Review Paper on Effect of Variable Thermal Properties of Working Fluid on Performance of an IC Engine Cycle

Desai Rahulkumar Mohanbhai[1], Kiran D. Parmar [2]

[1] *P. G. Student, Mechanical Engineering Dept., Hansaba College of Engineering & Technology, Gujarat, India*

[2] *Assistant Professor, Mechanical Engineering Dept., Hansaba College of Engineering & Technology, Gujarat, India*

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.

KEYWORD: *Thermal Fluids Analysis, Effects of Heat Transfer Losses, IC Engine Cycle*

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. LITERATURE REVIEW

Yanlin Ge, “Thermodynamic simulation of performance of an Otto cycle with heat transfer and variable specific heats of working fluid”.[1]

The performance of an air-standard Otto cycle with heat transfer loss and variable specific heats of working fluid is analyzed by using finite-time thermodynamics. 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 detailed numerical examples. Moreover, the effects of heat transfer loss and variable specific heats of working fluid on the cycle performance are analyzed. The results show that 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 obtained in this paper may provide guidance for the design of practice internal combustion engines.

Input Parameter: Compression ratio, working fluids, Heat Supply
Output Parameter: Work done, efficiency, Power, Heat transfer loss, frictional loss
Methodology: By using finite-Time Thermodynamics, Numerical examples solution
Numerical examples and graphs
According to Reference paper, the following parameters are used: A = 60000–70000 J·mol−1, B = 20–30 J·mol−1·K−1, bv = 19.868–23.868 J·mol−1·K−1, M = 1.57 × 10−5 kmol, T1 = 350 K, k1 = 0.003844 – .009844 J·mol−1·K−2,Takingequal heating and cooling times t1 = t2 = τ/2 = 16.6 ms(τ = 33.33 ms [4]), the constant temperature rates K1 andK2 are estimated as K1 = 8.128 × 10−6 s·K−1 and K2 =18.67×10−6s·K−1

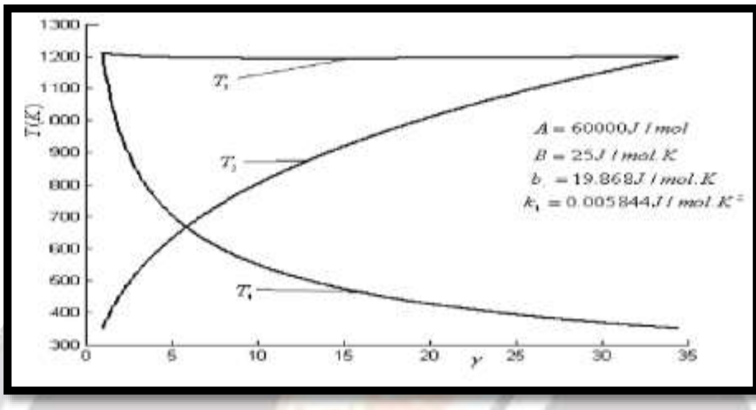


FIGURE 1: TEMPERATURE VS COMPRESSION RATIO

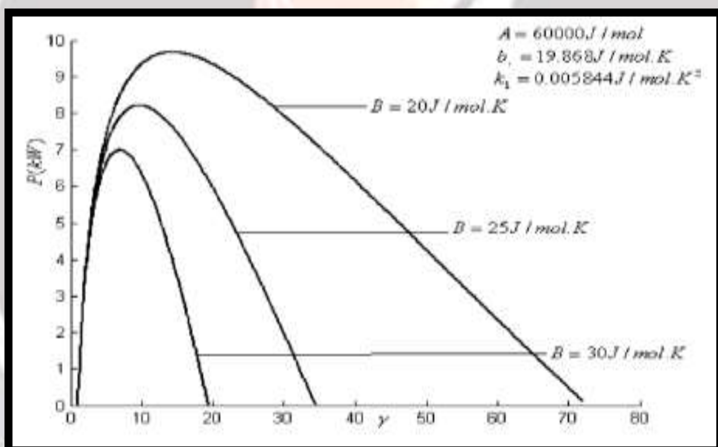


FIGURE 2: THE INFLUENCES OF B ON THE POWER OUTPUT VS COMPRESSION RATIO

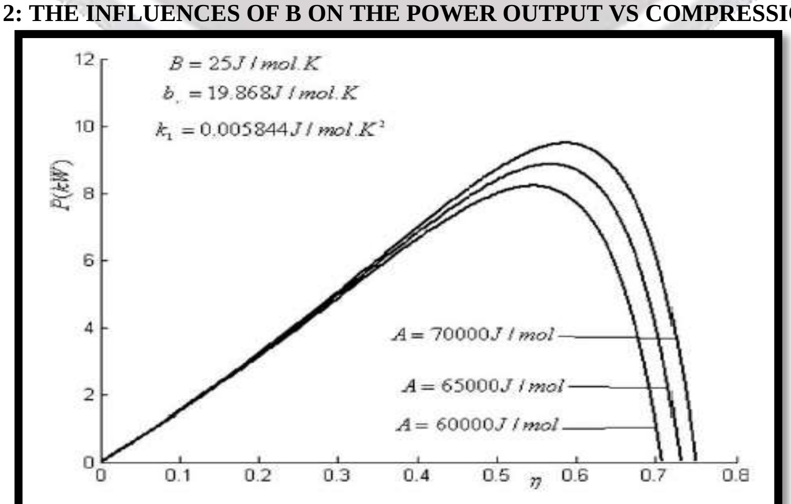


FIGURE 3: THE INFLUENCES OF A ON THE POWER OUTPUT VS EFFICIENCY

In this paper, an air standard Otto cycle model with the consideration of the heat transfer and the variable specific heats of working fluid was presented. The performance characteristic of the cycle was obtained by detailed numerical examples. 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 for the design of practice internal combustion engines. It would be more meaningful if one considers experimental results.

Mohamad Hashemi Gahruei , et al. investigate "Mathematical modeling and comparison of air standard Dual and Dual-Atkinson cycles with friction, heat transfer and variable specific-heats of the working fluid".[2]

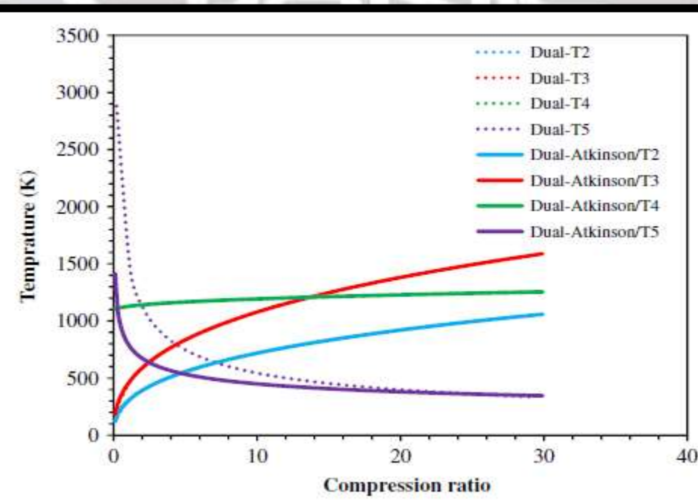
Based on finite-time thermodynamics, a comparative performance analysis of air standard dual and Dual-Atkinson cycles with heat-transfer loss, friction like term losses and variable specific-heats of the working fluid have been performed. Also the effects of heat loss, as characterized by a percentage of the fuel's energy, friction and variable specific-heats of the working fluid, on performance of the mentioned irreversible cycles are analyzed. Moreover, detailed numerical examples show 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 the power output and the thermal efficiency of cycles. Results show the importance of consideration of heat loss effects on the both cycles performance. Also performance comparison of two cycles show that heat efficiency and power output of a Dual-Atkinson cycle are higher than a Dual cycle's ones. The results obtained from this paper will provide guidance for the design of Dual-Atkinson engines.

Input Parameter: Compression ratio, working fluids, Heat Supply
Output Parameter: Work done, efficiency, Power, Heat transfer loss, frictional loss
Methodology: By using finite-Time Thermodynamics, Numerical examples solution mathematical modelling

Numerical examples and graphs

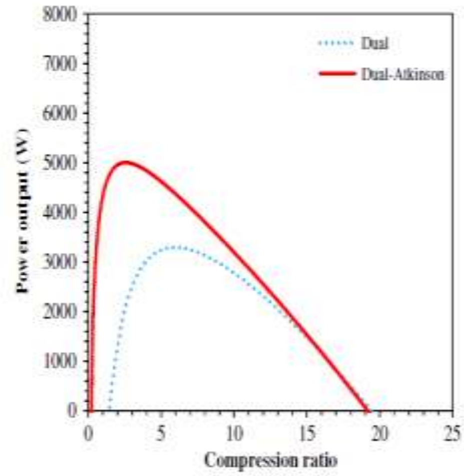
Sample data selected for analysis.

$A = 6000\ \frac{\text{J}}{\text{mol}}$	$B = 20 - 25\ \frac{\text{J}}{\text{mol K}}$	$T_1 = 280 - 320$ K	$M = 1.57 \times 10^{-5}$ k mol $N = 30$ cycles per second
$a = 28\ \frac{\text{J}}{\text{mol K}}$	$b = 19 - 23\ \frac{\text{J}}{\text{mol K}}$	$k = 0.004 - 0.009\ \frac{\text{J}}{\text{mol K}^2}$	$b_1 = 21$ KW $R_p = 1 - 1.5$



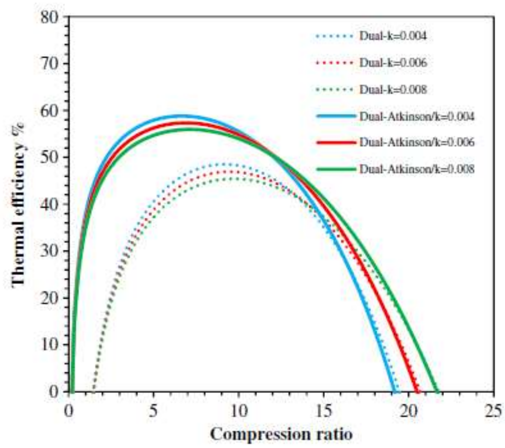
Variation temperature versus compression ratio ($A = 60{,}000, B = 25, a = 28, b = 20, T_1 = 300, k = 0.004, R_p = 1.2$).

FIGURE 4: TEMPERATURE VS COMPRESSION RATIO



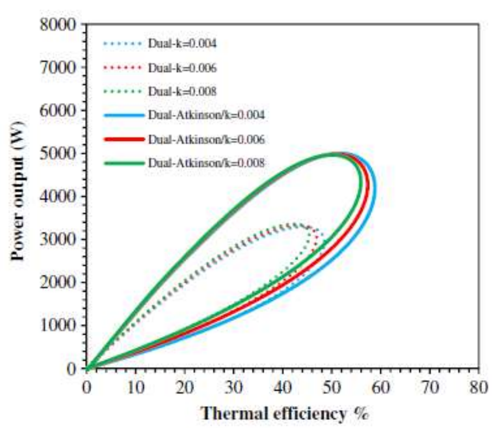
Power output versus compression ratio for Dual and Dual-Atkinson cycles ($A = 60{,}000, B = 25, a = 28, b = 20, T_1 = 300, k = 0.004, R_p = 1.2$).

FIGURE 5: POWER VS COMPRESSION RATIO



Effects of k on thermal efficiency of Dual and Dual-Atkinson cycles ($A = 60{,}000, B = 25, a = 28, b = 20, T_1 = 300, R_p = 1.2$).

FIGURE 6: TEMPERATURE VS COMPRESSION RATIO



Effects of k on power output versus thermal efficiency for Dual and Dual-Atkinson cycles ($A = 60{,}000, B = 25, a = 28, b = 20, T_1 = 300, R_p = 1.2$).

FIGURE 7: POWER VS THERMAL EFFICIENCY

Air-standard Dual and Dual-Atkinson cycle models, assuming temperature-dependent specific-heats of the working fluid, heat resistance and frictional irreversible losses, have been investigated numerically and the performance characteristics of them were obtained. Like previous studies, the results show that there are significant effects of the temperature dependence of the specific heat of the working fluid, friction and heat transfer losses on the performance of the cycles which should be considered in practical-cycle analysis. The general conclusions drawn from the results of this work are as follows:

- Comparison the results show that the power output and thermal efficiency of Dual-Atkinson cycle are higher than Dualcycle ones at their optimum compression ratio.
- The points of maximum power output and thermal efficiency of Dual-Atkinson cycle occur at the lower compression ratio.
- The points of maximum power output and thermal efficiency of two cycles will decreases with an increase of b, k, T1, andB.
- The points of maximum power output and thermal efficiency of Dual cycle will increase with an increase of Rp, but Dual-Atkinson cycle's ones will decrease with an increase of Rp.
- Reduction of T4 results in reduction of exhaust gas temperature which causes to the NOx reduction.
- The results of this investigation are of importance when considering the designs of Dual and Dual-Atkinson engines.

V. Esfahanian et al. investigate "Thermal analysis of an SI engine piston using different combustion boundary condition treatments". In this study, the heat transfer to an engine piston crown is calculated. Three different methods for the combustion boundarycondition are used. The results of different combustion side boundary condition treatments are compared and their effects on the thermal behavior of the piston are investigated. It has been shown that using spatial and time averaged combustion side boundarycondition is a suitable treatment method within engineering approximations. An interface between KIVA-3V and NASTRAN codesis developed. [3]

Methodology: Numerical solution, by using software KIVA-3V and NASTRAN

Numerical Approach

There are making a model in Solid works, piston mesh generation in KIVA-3V, combustion mesh generation in KIVA-3V as shown in below figures.

Specification of the engine under study	
Bore	8.735 cm
Stroke	6.667 cm
Compression ratio	8
Connecting rod	11.61 cm
IVO	44° bTDC
IVC	84° aBDC
EVO	46° bBDC
IP	0.83 bar
IT	297 K
λ	1.1
RPM	5000
Ignition time	55 bTDC

Three different combustion side boundary condition treatment methods for piston thermal analysis are carried out and a good interface between NASTRAN and KIVA-3V codes is developed. It is found that, using spatial and time averaged combustion side boundary condition is an effective way as is compared with surface and time averaged boundary condition in piston thermal analysis. In addition, applying the transient boundary condition is very time consuming and does not affect the results of piston thermal analysis within engineering approximations. Moreover, applying a time varying piston temperature boundary condition during the engine cycle does not affect the results of combustion analysis.

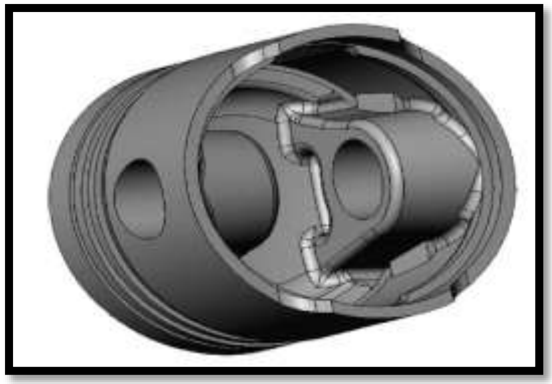


FIGURE 8: PISTON SOLID MODEL GENERATED BY SOLIDWORKS

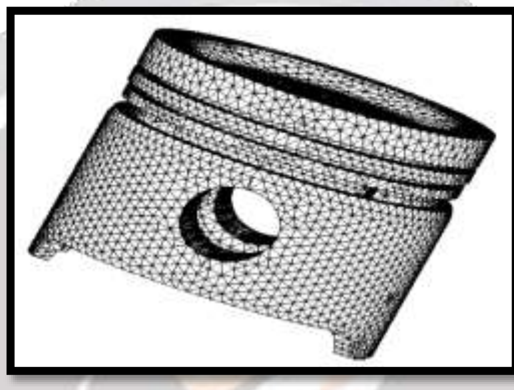


FIGURE 9: PISTON MESH GENERATED IN NASTRAN

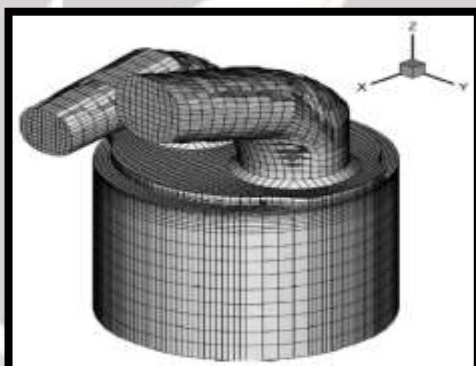


FIGURE 10: COMBUSTION CHAMBER MESH GENERATED IN KIVA-3V

Lingen Chen et al. investigate "Effects of heat transfer, friction and variable specific heats of working fluid on performance of an irreversible dual cycle" [4]

The thermodynamic performance of an air standard dual cycle with heat transfer loss, friction like term loss and variablespecific 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 theefficiency of the cycle, are derived by detailed numerical examples. Moreover, the effects of variable specific heats of theworking fluid and the friction like term loss on the irreversible cycle performance are analyzed. Th1e results show thatthe effects of variable specific heats of working fluid and friction like term loss on the cycle performance are obvious,and they should be considered in practical cycle analysis. The results obtained in this paper may provide guidance forthe design of practical internal combustion engines.

Input Parameter: Compression ratio, working fluids, Heat Supply
Output Parameter: Work done, efficiency, Power, Heat transfer loss, frictional loss
Methodology: applied Thermodynamics, Numerical solutions.\

Numerical solution and Graphs:

According to Reference paper the following parameters are used in the calculations: A = 60,000–70,000 J/mol, B = 20–30 J/mol K, ap = 28.182–32.182 J/mol K, bv = 19.868–23.868 J/mol K, M = $1.57 \cdot 10^5$ kmol, T1 =350 K, k1 = 0.003844–0.009844 J/mol K^2, x1 = 800, x2 = 100 m, N = 30

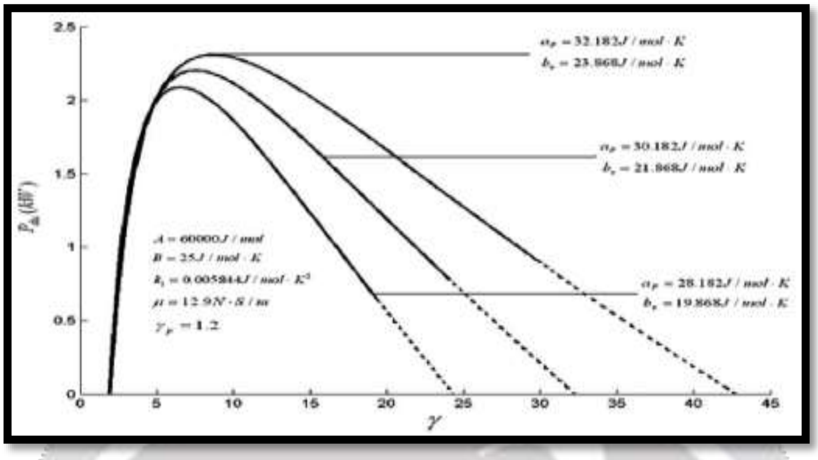


FIGURE 11: THE INFLUENCES OF AP AND BV ON CYCLE POWER OUTPUT

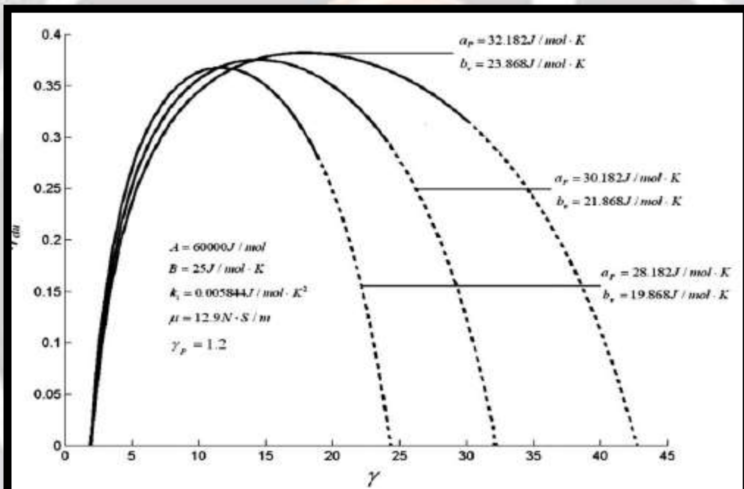


FIGURE 12: THE INFLUENCES OF AP AND BV ON CYCLE EFFICIENCY

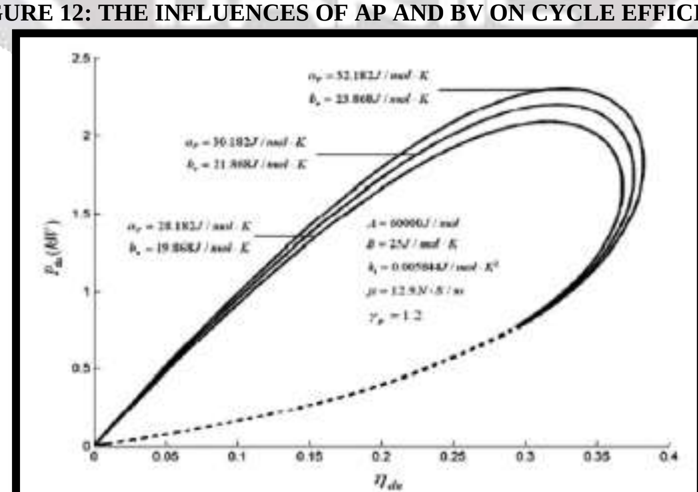


FIGURE 13: THE INFLUENCE OF AP AND BV ON CYCLE POWER OUTPUT VS EFFICIENCY

In this paper, an air standard dual cycle model with considerations of heat transfer loss, friction like term loss and variable specific heats of the working fluid was presented. The performance characteristics of the cycle were obtained by detailed numerical examples. The results show that the effects of variable specific heats of the working fluid and the friction loss on the cycle performance are obvious, and they should be considered in practical cycle analysis. The results obtained in this paper may provide guidance for the design of practical internal combustion engines.

Yingru Zhao et al. investigate “Optimum performance analysis of an irreversible diesel heat engine affected by variable heat capacities of working fluid”. [5]

An irreversible cycle model of the Diesel heat engine is established in which the temperature dependent heat capacities of the working fluid, the irreversibility’s resulting from non-isentropic compression and expansion processes and heat leak losses through the cylinder wall are taken into account. The adiabatic equation of ideal gases with temperature dependent heat capacity is strictly deduced without using the additional approximation condition in the relevant literature and is used to analyze the performance of the Diesel heat engine. Expressions for the work output and efficiency of the cycle are derived by introducing the pressure ratio and the compression and expansion efficiencies. The performance characteristic curves of the Diesel heat engine are presented for a set of given parameters. The optimum criteria of some important parameters such as the work output, efficiency, pressure ratio and temperatures of the working fluid are obtained. Moreover, the influence of the compression and expansion efficiencies, variable heat capacities, heat leak and other parameters on the performance of the cycle is discussed in detail. The results obtained may provide a theoretical basis for both optimal design and operation of real Diesel heat engines.
Input Parameter: Compression Ratio, working fluid, heat supply
Output Parameter: Work done, Efficiency, Power, Frictional loss
Methodology: Applied Thermodynamics, Numerical solutions.

In the present paper, an irreversible cycle model of the Diesel heat engine has been established by considering the variable heat capacities of the working fluid, the irreversibilities coming from the compression and expansion processes and the heat leak losses through the cylinder wall. The expression of the adiabatic equation of ideal gases with temperature dependent heat capacities is exactly deduced and used to investigate the performance of the Diesel heat engine. The performance characteristics of the cycle are obtained by detailed numerical examples. The optimum criteria of some important parameters such as the work output, efficiency, pressure ratio and temperatures of the working fluid are obtained. The influence of several important design parameters on the performance of the cycle is discussed. It is found that the variable heat capacities of the working fluid, the compression and expansion efficiencies of the adiabatic processes and the heat leak losses show obvious influences on the cycle performance and that they should be considered in practical cycle analysis. The results contained in this paper may provide insight into the design and operating criteria that are necessary for optimum operations in Diesel engines.

E. Abu-Nada et al. investigate, “Thermodynamic modeling of spark-ignition engine: Effect of temperature dependent specific heats”. [6]

This paper presents thermodynamics analysis of spark-ignition (SI) engine. A theoretical model of air-standard Otto cycle having temperature dependent specific heats has been implemented. It was compared to that which uses constant temperature specific heats. Wide range of engine parameters was studied. In most cases there were significant variations between the results obtained by using temperature dependent specific heats with those obtained at constant specific heats especially at high engine speeds. Therefore, it is more realistic to use temperature dependent specific heat. This should be considered in cycle analysis especially that temperature variation in the actual cycles is quite large.

It is concluded that engine working parameters are affected by variable specific heats, significantly. The results show that there is a great effect of the temperature dependent specific heat of the working fluid on the performance of the air- standard Otto cycle. Therefore, it is more realistic to use temperature dependent specific heat during the investigation of air-standard power cycles. This should be considered in the practical cycle analysis, especially, in the actual cycles the temperature variations are quite large. The results are expected to provide significant guidance for the performance evaluation and improvement of real SI engines.

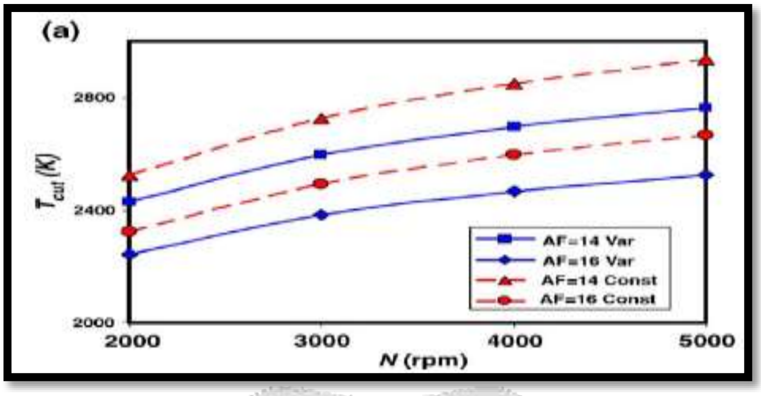


FIGURE 14: MAXIMUM GAS TEMPERATURE VERSUS ENGINE SPEED AT DIFFERENT AIR–FUEL RATIOS USING CONSTANT AND VARIABLE SPECIFIC HEAT MODELS.

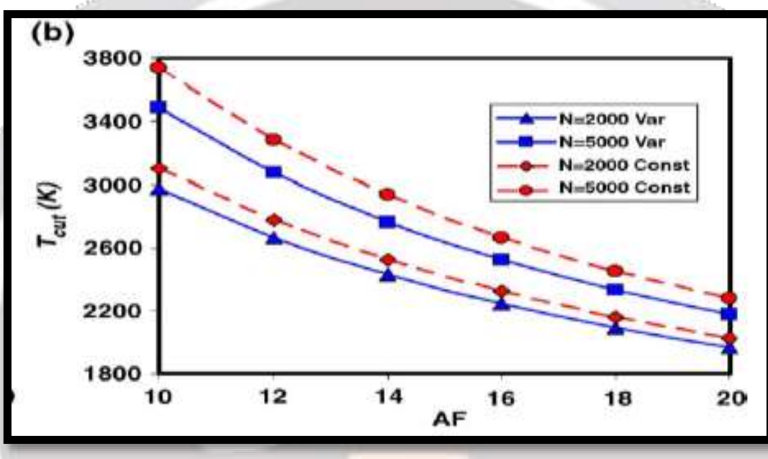


FIGURE 15: MAXIMUM GAS TEMPERATURE VERSUS AIR–FUEL RATIO AT DIFFERENT ENGINE SPEEDS USING CONSTANT AND VARIABLE SPECIFIC HEAT MODELS.

Shuhn-Shyurng Hou et al. investigate "Heat transfer effects on the performance of an air standard Dual cycle". [7]

There are heat losses during the cycle of a real engine that are neglected in ideal air standard analysis. In this paper, the effects of heat transfer on the net work output and the indicated thermal efficiency of an air standard Dual cycle are analyzed. Heat transfer from the unburned mixture to the cylinder walls has an negligible effect on the performance for the compression process. Additionally, the heat transfer rates to the cylinder walls during combustion are the highest and extremely important. Therefore, we assume that the compression and power processes proceed instantaneously so that they are reversible adiabatics, and the heat losses during the heat rejection process can be neglected. The heat loss through the cylinder wall is assumed to occur only during combustion and is further assumed to be proportional to the average temperature of both the working fluid and the cylinder wall. The results show that the net work output versus efficiency characteristics and the maximum net work output and the corresponding efficiency bounds are strongly influenced by the magnitude of the heat transfer. Higher heat transfer to the combustion chamber walls lowers the peak temperature and pressure and reduces the work per cycle and the efficiency. The effects of other parameters, in conjunction with the heat transfer, including combustion constants, cut-off ratio and intake air temperature, are also reported. The results are of importance to provide good guidance for the performance evaluation and improvement of practical Diesel engines.

Input Parameter: Compression Ratio, working fluid, heat supply
Output Parameter: Work done, Efficiency, Power, Frictional loss
Methodology: Numerical solutions.

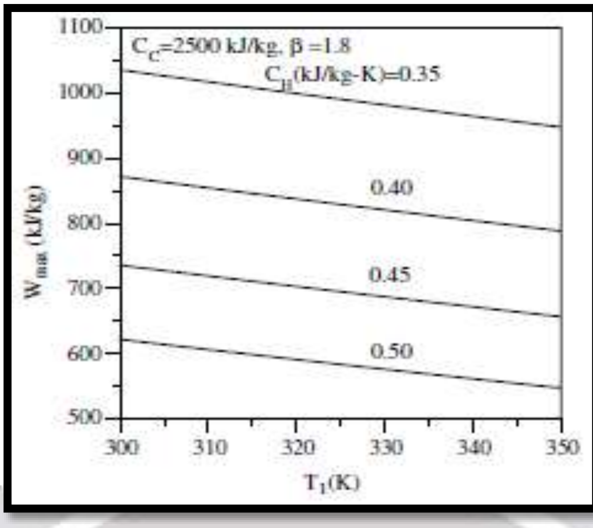


FIGURE 16: EFFECT OF CH AND T1 ON WMAX

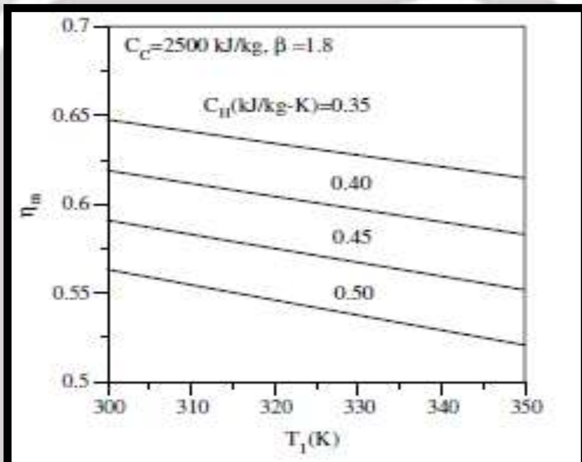


Figure 17: Effect of CH and T1 on Maximum efficiency

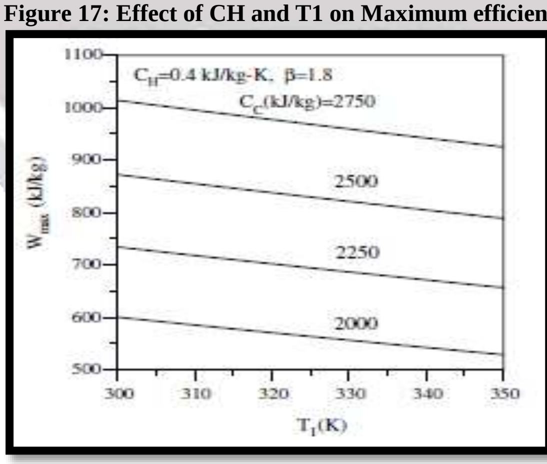


Figure 18: Effect of CC and T1 on Wmax

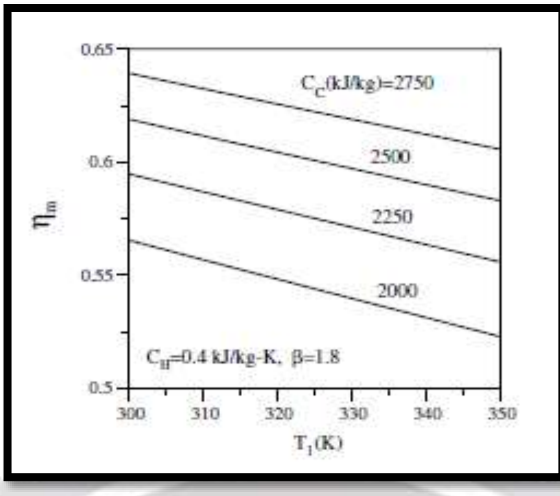


FIGURE 19: EFFECT OF CC AND T1 ON MAXIMUM EFFICIENCY

The effects of heat transfer through the cylinder wall on the performance of a Dual cycle are investigated in this study. The relation between net work output and thermal efficiency is derived, based solely on classical thermodynamics and heat transfer. Furthermore, the maximum work output and the corresponding thermal efficiency at maximum work output are also derived. In the analyses, the influence of four significant parameters, namely the heat transfer and combustion constants, cut-off ratio and intake air temperature on the net work output versus efficiency characteristics, and maximum work and the corresponding efficiency at maximum work are examined. The general conclusions drawn from the results of this work are as follows:

1. The maximum work output and the corresponding efficiency at maximum work output decrease as the heat transfer constant CH increases. In other words, higher heat transfer to the combustion chamber walls will lower the peak temperature and pressure and reduce the work per cycle and the efficiency.
2. The maximum work output and corresponding efficiency at maximum work output increase as the combustion constant CC increases.
3. The maximum work output and the corresponding efficiency at maximum work output decrease as the intake temperature (T1) or cut-off ratio (b) increases.
4. For a given value of heat release during combustion (CC), an increase in heat loss (CH) leads to a decrease of the compression ratio (rcm) that maximizes the work of the Dual cycle.

The analysis helps us to understand the strong effect of heat loss through the cylinder wall during combustion. Therefore, the results are of great significance to provide good guidance for the performance evaluation and improvement of real Diesel engines.

Yanlin Ge et al. investigate “Finite-time thermodynamic modelling and analysis of an irreversible Otto-cycle”. [8]

The performance of an air standard Otto-cycle is analyzed using finite-time thermodynamics. In the irreversible cycle model, the non-linear relation between the specific heat of the working fluid and its temperature, the friction loss computed according to the mean velocity of the piston, the internal irreversibility described by using the compression and expansion efficiencies, and the heat-transfer loss are considered. 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 the power output and theefficiency of the cycle are indicated by numerical examples. Moreover, the effects of internal irreversibility, heat-transfer loss and friction loss on the cycle performance are analyzed. The results obtained in this paper may provide guidance for the design of practical internal-combustion engines.

Input Parameter: Compression Ratio, working fluid, heat supply
Output Parameter: Work done, Efficiency, Power, Frictional loss, Heat Transfer loss
Methodology: By using Finite-Time Thermodynamics, Numerical solutions.

In this paper, an irreversible air standard Otto-cycle model which is close to realistic practice is founded. In this model, the non-linear relation between the specific heats of the working fluid and its temperature, the frictionloss computed according to the mean velocity of the piston, the internal irreversibility described by using the compression and expansion efficiency, and heat-transfer loss are presented. The performance characteristics of the cycle were derived by detailed numerical examples. The effects of internal irreversibility, heat-transfer loss and friction loss on the performance of the cycle were analyzed. The results obtained in this paper may provide guidance for the design of practical internal-combustion engines.

Yanlin Ge et al. investigate "Finite-time thermodynamic modeling and analysis for an irreversible Dual cycle". [10]

The performance of an air standard Dual cycle is analyzed by using finite-time thermodynamics. An irreversible Dual cycle model which is more close to practice is established. In the model, the nonlinear relation between the specific heats of working fluid and its temperature, the frictional loss computed according to the mean velocity of the piston, the internal irreversibility described by using the compression and expansion efficiencies, and heat transfer loss are considered. The relations between the power output and the compression ratio, between the thermal efficiency and the compression ratio, and the optimal relation between power output and the efficiency of the Dual cycle are derived by detailed numerical examples. Moreover, the effects of internal irreversibility, heat transfer loss, frictional loss and pressure ratio on the cycle performance are analyzed. The power output versus compression ratio and efficiency versus compression ratio curves of the Diesel and Otto cycles are the maximum and minimum envelope lines of the performance of the Dual cycle, respectively. The results obtained herein may provide guidelines for the design of practical internal combustion engines.

Input Parameter: Compression Ratio, working fluid, heat supply
Output Parameter: Work done, Efficiency, Power, Frictional loss, Heat Transfer loss
Methodology: By using Finite-Time Thermodynamics, Numerical solutions.

In this paper, an irreversible air standard Dual cycle model which is more close to practice is established. In the model, the nonlinear relation between the specific heats of working fluid and temperature, the friction loss computed according to the mean velocity of the piston, the internal irreversibility described by using the compression and expansion efficiencies, and heat transfer loss are considered. The performance characteristics of the cycle are obtained by detailed numerical examples.
The effects of internal irreversibility, heat transfer loss, frictional loss and pressure ratio on the performance of the cycle are analyzed. The power output versus compression ratio and the efficiency versus compression ratio curves of the Diesel and Otto cycles are maximum and minimum envelope lines of the performance of the Dual cycle, respectively. The results obtained herein may provide guidelines for the design of practice internal combustion engines.

Jiming Lin et al. investigate "Finite-time thermodynamic modeling and analysis of an irreversible Miller cycle working on a four-stroke engine". [11]

The performance of an irreversible air standard Miller cycle in a four-stroke free-piston engine is analyzed using finite-time thermodynamic. In the model, the relation between the internal irreversibility described by using the compression and expansion efficiencies, the specific heat of the working substance depending on its temperature, the heat transfer loss as a percentage of fuel's energy and the friction loss computed according to the mean velocity of the piston is considered. Moreover, the influences of the excess air coefficient, initial temperature, compression ratio and another compression ratio corresponding to expansion level on the Miller cycle are analyzed by detailed numerical examples. The results show that the efficiency increases with the decrease of specific heat of working substance. The heat transfer loss and friction loss have negative effects on the performance. Comparison of the Miller and Otto cycles shows that the Miller cycle has a higher efficiency through extra expansion work. The conclusions of this investigation are of importance to provide guidelines for the performance evaluation and improvement of practical Miller engines.
Input Parameter: Compression Ratio, working fluid, heat supply
Output Parameter: Temperature, Work done, Efficiency, Power, Frictional loss, Heat Transfer loss
Methodology: By using Finite-Time Thermodynamics, Numerical solutions.

In this article, an irreversible air-standard Miller cycle model which is more close to practical four-stroke free-piston engine is founded. In the model, the linear relation between the heat leakage as a percentage of fuel's energy, the friction loss computed according to the mean velocity of the piston, the internal irreversibility described using the compression and expansion efficiencies and the specific heat of working substance is considered. By using finite-time thermodynamic theory, the characteristic curves of the Miller cycle are obtained under detailed numerical examples. The effects of internal irreversibility, heat transfer loss, friction loss, compression ratio γc, initial temperature T1 and another compression ratio γ on the performance of the cycle are analyzed. The results obtained in here may provide guidance for the analysis of the behavior and design of practical four-stroke free-piston Miller engines.

Chao Wang et al. investigate “Comparison of air-standard rectangular cycles with different specific heat models”. [12]

In this paper, performance comparison of air-standard rectangular cycles with constant specific heat (SH),linear variable SH and non-linear variable SH are conducted by using finite time thermodynamics. The power output and efficiency of each cycle model and the characteristic curves of power output versus compression ratio, efficiency versus compression ratio, as well as power output versus efficiency are obtained by taking heat transfer loss (HTL) and friction loss (FL) into account. The influences of HTL, FL and SH on cycle performance are analyzed by detailed numerical examples.

Input Parameter: Compression Ratio, working fluid, heat supply
Output Parameter: Temperature, Work done, Efficiency, Power, Frictional loss, Heat Transfer loss
Methodology: By using Finite-Time Thermodynamics, Numerical solutions.

The performances of air-standard rectangular cycles with different SH models have been studied and compared in this paper. The HTL and FL have been taken into account to establish more realistic cycle models. The results show that the power output and efficiency increase with the increase of heating value and the decreases of initial temperature and coefficients of HTL and FL. The proper adoption of operating parameters can improve the cycle performance. The SH models have obvious effects on cycle performance. The variable SH model should be adopted to improve the accuracy in the performance analyses of real cycles.

7. REFERENCES

[1]. Yanlin Ge et al. “Thermodynamic simulation of performance of an Otto cycle with heat transfer and variable specific heats of working fluid” International Journal of Thermal Sciences 44 (2005) 506–511.
[2]. Mohamad Hashemi Gahruei et al. “Mathematical Modelling and comparison of air standard Dual and Dual-Atkinson cycles with friction, heat transfer and variable specific-heats of the working fluid” Applied Mathematical Modelling 37 (2013) 7319–7329.
[3]. Lingen Chen et al. “Effects of heat transfer, friction and variable specific heats of working fluid on performance of an irreversible dual cycle” Energy Conversion and Management 47 (2006) 3224–3234.
[4]. V. Esfahanian et al. “Thermal analysis of an SI engine piston using different combustion boundary condition treatments” Applied Thermal Engineering 26 (2006) 277–287.
[5]. Yingru Zhao et al. “Optimum performance analysis of an irreversible Diesel heat engine affected by variable heat capacities of working fluid” Energy Conversion and Management 48 (2007) 2595–2603.
[6]. E. Abu-Nada et al. “Thermodynamic modelling of spark-ignition engine: Effect of temperature dependent specific heats” International Communications in Heat and Mass Transfer 33 (2006) 1264–1272.
[7]. Shuhn-Shyurng Hou et al. “Heat transfer effects on the performance of an air standard Dual cycle” Energy Conversion and Management 45 (2004) 3003–3015.
[8]. Yanlin Ge et al. “Finite-time thermodynamic modeling and analysis of an irreversible Otto-cycle” Applied Energy 85 (2008) 618–624.
[9]. Jiming Lin et al. “Finite-time thermodynamic modelling and analysis of an irreversible Miller cycle working on a four-stroke engine” International Communications in Heat and Mass Transfer 54 (2014) 54–59.
[10]. Yanlin Ge et al. “Finite-time thermodynamic modelling and analysis for anirreversible Dual cycle” Mathematical and Computer Modelling 50 (2009) 101108.
[11]. Zhijun Wu et al. “Thermal efficiency boundary analysis of an internal combustion Rankine cycle engine” Energy 94 (2016) 38e49.

[12]. Chao Wang et al. "Comparison of air-standard rectangular cycles with different specific heat models" Applied Thermal Engineering 109 (2016) 507–513.
[13]. T.M. Yunus khan et al. "Effects of engine variables and heat transfer on the performance of biodiesel fueled IC engines " Renewable and Sustainable Energy Reviews 44 (2015) 682–691
[14]. Rahim Ebrahimi et al. "effect of specific heat ratio on the power output and efficiency characteristics for a irreversible dual cycle" Journal of American science (2010) 6-2
[15]. Jerald A. Caton et al. "On the importance of specific heats as regards efficiency increases for highly dilute IC engines" Energy Conversion and Management 79 (2014) 146–160
[16]. Zhijun Wu et al. "Thermal efficiency boundary analysis of an internal combustion Rankine cycle engine" Energy 94 (2016) 38e49
[17]. R. Ebrahimi et al. "Effect of specific heat ratio on heat release analysis in a spark ignition engine" Scientia Iranica B (2011) 18 (6), 1231–1236
[18]. Bilge Albayrak Ceper et al. "Performance and emission characteristics of an IC engine under SI, SICAI and CAI combustion modes" Energy xxx (2016) 1e8
[19]. A Text Book of Thermal Engineering by author Domkundaval