THERMAL ENERGY STORAGE TECHNOLOGY AND ITS APPLICATION IN POWER DATA REMOTE TRANSMISSION

by

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In order to meet the current situation of the strong growth of energy demand, the authors put forward the research of thermal energy storage technology and its application in power data remote transmission. The main content of the technology is based on heat energy storage technology, discuss the advantages of heat energy storage technology, and study the stability analysis in the remote transmission of power data, finally, the stability performance of heat energy storage technology in power data remote transmission is obtained through experiments. The experimental results show that the energy storage is added at bus 6 of the power supply end, and the transmission distance between the energy storage power station and bus 6 is changed and the energy storage output is kept at 100 MW, the power of the connecting line is 400 MW. With the increase of the transmission distance, the variation trend of the inter-region oscillation mode and the oscillation mode in Region 1 and Region 2 is that the oscillation frequency increases, the characteristic root moves to the left and the damping ratio increases, but the change is small. In conclusion it proves that heat energy storage technology has outstanding advantages, it has a broad development prospect and an important role in power data remote transmission.

Key words: *heat energy, storage technology, power data, remote transmission*

Introduction

Electric power energy is the main lifeline of national economic development, in the process of the continuous development of national economy, the electricity load is also increasing, the scope of power supply is expanding, the number of power distribution houses continues to increase, and the power system in various regions is becoming larger and larger. At present, multiple power grids have been developed to supply power to users jointly [1]. In this context, how to make the grid safe and effective operation, and cheap and high quality power supply problem is much attention of the power supply department. For effective and comprehensive collection of power load parameters, it plays an important role in the detection of the operation of power supply equipment, real-time detection and location of faults, and can make the power grid run safely and effectively, this aspect is also the main part of distribution network automation, which not only provides data for us to effectively grasp the operation of the power grid, but also can effectively realize the remote control of the power system.

In the future, the new generation of power systems will primarily focus on making extensive use of clean energy to generate electricity [2]. The power grid's security, adaptability, and optimal resource allocation are put at risk by the shifting energy structure. Renewable

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energy generation units can be complemented by energy storage systems to ensure that they can operate in both grid-connected and island modes with a wide range of power, maintain the system's efficiency and stability, and mitigate power fluctuations brought on by intermittent renewable energy output.

Literature review

In recent years, energy consumption has grown tremendously, and energy production and consumption have experienced changes. The energy storage can be easily adjusted to realize the fast decoupling control of active and reactive energy. As an immediate response power, it can be used in power generation, transmission, distribution and use of traditional power lines and power lines. New electricity. It has the effect of changing the supply immediately and the demand to balance the existing electricity [3, 4].

In view of the aforementioned problems, the author puts forward the research of thermal energy storage technology and its applications in the remote transmission of electronic data. Among many energy storage technologies, thermal energy conservation is one of the most promising of many energy storage technologies. Thermal energy storage technology consists of thermal storage, solar energy, geothermal energy, industrial waste heat, low energy products, or conversion of thermal energy. Electricity into heat energy for storage and release when needed, to solve the problem caused by the inconsistency of the supply and demand of heat energy in time, place or effort, and make the energy use of the whole system [5]. Compared with other energy storage technologies such as electrochemical energy storage and electrical energy storage, it has obvious advantages in installation capacity, energy storage speed, cost and utility people compared with compressed air energy storage and pumped energy storage, thermal energy storage technology has many advantages, such as small floor space, low cost, fast energy storage, small impact on the environment, and no area and environment. As a multi-purpose energy source with high energy, high conversion and high cost, thermal energy storage technology will play an important role in creating a clean, low carbon, safety and energy conservation, create new energy with new energy as the main body, and ensure the safety and stability of the transmission of electronic data.

Research methods

Research on heat energy storage technology

Overview of heat energy storage technology

Heat energy storage is a new type of energy technology, which is characterized by the storage of temporarily unused or excess heat energy through certain media, reuse as needed. As shown in fig. 1. The generation of thermal energy storage technology is to solve the problem of energy discontinuity in the utilization of solar energy and wind energy. With the further development of technology, it is also applied to the waste heat recovery of industrial heating process [6, 7].

Thermal energy storage technology is the storage of thermal energy, which allows the heat to be reused at another time or place. These two types of heating have different characteristics.

The purpose of the mature theory of heat energy is to store heat energy by allowing substances to change their temperature. The heat storage medium must have a special ability to heat, and there are two substances that meet this requirement: liquid and liquid. Stone, sand, metal, concrete, brick and other materials can be used as heating materials. Water, molten salt and hot oil are examples of liquids. In particular, water is the heat storage medium in electric

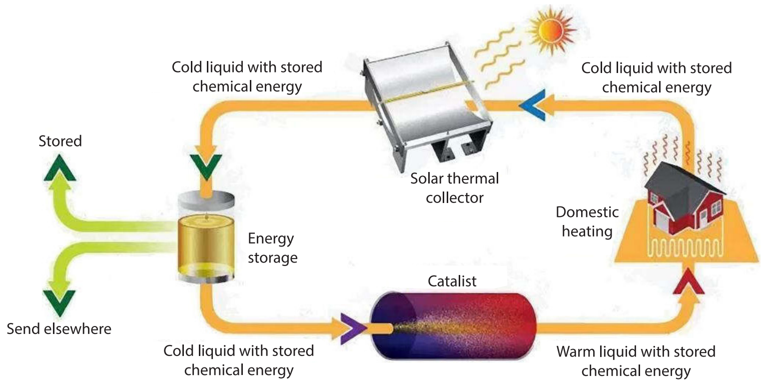

Figure 1. Principle of thermal energy storage technology

heating equipment, because it has a specific heat and is a cheap medium. On the other hand, the oil heat exchanger has a different temperature than the heat storage, but it has low gas, large evaporation and high cost. On the other hand, molten salt will be corroded under high temperature and easy to leak. Some salts also have some negative properties, such as poison, flame and explosion [8].

Phase change energy storage is often used as a result of the absorption of latent heat in the process of liquid conversion store heat energy. Compared with conventional energy storage, phase change energy storage has more heat storage capacity, so it is smaller in size and lighter in weight. At the same time, because the stored heat is released from the temperature change stage, the thermal energy of the stage change energy storage has the characteristics of stable energy and temperature continuously, so phase change energy storage systems are more reliable and competitive thermal energy storage systems.

Advantages of heat energy storage technology

The characteristics and advantages of thermal energy storage technology are large energy storage capacity, flexible configuration, no special environmental requirements. It has the advantages of large-scale construction and operation cost, and has obvious scale effect. According to user needs, to achieve a variety of energy grade cold, heat, electricity, gasoline supply. It can achieve peak cutting and valley filling, two-way regulation, and absorb the installed output of intermittent new energy (wind power, photovoltaic*, etc.*) in regional power grid, which is the best solution balance the peak-valley difference in power grid. The cycle times are large and the life is long, and the bidirectional regulation function of the energy storage power station will not lead to the efficiency reduction with the long time heat storage cycle. The storage process has no chemical reaction, the technical parameters and process are controllable, and the system security is high [9, 10].

In the direct utilization of heat energy, heat storage technology has higher energy utilization efficiency than electricity storage technology. Heat storage technology also includes the storage and utilization of heat energy lower than the ambient temperature, that is, cold storage technology has been maturely applied in cold chain related fields, and the market scale is also continuously expanding [11, 12]. The moment of inertia of the system continues to decrease, and the capability of frequency and voltage regulation is insufficient, posing a severe challenge to the safety of the power grid. Solar thermal energy storage power generation can effectively achieve frequency modulation through the rotational inertia of the turbine generator set. On the power supply and grid side, the current power system is characterized by a high proportion of power electronic equipment and a high proportion of renewable energy. In the flexible transformation of thermal power plants, thermal energy storage and power generation technology converts excess steam heat generated during variable load operation of units into heat energy of heat storage media and stores it, when needed, the heat energy is released, which cannot only increase the peak load depth of the unit, but also increase the peak load capacity, with low investment and operation cost, which has obvious advantages.

Stability analysis of heat energy storage technology in power data remote transmission

Construction of energy storage system

The energy storage system mainly includes two parts: power conversion system and battery system. The battery system is used to store or release electricity. The PCS consists of two parts: converter and control system, it connects energy storage and power grid, carries out charge and discharge management, power regulation and corresponding control for energy storage devices, and is the core component for bidirectional power flow between energy storage and power system [13, 14].

The energy storage system based on single-stage converter is shown in fig. 2. The structure is easy to implement, high conversion rate, simple control, the disadvantage is containing high harmonics, capacity selection is not flexible. The basic converters that can realize DC/AC functions are current converters, voltage converters and phase controlled converters. Phased converters have weak reactive power control ability and are mainly used to control active power. Both voltage-type converters and current-type converters can independently control active and reactive power, and voltage-type converters can provide continuous reactive power. Current – type converters can provide more capacitive reactive power.

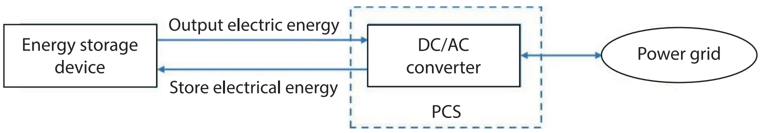

Figure 2. Energy storage system based on single-stage converter

The overall control model of energy storage power station is shown in fig. 3. Plant level active and reactive power P_{plant} and Q_{plant} output active and reactive power control commands P_{ord} and Q_{ord} through the plant level control model, the output active and reactive current control commands I_{pcmd} and I_{qcmd} are input to the converter stage control model with the emitted power P_{e}, Q_{e}, and SOC of the stored energy, then the converter is obtained through the current limiting model, and the final output current commands I'_{pcmd} and I'_{qcmd} are obtained, finally, output axis current d and q-axis current I_d and I_q through the converter model.

In order to facilitate the decoupling control of active and reactive power of the converter, the three-phase stationary co-ordinate system is transformed into d and q co-ordinate systems through equal co-ordinate transformation:

$$\begin{aligned} \frac{\mathrm{d}i_{\mathrm{s}d}}{\mathrm{d}t} &= \frac{1}{L}\left(U_{\mathrm{s}d} - U_{\mathrm{c}d} + \omega L i_{\mathrm{s}q} - R i_{\mathrm{s}d}\right) \\ \frac{\mathrm{d}i_{\mathrm{s}q}}{\mathrm{d}t} &= \frac{1}{L}\left(U_{\mathrm{s}q} - U_{\mathrm{c}q} - \omega L i_{\mathrm{s}d} - R i_{\mathrm{s}q}\right) \end{aligned} \tag{1}$$

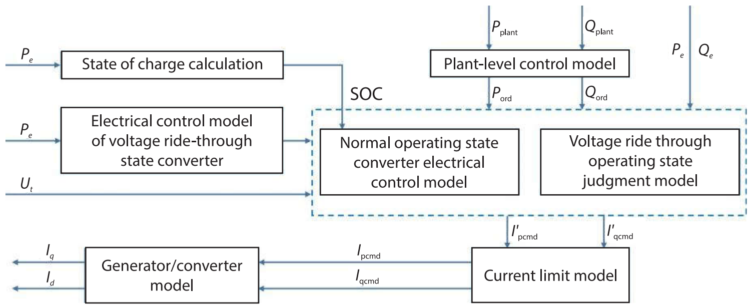

Figure 3. Overall control model of energy storage power station

Active and reactive power output can be controlled by controlling *d* and *q* axis current:

$$P_s = U_d I_d$$
$$Q_s = -U_d I_q \tag{2}$$

Stability analysis of system small disturbance

In order to study the influence of energy storage on small interference stability, a four-machine and two-area interconnection system is built in the comprehensive simulation software of power data remote transmission system [15, 16]. Simulation model of four-machine two-area system after energy storage is added.

Keep the transmission power of the contact line at 400 MW, and the output of each generator set at 700 MW. The electromechanical oscillation modes of the system before and after the power system stabilizer (PSS) is installed are shown in tab. 1.

Table 1. Electromechanical oscillation modes of the system before and after the power system stabilizer is installed

Conditions	Model	Characteristics of the root	Frequency [Hz]	Damping ratio [%]	Note
No PSS	1	–0.0387 ±j1.6967	0.2700	2.2804	Oscillation between regions
	2	–0.3666 ±j3.9972	0.6362	9.1325	Region 1 oscillation
	3	–0.38028 ±j4.0500	0.6446	9.3475	Region 2 oscillation
There are PSS	1	–0.0446 ±j1.6831	0.2679	2.6489	Oscillation between regions
	2	–0.3707 ±j3.9173	0.6235	9.4210	Region 1 oscillation
	3	–0.3848 ±j3.9681	0.6315	9.6514	Region 2 oscillation

According to tab. 1, the system has three oscillation modes: Mode 1 is the inter-region oscillation mode, Modes 2 and 3 are the oscillations of two units with opposite phase inside Regiones 1 and 2. The damping ratios of all oscillation modes of the system increased before and after the power system stabilizer was installed. In the further simulation, it was found that Mode 2 shifted to the left in the complex plane with the increase of power system stabilizer units installed in Area 1, when the frequency decreases, the damping ratio increases, when the power system stabilizer is installed in unit 2, the damping ratio decreases and the frequency decreases. The change law of Mode 3 is contrary to Mode 2, the stability of Mode 3 becomes worse when the power system stabilizer is installed in unit 1 in Area 1, then, with the addition of power system stabilizers in unit 2, the stability of Mode 3 is enhanced.

Result analysis

The influence of the transmission distance of the thermal energy storage power station on the stability of small interference of the system is analyzed, the energy storage is added at six busbars of the power supply end, change the transmission distance between the energy storage power station and bus 6, and maintain the energy storage output of 100 MW and the power of the contact line of 400 MW. Figure 4 shows the distribution of characteristic roots and damping ratio of the system under different transport distances.

As can be seen from figs. 4(a)-4(d), with the increase of the transportation distance, the variation trend of the inter-regional oscillation mode and the oscillation mode in region 1 and Region 2 is that the oscillation frequency increases, the damping ratio increases when the characteristic roots move to the left, but the change is small, the damping ratio and the transmission distance change almost linearly, the characteristic roots are all negative, and the system remains stable.

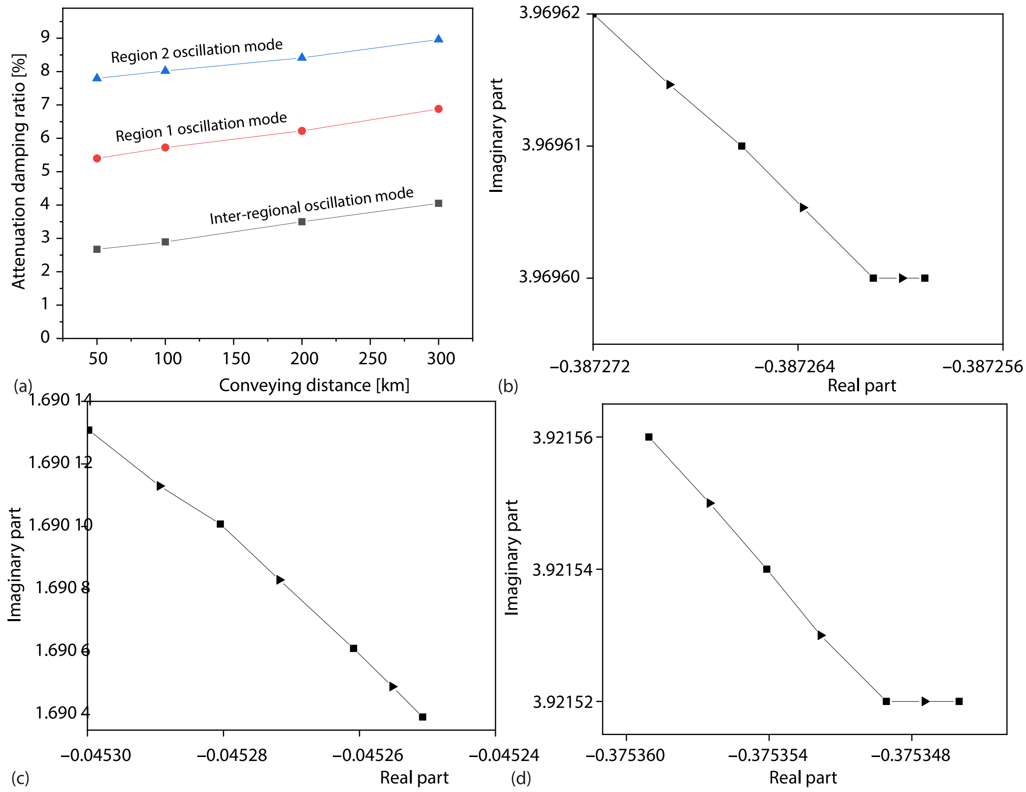

Figure 4. Distribution of characteristic roots and damping ratio of the system at different transport distances; (a) attenuation damping ratio, (b) oscillation mode in Region 2, (c) interregional oscillation mode, and (d) oscillation mode in Region 1

Conclusion

In a word, thermal energy storage technology has high performance in the wide application of cooling, heating and electric energy, and has the best of thermal storage capacity, construction size, cost, working life, safety and energy production, especially in terms of the average capacity of new intermittent energy (wind energy, photovoltaic, *etc.*). It is used to create new energy with new energy as the main body. It plays an important role in ensuring the safety and stability of the work of energy and remote transmission fabric paper power. It is the backbone of the big energy storage in the future, there is a wide expectation for development, and it plays an important role in the energy reform.

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