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Design of Plastic a Plastic Engine working on Modified Atkinson Cycle

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Abstract

The reduction of cost has become a major goal in the industrial world and over time this has resulted in the replacement of metallic components with plastic components which are not only equally reliable but also light in weight as compared to their metallic counter parts. The impact on the automotive industry is no different, plastic components are already being used in exterior and interior components such as bumpers, headlights and taillights, dashboards, doors, windows, mirror housing, trunk lids, hoods, grilles and wheel covers. This not only reduces the cost of production, but also optimizes weight to make vehicles more energy efficient. With regard to engines, though plastics have been used in making engine components such manifolds, engine covers, cylinder head covers and engine air flow components, not much progress has been made towards developing plastic engines.

Proposed herein is a design of a plastic engine which can be an alternative to the conventional internal combustion engine used in the automotive industry. The engine is made of thermoplastic material having high melting point and mechanical strength, making the overall engine light weight, resistant to corrosion, energy efficient, robust, resilient and durable. The engine works on a Modified Atkinson cycle which is more efficient than both a Diesel Cycle and an Otto Cycle. An Atkinson cycle is an ideal cycle for Otto engines, with modification the cycle gives an increased work output. The engine comprises of three main functional entities: a compression chamber, a combustion chamber and an expansion chamber. The compression and expansion chambers are made of thermoplastic, whereas the combustion chamber is metallic. Also provided herein are a plurality of different possible embodiments and evaluations required for the design of this particular engine.

Keywords

IC engine, Atkinson cycle, engineering plastic, alternative design, versatile application

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Introduction

With the advancement in technology and science there has been remarkable progress in the field of internal combustion engines. But there has not been much progress on the research and development of an engine that is made out of high performance plastic components.it has been rightly said that the 21th century being the era of the plastic age it is only inevitable to try and not replace conventional components which were earlier made of metal and alloy.Today's plastics make up 50 percent of the volume of new cars but only 10 percent of the weight, which helps make cars lighter and more fuel efficient, resulting in fewer CO_2 emissions. Proposed in this paper is a design of an engine which can be made of high performance plastic material which works on a modified Atkinson cycle which a benchmark cycle with increased efficiency itself.

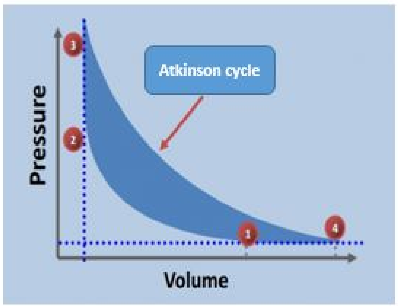
Benefits of a plastic Engine

The benefits of a plastic engine are stated as follows:

1. High power to weight ratio
2. Versatile application
3. Durable, tough and are resistant to corrosion
4. Provide flexibility in both designing and manufacturing

The Engine

The engine works on a Modified Atkinson cycle,the modified Atkinson cycle comprises of four processes: process 1-2: reversible adiabatic compression (v1 to v2), process 2-3:constant volume heat addition, process 3-4: Reversible adiabatic expansion (v3 to v4),process 4-1:Constant pressure heat rejection.It more efficient than both an Otto cycle and Diesel cycle.An Atkinson cycle is an ideal cycle for Otto engines, with modification the cycle gives an increased work output.



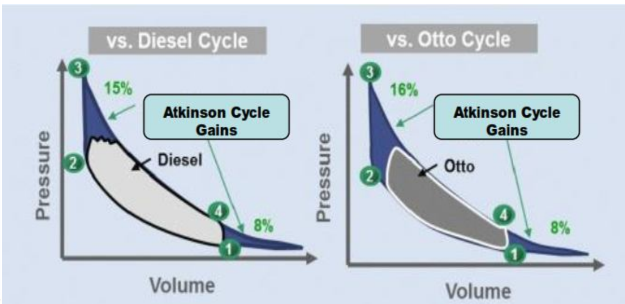


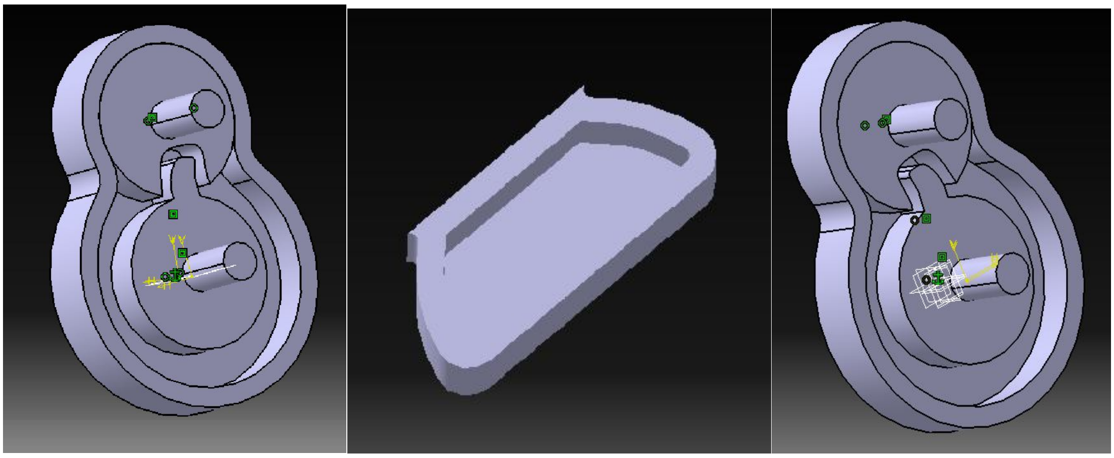
Fig.1 Atkinson Cycle **Fig.2 Comparason of Atkinson Cycle with Otto & Diesel Cycle**

The engine comprises of three main functional entities: a compression chamber, a combustion chamber and an expansion chamber. The compression and expansion chambers are made of high performance engineering plastic, whereas the combustion chamber is metallic. The air taken in from the atmosphere is compressed in the compression chamber, following which this compressed air goes to the combustion chamber where it is used in the air and fuel mixture for combustion. After the combustion, the air finds its way to the expansion chamber where it expands and gives us the working stroke. Also provided herein are a plurality of different possible embodiments and evaluations required for the design of this particular engine.

Description

The engine has been made by assembling three main components; the compression chamber, the combustion chamber and the expansion chamber.

The compression chamber is made of high performance engineering plastic. This chamber consists of acasing within which two rotors are contained .The primary rotor has a projection, this projection has a slight curvature. As the rotor rotates the projection has sliding motion with respect to the inner wall of the closure. The second rotor has a slot cut into in to accommodate the projection. The timings of the two are adjusted such that the projection of the first rotor fits into the machined slot of the other rotor.



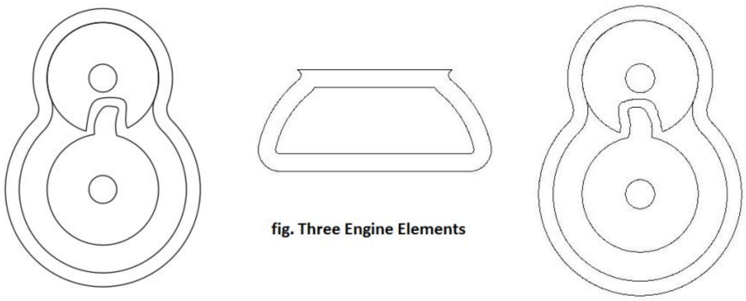


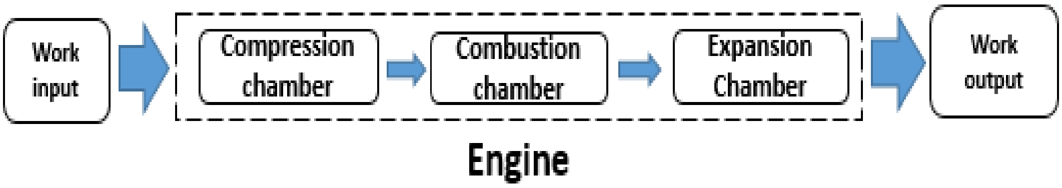
fig. Three Engine Elements

The next element is the combustion chamber. This chamber is made of metal alloy. The volume of this chamber is same as that of the compression chamber when the air fuel mixture is compressed. The chamber consist of a spark plug to ignite the air fuel mixture.

The final element is the expansion chamber, the design of the expansion chamber is the similar to the compression chamber i.e. it too consists of a casing with in which two rotors are contained. The only difference between this and the compression chamber is the projection and the slot in the primary and the secondary rotor of the expansion chamber respectively have profiles which is symmetrically opposite to the respective profiles of the combustion chamber. The three elements assembled together makes up the engine.

The Process

A calculated amount of air fuel mixture first enters the compression chamber, the idea is to compress the air in this chamber to a very high ratio, this is achieved when the primary rotor rotates about its axis in the case and the projection compresses the air by reducing the volume of the expansion chamber as it rotates.



The air fuel mixture is then isolated in a constant volume chamber; the combustion chamber. In this chamber the combustion takes place, but the fuel/air mixture isn't allowed to expand. Instead, it's kept compressed in a constant volume so it can burn over an extended period. The air is only able to expand in the expansion chamber. As product of combustion enters this chamber it pushes the projection of the primary rotor as it needs to expand this in turn makes the rotor rotate and gives the required work.

Calculations and Theoretical Evolutions

Basic stoichiometry has been used to derive the amount of air fuel mixture to be injected in the compression chamber. The burning of fuel is basically the reaction of fuel with oxygen in the air. The amount of oxygen present in the cylinder is the limiting factor for the amount of fuel that can be burnt. If there's too much fuel present, not all fuel will be burnt and un-burnt fuel will be pushed out to the expansion chamber.It's very important to know the air-fuel ratio at which exactly all the available oxygen is used to burn the fuel completely or at least to the best possible value. This ratio is called the stoichiometric air-fuel ratio.The fuel combustion process takes place under very hot and pressurized conditions and to avoid any unsafe consequences, excess air operations are carried out. Excess air level keeps a check on the various factors like fuel composition variation, oxygen availability and pressure, which can lead to an explosion.

The air to fuel ratio is the property of fuel and chemical composition of the fuel that defines the value for this ratio. Most of the fuels we use in internal combustion engines are hydrocarbons, and their burning will obviously result in the release of hydrogen and carbon as residuals, along with heat and pressure.

Gasoline or petrol like all fuels contains hydrocarbons a mixture of n-heptane and iso-octane and atmospheric air contains 21% of oxygen and 79% of nitrogen and the product of the reaction is water and carbon dioxide.

The reaction involved:

Iso-octane: $C_8H_{18} + O_2 \rightarrow CO_2 + H_2O$
n-heptane : $C_7H_{16} + O_2 \rightarrow CO_2 + H_2O$

Sl no.	Elements	Molecular wt.
1	Hydrogen	1
2	Nitrogen	14
3	Carbon	12
4	Oxygen	16

Table 1: Molecular Wt. of elements

Sl no.	Compounds	Chemical Formula	Molecular Wt.
1	N-heptane	C_7H_{16}	100
2	Iso-Octane	C_8H_{18}	114
3	Water	H_2O	18
4	Carbon dioxide	CO_2	44

Table 2: Molecular Wt. of Compounds

Basic thermo dynamical formulas have been used for deriving the theoretical efficiencies and the mass of mixture, compression ratio, volume of the compression chamber etc.

The volume of the compression chamber has been calculated by,

$$V_1 = \pi r^2 \text{h} - (\pi r^2 h_1 \text{- L x B})$$

The compression ratio C_r have been evaluated by,

$$C_r = \frac{V_1}{V_2}$$

The temperature, pressure and volume of each individual chamber have been evaluated with basic Atkinson cycle derivations,

$$T_2 = T_1 r^{\gamma-1} \frac{P_1}{P_2} = (\frac{V_1}{V_2})^{\gamma} = r^{\gamma}$$

The theoretical thermal efficiency have been found out to be 68.15% by,

$$\eta_{th} = 1 - (\frac{1}{r})^{\gamma-1}$$

The mass of the mixture was calculated with,

$$P_1 V_1 = mRT_1$$

The theoretical volumetric efficiency have been found out to be 99.62% from,

$$\eta_v = \frac{ma}{\rho V_1}$$

Future Scope of Research

As it is just the initial stage of the project there is huge scope for further development of this design, particularly calculation to calculate the amount of fuel that can be used and the heat generated, selection of a suited engineering plastic material, functionality at higher temperatures. Alternative design prospective such as development of a venin projections attached to the rotors instead of a single projection, this will aid in continuous air/ fuel mixture supply.

Conclusion

The plastic engines have a huge potential to not only to reduce the cost but also reduces weight. They have durability and toughness, are resistant to corrosion and provide flexibility in designing making it possible to be implemented across versatile technology domains not only in the automotive sector but also in the field of integrated gasification combined cycles

References

[1] WILLARD W. PULKRABERK University of Wisconsin Engineering Fundamentals of Internal combustion engine.
[2] Cengel, Boles, Thermodynamics.
[3] Prof. U.S.P. Shet, Prof. T. Sundararajan and Prof. J.M . Mallikarjuna , IIT Madras gas power cycles.
[4] LiquidPiston.com
[5] abengine.com
[6] Ignition coil for use in engine and engine having plastic cylinder head cover, US7013883 B2.
[7] Plastic engine cover, WO2013167436 A1.
[8] Plastic engine inlet manifold provided with water passages, CN202451320 U.
[9] Plastic air flow engine, CN103967710 A.
[10] Plastic product design and process engineering , Harold Belofsky.
[11] A. Colchin and V.Demidov, Design of automotive engines.
[12] P.K Nag, Basic and Applied Thermodynamics.
[13] www.physicsforums.com/threads/stoichiometry-of-gasoline