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Studies on Atkinson Cycle Performance- A Review

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Abstract

The upliftment of hybrid vehicles leading to a cleaner environment and better fuel economy is not possible without the applicability of the Atkinson cycle in vehicle engines. The Atkinson cycle's viability for usage in hybrid cars is demonstrated through time-dependent thermodynamics. This cycle engine accomplishes full combustion at constant volume and has an enhanced grade of ignition. These insights can be utilized to create new Atkinson cycle engines as guides. With the help of research articles, researchers investigate the performance of the Atkinson cycle to identify what changes in parameters maximize the Atkinson cycle's operation.

Keywords: *ACE, HEV, Otto cycle, Engine performance, Compression ratio.*

1. INTRODUCTION

The increasing social responsibilities of automobile makers toward cleaner fuels have led researchers to think in directions other than crude oil applications. This led to an increase in research towards bio-fuels, Hybrid energy vehicles (HEV), and fuel cell electrical vehicles. James Atkinson, a British engineer, improved the research of heat engines in 1882 by designing various heat engines that are more efficient than the Otto cycle.

Nowadays, more emphasis is laid upon Hybrid energy vehicles employing Atkinson processes in their engines as they have prolonged power production and shorter intake. This feature of ACE helps in increasing thermal efficiency and reduces pollutant emissions. Besides these advantages, it has a drawback: it is strongly dependent upon engine speed, which restricts its application and use. The Atkinson cycle has a mechanism that is different from the Otto cycle as it is performed using linkages. The wide use of the Atkinson Cycle led researchers to explore the effects of various parameters and their variations. The Atkinson cycle is designed to increase efficiency while sacrificing power density. When two engines of identical displacement volume are run at the same speed, the one with an Otto cycle produces more network and, if the engines are run at the same speed, more power. The Atkinson cycle, on the other hand, would have higher thermal efficiency and so use less fuel.

Atkinson cycle increases fuel economy by 20-30% and thus is an ideal type of engine for Hybrid vehicles. The purpose of this paper is to outline different researchers' papers and have a look at the escalation of these engines. For optimization, parameters such as intake valve closing, and exhaust fuel economy are jumbled to analyze the results, and similar modifications can be done in the cycle to boost the volume ratios and thus the cycle efficiency and performance.

2. EARLIER STUDIES ON THE ATKINSON CYCLE

Jianqin et al. [1] performed a bench test on a three-cylinder GDI engine that employed an Atkinson cycle engine (ACE) in a hybrid energy vehicle (HEV) to get the performance and outcomes of fuel injection parameters as well as EGR on combustion and emission. They deduced that only before 280 deg. Injection advance, maximum combustion pressure increases with injection pressure. They suggested a low EGR rate coupled with an appropriate injection timing to increase the performance of ACE to meet SI engines emission regulations.

According to Qingyu et al. [2], Atkinson Cycle has an edge over the Otto cycle in HEV due to greater fuel economy. They proposed a performance gain approach by varying the compression ratio with respect to cycle efficiency with a low-pressure ratio and boosting the apex CR and closing valve timing underneath the limitation of pressure after the compaction. They experimentally validated outcomes of improved fuel economy and pumping losses and remarkable improvements in cycle efficiency at low and medium pressure ratios.

Benajes et al. [3] explored the perspective of the accumulation of Exhaust gas recirculation with the cycle to reduce contamination of diesel engines. They deduced that promoting the degree of shutting valve diminishes NOx from the engine, but other emissions changes are not observable. Mohammad and Mojtaba [4] saw the prospects of using the overexpansion concept in SI engines by modeling mathematically a two-stroke Atkinson SI engine accomplished by employing combustion examination to get a representation of the emission from the exhaust which is then matched to the usual spark-ignition engine. They also looked at how the engine can run with low emission and with better performance.

Zhao [5] suggested that the overexpansion Atkinson cycle would be suitable for HEV as it would get a high expansion ratio while not risking the possibility of knocking and suppressing NOx emissions. The cycle is then said to be handy for manual effort and lowers the temperature at the outlet of the engine. Jiann-Chang and Hou [6] stated that the Atkinson cycle forces the outlet spigot to be closed till the pressure reaches surrounding pressure which helps in doing extra work that would be lost in the Otto cycle. Also, if we increase intake temperature T1, we can reduce the compression ratio for the same peak power.

Yuanhui et al. [7] investigated the layout of the engine and performance characteristics that affect the Atkinson cycle and evaluated that power was lost due to friction, transferring heat with the rise in compression ratio, while increment in friction loss and cylinder length decreases the cycle performance. Shuhn-Shyurng [8] compared the Otto and Atkinson cycle taking heat exchange, then clarifies that work output and thermal efficiency are more than an engine with Otto if both engines are handled under the same setup. Rahim [9] analyzed numerically the Atkinson cycle employing thermodynamics in a fixed time scenario and based on the conclusion from the model deduced that both mean piston speed and compression ratio decide how the power output curve will behave. Also, he states that net energy will rise and fall with the growth in the ratio of actual air/fuel ratio to stoichiometric air/fuel ratio.

Gonca [10] investigated the presentation of the Atkinson cycle with a Dual irreversible engine and figured that better optimal performance of cycle is achieved when conditions at inlet and coefficient of heat dissipation are reduced while increasing combustion constant. Wang and Hou [11] coupled the varying heat sources with the engine and found that the temperature proportion of the heat source changes the outcome in Atkinson cycle at a higher rate. Zhao and Chen [12] made a model of the Atkinson cycle where they considered the irreversibilities caused by insulated wall procedures and heat dissipation from the external boundary of control volume and concludes that due to irreversibility by adiabatic processes, net output and performance falls rapidly, as well as irreversibility caused by heat loss have no effect on power output but decreases efficiency when loss increases.

Miganakallu et al. [13] carried out a 1-D simulation of over expanded 4-stroke Atkinson engine. On basis of a model, they concluded that over-expansion of the power stroke in the Atkinson cycle helps in increasing the anti-knock properties of the fuel. Other benefits include increased thermal efficiency at high load. Min Xu et al. [14] optimized the network made by neurons in the engine and states that fuel economy is increased and the most appropriate compression ratio for the total speed series. Emphasis was laid upon repercussions of changing thermal capacity and drag due to variable specific heats which is generally considered constant, here it is taken variable with respect to temperature and also the friction losses through numerical model made by Yanlin et al. [15] using the principle of finite-time thermodynamics.

3. CONCLUSION

As a result, from the literature review discussed above the different areas that will be covered in this study are as follows-

- Low EGR rate with optimized injection timing will increase the performance of ACE and meet emission regulations such as NOx emissions are low than regulations, but soot and CO emissions are more than Otto cycle in Atkinson engines.
- At low and medium pressure ratios, the Atkinson cycle gives better fuel economy and low pumping losses.
- The major change in the Atkinson cycle when compared with others is that it uses longer expansion ratios and extended auto-ignition delay which aids in premixed combustion.
- Over expansion of power stroke helps in increasing thermal efficiency at high loads and improves the anti-knock properties of the fuel.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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