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Combination of Lithium Iron Phosphate Battery and Super-Capacitor to Improve the Efficiency of Engine

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Abstract— **Lithium iron phosphate is the recent high-profile of the lithium battery cathode material, as opposed to conventional lithium-cobalt batteries, the lithium-iron battery characteristics are long life, high safety, good heat level, and can withstand 3 ~ 5C, and even higher charge-discharge rate, while the use of lithium iron battery raw materials are not rare, you can significantly reduce costs. Super-capacitors have a stable voltage, stable and full-vehicle power systems, protection of vehicle electronics and extended battery life features. It need not destroy the car line. Do not change the original design, easy to install, direct bridging car battery so that the original battery into a high-power batteries, to enhance an instant high-power output, improving vehicle ignition effect, increase engine combustion efficiency and increased power. Reduce fuel consumption.**

Combination of lithium iron phosphate battery and super-capacitors as an energy saving device. Hope to use this energy-saving device to reduce engine fuel consumption, improve engine exhaust and reducing air pollution. Researchers found that if no energy-saving equipment installed, the engine exhaust components are still up to 2 vol.ppm hydrocarbons (such as benzene), 0.07 vol.% CO exist, but, if installation of energy-saving equipment, engine exhaust components in the composition of hydrocarbons and CO have been very few ingredients and no benzene was detected. Energy-saving device can increase the fuel efficiency of car engines. In the seven-seater 2500cc car were installed an energy-saving device. The increased fuel efficiency about 20% to 12%, when the installation of energy efficient device and speed is at 50km/hr to 90km/hr range.

Keywords- lithium iron phosphate batteries; super capacitors; fuel efficiency

I. INTRODUCTION

Engine according to different operation modes can be divided into spark ignition (SI) engines and compression ignition (CI) engines, gasoline engine is a spark ignition engines, diesel engine is a compression ignition engines. Gasoline engine ignition must be through an ignition system. Gasoline engine ignition need spark plug ignition sparks. The distance between the two electrodes of spark plug need to be maintained at 0.7 to 0.9mm, and it is connected to high voltage wires. High voltage between two electrodes of spark plug produce electric arc, and ignite the fuel vapor in the engine.

Automotive lead-acid battery is an auxiliary power unit. But the lead-acid battery charging and discharging speed is very slow, can not keep up with the speed of ignition, and can not provide sufficient supporting power. Because lead-acid battery without a protection circuit, so there will cause the over recharge to lead-acid battery, when the battery short circuit caused by motor vehicle collision or the generator breaks down and produces high voltage, and there is the possibility of battery explosion.

Lithium iron phosphate is very popular in recent attention lithium battery cathode material, Compared with traditional lithium-cobalt battery, lithium iron phosphate battery characteristics are long life, high safety, good heat resistance and can withstand 3~5C, or even higher rate of charge and discharge, meanwhile, the raw materials of lithium iron phosphate batteries do not use precious metals, can significantly reduce costs.

Super-capacitor can stabilize the voltage of the entire vehicle electrical system. It protects the car's electronic components and extended battery life. It need not destroy the car line, and It need not change the original design, easy to install, direct bridging car battery. It enables the original battery into a high-power battery. It enables instant battery

power output, improve the vehicle ignition effect, improve engine combustion efficiency and increase power, and reduce fuel consumption.

We study is to combine the lithium iron phosphate batteries and super capacitors as an auxiliary power system. Hope to stabilize the voltage through the ultra-capacitor and can instantly power output, and high-speed lithium iron phosphate batteries to charge and discharge, and can improve the performance of the original lead-acid batteries. Combination of lithium iron phosphate batteries to adjust to the discharge voltage higher than 13.6V, hoping to improve the effect of the vehicle ignition to increase engine combustion efficiency, to reduce fuel consumption.

II. THEORY

Lead-acid battery is the most automobile as part of power system. Lead-acid battery is a sccessful commodity since the mid-twentieth century, it is already very mature product technology, now widely used in many fields, such as transport, power systems, energy storage equipment and uninterruptible power systems. The performance of lead-acid batteries is best, when it is full charged, lead-acid battery performance is better in the warm days than its' performance in the cold days [1].

Lithium iron phosphate cathode material using lithium iron phosphate. Lithium iron phosphate is a special kind of material, there is a stable structure, which makes it safer than other lithium ion battery cathode materials, such as lithium cobalt oxide and lithium manganese oxide. It is not toxic, and even cheaper. Because it contains iron and phosphate, so that the battery can be made with high-capacity C, the theoretical value of about 170mAhr/g. Lithium iron phosphate is not flammable, it can allow the charging of excessive or short circuit, they can work in high temperatures without decomposition, After a long work in such conditions, they will not burn [2] [3]. Lithium iron phosphate can be safe and fast recharged. Some cell types can be recharged in 15 minutes up to 90% [4] [5].

Kim and others, to intensify the synthesis of lithium iron phosphate（LiFePO4/ C）coating on the cathode. By the performance of the new batteries and primary batteries found that the former is less resistance[6][7]. Zhang et al, in order to improve the electrochemical performance of LiFePO4, chemical co-precipitation method is used to the synthesis of doped metal ion and lithium iron phosphate coating on the carbon layer [8]. Zwia et al, for the first time to pressure quenched amorphous prepared lithium iron phosphate (lithium-iron phosphates, LFP) for the lithium-ion battery cathode materials, nano-technology at room temperature, the sample conductivity higher than the 4-10 Times [9]. Lithium iron phosphate battery protection circuit due to, and through the UL certification, even if the over-charge, short circuit within the collision or explosion can not be burning issues [10]. Lithium iron phosphate batteries are required to use the rare metal raw materials, in addition to cheap and abundant nature, their toxicity is lower than cobalt, nickel, manganese [11].

Harada et al, they found that supercapacitors provide the high power system reliability, high efficiency, is a redundant unit, which maintains the output voltage in the power unit start-up time [12]. Wang et al, they found that vehicle performance analysis shows that the super capacitor can make the car better performance, including speed, variable speed, acceleration / deceleration [13,14]. Marcel and others, they believed that the car joined the ultra-capacitor design will greatly increase the power density and performance of the system [15].

Shiraishi and others, they studied the formation of arc discharge plasma, to form a multi-channel discharge, and spark spread into a larger capacity in order to achieve low power consumption [16]. Plasma probe to measure the plasma produced by spark ignition combustion engine, degree of ionization is estimated to be as high as 1:104 [17]. Electromagnetic force to drive the ignition system to produce high current (near 1000A) and accelerated the generation of discharge plasma [18].

We know from the above literature, super capacitor can stabilize the voltage, and can provide high current in instantaneous time. Lithium iron phosphate battery can perform high-speed charge and discharge. Arc discharge plasma in the cylinder can form a multi-channel discharge, and that will improve the combustion efficiency and will reduce fuel consumption.

So it is possible, lithium iron phosphate battery plus ultra capacitor combination to stabilize the voltage, to increase the current output, to high-speed charge and discharge, and to raise the voltage higher than 13.6V, etc., can improve the vehicle's ignition effect, can improve the engine combustion efficiency, and can reduce fuel consumption.

III. EXPERIMENTAL

We want to reach to the combination of lithium iron phosphate batteries and super capacitors as an auxiliary power system. Hope to stabilize voltage by super capacitor features and functions to instantaneous power output, and high-speed lithium iron phosphate batteries to charge and discharge, and can improve the function of the lack of the original lead-acid batteries.

Our research is to combine lithium iron phosphate batteries and super capacitors as the energy-saving devices with a capacity of 20μF, output voltage of 13.6V, and the device is in parallel with lead-acid batteries of a vehicle. Automotive exhaust component analysis can show this device can make change in the efficiency of the combustion cylinder.

When vehicle fuel efficiency is defined as a liter of gasoline can travel miles. Fuel efficiency make the province can show the effect of this device. Analysis of research to be undertaken include: 1. exhaust analysis --- to use instruments with GC/MS, IR and exhaust gas analyzer; 2. automotive fuel analysis --- include modified car fuel metering device, speed adjustment and control devices, in order to understand the car running various operating conditions to understand the fuel consumption. We hope that those analysis data above can be inferred energy-saving effect of this device.

IV. RESULTS AND DISCUSSION

An ignition coil of car ignition system is a transformer. It lets 12V transform into a 20kV or more. A lead-acid battery output voltage is 12V. Tthe Lithium iron phosphate battery of the devices we made, its output voltage is 13.6V and An ignition coil of car ignition system will lets 13.6V transform into a 22.6kV or more. High voltage can produce a strong spark inside the cylinder and a higher fuel burn rate.

We installed energy-saving device, it is a combination of lithium iron phosphate batteries and super capacitors, and installed in a 2500cc, 7 seat car. This combination of lithium iron phosphate batteries and ultra-capacitor device referred to as energy-saving device. When we analysis the concentrations of hydrocarbons, carbon dioxide, and carbon monoxide by an automobile exhaust testing equipment, We found that, as shown in Table 1 and Table 2 below. Table 1 is the automotive exhaust analysis of the car, which do not installed energy-saving device, and Table 2 is the automotive exhaust analysis of the car, which have installed energy-saving device. HC is hydrocarbons.

Table 1 showed that the concentration of hydrocarbons in automotive exhaust waste is 1 to 2 vol.ppm, carbon monoxide concentration was 0.01 to 0.07vol.%, when did no have energy-saving devices and speed was 800 to 2000 rpm. However, Table 2 found that the concentrations of hydrocarbons and carbon monoxide in automotive exhaust waste were below the instrument measurement range, when had energy-saving devices. That is to install energy-saving device can increase the burn rate of gasoline inside the cylinder. We compared the carbon dioxide concentration in Table 1 and Table 2 and plotted in Figure 1, Figure 2 and Figure 3. Figure 1 shows that the concentration of carbon dioxide in automobile exhaust waste, when there is installation of energy-saving devices, is higher than the concentration of carbon dioxide, when there is no installation of energy-saving devices, and the difference between the concentrations of the average carbon dioxide are 0.25 vol.%.

Figure 2 shows the concentration of carbon monoxide decreases with the increase in rpm, when the vehicle without installation of energy-saving devices, but when the car has installed energy-saving devices, carbon monoxide concentration is lower than the lower limit for measurement instruments. Figure 3 shows the concentration of hydrocarbon decreases slowly with the increase in rpm, when the vehicle without installation of energy-saving devices, but when the car has installed energy-saving device, the hydrocarbon concentration is lower than the lower limit for measurement instruments.

TABLE I. THE AUTOMOTIVE EXHAUST ANALYSIS OF THE CAR, WHICH DO NOT INSTALLED ENERGY-SAVING DEVICE

rpm	CO(vol %)	HC(vol ppm)	CO_2(vol %)
800	0.07	2	16.78
800	0.04	2	16.82
800	0.08	2	16.79
1500	0.02	2	16.93
1500	0.03	2	16.94
1500	0.02	2	16.93
1900	0.00	2	16.98
1900	0.00	1	16.96
1900	0.00	1	16.97
2350	0.01	2	16.98
2350	0.00	1	16.95
2350	0.00	1	16.96
2750	0.00	0	16.94
2750	0.00	0	16.92
2750	0.00	0	16.94

TABLE II. THE AUTOMOTIVE EXHAUST ANALYSIS OF THE CAR, WHICH HAVE INSTALLED ENERGY-SAVING DEVICE

rpm	CO(voL %)	HC(voL ppm)	CO_2(voL %)
800	0.00	0	17.08
800	0.00	0	17.12
800	0.00	0	17.16
1500	0.00	0	17.18
1500	0.00	0	17.19
1500	0.00	0	17.18
2000	0.00	0	17.18
2000	0.00	0	17.20
2000	0.00	0	17.19
2600	0.00	0	17.17
2600	0.00	0	17.15
2600	0.00	0	17.19

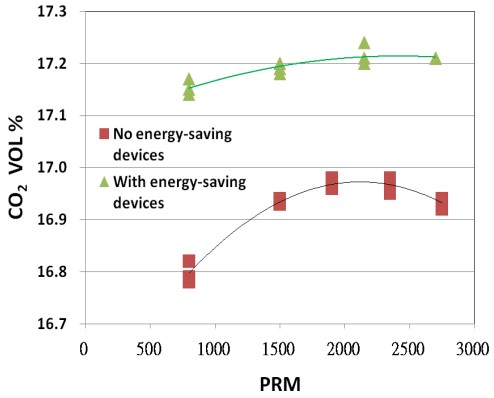

Figure 1: The concentration of carbon dioxide in automobile exhaust waste

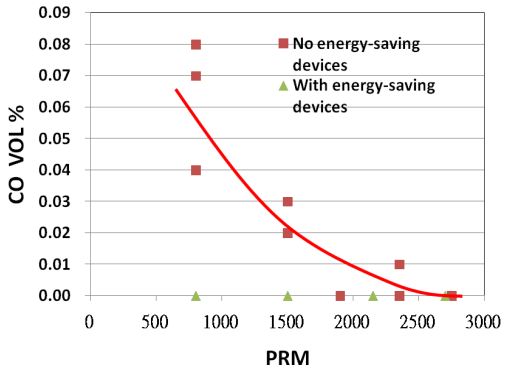

Figure 2: The concentration of carbon monoxide in auto exhaust waste

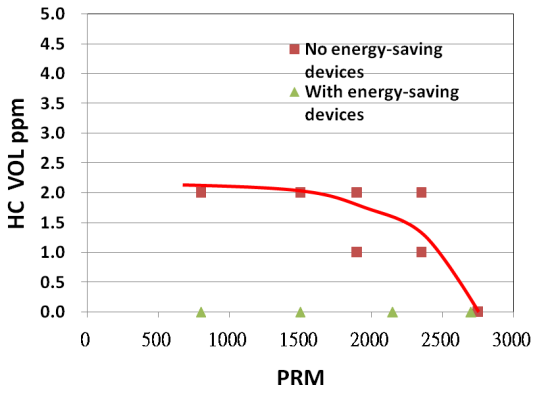

Figure 3: The concentration of hydrocarbons in automotive exhaust waste

Table 3 and Figure 4 are the fuel efficiency data, when the car has installed energy saving devices or no device installed. Table 3 and Figure 4 shows the increase fuel efficiency about 20% to 12%, when the installation of energy efficient device and speed at 50km/hr to 90km/hr range.

TABLE III. THE AUTOMOTIVE GASOLINE FUEL EFFICIENCY

device	Speed (km/hr)	Fuel efficiency (km/l)	Speed (km/h)	Fuel efficiency (km/l)
With energy-saving device	71.5	16.64	79.4	13.19
	68.8	13.32	79.1	12.9
	68.6	12.13	79	12.81
	71.2	12.77	53.6	13.45
	78.9	12.91	55.8	13.66
	78.2	14.03	82.1	13.19
	80.5	12.58	87	12.6
	81.1	13.52	87.6	11.86
	81	13.34	82.8	12.37
	84.9	12.98	55.5	11.75
	84.6	13.12	72.3	13.2
	79.4	12.68	81.9	13.12
No energy-saving device	69.7	11.05	86.3	10.26
	76	11.74	91.1	12.54
	76.1	10.41	90.7	12.25
	80.5	11.3	84.3	12.46
	86.6	10.52	56.2	11.14
	86.3	10.26	68.3	13.55
	91.1	12.54	72.7	10.68
	90.7	12.25	72.3	10.64
	84.3	12.46	79.4	9.96
	69.7	11.05	64.3	10.44
	76	11.74	58.2	10.11
	76.1	10.41	57.5	10.13
	80.5	11.3	55.4	11.34
	86.6	10.52	56.4	10.79

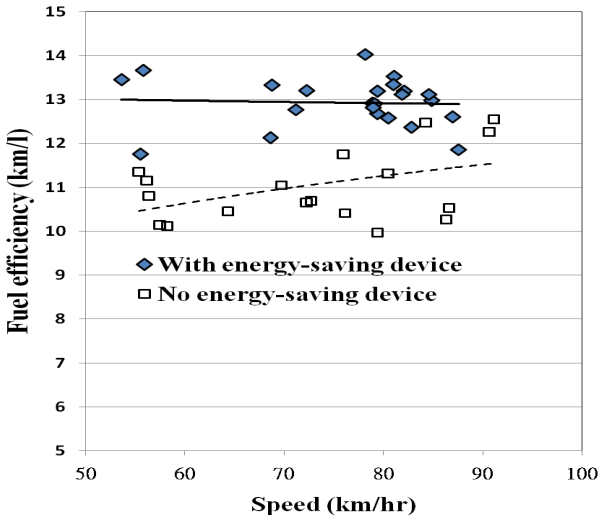

Figure 4: The automotive fuel efficiency

V. CONCLUSION

We found that super capacitor can stabilize the voltage, and can provide high current in instantaneous time. Lithium iron phosphate battery can perform high-speed charge and discharge. Arc discharge plasma in the cylinder can form a multi-channel discharge, and that will improve the combustion efficiency and will reduce fuel consumption.

Our energy-saving device can improve the engine combustion efficiency, and can reduce air pollution. The concentrations of hydrocarbons and carbon monoxide in automotive exhaust waste, when that had energy-saving devices, less than the concentrations of hydrocarbons and carbon monoxide in automotive exhaust waste, when that had not energy-saving devices. The concentration of carbon dioxide in automobile exhaust waste, when there is installation of energy-saving devices, Is higher than the concentration of carbon dioxide, when there is no installation of energy-saving devices, and the difference between the concentrations of the average carbon dioxide are 0.25 vol.%.

Combination of lithium iron phosphate battery and super-capacitors as an energy saving device. Hope to use this energy-saving device to reduce engine fuel consumption, improve engine exhaust and reducing air pollution. Researchers found that if no energy-saving equipment installed, the engine exhaust components are still up to 2 vol.ppm hydrocarbons (such as benzene), 0.07 vol.% CO exist, but, if installation of energy-saving equipment, engine exhaust components in the composition of hydrocarbons and CO have been very few ingredients and no benzene was detected.

Energy-saving device can increase the fuel efficiency of car engines. The increase fuel efficiency about 20% to 12%, when the installation of energy efficient device and speed is at 50km/hr to 90km/hr range.

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