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# Design of Secondary Air injection System in Lower CC Engines- A Review

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**Abstract—** *This paper reviews about how Secondary air injection system works in an automotive engine. Now a day all automobile manufacturers are very much concern in making less emission vehicles in order to meet the emission norms and also concern on global warming. Hence in order to reduce emission in engines, Secondary air injection system is one of the methods to control emissions. This secondary air injection system can be used in all type of vehicles like two wheelers, four wheeler, Heavy vehicles, etc. Hence here we are going to discuss about how Secondary air injection system can be used in Lower CC engines and also the working principle of secondary air injection system in automotive engines.*

***Keywords—*** Secondary air Injection System, Emission Control, Automotive Engine

## I. INTRODUCTION

Secondary air injection (commonly known as air injection) is a vehicle emissions control strategy, wherein fresh air is injected into the exhaust stream to allow for a fuller combustion of exhaust gases**.** Secondary air injection system is one of the method to control Carbon Monoxide and Hydrocarbon emission in engines. There are various methods used to reduce emissions in engines. Secondary air injection is the cheapest method to reduce carbon monoxide and hydrocarbon emission. In order to meet government emission norms and also to prevent environment from global warming. There is a need to introduce a additional system to reduce emission.

## II. WORKING PRINCIPLE

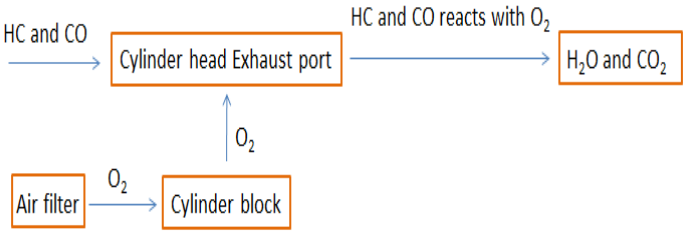
Secondary Air injection (SAI) pushes air into the exhaust system right after the exhaust manifold, to help intercept and burn those unburned fuels. The system is critical to help cars achieve government emissions standards. So, the law says you need a secondary air injection system.

There are various methods to control emissions in engines. Some of them are as follows:

- Thermal converters,
- Catalytic Converters,
- Particulate Traps,
- Exhaust Gas Recirculation (EGR),
- Air Injection,
- Evaporative Emissions Control,
- Ceramic Engine Coatings and Other Methods.

Since we are going to reduce emission in lower CC engine, secondary air injection is one the best method and also cost wise it will be very cheaper. Here we are going to take a separate path from air filter to cylinder block which will carry $O_2$ with it. There is a separate connecting passage introduced between Cylinder block to cylinder head exhaust port in order to transfer the $O_2$ into it. The harmful hydrocarbon and Carbon monoxide which comes out from combustion chamber will reacts with Oxygen to form Water and Carbon dioxide.

The below figure clearly explains about the function of secondary air injection system in automotive engine.




Motor vehicles produce more than two-thirds of the man-made carbon monoxide in the atmosphere. Carbon monoxide reduces the volume of oxygen that enters the bloodstream and can slow reflexes, cause drowsiness, impair judgment and vision and even cause death. Hydrocarbons are unburned fuel vapours. The chemical balancing equation of hydrocarbon, Carbon monoxide which reacts with Oxygen are as follows:

Hydrocarbon reacts with Oxygen:

$$4\ HC + 5\ O_2 = 4\ CO_2 + 2\ H_2O$$

Carbon monoxide reacts with Oxygen:

$$2\ CO(g) + O_2(g) = 2\ CO_2(g)$$

Hence by using Secondary air injection system in enigne exhaust system, there would be a significant resuction in Carbon monoxide and hydrocarbons.

## III. SECONDARY AIR INJECTION

**Andrew Roberts [1]** discussed that the thermal efficiency of the internal combustion engine is significantly lower at cold start In these cases it is primarily focused on the lubricant system. Lubricant viscosity is highly sensitive to temperature and the increased viscosity at low temperatures results in higher frictional and pumping losses. This paper includes both system developments and material selection issues and the role the two fields have to play in tackling this critical issue.

**Avinash Gangadhar Virale [2]** said that the excess energy in the form of heat in SI engine needs to be removed by the Jacket cooling water in order to maintain the temperature of the engine within the optimum range. Therefore the emissions and the losses are maintained to be minimum. In engine Very high temperature leads to increase in the emissions and friction power (losses). Where Low engine temperature leads to improper vaporization of the fuel and also starting problems. They had carried out an experimentation to analyze various operating parameters and emission characteristics and found the range for operating parameters and emission reduction.

**Branislav Sarkan [3]** analysed the level of exhaust gases production of road vehicles is mainly influenced by legislation that determines the maximum values of individual gases elements. This paper they focused on the data analysis of the emission controls results in selected workstation during years 2005 to 2014. In this paper, they did a analysis regarding the relation of level of the exhaust emissions selected elements of different emission systems according to year of vehicle production is processed.

**Debora Fino [4]** reviewed the current soot oxidation catalyst scenario, they examined that the main factors that affect the activity of powder catalysts have been highlighted and kinetic soot oxidation models. Also they did a critical review of recent advances in modelling approaches has also been presented. They analysed that the multiscale nature of DPFs lends itself to a hierarchical organization of models, over various orders of magnitude. Also they addressed in different observation scales (e.g., wall, channel, entire filter) with separate modelling approaches that are rarely connected to one another, mainly because of computational difficulties. Hence they found that DPFs exhibit an intrinsic multi-scale complexity that is reflected by a trade-off between fine and large-scale phenomena. Also consequently, the catalytic behaviour of DPFs usually results in a non-linear combination of multi-scale phenomena.

**Edward Rakosi [5]** they had found a most efficient and simple solutions for changing of some automotive SI engine to reduce Emission. They had used a new concept named PMACC (poor Mixtures in Auxiliary Combustion Chambers) to generate inhomogeneous poor mixture. They had concluded that PMACC concept had increased the engine efficiency. Carbon monoxide and Hydrocarbon emission has be reduced significantly.

**Georgina Santos [6]** had analysed that Carbon Monoxide, carbon dioxide, hydro carbon, Particulate Matters are the Major things which causes emission severe. In this paper they said that to use some in-Cylinder solutions to reduce emissions. Such as Exhaust Gas Recirculation (EGR), Low Temperature Combustion (LTC), Homogeneous Charge Compression Ignition (HCCI), Premixed Charge Compression Ignition (PCCI)

**Georgios Fontaras [7]** proved that there is an increasing evidence to suggest that officially reported $CO_2$ values do not reflect the actual performance of the vehicles on road. There is a difference of 30% to 40% b/w official and real world estimates found continuously increasing. Due to Driving behaviour, Vehicle configuration, Traffic conditions etc,. Then finally they said that this can be rectified by quality checks of the $CO_2$ certification procedure.

**Hanzhengnan Yu [8]** found out the effects of the two-stage injection in a diesel engine using two-stage injection strategy have been investigated by numerical using modelling methods. They also showed the results of combustion and emission characteristics of the diesel engine using two stage injection strategy were both improved comparing to the original engine. They concluded that together considering the fuel economy and emissions problems, the two-stage injection strategy with the injection interval of 30 to 50° CA and first injection proportion of 50% to 70% was recommended.

**Hyun Sung Sim [9]** had investigated about the effect of Secondary air injection (SAI) on exhaust hydrocarbon (HC) emission in SI engine. They had tested with both Continuous SAI and synchronized SAI, which corresponds to intermittent secondary air injection to exhaust port. They had monitored the oxidation characteristics of HC with FID analyser and exhaust gas temperature with thermocouples. The results what they found shows that HC reduction rate increases as the location of SAI is closer to exhaust valve for both Synchronized and continuous SAI's.

**Heiko Oertel [10]** studied to minimize exhaust gas emission to meet SULEV (Super ultra-Low Emission Vehicle) targets on V6 engine by using cost efficient system configuration. This paper consists of three parts. a) Both raw emission and catalyst light off performance to be optimized in first stage b) Test should be conducted on predefined high cell density in engine test bench. c) At final stage, the emission performances of test matrix were studied during FTP cycle.

**Ivan Arsie [11]** deal with the analysis of opportunities and challenges of TEG and ETC technologies for a compact car, powered by a turbocharged SI engine. They had investigated that the benefits achievable by TEG and ETC Specifically by simulation analyses carried out by a dynamic engine-vehicle model, validated against steady-state and transient experimental data. They had carried out the simulations have by considering standard driving cycles (i.e. NEDC, WLTC) and the results evidence that significant improvement of fuel economy and CO2 reduction can be achieved by suitable management and configuration of the WHR systems, depending on engine speed and load and auxiliaries demand.

**Juhi Sharaf [12]** analysed that the main pollutant contributed by IC engines are CO, Nox, Unburned HC and other particulate emissions. They had used three way Catalytic converter which converts Carbon Monoxide and hydro carbon into carbon dioxide and water, also nitrogen oxide to elemental nitrogen and oxide. An extensive analysis of energy usage and pollution shows that alternative power systems are still a long way behind the conventional ones. Further developments in petrol and diesel engines, combined with improvements in the vehicles, will make fuel consumption reduction of 40% or more in the future cars.

**Kaustubh P.Ghodke [13]** discussed that Diesel powered vehicles are preferred due to higher thermal efficiency and lower fuel consumption hence inherently it emits more oxides of Nitrogen and particulate matters. They said that exhaust after-treatment system plays vital role in controlling vehicle tailpipe emissions. In this paper, they did a overview of NOx and PM control technologies. The analysed that the two technologies effective for controlling NOx emission from diesel engine are EGR (Exhaust Gas Recirculation) and SCR (Selective Catalyst Reduction).First method became popular due to easy of adaptation and no additional infrastructure requirement. The use of high pressure EGR cooler helps NOx reduction up to about 60%.

**Kenneth P. Coffin [14]** took a single cylinder of an automotive V-8 engine was fitted with an electronically timed system for the pulsed injection of secondary air. A straight- tube exhaust minimized any mixing other than that produced by secondary-air pulsing. The device was operated over a range of engine loads and speeds. Effects attributable to secondary-air pulsing were found increased.

**Maciej Dzikuc [15]** had consolidated a report of World Health Organization (WHO). On the list of 50 cities with the most polluted air in Europe as many as 33 are located in Poland. They said that one of the main factors affecting the poor air quality in the region is road transport. Hence its not just a problem near roads with heavy traffic, but also applies to the cities, where there is a large movement of cars, which are often old and do not meet current environmental standards. In this paper they had identified the main sources of low emission from road transport and also the potential solutions that to help reduce emission from this sector. The actions aimed at limiting low emission from road transport. In addition, this paper also presents the three-scenario simulation of annual emissions from passenger cars that could take place in 2020.

**M.S. Shehata [16]** had did an experimental study to investigate engine performance parameters and methods of reducing emissions from spark ignition engine. They had used a four stroke four cylinder naturally aspirated spark ignition engine with bore diameter of 80 mm, compression ratio of 9 and stroke of 90 mm. The engine performance parameters are calculated with and without exhaust gases recirculation (EGR). They had used EGR rate of 5%, 7%, 8%, 10% and air injection rate of 3%, 4%, 5%, 6% in present work. They analyzed that Catalyst converter and air injection in exhaust manifold are useful methods for reducing UHC and CO concentrations. And also Air injection in the exhaust manifold represents method for reducing UHC and CO exhausted from spark ignition engine. Hence they had concluded that the present work is useful for improving engine performance parameters, reducing engine emissions and further development of spark ignition engines.

**M. Vijay Kumar [17]** they reviewed that growing demand of fuel in daily life and its risk cause serious problem for this globe. For that they had planned to use bio diesel with the combination of metal based additives, cetane number additives, antioxidant additives and oxygenated additives help in improving the quality of the biodiesel. They had concluded that uses of additive to the 2nd generation of biodiesel are the best in improving the combustion performance and emission reduction.

**Pablo Mendoza-Villafuerte [18]** said that Euro VI emission standards for heavy-duty vehicles (HDVs) introduced for the first time limits for solid particle number (PN) and NH3 emissions. They did a comprehensive study on the real-time on-road emissions of NOx, NH3, N2O and PN from a Euro VI HDV equipped with a Diesel Oxidation Catalyst (DOC), a Diesel Particle

Filter (DPF), a Selective Catalytic Reduction (SCR) system and an Ammonia Oxidation Catalyst (AMOX) is presented. Their analyses has revealed up to 85% of the NOx emissions measured during the tests performed are not taken into consideration if the boundary conditions for data exclusion set in the current legislation are applied. They found that the highest NOx emissions were measured during urban operation.

**P. Brijesh [19]** reviewed that CO2, CO, HC, NOx, SO2 and PM comes out as harmful products during incomplete combustion from internal combustion (IC) engines. Hence they said that it is required to modify existing engine technologies and to develop a better after-treatment system to achieve the upcoming emission norms. Since Exhaust gas recirculation (EGR) technology has been utilized previously to reduce NOx. Even though it is quite successful for small engines, problem persists with large bore engines and with high rate of EGR. They said that modern combustion techniques such as low temperature combustion (LTC), homogeneous charge compression ignition (HCCI), premixed charge compression ignition (PCCI) etc. would be helpful for reducing the exhaust emissions and improving the engine performance.

**Pritchard [20]** discussed that the effects of secondary air on the exhaust oxidation of particulate matters (PM) have been assessed in a direct-injection-spark-ignition engine under fuel rich fast idle condition (1200 rpm; 2 bar NIMEP). Substantial oxidation of the unburned feed gas species (CO and HC) and they found that there is a significant reduction of both the particulate number (up to ~80%) and volume (up to ~90%) has been observed.

## IV. CONCLUSION

Secondary Air injection (SAI) System is one of the best methods to reduce Carbon monoxide and hydrocarbons in exhaust emission. Hence to achieve the future emission norms in lower CC engines, Secondary air injection system to be used in all kind of vehicles in order to control the emissions and also to save the environment from global warming.

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