The DC Melting Technology Research of the 500 kV Transmission Line

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Abstract. Transmission lines ice cover is a kind of serious natural disasters, is one of the major problems to endanger the safety of transmission lines running.Communication often short-circuit current melting ice is melting ice the problem of insufficient power supply capacity is much, and dc melting technology is a kind of ideal and effective method.The basic theory of dc melting technology was analyzed, and the critical current of melting ice in dc are calculated, the calculated for a specific current 500 kv transmission line of melting ice, and preliminarily determines the melting ice, has carried on the simulation analysis using PSCAD/EMTDC software, in order to confirm the availability and effectiveness.

Introduction

Power system suffered from natural disasters such as ice storm, earthquake, disaster, ice disaster is one of the most serious threat to the power system.[1]Compared with other accident, ice damage to power grid losses tend to be more serious, flash light, ice, or cause tower (rod), bolt, or even shut down power grid.And with the rapid development of power grids, high pressure and ultra-high voltage transmission lines across the ice region is becoming more and more affected the possibility of ice caused power grid is becoming more and more big.Ice disaster prevention and control is one of the key research of the development of grid technology, both at home and abroad of anti-icing and deicing of methods and techniques are studied, and effective melting technology will play an important role in the fight against the ice disaster, this paper introduces the theory of melting ice in dc, are compared, and the related technology of direct melt and illuminates the 500 kv and above level line using dc melting method, the advantages of a specific 500 kv line, for example, has carried on the design of the dc melting ice[3].

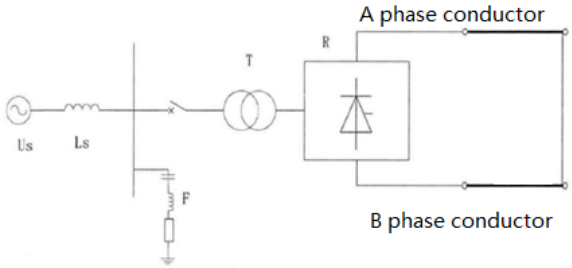
Principle of DC melting ice

Method of melting ice in the dc to ac power through the large capacity power electronic equipment is converted to dc and then heating with a certain length of ice line to achieve the objective of the melting ice.Due to dc wire melting ice is only related to the resistance of the circuit, so the lines don't consume reactive power, reactive power, dc rectifier consumes only dc short-circuit method can melt for each voltage grade lines, without considering the problem of shortage of reactive power compensation in line.When the heat generated by the high voltage transmission line dc current is greater than the conductor is the sum of heat and melting heat, high voltage transmission lines ice will melt.So dc design basic principle is that melting ice ice lines through the current is greater than the minimum line of melting current is less than the line at the same time the maximum allowable current.When the power supply provided by the system of melting ice, ice line (T) through the rectifier transformer, rectifier (R), connected to the ac system, its principle diagram is shown in figure a or b[2].

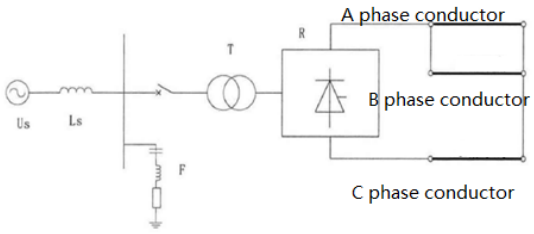
Because it is three phase line ice, so ice line has two kinds of connection mode, as shown in figure (a) and (b). As shown in figure (a) ,which is short answer the end of the line A and C .and

then connect into the rectifier. As shown in figure(b) ,which is the ice melting ice way lines A,B, C three-phase short end, after A, B two phase conductor and an output of the rectifier, and the phase C wire access another output rectifier, the wiring method can only to melt phase C.

The above two methods, the method is a method of power supply capacity and power supply voltage than b decreases by 25%, but the method is a method of operation than b step, more complicated operation.



(a) The way Ⅰ of DC melting ice



(b) The way Ⅱ of DC melting ice

DC system design of melting ice

DC design basic idea is based on ice melt line length and model, calculate the melting ice currents, in turn, determine the rated dc voltage of the rectifier, rated current and rated capacity, capacity of rectifier transformer and rectifier busbar voltage distortion rate variable network side.And reasonable configuration of the filter according to the voltage distortion rate[4].

Melting ice line current and melting time calculation

1.Critical current calculation of melting ice

In engineering practice, to calculate the critical current of melting ice of the wire, for ice power line of melting ice, ice prevention work is extremely important.Critical melting ice line current can be calculated by the type[5]:

$$I_d \approx [\frac{8(T_r - T_a)(R+b)^3}{0.525((T_r+T_a)/2+273.15)}]^{0.25} + 9.532\times10^{-8}(R+b)(T_a+273.15)^3 + 4.9\times10^{-3}CR_e^n \quad (1)$$

$R_e \approx 15.04\times10^4(R+b)v$;b : the conductor ice thickness; T_r : the ice temperature.the value of R_e has a certain relationship with C and n , such as form 1.

Form 1 the relationship between C ,n and Re

Re	C	n
40≤ Re ≤4000	0. 683	0. 466
40≤ Re ≤4000	0. 193	0. 618
40≤ Re ≤4000	0. 0266	0. 805

2.The melting time calculation

When a ice link to exert a greater than the critical current of the current value of melting ice in the I, wires on the ice .Should be realized in a certain period of time the melting of the ice, ice melting time T by type calculation:

$$T = \{[1.505237870675\times10^6 b(2R+b) - 1.0540915\times10^6 R(0.2146R+b)]T_r + 6.75829\times10^8(0.2146R+b)R - [6.0209514827\times10^6(2R+b) + 2.44442\times10^6 A_{Al} + 3.6989\times10^6 A_{Fe}]T_a\} / [R_e(I^2 - I_d^2)] \quad (2)$$

A_{Al} : cross-sectional area of aluminum conductor A_{Fe} :Cross-sectional area of said steel core

3. The maximum allowable melting of ice wire current

Practical engineering applications, the running of electric line of the maximum allowable temperature is 90 ℃, thus, ice wires through the current too high, heating wire or wires produce joule heat will give more than most high temperature allowed.According to the maximum allowable temperature ice maximum allowable current of the wire can be calculated:

$$I_{\max}=\begin{cases}[(0.006908+0.00006908T_a+0.16014b^{-0.25})(90-T_a)^{1.3}b/R_{90}], & v>2m/s\\ [(0.2532552+0.0003982T_a+0.7(90-T_a)(vR)^{0.75}/R_{90} & , v\le 2m/s\end{cases} \quad (3)$$

R_{90}:the resistance of the conductor temperature at 90 ℃,is $0.0000748\Omega/m$， $I_{\max}$ is the allowable current conductor. T_a is the ambient temperature, ℃.

The example analysis

Below with a 100 km long transmission lines of 500 kV as a example for research. Line wire type is LGJ-4×400/35，Conductor dc resistance is r=0.0185 Ω/km，Thickness of the ice is 10mm，Environment temperature is -5℃， Wind speed is 5m/s .

Combination of a given conductor model parameters and external environment, according to the Formula 2 and Form3 the data calculated, the critical current of melting ice：$I_d=3475.2A$ According to the Formula (3) Calculate dc maximum permissible current of the melting ice : $I_{\max}=6882A$

The way I of DC melting ice in figure1-1(that is, The two phase lines directly in series) calculation:

Active capacity: $P=2I_d{}^2rL=2\times3475.2^2\times0.0185\times100=44.68MW$

DC output voltage :$U_{dc}=2I_drL=2\times3475.2\times0.0185\times100=12.86kV$

The way Ⅱof Dc melting ice in figure1-1(that is, two phase parallel again with another series) calculation:

Active capacity: $P=1.5I_d{}^2rL=1.5\times3475.2^2\times0.0185\times100=33.51MW$

DC output voltage :$U_{dc}=1.5I_drL=1.5\times3475.2\times0.0185\times100=9.64kV$

Melting ice device selection and calculation, the results shown in the form below:

Form2 Circuit parameters

Voltage grade	linear	length /km	resistance / Ω at 20 °C	Minimum melting ice current /A
500kV	LGJ-4×400/35	100	0.0185	3475.2

Note: the environment temperature is -5 °C , thick ice is 10mm.

Form3 The key parameters of theory design

Trigger Angle/°	Dc voltage/kV	Active power/MW	Reactive power/M var
30.7	13	45.5	27.3

System simulation diagram is as follows:

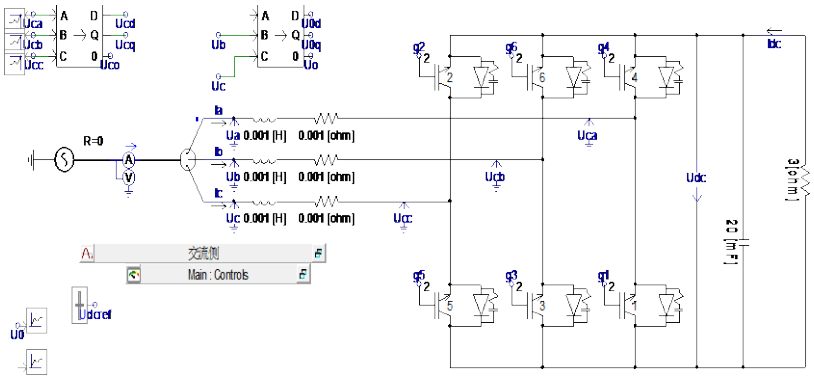


Figure c The simulation diagram of DC melting ice

Figure d The simulation waveform figure of the melting ice critical current and output dc voltage

Getting the simulation of dc current effective value is 3.55 kA, the dc output voltage is 13.15 kV, which is same as the technical parameters of melting ice in the theoretical calculation of dc.

Conclusion

The in-depth study of the technology of ice cover, anti-icing and melting ice on the power grid , can guarantee the running stability of power system during the ice disaster , and ensure reliable power supply.Research on the mechanism of melting ice, parameters of melting ice, and device design, is of great significance to the safe and stable operation of transmission line.

This paper introduces the principle of dc melting ice,and analyses the key technology of dc melting ice and research.The key parameters in the process of design of dc melting ice was calculated, and get the line of melting ice in the ice melting current and time.

In view of the 500 kv transmission line, the design scheme of melting ice in the dc, and the simulation analysis are carried out using PSCAD/EMTDC software, verify the validity of the method.

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