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Research Article

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The research of a new charging control method to reduce the power grid harmonic

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ABSTRACT

The paper comes up a kind of charging control method about Multi-objective search algorithm based on PSO charging control strategy which can reduce the harmonic content and power load of charging at noon to reduce the impact of the actual bus charging station running bringing to the power grid harmonic and power load. The simulation is carried on according to the charging station actual operation from the angle of harmonic suppression and power load balance by constructing the model analysis of charging stations harmonic characteristic. The simulation shows that the charge under this kind of charging control strategy can reduce the harmonic content effectively and cut down the peak load availably.

Keywords: Charging station; power grid harmonic; Charging control method; PSO

INTRODUCTION

With the development of science and technology, petroleum resources, the deterioration of environment, development of environmental protection and energy saving green transport has become an important problem the car industry [1]. Electric vehicles have the double advantages of energy-saving and environmental protection as new energy vehicles. Oil is to alleviate the crisis, beautify the urban environment necessary to choose. Electric cars replace fuel electricity and reduce the urban vehicle exhaust emissions, energy sources. Cooperating with the use of the other new energy like clean energy such as wind, solar, geothermal energy, the effect is good. Therefore, the use of new energy is the important way to solve the problem of energy shortage and environmental problems.

Many scholars at home and abroad are doing the research. The study way roughly divided into two kinds: one kind is on the basis of probability analysis and the mathematical model is established to study through the establishment of charging station simulation mode [2]. The other is a simulation of charging station actual operation condition to study [3~4]. The first kind of research method in the research process add a lot of assumptions such as the research process on the premise of charging time conform to the Gaussian distribution and the actual charging time decided by the charging stations own operation mode which reduce the accuracy of the research. The running status of the second simulates the actual charging stations according to the actual need to add the corresponding influencing factors. It make the research result is of practical as a whole. This paper uses the second method to complete the study of harmonic suppression. A simulation model is built to charge stations harmonic characteristic analysis with matlab simulink. In view that the charging stage is unable to avoid charging the harmonic content of peak and the peak power load problem at noon, the paper put forward a kind of charging control strategy about Multi-objective search algorithm based on PSO charging control strategy. The simulation is carried out to verify its feasibility.

EXPERIMENTAL SECTION

Electric vehicle control problem is a nonlinear, high dimension, multivariable, constraint optimization problem. The general linear optimization algorithm is difficult to solve such problems. This paper uses particle swarm objective (PSO) search algorithm. Particle swarm optimization algorithm (PSO) has simple process, fast convergence rate and is easy to implement. It is not only can effectively solve the single objective optimization problem but also solve multi-objective optimization problems which have the very good effect.

In this algorithm, the speed of the particle of ith of vi and their locations xi expression formula is:

$$v_i = v_{i-1}w + C_1 Rand()(pBest[i] - x_{i-1}) + C_2 rand()(gBest[i] - x_{i-1}) \quad (1)$$

$$x_i = x_{i-1} + v_i \quad (2)$$

In Type, i is the number of iterative update, w as the inertia weight, x_i is the first iteration update particle space position, v_i is the i^{th} particle iteration speed, the Rand ()and the rand () is a constant between interval [0, 1], C1 and C2 respectively is learning factor and constant.

The working principle of the electric car charger is that three-phase power grid transform alternating current to direct current through the rectifier device. Then a high frequency power conversion circuit and filter circuit output charge to battery[5-7]. The general structure diagram is shown in figure 1.

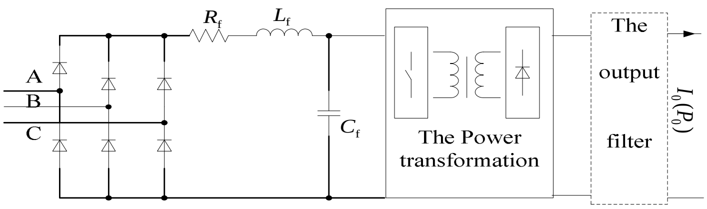

Fig.1 charger structure diagram

Power battery charging time is for up to four and a half hours, while the charger is changing the output voltage and current, but can be thought of in a very small time constant output voltage and current of the charging machine, the output power is constant, so the available a resistor in a short period of time to simulate the input impedance of power conversion circuit. The entire charging process can use a nonlinear resistor to wait instead of power conversion circuit impedance. So it can use a resistor in a short period of time to simulate the input impedance of the power conversion circuit and the charging process of a nonlinear resistor can be used in place of the power conversion circuit impedance.

$$R = \frac{U_I}{I_I} = \frac{U_I^2}{P_I} = \frac{\eta \times U_I^2}{P_O} = \frac{\eta \times U_I^2}{U_O \times I_O} \quad (3)$$

Charger power output curve through data collection and battery charging process, using curve fitting.

$$P_o(t) = \begin{cases} 0.79 P_{o\max} t^{0.048}, 0 < t \le 150 \\ P_{o\max} e^{-0.021 \times (t-150)}, 150 < t \le 270 \end{cases} \quad (4)$$

The bus charging station is basically charging twice for bus during the day. Time: 11:00-13:00. 20:00-1:00. The two hours during the day is a supplementary power stage, and during this time each vehicle access for very short intervals, which prevent the bus station avoid the peak harmonic content and peak power load at noon.

The three-phase controlled rectifier circuit as input charger, AC side current main fundamental consist of 5th, 7th, 11th, et al harmonic. A phase current can be expressed as:

$$i_a(t) = f(P_O) = \sum_{m=1}^{\infty} f_{am}(P_O)\cos m\omega t + f_{bm}(P_O)\sin m\omega t$$
$$= \sum_{m=1}^{\infty} \sqrt{2} f_{\mathrm{Im}}(P_O)\sin(m\omega t + f_{\varphi m}(P_O)) \quad (5)$$

In type：

$$f_{\mathrm{Im}}(P_O) = \sqrt{(f_{am}^2(P_O) + f_{bm}^2(P_O))/2}$$
$$f_{\varphi m}(P_O) = f_{am}(P_O)/f_{bm}(P_O)$$
$$m = 6k \pm 1(k = 0,1,2,\cdots, m > 0)$$

The charging station harmonic superposition rule related with power charger when the charger power is the same. Each harmonic superposition RMS will increase exponentially and when the charger is not the same power output and each harmonic superposition RMS, phase angle are changed, the offset phenomenon occurred.

There is often a certain amount of remaining after the day’s work, remaining charge too much as increasing the charging load day supplement power stage. The reduction of the remaining SOC can be used to reduce the harmonic content and the load.

RESULTS AND DISCUSSION

Bus station simulation model is established including three phase power supply, transmission line, transformer and charging machine. 10 kV power utility grid by 5 Km transmission line due to the actual power grid. The length of the transmission lines can produce certain influence to analysis in this paper. This article uses a PI type circuit to simulate the actual transmission lines. Simulation model select the type distribution transformer adopts Dyn11 connection mode to make 3 times and 3 integer harmonics in the transformer high voltage side of the triangle formed in the winding circulation, prevent charging stations within the part of the higher harmonic injected into power grid.Its equivalent simulation model is shown in figure 2.

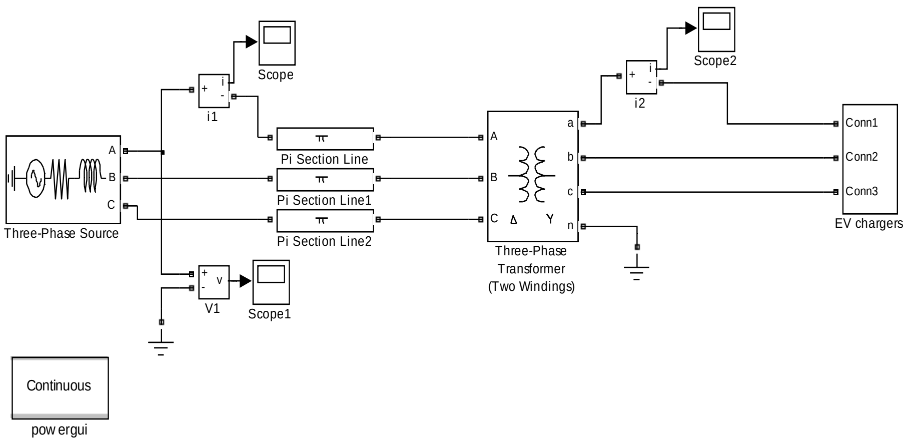

Fig. 2 charging station simulation model

The charger for the simulation parameters is: L=1.5mH, C=2000μF,ŋ=94%.Research on the effects of charging stations for grid generally is divided into two parts: 0.4 kV side harmonic and 10 kV power grid side power grid harmonic. As an example, five to 10 kV power grid side harmonic current according to the model simulation analysis of harmonic current change characteristic. The simulation results as shown in figure 3.

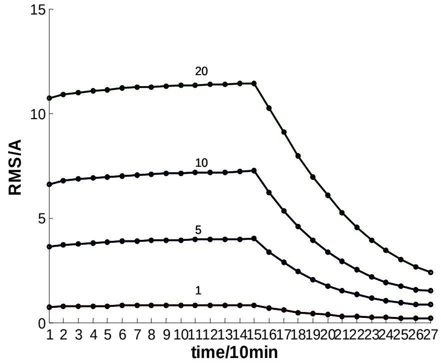

Figure 3 different sets of 5 harmonic change curve

From the figure 3, We can see that the entire charging process harmonic current decreases after increasing first peaked at 150 min and the harmonic maximum points to judge whether the harmonic content standards and determine the harmonic control scheme plays an important role. The harmonic RMS increase gradually with the increase of the number of charger but the harmonic current RMS is not multiply but a certain degree of offset each other.

Assuming the same charger other parameters, only the output power is different. The 9 kw power, 25 kw, 45 kw charger and 60 kw charger which is used respectively with two 60 kw charger do comparison and analysis at the same time. The simulation is used under maximum power charger. Simulation can get harmonic content such as table 1,2.

Table 1 10kv side RMS harmonic current injection

Power charger Ⅰ/Ⅱ	Harmonic frequency and harmonic current RMS（A）	
	5	7
60kw/60kw	1.65	0.83
60kw/45kw	1.48	0.74
60kw/25kw	1.23	0.6
60kw/15kw	1.11	0.53
60kw/9kw	1.04	0.35

Table 1 0.4kv side RMS harmonic current injection

Power charger Ⅰ/Ⅱ	Harmonic frequency and harmonic current RMS（A）					
	5	7	11	13	17	19
60kw/60kw	43.59	22	15.38	11.02	8.16	6.48
60kw/45kw	38.83	19.3	13.68	9.76	7.41	5.88
60kw/25kw	32.46	15.74	11.33	7.95	6.3	4.95
60kw/15kw	29.26	14.06	10.15	7.09	5.73	4.49
60kw/9kw	27.31	13.04	9.36	6.46	5.3	4.1

The table shows that every harmonic current RMS with the increase of charger power is different.

CONCLUSION

This article comes up with a kind of charging control method about Multi-objective search algorithm based on PSO charging control strategy through the charging station built imitation summarized the basic characteristic of the charging station harmonic, and basic features of harmonic analysis. Verification results show that the scheme can effectively reduce the harmonic content and can reduce the load.

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