

Development of Fuel Consumption Correction Factors for GTL Synthetic Diesel Fuel in Diesel Vehicles under Field Operating Conditions

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Abstract. This paper proposes a compact operational method for adapting fuel-consumption norms when gas-to-liquid (GTL) synthetic diesel fuel is used in existing diesel vehicles. Field tests were conducted on an ISUZU NQR71PL vehicle operated on petroleum diesel and GTL fuel under comparable conditions. The test indicators included maximum speed, acceleration time to 60 km/h, and fuel consumption at 40-90 km/h. The maximum speed remained practically unchanged (104.17 and 105.50 km/h), while acceleration time increased from 15.91 to 16.86 s. GTL volumetric consumption exceeded diesel consumption by 4.56-6.10%, mainly because of the lower density and lower energy content per litre of GTL fuel. Speed-dependent correction factors of 1.046-1.061 were obtained, and an average value of 1.055 is recommended for preliminary fleet accounting. The results confirm that GTL fuel can be used without major vehicle modification, but separate consumption norms are required.

Keywords: GTL fuel; synthetic diesel; correction factor; fuel-consumption norm; ISUZU NQR71PL; field test.

1. Introduction

Diesel engines remain important in road transport, agricultural machinery and stationary power units because of their reliability and high thermal efficiency. However, the environmental limitations of petroleum diesel fuel require cleaner alternatives that can be introduced without replacing the existing diesel-engine infrastructure [1-4]. GTL synthetic diesel fuel is produced from natural gas through synthesis-gas generation and Fischer-Tropsch synthesis. It is characterized by a high cetane number, very low sulfur content, reduced aromatic hydrocarbons and a mainly paraffinic composition [5-9]. These properties improve combustion stability and can reduce smoke and particulate emissions. In practical vehicle fleets, however, fuel consumption is normally accounted in litres per 100 km. Since GTL fuel has a lower density than petroleum diesel, its volumetric consumption may be higher even when vehicle performance remains close to diesel operation [6,8,14]. Therefore, direct transfer of diesel consumption norms to GTL operation may lead to inaccurate accounting. The aim of this study is to justify a simple speed-dependent correction-factor approach for GTL fuel consumption using field-test data from an ISUZU NQR71PL diesel vehicle.

2. Materials and methods

The experimental object was an ISUZU NQR71PL diesel vehicle tested successively on conventional petroleum diesel and GTL synthetic diesel fuel without major structural changes to the engine or fuel system. The assessment included maximum vehicle speed, acceleration time to 60 km/h and steady-speed fuel consumption at 40, 50, 60, 70, 80 and 90 km/h. The selected modes cover typical urban, suburban and intercity operation of a light-duty truck. Tests were carried out under comparable road, loading and environmental conditions.

Table 1. Main operational differences between petroleum diesel and GTL synthetic diesel fuel.

Parameter	Unit	Petroleum diesel	GTL synthetic diesel
Cetane number	-	48-52	60-70
Density at 15 °C	kg/m ³	820-845	765-790
Kinematic viscosity at 40 °C	mm ² /s	2.5-3.5	1.7-2.4
Sulfur content	ppm	up to 10 or more	<5
Aromatic hydrocarbons	%	present	very low

The relative change in fuel consumption and the GTL correction factor were calculated as follows:
 $\Delta q = ((q_{GTL} - q_D) / q_D) \times 100\%$, $K_{GTL} = q_{GTL} / q_D$, $q_{GTL,norm} = K_{GTL} \times q_{D,norm}$,
 where q_{GTL} and q_D are GTL and petroleum diesel consumption values. The physical reason for the correction is expressed by $Q_f = \rho_f V_f H_u$; therefore, at the same injected volume, a lower-density fuel supplies a lower fuel mass per cycle [6,8,14].



Figure 1. Experimental documentation of the GTL tests: (a) PIUSI digital fuel-flow meter; (b) laboratory engine test stand; (c) GTL fuel samples and storage barrels; (d) refuelling of the ISUZU NQR71PL test vehicle.

3. Results and discussion

The maximum speed of the vehicle changed only slightly when GTL fuel was used. The acceleration time increased moderately, which is attributed to the lower density of GTL fuel and the absence of special injection-system calibration. The main operational difference was observed in volumetric fuel consumption. Table 2 combines the vehicle performance results, fuel-consumption values and calculated correction factors.

Table 2. Field-test results and calculated GTL fuel-consumption correction factors.

Indicator / speed	Diesel	GTL	Difference	K GTL
Maximum speed, km/h	104.17	105.50	+1.28%	-
0-60 km/h acceleration, s	15.91	16.86	+5.97%	-
40 km/h, L/100 km	15.42	16.36	+6.10%	1.061
50 km/h, L/100 km	15.06	15.95	+5.91%	1.059
60 km/h, L/100 km	13.84	14.55	+5.13%	1.051
70 km/h, L/100 km	14.04	14.68	+4.56%	1.046
80 km/h, L/100 km	14.42	15.22	+5.55%	1.055
90 km/h, L/100 km	14.62	15.46	+5.75%	1.057

The calculated correction factor varied from 1.046 to 1.061. For preliminary fuel accounting under comparable operating conditions, the average factor $K_{GTL,avg} = 1.055$ may be used. For example, if a diesel norm is 15.0 L/100 km, the GTL norm can be estimated as $1.055 \times 15.0 = 15.83$ L/100 km. This increase should not be interpreted only as a loss of efficiency; it is mainly related to volumetric accounting and the lower density of GTL fuel. At the same time, GTL fuel has advantages connected with high cetane number,

low sulfur content and low aromatic hydrocarbon content, which can improve combustion quality and reduce smoke-forming tendency [5,7,9,20,21]. For practical use, transport enterprises should not apply petroleum diesel norms directly to GTL operation. It is advisable to introduce separate GTL norms, monitor fuel quality, inspect fuel-system elements and, where possible, optimize injection parameters. Future work should include direct measurement of NO_x, CO, HC, particulate matter and smoke opacity under real operating conditions.

4. Conclusions

1. GTL synthetic diesel fuel was successfully used in an ISUZU NQR71PL diesel vehicle without major structural modification.
2. Maximum speed remained practically unchanged: 104.17 km/h for petroleum diesel and 105.50 km/h for GTL fuel.
3. Acceleration time to 60 km/h increased from 15.91 to 16.86 s, corresponding to approximately 5.97%.
4. GTL volumetric consumption was 4.56-6.10% higher than petroleum diesel consumption in the tested speed range.
5. The calculated GTL correction factors ranged from 1.046 to 1.061; an average factor of 1.055 is recommended for preliminary operational accounting.
6. Separate GTL fuel-consumption norms are required for correct fleet accounting and practical implementation.

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