Dual Fuel Engine Locomotives in India

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Abstract

According to the research and development projects under Research Designs and Standards Organization (RDSO) and Indian Railways Organization on Alternate Fuels (IROAF), it would be more effective to mix 5% Bio-Diesel on Diesel Locomotives. Double fuel motors with Compressed Natural Gas (CNG) and diesel have been presented on Diesel Electric Multiple Unit (DEMUs). Assistant Power Unit (APU) is fitted on diesel trains to diminish the fuel utilization by closing down principle motor. The railroads has altered the 1,400 HP motor to keep running on double fuel through "fumigation" technology where natural gas enters with required combustion air with the help of air filter before entering the turbo charger. A decreased amount of diesel enters into the engine continuously ,which is used as pilot ignition source of natural gas. The control framework keeps up the best possible equalization of Natural gas, diesel and air to meet the power requirements of the engine.

***Keywords** : RDSO, IROAF, DEMUs, APU, fumigation technology.*

Introduction

Air Contamination has been a major natural issue everywhere throughout the world. Expanding number of vehicles in the urban communities is the fundamental driver of air contamination. Diesel vehicles are more risky than the oil vehicles as they radiate more carbon dioxide and carbon monoxide, diesel trains additionally assume an indispensable job in causing contamination. As on date, in excess of one million vehicles are running with CNG on the planet. Indeed, even in our nation in the wake of understanding the antagonistic effect of expanded natural contamination and the expansion in import bill of oil raw petroleum, CNG is opted by a society in a big way. The presentation of CNG trains will decrease the discharge of ozone harming substance and furthermore cut the transporter's fuel charge by diminishing diesel usage . The traveller prepare would expend more than 20 percent of CNG for covering a separation of 81 km in around 2 hours. Brings about expanding the CNG utilization to around half.

According to Indian Railways ministry , many such trains will be introduced soon. Moreover , the train consisting of two power cars and six car coaches are manufactured at the Integral Coach Factory (ICF) in Chennai, India with the CNG conversion system being supplied by Cummins.

Literature Survey

In a noteworthy advance towards embracing green fuel, the railroads has propelled a prepare kept running on Dual Fuel System – diesel and CNG. Rohtak– Rewari DEMU is a traveler prepare of Indian Railways which keeps running between Rohtak Junction railroad station of Haryana and Rewari Junction railroad station of Haryana. This prepare was India's first CNG prepare which was started on January 14, 2015, by Union Minister of Railways Suresh Prabhu .

Prior to stepping up, some significant advances were taken are examined beneath:-

1.Central Electricity specialist (CEA) was named by railroads for getting ready "Vitality plan for Indian Railways" and proposing approaches to streamline the expense of purchasing power for rail lines.

2.Zonal Railways have been encouraged to buy Bio-diesel for use on diesel trains. DEMU prepare sets have been presented in administration with double fuel CNG and diesel motors.

3.100 diesel trains are fitted with APUs. Two multigenset trains are presented on line.

These points were discussed in Lok Sabha by the State minister for Railways Shri Manoj Sinha.

Figure 1 – Rohtak-Rewari DEMU (India's first CNG locomotive)

Methodology

Significance of Natural Gas

Natural Gas is a mixture of gases which have high amount of hydrocarbons contained in it . It isn't utilized in its unadulterated frame, it is processed and modified to get cleaner fuel for utilization. All these gases (methane, nitrogen, carbon dioxide, and so on.) are contained in our environment . Natural gas reservoirs are somewhere in the earth crust near other strong and fluid hydrocarbons beds like coal and unrefined petroleum. Numerous side-effects may happen while handling of gaseous petrol like propane, ethane, butane, carbon dioxide, nitrogen, and so forth, which can be additionally utilized.

Consumption of Natural Gas is increased very fastly in the last few years and is expected to grow more. The main reasons are the increase in demand of gases like CNG, increasing demand in fertilizers which use ammonia gas which is obtained through processing of natural gas. Also it is used

for domestic applications as well. The share of natural gas in the energy consumption is 8% of the total consumption.

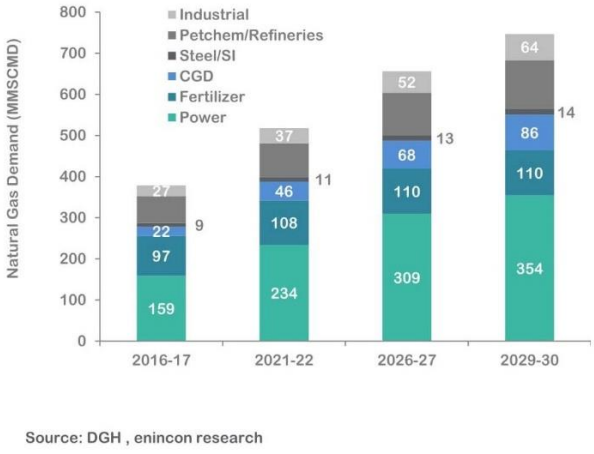
What's more, there is a disposal of noticeable smoke from these trains and huge decreases in other managed and unregulated emanations. When Indian Railways changes over totally to flammable gas as fuel for its diesel trains, it would add up to just 2.2% of India's yearly gaseous petrol utilization of 81 million tons and subsequently monetarily achievable.

At present, Indian railroads are running its armada of trains on two energizes, i.e., diesel and electric power. Costs of both these powers have been rising quickly because of expanding costs of raw petroleum/imported coal and the debasement of rupee.

Petroleum gas is developing as a promising fuel without bounds. The flammable gas is accessible as convectional petroleum gas, shale gas, gas hydrates, and so forth. With the presentation of efficient procedures of extraction of shale gas, misuse of shale gas saves has turned into a business reality.

Compound	Symbol	Percent in Natural Gas
Methane	CH_4	60–90
Ethane	C_2H_6	0–20
Propane	C_3H_8	0–20
Butane	C_4H10	0–20
Carbon dioxide	CO_2	0–8
Oxygen	O_2	0–0.2
Nitrogen	N_2	0–5
Hydrogen sulphide	H_2S	0–5
Rare gases	A, He	0–2

Table 1. – chemical composition of natural gas.



Graph 1.- Future Natural Gas demand for India 2030.

Benefits of using Natural Gas

a. Reduction in Carbon monoxide outflows by 90 to 97%.

b. Reduction in Carbon dioxide outflows by 25%.

c. Reduction in Nitrogen oxide outflows by 35 to 60%.

d. Reduction in non-Methane hydrocarbon outflows by 50 to 75%.

e . Fewer lethal and cancer-causing contaminations.

f. No particulate issue delivered. Use of CNG is not only cheap but also helps in achieving lesser degree of damage to engine parts.

Dual Fuel Engines

Compressed Natural Gas (CNG) is a magnificent option in contrast to the present non-renewable energy sources, for example, diesel and oil. Railroads have effectively changed over couple of Driving Power Cars (DPC) into double fuel mode with CNG. The tail pipe outflows are incredibly lessened and in this manner guaranteeing a cleaner situation. A double fuel diesel motor is a diesel

motor that has been fitted with extra gadgets, for example, gas prepare, valves, evaporator framework, control module, and so forth., enabling it to use gaseous petrol as an enhancement fuel. This motor requires some measure of diesel for task, for start of the gas fuel. The double fuel motor compose has various quality characteristics, for example, that of fuel adaptability, working with cleaner gaseous petrol when accessible and on diesel alone when fundamental.

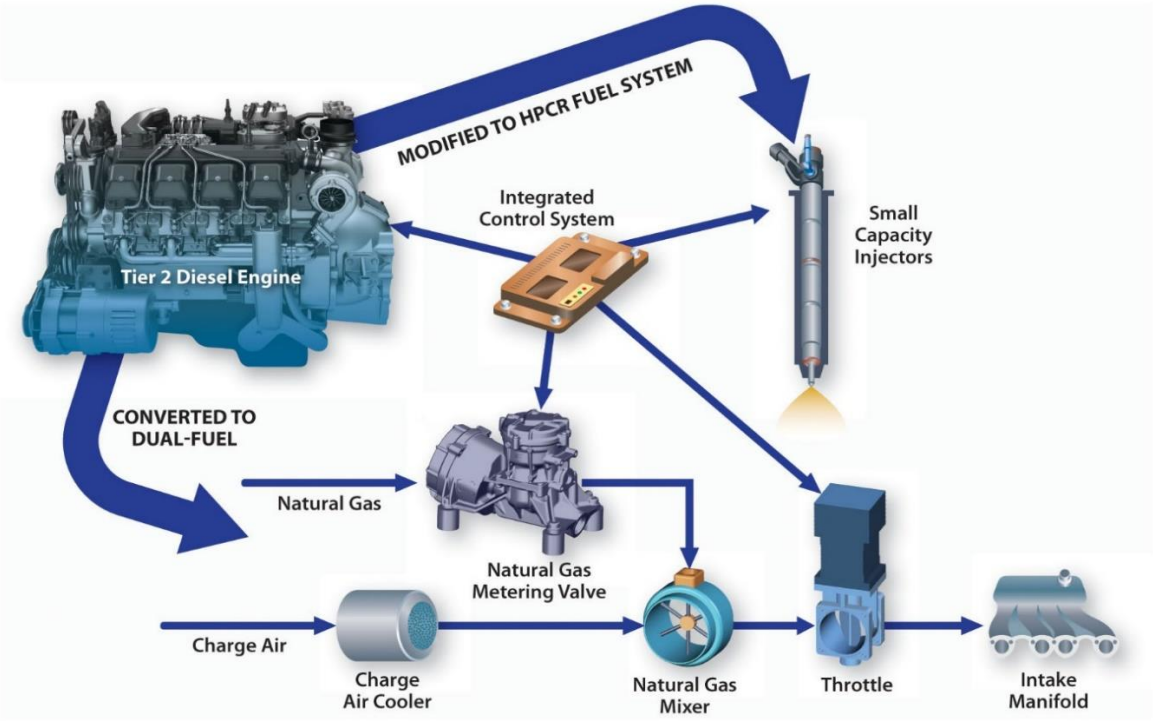


Figure 2. Block Diagram of various components attached to the Dual Fuel System

Components of Dual Fuel Engine

Major dual fuel system components are as follows :

- **Gas Train :**

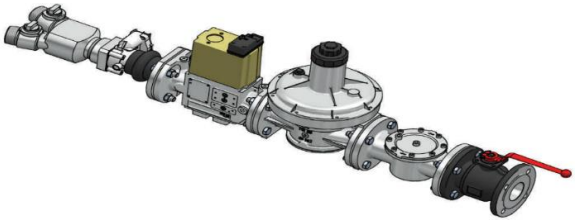


Figure 3. Gas train

Molding and controlling the flammable gas before entrance into the motor is a basic piece of our double fuel framework. The framework gas prepare incorporates a manual shutoff valve, 50-micron channel, a zero senator controller, a double solenoid shutoff valve, a variable fuel metering valve, the y-valve.

- **Mixer :**

Figure 4. Mixer

The blender is found downstream of the y-valve and joins a settled venturi outline. This creative blender is introduced wind streams through the blender. For motors in numerous air admission frameworks, one blender is at every one of the admissions. The framework utilizes blending device that don't use any sort of air throttle plate in their outline. In the wake of leaving the blending gadget, the air-gas blend enters the air-consumption complex, and appropriates the charge to every barrel by means of the typical air dispersion plan of the motor.

- **Y-Valve :**

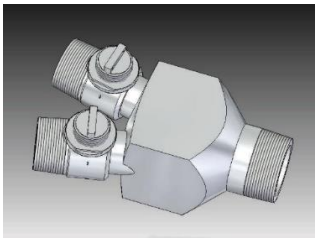


Figure 5. Y-Valve

The y-valve, found downstream of the gas pressure regulator, is a needle compose valve and this enables bank to bank alteration on dual or quad turbo setups.

- **Variable Fuel Metering Valve :**

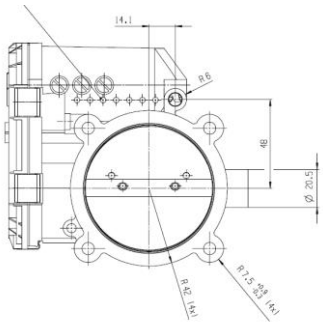


Figure 6. **Variable Fuel Metering Valve**

The variable fuel metering valve enables us to custom tailor the gas substitution at any heap run. The valve utilized is to a great degree quick acting to stay aware of changing interest and enables us to assemble a framework that will give your motor the correct measure of flammable gas required at some random load.

- **Gas Filter :**

Figure 7. **Gas Filter**

The gas filter is fitted with a 50-micrometer channel that will get any particles or scale that might be caught in the gas line

- **Control Panel :**

Figure 8. Control Panel

The control board is easy to work and simple to use . With a straightforward change to kill the framework on and a crisis stop catch task is a breeze. Splendid lights effortlessly let you know whether the framework is working or if there is a caution.

- **Electronic Control Module :**

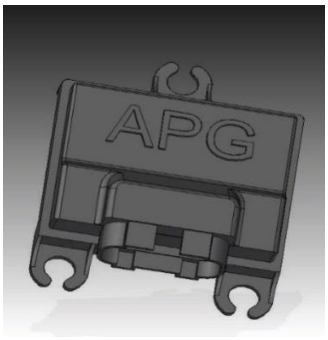


Figure 9. ECM

The brains of the whole operation. The ECM stores all the programming data of the system. The unit has the ability to store a prewritten program that fits the engine.

Working process of Dual Fuel Engines

The dual fuel engine works on the compression ignition principle.

At first the air-fuel is drawn into the engine cylinder which is highly compressed in the cylinder. Next step is the ignition process, but this fuel (also called gaseous fuel) is not a good compression ignition fuel. Hence a small amount of diesel (called as pilot fuel) is injected, which act as a catalyser to the ignition process. As the fuel is ignited due to the temperature rise, the whole air-fuel mixture ignites and rapid combustion takes place. Due to this rapid combustion the pressure inside the cylinder is increased causing the piston to move and produce engine power.

The sudden increase in the dual fuel engine causes knocking problem, which can be controlled by injecting a definite quantity of diesel fuel. In dual fuel engine, the combustion takes place as a CI engine but the propagation of the flame front is just like the SI engine.

The air standard efficiency for any engine is given by, the ratio of heat added minus heat rejected to the total heat added.

The mathematical formula for efficiency is given as,

$$\eta = 1 - \frac{1}{r^{(\gamma-1)}}\left[\frac{r_p r_c^{\gamma} - 1}{(r_p - 1) + r_p\gamma(r_c - 1)}\right]$$

The efficiency of the dual fuel engine lies between the Otto and Diesel cycle.

When the r_c (cut-off ratio) is equal to 1, it becomes an Otto engine and when the r_p (pressure ratio) is equal to 1, it becomes a diesel engine.

Special Safety Features

a) Flame arrester which keeps any regressive travel of fire if there should arise due to failing of valves in blend camber of motor.

b) Leak indicator and auto stop of gas supply amid gas spillage, assuming any,

c) Pressure Relief gadgets PRDs are given to secure against the conceivable blast of CNG barrel if by chance it were associated with flame.

d) Separate chamber for capacity of CNG barrels is totally confined from motor room, consequently making the framework free from flame perils in the event of any spillage.

Conclusion

With the developing worry for better condition and less repulsive gases in climate Natural gas has risen as a reasonable answer for substitution of diesel. Cost viability will be another preferred standpoint.

Facilitate IROAF is searching for the utilization of LNG and better diesel substitution, as of now CNG has confinement of less vitality thickness and along these lines represents a space impediment for installed fuel. LNG has tantamount vitality thickness with diesel and is in a perfect world suited for installed stockpiling of fuel. In future changes, LNG will be a superior fuel alternative.

CNG course space restrictions are the real bottlenecks. With CNG the volume required is four/five times that of the diesel tank. This can be lessened later on with acceptance of LNG innovation.

Particular stockpiling of LNG can be utilized for DPCs. Trains can have LNG stockpiling and a driving taxi mounted on another loco under edge and combined with other train.

IROAF has the mandate to convert existing DPCs into dual with natural gas.

Present achievements in this field :

Substitution of convection fuels with natural gas-CNG/LNG.

23 Diesel Power Cars (DPCs) of Diesel Electric Multiple Units converted to dual fuel with CNG during last two years. First ever in the world in train sets.

Based on the analysis of combustion characteristics of duel fuel engines, its working and major components and the facts related to it are discussed in this paper.

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