Effect Of Variable Thermal Properties Of Working Fluid On Performance Of An IC Engine Cycle

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ABSTRACT
The performance of an air-standard Otto cycle with heat transfer loss and variable specific heats of working fluid is analyzed. The relations between the power output and the compression ratio, between the thermal efficiency and the compression ratio, as well as the optimal relation between power output and the efficiency of the cycle are derived by numerical simulations. Moreover, the effects of heat transfer loss and variable specific heats of working fluid on the cycle performance are analyzed. The effects of heat transfer loss and variable specific heats of working fluid on the cycle performance are obvious and they should be considered in practice cycle analysis. The results of this project may provide guidance for the design of practice internal combustion engines. Thermal distortions of engine components are to be studied. The Results may provide guidance for the Design of Practice Internal Combustion Engines.


1. INTRODUCTION

Presently IC Engine are Designed based on Theoretical cycle and Actual efficiency of engine gets effected by various Irreversibility of system. The actual engine also has temperature dependent specific heats and Frictional losses which one to be accounted properly.

The actual deviate from Ideal IC Engine Cycle due to Temperature variation Frictional Losses and Irreversibility. The foam of work is to develop a reference study for future design of Actual IC engine. The Efficiency of IC Engine is optimized and Thermal Distribution of engine components are studied in this paper.

The effect of irreversibility introduced because of Temperature dependent specific heats and Friction losses on the efficiency of Otto cycle. Further, the optimization study of specific heat will result in achieving better efficiency of IC Engine performance. The effect of heat loss will be studied and applied for thermal distortion analysis of Piston.

2. METHODOLOGY

The proposed work will be solved as per major steps mentioned below:
A. Creation of 3D model in CAD software
B. Finite Element Analysis of Reference Problem asper base paper
C. Validation of base paper result with developing aPlots and Codes in Matlab software
D. Validation of output results with Experimental results of Paper
E. Optimization of Existing problem to increase the efficiency if Otto cycle
F. LMS_IMAGINE.LAB AMESIM 15 by SIEMENS software by creating a model also optimized model
G. Creating output results

FIGURE 1: SHOWING 3D CREATION OF VARIOUS PARTS OF IC ENGINE

can see that T3 and T4 decrease with the increase of compression ratio, and T2 increases with the increase of compression ratio. Also there are two special states: 1. With Gamma=1, and in this case T4=T3 and T2=T1 hold, 2. With Gamma=34.5, and in this case T4=T1 and T2=T3 hold. In this two special states, the power output of the cycle is zero.

FIGURE 2: CREATION OF 3D MODEL OF PISTON, CONNECTING ROD, CRANK SHAFT ASSEMBLY

3. PLOTS AND DISCUSSION
3.2 POWER VERSUS COMPRESSION RATIO

According to ref. [1], the following parameters are used: $A = 60000-70000 \text{ J/ mol } * \text{ K}$, $b = 19.868-23.868 \text{ J/ mol } * \text{ K}$, $B = 20-30 \text{ J/mol}$ 
$k = 1.57 \times 10^{-5} \text{ kmol}$, $T_1 = 350 \text{ K}$, $k_1 = 0.003844-0.009844 \text{ J/mol K}^2$. Taking equal heating and cooling times $t_1 = t_2 = t/2 = 16.6 \text{ ms}$ ($t = 33.33 \text{ ms}$), the constant temperature rates $K_1$ and $K_2$ are estimated as:

$K_1 = 8.128 \times 10^{-6} \text{ s/K}$ and $K_2 = 18.67 \times 10^{-6} \text{ s/K}$. 
TEMPERATURES VERSUS COMPRESSION RATIO

\[ T_1 = 600000 \text{ J/mol} \]
\[ B = 25.1 \text{ J/mol K} \]
\[ h = 15.3685 \text{ J/mol K}^2 \]
\[ \alpha = 0.0003 \times 10^{-4} \text{ J/mol K} \]

FIGURE 3: TEMPERATURES VERSUS COMPRESSION RATIO BY RP
FIGURE 5: POWER VERSUS COMPRESSION RATIO (THE INFLUENCES OF B ON THE POWER BY RP)

![Graph of power versus compression ratio](image)

FIGURE 6: POWER VERSUS COMPRESSION RATIO BY CODING (THE INFLUENCES OF B THE POWER O/P)

POWER OUTPUT VERSUS EFFICIENCY

![Graph of power output versus efficiency](image)

FIGURE 4: TEMPERATURES VERSUS COMPRESSION RATIO BY CODING

CONCLUSION
The variations in the temperatures T2, T3 and T4 with the compression ratio are shown in fig a, one

FIGURE 7: THE INFLUENCES OF B ON THE POWER O/P VERSUS EFFICIENCY CHARACTERISTIC BY RP

![Graph of the influences of B on power output versus efficiency characteristic](image)
FIGURE 8: INFLUENCES OF B ON THE POWER

FIGURE 11: THE INFLUENCES OF THE POWER OUTPUT VERSUS EFFICIENCY CHARACTERISTIC BY RP O/P VERSUS EFFICIENCY BY CODING

POWER OUTPUT VERSUS COMPRESSION RATIO
ACTERISTIC

FIGURE 12: THE INFLUENCES OF A ON THE POWER O/P VERSUS EFFICIENCY CHARACTERISTIC BY RP

3.5.2 CONCLUSION

Figs. 5–12 show the effects of the heat transfer loss

FIGURE 9: THE INFLUENCES F A ON THE POWER OUTPUT VERSUS COMPRESSION on the cycle performance. One can see that the power versus compression ratio characteristic and

RATIO BY RP

the power versus efficiency characteristic are parabolic-like curves. For any given \( \gamma \), when the heat transfer loss increases, i.e., A decreases or B increases, the power output, the working range of the cycle, as well as the efficiency at the maximum power point will become smaller. If B increases by about 50\%, the maximum power of the cycle decreases by about 28\%, and the efficiency at the maximum power point decreases by about 20\%. If A decreases by about 14\%, the maximum power decreases by about 14\%, and the efficiency at the maximum power point decreases about 8\%. 
3.6 POWER VERSUS COMPRESSION RATIO

FIGURE 10: THE INFLUENCES OF A ON THE POWER OUTPUT VERSUS COMPRESSION RATIO BY CODING

POWER OUTPUT VERSUS EFFICIENCY

FIGURE 13: THE INFLUENCES OF BV ON THE POWER OUTPUT VERSUS COMPRESSION RATIO BY RP

FIGURE 16: THE INFLUENCES OF BV ON THE EFFICIENCY VERSUS COMPRESSION RATIO BY CODING

3.8 POWER OUTPUT VERSUS COMPRESSION RATIO

FIGURE 14: THE INFLUENCES OF BV ON THE POWER OUTPUT VERSUS COMPRESSION RATIO BY CODING
3.7 EFFICIENCY VERSUS COMPRESSION RATIO

FIGURE 15: THE INFLUENCES OF BV ON THE O

FIGURE 17: THE INFLUENCES OF BV ON THE POWER O/P VERSUS EFFICIENCY CHARACTERISTIC BY RP

FIGURE 18: THE INFLUENCES OF BV ON THE EFFICIENCY VERSUS COMPRESSION RATIO BY RP
POWER O/P VERSUS EFFICIENCY CHARACTERISTIC BY CODING

3.8.2 CONCLUSION

Figs. 13–18 reflects the effects of bv on the performance of the cycle. One can see that for any given $\gamma$, the power and the working range of the cycle decrease with the decrease of bv, while the efficiency increases with the decrease of bv. It also can be found that the decrease of bv almost have no effects on the efficiency at the maximum power point of the cycle. If bv decreases by about 17%, the maximum power decreases by about 14%.

POWER OUTPUT VERSUS COMPRESSION RATIO
FIGURE 22: THE INFLUENCES OF K1 ON THE EFFICIENCY VERSUS COMPRESSION RATIO BY COD NG

3.11 POWER OUTPUT VERSUS EFFICIENCY

FIGURE 19: THE INFLUENCES OF K1 ON THE POWER OUTPUT VERSUS COMPRESSION RATIO BY RP

FIGURE 20: THE INFLUENCES OF K1 ON THE

FIGURE 23: THE INFLUENCES OF K1 ON THE POWER O/P VERSUS EFFICIENCY CHARACTERISTIC BY RP
POWER OUTPUT VERSUS COMPRESSION RATIO BY CODIN

EFFICIENCY VERSUS COMPRESSION RATIO

FIGURE 21: THE INFLUENCES OF K1 ON THE EFFICIENCY VERSUS COMPRESSION RATIO BY RP

3.12 POWER OUTPUT VERSUS J•mol⁻¹•K⁻², the optimum compression ratio at COMPRESSION RATIO

FIGURE 25: THE POWER OUTPUT VERSUS COMPRESSION RATIO WITH AND WITHOUT CONSIDERING VARIABLE SPECIFIC HEATS OF WORKING FLUID.
FIGURE 26: POWER OUTPUT VERSUS COMPRESSION RATIO BY CODING

3.12.2 CONCLUSION

maximum power output point is $\gamma \approx 11$. This is consistent with the practical working compression ratio of SI engines, which are between 9.0 and 11.5 in general.

4. MODEL FOR OPTIMIZATION OF IC ENGINE
FIGURE 27: MODEL 1 BY SOFTWARE

Figs. 20-26 show the effects of k1 on the performance of the cycle. It can be found that the effects of k1 on the performance of the cycle is related to compression ratio γ. If γ is less than certain value, the decrease of k1 will make the power bigger, on the contrast, if γ exceeds certain value, the decrease of k1 will make the power less. One also can see that the maximum power, and the efficiency at the maximum power point decrease with the decrease of k1. The maximum power increases by about 18% and the efficiency at the maximum power point increases by about 10% if k1 increases by about 61%. In order to observe the practice meaning, one can compare the performance of the Otto cycle with constant molar specific heat and variable molar specific heat. Fig.26 shows the power output versus compression ratio characteristic with k1 = 0.005844 J•mol⁻¹•K⁻² and k1 = 0 J•mol⁻¹•K⁻². One can
FIGURE 28: MODEL 2 BY SOFTWARE
see that for the case of $k1 = 0.005844$
FIGURE 29: MODEL 3 BY SOFTWARE

Figure 33: FE MESH MODEL AND 3D MODEL OF FE

5. RESULTS AND DISCUSSION
CONCLUSION
In the presented dissertation

AND PISTON MODEL

, an air standard Otto
cycle has been studied for consideration of specific heats of working fluid varying with temperature. The effect of input to output temperature has been analyzed using software. The output temperature is being superimposed on a piston to study thermal distortions. The results indicated that by increasing input temperature of working fluid by 50K the put temperature varies by large amount. This further increases the thermal distortion of piston. The results show that the effects of the heat transfer loss and variable specific heats of working fluid on the cycle performance are obvious and they should be considered in practice cycle analysis. The results obtained in this paper may provide guidance in engine design and can be used as ready reference.

FIGURE 31: FOR INPUT TEMPERATURE OF 350 AND 400K
7. REFERENCES


[17]. R. Ebrahimi et al. “Effect of specific heat ratio on heat release analysis in a spark ignition

[19]. A Text Book of Thermal Engineering by author Domkundav