© 2026 IJRTI | Volume 11, Issue 4 April 2026 | ISSN: 2456-3315

Thermodynamic Analysis of the Diesel Cycle in Applied Thermodynamics

[1] Urmila Nagargoje,[2] Mayur Gitay [3]Abhishek Wakade, [4]Kisankumar Singh,

[1]Assistant Professor, [2]Assistant Professor, [3,4]Student

[1]Mechanical Engineering Department,

[1]S. G. V. V. S Adsul's Technical Campus, Chas, Ahilyanagar, India

Abstract -

The Diesel cycle is one of the most important thermodynamic cycles used in compression ignition engines. It plays a vital role in the field of applied thermodynamics, especially in transportation and power generation systems. The cycle consists of four main processes: isentropic compression, constant pressure heat addition, isentropic expansion, and constant volume heat rejection.

In this paper, a detailed analysis of the Diesel cycle is presented, including its working principle, thermodynamic processes, and performance characteristics. The efficiency of the Diesel cycle depends mainly on parameters such as compression ratio, cut-off ratio, and specific heat ratio. Compared to other thermodynamic cycles like the Otto cycle, the Diesel cycle provides better fuel efficiency and is more suitable for heavy-duty applications.The study also highlights the practical applications of the Diesel cycle in diesel engines used in automobiles, trucks, marine engines, and power plants. Additionally, the advantages such as higher efficiency, better fuel economy, and durability are discussed along with its limitations like higher weight and cost.

Overall, the Diesel cycle remains a fundamental concept in applied thermodynamics and continues to be widely used in modern engineering systems due to its reliability and performance.

1.INTRODUCTION -

Applied thermodynamics is a branch of engineering that deals with the practical application of heat and energy in various systems such as engines, turbines, refrigerators, and power plants. It focuses on the conversion of heat energy into useful mechanical work and vice versa. Among the various thermodynamic cycles, the Diesel cycle is one of the most important and widely used cycles in engineering applications.The Diesel cycle is the ideal cycle for compression ignition (CI) engines, commonly known as diesel engines. These engines are widely used in automobiles, trucks, buses, marine engines, and power generation units due to their higher efficiency and better fuel economy compared to petrol engines. The working of the Diesel cycle is based on the principle of compressing air to a high pressure and temperature, followed by the injection of fuel, which ignites automatically without the need for a spark plug.

The cycle consists of four distinct thermodynamic processes, namely isentropic compression, constant pressure heat addition, isentropic expansion, and constant volume heat rejection. Each of these processes plays a significant role in determining the performance and efficiency of the engine. The efficiency of the Diesel cycle mainly depends on factors such as compression ratio and cut-off ratio.

2.PROCESSES OF DIESEL CYCLE -

The Diesel cycle consists of four thermodynamic processes:

1. Isentropic Compression (Process 1–2)

In this process, air is compressed adiabatically inside the cylinder. There is no heat transfer, and the entropy remains constant. Due to compression, the pressure and temperature of air increase significantly.

2. Constant Pressure Heat Addition (Process 2–3)

In this process, fuel is injected into the compressed air, and combustion takes place. Heat is added at constant pressure, and the volume increases.

3. Isentropic Expansion (Process 3–4)

The high-pressure gases expand adiabatically, producing useful work. During this process, the pressure and temperature decrease.

4. Constant Volume Heat Rejection (Process 4–1)

In this process, heat is rejected from the system at constant volume, and the cycle returns to its initial state.

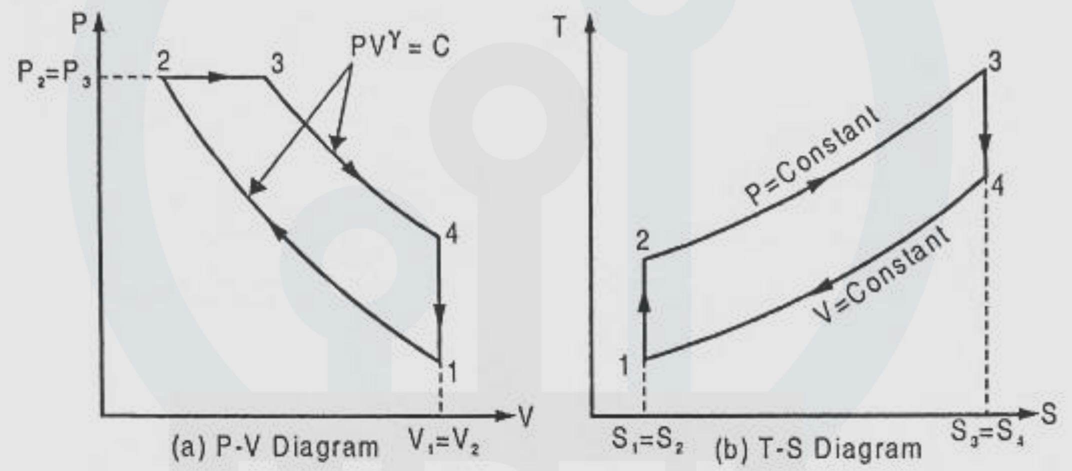

Fig:2.3 Diesel Cycle

2.1 P–V Diagram of Diesel Cycle

The pressure-volume (P–V) diagram represents the variation of pressure with respect to volume during the Diesel cycle. The process 1–2 shows isentropic compression, where the volume decreases and pressure increases. The process 2–3 represents constant pressure heat addition, where volume increases while pressure remains constant. The process 3–4 shows isentropic expansion, where the gas expands and pressure decreases. Finally, process 4–1 represents constant volume heat rejection, completing the cycle. The area enclosed by the cycle on the P–V diagram represents the net work output of the engine.

2.2 T–S Diagram of Diesel Cycle

The temperature-entropy (T–S) diagram shows the variation of temperature with entropy during the Diesel cycle. The process 1–2 is isentropic compression, represented by a vertical line indicating constant entropy. The process 2–3 shows heat addition at constant pressure, where both temperature and entropy increase. The process 3–4 represents isentropic expansion, again shown by a vertical line. The process 4–1 indicates heat rejection at constant volume, where entropy decreases. This diagram helps in understanding heat transfer and entropy changes during the cycle.

3.1 APPLICATION

The Diesel cycle is widely used in various engineering applications due to its high thermal efficiency, reliability, and ability to operate under high load conditions. It forms the basis of compression ignition (CI) engines, which are extensively used in transportation, power generation, and industrial sectors.In the automotive industry, the Diesel cycle is used in heavy vehicles such as trucks, buses, and commercial transport systems. These engines are preferred for long-distance travel because they provide better fuel economy and durability compared to petrol engines. In addition, many modern cars also use diesel engines for improved mileage and performance.

The Diesel cycle is also widely applied in power plants, especially in diesel power stations, where it is used for electricity generation. These power plants are commonly used as standby or backup power sources due to their quick starting capability and reliability.

3.2 Limitations of Diesel Cycle (Detailed)

Despite its advantages, the Diesel cycle has several limitations that affect its performance and application in certain conditions. One of the major limitations is the requirement of a high compression ratio, which leads to increased mechanical stress on engine components. This necessitates stronger and heavier engine construction, resulting in higher initial cost and increased weight.

Another limitation is related to incomplete combustion, especially at low load conditions. This can reduce engine efficiency and increase fuel consumption. The Diesel cycle also produces higher emissions of nitrogen oxides (NO_x) and particulate matter, which contribute to environmental pollution and health issues.

3.3 Improvements in Diesel Cycle

Over the years, significant improvements have been made in the Diesel cycle to enhance its efficiency, performance, and environmental compatibility. One of the major advancements is the use of turbocharging and supercharging, which increases the amount of air entering the engine, thereby improving combustion and power output.Another important development is the introduction of common rail direct fuel injection systems. These systems allow precise control over fuel injection timing and quantity, resulting in better fuel atomization, efficient combustion, and reduced emissions. Multiple fuel injection techniques further improve performance and reduce engine noise.

Modern diesel engines also use intercoolers to reduce the temperature of compressed air, increasing air density and improving efficiency. Advanced electronic control units (ECUs) are used to monitor and optimize engine performance under different operating conditions.

3.4 Environmental Impact

Diesel engines based on the Diesel cycle have a significant impact on the environment due to the emission of harmful gases and particles. The major emissions include carbon dioxide (CO_2), nitrogen oxides (NO_x), carbon monoxide (CO), and particulate matter (PM). These pollutants contribute to air pollution, global warming, and health-related issues.Nitrogen oxides are responsible for the formation of smog and acid rain, while particulate matter can cause respiratory problems in humans. The higher compression ratio and combustion characteristics of diesel engines result in higher NO_x emissions compared to petrol engines.To reduce environmental impact, modern diesel engines are equipped with emission control technologies such as exhaust gas recirculation (EGR), diesel particulate filters (DPF), and catalytic converters. These systems help in reducing harmful emissions and improving air quality.

3.5 Future Scope of Diesel Cycle

The future of the Diesel cycle is focused on improving efficiency while minimizing environmental impact. Researchers and engineers are continuously working on advanced combustion techniques to achieve cleaner and more efficient engines. The use of low-emission fuels such as biodiesel and synthetic fuels is expected to reduce dependence on conventional diesel fuel.Hybrid diesel engines, which combine diesel engines with electric motors, are being developed to improve fuel efficiency and reduce emissions. These systems are particularly useful in transportation and industrial applications.

Advanced technologies such as homogeneous charge compression ignition (HCCI) and low-temperature combustion are also being explored to improve combustion efficiency and reduce emissions.

Conclusion

The Diesel cycle is one of the most important thermodynamic cycles used in compression ignition engines. It provides higher thermal efficiency and better fuel economy compared to other cycles such as the Otto cycle. The study of the Diesel cycle helps in understanding the working of modern engines and the conversion of heat energy into useful work.In this paper, the working principles, processes, efficiency, applications, advantages, and limitations of the Diesel cycle have been discussed in detail. The analysis shows that the Diesel cycle is highly suitable for heavy-duty and industrial applications due to its reliability and performance.

References

1. P.K. Nag – Engineering Thermodynamics
2. R.K. Rajput – Thermodynamics
3. C.P. Arora – Thermodynamics
4. Bansal – Applied Thermodynamics
5. Yunus A. Çengel & Michael A. Boles – Thermodynamics: An Engineering Approach
6. V. Ganeshan – Internal Combustion Engines
7. Heywood J.B. – Internal Combustion Engine Fundamentalssossss