POWER SYSTEM PLANNING

EXERCISE 1.2

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GitHub Repository

https://github.com/rbuddhila95/PSPlab22_1120079_Ravindu.git

Selection of optimal voltage and current rating for an overhead line

$k_A = 240 \frac{€}{km.mm^2}$

$k_V = 2.800 \frac{€}{km \cdot kV}$

$k = 0{,}1 \frac{€}{kWh}$

$\alpha = 10 \frac{\%}{a}$

$h_r = 3.000 \frac{h}{a}$

Assume $I_o = 1000$ €

$$K = \alpha(I_0 + k_V \cdot V + k_A \cdot A) + k \cdot h_r \cdot \frac{\rho}{A} \cdot \frac{S_r^2}{V^2}$$

Take cross section values as 10, 16, 25, 35, 50, 70, 95, 120, 150, 185, 240, 300, 400, 500 mm^2

Let's find the optimal voltage values for each cross-section value and hence, the Annual cost each:

Cross-section mm^2	Optimal Voltage kV	Annual Cost €
10	21.24	925885.39
16	18.16	810951.28
25	15.65	727146.77
35	13.99	681425.82
50	12.42	651577.74
70	11.10	644240.18
95	10.02	659115.45
120	9.28	687566.82
150	8.61	731641.80
185	8.02	791223.99
240	7.36	895199.39
300	6.83	1017035.29
400	6.20	1230788.87
500	5.76	1452094.94

According to the mathematical calculation the minimum annual cost is for **70 mm^2** cable with **11.10 kV**

But the standardized voltage levels are, 11kV, 22kV and 33 kV

So, we can select **11kV voltage level** and **70 mm^2 cross-section**

For that case,

Optimum cost = 644279.22 €

ANNEX

```
from sympy import *
spResistivity = 2.86*10**(-2) #convert to mm^2/m
kA = 240
kV = 2800
k = 0.1
alpha = 10
hr = 3000
Sr = 10**4/0.8
Io = 1000 #assume invariable investment cost is equal to 1000 EUR
A = [10,16,25,35,50,70,95,120,150,185,240,300,400,500]
V = symbols("V")

for a in A:
    dCostbydA = alpha*kV - 2*k*hr*(spResistivity/a)*(Sr**2/V**3)
    v = solve(Eq(dCostbydA,0))[0]

    AnCost = alpha*(Io+kV*v+kA*a) + k*hr*(spResistivity/a)*(Sr**2/v**2)
    print ("Cross section ", a, " mm^2, = Voltage = ",v, "kV, Annual Cost = ", AnCost, "EUR")
```

```
from sympy import *
spResistivity = 2.86*10**(-2) #convert to mm^2/m
kA = 240
kV = 2800
k = 0.1
alpha = 10
hr = 3000
Sr = 10**4/0.8
Io = 1000 #assume invariable investment cost is equal to 1000 EUR
A = 70
V = 11


AnCost = alpha*(Io+kV*V+kA*A) + k*hr*(spResistivity/A)*(Sr**2/V**2)
print ("Cross section ", A, " mm^2, = Voltage = ",V, "kV, Annual Cost = ", AnCost, "EUR")
```