Calculation of efficiency of AB Engine and its comparison with the conventional engine.

Lets fist derive the expression for conventional engine, which is based on a standard Otto cycle. Using notations in Fig.1 for conventional Otto cycle, the efficiency η can be expressed as follows:

$$\eta = \frac{W_{net}}{g_{in}} = 1 - \frac{g_{out}}{g_{in}} = 1 - \frac{T_4 - T_1}{T_3 - T_2} \qquad (9)$$

The fact that compression and expansion ratios are equal in conventional engine leads to the following relation:

$$\frac{T_3}{T_4} = \frac{T_2}{T_1} = \left(\frac{V_2}{V_1}\right)^{k-1} = r^{k-1} \qquad (10)$$

where r is a compression ratio for conventional Otto cycle, k is an effective value of γ from formula (3) which is equal to 1.35 for typical air-fuel mixture.

From (10) it follows that:

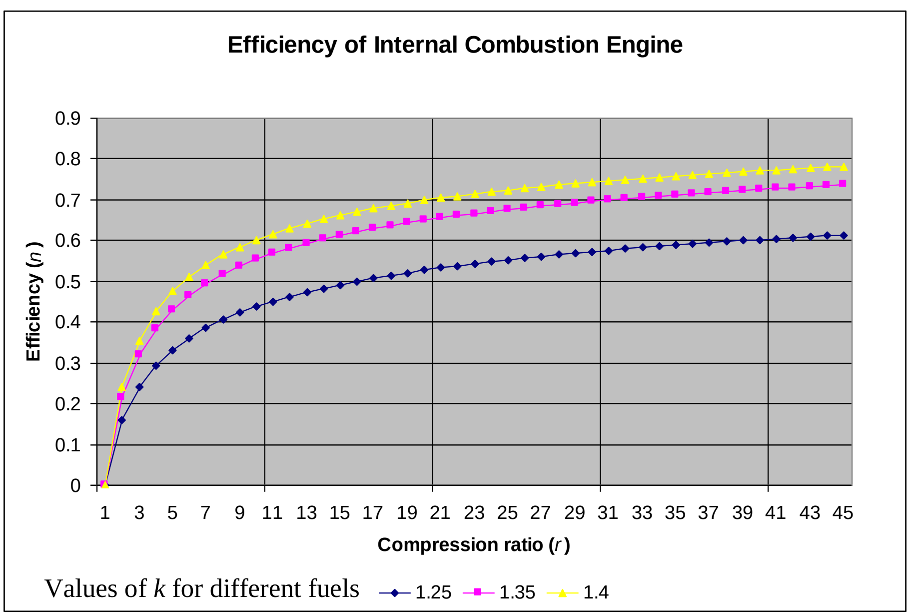
$$T_3 = T_4 r^{k-1} \qquad (11)$$

$$T_2 = T_1 r^{k-1} \qquad (12)$$

$$T_3 - T_2 = (T_4 - T_1) r^{k-1} \qquad (13)$$

From (9) and (13) we have:

$$\eta = 1 - \frac{1}{r^{k-1}} \qquad (14)$$



The above is a classical derivation based on the proportional relation between change in internal energy and change in temperature and can be found in numerous classical textbooks as well as in recent publications. The one given here was taken from the following reference:
http://www.engr.colostate.edu/~allan/thermo/page5/page5.html
For the purpose of efficiency calculation in the proposed engine, it must be taken into consideration that the compression and expansion ratios are different. According to Fig.2, the gas is compressed above atmospheric pressure from volume V_2 to V_1 (trace 2-4), but expands from volume V_1 to effective volume V_E (trace 5-6-7). To account for this change the formula (9) must be modified as follows:

$$\eta = 1 - \frac{T_E - T_1}{T_3 - T_2} \qquad (15)$$

The relation between temperatures and volumes during compression gives:

$$\frac{T_2}{T_1} = \left(\frac{V_2}{V_1}\right)^{k-1} = r_C^{k-1} \qquad (16)$$

where r_C is the compression ratio for the proposed engine.
The similar relation for expansion gives:

$$\frac{T_3}{T_E} = \left(\frac{V_E}{V_1}\right)^{k-1} = r_E^{k-1} \qquad (17)$$

where r_E is the expansion ratio for the proposed engine.
Expressing T_2 and T_E from (16) and (17) and inserting them into (15) gives the following expression for η:

$$\eta = 1 - \frac{\dfrac{T_3}{r_E^{k-1}} - T_1}{T_3 - T_1 \cdot r_C^{k-1}} = 1 - \frac{(T_3 / T_1)/ r_E^{k-1} - 1}{T_3 / T_1 - r_C^{k-1}} \qquad (19)$$

Note that η now depends on the ratio T_3 /T_1, which has approximate value of 8 for most of typical gasoline engines. Assuming the compression ratio of best gasoline engines $r_C \approx 10$ and twice higher expansion ratio of the proposed engine $r_E \approx 20$, the value of η can be calculated as:

$$\eta = 1 - \frac{8 / r_E^{k-1} - 1}{8 - r_C^{k-1}} = 1 - \frac{8/2.85 - 1}{8 - 2.24} = 1 - \frac{1.8}{5.76} = 1 - 0.31 = 0.69 \qquad (20)$$

The same formula (19) can be used to calculate η for conventional engine, which gives:

$$\eta = 1 - \frac{8/2.24 - 1}{8 - 2.24} = 0.55 \qquad (21)$$

Note that this value is in a perfect agreement with a classical formula (14):

$$\eta = 1 - \frac{1}{r^{k-1}} = 1 - \frac{1}{10^{0.35}} = 1 - \frac{1}{2.24} = 1 - 0.45 = 0.55 \qquad (22)$$