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# Gasoline Direct Injection: An Efficient Technology

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**Abstract**

Most of the researchers wanted to work with diesel engine because of complexity in the gasoline engine. Author tried to review gasoline direct injection (GDI) a new technology in the gasoline engine with the objective to motivate the researchers to work with this field. This paper reviews the benefits of direct injection in the gasoline engine in terms of fuel consumption and emission. The effect of stratified and homogeneous mode on the performance parameter along with combustion system (wall guided/ spray guided and air guided), its extend feasibility and complexity in the individual and combine mode of operation is reviewed in detail. The review comes up with the need of optimization in mixture formation to reduce in-cylinder wall wetting, increase combustion stability, and extend up to which charge cooling occurs and feasibility of stratified mode operation in GDI engine. Optical diagnostic and CFD are the tools which can help in optimizing this complex system


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*Keywords: GDI; PFI; CFD; UBHC;SI; BSFC*

## 1. Introduction

Continuous hike in petroleum products and tighten global emission standards made the engine development towards notable engine technology whose objective to 1) minimize fuel consumption at the inlet, pollutant and noise emissions at exit of engine 2) maximize the fuel energy conversion efficiency and 3) higher specific power output.. The fuel conversion efficiency is the function of mixture formation process i) internal ii) external iii) internal plus external. Gasoline direct injection engine is the new thought of in cylinder mixture formation technology in which gasoline like fuel is directly added into the cylinder and ignited with spark which enables to combine best features of

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diesel and gasoline engine. BSFC approaching that of the diesel engine, specific power output of the SI engine [1]. 20th century was fully dedicated to external mixture formation by using carburetors and low pressure manifold injection system which dominated SI engine development in the full century. External mixture formation allows larger time for the mixture preparation hence it is independent of phase transformation within cylinder, leads towards good fluid dynamic condition, simple and better control [1, 3, 14] in spite of these advantages Throttling and liquid fuel film formation in the inlet port and charge loss during valve overlap are still disadvantages of the PFI engine, even PFI engine is at its development peak. GDI engine does not have these limitations and during part load condition operates in unthrottled manner which significantly improves specific fuel consumption and emissions and permits for the leaner combustion. Charge cooling occurs in early injection (homogeneous condition) benefits in terms of higher compression ratio, lower octane requirement and improvement in specific fuel consumption up to 30%. [4].

### *1.1. Direct injection methods:*

There are two ways of direct injection 1) direct injection of liquid fuel and 2) direct injection of premixture injection. Direct injection of liquid fuel: it is a high pressure fuel injection system in which liquid fuel is directly injected into the engine cylinder. The fuel injection pressure should be sufficiently higher than cylinder pressure in the range of 4Mpa- 15Mpa which is sufficient to produce well atomize spray. Direct injection of air fuel premixture: It is a low pressure injection system in which mixture is formed outside the cylinder by injecting fuel (Pressure range 0 .6 Mpa) in the part of air (Pressure 0.55 MPa). The premixture is transformed into combustion chamber by mechanical valve with mechanical control or by solenoid with electronic control. Short duration needed for the complete mixture formation diluting premixture in the engine cylinder results complete combustion and less emissions. [5, 6, 7].

**Nomenclature**

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| GDI | Gasoline direct injection |
| PFI | Port Fuel Injection |
| UBHC | unburned hydrocarbon |
| SI | spark ignition |
| BSFC | Brake specific fuel consumption |
| CFD | computational fluid dynamics |

## 2. Novel approaches towards GDI from PFI

Mixture formation strategies make difference between PFI and GDI engine. In PFI engine fuel injected on the back of inlet valve when the valve is in closed position. Liquid film formation on the back of the inlet valve and fuel wall wetting in the intake port are the major problems in the PFI engine which Results in the disadvantages like metering error, fuel delivery delay. The time lag between fuel injection and induction into the cylinder may cause misfire and significant increase in UBHC. Most of the problems associated with PFI are overcome in GDI by injecting fuel directly into the cylinder; it avoids the wall wetting in the port, reduction in the fuel transport time, more accurate control over fuel quantity entering into the cylinder and offer potential for leaner combustion and low emissions. The better atomization of fuel entering into the cylinder due to high fuel injection pressure increases vaporization rate and hence overcome cold start problems this can be explained by comparing the quantity of the fuel to start GDI and PFI engine [8, 20]. Other advantages of the GDI are the fuel cut-off in deceleration and the cooling of the inducted charge. The evaporation of the fuel droplets cools the air and this allows higher compression ratios and lowers the octane requirement of fuels, and, in addition, if the injection occurs during the induction event also the volumetric efficiency can be enhanced. Another limitation of PFI is the use of throttling for load control