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Design and Development of a Plastic Engine

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Abstract—*With cost reduction becoming a major goal for the automotive industry around the world, one of the major approaches taken by the industry is the replacement of steel and aluminium components with plastic. 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. The continuous development of improved and superior quality thermoplastics having high performance and versatile applications has increasingly helped in their implementation across different technological domains in the automotive industry. These plastics are cost effective and provide durability and toughness, are resistant to corrosion and provide flexibility in designing. 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, but not much progress has been made towards developing plastic engines.*

1. INTRODUCTION

The internal combustion engine has been remarkably been successful for more than a century and a half, ever since its invention. Unfortunately, but not much progress has been made in the field of developing a plastic engine for the automotive industry.

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.

2. THE ENGINE

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 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.

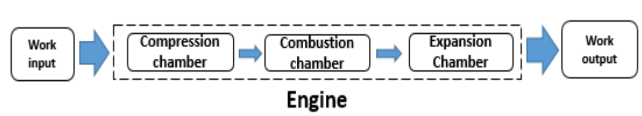
3. DESCRIPTION

As stated the design of the engine has been divided into three functional entity: the compression chamber, the combustion chamber and the expansion chamber.

The compression chamber is made of high performance engineering plastic. This chamber consists of an enclosure 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.

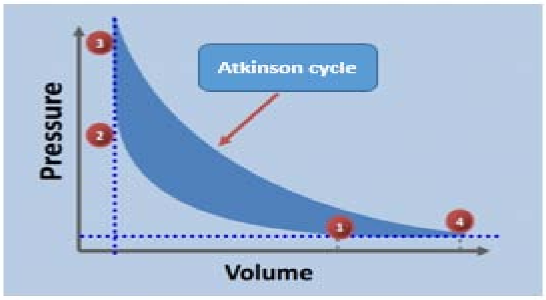
The next element is the combustion chamber. This chamber is made of metal alloy. The volume of this chamber is same as that of the compression chamber when the air fuel mixture is compressed. The chamber consist of a spark plug to ignite the air fuel mixture.

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 closure 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.



4. PROCESS

The process works on an Atkinson cycle



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.

5. CALCULATIONS AND THEORETICAL EVOLUTIONS

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

$$V_1 = \pi r^2 h - (\pi r^2 h_1 - L \times B)$$

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.

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

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

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

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,

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

6. OUTLINE SKETCH OF THE ENGINE

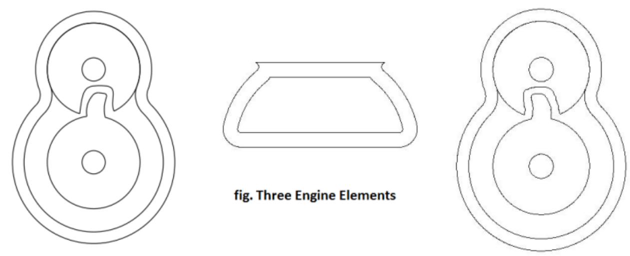


fig. Three Engine Elements

Table 1: Design Parameters

Component	Symbol	Quantity	Unit
Compression chamber	Volume V_1	26.94	Cm^3
	Temperature T_1	300	K
	Pressure P_1	1	atm
Compression Chamber	Volume V_2	2	Cm^3
	Temperature T_2	941.98	K
	Pressure P_2	42.295	atm
Others	Thermal efficiency η_{th}	68.15	%
	Mass of a/f mixture	.000317	kg
	Volumetric efficiency η_v	99.62	%

7. FUTURE WORK AND SCOPE FOR RESEARCH

As it is just the initial stage of the project there is huge scope for further development of this design, particularly stoichiometric 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.

8. CONCLUSION

Hence we see that 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.

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