AFT OF BIO FUELS USED AS ALTERNATIVE SOURCES OF ENERGY IN ENGINES.

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Abstract. *Bio-fuel is any fuel that is derived from biomass — living organisms or their metabolic byproducts, Sugar cane, corn, soyabeans , palm oil, straw, timber, manure or the mixture of these in relative proportions or any other similar renewable source of energy. Heat energy supplied to the engine in the form of power depends on the temperature of the exit gases obtained on the combustion of the fuel. When this is carried out in a flow system as in the case of Automobile engines, the temperature of the exit gases is called as Adiabatic Flame Temperature (AFT). So in the case of Combustion of Bio-Fuels in the engine the AFT is influenced by gas composition, extent of premixing and initial temperature of the mixture. AFT is determined by mathematical analysis of a fifth degree equation obtained by considering the above factors. Depending upon the energy to be supplied (i.e),the automobile the AFT has to vary within defined limits. The feasibility which is directly related to this in order to remain constant has to modify the remaining factors suitably. In this paper, the AFT of different Bio Fuels and their variation with various parameters are analyzed. Its possible influence on the engine performance is also discussed.*

***Keywords**:* Adiabatic Flame Temperature (AFT), Bio-Fuel, Pre-Mixing, feasibility

Nomenclature

H_R	: Enthalpy of reactants(kJ/mol)
H_P	: Enthalpy of products(kJ/mol)
H^0_R	: Enthalpy of reactants at 298 K (kJ/mol)
H^0_P	: Enthalpy of products at 298K
Cp^R	: Specific heat capacity of reactants at constant pressure(kJ/kg/K)
C_P^P	: Specific heat capacity of products at constant pressure(kJ/kg/K)
T_{IN}	: Temperature at Inlet(K)
T_0	: Room Temperature(K)
A_I,B_I,C_I,D_I	: Coefficients in the Cp term(no unit)
T_{AD}	: Adiabatic Flame temperature(K)
AFT	: Adiabatic flame temperature(K)
E	: Energy of The exit gases(kJ/mol)
% O	: Excess percentage of Oxygen(%)
A/F	: Air Fuel Ratio(No unit)
M	: Mass of the food stuff
T_F	: Cooking temperature of food stuff
N	: Number of moles of LPG
T	: Temperature (K)
τ	: T/T_O (No unit)
n	: Number of moles of each reactant or product in the stoichiometric equation
ΔH	: Enthalpy Change(kJ/mol)

1.INTRODUCTION

Gasoline and Diesel nowadays are tending to get more and more costly. Since they are non renewable resources one tends to get a feeling that there would be no more of these fuels left after sixty to seventy years. When we begin to go towards the cheaper fuels they tend to give les energy. Hence an acute balance can be maintained if we can go in for Bio Fuels which are cheap and at the same time release a larger amount of useful energy. Some of the bio fuels whose behaviour can be studied are Bio-Gas and Producer Gas.As in the web references Bio-Gas is obtained from any of the waste products or decaying matter. Its composition has also been listed in the calculations. We find that producer gas is of two types namely Wood gas and Town gas. The composition of wood gas and Town gas are stated in the forthcoming part of the paper.

An adiabatic process is one in which there is no external heat Energy supplied. In other words the change in Internal Energy is equal in magnitude to the work done by the system. In the case of Combustion of fuel in a car the combustion is almost an adiabatic process. The temperature of the exit gases reach a maximum value when there is no external heat supplied. This particular temperature is called as adiabatic flame temperature.

Domnina Razus et al. (March 2006) developed a useful tool/procedure for estimating the limiting values of fuel concentration by considering the information regarding the flammability of fuel-air mixtures at higher temperatures.The procedure for the estimation was mainly based on the adiabatic flame temperature for each reaction. This was found to vary with addition of inert components to the mixture. The two limits namely the lower explosion limit and the upper explosion limit were determined which were also found to vary with the composition of the mixture.

Domnina Razus et al. (June 2004) developed an alternative method to evaluate limiting oxygen concentration of fuel air inert premixed systems using the values of the explosion limits. The procedure is based on an empirical correlation established between the Adiabatic Flame Temperature computed for fuel–air–nitrogen mixtures at Limiting Oxygen Concentration and at Explosion Limits for a large number of flammable gases and vapors.

Aswin Kannan et al .(May 2007) developed a mathematical methodology for estimating the oxygen concentration and air fuel ratios for different levels of output energy.The method employs computation of Adiabatic Flame Temperature for its methodology. .The major fuel considered was LPG(Liquified Petroleum Gas). In case of LPG burning in a domestic stove, the AFT is found to be influenced by gas composition, extent of premixing and initial temperature of the mixture. AFT is determined by mathematical analysis of a fifth degree equation obtained by considering the above factors..It also idealizes the perfect AFT for an especial cooking process and also suggests several energy conserving measures.

This paper focusses on an alternative method of computation of Adiabatic Flame Temperature using the heat of the involving reaction.The paper specializes on such a methodology for the combustion of bio fuels.Then the energy available at the ouput is computed.A relation between the energy,the AFT and the Air/fuel ratio (Oxygen content) is also established.The most optimum fuel is also deciphered from the given set of bio-fuels.The procedure and analysis are as described below.

For any adiabatic process,

$$\Delta H=0$$

In other words,

$$H_R=H_P$$

$$H_R=H^0_R+C_P^R\,(T_{IN}-T_0) \quad (1)$$

From Smith(2000) the values of C_P for the products of combustion at various temperatures are calculated using the relations provided as shown below,

$$Cp=(\sum n_I\, A_I+\sum n_I\, B_I(\tau_I+1)*T_0/2+\sum n_I\, C_I*\, T_0^2\,(\tau_I^2+\tau_I+1)/3+\sum n_I\, D_I\,(\tau_I-1/\tau_I*T_0)*R \quad (2)$$

Where, $\tau_1=T_{IN}/T_0$

A_I, B_I, C_I, D_I are the coefficients of Cp for every molecule involved in the reaction.
And Cp is a function of temperature,

For the products,

$$H_P=H^0_P+C_P^P(T_{AD}-T_0) \quad (3)$$

Similar definition of Cp holds good except for the changing of $\tau 1$ to $\tau 2$ and the corresponding A,B,C,D values for the products.

Where $\tau_2=T_{AD}/T_0$

For a known Inlet temperature Hr can be calculated for a particular reaction

$$H_R=H^0{}_P+(\sum A_I+\sum B_I(\tau_I+1)*T_0/2+\sum CI*T_0{}^2(\tau_I{}^2+\tau_I+1)/3+\sum DI(\tau_I-1/\tau_I*T_0)*R*(\tau-1)*T_0 \qquad (4)$$

The above equation is a fourth degree equation in terms of τ .Solving this equation the value of τ can be found out. From this value the value of T_{AD} can be deciphered.

2. ANALYSIS

Web references(2007) state the composition of Bio fuels namely wood gas,town gas and bio-gas..Producer gas is of two types namely town gas and Wood gas. The composition of Wood gas is stated to be 50.9% Nitrogen, 27% Carbon Mon-Oxide, 14% Hydrogen, 4.5% Carbon Di Oxide, 3% Methane and 0.6% Oxygen.Town gas has been found to be a mixture of Hydrogen, Carbon Mon Oxide, Carbon Di Oxide, Methane and Nitrogen constituting 51%, 15%, 7%, 21%, 3% respectively of the total composition. The remaining 3% is waste the weight of which is negligible. Biogas is found in many compositions out of which two of the important samples are discussed here.The composition of one of the samples (Bio Gas I) is stated to consist of 60% methane, 30% Carbon -Di- Oxide, 9% Nitrogen and 1% Hydrogen.The other sample (Bio Gas II) has been stated to consist of 55% Methane, 40% Carbon-Di-Oxide, 3% Nitrogen and 2% Oxygen.

The analysis is done by calculating the AFT as mentioned in the previous section.The AFT value for various inlet temperatues is computed.Then the oxygen concentrations are varied and then the corresponding values are found outThen the Cp value is calculated and then the product of both would yield the energy per mole.But the expression would be optimal if the energy is in kJ/kg.Hence calculations are carried out to obtain energy per kg of the fuel.In short the calorific value of the fuel is calculated.

2.1 Calculation Of AFT and Energy

Wood gas

The burning equation for Wood gas with no excess air is shown below(that is when 1 mole of wood gas is burnt with no excess air).

$$0.27CO + 0.14H_2 + 0.045CO_2 + 0.03CH_4 + 0.006O_2 + 0.509N_2 + 0.265O_2 + N_2 \rightarrow 0.345CO_2 + 0.12H_2O + 0.006O_2 + 1.509N_2$$

The stoichiometric coefficients are to be substituted for n_I respectively. For the above reaction the Adiabatic Flame Temperature is as follows.

For $T_{IN} = 300$ K.

$$1.91721\,\tau^3+62.724033\,\tau^2-394.38\,\tau+2.95672=0 \qquad (6)$$

For $T_{IN} = 350$ K.

$$1.91721\,\tau^3+62.724033\,\tau^2-405.23\,\tau+2.95672=0 \qquad (7)$$

The burning equation in the case of 25% excess oxygen is ,

$$0.27CO + 0.14H_2 + 0.045CO_2 + 0.03CH_4 + 0.006O_2 + 0.33125 + 1.759N_2 \rightarrow 0.345CO_2 + 0.12H_2O + 0.07225O_2 + 1.759N_2$$

Similarly the burning equation for 50%, 75%, 100%, 125% excess air are written. The Equation in each case for varying Inlet temperatures are deciphered. Then the equation is solved where the AFT is calculated. Similarly using the equation(2) Cp of the products is computed.Then Cp*T_{AD}.From this the energy available at the outlet in the form of gases per kg of the fuel is computed.1 mole of fuel corresponds to 24.744 g of the fuel.So 1 kg of the fuel would be equal to 1000/24.744 moles of the fuel.

$$E/kg=(1000/24.744)*E/mol=40.4138*E/mol=40.4138*Cp*AFT \quad (8)$$

The tabulation below yields the various values of AFT, Cp and Energy/kg for various inlet temperatures and A/F ratios.

T_{IN}	Stoichiometric Oxygen			25% excess Oxygen			50% excess oxygen		
	T_{AD}	Cp	E/kg	T_{AD}	Cp	E/kg	T_{AD}	Cp	E/kg
(K)	(K)	kJ/mol/K	kJ/kg	(K)	kJ/mol/K	kJ/kg	(K)	kJ/mol/K	kJ/kg
250	2001.0	0.0754	6096.6	1815.1	0.0843	6183.8	1664.8	0.0933	6277.3
300	2037.2	0.0756	6224.2	1852.4	0.0846	6333.3	1703.2	0.0936	6442.7
350	2073.7	0.0758	6352.5	1890.1	0.0849	6485.1	1741.7	0.0939	6609.5
400	2103.6	0.0761	6469.6	1927.9	0.0853	6646.0	1780.5	0.0943	6785.5
450	2147.2	0.0764	6629.7	1965.9	0.0855	6792.9	1819.5	0.0946	6956.2
500	2184.3	0.0766	6761.9	2004.0	0.0857	6940.7	1857.2	0.0949	7122.8
550	2221.5	0.0768	6895.0	2042.4	0.0860	7098.5	1897.8	0.0952	7301.5
600	2258.8	0.0771	7038.2	2080.8	0.0863	7257.2	1937.2	0.0956	7484.4
650	2296.3	0.0773	7173.6	2119.5	0.0866	7417.9	1976.7	0.0959	7661.0
700	2334.0	0.0776	7319.6	2158.2	0.0870	7588.2	2016.3	0.0962	7838.9
750	2371.7	0.0778	7457.0	2211.5	0.0872	7793.5	2056.1	0.0965	8018.8
800	2409.7	0.0781	7605.7	2236.1	0.0875	7907.3	2096.0	0.0969	8208.1
850	2447.7	0.0783	7745.5	2275.2	0.0877	8063.9	2136.0	0.0972	8390.6
900	2485.9	0.0785	7886.4	2314.5	0.0879	8221.9	2176.1	0.0975	8574.5

T_{IN}	75% Excess Oxygen			100% Excess Oxygen			125% Excess Oxygen		
	T_{AD}	Cp	E/kg	T_{AD}	Cp	E/kg	T_{AD}	Cp	E/kg
(K)	(K)	kJ/mol/K	kJ/kg	(K)	kJ/mol/K	kJ/kg	(K)	kJ/mol/K	kJ/kg
250	1540.9	0.1023	6373.7	1465.6	0.1116	6610.1	1348.4	0.1301	7093.2
300	1580.0	0.1026	6554.6	1507.0	0.1120	6824.6	1388.8	0.1306	7333.8
350	1619.4	0.1030	6744.3	1548.6	0.1124	7038.0	1429.6	0.1310	7572.4
400	1659.0	0.1034	6936.0	1578.2	0.1128	7198.1	1470.4	0.1315	7818.2
450	1698.7	0.1037	7122.6	1632.3	0.1132	7471.2	1511.4	0.1320	8066.7
500	1738.7	0.1041	7318.5	1674.5	0.1136	7691.5	1552.6	0.1325	8318.0
550	1778.7	0.1044	7508.4	1716.8	0.1139	7906.6	1593.8	0.1329	8564.0
600	1818.9	0.1048	7707.5	1747.4	0.1143	8075.8	1635.2	0.1334	8820.1
650	1859.2	0.1052	7908.4	1787.7	0.1149	8305.4	1676.7	0.1339	9077.8
700	1899.6	0.1055	8103.3	1844.7	0.1153	8600.0	1718.3	0.1343	9330.8
750	1940.1	0.1059	8307.4	1887.7	0.1157	8831.0	1760.0	0.1348	9592.9
800	1980.7	0.1063	8513.3	1930.7	0.1161	9063.4	1801.8	0.1353	9857.1
850	2021.5	0.1066	8713.2	1973.9	0.1166	9306.1	1843.7	0.1357	10116.2
900	2062.3	0.1069	8914.0	2017.2	0.1170	9542.9	1885.7	0.1361	10377.1

$$\text{Equation Of Fit : } E/kg=2.5*T_{IN}+5500+0.011*(\%O)^2-7.8*(\%O) \quad (9)$$

Town Gas

The burning equation for Town gas with no excess air is shown below(1 mol of the)fuel

$0.15CO + 0.51H_2 + 0.07CO_2 + 0.21CH_4 + 1.5O_2 + 5.67N_2 \rightarrow 0.43CO_2 + 0.93H_2O + 5.67N_2$

$$6.38925\ \tau^3 + 200.8627\ \tau^2 - 1293.8035\ \tau + 1.4802 = 0 \qquad (T_{IN} = 300\ K) \qquad (10)$$

1 mole of fuel corresponds to 12.5 g of the fuel. So 1 kg of the fuel would be equal to 1000/24.744 moles of the fuel.

$$E/kg = (1000/12.5)*E/mol = 80*E/mol = 80*Cp*AFT \qquad (11)$$

T_{IN}	Stoichiometric Oxygen			25% excess Oxygen			50% excess oxygen		
	T_{AD}	Cp	E/kg	T_{AD}	Cp	E/kg	T_{AD}	Cp	E/kg
(K)	(K)	kJ/mol/K	kJ/kg	(K)	kJ/mol/K	kJ/kg	(K)	kJ/mol/K	kJ/kg
250	1634.1	0.2365	30917.1	1390.8	0.2871	31943.8	1220.1	0.3371	32903.6
300	1676.1	0.2374	31832.4	1433.1	0.2882	33041.5	1264.1	0.3391	34292.0
350	1718.5	0.2383	32761.4	1477.5	0.2893	34195.2	1308.3	0.3405	35638.0
400	1761.1	0.2392	33700.4	1521.1	0.2905	35350.3	1352.8	0.3418	36990.9
450	1803.9	0.2402	34663.7	1565.0	0.2916	36508.3	1397.4	0.3432	38367.0
500	1846.9	0.2411	35623.0	1609.0	0.2928	37689.2	1442.1	0.3445	39744.2
550	1890.0	0.2421	36605.5	1653.2	0.2939	38870.0	1487.0	0.3459	41148.2
600	1933.3	0.2430	37583.3	1697.5	0.2951	40074.5	1531.6	0.3472	42541.7
650	1976.8	0.2439	38571.3	1741.9	0.2962	41276.0	1577.1	0.3486	43982.1
700	2020.4	0.2449	39583.6	1786.5	0.2974	42504.4	1622.3	0.3500	45424.0
750	2064.2	0.2458	40590.4	1831.2	0.2985	43729.0	1667.6	0.3513	46866.2
800	2108.1	0.2468	41622.3	1876.0	0.2997	44978.9	1713.1	0.3527	48336.8
850	2152.1	0.2477	42646.0	1920.9	0.3008	46224.5	1758.6	0.3541	49817.6
900	2196.2	0.2486	43678.0	1965.9	0.3015	47417.5	1804.2	0.3555	51311.4

T_{IN}	75% Excess Oxygen			100% Excess Oxygen			125% Excess Oxygen		
	T_{AD}	Cp	E/kg	T_{AD}	Cp	E/kg	T_{AD}	Cp	E/kg
(K)	(K)	kJ/mol/K	kJ/kg	(K)	kJ/mol/K	kJ/kg	(K)	kJ/mol/K	kJ/kg
250	1093.8	0.3885	33995.3	996.53	0.4393	35022.0	919.39	0.4900	36040.0
300	1138.4	0.3901	35527.1	1041.6	0.4410	36747.6	964.80	0.4920	37974.5
350	1183.2	0.3916	37067.2	1086.8	0.4428	38498.0	1010.4	0.4940	39931.0
400	1228.2	0.3932	38634.2	1132.2	0.4446	40270.0	1056.2	0.4960	41910.0
450	1273.3	0.3947	40205.7	1177.8	0.4464	42061.5	1102.0	0.4980	43903.6
500	1318.6	0.3963	41804.8	1223.5	0.4482	43869.8	1148.1	0.5000	45924.0
550	1364.0	0.3979	43418.8	1269.3	0.4499	45684.6	1194.2	0.5020	47959.0
600	1409.5	0.3995	45047.6	1315.2	0.4517	47526.0	1240.4	0.5040	50012.9
650	1455.1	0.4010	46679.6	1361.2	0.4535	49384.3	1286.7	0.5060	52085.6
700	1500.8	0.4026	48337.7	1407.3	0.4553	51259.0	1333.1	0.5080	54177.1
750	1546.7	0.4042	50014.0	1453.5	0.4571	53151.5	1379.5	0.5100	56283.6
800	1592.9	0.4058	51711.9	1499.7	0.4589	55056.9	1426.1	0.5120	58413.0
850	1638.5	0.4074	53401.9	1546.0	0.4607	56979.3	1472.7	0.5140	60557.4
900	1684.6	0.4090	55120.1	1592.5	0.4626	58935.2	1519.4	0.5160	62720.8

$$\text{Equation Of Fit}\ :\ E/kg = 20*T_{IN} + 28400 - 0.0002*(\%O)^2 + 0.42*(\%O) \qquad (12)$$

Biogas I

The burning equation for Biogas I gas with no excess air is shown below

$0.09\ N_2 + 0.01H_2 + 0.3CO_2 + 0.6CH_4 + 1.2O_2 + 4.512N_2 \rightarrow 0.9CO_2 + 1.21H_2O + 4.602N_2$

$$6.71592\ \tau^3 + 201.139\ \tau^2 - 1808.3829\ \tau + 6.6515 = 0 \quad (AT\ T_{IN}=300K) \quad (13)$$

1 mole of fuel corresponds to 25.34 g of the fuel. So 1 kg of the fuel would be equal to 1000/24.744 moles of the fuel.

$$E/kg = (1000/25.34)*E/mol = 39.463*E/mol = 39.463*Cp*AFT \quad (14)$$

T_{IN}	Stoichiometric Oxygen			25% excess Oxygen			50% excess oxygen		
	T_{AD}	Cp	E/kg	T_{AD}	Cp	E/kg	T_{AD}	Cp	E/kg
(K)	(K)	kJ/mol/K	kJ/kg	(K)	kJ/mol/K	kJ/kg	(K)	kJ/mol/K	kJ/kg
250	2156.7	0.2495	21234.91	1892.3	0.2898	21641.06	1691.9	0.3302	22046.6
300	2188.1	0.2502	21604.52	1925.9	0.2907	22093.72	1727.3	0.3313	22582.8
350	2220.2	0.2510	21991.55	1960.1	0.2916	22555.68	1763.1	0.3324	23127.4
400	2252.9	0.2517	22377.69	1994.8	0.2926	23033.7	1799.4	0.3335	23681.7
450	2286.0	0.2525	22778.64	2029.9	0.2935	23511.09	1836.1	0.3346	24244.4
500	2319.6	0.2533	23186.67	2065.4	0.2945	24003.78	1873.1	0.3356	24806.9
550	2353.6	0.2541	23600.84	2101.3	0.2954	24495.63	1910.5	0.3366	25377.6
600	2387.9	0.2549	24020.17	2137.6	0.2963	24994.72	1948.2	0.3376	25955.0
650	2422.2	0.2556	24432.11	2174.2	0.2973	25508.48	1986.2	0.3387	26547.7
700	2557.7	0.2563	24851.00	2211.0	0.2982	26018.75	2024.5	0.3398	27147.5
750	2493.1	0.2570	25285.00	2248.2	0.2991	26536.37	2062.5	0.3409	27746.6
800	2528.8	0.2577	25716.92	2285.6	0.3001	27068.01	2101.8	0.3420	28366.6
850	2564.8	0.2584	26153.88	2323.3	0.3011	27606.17	2140.8	0.3431	28985.9
900	2601.1	0.2591	26595.89	2361.3	0.3021	28150.88	2180.1	0.3442	29612.6

T_{IN}	75% Excess Oxygen			100% Excess Oxygen			125% Excess Oxygen		
	T_{AD}	Cp	E/kg	T_{AD}	Cp	E/kg	T_{AD}	Cp	E/kg
(K)	(K)	kJ/mol/K	kJ/kg	(K)	kJ/mol/K	kJ/kg	(K)	kJ/mol/K	kJ/kg
250	1535.1	0.3678	22281.2	1408.9	0.4111	22856.9	1305.2	0.4513	23245.1
300	1571.0	0.3691	22882.8	1446.6	0.4126	23554.1	1343.9	0.4529	24019.2
350	1608.9	0.3703	23511.1	1484.8	0.4140	24258.1	1383.0	0.4545	24805.0
400	1646.4	0.3716	24143.5	1523.4	0.4155	24976.0	1422.4	0.4560	25596.2
450	1684.3	0.3729	24785.7	1562.4	0.4170	25710.9	1462.2	0.4575	26399.0
500	1722.6	0.3742	25437.7	1601.6	0.4185	26450.8	1502.3	0.4590	27211.9
550	1761.2	0.3755	26098.0	1641.1	0.4200	27200.3	1542.6	0.4605	28033.2
600	1800.0	0.3768	26765.3	1680.9	0.4215	27959.5	1583.2	0.4620	28864.7
650	1839.2	0.3781	27442.6	1708.7	0.4230	28523.0	1624.0	0.4637	29717.5
700	1878.5	0.3794	28125.3	1761.3	0.4245	29505.3	1665.0	0.4654	30579.5
750	1918.1	0.3807	28816.7	1801.7	0.4259	30281.7	1706.2	0.4670	31443.9
800	1958.0	0.3820	29516.5	1842.5	0.4274	31076.0	1747.6	0.4686	32317.2
850	1998.0	0.3834	30229.9	1883.4	0.4289	31877.8	1789.2	0.4702	33199.5
900	2038.3	0.3847	30944.2	1924.5	0.4304	32687.3	1831.0	0.4720	34105.1

$$Equation\ Of\ Fit\ :\ E/kg = 8.3*T_{IN} + 19000 + 0.07*(\%O)^2 + 34*(\%O) \quad (15)$$

Biogas II

The burning equation for Bio-Gas II gas with no excess air is shown below

$0.03\ N_2 + 0.02O_2 + 0.4CO_2 + 0.55CH_4 + 1.1O_2 + 4.136N_2 \rightarrow 0.95CO_2 + 1.1H_2O + 4.13602N_2$

$$6.253501\ \tau^3 + 188.138\ \tau^2 - 1655.8559\ \ \tau + 7.5343 = 0 \qquad (AT\ T_{IN}=300K) \qquad (16)$$

1 mole of fuel corresponds to 27.88 g of the fuel.So 1 kg of the fuel would be equal to 1000/27.88 moles of the fuel.

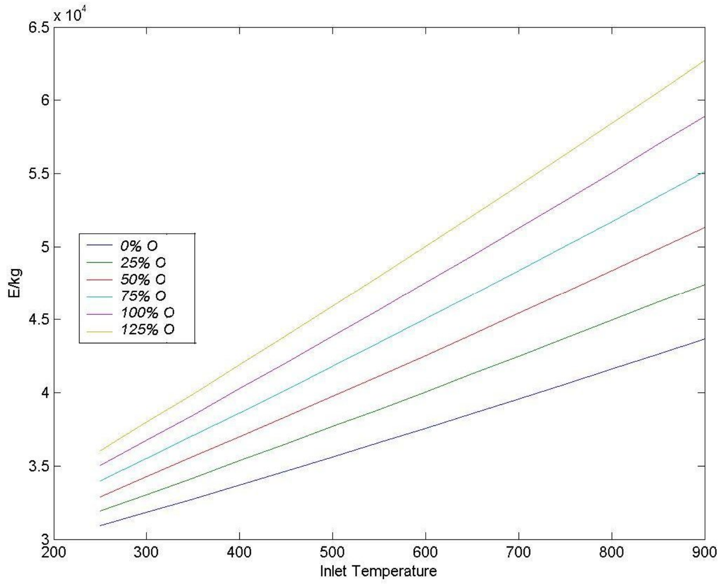
$$E/kg=(1000/27.88)*E/mol=35.859*E/mol=35.859*Cp*AFT \qquad (17)$$

T_{IN}	Stoichiometric Oxygen			25% excess Oxygen			50% excess oxygen		
	T_{AD}	Cp	E/kg	T_{AD}	Cp	E/kg	T_{AD}	Cp	E/kg
(K)	(K)	kJ/mol/K	kJ/kg	(K)	kJ/mol/K	kJ/kg	(K)	kJ/mol/K	kJ/kg
250	2119.9	0.2322	17651.2	1861.6	0.2694	17983.8	1665.1	0.3070	18330.6
300	2150.6	0.2329	17960.8	1895.2	0.2703	18369.5	1700.4	0.3080	18780.1
350	2182.9	0.2336	18285.4	1929.4	0.2711	18756.4	1736.2	0.3090	19237.8
400	2215.8	0.2343	18616.6	1964.2	0.2719	19151.0	1772.6	0.3100	19704.7
450	2249.3	0.2350	18954.5	1999.5	0.2727	19552.6	1809.4	0.3110	20178.0
500	2283.2	0.2357	19297.5	2035.1	0.2736	19966.4	1846.6	0.3120	20659.7
550	2317.5	0.2364	19645.6	2071.2	0.2745	20387.4	1884.1	0.3130	21146.8
600	2352.2	0.2371	19998.8	2107.6	0,2754	20813.7	1922.0	0.3140	21641.1
650	2387.3	0.2378	20357.1	2144.3	0.2763	21245.3	1960.1	0.3150	22140.4
700	2422.7	0.2385	20719.8	2181.4	0.2772	21683.3	1998.5	0.3160	22645.8
750	2458.5	0.2392	21087.7	2218.7	0.2781	22125.7	2037.2	0.3170	23157.4
800	2494.5	0.2399	21459.1	2256.3	0.2790	22573.5	2076.2	0.3180	23675.2
850	2530.9	0.2406	21835.7	2294.2	0.2799	23026.7	2115.3	0.3190	24196.9
900	2567.5	0.2413	22216.0	2332.3	0.2808	23484.4	2154.7	0.3200	24724.9

T_{IN}	75% Excess Oxygen			100% Excess Oxygen			125% Excess Oxygen		
	T_{AD}	Cp	E/kg	T_{AD}	Cp	E/kg	T_{AD}	Cp	E/kg
(K)	(K)	kJ/mol/K	kJ/kg	(K)	kJ/mol/K	kJ/kg	(K)	kJ/mol/K	kJ/kg
250	1515.1	0.3414	18548.2	1390.5	0.3811	19002.3	1263.6	0.4266	19329.8
300	1551.7	0.3426	19063.0	1428.2	0.3824	19584.1	1301.6	0.4281	19981.1
350	1588.8	0.3438	19587.2	1466.4	0.3838	20181.0	1340.1	0.4296	20644.2
400	1626.4	0.3450	20120.7	1505.1	0.3852	20789.7	1378.9	0.4311	21316.1
450	1664.4	0.3462	20662.0	1544.1	0.3866	21406.0	1418.1	0.4325	21993.3
500	1702.8	0.3474	21212.4	1583.4	0.3880	22030.3	1457.6	0.4341	22689.5
550	1741.4	0.3486	21768.2	1623.0	0.3894	22662.7	1497.3	0.4356	23388.1
600	1780.4	0.3498	22332.4	1663.0	0.3908	23304.7	1537.3	0.4371	24095.5
650	1819.6	0.3510	22902.4	1702.9	0.3922	23949.4	1577.6	0.4386	24812.1
700	1859.1	0.3522	23479.5	1743.5	0.3936	24264.8	1618.1	0.4401	25536.1
750	1898.8	0.3534	24062.6	1784.1	0.3950	25270.5	1658.8	0.4416	26267.6
800	1938.8	0.3546	24653.0	1824.9	0.3964	25940.0	1699.6	0.4430	26999.0
850	1979.0	0.3558	25249.3	1865.9	0.3978	26616.5	1740.7	0.4445	27745.5
900	2019.3	0.3570	25850.0	1907.1	0.3992	27299.9	1782.0	0.4460	28499.7

$$Equation\ Of\ Fit\ :\ E/kg=7*T_{IN}+16000-0.064*(\%O)^2+26*(\%O) \qquad (18)$$

2.2 Plots



Plot of E/kg vs Inlet temperatures for the most optimum fuel(Town Gas)

3.CONCLUSIONS

The adiabatic flame temperature is the theoretically attainable maximum temperature and it is used to determine the ideal performance of the system and the suitable material for the construction of such reactors. In the age of fuel crisis, the knowledge of fuel performance parameters will enable us to put the new generation fuels to better use.The adiabatic flame temperature is found to be greatly influenced by the fuel composition, equivalence ratio and initial air temperature. We can find that the AFT is highest for Biogas I for any value of inlet temperature and A/F ratio. One can also state that the highest amount of energy obtained would be from Town gas. This is primarily because of its higher Cp value and its increase with temperature. So use of Bio Gas I as an alternate fuel would be of good use in the case of engines which operate at a higher temperature and use of Wood gas in the case of engines which need higher power would be optimum.

4.REFERENCES

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