EXPLORING THE INTERNAL COMBUSTION ENGINE: A BRIEF OVERVIEW OF ITS HISTORY, APPLICATION, EVOLUTION, AND ENVIRONMENTAL IMPACT

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Abstract. *The internal combustion engine alongside electric engines represent backbone of the modern manufacturing, mining and transport industry. This article looks into the history, application, and the technological advancements that the internal combustion engine went throughout the years. From simple prototypes to highly sophisticated models, satisfying the needs of a variety of applications and needs of different industries. This article points up the versatility of internal combustion engines (ICEs) by examining their many uses and types, It also looks closely at the important impacts that the ICEs have on human civilization and the environment. From its first appearance, ICEs have produced unimaginable levels of economic growth and mobility, but at the cost of semnificative negative impacts on the environment, emanating yearly immense amounts of greenhouse gasses. Understanding the relationship that exist between ICEs and the environment is crucial to our society, a society that tries to encompass, and reach an adequate level sustainability by attentively examining their effects on the environment and looking into alternatives to existing technologies. This article attempts to provide a broad overview of ICE, from their history to their environmental involvement, to aid in discussions and to make thoughtful decision about the future of internal combustion engines.*

Keywords: *internal combustion engines, industry, environmental impact*

Introduction

Internal combustion engines (ICEs) power over 1.4 billion vehicles across the world, marking their critical role in the modern manufacturing, mining, and transport industry. These engines boast the ability to use a variety of fuels, including gasoline, diesel, natural gas, and more, showcasing the versatility that supports their widespread application across different industries. The adaptability of ICEs, demonstrated through their compatibility with hybrid and plug-in electric systems, underlines their centrality in fostering economic growth and enhancing mobility while managing environmental impacts [1].

The expansive use of internal combustion engines, from spark ignition gasoline engines to compression ignition diesel engines, is instrumental in their dominance within the ground, aeronautical and marine transportation sector. Their operation, based on a two stroke and four-stroke cycle, is a testament to the engine's efficiency and esteem as a prime mover in the industry. As this article delves into the history, application, and technological advancements of ICEs, it will also examine the significant effects of these engines on human civilization and the environment, highlighting the ongoing challenge of achieving sustainable practices within the industry [2].

History and Development

The first appearance of the internal combustion engine (ICE) can be traced back to ancient China, between the 10th and 13th centuries, with the invention of the first rocket engines, marking a primitive form of combustion technology.

The evolution of the ICE began to take shape in the 18th century with several inventors attempting to develop more efficient engines. Notably, John Barber received a patent in 1791 for a gas turbine, and Thomas Mead patented a gas engine in 1794 [3].

The early 19th century saw further significant developments:

1. François Isaac de Rivaz built a car-like vehicle powered by an internal combustion engine in 1813, which is considered one of the earliest attempts to apply ICEs to road vehicles.
2. The first internal combustion engine applied industrially in the United States was patented by Samuel Brown in 1823.

The practical application and widespread adoption of ICEs were propelled by several key inventions in the 19th century:

1. Étienne Lenoir invented the first practical internal combustion engine in 1860, a two-stroke engine that, despite its low efficiency of 4%, represented a significant technological advance.
2. The four-stroke internal combustion engine, which significantly improved efficiency and practicality, was invented by German engineer Nikolaus Otto in 1876, known as the 'Otto cycle engine'.

Basic Principles of Operation

The basic operation of internal combustion engines (ICEs) involves a series of repetitive cycles and phases that convert the energy from fuel into mechanical power. This section outlines the fundamental principles of operation for both gasoline and diesel engines, which are the most common types of ICEs.

Two-Stroke Engines

Unlike four-stroke engines, two-stroke engines complete the same four events (intake, compression, power, and exhaust) in just two strokes of the piston, resulting in one crankshaft revolution per cycle. This allows for a simpler design and potentially greater power output relative to engine size, but often at the cost of increased emissions [5].

Four-Stroke Engines

1. Intake Stroke: The cycle begins with the intake stroke, where the piston moves down, creating space for the air-fuel mixture to enter the combustion chamber through the open intake valve.
2. Compression Stroke: As the intake valve closes, the piston moves upwards, compressing the air-fuel mixture, which increases the potential energy of the mixture.
3. Power Stroke: The compressed air-fuel mixture is ignited by a spark from the spark plug (in gasoline engines) or by the heat of compression (in diesel engines), causing a rapid combustion. The force of this combustion drives the piston downward, which in turn rotates the crankshaft, producing mechanical power.
4. Exhaust Stroke: Finally, the exhaust valve opens, and the piston moves upwards again, expelling the spent combustion gases from the cylinder, completing the cycle

Environmental Impact and Emissions

Greenhouse Gas Emissions:

- Internal combustion engines (ICEs) are significant contributors to environmental pollution, emitting a variety of greenhouse gases (GHGs) such as Carbon dioxide (CO_2), Methane (CH_4), and Nitrous oxide (N_2O).

- These emissions have a profound impact on the environment, disrupting natural cycles and contributing to global warming and climate change.
- Diesel engines, in particular, are known for their emission of particulate matter (PM), which poses serious health risks to humans and can cause environmental damage, especially diesel engines used in maritime applications.
- ICEs also release hazardous gases including Carbon monoxide (CO) and Nitrogen oxides (NOx), which contribute to air quality degradation and pose health risks, particularly affecting the respiratory and cardiovascular systems of vulnerable populations such as children, the elderly, and those with pre-existing health conditions [6].

Technological Innovations to Reduce Emissions:

Advancements in engine technology such as turbocharging, direct injection, and variable valve timing have contributed to increased efficiency, reducing fuel consumption and lowering emissions.

Hybridization and electrification strategies combine the benefits of ICEs with those of electric motors and batteries, leading to the creation of vehicles that are less reliant on fossil fuels and produce fewer emissions. These factors highlight the environmental challenges posed by internal combustion engines and underscore the importance of continued innovation and the adoption of cleaner technologies to mitigate these impacts [8].

The Future of Internal Combustion Engines

Despite the rising popularity of electric vehicles (EVs), internal combustion engines (ICEs) are projected to remain a significant portion of vehicles on the road. This enduring presence is attributed to several factors including the versatility of ICEs in adapting to various fuels such as hydrogen, gasoline, diesel fuel, ethanol, and biodiesel, and their suitability for a wide range of driving conditions. The internal combustion engine market itself is forecasted to reach a staggering $90,000 billion by 2029, driven by exponential growth in sectors like agriculture, construction, mining, and power generation. The global lack of EV infrastructure is partly responsible for the sustained growth of the ICE market. This scenario underscores the need for the aftermarket to adapt by developing new products and services that cater to both EVs and ICE vehicles. By investing in research and development, the aftermarket can significantly influence the future trajectory of ICE vehicles [11].

Conclusion

While the future of ICE vehicles carries a degree of uncertainty, the potential for adaptation and growth remains robust. The aftermarket sector plays a pivotal role in shaping this future, suggesting a landscape where ICEs continue to evolve alongside emerging automotive technologies.

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