Economic and Technical Indicators of Internal Loop Opening of 500kV/220kV Electromagnetic Loop Network of Regional Power Network

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Abstract. With the strengthening of the regional power network at 500 kV and above level and the increase of load density, the contradiction between the electromagnetic loop network and the short-circuit current becomes more and more prominent, so it is necessary to open the internal electromagnetic loop network in due time. This paper puts forward the economic and technical indicators of the internal opening of the electromagnetic loop network, through the calculation of examples, the advantages and disadvantages of various internal open-loop schemes are evaluated, and the recommended schemes are obtained.

1. Introduction

The electromagnetic loop network is an inevitable product of the development process of the backbone power grid from low voltage level to high voltage level. The appearance of high voltage level greatly improves the transmission capacity of power grid, at the early stage of the development of high voltage level power network, the electromagnetic loop network plays a beneficial role in improving the electrical equipment’s utilization efficiency and the reliability of power supply \cite{1, 2}. With the significant enhancement of high-voltage level power grid, the problems of thermal stability, dynamic stability and excessive short-circuit current of power system caused by the operation of electromagnetic loop network become more and more prominent \cite{3, 4}.

2. Economic and technical indicators of internal loop opening of the electromagnetic loop network

Regional power grid is supported by 500kV substations, and the 220kV power grid is gradually developed into a double-loop ring network or double-loop chain network. In order to control the short-circuit current, simplify the network structure and form a reasonable power supply division, the regional power network internal loop opening should be adopted in due time \cite{5}.

The short-circuit current of substation, power flow transfer of transmission line, and network loss will all change after the regional power network internal loop opening. The following economic and technical indicators are developed based on the above variables.
Suppose substation $A_i$, before the loop opening of the regional grid, the short-circuit current is $I_i$, and after the loop opening, the short-circuit current becomes $I'_i$, and the drop rate of short-circuit current is $J_i$, and its average value is $\bar{J}$.

$$J_i = \frac{I'_i - I_i}{I_i}$$

(1) indicator $T_1$: short-circuit current decline

$T_1$ takes the standard deviation of the drop rate of short-circuit current at each substation.

$$T_1 = \sqrt{\frac{\sum_{i=1}^{n} (J_i - \bar{J})^2}{n}}$$

(2) indicator $T_2$: the load rate of 500kV substation

Supposing that the load rate of 500 kV substation is $B_i$, the mean value is $\bar{B}$, $T_2$ takes the standard deviation of the load rate of 500 kV substation.

$$T_2 = \sqrt{\frac{\sum_{i=1}^{n} (B_i - \bar{B})^2}{n}}$$

(3) indicator $T_3$: the active power flow transfer of transmission line near internal loop opening

Supposing that the active power flow near the internal loop opening is $P_i$, its thermal stability limit is $P_{\text{max}}$, the active power flow after the internal loop opening is $P'_i$, and the proportion of the transfer power flow of the relevant transmission lines in the available transmission allowance before internal loop opening is $K_i$

$$K_i = \frac{P'_i - P_i}{P_{\text{max}} - P_i}$$

$T_3$ takes average value of $K_i$

$$T_3 = \bar{K}_i$$

(4) indicator $T_4$: regional network loss rate

Supposing that regional network loss before the internal loop opening is $D$, regional network loss after the internal open loop is $D'$, and $T_4$ takes the rate of regional network loss.

$$T_4 = \frac{D' - D}{D}$$

On the basis of the detailed analysis and calculation before and after the internal loop opening of regional power network, the internal loop opening scheme is evaluated according to the network economic and technical indicators.
3. Case analysis

A regional power network is shown in the following figure, at present, the three-phase short-circuit current of A and B 220 kV side of 500kV substation is close to 50kA, and the short-circuit current shall be controlled by the internal loop opening, the following three internal loop opening schemes are proposed.

![Topology diagram of a regional power network](image)

**Figure 1.** Topology diagram of a regional power network

Scheme 1: Break A-a17 double lines and a11-a12 double lines. Type of transmission lines near the internal loop opening: a16-a17 line is LGJ-2×300, a16-a19 line is LGJ-2×400, and B1-a12 double lines are LGJ-2×400. As calculated, the economic and technical indicators of scheme 1 are shown in the table1.

| Indicators Calculation results | T1   | T2   | T3   | T4   |
|-------------------------------|------|------|------|------|
| Scheme 1                      | 0.102| 0.059| 29%  | 53%  |

Scheme 2: Break a16-a17 line, a16-a19 line and a11-a12 double lines. Type of transmission lines near the internal loop opening: A-a17 double lines are LGJ-2×630, and B1-a12 double lines are LGJ-2×400. As calculated, the economic and technical indicators of scheme 2 are shown in the table 2.

| Indicators Calculation results | T1   | T2   | T3   | T4   |
|-------------------------------|------|------|------|------|
| Scheme 2                      | 0.105| 0.104| 12%  | 22%  |

Scheme 3: Break a16-a17 line, a16-a19 line, a8-a10 double lines and a8-a9 line. Type of transmission lines near the internal loop opening: A-a17 double lines are LGJ-2×630, and a10-a11 double lines are LGJ-2×185. As calculated, the economic and technical indicators of scheme 3 are shown in the table 3.
Table 3. Economic and technical indicators of scheme 3

| Indicators          | T_1   | T_2   | T_3   | T_4   |
|---------------------|-------|-------|-------|-------|
| Calculation results | 0.118 | 0.106 | 20%   | 25%   |

Compared with the above three internal loop opening schemes, the indicators of scheme 1: T_1 and T_2 are the best, while T_3 and T_4 are the worst, the indicators of scheme 2: T_1 and T_2 are in the middle, while T_3 and T_4 are the best, the indicators of scheme 3: T_1 and T_2 are the worst, while T_3 and T_4 are in the middle. Taking into account the economic and technical indicators, it is suggested to adopt scheme 2 as the internal loop opening scheme.

4. Summary

In this paper, a set of economic and technical indicators of regional power grid internal loop opening scheme are proposed. Mainly includes short-circuit current decline, the load rate of 500kV substation, the active power flow transfer of transmission line near internal loop opening, regional network loss rate, the specific meaning of each indicators are expounded, and the calculation and analysis method of indicators is illustrated by an example. The indicators can provide important reference for the economic and technical evaluation of the internal loop opening of regional power network.

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