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Atkinson Cycle Engine Using Electrostatic Fluid Acceleration and Charged Combustion Chamber: Back Flow Reduction and Increased Efficiency

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Abstract: **Decreasing the size of internal combustion engines (ICE) is already recognized as a very suitable method for the enhancement of the indicated fuel conversion efficiency (IFCE) and lowering of the CO_2 and NO_x emissions. The decrement of size is implemented by means of Atkinson cycle engines, using normal crank mechanism, combined with a turbocharging, fuel ionizers and electrostatic fluid acceleration at inlet. This will allow increase of Internal Combustion Engine performance. The electrostatic fluid acceleration will prevent the back flow of fuel in the inlet port. The electrostatic setup involves charged combustion chamber. That will decrease the turbocharger work in short increased efficiency.**

Keywords: **Atkinson cycle, increased IFCE, increased IMEP, electrostatic fluid acceleration in fuel line, fuel line ionization of fuel.**

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1. INTRODUCTION

The available oil and gas reserves are vanishing and the global warming phenomenon is constantly increasing. The automotive industry is vitally responsible towards the fuel consumption and global warming both and thus a reduction of CO_2 emissions and better IFCE can help a lot.

Atkinson had a realization: if the compression in the cylinder were lowered and the power stroke was longer than the intake stroke, the engine would work more efficiently. It would take less fuel to turn the engine, which turns the wheels and makes the car go.

Decreasing the size of the internal combustion engines means simultaneous decreasing of the displaced volume (usually by reducing the number of cylinders) and increasing of the indicated mean pressure (IMEP) by means of turbocharging and electrostatic setup explained in the paper. This allows the increase in power and torque performance while decreasing the engine size.

The current ICEs have classical (symmetrical) crank mechanisms (i.e. with compression and expansion strokes of equal length) and follow the Otto cycles. Real implemented Atkinson cycles require unequal strokes featuring a shorter compression stroke, which leads to a higher IFCE. Atkinson cycles have been used so far mostly with symmetrical crank mechanisms, where the intake valves are closed very late in the cycle. Thus, a part of the charge sucked into cylinder is push back to the intake pipes and the effective compression stroke is decreased, to overcome this problem, electrostatic fluid acceleration is introduced in the inlet port.

Real Atkinson cycles can be implemented only with the help of asymmetrical crank mechanisms. This allows to use high boost pressures (to increase the IMEP) and higher VCR and to set them much more independently of each other compared to Otto cycles. Because an important part of the fresh charge compression takes place beyond the cylinder, the high compressed fresh charge can be cooled intensively before it is sucked in cylinder. Following moderate compression in the cylinder (i.e. with relative lower VCR) lead to lower temperature peaks during the combustion process and, consequently, to less NO_x emissions.

2. ELECTROSTATIC FLUID ACCELERATION

The fuel Conditioner ionizer, interposed in a fuel line leading to an engine, includes housing, an inlet sealed to the fuel supply line and an outlet sealed to the fuel line leading to the engine. Angular and directional fuel How is generated by a fluid mixing device mounted in the housing. The mixer is a stationary turbine with a plurality of radially extending blades, circumferentially disposed in the housing. Improvements include an annular ring holding the blades, a central hub in the ring and additional or secondary flow directing blades. That will create a swirl or vortex in the fuel supply line.

For electrostatic acceleration, the gas is ionized. The electrons are contained within this chamber by a charged set of grids at the opening. One grid, held at high potential, with the other grid at ground, creates a potential difference. A force due to the potential difference, repels the electrons, but attracts the ions, accelerating them through the opening of the grids. The acceleration produces a momentum exchange, thus providing thrust.

As the gas enters the chamber; an electrostatic plates surrounds the chamber creating a repulsive flow in the radial direction inside the chamber towards the center. Thus the problem we were facing due to the fluid going back in inlet port will be resolved. This increases the IMEP at the time of the compression stroke i.e. the effective compression stroke increases that eventually IFCE is increased. The TDC of the chamber is also charged oppositely. As the gas is in ionized form; the ions are passed through the inlet valve ionized such that the fuel back flow is obstructed. The electrostatic force will push the gas in the chamber downwards. As by coulomb’s law of repulsion the charges are repelled in the chamber. And ionized fuel is burnt. As the ionized fuel burn better. Then after the successive compression stroke and combustion, the exhaust stroke is completed.

Whole system can be diagrammatically represented in the figure 2 shown below.

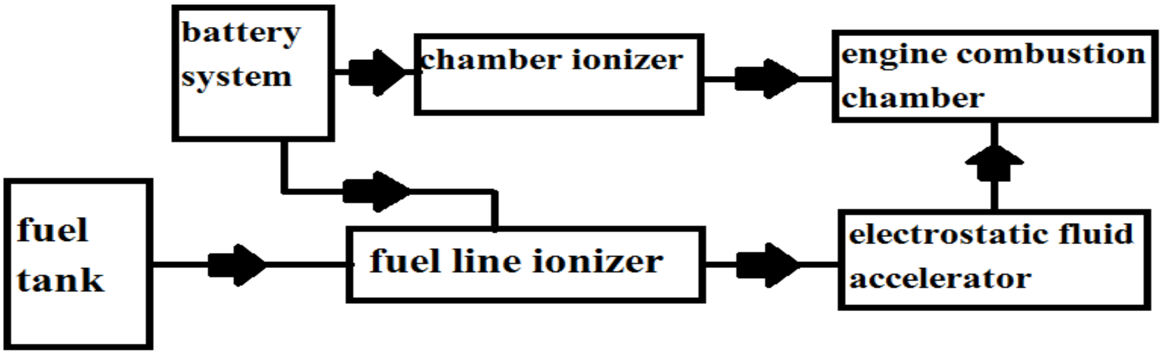


Figure 1

3. ATKINSON CYCLE AND HIGH PRESSURE TURBOCHARGING

Atkinson cycle is an ideal cycle for Otto engine exhausting to a gas turbine. In this cycle as shown in figure 1, **the** isentropic expansion (3-4) of an Otto cycle (1-2-3-4) is further allowed to proceed to the lowest cycle pressure so as to increase the work output. With this modification the cycle is known as Atkinson cycle. The cycle is shown on p-v and T-s diagrams in figure below. Processes involved are:

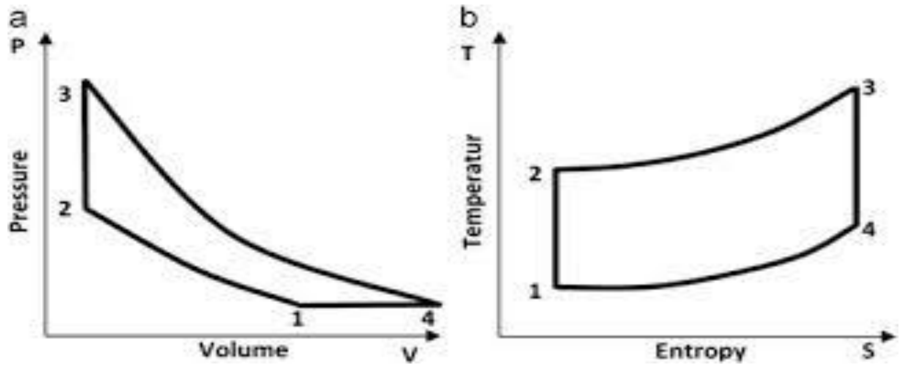
Process 1-2: Reversible adiabatic compression (v1 to v2).

Figure 2

Process 2-3: Constant volume heat addition.

Process 3-4: Reversible adiabatic expansion (v3 to v4).

Process 4-1: Constant pressure heat rejection.



The ionized fuel entering in the charged combustion chamber is repelled from all the sides. That will increase the effective compression. The IMEP is increased hence the efficiency is also increased.

4. ATKINSON CYCLE ENGINE CALCULATIONS

Heat supplied = $C_v(T_3 - T_2)$

Heat rejected = $C_p(T_4 - T_1)$

Work done = $C_v(T_3 - T_2) - C_p(T_4 - T_1)$

$$\eta_{th} = \frac{C_v(T_3 - T_2) - C_p(T_4 - T_1)}{C_v(T_3 - T_2)}$$

$$r_p = \frac{T_3}{T_2} = \frac{P_2}{P_3}$$

Resolving the above equation

$$\eta_{th} = 1 - \left(\frac{r_p^{\frac{1}{\gamma}} - 1}{(r_p - 1) r_p^{(\gamma - 1)}} \right)$$

r_p Represents the compression ratio. Now by using the new methods for improvement of Atkinson engine; the compression ratio can be modified to new compression ratio say, r_p'. The ratio must be greater than the previous one because of the use of electrostatic setup.

5. ELECTROSTATIC FLUID ACCELERATION CALCULATIONS

The electrostatic acceleration depends on According to Weber electrodynamics, the force (F) acting simultaneously on point charges $q_1$and q_2, is given by

$$F = \frac{q_1 \, q_2}{4\pi\varepsilon_0 r^2} \left(1 - \frac{\dot{r}^2}{2c^2} + \frac{r \, \ddot{r}}{c^2} \right)$$

Where r is the vector connecting q_1 and q_2, the dots over r denote time derivatives and c is the speed of light. In the limit that speeds and accelerations are small this reduces to the usual Coulomb's law. The potential with which the charges are pushed can be calculated from the estimated force from weber electrodynamics.

Therefore, the new thermal efficiency will be.

$$\eta'_{th} = 1 - \left(\frac{{r'}_p^{\frac{1}{\gamma}} - 1}{(r'_p - 1){r'}_p^{(\gamma-1)}} \right)$$

As because of the electrostatic setup provided in the chamber, $r'_p > r_p$

Hence the overall $\eta'_{th} > \eta_{th}$

The ionized fuel creates better burning. The walls of the chamber will push the ions towards the center as well as the ions are repelled from TDC as it is also charged with the same charge. Hence it increases the IMEP.

Hereby we can state the advantages of the new modified Atkinson cycle engine as below

1. Increased IMEP due to electrostatic acceleration.
2. The back flow of fuel in the inlet port is reduced.
3. Increased IFCE by the use of Atkinson cycle.
4. Decrement of size due to use of the normal crank mechanism.
5. Improved overall performance.
6. Reduced emissions.

6. CONCLUSIONS

System explained in the paper can reduce the emissions as size of engine is reduced and as well as it can increase the IMEP and IFCE of the Atkinson cycle engine. Hence the efficiency is also improved. Higher IFCE leading to few CO2 emissions and lower temperatures during the combustion stage leading to few NOx emissions. One can assume that an internal combustion engine is getting maximum energy per liter as well as environment with lowest possible level toxic emission. From this research study, it is shown that the electrostatic fluid acceleration can help with controlling the back flow in the inlet port. That reduces the losses in combustion chamber. Size decrement can be easily done by using the electrostatic fluid acceleration. As well as the turbocharger levels required can be reduced. Increase in IMEP, increases the network output hence there is increase in efficiency. Hence number of complementary technologies exist that can be used either in isolation, or in combination to give specific benefits to the efficiency of engines.

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