Research On the Application of Static Var Compensator in Fushun Power Grid

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Abstract

in recent two years, electrical load in Fushun District increases continuously, and the impact and harmonic pollution on the power grid rises continuously, voltage quality problem becomes aggravated. Through multi-disciplinary analysis and demonstration, Fushun Power Supply Company installed SVC/SVG in 220kV load center substation and 66kV terminal substation in 2010 and 2011 respectively to regulate reactive power of the system for the purpose of stabilized voltage and less line loss. This paper introduces actual operation situation of these two sets of SVC/SVG in the substations, and provides helpful reference for similar applications in the future by conducting effectiveness analysis and summarizing experiences and lessons.

Keywords: 66kV directly connected SVC, chain SVG, line loss rate

Introduction

Fushun is always a heavy industry city in Liaoning District with numerous metallurgy and petrochemical enterprises. In recent years, several new economic development zones and residential areas have been built in the suburb of Fushun City and peripheral rural areas. The inrush of a large number of enterprises and residents activates the conflict between electrical load and power supply capability. For example, Fushun Lishizhai 220 kV Substation, although its 220kV bus voltage is in reasonable scope, 66kV bus voltage fluctuates greatly (see Fig.1) and both long-term flicker and short-term flicker are overproof caused by the load at lower-level.

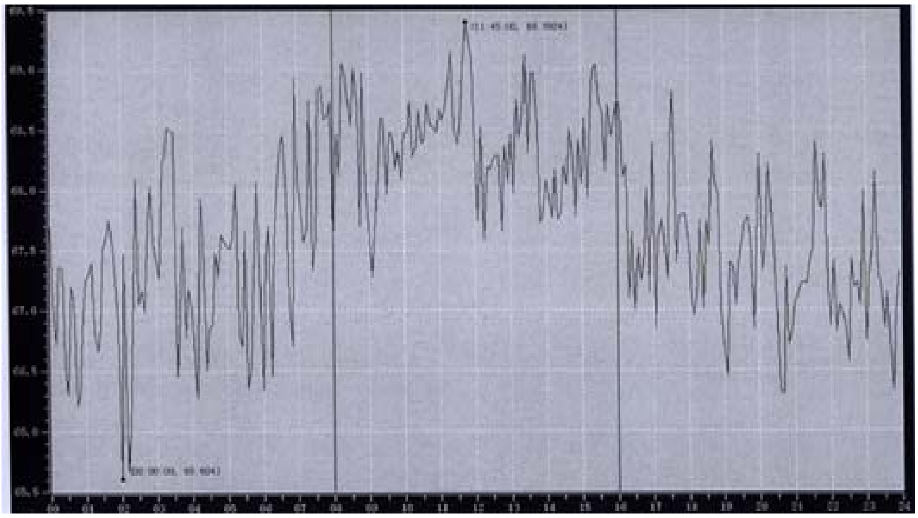

Fig. 1 Bus Voltage Curve of Lishizhai Substation 66kV
(before SVC was put into operation)

Table 1, Power Quality Indexes of Lishizhai Substation 66 kV Bus

Parameters		Max. value	Min. value	95% value	International value
Three-phase voltage unbalance (%)		0.73	0.06	0.48	2.00
Short-term flicker (1)	Phase A	2.62	0.30	2.10	0.80
	Phase B	2.38	0.29	1.96	0.80
	Phase C	2.46	0.24	2.04	0.80
Long-term flicker (1)	Phase A	1.58	1.01	1.58	0.60
	Phase B	1.49	1.01	1.49	0.60
	Phase C	1.59	0.91	1.59	0.60
Harmonic voltage distortion factor (%)		1.15	0.34	0.85	3.0

Voltage of 66kV and 10kV buses in lower-level 66 kV substations (such as Maoyan Substation etc) of Lishizhai 220 kV Substation is affected with high fluctuation, below lower limit and high line loss.

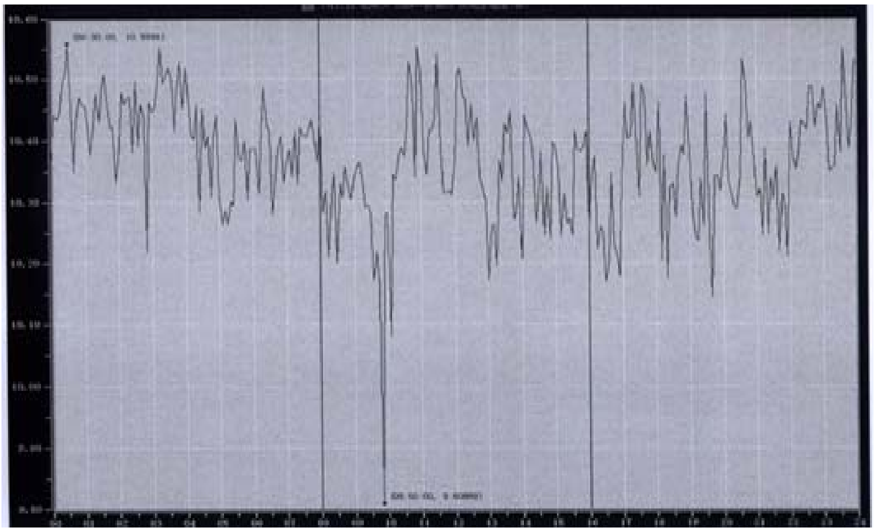

Fig. 2 10 kV Bus Voltage Curve of Maoyan (before SVC was put into operation)

In Fushun Power Grid, some substations also have similar voltage quality problem due to their location on the terminals of power supply line. For example, with respect to 66kV Qingyuan Substation on the terminal of 220kV Zhongqing Line 1, voltage of 10 kV bus is low, and line loss is high. See Fig.2.

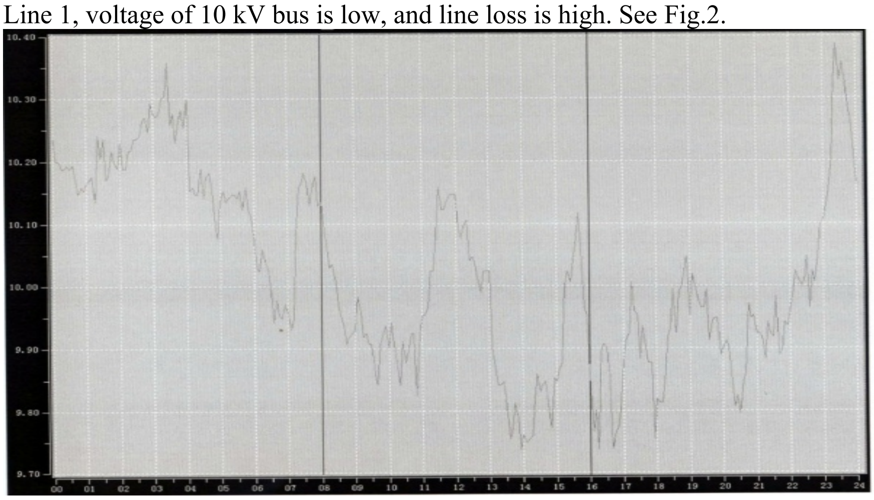

Fig. 3 Voltage Curve of 10 kV Section I Bus at Qingyuan Substation
(before SVG was put into operation)

To sum up, voltage quality problem of 66kV Maoyan Substation is mainly caused by 220 kV Substation at the next higher level, while voltage quality problem of 66kV Qingyuan Substation is caused by its geographic location. Although the reasons are different, power consumption quality of the users is affected, and line loss is high, which all should be solved.

Through comprehensive investigation of 220kV Lishizhai Substation, 66kV Maoyan Substation and 66kV Qingyuan Substation, as well as domestic manufacturing capacity of dynamic reactive power compensation equipment, a scheme is finally formulated to install 66kV directly connected SVC(compensating capacity 70M) at Lishizhai Substation and 10kV chain SVG (compensating capacity ±5M) at Qingyuan Substation for compensation purpose.

Application of 66kV directly connected SVC at Lishizhai Substation

Basic parameters of this SVC are as follows: rated capacity 70MVar, rated voltage 66kV, rated current 371A; valve block trigger mode: light triggered; installed capacity of filter: 98MVar(fundamental wave compensating capacity: 70MVar); filter branch: 3rd, 5th, 7th; cooling system: closed circulating pure water cooling device; land area: 85m*25m; installation site: Lishizhai Substation 66kV bus; control strategy: constant voltage control.

Before SVC was put into operation, voltage fluctuation range of Lishizhai 66kV bus was 65.60 to 69.39kV while 67.31 to 68.01kV after putting into operation.

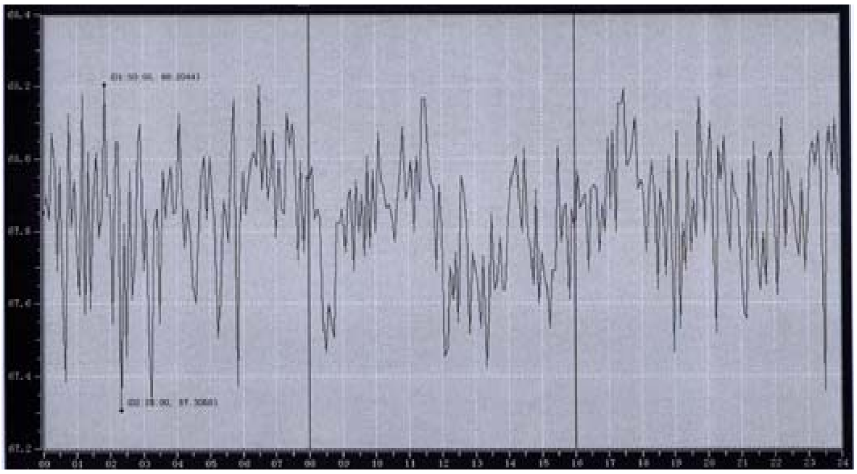

Fig. 4 Voltage Curve of 66kV Bus at Lishizhai Substation
(after SVC was put into operation)

In addition, voltage fluctuation range of 10kV bus at its affiliated Maoyan Substation changed from 9.81-10.56kV to 10.35-10.67kV.

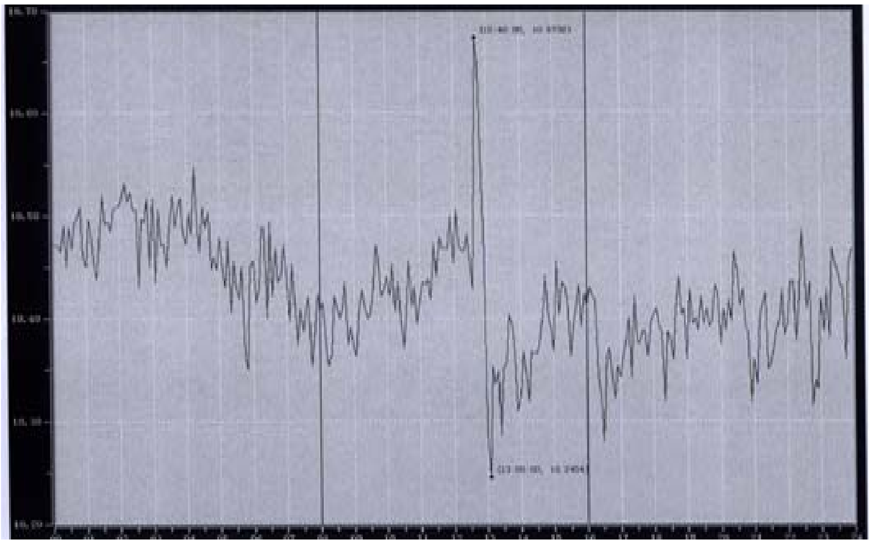

Fig. 5 Voltage Curve of 10 kV Bus at 5 Maoyan Substation
(after SVC was put into operation)

Application of SVG at Qingyuan Substation

Basic parameters of this SVG: rated capacity ±5MVar, rated voltage 10.5kV, rated current 289A; cooling system: air cooling; land area: 9.6m*12m; installation site: Qingyuan Substation Section I 10kV bus; control strategy: constant voltage control.

Before SVG was put into operation, voltage fluctuation range of 10kV bus at Qingyuan Substation was 9.8-10.3kV while 10.3-10. 7 kV after putting into operation.

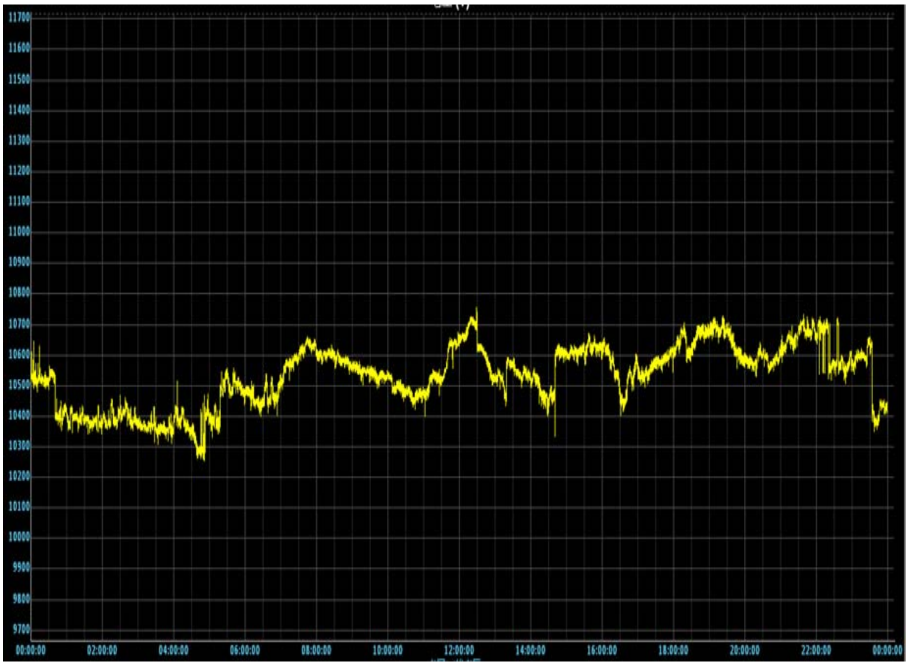

Fig. 6 Voltage Curve of 10 kV Section I Bus at Qingyuan Substation
(after SVG was put into operation)

Economic Benefits Analysis After SVC was Put into Operation

(1) Analysis on transmission loss of 220 kV and above

After SVC was installed, subsequent reduction of primary transmission loss is calculated as per 1.97MW and annual operation time as per 8700 h, the reduced primary transmission loss of Liaoning Power Grid in one year: 1.97(MW)×8700 (hour) =17.139 million (kWh).

(2) Analysis on transmission loss below 220kV

The power loss of two main transformers at Lishizhai Substation in 2009 was 5.93 million kWh, and according to the power supply quantity of Lishizhai Substation about 598.90 million kWh in 2009, total power loss about 7.60 million kWh. After SVC was installed, 66 kV system voltage became 68kV, secondary transmission loss of the system could reduce power loss 2.17 million kWh.

(3) Annual power consumption of SVC

It is estimated that comprehensive loss of SVC (including various auxiliary equipments, station-service power and power penetrating main transformer loss etc) is 0.3%, total consumed active electricity is calculated as 2.349 million kWh

Then after SVC was put into operation, the reduced power loss is 1713.9+217-234.9=16.96 million kWh

Calculate as per 0.5 Yuan per kWh, annual income is 8.48 million Yuan.

Economic Benefits Analysis after SVG was Put into Operation

After SVG was put into operation, average power transmission and transformation loss rate of Zhongqing Line 1 decreases 1.01%, compared with that before SVG was put into operation

Direct economic benefits of line loss = annual sold electricity * reduced line loss rate * average unit price of electricity sold =219 million kWh *1.01%*5950 Yuan/ten thousand kWh=1.316 million Yuan

Daily average power supply quantity of Qingyuan Substation increases from original 93101 kW·h to current 101814 kW·h, growth rate is 9.35%. Benefits of additional electricity sold = annual quantity of additional electricity sold * profit of electricity price =3.18 million kWh ×(5950-3672) Yuan/ten thousand kWh =0.724 million Yuan

Annual comprehensive economic benefits after SVG was put into operation = benefits of additional electricity sold + direct economic benefits of line loss =2.0404 million Yuan.

Conclusion

Facts have proved that, both the SVC at 220kV Lishizhai Substation and the SVG at Qingyuan Substation have solved the problems of local grid, i.e. large voltage fluctuation, low voltage and high line loss effectively, and achieved relatively high economic benefits and social benefits. Through contrast analysis, the advantage of the installation at 220 kV Substation is wide compensation coverage and the disadvantage is large footprint, which might impact the system to certain degree; for the installation at 66 kV Substation, advantages include god compensation effect and strong pertinency, and the disadvantage is heavy investment. In addition, since 66kV directly connected SVC adopts water cooling method, regular maintenance is required for the water cooling system, while SVG also requires regular cleaning of the air cooling system, so maintenance workload of operating and maintenance personnel is increased.

References

[1] Luo Chenglian "Principle and Realization of Static Reactive Synchronous Compensator (STATCOM)" [M]. Beijing: China Electric Power Press, 2005;

[2] An Wanzhu, Wang Jian, Wang Xiaoyan, Wang Zhiming, Ge Weichun, Gong Hengyu. Double Redundancy Control System of 66kV Vertical SVC [J]. Electric Age. 2010(2):48-51.

[3] Liu Wenhua,Song Qiang,Teng Tianle,et al.Transient Voltage stability and static synchronous compensator [J]. Transactions of China Electrotechnical Society,2007,2(7):18-23.

[4] Weng Limin,Xin Jianfeng.Performance comparison and application analysis between STATCOM and SVC [J]. Power Capacitor &Reactive Power Compensation,2010,31(4):1-4.