

# Comparative Analysis of Traditional and Hybrid Engines: Efficiency and Emissions

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**Abstract.** As two dominant types of automotive engines, traditional internal combustion engines and hybrid engines hold significant market shares. This paper focuses on comparing the efficiency and emissions of these two engine types. The traditional engine, characterized by its crankshaft linkage structure, presents both its best feature and its biggest drawback. This structure leads to substantial efficiency losses and increased combustion time, resulting in lower overall efficiency and higher environmental pollution compared to hybrid engines. On the other hand, hybrid engines boast a more intelligent system, offering three distinct modes that can be selected based on the required power. This flexibility enables hybrid engines to conserve energy more effectively, thereby achieving higher efficiency. Regarding emissions, hybrid engines can switch between electric power and internal combustion depending on the situation, resulting in healthier emissions profiles. This paper aims to elucidate the operational differences and environmental impacts of traditional and hybrid engines, encouraging readers to form their own opinions on potential improvements for these technologies.

**Keywords:** Engine, hybrid engine, efficiency, emission.

## 1. Introduction

As two mainstream engines, traditional engines and hybrid engines versus a lot, this paper is in order to compare the efficiency and emission of them. People would choose different engines depending on their background, in terms of the background of the hybrid engine. Hybrid technology, especially gasoline-electric hybrid technology, was originally developed by Toyota. In the face of the oil crisis and the increasingly serious problem of environmental pollution, Toyota did not choose to develop pure electric vehicles directly but adopted a more practical direction of "gasoline-electric motor hybrid". For the efficiency of a traditional engine, because of its crankshaft linkage mechanism, it gets a big loss of indicated thermal efficiency and mechanical efficiency. For the efficiency of hybrid engines, because of the impact of parking idling and the impact of working efficiency, it saves much efficiency. The emission of traditional engines, it makes a big pollution because of the long combustion duration. Because of its crankshaft connection rod mechanism, it is hard to reduce the pollution of its emission. For the emission of a hybrid engine, it can choose three kinds of modes in different situations. It makes the time of combustion duration less. In that case, a hybrid engine has a greener emission compared with a traditional engine [1]. This paper will conclude them. It would prove that traditional engines are more efficient than hybrid engines because of their crankshaft linkage mechanism. Compared with traditional engines, hybrid engines have greener emissions and a longer driving range than traditional engines. This paper will evaluate all above objectively.

## 2. Efficiency of the Traditional Engine

The biggest problem for the traditional engine is its crankshaft linkage mechanism. Efficiency will divide into two parts. One is indicated thermal efficiency; another is mechanical efficiency. This paper will prove that both of them would be reduced because of their crankshaft linkage mechanism [2].

## 2.1. The Crankshaft Linkage Mechanism Reducing Indicated Thermal Efficiency

In a traditional engine, there would be a piston located between 12 and 15 crankshaft angles of the stop point. From Fig. 1, it can be seen that the maximum force  $F_1$  at the 0 crankshaft angle is greater than the maximum piston force  $F$  at the 13.5 crankshaft angle, for example. Secondly, from Fig. 2, the yellow line is the piston pressure with a long combustion duration, and the blue line is the piston pressure with a short combustion duration. It is known that the combustion duration requires a 50 or 60-crankshaft angle. However, in Fig. 2, it can show that the combustion pressure drops quickly after about 15 crankshaft angles. These two situations would reduce the force that which piston gives. As the force is reduced, the expansion work reduces which means that some fuel has not been fully used. As a result, the crankshaft angle caused a big loss of indicated thermal efficiency [3].

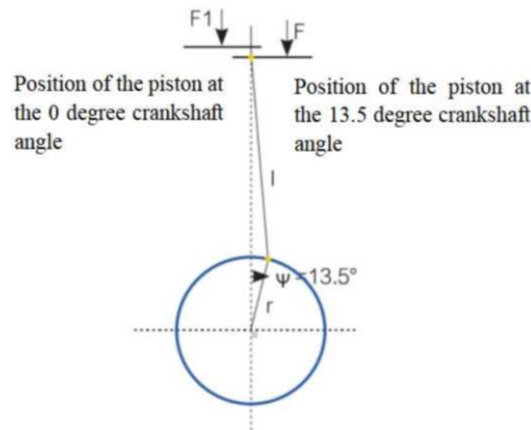


Figure 1. Maximum combustion pressure loss [4]

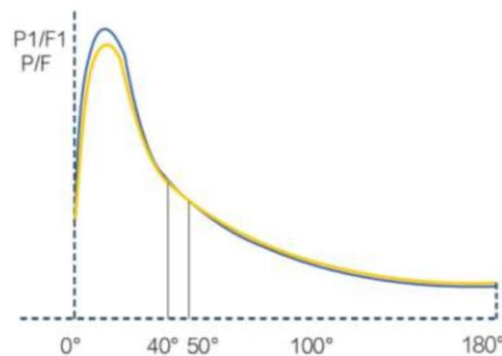


Figure 2. Combustion duration of time loss [4]

## 2.2. The Crankshaft Linkage Mechanism Reduces Mechanical Efficiency

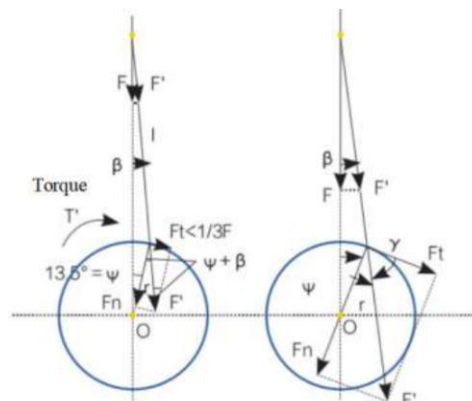


Figure 3. Combustion duration of time loss [4]

As Fig. 3 shows, the force divided into two parts: one is tangential force  $F_t$ , another is radio force  $F_n$ .  $F_t = f \times \sin(\Psi + \beta)$ , then the tangential force  $F_t$  gets down. The known moment = tangential  $\times$  arm

radius. The arm radius is the same, but the tangential force gets down. In that case, the moment it gets down, the power also decreases, and the mechanical efficiency decreases. So, the mechanical efficiency decreases. Actually, the radial force also makes a loss of mechanical efficiency. The radial force acts on the crankshaft through the compression of the crank, it produces small deformation and its high-frequency fibrillation to produce useless deformation energy, and finally causes the loss of mechanical conversion. So, the crankshaft linkage mechanism reduces mechanical efficiency [4].

In Fig. 4, the crankshaft tangential force  $F_t$  forms a yellow line, and the freight forwarder force forms a blue line. The difference between the two areas is the mechanical conversion loss. The mechanical conversion loss is much greater than the friction loss, which is 75% of the effective thermal efficiency.

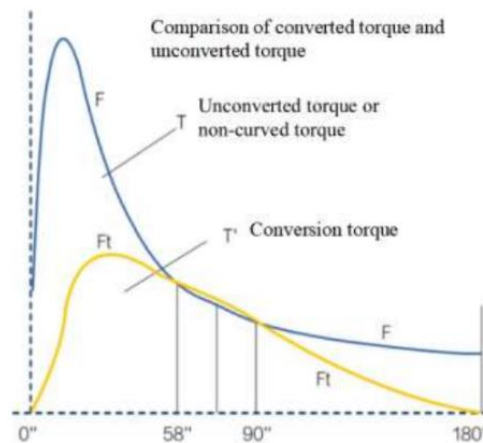


Figure 4. Mechanical conversion loss [4]

### 3. Efficiency of Hybrid Engine

For the efficiency of the hybrid engine, this paper will focus on the impact of parking idling and the impact of working efficiency.

#### 3.1. Impact of Parking Idling

First of all, Idle is the state of an internal combustion engine at no load where the engine is running at a minimum steady speed. In this state, the gas pedal is not depressed and the engine maintains only basic operation to drive the vehicle's accessory systems, such as the cooling system and power supply system. The idle speed is usually low to ensure smooth engine operation and normal operation of various accessories for the impact of parking idling. When a hybrid engine gets in the situation of parking idling, it would give a perfect solution. When it is parked, the hybrid engine can continue to work in economic mode, converting energy into storage rather than outputting it. Hybrid engines can store energy while the car is idle. Because it saves the idles time, hybrid engines become more efficient [5].

#### 3.2. Impact of Working Efficiency

There are two power sources in a hybrid engine. They are the engine and motor. Hybrid engines can change their mode in different situations. It always selects smaller power engines through a control strategy in order to make most of the working points fall in the efficiency range of the engine. At low speed and load, it would choose pure electric mode. When it is at high speed and load, the engine would be in an efficient working area. This kind of change controls the engine work in the efficient spare time, which can improve the economic by 5% to 10% [6].

## 4. The Emission Comparison of Traditional and Hybrid Engine

It is known that one of the main reasons for hybrid engines is for greener emissions. However, hybrid engines always rely on combustion engines, it just can reduce the pollution of emissions compared with traditional engines. This paper will talk about it in detail [7].

### 4.1. The Emission of Traditional Emission

For the emission of traditional engines, it causes much pollution. The main reason for this is the long combustion duration and the uneven mixing of gases. It has a bad emission because of the deflagration or rough binding restriction. It is an inherent defect of the crankshaft connection rod mechanism. So, it is hard to promote the emission of traditional engines [8].

Due to the nature of China's crude oil and the fact that crude oil metallurgy is mainly based on catalytically cracked gasoline, the olefin content of China's gasoline is relatively high, generally in the range of 30% to 50%, while that of the United States and Japan is generally in the range of 13% to 20%. The sulfur content of gasoline is low. Daqing, China's main oil production base, has low-sulfur crude oil, which is refined to produce oil with low sulfur content. The nature of domestic crude oil and the refining facilities and technologies used in the refining of Chinese products have resulted in Chinese gasoline containing lower aromatic and benzene values than foreign gasoline. The main excretions from traditional engines include NO<sub>x</sub>, HC and CO. Fig. 5 shows a comparison of the major exhaust emissions of gasoline and diesel engines at the same displacement.

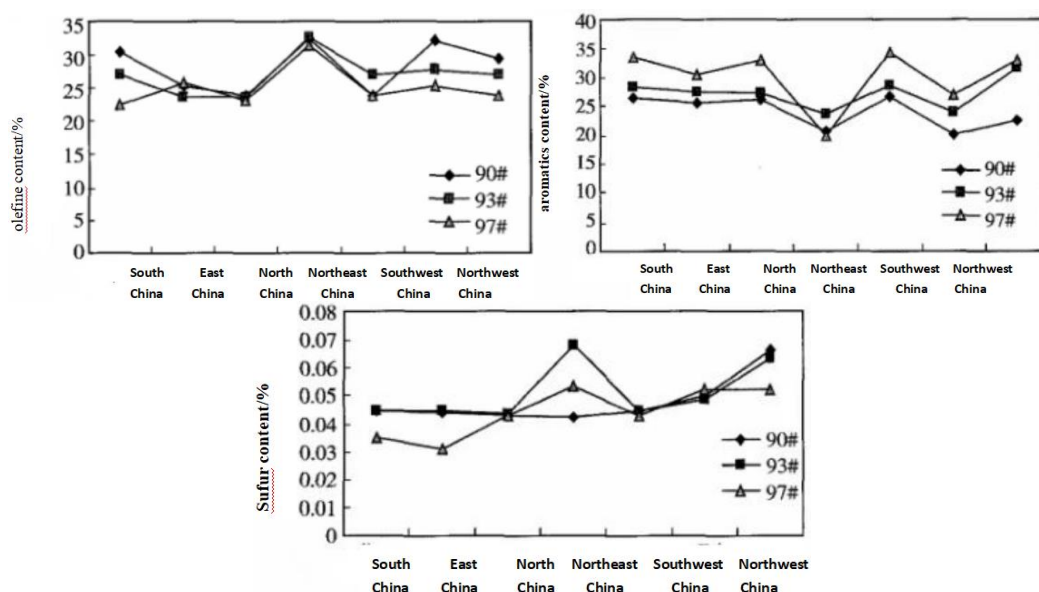


Figure 5. The emission content [9]

### 4.2. The Emission of Hybrid Engine

For a hybrid engine, you know that it has two power engines. It can change three different kinds of mode. It can always be working in the area with the best comprehensive performance which is the area with the lowest fuel consumption and the least pollution, so that it can achieve energy saving and reduction.

Table 1 lists the data of the five solutions and the comparison of the results using the rule-based control strategy" results. As shown in Table 1, the fuel consumption and fuel consumption of the single-objective optimization under NEDC conditions using the dynamic programming algorithm are compared. As shown in Table 1, the optimal solutions of fuel consumption and HC and NO CO emissions obtained by single-objective optimization under NEDC conditions using a dynamic programming algorithm are lower than the rule-based control. The optimal solutions for HC and NO CO emissions are 7.29% and 14.43% lower than the rule-based control, respectively. 7.29%, 14.43%, 9.78% and 48.53%, respectively, while the optimal solutions of fuel consumption and HC and NO

CO emissions obtained by single-objective optimization under NEDC conditions using dynamic programming are lower than the rule control. The results of multi-objective optimization with a set of weighting coefficients ( $W = 0.7$ ,  $W = W$ ,  $=W = 0.1$ ) are very similar to those of the rule control. As a result, compared with the rule-based control, except for the 12.79% increase in NO emissions increased by 12.79%, the fuel consumption and HC and CO emissions were reduced by 6.19%, 13.12% and 41.36%, respectively. 41.36%, respectively. The obtained Pareto solution set provides a good basis for matching the vehicle driving and developing the vehicle control strategy. The obtained Pareto solution set provides a reference for matching the vehicle driving and formulating the control strategy of the whole vehicle. In the formulation of a real-time control strategy, different weighting coefficients can be selected according to different requirements to obtain specific solutions in the optimal solution set. The optimal solution set can be used to obtain a specific solution [10].

**Table 1.** Fuel consumption and emissions with different weights [10]

| Weighting factor | 100/km fuel consumption | HC/g | NOx/g | CO/g   |
|------------------|-------------------------|------|-------|--------|
| 1,0,0,0          | 5.21                    | 5.99 | 37.12 | 62.25  |
| 0,1,0,0          | 5.73                    | 5.87 | 39.52 | 57.96  |
| 0,7,0.1,0.1,0.1  | 5.272                   | 5.96 | 37.22 | 50.37  |
| 0,0,1,0          | 5.91                    | 6.45 | 29.77 | 136.88 |
| 0,0,0,1          | 5.65                    | 5.89 | 37.84 | 44.21  |
| rules            | 5.62                    | 6.86 | 33    | 85.9   |

## 5. Conclusion

To summarize, there is a difference between traditional engines and hybrid engines. The traditional engine has a large market share, but its crankshaft linkage mechanism causes a significant loss of efficiency. Its outlook remains one of reliable safety and a solid market. It is more problematic when it comes to emissions. The pollution it causes is difficult to control due to its crank linkage structure and the longer time required to burn the internal combustion engine. The hybrid engine has more advantages compared to the traditional engine. It has two powertrains, an electric drive and an internal combustion engine drive. The hybrid engine has three modes, which are chosen according to the power required. This not only improves efficiency but also reduces the usage time of the internal combustion engine, thus reducing emissions. The hybrid engine is a new type of engine that is mostly better than the traditional engine in terms of performance.

In contrast, hybrid engines are still lacking in safety as they have batteries. To talk about the future of them. Conventional and hybrid engines each have their own advantages and development prospects. While conventional engines continue to progress in terms of energy efficiency, cleanliness, small displacement and dieselization, hybrid engines are showing strong development potential due to market growth, technological advancement and policy support. In the future, the two engine technologies may play their respective advantages in different application scenarios and jointly promote the sustainable development of the automotive industry.

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