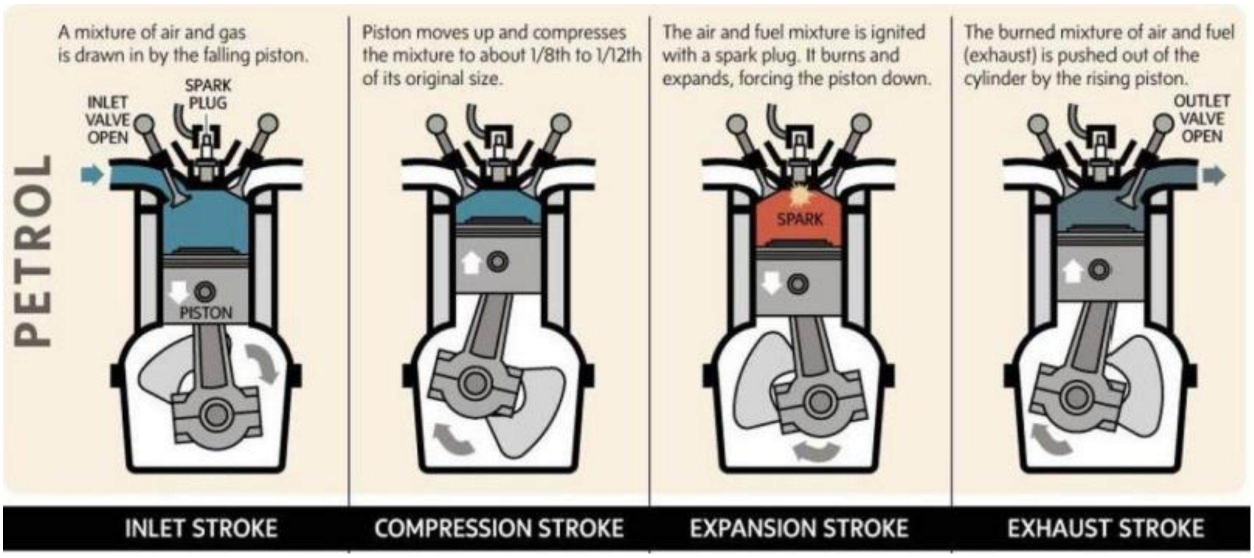
An essential part of a diesel engine is the injector. It ought to be able to withstand the pressure and heat inside the cylinder while dispensing the fuel as a fine mist. Glow plugs are used in some diesel engines to warm the combustion chamber and increase air temperature when the engine is cold.

Today, a complex system of sensors measuring everything from RPM to engine coolant and oil temperature and TDC is used to operate every function of a contemporary engine. On contemporary engines, glow 27 plugs are rarely used. ECM detects the temperature of the surrounding air and delays the engine's timing so that the injector sprays fuel later. As a result, the air is compressed more and produces more heat, which helps the engine start.

Diesel and gasoline engines show a number of development paths for better torque generation, fuel efficiency, emission control, and noise reduction.Improved driveability features, increased specific power, better noise attenuation, decreased fuel consumption and CO_2 emissions, decreased specific emissions (HC, NOx, CO, particulates, and dust), reduced friction, and effective exhaust after treatment systems are some of the most recent engine technology advancements.

Engines are equipped with mechatronic parts such electronic throttle intake systems, high-pressure common rail injection systems with solenoid or piezoelectric injectors, VVT, VGT, and variable camshafts to increase their variety and control functions. These parts can be categorised as electrical, pneumatic, or hydraulic actuators, solenoid and switching injection valves, electrical drives, pumps, and fans.

While some of these are controlled centrally by an ECU, others are controlled locally by sensors that are incorporated locally. The development of hybrid drives, which improve fuel efficiency and reduce pollutants, is a cutting-edge step in the electrification of automobiles. All of these developments suggest that electronics will continue to increase rapidly and that mechatronic design will generally improve. The proliferation of electronic components emphasises how important fault diagnosis functions are



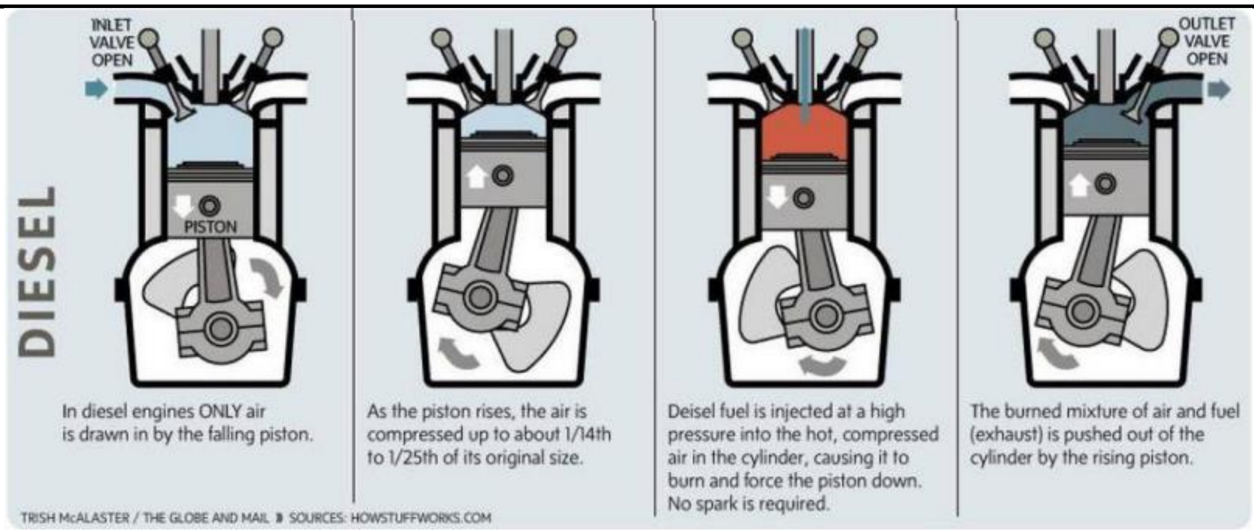


Fig – 5: Gasoline and diesel engine.

V. SCR WORKING PRINCIPLE

The essential parts of the urea SCR system are represented schematically in Fig 6, together with the DOC (Diesel Oxidation Catalyst), DPF (Diesel Particulate Filter), DEF (Diesel Exhaust Fluid), and SCR. Engine exhaust is sent to DOC, where the hydrocarbons are transformed into carbon particles. The DPF gathers and preserves the carbon atoms. These soot particles are frequently burned. SCR uses alkali and NH3 as a reductant to lower NOx emissions in the exhaust gas. DEF is an aqueous solution that is sprayed into the exhaust stream to reduce NOx. It contains 32.5 percent urea and 67.5 percent deionized water. It was discovered that DEF usage accounted for 2% of gasoline consumption.

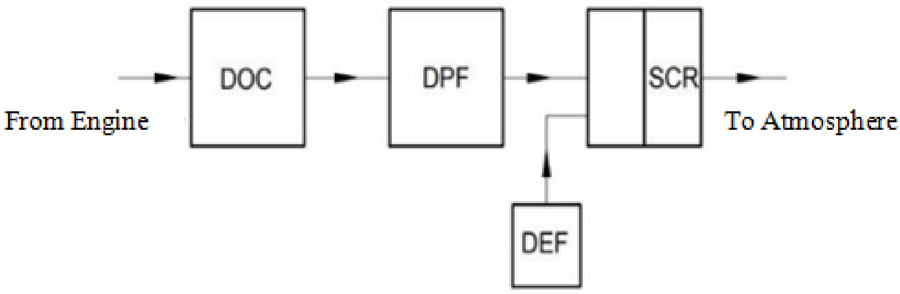


Fig – 6: Schematic diagram of urea SCR.

Pollutant emissions from diesel engines, such as soot (also known as particulate matter, or PM), and NOx, typically exceed the legal limits. Recent research has shown that cutting these pollutants by more than 46 to 90 percent is possible with sophisticated diesel aftertreatment systems. More than 90% of the particulate matter (PM) in the exhaust gas from a diesel engine can be captured by a DPF, also known as a catalytic particulate filter (CPF). The DPF removes CO and CO2 after oxidising the particles it has caught using the thermally aided and NO2-assisted reactions described in Equations. (4) and (6). DPF regenerations are the common name for these procedures.

5.1 CHEMICAL REACTIONS INVOLVED

Urea breaks down into ammonia and isocyanic acid when DEF is injected into the exhaust stream because of the exhaust temperature.

$(NH_2)CO(NH_2)\ (\text{molten}) \rightarrow NH_3 + HNCO$ ……. (1)

Ammonia and carbon dioxide gases are created as a result of the hydrolysis of this isocyanic acid.

$HNCO + H_2O \rightarrow CO_2 + NH_3$ ……. (2)

Oxides of nitrogen are now reduced by ammonia in the presence of oxygen and an SCR catalyst

$4NH_3 + 4NO + O_2 \rightarrow 4N_2 + H_2O$ ……. (3)

$8\ NH_3 + 6NO_2 \rightarrow 7N_2 + 12\ H_2O$ ....…. (4)

$4\ NH_3 + 2NO + 2NO_2 \rightarrow 4N_2 + 6\ H_2O$ ……. (5)

$2\ NH_3 + 2NO_2 \rightarrow NH_4NO_3 + N_2 + H_2O$ ....… (6)

Equation (1) demonstrates how the high temperature of the exhaust causes molten urea to break down into ammonia and hydrocyanic acid. Ammonia and carbon dioxide are the major by-products of the isocyanic acid hydrolysis shown in equation (2). These two reactions take place without the need for a catalyst. Equation (3) represents the typical reaction in which oxygen and the equal amounts of ammonia and NO are involved. The quick and slow SCR reactions are shown in equation (4). At temperatures below 2000 C, ammonium nitrate is formed as a result of some unfavourable reactions.

Numerous competitive & nonselective reactions with oxygen, which is plentiful in the system, are among the undesirable activities that take place in SCR systems. These reactions can either result in additional emissions or, at worst, use ammonia ineffectively. Nitrous oxide (N_2O) or elemental nitrogen may result from the partial oxidation of ammonia, as shown in Equations (7) and (8). Nitric oxide (NO) is produced by the complete oxidation of ammonia, as demonstrated by Equation (9).

$2NH_3 + 2O_2 \rightarrow N_2O + 3H_2O$ …......... (7)

$4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$ ………. (8)

$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$ ………. (9)

The ammonia injection rate needs to be precisely controlled for the SCR process. Low NOx conversions due to insufficient injection may be unacceptable. Unwanted ammonia is released into the atmosphere when the injection rate is too high. Ammonia slip refers to these ammonia emissions from SCR systems. At greater NH_3/NOx concentrations, the ammonia slip increases. The stoichiometric NH_3/NOx ratio in the SCR system is around 1, according to Equation (2), which describes the primary SCR reaction. The ammonia slip is greatly increased by ratios greater than 1. In reality, ratios between 0.9 and 1 are employed to reduce ammonia slip while maintaining sufficient NOx conversions.

It is clear from the chemical reactions discussed above that NO_2 is crucial to the reactions taking place inside DPFs and SCR catalysts.The presence of NO_2 can hasten the regeneration of the DPF, and a higher NO_2/NOx ratio (but not more than 50%) can hasten the effectiveness of the SCR's NOx conversion.Although NO makes up the majority of the NOx composition of diesel engine exhaust, it is known that a higher NO_2/NOx ratio is advantageous for DPF PM removal and SCR NOx reduction.

Due to this property, diesel oxidation catalysts (DOCs) are frequently utilised upstream of DPFs and SCRs to increase their performance. DOCs catalyse the conversion of a portion of NO to NO_2 and can result in a greater NO_2/NOx ratio than engine-out exhaust.Figure 2.2 depicts a typical configuration for a diesel engine's aftertreatment system (DOC-DPF-SCR).One of the key factors in the performance analysis of SCR NOx conversion is the effectiveness of NOx conversion in diesel engine cars.SCR NOx conversion = [1 – (NOx out/NOx in)] 100% provides the answer.

VI. WORK ENVIRONMENT

The details of the various software used to carry out the proposed work is as listed below:

6.1 DESIGN AND CODE GENERATION IN ASCET

Advanced Simulation and Control Engineering Tool is referred to as ASCET. It is a multifaceted and adaptable product family that offers an original approach to the functional and software design of contemporary automotive embedded systems. With a fresh take on modelling, code generation, and simulation, ASCET supports each step of the development process, enabling improved quality, quicker innovation cycles, and lower costs. ASCET makes it simple to blend text and visuals to meet our programming requirements. Our logic can be modelled in a variety of ways, allowing us to operate as effectively as we see fit.

As a result, we have four specification options.:

1) Graphic specification using Block Diagram;
2) Graphic specification using State Machine Editor;
3) Textual specification using ESDL Editor;
4) Textual specification using C Code Editor

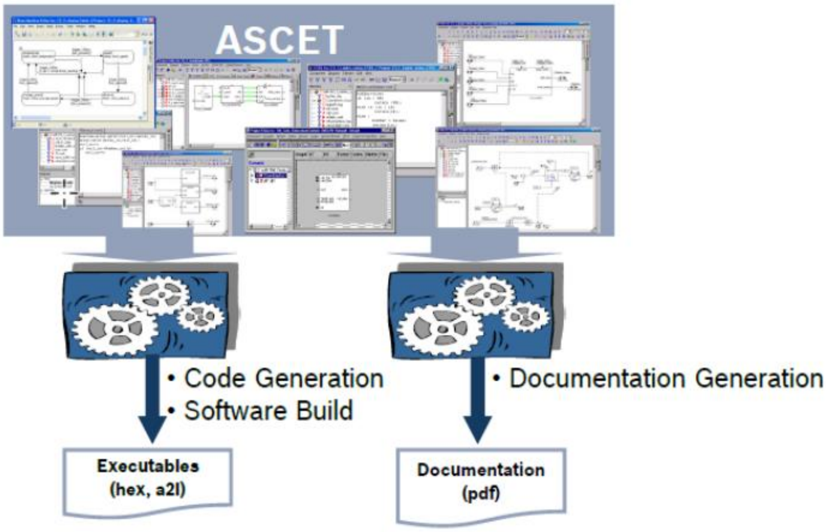


Fig - 7: Working of ASCET tool.

ASCET tool operation is depicted in Fig 7. Using graphical models and textual programming notations, ETAS ASCET is a tool for creating software for embedded systems. The created function models will be converted by the ASCET Code Generator into extremely effective and secure embedded C-Code for AUTOSAR applications.

The ASCET has been specifically created to meet the difficulties in software development for sectors where goods must be produced in large quantities, at a lower cost, in compliance with industry standards, and without any flaws. The ASCET tool gives software engineers the ability to create embedded software that is high performing, low overhead, simple to maintain, secure, and safe. High levels of automation enable productive and safe workplaces.

The ASCET tool for Automotive Software Development has the following features:

- Safe – Automatic introduction of defensive code, ISO26262 and IEC61508 TUV-certified code generation, MISRA-C:2012 compliance.
- Proven in usage – Used for brake systems (such ABS, ESP), powertrain, generation, compliance with MISRA-C:2012 Proven in use – Used for brake systems (such ABS, ESP), powertrain, Driver assistance, Battery management, 450+ million ECUs on the road are powered by ASCET produced code.
- Flexible – Multiple specification notations, Block diagram, state machine, textual editor for ESDL, and C-code editors.
- Quick and effective — Real-time static analysis for quick feedback, quicker code creation.
- A variety of testing alternatives, including unit testing, PC-based open-loop simulation, closed-loop simulation, and rapid prototyping.
- Embedded Software Development Language (ESDL), which has an abstract data type, easy-to-understand syntax, and object-oriented encapsulation.

6.2 DOCUMENTATION IN ECU WORX

ECU Worx is software used to custom tools for tuning and modifying the Electronic Control Unit used in cars and other passenger vehicles. In this software, the documentation containing all the details of the project is prepared and necessary changes if required can be modified. Also, a DLL; Dynamic Link Library file can be generated in ECU Worx. A DLL is a library that has data and code that can be utilised by several programmes at the same time. By using a DLL, a program can be modularized into various separate components. The example of ECU Worx software is as shown in Fig 8.

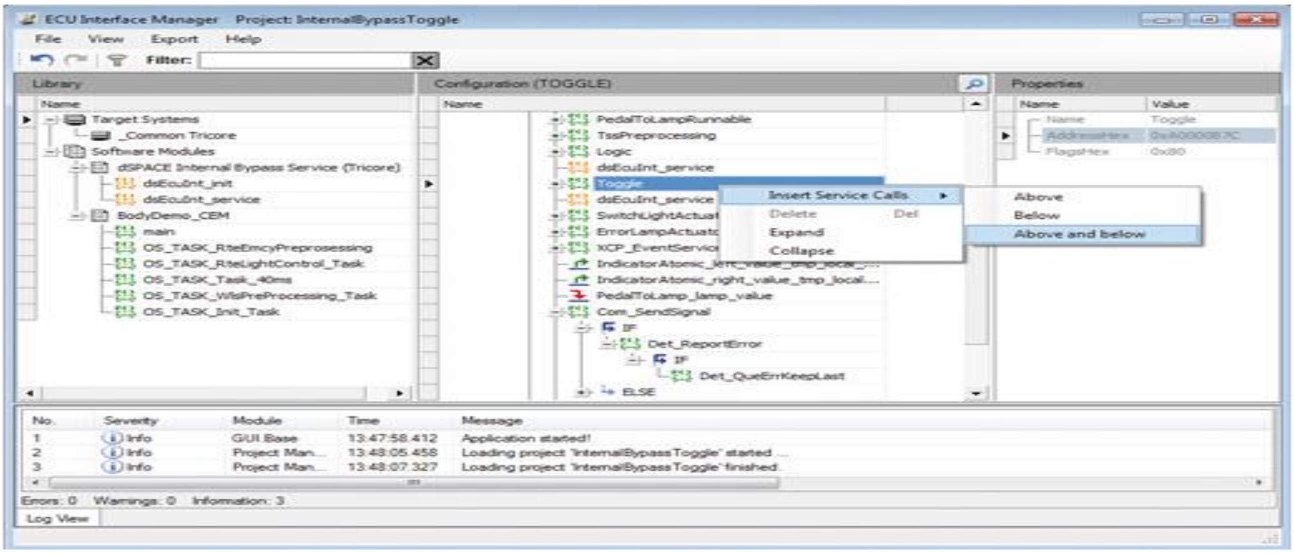


Fig - 8: Example ECU Worx software image

6.3 SOFTWARE BUILD IN CI DASHBOARD

The Continuous Integration dashboard displays key metrics for builds that can be used to gain insight into the organization's build throughput and to bubble up any of the potential build issues. The Continuous Integration dashboard provides indicators to measure the agility of development. An example image of CI dashboard is as shown in Fig 9.

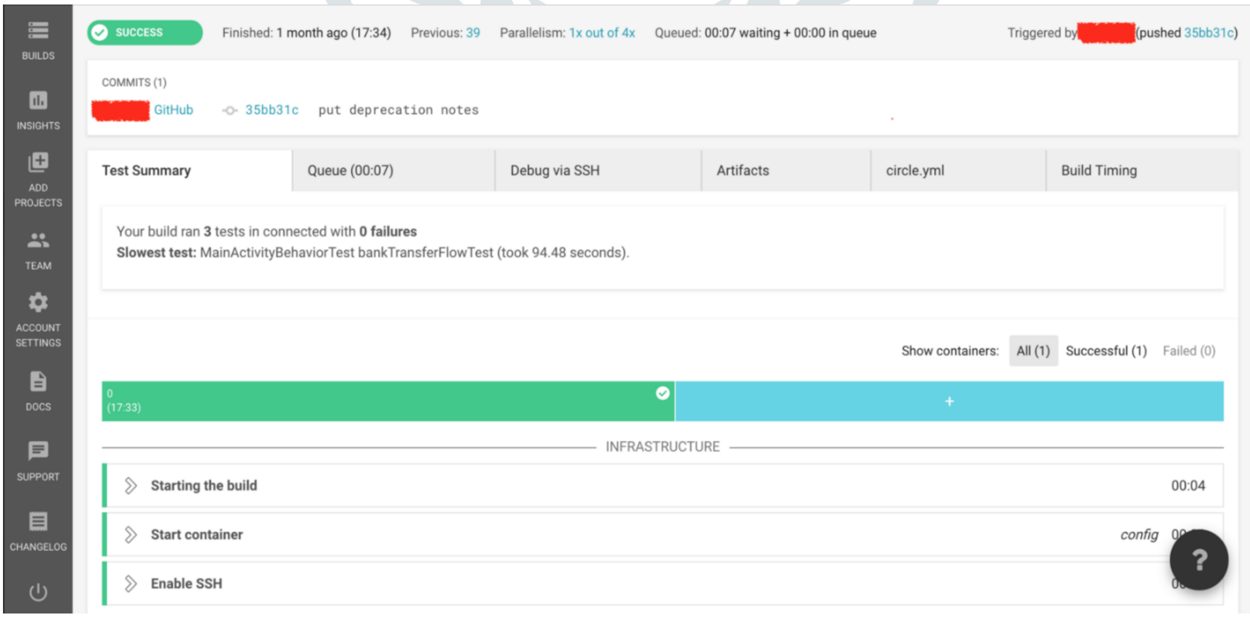


Fig - 9: Example CI dashboard software image.

6.4 TESTING IN TPT

Piketec's Time Partitioning Testing programme is known as TPT. With TPT, one may test embedded control systems and ECU software during all phases of development, including model-in-the-loop (MiL), software-in-the-loop (SiL), processor-in-the-loop (PiL), hardware-in-the-loop (HiL), and ECU and vehicle testing. TPT offers special tools to help you write those tests freely and easily, whether you're creating a basic module test or a comprehensive system test. Fig 10, displays an illustration of a TPT software image.

VII. DESIGN REQUIREMENTS

1. There are no sensor related errors.
2. Tank temperature is above threshold freezing temperature.
3. Environment temperature is above threshold value.
4. Vehicle speed below a threshold value.
5. Bit mask the above conditions.
6. Validate the level sensor signals.
7. Set or reset of total number of evaluations based on release conditions.
8. Fault check diagnosis should be reported accordingly.
9. Compute number of times the error is set, and this should be available between different driving cycle.

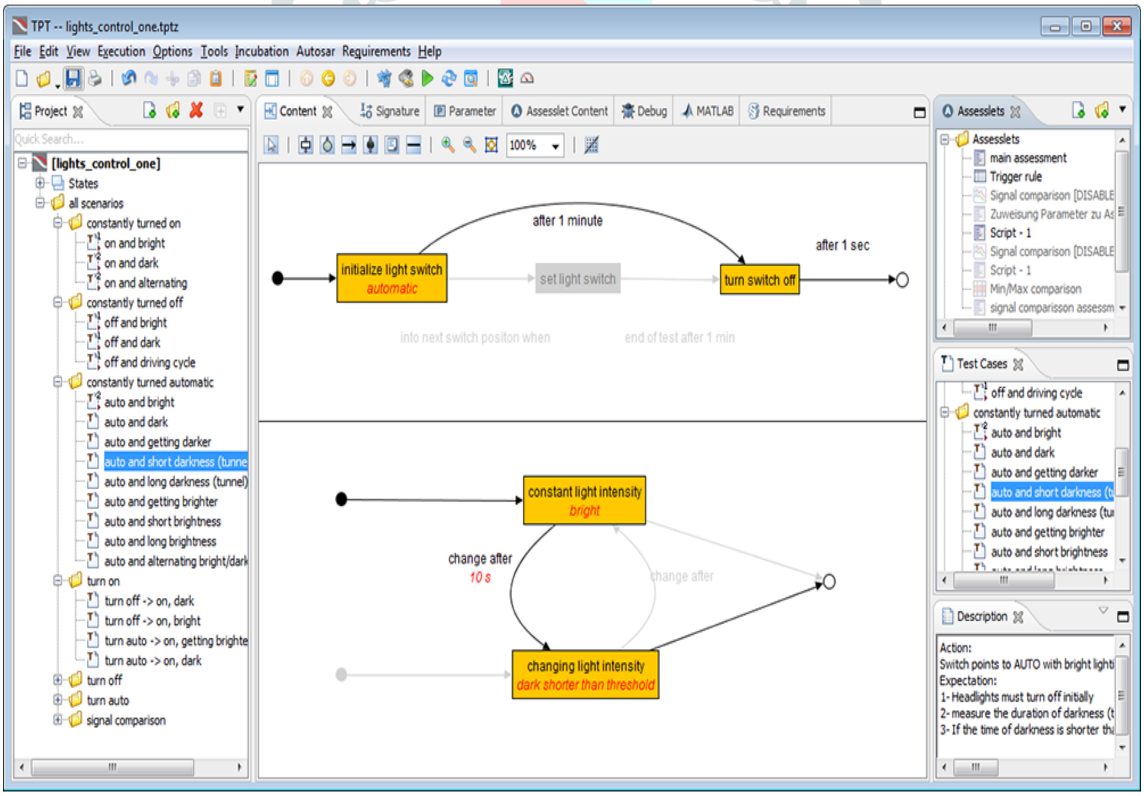


Fig - 10: Example TPT software image.

VIII. BLOCK DIAGRAM

The block diagram of the urea tank level detecting system used in diesel-powered cars is shown in Fig 11. A block diagram is used to show the fundamental design in accordance with the particular conditions specified by the client. The block diagram shows the interconnection of the numerous sensors as well as the timer and counter for the various fault checks, continuous monitoring, reporting, diagnostics, and data storage.

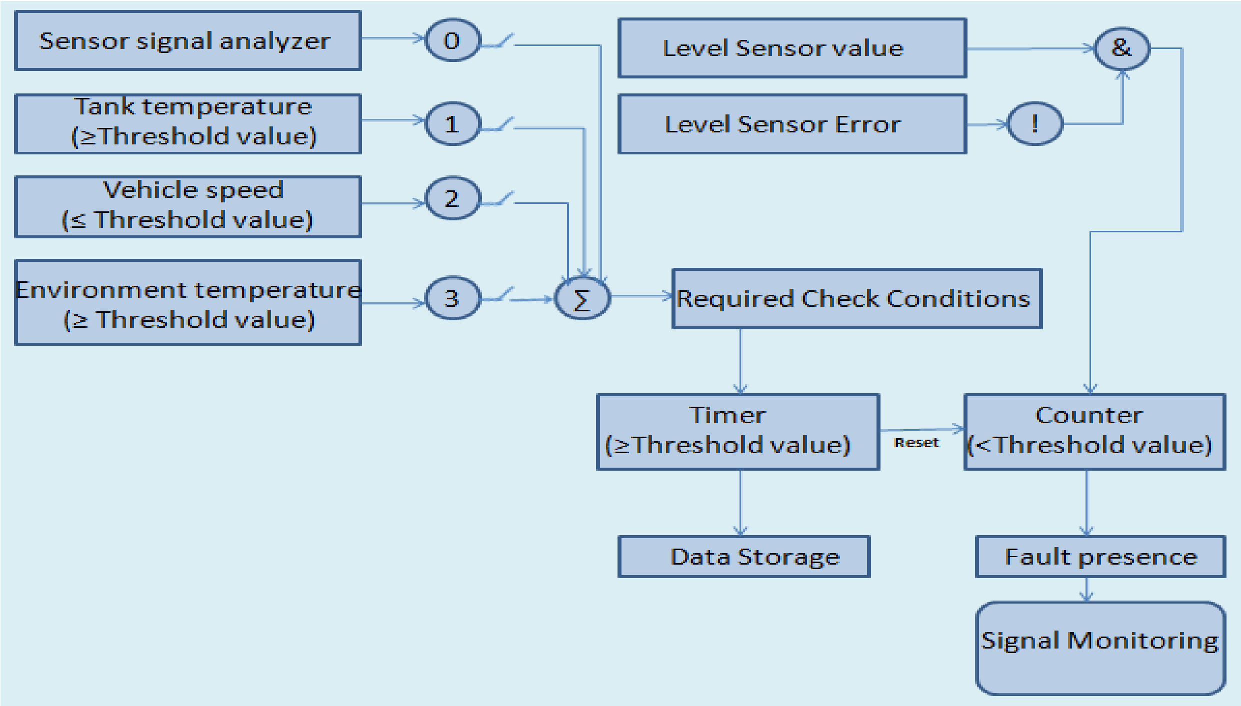


Fig - 11: Block diagram.

IX. SIMULATION AND RESULTS

According to the design requirements, part A design as shown in Fig 12 satisfies the design condition 1 to 5 mentioned under section VII. In Fig 12, function type identifies the type of incoming signal and the sensor error detection block helps in identifying the presence of any errors. If there are no sensor related errors, it passes on the signal to the putbit. Tank temperature sensor measures the urea tank temperature and if the measured value is greater or equal to a preset threshold value, then the second bit input signal is passed onto putbit. Similarly vehicle speed and environment temperature is measured by respective sensors and compared with the threshold value. If the Vehicle speed is lesser or equal to its threshold value and the environment temperature is greater or equal to its threshold value, then the third and fourth signal is obtained by a putbit. Bitmask option is provided so as to select the conditions mentioned above. One has an option to select the conditions as required according to the necessary demand, until the design and testing stage only.

If all the cumulative conditions are true, then the selected signal block passes on the signal to the next stage of design. Part B design shown in Fig 13., has continuous urea tank level sensor updating signal along with the level sensor error detection block. If there is any tank level signal update and there is no level sensor error, in the presence of the previous obtained selected signal, counter is set to compute the number of times the error has occurred between different driving cycle. If the count is less than the set threshold value then it reports, no fault to the signal monitor. If the count is greater or equals to the set threshold value, then it reports the presence of fault in the system to the signal monitor. Also, when the selected signal block passes its output, a timer is triggered to monitor the duration of fault occurrence. If the required timer value is greater or equals to the set threshold value a timer output is generated to reset the counter, timer and a trigger to non-volatile memory for data storage.

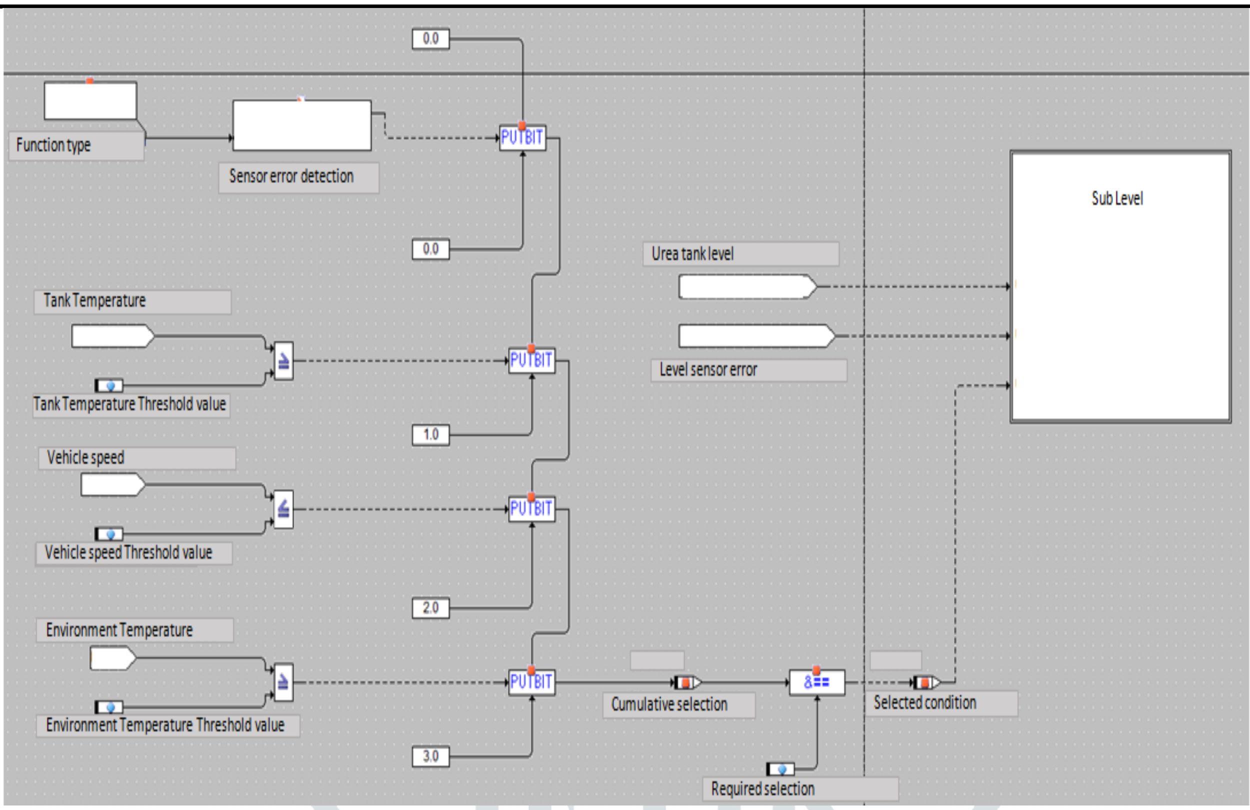


Fig - 12: Part A Design.

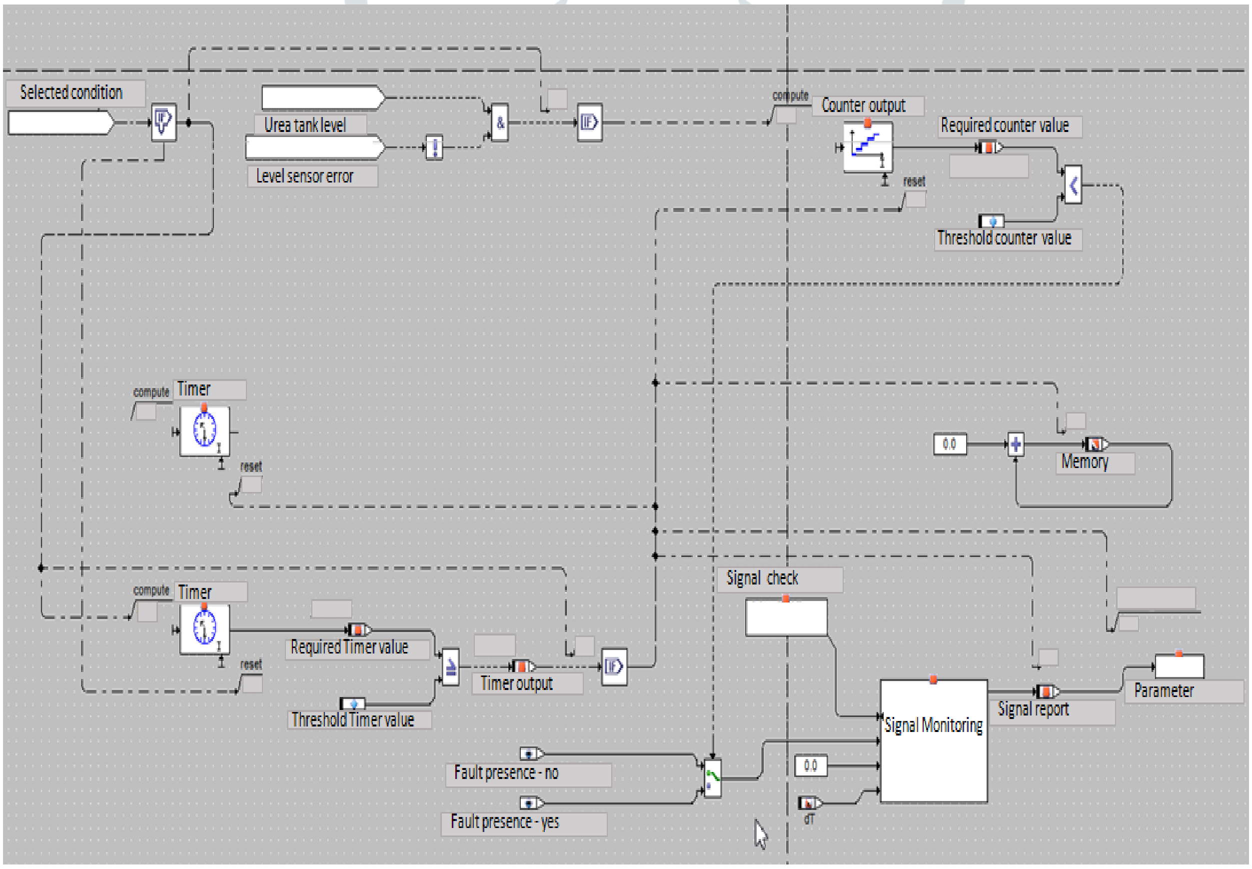


Fig - 13: Part B Design

Fig - 14: TPT report overview.

After the successful design, documentation in ECU Worx is performed by editing fs.xml file in an appropriate editor to maintain the record of the project. The modifications are made in SDOM, a project that intends to provide a comprehensive Scheme implementation of the Document Object Model API suggestion made by the W3C. To check for defects in the programme code, design, and other areas, the document is created using CI dashboard.. If the build is successful, DLL generation in ECU Worx is performed to generate a .dll file for the testing purpose in TPT software.

To determine whether the generated design satisfies all of the conditions as illustrated in Fig 14, test cases are written in the Time Partial Testing software. For test management, a thorough and customizable test report that includes the computed test results and pertinent test data is produced. Specifying expected values in test cases is the simplest type of assessment. The expected values are given as a system output in this location, right next to the test stimulus. The tolerance requirements are extremely simple to include in TPT.

X. CONCLUSION

A urea tank level detection system in diesel engine vehicles employing selective catalytic reduction technique is designed simulated and tested for a specific required condition. The literature survey explains about the importance of SCR technique and role of DEF in SCR technique. The objectives for the project are identified. An appropriate design satisfying the required conditions to be satisfied by the urea tank in diesel engine vehicles is developed and simulated in ASCET. Further the simulations are carried out in ECU Worx for documentation and DLL generation. The developed software design build through CI dashboard and finally tested in TPT software. Lastly the developed software system is tested on a prototype in LABCAR.

Indicators on the dash of vehicles that employ DEF will inform the driver of the amount of DEF present. The level of DEF will be displayed on a gauge resembling a gasoline gauge. When DEF levels are low, a warning lamp for low-DEF levels will turn on. The vehicle's power will be significantly diminished if the DEF tank runs out completely, which will prompt the driver to top it off. The engine's power output will return to normal once the tank has been filled.

Efficiency gains in the future will be linked to a greater adoption of technologies that have already shown to be commercially viable as these technologies become more widely used and more affordable. Examples of other technologies include cooled EGR, integrated exhaust manifolds, variable valve lift, variable geometry turbochargers, cylinder deactivation, and variable compression ratio.

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