# EFFECT OF WATER INJECTION SYSTEM ON DIESEL ENGINE EMISSION: A REVIEW

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***Abstract -In diesel engines, NOx formation is a highly temperature-dependent phenomenon and takes place when the temperature in the combustion chamber exceeds 500 K. Therefore, in order to reduce NOx emissions in the exhaust, it is necessary to keep peak combustion temperatures under control. One simple way of reducing the NOx emission of a diesel engine is by late injection of fuel into the combustion chamber. This technique is effective but increases fuel consumption by 10–15%, which necessitates the use of more effective NOx reduction techniques like water injection in intake manifold. Water injection method is applied to a direct injection (DI) diesel engine to control NOx emissions. This method affects the intake air of an internal combustion engine with cool purified Water, deriving benefits of preventing the formation of excessive oxides of nitrogen and Carbon, affecting a more Complete Combustion of hydrocarbon fuels, reducing the latent heat of combustion and increasing the power of combustion. The obtained results are compared with conventional diesel engine in terms of performance and NO, CO, HC emissions. Various systems have been proposed for conveying water vapor into the combustion chambers of an internal combustion engine to increase the power output therefore and also to provide for better fuel economy.***

***Keywords:*** ***Diesel engine, NOx emissions, Water injection***

## 1. INTRODUCTION

A detailed experimental study has been conducted to evaluate the effect of water injection on engine performance and emission, and comparison is made against base diesel fuel. The experimental setup for the proposed experiments was developed on a single cylinder, four stroke, multi-fuel, research engine connected to eddy type dynamometer for loading and by analyzing different values to improve the engine performance and reducing the NOx emission. The water-injection system was investigated on a stationary direct injection (DI) diesel engine to reduce exhaust and Specific fuel consumption up to acceptable level under variable engine running conditions. Diesel inlet was supplied with air and sprayed water and passed through an inlet main fold pipe. A matrix of experiments was conducted for observing the effect of different quantities of water on exhaust gas temperatures and emissions.

### 1.1 Mechanism of NOx formation

A major hurdle in understanding the mechanism of formation and controlling its emission is that combustion is highly heterogeneous and transient in diesel engines. While NO and are lumped together as NOx, there are some distinctive differences between these two pollutants. NO is a colourless and odourless gas, while is a reddish brown gas with pungent odor Both gases are

considered toxic; but have a level of toxicity 5 times greater than that of NO..

In diesels, $NO_2$ can be 10 to 30% of total exhaust emissions of oxides of nitrogen. The local atomic oxygen concentration depends on molecular oxygen concentration as well as local temperatures. can keep the instantaneous local temperature in the combustion chamber below 500 K, will be able to reduce NOx formation.

Although $NO_2$ is largely formed from oxidation of NO, attention has been given on how NO can be controlled before and after combustion (Levendis *et al* 1994) NO is formed during the post flame combustion process in a high temperature region. The most widely accepted mechanism was suggested by Zeldovich (Heywood 1988). The Principal source of NO formation is the oxidation of the nitrogen present in. atmospheric air. The nitric oxide formation chain reactions are initiated by atomic oxygen, which forms from the dissociation of oxygen molecules at the high temperature reached during the combustion process.

The principal reactions governing the formation of NO from molecular nitrogen are,

$$N_2 + O \rightarrow NO + N$$
$$N + O_2 \rightarrow NO + O$$
$$N + OH \rightarrow NO + H$$

## 2. METHODOLOGY CONTROLING METHODS)

### 2.1 Exhaust Gas Recirculation (EGR)

The main principle employed in EGR is re-circulation of a portion of an engine's exhaust gas back to the engine cylinders. The re-circulated exhaust gas decreases the local temperature in the combustion chamber. It is mostly effective in particular time/space zones during which the NOx emission is produced, specifically during the fuel injection and after the end of the injections [1]. In the EGR system, the heat of combustion from the fuel is used to heat the exhaust gas. The exhaust gas is essentially inert and therefore does not react in the combustion chamber and only absorbs heat [2]. Even though, the EGR has a potential of reducing NOx up to 50%, it has an inherent drawback of increasing the PM emissions [3,4,5]. In addition, the heat absorption by exhaust inert gas in the cylinder chamber results in small amount of power loss from the engine as well.

### 2.2 Controlling Methods Using Water Injection

This available method to reduce local combustion temperature and consequently the NOx emission is the injection of water into an engine system [6-10]. One of the advantages of the water injection as compared with the EGR and the catalytic converter is the enhanced possibility of reduction of NOx over the entire engine load range without affecting the PM emission negatively. Even though water is inert, in the combustion cylinder it decreases the local adiabatic flame temperature by absorbing heat of water vapour [11-13]. As a result the NOx emission, which depends on the peak flame temperature, is reduced [14], In addition to the reduction of NOx; water emulsion reduces the HC, soot and particulate matter as well. There are three main methods that are used to introduce water into a diesel engine. These are

#### Direct Water Injection

Direct water injection into the cylinder using separate injector, injecting water/diesel emulsion and Spraying/injecting water into the intake manifold [15,16]. The first water based injection system involves direct injection of water within the combustion cylinder. This method provides an option of controlling water and fuel ratio [17].It has been reported that this method enables NOx emission to be reduced by 42% and in combination with EGR this method enables NOx emission to be reduced up to 82% [18]. The drawback of this method is the amount of complexity involved in integrating additional components to the existing engine system and further requirements of a redesign of the fuel supply system integrated with the engine.

#### Emulsification of Water and Fuel

The second water based injection system involves emulsification of water and fuel in the presence of some surfactants in an appropriate mixer. It has been also shown that adding water in the fuel may help to improve atomization and mixing characteristics, which is attributed to droplet micro-explosions. The micro-explosions phenomena are induced by volatility differences between the water and the fuel [16].The water-fuel emulsion methods have several shortcomings that impede emulsion fuels from becoming widely used in the practice. The effects of water emulsion on the performance of the engine vary with the operational modes of the engine. In most of the previous studies the water emulsion has been shown to have positive effect on engine performance parameters [14]. The water diesel emulsion has some drawbacks: firstly, the water emulsions needs a more advanced and well developed infrastructure for the implementation of a complex on-board water-in-diesel emulsion production system integrated with the engine, which may increase the cost of the engine [3]. To produce smaller and well scattered water droplets, the engine operating parameters need to be controlled with very high accuracy [16]. Secondly, the physical properties of the fuel emulsion may (viscosity, density and bulk modules) change. It is observed that the viscosity and density of the water emulsified fuel have higher values than the normal fuel [20]. Change in these parameters can significantly affect the performance of the fuel injection system.

#### Intake Manifold Water Injection

The third method of water based injection system is intake manifold water injection. Currently this method is widely used on large marine diesel engines. The main advantage of water injection into the intake manifold is its simplicity and ease with

which it can be integrated within existing engines and also with any new design. Since in this system water is injected through a separate valve and it does not mix with fuel directly, it does not affect the fuel flow properties in fuel supply line. It can be seen from the above discussion that injection of water into the intake manifolds has potential to be the most effective method of NOx reduction. As described above the application of water injection to an engine running with diesel to reduce NOx emission has been reported extensively. The main objective of the present work is to investigate performance and emission characteristics of a CI engine running with diesel and integrated with water injection system into the intake manifold. Furthermore the thermodynamic effects of water injection on the combustion behavior within the cylinder have also been investigated.

## 3. CONCLUSION and SCOPE OF WORK:

- From above experiment and investigation carried by various researchers conclude that the intake manifold water injection is most effective technique to reduce engine emission at lower and full engine load as water ratio of 10%, 20% and 30%. It has directly effect on reduction $NO_x$ and soot formation but increasing water percentage has inversely effect on formation rate of HC, $CO_2$, CO and negligible increase in BSFC.
- It has effect capability of reducing $NO_x$ without major modification of inlet manifold of engine. In place of water, steam can also be used to reduce $NO_x$ emission.

## SCOPE OF WORK:

- In this experiment reduction of NOx of single cylinder diesel engine using diesel as a fuel it requires large number of experiment using water flow of 9ml/min, 16ml/min, and 38ml/min. This method will minimize the effect of emission like NOx, PM by keeping constant or decreasing specific fuel consumption.
- Comparation will do about data obtain in past without WIS and with WIS. Also find out the water flow percentage at which minimum level of NOx production in diesel engine.

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