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A STUDY ON CONVENTIONAL AND NEW INTERNAL COMBUSTION ENGINE AND THEIR EFFECTS ON THE ENVIRONMENT

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Abstract:

This paper will present one idea of how to improve overall internal combustion engine efficiency. We try to make a brief description of most important and basic parts of a new internal combustion engine. Described engine have several advantages over conventional IC engine.

Keywords: Internal combustion engine, fuels, motor vehicle, generators.

Introduction:

Why do internal combustion (IC) engine studies still need to be done? For power generation, trade, and transportation, society continues to rely significantly on IC engines. Because of this, engine research has a rich history dating back more than a century and is still active today. Model airplane engines that fit in the hand and massive marine engines that are as large as a four story structure are two sizes of reciprocating internal combustion (IC) engines. In addition to the 750 million passenger cars on the planet's roads, IC engines also power a wide range of utility devices (such as pumps, mowers, chainsaws, portable generators, etc.), tractors, propeller aircraft, ocean liners, and ships. Additionally, there are 250 million vehicles in the U.S. alone, or nearly one vehicle per person. In 2012, 60 million cars will be produced worldwide, a 50% increase from ten years ago. A portion of this growth can be attributed to the fact that China, which now accounts for one-fourth of global auto production and in 2011, became the world's largest auto market. In the European Union, where cars make up a third of the global market, diesel engines account for half of all vehicle power. Engine research therefore includes both diesel and gasoline engines, and even modest increases in their efficiency have a significant influence on both economy and emissions. Fuel is burned in enormous amounts due to the sheer number of cars and engines on the world. In fact, IC engines use 70% of the 86 million barrels of crude oil that we use each day. Additionally, the U.S. uses 10 million barrels per day for light-duty and heavy-duty vehicles combined, which equates to around 2.5 gallons per person daily. Since there aren't enough fuel reserves to cover this demand, 62% of the fuel is imported, costing the United States nearly $1 billion per day at the current price of $80 per barrel. This price will undoubtedly go up if global demand for vehicle fuels rises as a result of continued economic growth. This extensive usage of oil is accompanied by the release of pollutants including nitric oxides (NOx) and particulates (soot), as well as the creation of CO2. Most countries have established strict car emissions standards that are always being tightened since pollutant emissions have detrimental effects on both the environment and human health. Additionally, the 37 billion tons of CO2 produced globally each year contributes to Green House Gases (GHG), which some worry may cause climate change with unknown effects. Fuel consumption would need to be drastically reduced in order to noticeably alter GHG trends. For instance, according to the International Energy Agency's plan, all automobiles globally should consume 30 to 50 percent less fuel per kilometer by 2050 than they do today. The goal is to limit the global average temperature rise which some climatologists project for 2050 (the 2DS scenario) . Government mandates requiring such reductions impose a tall order on the already high-tech and high-cost automotive industry. And, although 2050 seems a long time in the future, the time required to bring new engines to production, together with the years needed for new technology to permeate the overall vehicle fleet, means that major effort (and investment) is needed in IC engine research over the next decades.[1]

Background:

Electrical generators capable of high conversion efficiencies and extremely low exhaust emissions will no doubt power advanced hybrid vehicles and stationary power systems. Fuel cells are generally considered to be ideal devices for these applications where hydrogen or methane are used as fuel. However, the extensive development of the IC engine, and the existence of repair and maintenance industries associated with piston engines provide strong incentives to remain with this technology until fuel cells are proven reliable and cost competitive. In addition, while the fuel cell enjoys high public relations appeal, it seems possible that it may not offer significant efficiency advantages relative to an optimized combustion system. In light of these factors, the capabilities of internal combustion engines have been reviewed.

In regards to thermodynamic efficiency, the Otto cycle theoretically represents the best option for an IC engine cycle. This is due to the fact that the fuel energy is converted to heat at constant volume when the working fluid is at maximum compression. This combustion condition leads to the highest possible peak temperatures, and thus the highest possible thermal efficiencies.

Edson (1964) analytically investigated the efficiency potential of the ideal Otto cycle using compression ratios (CR) up to 300:1, where the effects of chemical dissociation, working fluid 3 thermodynamic properties, and chemical species concentration were included. He found that even as the compression ratio is increased to 300:1, the thermal efficiency still increases for all of the fuels investigated. At this extreme operating for instance, the cycle efficiency for isooctane fuel at stoichiometric ratio is over 80%.
Indeed it appears that no fundamental limit exists to achieving high efficiency from an internal combustion engine cycle. However, many engineering challenges are involved in approaching ideal Otto cycle performance in real systems, especially where high compression ratios are utilized. Caris and Nelson (1959) investigated the use of high compression ratios for improving the thermal efficiency of a production V8 spark ignition engine. They found that operation at compression ratios above about 17:1 did not continue to improve the thermal efficiency in their configuration.

They concluded that this was due to the problem of non-constant volume combustion, as time is required to propagate the spark-ignited flame.

In addition to the problem of burn duration, other barriers exist. These include the transfer of heat energy from the combustion gases to the cylinder walls, as well as the operating difficulties associated with increased pressure levels for engines configured to compression ratios above 25:1 (Overington and Thring 1981, Muranaka and Ishida 1987). Still, finite burn duration remains the fundamental challenge to using high compression ratios.

The goal of emissions compliance further restricts the design possibilities for an optimized IC engine. For example, in order to eliminate the production of nitrogen oxides (NOx), the fuel/air mixture must be homogeneous and very lean at the time of combustion (Das 1990, Van Blarigan 1995). (It is subsequently possible to use oxidation catalyst technologies to sufficiently control other regulated emissions such as HC and CO.) Homogeneous operation precludes diesel- type combustion, and spark-ignition operation on premixed charges tends to limit the operating compression ratio due to uncontrolled autoignition, or knock. As well, very lean fuel/air mixtures are difficult or impossible to spark ignite.

On the other hand, lean charges have more favorable specific heat ratios relative to stoichiometric mixtures, and this leads to improved cycle thermal efficiencies. Equivalence ratio is no longer required to be precisely controlled, as is required in conventional stoichiometric operation when utilizing tree way catalysts. Equivalence ratio is defined here as the ratio of the actual fuel/air ratio to the stoichiometric ratio.[2]

Implementation and application:

Mobile propulsion systems are most frequently powered by internal combustion engines. Internal combustion is advantageous in mobile situations because it can offer high power to weight ratios and excellent fuel energy density. These engines can be found in nearly all cars, motorcycles, boats, a wide range of airplanes, and locomotives. They typically appear in the form of gas turbines where very high power is required, such as in jet aircraft, helicopters, and huge ships. In addition, industry and power generators use them. Electric motors are a competitive alternative for many low power mobile and non-mobile applications. Electric motors might possibly become affordable in the future for the majority of mobile applications. However, the usage of lead-acid batteries and even NiMH batteries has been mainly constrained to specialized applications due to their high price, weight, and poor energy density as well as the absence of accessible onboard electric generators like fuel cells. The safety, power density, longevity, and affordability of batteries have recently improved thanks to developments in lightweight Li-ion and Lipoly chemistries, bringing them to levels that are tolerable or even desired. For instance, battery electric vehicles recently started to show 300 miles of range on lithium; now better power makes them interesting for plug-in hybrid electric vehicles; its electric range is less necessary having internal combustion for unlimited range. [3]

Conventional I.C. Engine:

It is well known that ordinary IC engines are based on a slider-crank mechanism. This way of piston motion provides a relatively simple solution to achieve a thermodynamic cycle to produce mechanical power. As can be seen from theory, the most efficient thermodynamic cycle for IC engines is the Otto cycle, because the constant volume heat addition is essential for high efficiencies. Common to most reciprocating enginesis a linkage known as a crank-slider mechanism. Slider-crank mechanism was shown in figure 1, this mechanism is one of several capable of producing the straight-line, backward-and-forward motion known as reciprocating. Fundamentally, the crank-slider converts rotational motion into linear motion, or vice-versa. With a piston as the slider moving inside a fixed cylinder, the mechanism provides the vital capability of a gas engine: the ability to compress and expand a gas. One of the major disadvantages of the conventional linkage is the fact that this setting produces very limited motion of piston (large changes of volume during combustion) and high mechanical losses due to the friction between piston and cylinder liner. Friction between piston and cylinder is the biggest source of friction in ordinary engine, more than half of all mechanical losses came from contact between parts like piston, rings and cylinder.[3]

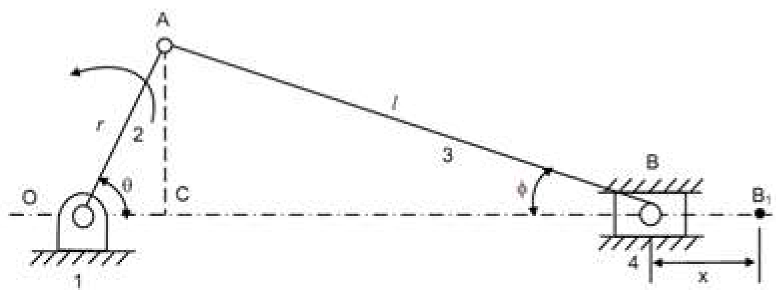

Fig.1: Slider-crank mechanism

New I.C. Engine:

A real engine cannot add heat while running at a steady loudness. The piston can only continually reciprocate between top dead center (TDC) and bottom dead center (BDC) when the engine is running, and at a frequency proportionate to the engine speed. However, the duration of the chemical reaction process linked to combustion events is essentially fixed and mostly unaffected by engine speed. The air/fuel mixture must be ignited before the piston reaches TDC in order to maximize the work produced by the heat energy released during combustion. The ignition timing should be adjusted in accordance with the engine speed stage because heat release before the piston reaches TDC produces negative work. True constant volume heat release is not possible since the crank rotation defines the piston movement throughout the combustion event. The ideal scenario is for the combustion event to start and finish with the piston still at TDC. Reducing the engine crank rotation speed at the TDC point is a workable solution to give the combustion process more time to complete. The result will be the creation of a novel combustion cycle called quasi-constant volume (QCV), which lies halfway between the ideal Otto constant volume combustion cycle and the typical IC engine combustion cycle. As can be seen from the aforementioned figure, the crankshaft and connecting disc form the basis of the mechanism that causes the pistons to move. In this paper, will be presented brief features and advantages over ordinary SI engines. Dwell time or dwell angle is important fact during combustion process. In conventional engine this dwell angle can be changed due to variations of ratio between connecting rod and crank radius. Piston dwell at TDC and at BDC are often mentioned, it should be noted that strictly, there is no dwell period in ordinary mechanism. The piston comes to rest at precisely the crank angle that the crank and rod are in line (TDC and BDC), and is moving at all other crank angles. At crank angles which are very close to the TDC and BDC angles, the piston is moving slowly. It is this slow movement inthe vicinity of TDC and BDC that give rise to the term piston dwell. In this described concept there is also no piston dwell in classical sense, there is only very small changes of volume near TDC. If the piston dwells longer near TDC and ignition is initiated properly, there will actually be a longer period of time for the pressure created during combustion to press against the top of the piston. Also, if the dwell period is too long, there is a possibility for unfavorable energy conversion. In real engine ideal Otto cycle have certain disadvantages because there are a lot of heat losses in case when full combustion is obtained in TDC. Optimal heat addition should be found somewhere between pure constant volume combustion and combustion at variable volume-quasiconstant volume combustion.[3]

Main engine parts:

Main engine parts of a new concept are shown in the following figures:

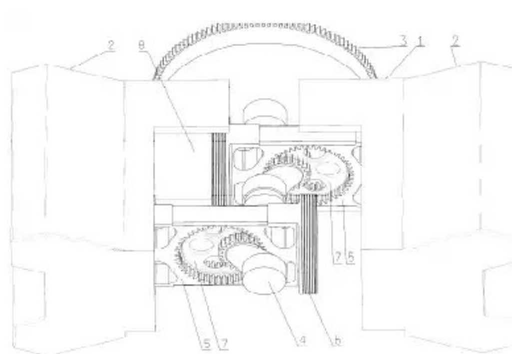

Fig.2: Main engine parts

- Basic engine design is very similar to well-known boxer or flat engine or even rare V-180o . These similarities can be seen from next Fig 3. Where is presented flat engine with several parts: 1-engine block, 2-engine head and 3- flywheel.

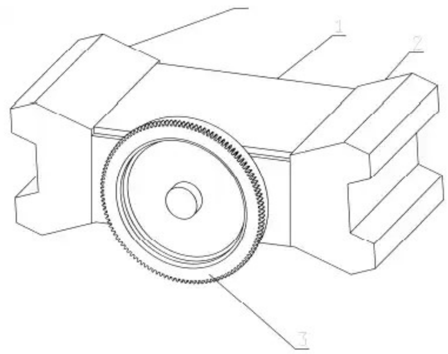

Fig.3: View on new flat engine

- One of the most important parts in every engine is the crankshaft. In this engine design crankshaft is shaped in such way that is able to connect with piston via gear teeth. As an ordinary crankshaft this one also has journal bearing which is necessary because of connection with piston disc. On Fig.4 was presented new crankshaft with gears and flywheel. Gears and crankshaft have rigid connection.

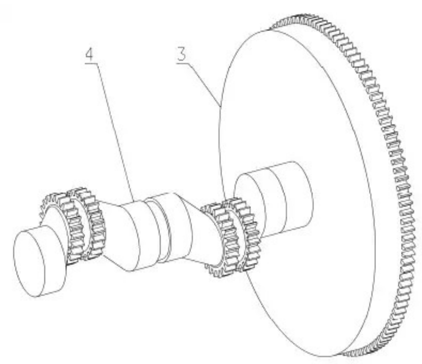

Fig.4: Crankshaft of new IC engine

- Double acting piston is one of the most important features of new engine design.

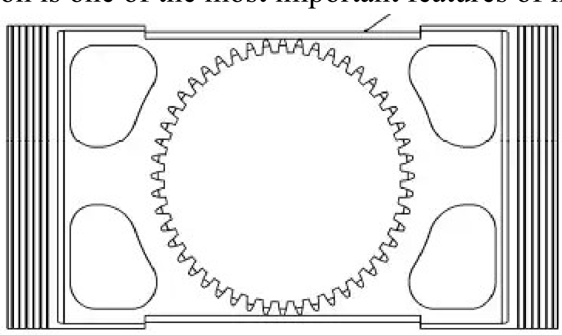

Fig.5: Double acting piston

- The idea is to eliminate normal force on cylinder wall. Normal force is product of piston mechanism design and one of the main reasons for high values of mechanical losses in piston engines. Normal force from cylinder surface can be transfer into forces on elements like piston disc (Fig. 6). Piston disc is fully hydrodynamic lubricated and the total friction force is very small in relation to friction between piston and cylinder liner. Piston disc is placed between crankshaft and piston, hydrodynamic lubrication was achieved on both surface, first is in contact with crankshaft and the second is in contact with piston. Contact surfaces can be seen from Fig 6

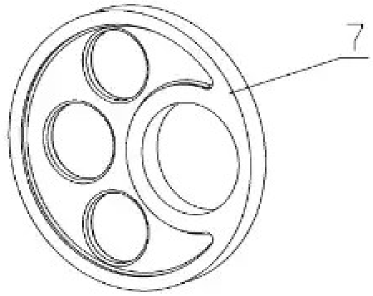

Fig.6: Piston Disc

The traditional advantages of internal combustion (IC) engines refer to:

A. The high-power density (power to volume and weight).

B. The high energy content and the ease of onboard storage of liquid fuels.

C. The well-established manufacturing processes that has been optimized through many years.

D. The driving distance between two refueling events (which is typically much longer with IC engines than with many of the discussed future alternatives).

E. The well-established worldwide fuel supply infrastructure.

F. The capability to effectively use a variety of alternative gaseous and liquid fuels.

G. IC engines still have a huge potential to effectively deal with most of the sometimes conflicting requirements for future automotive power trains. In particular they can achieve:

i. Further increase of power and torque.
ii. Further size and weight reductions.
iii. Further improved fuel economy.
iv. Further reduced emissions.[4]

Engine emissions and the environment:

Researchers have worked to increase the fuel efficiency of IC engines for decades, long before concerns about climate change gained popularity. They have also worked to lower operating costs and pollutant emissions while ensuring that present and future generations make the best use of finite fuel resources. Due to a 1000-fold reduction in harmful exhaust emissions (particulates, NOx, CO, and unburned hydrocarbons (uHCs), research on engine combustion, exhaust after-treatment, and controls has been conducted over the past 40 years in response to concerns about air quality. Technical articles in this journal have provided documentation for many advancements in these fields. Local, national, and international policy, however, has recently started to be significantly influenced by significant increases in concern about both air quality and the effect of GHG emissions on global warming. The electrification of vehicles is being extensively promoted, and a number of projects are advocating for radical changes. For instance, the C40 Cities Climate

Leadership Group is dedicated to promoting urban action to decrease GHG emissions and climate risks. The group is made up of 90 cities from across the world, representing more than 650 million people and one-fourth of the global economy. Demands include switching to wind and solar energy as the main energy sources and getting rid of internal combustion engines from inner city transportation. Only a very small portion of the world's energy needs are met by wind and solar energy. Despite technical advances and cost reductions for wind and solar power, it appears very unlikely that most fossil-fuel energy sources will be replaced by alternative carbon-neutral sources over the next two or three decades.

IC engine and electrification:

Depending on consumer acceptance (e.g., cost), the country under consideration, and the specific application (city, country, personal, freight, etc.), future mobility is likely to be characterized by a mix of solutions involving battery electric and hybrid electric vehicles (BEV and HEV), fuel cell electric vehicles (FCEVs), and conventional vehicles. Thus, even with heavily electrified powertrain systems, the combustion engine will continue to be a key component, whether it is utilized to generate electricity or to drive the vehicle itself. Because of this, there is a lot of interest in raising the thermal efficiency of IC engines without significantly raising their short- to medium-term purchase and operating costs. These objectives can be met by enhancing the combustion, after-treatment, and control systems, partially electrifying the vehicle through hybridization, reducing vehicle weight, and developing more effective ancillary systems.

Even if there is a lot of interest in the electrification of transportation currently, only BEVs do so. However, life-cycle analyses7 of the GHG impact of BEVs, which take into account the energy needed in power generation and battery manufacture, reveal that their genuine benefit is far less than what is initially evident. The upstream CO2 produced during the extraction, refinement, and transportation of fuels as well as the creation and distribution of power is often ignored in assessments. Cobalt, lithium, rare earths, and other essential raw materials for batteries and electric motors, along with a significant amount of water, must be extracted. Life-cycle studies also need to take end-of-life disposal—toxicity in particular—into account. (Many of these factors also apply to solar and wind photovoltaic power producing equipment.) Additionally, the development of a new electrical grid that can recharge millions of BEVs will require more raw materials, energy, and CO2 emissions, and may be constrained by the availability of essential resources. The high price of BEVs in comparison to conventional or hybrid vehicles with IC engines is also pushing the development of efficient but previously believed uneconomical ways to improve the IC engine's efficiency with advanced combustion modes and to further minimize polluting emissions. In this way, the competition between IC engines and electric motors is promoting the thermal engine's own advantageous progress. [5]

Conclusion:

In this paper was presented one approach for improvement of spark ignition engine efficiency. Described concept has several advantages over ordinary SI engines. All of these mentioned advantages show that the potential to increase the efficiency of the SI engine conditions is not yet exhausted. The engine used for most contemporary motor vehicles is the four-stroke SI internal combustion engine, in that sense in this paper is presented such engine. A novel Otto cycle engine concept in which intake and compression are carried out through unconventional piston mechanism is presented in this paper. With longer piston dwell near TDC and eliminating normal force on cylinder wall it can be expected that thermal efficiency and mechanical efficiency will be increased. It can be noted that this engine concept has lower number of parts than ordinaryboxer engine. It is clear that the efficiency of modern IC engine cannot be much increased, which is also one of the reasons for the development of new propulsion systems. However, at the time in which every year world produces a large number of vehicles, where there is still no real alternative, a minimum improvement of any segment of today`s engines will certainly be felt on a global level.

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