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## COMPARATIVE ANALYSIS ON PERFORMANCE EMISSION TEST OF SINGLE CYLINDER ENGINE AND MULTI CYLINDER ENGINE

- ©*Shi Yuan Yuan*, Henan Diesel Engine Industry Co., Ltd., Luoyang, China,  
*shiyuanyuan0908@163.com*  
©*Niu XiaoXiao*, Ph.D., Henan Diesel Engine Industry Co., Ltd., Luoyang, China,  
*xiaoxiaoniu1988@126.com*  
©*Zhang XiangChen*, Henan Diesel Engine Industry Co., Ltd., Luoyang, China,  
*2316216030@qq.com*  
©*Wang ZhiLei*, Henan Diesel Engine Industry Co., Ltd., Luoyang, China

## СРАВНИТЕЛЬНЫЙ АНАЛИЗ ВЫБРОСОВ ОДНО- И МНОГОЦИЛИНДРОВОГО ДВИГАТЕЛЯ

- ©*Ши Юаньюань*, Henan Diesel Engine Industry Co., Ltd.,  
г. Лоян, Китай, *shiyuanyuan0908@163.com*  
©*Ню Сяосяо*, Ph.D., Henan Diesel Engine Industry Co., Ltd.,  
г. Лоян, Китай, *xiaoxiaoniu1988@126.com*  
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г. Лоян, Китай, *2316216030@qq.com*  
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*Abstract.* In the research and test of diesel engine, because the performance test of multi cylinder engine with different configuration needs to be replaced, and there is a certain risk in the first test, while the single cylinder engine is more suitable for the research and test of different configurations because of its simple structure and convenient replacement of components. Therefore, by comparing the differences of combustion state between single cylinder engine and multi cylinder engine with the same configuration, the change law of performance characteristics of single cylinder engine and multi cylinder engine under different working conditions is confirmed. By analyzing the difference of emission performance of single cylinder engine with different configuration, the emission performance of multi cylinder engine under different configuration is predicted. The research in this paper has important significance for further research and test of diesel engine.

*Аннотация.* При исследовании и испытании дизельных двигателей проводилось сравнение различий в состоянии сгорания между одно- и многоцилиндровым двигателем с одинаковой конфигурацией в различных рабочих условиях. Анализировалась разница в характеристиках выбросов одноцилиндрового двигателя с разной конфигурацией, что позволило спрогнозировать характеристики выбросов многоцилиндрового двигателя в разной конфигурации. Приведенные данные имеют важное значение для дальнейших исследований и испытаний дизельных двигателей.

*Keywords:* diesel engine, single cylinder engine, multi cylinder engine, performance test.

**Ключевые слова:** дизель, одноцилиндровый двигатель, многоцилиндровый двигатель, испытание производительности.

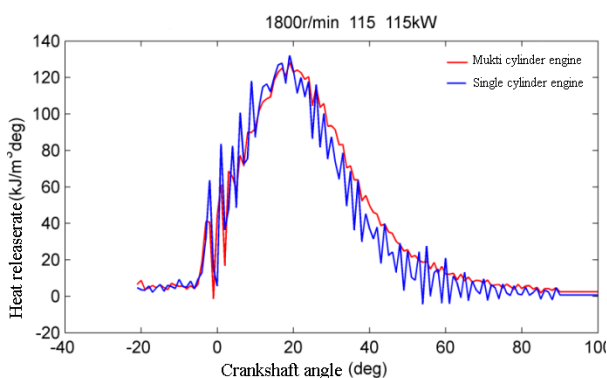
### Introduction of test methods

A common rail diesel engine (1800r / min) produced by China Henan Diesel Engine Industry Co, Ltd. (HND) is selected. The single cylinder diesel engine was tested with 25%, 50%, 75%, 90% and 100% propulsion performance tests and 10%, 25%, 50%, 75% and 100% load characteristic tests, respectively. Through the comparative analysis of the test results (explosion pressure, exhaust temperature, smoke, mechanical efficiency, fuel consumption), the variation rules of single cylinder diesel engine and multi cylinder diesel engine under the same working condition were verified.

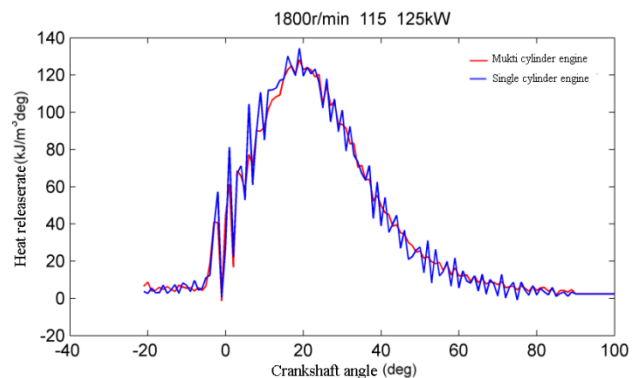
### Calibration of single cylinder engine

Due to the structural differences between single cylinder engine and multi cylinder engine, including the differences of intake and exhaust system, fuel system, oil system and cooling system of single cylinder engine, it is necessary to calibrate single cylinder engine and multi cylinder engine before verification test. By adjusting the single cylinder power, controlling the injection signal and intake pressure, the consistency of combustion state between single cylinder engine and multi cylinder engine is ensured [1–2].

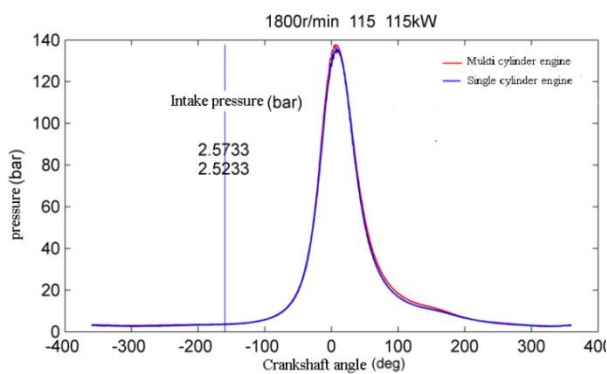
By adjusting the control fuel injection signal to make the combustion start point consistent; by adjusting the intake pressure to make the intake air consistent; by adjusting the single cylinder power to make the indicated work the same. (Note: only 100% working condition comparison chart is reserved).



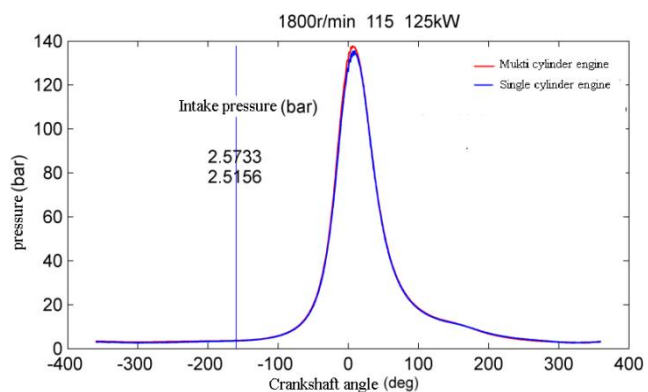
a) Comparison chart of combustion heat release rate.



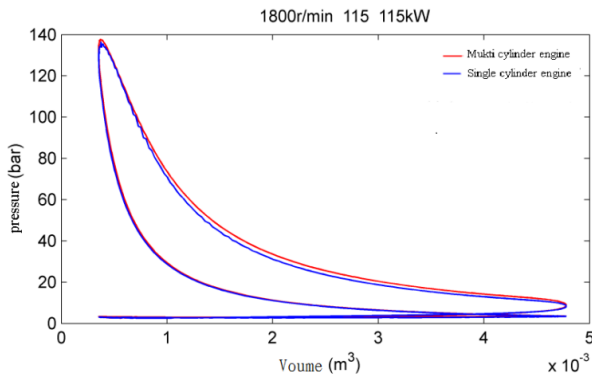
a) Comparison chart of combustion heat release rate.



b) Comparison chart of cylinder pressure curve.

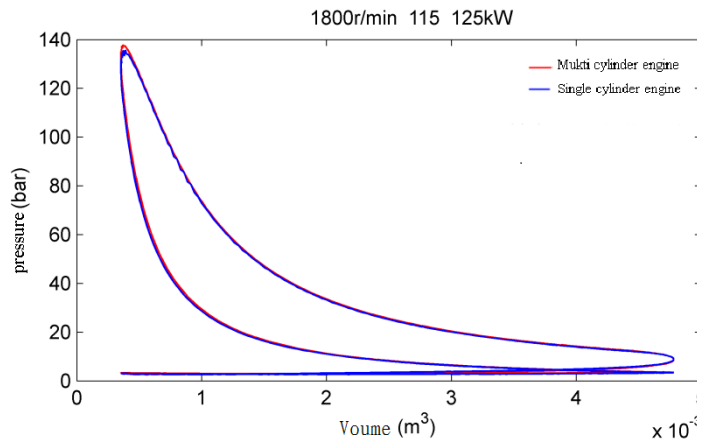


b) Comparison of cylinder pressure curves.



c) Indicator diagram.

Figure 1. 1800rpm/115kW (same output work) combustion in cylinder.



c) Indicator diagram.

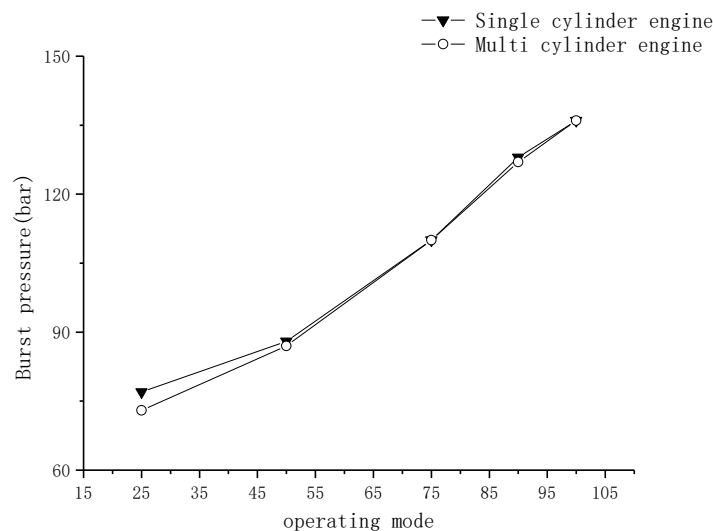
Figure 2. 1800rpm/115kW (same indication work) combustion in cylinder.

By comparing the heat release rate and cylinder pressure curves of multi cylinder engine and single cylinder engine, it is concluded that the combustion state of single cylinder engine and multi cylinder engine is basically the same when the fuel injection state is consistent with the intake and exhaust state. Therefore, the single cylinder engine test can be used as the basis for piston verification.

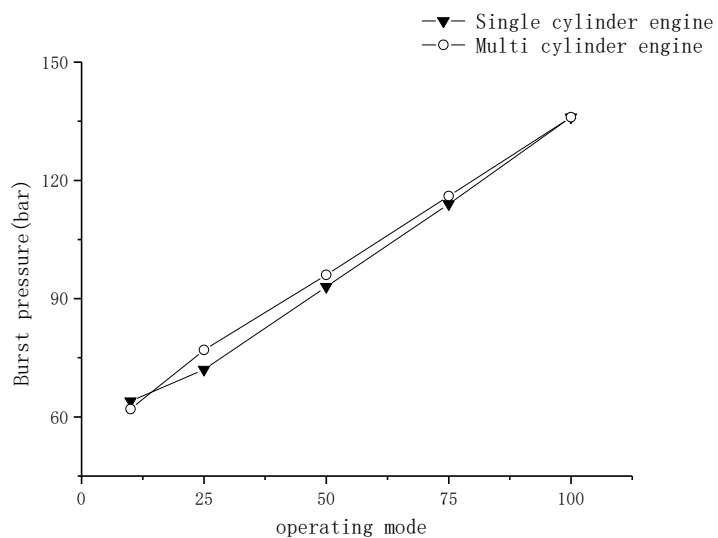
#### Comparison of test data

Through the test of a single cylinder engine and a multi cylinder engine, the comparison curves of explosion pressure, exhaust temperature, smoke, mechanical efficiency and fuel consumption are obtained (see the figure below for details).

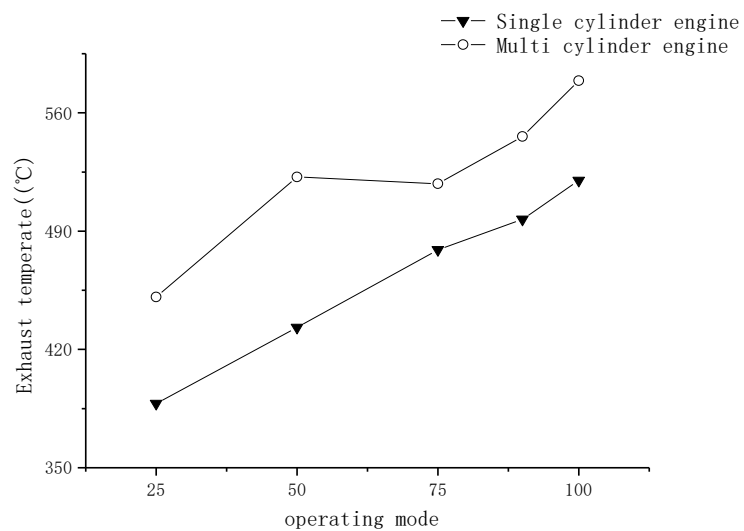
(a) Explosion pressure of propulsion line



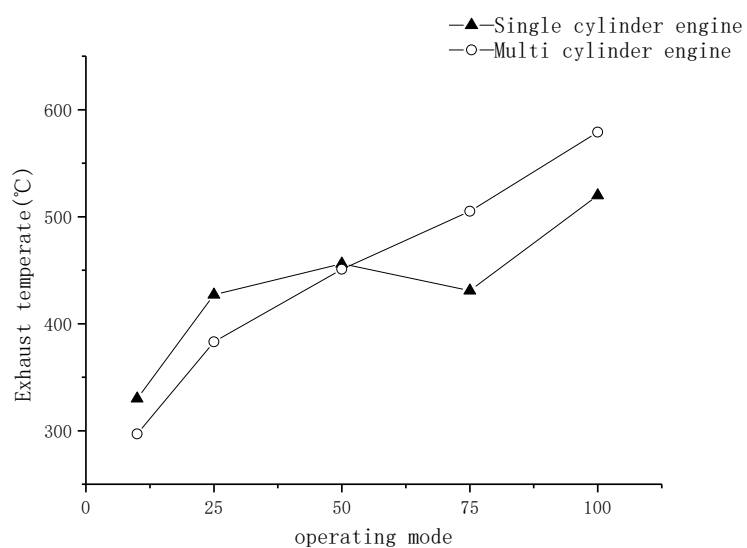
(b) Explosion pressure of load line



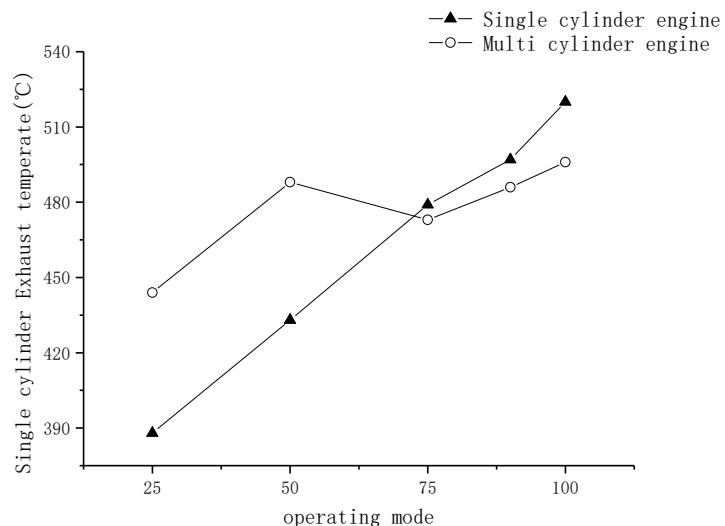
(c) Exhaust temperature of propulsion line



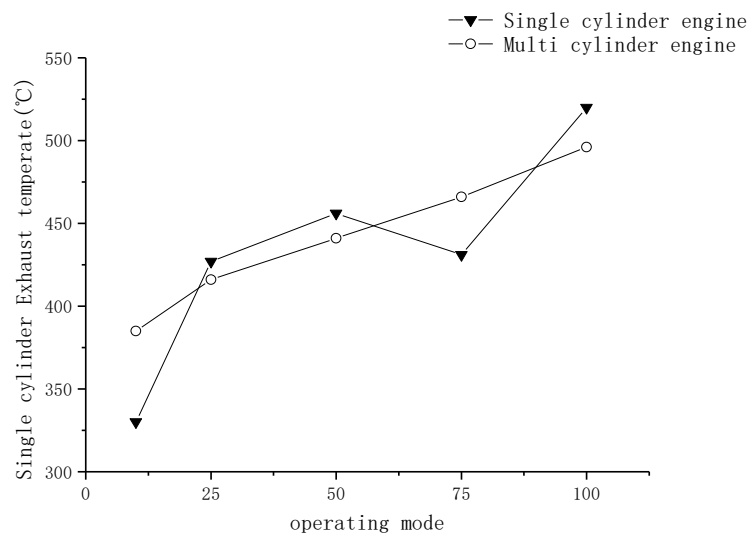
(d) Exhaust temperature of load line



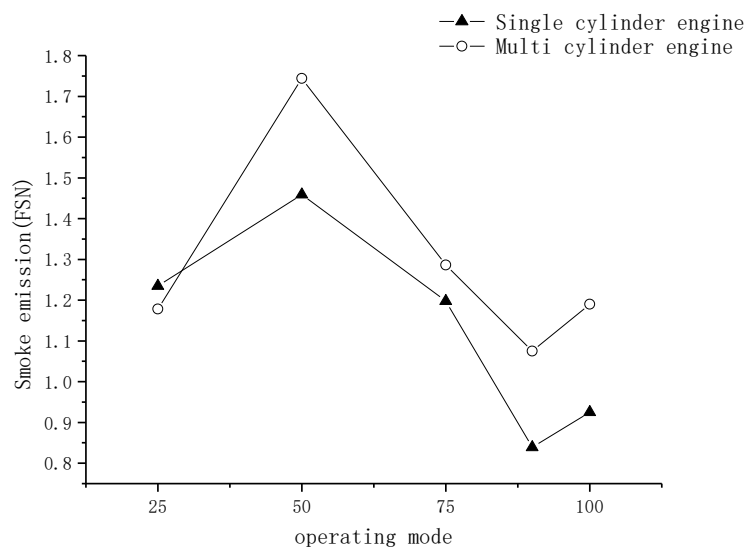
(e) Single cylinder exhaust temperature of propulsion line



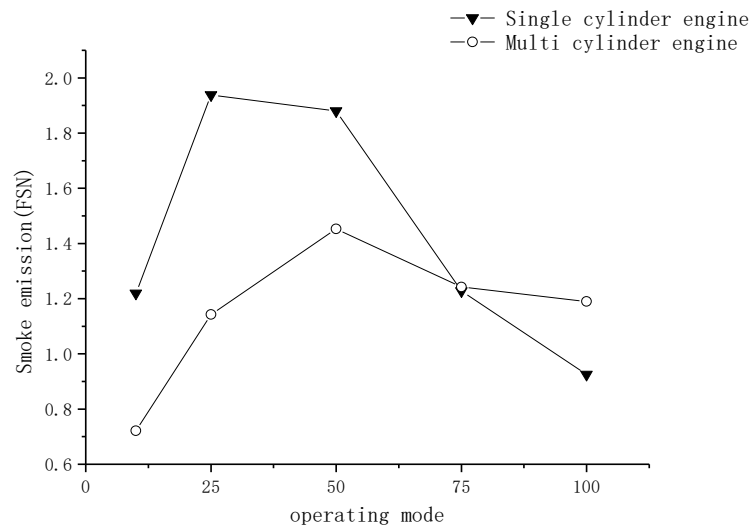
(f) Single cylinder exhaust temperature of load line



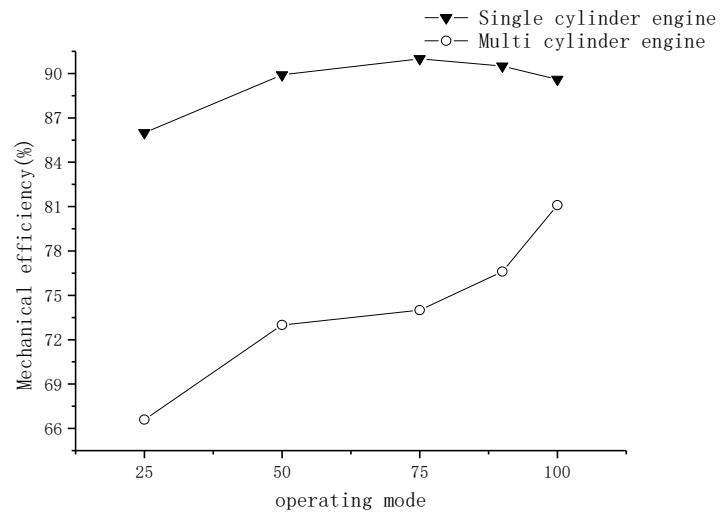
(g) Smoke intensity of propulsion line



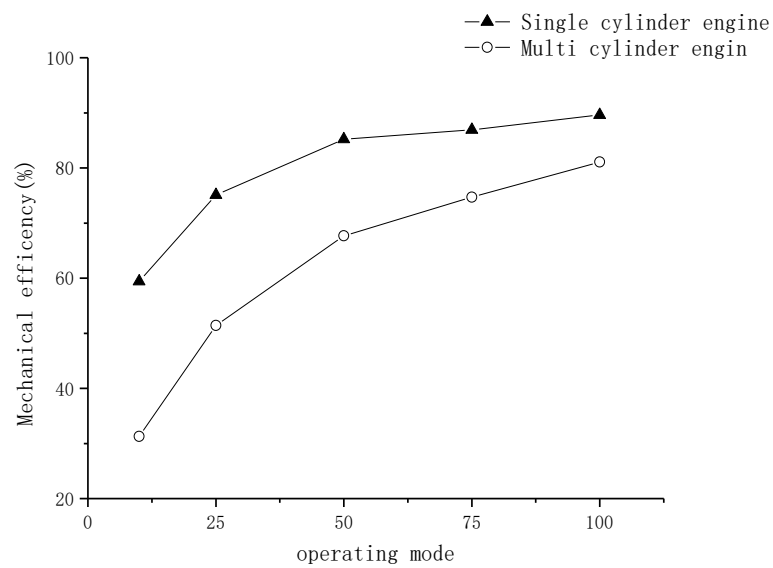
(h) Smoke intensity of load line



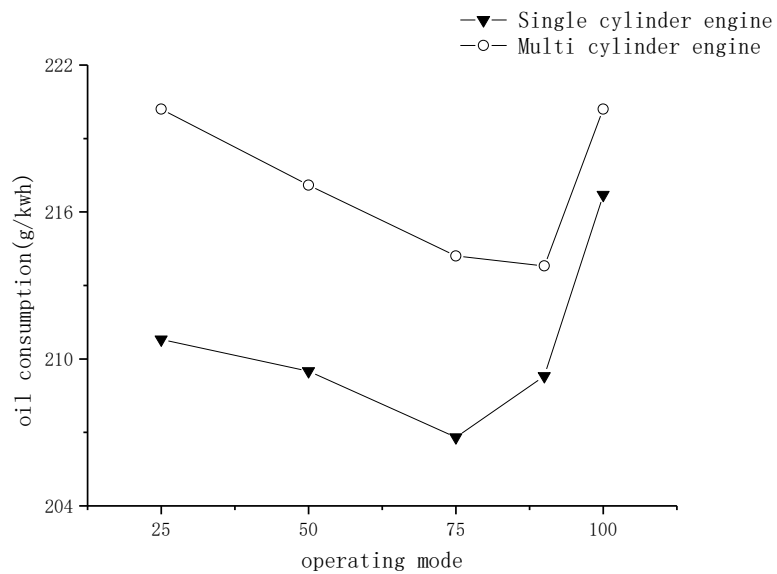
(i) Mechanical efficiency of propulsion line



(j) Mechanical efficiency of load line



(k) Fuel consumption of propulsion line



(l) Fuel consumption of load line

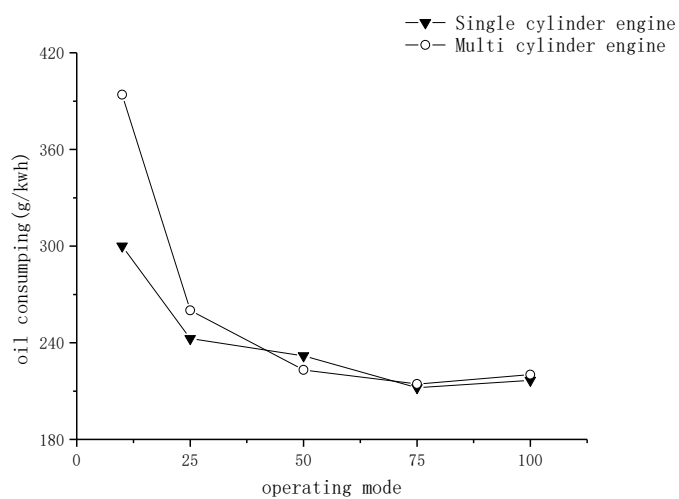


Table 1.  
 COMPARISON TABLE OF SINGLE CYLINDER ENGINE/MULTI CYLINDER ENGINE TEST DATA  
 (PROPULSION CHARACTERISTICS)

<i>Working condition</i>	<i>Model</i>	<i>Single cylinder power</i>	<i>Oil consumption</i>	<i>Explosion pressure</i>	<i>Smoke intensity</i>	<i>Mechanical efficiency</i>
25%	Single cylinder	37	210.8	77	1.235	86
	Multi cylinder	29	220.2	73	1.178	66.6
50%	Single cylinder	63	209.5	88	1.459	89.9
	Multi cylinder	58	217.1	87	1.744	73
75%	Single cylinder	102	206.8	110	1.198	91
	Multi cylinder	86	214.2	110	1.286	74
90%	Single cylinder	118	209.3	128	0.839	90.5
	Multi cylinder	104	213.8	127	1.075	76.6
100%	Single cylinder	125	216.7	136	0.925	89.6
	Multi cylinder	115	220.2	136	1.19	81.1

Table 2.  
 COMPARISON OF SINGLE CYLINDER ENGINE/MULTI CYLINDER ENGINE TEST DATA  
 (LOAD CHARACTERISTICS)

<i>Working condition</i>	<i>Model</i>	<i>Single cylinder power</i>	<i>Oil consumption</i>	<i>Explosion pressure</i>	<i>Smoke intensity</i>	<i>Mechanical efficiency</i>
100%	Single cylinder	125	216.7	136	0.925	89.6
	Multi cylinder	115	220.2	136	1.19	81.1
75%	Single cylinder	98	212.1	114	1.228	86.9
	Multi cylinder	86	214.4	116	1.242	74.7
50%	Single cylinder	72	231.9	93	1.88	85.2
	Multi cylinder	58	223.1	96	1.453	67.7
25%	Single cylinder	40	242.5	72	1.938	75.1
	Multi cylinder	29	260.1	77	1.143	51.4
10%	Single cylinder	22	300	64	1.219	59.4
	Multi cylinder	12	394	62	0.721	31.3

Through the analysis and comparison of the above test results, the following conclusions are obtained:

(1) When the intake state and combustion state are the same, the burst pressure of single cylinder engine and diesel engine is basically the same.

(2) The fuel consumption rate of multi cylinder engine is about 3–7 g/kWh higher than that of single cylinder engine.

(3) The temperature difference between multi cylinder engine and single cylinder engine is about  $\pm 20$  °C.

(4) The smoke values of multi cylinder engine and single cylinder engine are different.

(5) Due to the different piston types of single cylinder engine and multi cylinder engine, there is a certain difference in smoke and fuel consumption rate, but the performance and burst pressure of single cylinder engine can basically reflect the performance changes of the whole engine.



### Conclusions

1. After completing the single cylinder emission test, it can be concluded that the performance of the single cylinder engine can basically reflect the performance of the whole machine, and no other emission performance tests can be carried out in the future.

2. The combustion state of the single cylinder engine is basically consistent with that of the whole engine, and the single cylinder engine test can be used as the basis for piston verification.

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