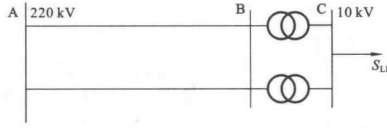
11-1 输电系统如题 11-1 图所示。已知：每台变压器 $S_N=100$ MV·A，$\Delta P_0=450$ kW，$\Delta Q_0=3500$ kvar，$\Delta P_S=1000$ kW，$U_S=12.5\%$，工作在-5%的分接头；每回线路长 250 km，$r_1=0.08\ \Omega/\text{km}$，$x_1=0.4\ \Omega/\text{km}$，$b_1=2.8\times10^{-6}$ S/km；负荷 $P_{LD}=150$ MW，$\cos\varphi=0.85$。线路首端电压 $U_A=245$ kV，试分别计算：

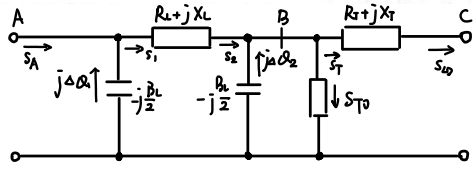


题 11-1 图

(1) 输电线路、变压器以及输电系统的电压降落和电压损耗；

(2) 输电线路首端功率和输电效率；

(3) 线路首端 A、末端 B 及变压器低压侧 C 的电压偏移。



线路参数 $R_L=\frac{1}{2}rl=\frac{1}{2}\times0.08\times250\ \Omega=10\Omega$

$X_L=\frac{1}{2}xl=\frac{1}{2}\times0.4\times250\ \Omega=50\Omega$

$B_L=2b_1l=2\times2.8\times10^{-6}\times250\ S=14\times10^{-4}S$

变压器参数 $R_T=\frac{\Delta P_S U_N^2}{S_N^2}\times\frac{1}{2}=\frac{1000\times220^2}{100^2}\times10^{-3}\times\frac{1}{2}\Omega=2.42\Omega$

$X_T=\frac{U_S\%}{100}\times\frac{U_N^2}{S_N}\times\frac{1}{2}=\frac{12.5}{100}\times\frac{220^2}{100}\times\frac{1}{2}\Omega=30.25\Omega$

$\Delta P_{T0}=2\Delta P_0=2\times450\ kW=900kW$

$\Delta Q_{T0}=2\Delta Q_0=2\times3500\ kvar=7000\ kvar$

$S_{T0}=\Delta P_{T0}+\Delta Q_{T0}=(900+j7000)\ kVA=(0.9+j7.0)\ MVA$

假设各电压均为额定电压，计算功率分布

由 $P_{LD}=150MVA$ $\cos\varphi=0.85$ 得 $Q_{LD}=P_{LD}\cdot\tan\varphi=92.961\ Mvar$

$\Delta S_T=\frac{P_{LD}^2+Q_{LD}^2}{U_N^2}(R_T+jX_T)=\frac{150^2+92.961^2}{220^2}(2.42+j30.25)\ MVA$

$=(1.5571+j19.4637)\ MVA$

$S_T = S_{1b} + \Delta S_T = [(150 + j92.9617) + (1.5571 + j19.4637)]\ MVA$

$= (151.5571 + j112.4254)\ MVA$

$\Delta Q_1 = \Delta Q_2 = \frac{B_L}{2} U_N^2 = 7\times10^{-4}\times220^2\ Mvar = 33.88\ Mvar$

$S_2 = S_T + \Delta S_{T0} - j\Delta Q_2$

$= [(151.5571 + j112.4254) + (0.9 + j7.0) - j33.88]\ MVA$

$= (152.4571 + j85.5454)\ MVA$

$\Delta S_L = \frac{P_2^2 + Q_2^2}{U_N^2}(R_L + jX_L) = \frac{152.4571^2 + 85.5454^2}{220^2}(10 + j50)\ MVA$

$= (6.3143 + j31.5715)\ MVA$

$S_1 = S_2 + \Delta S_L = [(152.4571 + j85.5454) + (6.3143 + j31.5715)]\ MVA$

$= (158.7714 + j117.1169)\ MVA$

$S_A = S_1 - j\Delta Q_1 = [(158.7714 + j117.1169) - j33.88]\ MVA$

$= (158.7714 + j83.2369)\ MVA$

1D1的输电线路：

求压降落：

$d\dot{U}_L = \frac{P_1R_L + Q_1X_L}{U_A} + j\frac{P_1X_L - Q_1R_L}{U_A}$

$= \left(\frac{158.7714\times10 + 117.1169\times50}{245} + j\frac{158.7714\times50 - 117.1169\times10}{245}\right)kV$

$= (30.3819 + j27.6220)kV = 41.0614\angle42.476°\ kV$

$U_B = \sqrt{(U_A - \Delta U_L)^2 + (\delta U_L)^2} = 216.3883\ kV$

电压损耗：$U_A - U_B = (245 - 216.3883)kV = 28.611\ kV$

10)变压器

电压降落

$$d\dot{U}_T = \frac{P_T R_T + Q_T X_T}{U_B} + j\frac{P_T X_T - Q_T R_T}{U_B}$$

$$= \left(\frac{151.5571\times 2.42 + 112.4239\times 40.75}{216.3883} + j\frac{151.5571\times 40.75 - 112.4239\times 2.42}{216.3883}\right) kV$$

$$= (17.9115 + j\,19.7296)\,kV = 26.4641\angle 48.859^\circ kV$$

$$U_c' = \sqrt{(U_B - dU_T)^2 + (\delta U_T)^2} = 199.9724\,kV$$

电压损耗 $U_B - U_c' = (216.3883 - 199.9724)\,kV = 16.4159\,kV$

(c)输电系统

电压降落 $d\dot{U} = d\dot{U}_L + d\dot{U}_T = [(30.3589 + j\,27.6220) + (17.9115 + j\,19.7296)]\,kV$

$$= (47.7934 + j\,47.3516)\,kV$$

电压损耗 $U_A - U_c' = (245 - 199.9724)\,kV = 45.0276\,kV$

12) 首端功率 $S_1 = (158.7714 + j\,83.2369)\,MVA$

输电效率 $\eta = \frac{P_D}{P_S}\times 100\% = \frac{150}{158.7714}\times 100\% = 94.48\%$

13)

点A电压偏移 $\frac{U_A - U_N}{U_N}\times 100\% = \frac{245-220}{220}\times 100\% = 11.36\%$

点B电压偏移 $\frac{U_B - U_N}{U_N}\times 100\% = \frac{216.3883-220}{220}\times 100\% = -1.64\%$

变压器实际变比 $k_T = \frac{220(1-0.05)}{11} = \frac{209}{11} = 19$

点c实际电压 $U_c = \frac{U_c'}{k_T} = \frac{199.9724}{19}\,kV = 10.5248\,kV$

点c电压偏移 $\frac{U_c - U_N}{U_N}\times 100\% = \frac{10.5248-10}{10}\times 100\% = 5.25\%$