Экспериментальные данные

| № | $U_N$ $(mV)$ | $U_T$ $(V)$ | $T_{cm}$ $(°C)$ |
|---|---|---|---|
| 1 | 34.02 | 0.108 | 18.8 |
| 2 | 65.01 | 0.214 | 18.8 |
| 3 | 87.43 | 0.312 | 18.9 |
| 4 | 109.45 | 0.417 | 19.1 |
| 5 | 116.35 | 0.463 | 19.3 |
| 6 | 135.43 | 0.593 | 19.6 |
| 7 | 162.47 | 0.835 | 19.9 |
| 8 | 168.76 | 0.900 | 20.2 |
| 9 | 188.00 | 1.100 | 20.6 |
| 10 | 187.30 | 1.120 | 21.0 |

Данные установки

$R_N := 0.1\ \Omega$ $R_0 := 0.28736\ \Omega$ $l := 81.5\ mm$ $d_1 := 0.189\ mm$

$c_0 := 5.67 \cdot 10^{-8}\ \frac{W}{\left(m^2 \cdot K^4\right)}$ $\varepsilon(t) := \left(0.00013 \cdot \frac{t}{K} - 0.0025\right)$ $d_2 := 0.0025\ m$

Расчёт

$$I_{нити} := \frac{U_N}{R_N} = \begin{bmatrix} 0.34 \\ 0.65 \\ 0.874 \\ 1.095 \\ 1.164 \\ 1.354 \\ 1.625 \\ 1.688 \\ 1.88 \\ 1.873 \end{bmatrix} A \qquad R_{нити} := \frac{U_T}{I_{нити}} = \begin{bmatrix} 0.317 \\ 0.329 \\ 0.357 \\ 0.381 \\ 0.398 \\ 0.438 \\ 0.514 \\ 0.533 \\ 0.585 \\ 0.598 \end{bmatrix} \Omega$$

$$R_T := \frac{R_{нити}}{R_0} - 1 = \begin{bmatrix} 0.105 \\ 0.146 \\ 0.242 \\ 0.326 \\ 0.385 \\ 0.524 \\ 0.788 \\ 0.856 \\ 1.036 \\ 1.081 \end{bmatrix}$$

$$T_1 := \left\| \begin{array}{l} \text{for } i \in 0..9 \\ \quad C_i \leftarrow \left( 273.15 + 252.0 \cdot R_{T_i} \cdot \frac{2}{1 + \sqrt[2]{1 - 0.1485 \cdot R_{T_i}}} \right) \cdot K \\ C \end{array} \right\| = \begin{bmatrix} 299.65 \\ 310.024 \\ 334.652 \\ 356.282 \\ 371.547 \\ 407.806 \\ 478.034 \\ 496.155 \\ 545.158 \\ 557.447 \end{bmatrix} K$$

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$$q_l := \left\| \begin{array}{l} \text{for } i \in 0..9 \\ \quad C_i \leftarrow \frac{I_{нити}^{\widehat{i}} \cdot U_T^{\widehat{i}}}{l} \\ C \end{array} \right\|$$

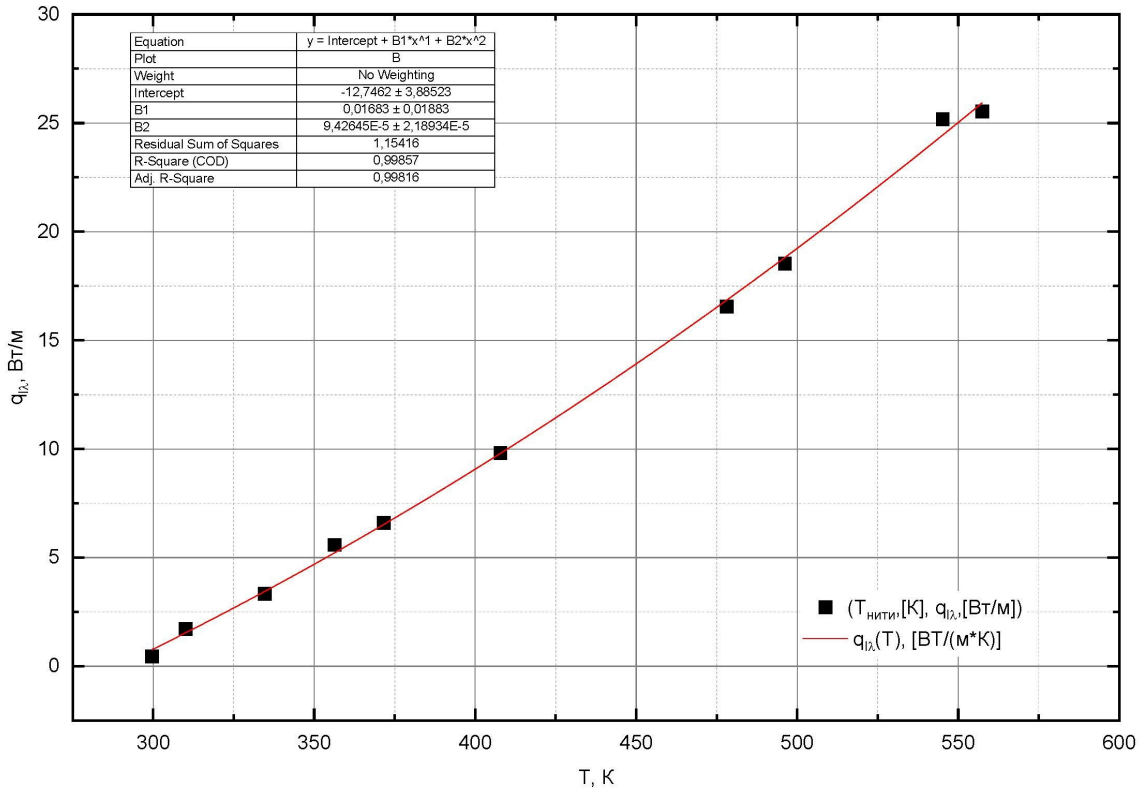
$$q_l = \begin{bmatrix} 0.451 \\ 1.707 \\ 3.347 \\ 5.6 \\ 6.61 \\ 9.854 \\ 16.646 \\ 18.636 \\ 25.374 \\ 25.739 \end{bmatrix} \frac{W}{m}$$

$$q_{lR} := \left\| \begin{array}{l} \text{for } i \in 0..9 \\ \quad C_i \leftarrow \varepsilon\left(T_1^{\widehat{i}}\right) \cdot c_0 \cdot \left(\left(T_1^{\widehat{i}}\right)^4 - \left(\left(T_{cm}\right)^{\widehat{i}}\right)^4\right) \cdot \pi \cdot d_1 \\ C \end{array} \right\|$$

$$q_{lR} = \begin{bmatrix} 9.785 \cdot 10^{-4} \\ 0.003 \\ 0.007 \\ 0.013 \\ 0.018 \\ 0.035 \\ 0.09 \\ 0.111 \\ 0.186 \\ 0.21 \end{bmatrix} \frac{W}{m}$$

$$q_{l\lambda} := q_l - q_{lR} = \begin{bmatrix} 0.45 \\ 1.704 \\ 3.34 \\ 5.587 \\ 6.592 \\ 9.819 \\ 16.556 \\ 18.525 \\ 25.188 \\ 25.53 \end{bmatrix} \frac{W}{m}$$

Произведём аппроксимацию полученных данных в OriginPro,
ниже представлен график




$$a := -12.7462 \qquad b := \frac{0.01683}{K} \qquad c := \frac{9.42645 \cdot 10^{-5}}{K^2}$$

$$q_{l\lambda}\_fitting(t) := a + b \cdot t + c \cdot t^2$$

$$A := \frac{1}{2 \cdot \pi} \ln\left(\frac{d_2}{d_1}\right) \qquad B := b \cdot K \qquad C := 2 \cdot c \cdot K$$

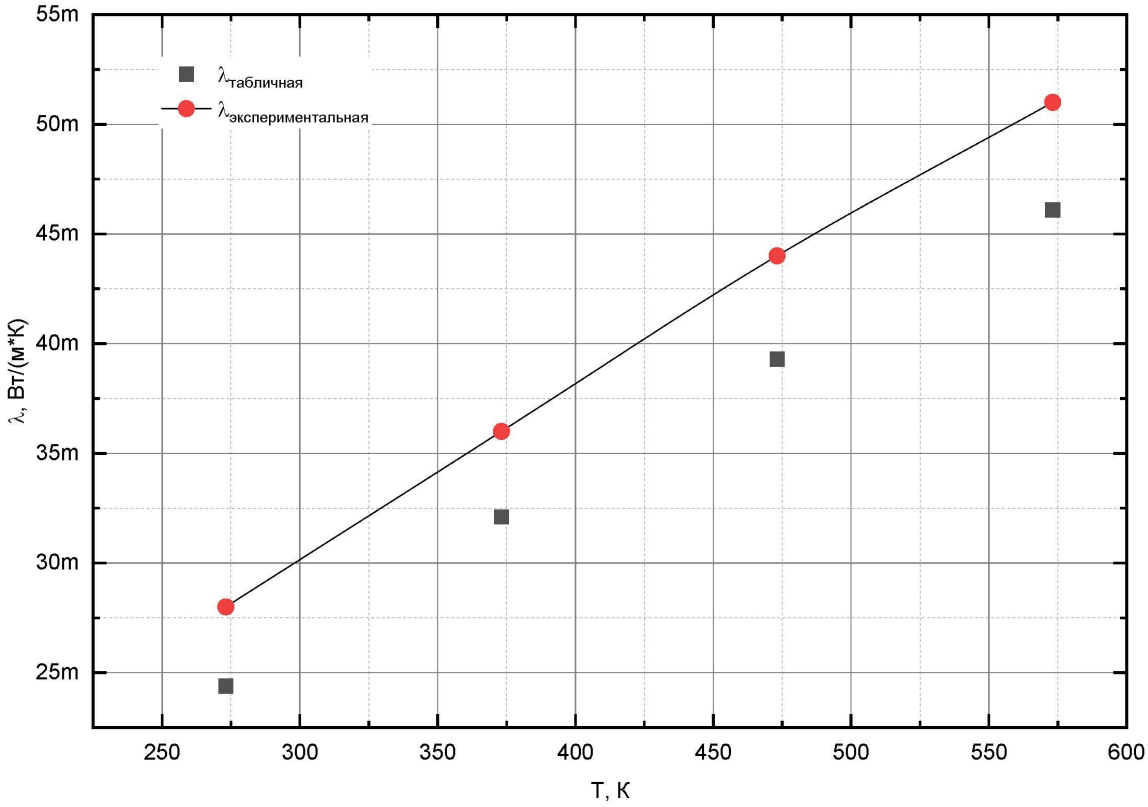
$$\lambda(T) := A \cdot (B + C \cdot T)$$

| $T_{табличная}$ $(K)$ | $\lambda_{табличная}$ $\left(\frac{W}{m \cdot K}\right)$ |
|---|---|
| 273.15 | 0.0244 |
| 373.15 | 0.0321 |
| 473.15 | 0.0393 |
| 573.15 | 0.0461 |

$$\lambda_{экспериментальная} := \lambda\left(T_{табличная}\right) \cdot \frac{W}{m \cdot K}$$

$$\lambda_{экспериментальная} = \begin{bmatrix} 0.028 \\ 0.036 \\ 0.044 \\ 0.051 \end{bmatrix} \frac{W}{m \cdot K}$$

Построим график в OriginPro

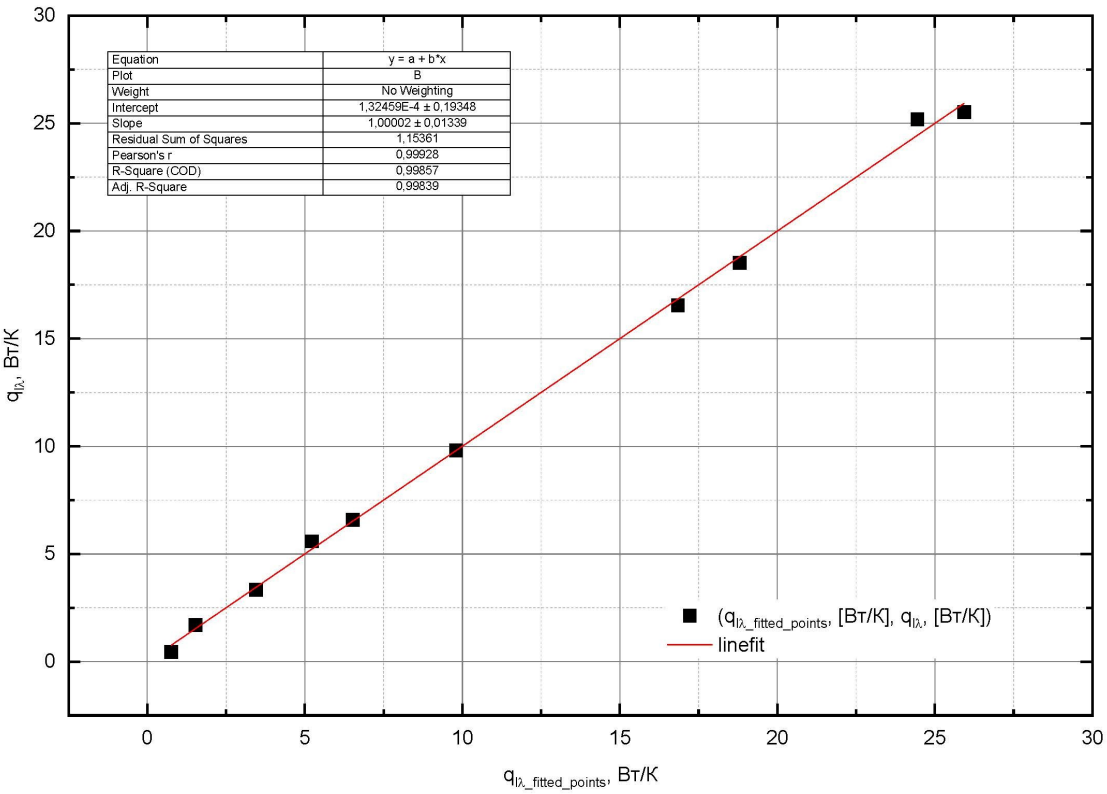



$$\Delta\lambda := \frac{\left|\lambda_{экспериментальная} - \lambda_{табличная}\right|}{\lambda_{табличная}} = \begin{bmatrix} 0.35 \\ 0.266 \\ 0.218 \\ 0.185 \end{bmatrix}$$

$$q_{l\lambda\_fitted\_points} := q_{l\lambda}\_fitting\left(T_1\right) \cdot \frac{W}{m}$$

$$q_{l\lambda\_fitted\_points} = \begin{bmatrix} 0.761 \\ 1.532 \\ 3.443 \\ 5.216 \\ 6.52 \\ 9.794 \\ 16.84 \\ 18.809 \\ 24.444 \\ 25.928 \end{bmatrix} \frac{W}{m}$$

Построим график в OriginPro



Расчёт случайной ошибки эксперимента

$\sigma_B := 0.01883$ $\sigma_C := 2 \cdot \frac{\left(2.18934 \cdot 10^{-5}\right)}{K}$

$\sigma_\lambda := A \cdot \sqrt{{\sigma_B}^2 + {T_1}^2 \cdot {\sigma_C}^2}$

$\sigma_\lambda = \begin{bmatrix} 0.009 \\ 0.01 \\ 0.01 \\ 0.01 \\ 0.01 \\ 0.011 \\ 0.012 \\ 0.012 \\ 0.012 \\ 0.013 \end{bmatrix}$ $\frac{\sigma_\lambda}{\lambda\left(T_1\right)} = \begin{bmatrix} 0.313 \\ 0.308 \\ 0.299 \\ 0.291 \\ 0.286 \\ 0.277 \\ 0.263 \\ 0.26 \\ 0.254 \\ 0.253 \end{bmatrix}$

Обработка данных по методу цилиндрического слоя

$\lambda_{cp} := \left(\frac{1}{2 \cdot \pi} \cdot \ln\left(\frac{d_2}{d_1}\right)\right) \cdot \frac{q_l}{T_1 - T_{cm}} = \begin{bmatrix} 0.024 \\ 0.039 \\ 0.032 \\ 0.036 \\ 0.034 \\ 0.035 \\ 0.037 \\ 0.038 \\ 0.041 \\ 0.04 \end{bmatrix} \frac{W}{m \cdot K}$

$T_m := \frac{T_1 + T_{cm}}{2} = \begin{bmatrix} 295.8 \\ 300.987 \\ 313.351 \\ 324.266 \\ 331.998 \\ 350.278 \\ 385.542 \\ 394.752 \\ 419.454 \\ 425.799 \end{bmatrix} K$

$$\lambda_m := \frac{1}{2 \cdot \pi} \cdot \ln\left(\frac{d_2}{d_1}\right) \cdot \frac{q_{l\lambda}}{T_1 - T_{cm}} = \begin{bmatrix} 0.024 \\ 0.039 \\ 0.032 \\ 0.036 \\ 0.034 \\ 0.035 \\ 0.037 \\ 0.038 \\ 0.041 \\ 0.04 \end{bmatrix} \frac{W}{m \cdot K}$$

Построим график в OriginPro