DC Transmission and FACTS

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Abstract

High-voltage direct current transmission (HVDC) is a high-power long-distance direct current transmission that utilizes the advantages of stable direct current with no inductive reactance, capacitive reactance does not work, and no synchronization problems. The transmission process is DC. HVDC transmission has many advantages that AC transmission cannot have, so although the current application and popularity are less, it has broad development prospects. Commonly used in submarine cable power transmission, communication between asynchronously running AC systems, etc. A large number of power electronic technologies are used in the process of DC transmission, and these technologies are also widely used in FACTS. FACTS technology uses a large number of FACTS controllers to improve the efficiency, stability and reliability of the transmission system. In today's power grids, these two technologies are constantly gaining popularity.

Keywords

Transmission, Advantages, Systems, Technology.

1. Introduction

The DC transmission project is a project that realizes the transmission of electrical energy in the form of direct current. The place where the sending end performs the rectification transformation is called a rectification station, and the place where the receiving and performs the transformation is called an inverter station. Rectifier station and inverter station can be collectively referred to as a converter station. The devices that realize rectification and inverter conversion are called rectifier and inverter, respectively, and they are collectively called converters. The system structure of the DC transmission project can be divided into two categories: two-terminal (or end-to-end) DC transmission system and multi-terminal DC transmission system. The DC transmission system at both ends is a DC transmission system with only one rectifying station (transmitting end) and one inverter station (receiving end), that is, there is only one transmitting end and one receiving end, and it has only two connection ports with the AC system. It is the simplest DC transmission system. The multi-terminal DC transmission system and the AC system have three or more connection ports, and it has three or more converter stations. The back-to-back DC system is a two-terminal DC transmission system with zero transmission line length (no DC transmission line). The basic connotation of FACTS is based on various FACTS controllers composed of modern high-power power electronic technology, combined with advanced control theory and computer information processing system, etc. So we can realize the operation parameters and variables of AC transmission grid (such as voltage, phase angle, impedance, Tide) more rapid, continuous and frequent adjustment. That is the so-called flexible transmission control, and then achieve the purpose of improving the operation efficiency, stability and reliability of the transmission system. Both methods use high-power modern power electronic devices. They have a lot in common, and have some of the same advantages. Of course, because one is used in the DC grid and the other is used in the AC grid, there are some differences before them. There is also a competitive relationship between the AC grid and the DC grid.

2. Organization of the Text

2.1 DC Transmission

In 1882, French physicist Deppler conducted the first DC transmission test at an international exhibition. The DC voltage is 1500~2000V, the transmitted power is 1.5kW, and the transmission distance is 57 kilometers. In 1901, the American Petet Cooper Hewitt invented the mercury gas-vapor lamp, and then invented the mercury arcrectifier. In 1954, the first commercial submarine cable DC transmission system appeared on the Swiss island of Gotland, which was rated at 20MW, 200A, 100KV. The emergence of thyristors in the 1960s created more favorable conditions for HVDC transmission. As of 1988, there were about 45 DC transmission projects in the world, with a total capacity of 35,000MW.

Fig. 1 Thyristor valve

Fig. 2 A DC transmission project

At present, the world's leading transmission technology and power equipment countries have adopted DC transmission as the first solution to effectively solve the problem of long transmission distance. The voltage level of UHVDC technology in China refers to the voltage of ± 800kV and above. In recent years, with the increasing transmission capacity, stability during the transmission process, and the safety requirements of transmission equipment in various regions of my country, the demand for electricity in economically developed regions has increased year by year [1]. In order to make our country's power resources better developed and efficiently utilized, my country's power experts have begun to pay close attention to and study UHV DC transmission technology. At the same time, UHV DC transmission can achieve the goal of a long transmission distance. In addition to the uneven

distribution of natural resources and energy in my country, the distance between the power supply side and the power consumption side is relatively long. Comprehensive comparison of existing relatively cost-effective transmission methods, the use of UHV DC transmission technology is undoubtedly the first choice, and can reduce line losses in the transmission process, rational use of the rich resources contained in regions where geographical advantages are not obvious, and promote the energy revolution. It has been transformed into a green economy, improving primary energy utilization while effectively protecting the environment.

There are many differences between DC transmission and AC transmission. In terms of economy, for transmission lines, the DC transmission line is cheaper than the AC transmission line, and the power loss is also smaller. For the equipment at both ends, the equipment at both ends of the DC transmission is much more expensive than the equipment at both ends of the AC transmission. Because the cost of converter stations is very high, the economics of DC transmission and AC transmission are different in different places. DC transmission is cheaper in some places and AC transmission is cheaper in some places. The concept of equivalent distance is involved here. Technically, AC transmission needs to consider the stability of the transmission system, which will cause more complicated problems such as oscillation, while the stability of DC transmission is very strong. For short-circuit capacity, the short-circuit capacity of the DC transmission system is even smaller. In addition, the DC transmission system can achieve asynchronous communication, and its power transmission adjustment is also more convenient and flexible [2].

In addition, DC transmission has many other advantages, such as the transmission capacity is not limited by stability, the network does not increase the short-circuit capacity, the corona interference of the line is small, there is basically no capacitive current in the line, and reactive power compensation is not required. Of course, DC transmission also has its shortcomings. For example, the cost of converter stations is high. There is currently no suitable DC circuit breaker. The development of multi-terminal DC transmission systems is subject to certain restrictions. The transformer cannot be used to change the voltage level. Harmonics are generated during operation. The flow station needs a lot of reactive power compensation, complicated control, etc. It is mainly suitable for long-distance high-power transmission, submarine cable transmission, cable transmission to high-density large cities, or communication between different frequencies or the same frequency asynchronous operation of AC systems.

Although my country's DC power grid is constantly developing, there are still many problems that need to be solved, such as electromagnetic environment problems, overvoltage and insulation problems, equipment reliability problems and control problems. As for the electromagnetic environment issue, the electromagnetic environment issue is a technical issue that must be considered before implementing the UHV transmission project. In the UHV transmission project, due to the voltage transmission, a magnetic field is generated in the space around the transmission line, which will adversely affect the environment and human body near the equipment. For example, the converter station generates radio waves to interfere with the communication equipment during operation. Not only will it disturb the daily lives of nearby residents, but it may even cause a DC bias to destroy the transformer and cause power equipment operation failure. In particular, my country is currently innovating and breaking through UHV DC transmission technology in an all-round way, and it is necessary to solve the problem of the adverse impact of electromagnetic pollution generated during the transmission process on the environment. The converter station and other power equipment put into operation during the UHV DC transmission process must meet the environmental protection requirements stipulated by the state in order to fundamentally solve the electromagnetic environment problems generated during the transmission process.

2.2 FACTS

FACTS is a new technology for the control of AC transmission formed by the integration of power electronics technology, microelectronic technology, communication technology and control technology. The development of flexible AC transmission system (FACTS) has undergone three

generations of technical updates today. The first generation of FACTS devices are mainly composed of capacitors and reactors controlled by thyristors, and the second generation of FACTS devices use fully controlled devices such as gate turn-off devices. The external circuit does not need to install large-scale power equipment. The third-generation FACTS device uses a FACTS device composed of two multiple controllers, and has a unified control system. FACTS technology plays an important role in new energy and green energy power generation because of its flexible and fast control characteristics that can improve the transmission capacity, reliability and response speed of the power grid (Dayu He, new progress in the research of flexible AC transmission system concepts: Grid Technology, 1997). The application of FACTS technology can coordinate the energy exchange between the local power grid and the total power grid [3]. The foundation of China's smart grid is the high-voltage transmission system, but the high-voltage transmission system has certain requirements for the access and isolation of new energy and green energy power generation. FACTS technology can transform the alternating current in the smart grid into other forms. The flexible control of voltage and power solves the problem of access and isolation of green energy and new energy in the high-voltage transmission link and reduces line losses. my country's flexible AC transmission system has greatly improved the transmission capacity of the power grid due to the use of converter equipment in independent control mode and self-commutation mode. The existing FACTS controllers are SVC, STATCOM, SVG, SVS, SSG, SSSC, TCSC, etc.

Each controller has many engineering applications. Such as SVC, SVC is widely used in the power system. Anshan Hongyi Substation is the hub substation of Northeast Power Grid. It is mainly responsible for the power supply task of Anshan Iron and Steel Company. The original four main transformers have a total capacity of 400MVA. Of the cameras with a capacity of 90 MVar, one of them has been scrapped, and the other can only send 20 MVar of reactive power and is facing scrapping. The load of Anshan Iron and Steel Company has the characteristics of large capacity and impact, but there is no large power supply support in Anshan area. The dynamic reactive power compensation measures of Anshan Hongyi Substation are very disproportionate to its pivotal substation. The Anshan Hongyibian SVC localization demonstration project is a key technology demonstration project of the State Grid Corporation of China in 2002. It started construction in November 2003 and was officially put into operation in September 2004. It is the first localization after the introduction of 6 sets of SVCs in the domestic transmission grid The SVC project has really played a demonstrative role in the localization of SVC transmission grids. SVC replaces the original tuning camera to realize the dynamic reactive power adjustment of the power grid, and its economic benefits are significant, mainly reflected in: reducing the long-distance transmission of reactive power and reducing the network loss; compared with the tuning camera, reducing the operation and maintenance costs ;Improved system power flow distribution; Increased stability level of Anshan power receiving section; Suppressed harmonic interference caused by impact load, improved power quality. In addition, the TCR+FC SVC has been widely used in the metallurgical industry, and has achieved remarkable results, and has formed a mature technical solution. SVC installed in a traction substation of Baoji section of Xi'an Railway Branch. Under the condition of compensation by fixed capacitors only, the power factor is about 0.85 (the assessment value is 0.9), and a low power factor fine is paid every month. After the SVC system is installed, the power factor is increased to 0.95, except for the reward from the local power supply department. The required cost investment is also recovered in more than one year, and the economic benefits are quite significant. Another example is TCSC, which can be used for reactive power compensation in power systems. In 2003, China's first TCSC device was put into operation in a substation of China Southern Power Grid. The withstand voltage level was 500kV, and the controllable partial compensation degree was 5%. In 2004, the TCSC device independently developed by the China Electric Power Research Institute was completed and put into operation in a 220kV substation of the Northwest Power Grid. The controllable part compensation degree is 50%, which is the project with the largest controllable part compensation degree in the world. In 2007, the domestically developed TCSC device was put into operation in a 500kV substation of Northeast Power Grid with a compensation capacity of 652Mvar.

Fig. 3 SVC

3. Conclusions

Although DC transmission technology and FACTS technology are still not widely popularized in today's power grid, the emergence and improvement of these technologies have unique advantages for us to develop the power grid. In the future, when these technologies have become very mature, they Can bring considerable benefits.

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