Use of Methanol Blended Diesel in Indian Railways Diesel Locomotives

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Introduction

Indian Railways has tested a cleaner alternative fuel Methanol Blended Diesel for its 4756 strong fleet of diesel locomotives. Methanol (CH_3OH) contains 37.5% carbon by mass compare to 86% in diesel and offers improved combustion characteristics, potentially reducing harmful emissions. Methanol's lower energy density and corrosive nature require careful consideration of the methanol-diesel blend ratio to ensure engine performance and longevity. The initiative is expected to reduce the carbon footprint by about 426 kilo tonnes of CO_2e and saving about 260 million liters of diesel annually. The primary objective is to utilize 15% methanol diesel blend (MD15) without significant modifications to the existing engine, while maintaining rated power output.

Experimental work

Indian Railways has evaluated 15% Methanol blended Diesel (MD15) on test bed for 2-stroke, 16-cylinders-45V, 710 $inch^3$ displacement/cylinder, 16:1 compression ratio, turbocharged locomotive engine with a rated power of 4500 HP at 954 rpm. Engine set up is shown in figure 1. The engine was tested using diesel conforming to standard IS:1460 as a baseline, followed by tests with MD15 blend with proprietary surfactant. Key performance parameters, such as power output, brake-specific fuel consumption, turbine inlet and outlet temperatures, boost air pressure, cylinder temperature, peak cylinder pressure, and fuel consumption, were recorded. Additionally, exhaust emissions parameters- nitrogen oxides (NOx), carbon monoxide (CO), hydrocarbons (HC), particulate matter (PM), and smoke opacity were also measured. Experimental Test Set-up is shown in figure 2. Emission equipment conforming to 40CFR1065 are used for measuring emission parameters. Test set up for measuring emission parameters are shown in figure 3. Due to low calorific value of MD15 fuel and fuel delivery limitation, engine was unbale to produce rated power of 4500 HP with Mechanical Unit Injector. Hence tests were carried out using Electronic Unit Injection (EUI) system in the engine. After analysis of test result, further tests were carried out at different injection timing of MUIs with different fuel delivery rates for achieving rated power output.

Figure 1. Test Bed Engine

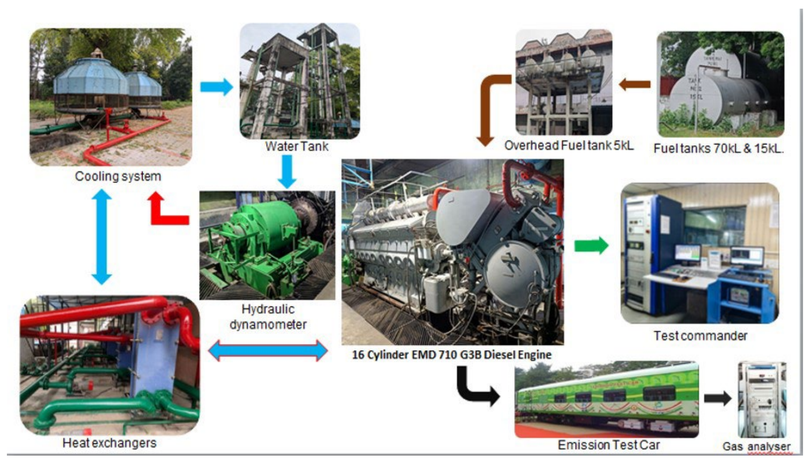

Figure 2. Experimental Test Set-up

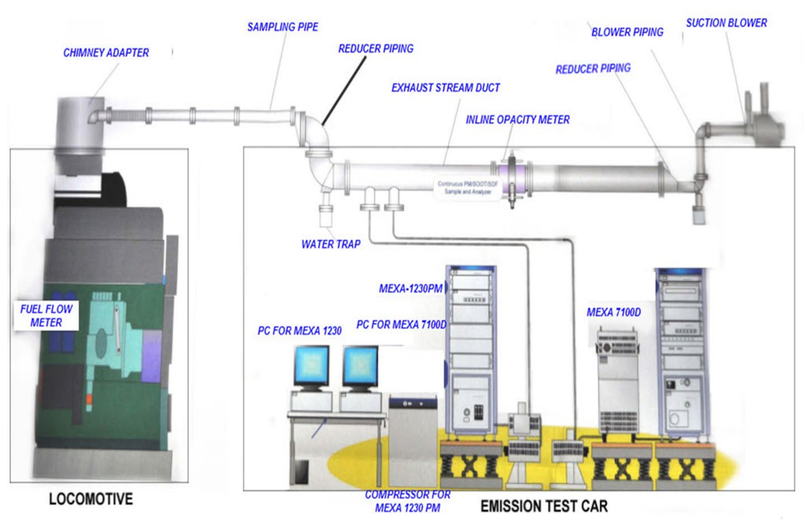

Figure 3: Engine Testing Setup

Results

Due to low calorific value of methanol and limitation of Mechanical Fuel Injection (MUI), the test bed engine maximum power output fell marginally short of the rated 4500 HP even though adequate control and stabilization was achieved at lower Power demand. However engine could achieve rated power of 4500 HP with EUI system. After analysis of the results it is found that there is ignition delay with MD15. To compensate longer ignition delay with MD15, tests were conducted with retarded fuel injection timings in MUI. Also MUIs were recalibrated to deliver ~5% more fuel at 0.875" rack setting. After repeated tests, engine performance with MUI was optimized at 1° retard in fuel injection timing producing rated power of 4500 HP. Result of fuel flow rate are shown in table 1. Key exhaust emissions, namely nitrogen oxides (NOx), carbon monoxide (CO), hydrocarbons (HC) and particulate matter (PM) were significantly reduce with MD 15.

Conclusions

This experiment concludes that MD15 can be used into Indian Railways' existing locomotive fleet with minimal engine modifications, providing substantial environmental benefits in reducing emission of NOx, HC, CO and Particulate matter (PM) for about 10-20% over duty cycle. The minor modifications to the existing Mechanical Unit Injector- a slight increase in fuel flow rate and retarded injection timing can effectively compensate for lower calorific value of MD15 fuel, enabling locomotives to maintain rated power output. Given that MUIs are simpler and more cost-effective than Electronic Unit Injection systems, this approach offers a practical and economical pathway for MD15 usage. MD15 offers significant environmental advantages, achieving a 10–20% reduction in exhaust emissions and 18–20% diesel consumption across the duty cycle, making MD15 a promising solution for cleaner and more efficient rail operations. The results confirm that MD15 can successfully be utilized in the current Indian Railways locomotive fleet.

Engine Notch	Power (HP)	HSD (Litre/hr)	MD 15 (Litre/hr)		
			MUI	EUI	MUI with 1° retard
Idle	150	32	40	36	36
1	259	50	64	60	57
2	607	108	130	125	123
3	1148	200	237	232	227
4	1573	274	321	314	309
5	1916	331	389	379	373
6	2960	524	625	588	592
7	3822	668	778	757	763
8	4500	794	892#	897	905
	# engine could produce 4359 HP				

Table 1: Fuel flow rate for rated power at different notches

References

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