Developing Liquefied Natural Gas as Transport Fuel for Developing Nations

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Statement of problem: Petroleum refineries not meeting up with demand for transportation fuel in some developing nations like Nigeria which are primarily oil and gas host countries have been investigated to result from weak maintenance culture and technical issues. This has led to often several man-hour losses, over dependence on foreign imported refined products and many more not to mention.

Introduction: Nigeria holds a total proven Natural Gas reserves of 187tcf which most of them are underutilized in several sectors. Hence, the idea of using Liquefied natural gas (LNG) as a transportation fuel is being considered. This paper looks at the thermodynamic effect and computational fluid dynamics considerations involved in applying the LNG as a transportation fuel to achieve longer distance travel. A look into boil-off gases from the LNG carrier tank as it supplies a retrofitted engine, indicates the fundamental principle that govern the process.

This work is intended to be demonstrated in the Conventional vehicle where LNG from the Nigerian Liquified Natural Gas (NLNG) company will be stored in Cryogenic tanks and used as fuel in a retrofitted car engine. The surrounding analysis involved in this process will be carried out using high Computer aided Engineering (CAE) packages to foster the required and expected results.

The purpose of this study is to research on the viability of using LNG in conventional Car engines for the transportation sector.

The Redlich-Kwong (SRK) real gas equation of state model will be employed to predict gas dynamics parameters from natural gas to LNG. HYSYS

$$P = \frac{RT}{V_m - b} - \frac{a}{\sqrt{T}V_m(V_m + b)} \qquad (1)$$

$$a = 0.42748\frac{R^2T_c^{2.5}}{p_c} \quad b = 0.08664\frac{RT_c}{p_c}$$

To determine the rate at which LNG will be converted back to natural gas in the cryogenic tank as a result of external factors which will be used for fuelling the Retrofitted engine.

$$BOR = \frac{V_{BOG}\cdot 24}{V_{LNG}\cdot \rho} = \frac{Q\cdot 3600\cdot 24}{\Delta H\cdot V_{LNG}\cdot \rho}\cdot 100 \qquad (2)$$

This model will be used to determines the Heat transferred from the environment that passes through the tank's insulator then to the LNG in the cryogenic tank which creates the boil-off.

$$Q_1 = Q_2 = Q_3 \qquad (3)$$

$$\begin{cases} K_1A_{12}\frac{T_2-T_1}{L_{12}} = K_rA_{23}\frac{T_3-T_2}{L_{23}} \\ K_1A_{12}\frac{T_2-T_1}{L_{12}} = KA_4\alpha P(T_4-T_3)+\sigma\varepsilon_{4-3}A_4(T_4^4-T_3^4)\varphi_{34} \end{cases}$$

When the LNG is flowing in the x direction parallel to the cryogenic tank, and its concentration is $v_x\rho$. By random diffusion of molecules there is an exchange of molecules in the z direction. from the faster- to the slower-moving layer

$$\tau_{zx} = -\nu\frac{\partial \rho v_x}{\partial z} \qquad (4)$$

This equation demonstrates the boil-off gas moving through the pipes from the concentrated cryogenic tank to the retrofitted engine for combustion process.

$$J_{Ay} = -D_{AB}\frac{\partial Ca}{\partial y} \qquad (5)$$

Methods: The process will be attended to experimentally and numerically, where the LNG sample is collected and stored in a thermo-cooled cryogenic tank. Observations on the operating conditions necessary for the boil-off production will be considered. which will initiate process of numerically determining its effect on the retrofitted engine.

Results: The analysis of corresponding graphs (Fig. 1& 2) shows proximity of boil-off production under ambient (25oC) and increased temperature(35C) at the cryogenic tank. The rate of boil-off gas increases with temperature from the surrounding at 0.0634kg/s and 0.0811kg/s respectively.

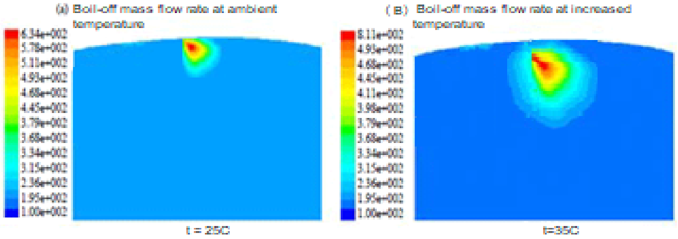

Fig 1 (a & b)- Boil-off mass flow rate at different temperatures

Experimentally, lesser boil-off mass flow rates from the tank was observed

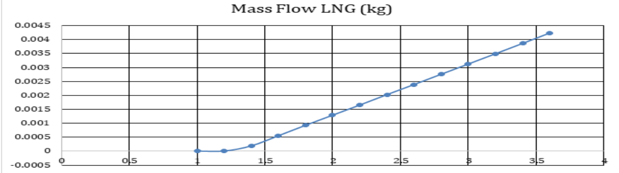

Fig 2- Experimental Boil-off mass flow rate at increasing temperature

Conclusions: the results obtained systematically indicates that the boil-off gas coming from the cryogenic tank can be situated as the fuel option for the retrofitted engines due to its increasing flow rate by step-wise temperature increment. Nigerian's transportation sector can be boosted through the integration of LNG alternative as the fuel for the future.