1. Temperature-dependent material properties of UO2

(1) Density（$\mathrm{kg/m^3}$）[1]

$$\rho_{\mathrm{u}} = 10960(a + bT + cT^2 + dT^3)^{-3}$$

Where, T represents the temperature (K).

Table 1: Material parameter values for the density.

Parameter	$T \le 923K$	$T > 923K$
a	0.99734	0.99672
b	9.802×10^{-6}	1.179×10^{-5}
c	-2.705×10^{-10}	-2.429×10^{-9}
d	4.391×10^{-11}	1.219×10^{-12}

(2) Thermal conductivity（$\mathrm{W/m/K}$）[2]

$$k_{\mathrm{u}} = k_{95}\cdot f_{\mathrm{d}}\cdot f_{\mathrm{p}}\cdot f_{\mathrm{pro}}\cdot f_{\mathrm{x}}\cdot f_{\mathrm{r}}$$

k_{95} refers to the thermal conductivity of unirradiated uranium dioxide at 95% theoretical density（$\mathrm{W/m/K}$）; f_{d} is the soluble fission product correction factor; f_{p} is the insoluble fission product correction factor; f_{pro} is the porosity correction factor; f_{x} represents the deviation from stoichiometry, taken as 1.0 in this case; and f_{r} is the irradiation effect correction factor.

The temperature range for this model is 298~3120K, and the specific forms of these correction factors are as follows:

$$k_{95} = \frac{100}{7.5408 + 17.692\cdot T^{-3} + 3.6142\cdot T^{-6}} + \frac{6400}{T^{-15/2}}\exp\left(-\frac{16.35}{T^{-3}}\right)$$

$$f_{\mathrm{d}} = \left(\frac{1.09}{Bu^{3.265}} + 0.0643\cdot\sqrt{\frac{T}{Bu}}\right)\times\arctan\left(\frac{1.0}{\frac{1.09}{Bu^{3.265}} + 0.0643\cdot\sqrt{\frac{T}{Bu}}}\right)$$

$$f_{\mathrm{p}} = 1.0 + \left(\frac{0.019Bu}{3.0 - 0.019Bu}\right)\times\left(\frac{1.0}{1.0 + \exp\left(\frac{-T + 1200}{100}\right)}\right)$$

$$f_{\mathrm{por}} = \frac{1.0 - p}{1.0 + 0.5p}$$

$$f_{\mathrm{r}} = 1.0 - \frac{0.2}{1.0 + \exp\left(\frac{T - 900}{80}\right)}$$

Where, Bu represents the burnup (%); p represents the fuel porosity (%).

(3) Specific heat capacity（$\mathrm{J/kg/K}$）[3]

$$C_{\mathrm{u}} = C_1\left(\frac{\theta}{T}\right)^2\exp\left(\frac{\theta}{T}\right)\left(\exp\left(\frac{\theta}{T}\right) - 1\right)^{-2} + 2C_2T + C_3E_{\mathrm{a}}\exp\left(\frac{-E_{\mathrm{a}}}{T}\right)T^{-2}$$

Where C_1, C_2 and C_3 are material parameters, with values of $302.27\ \mathrm{J/kg/K}$, $8.463\times10^{-3}\ \mathrm{J/kg/K}$ and $8.741\times10^{7}\ \mathrm{J/kg/K}$, respectively. θ is the Einstein temperature, with a value of $548.68\ \mathrm{K}$; E_a is the ratio of electronic activation energy to the Boltzmann constant, with a value of $18531.7\ \mathrm{K}$.

(4) Coefficient of thermal expansion ($1/\mathrm{K}$) [4]

$$\alpha_\mathrm{u} = m + nT + jT^2 + kT^3$$

Table 2: Material parameter values for the coefficient of thermal expansion.

Parameter	$T \le 923K$	$T > 923K$
m	9.28×10^{-6}	1.183×10^{-5}
n	-6.390×10^{-10}	-5.103×10^{-9}
j	1.33×10^{-12}	3.756×10^{-12}
k	-1.757×10^{-17}	-6.125×10^{-17}

(5) Young's modulus (Pa) [5]

$$E_\mathrm{u} = 2.334\times10^{11}(1-2.752(1-D))(1-1.0915\times10^{-4}T)$$

2. Temperature-dependent material properties of 316SS [6]

(1) Density ($\mathrm{kg/m^3}$)

$$\rho = 8084 - 0.4209T - 3.894\times10^{-5}T^2$$

(2) Thermal conductivity ($\mathrm{W/m/K}$)

$$k = 9.248 + 0.01571T$$

(3) Specific heat capacity ($\mathrm{J/kg/K}$)

$$c_\mathrm{p} = 462 + 0.134T$$

(4) Coefficient of thermal expansion ($1/\mathrm{K}$)

$$\alpha_\mathrm{c}(T) = 1.789\times10^{-5} + 2.398\times10^{-9}T + 3.269\times10^{-13}T^2$$

(5) Young's modulus (Pa)

$$E = 2.15946\times10^{11} - 7.07727\times10^{7}T$$

(6) Melting point: 1700K

(7) Yield strength (MPa)

$$\sigma_{0.2\%} = \begin{cases} 555.5 - 0.25T & \text{if } T < 600^\circ\mathrm{C} \\ 405.5 - 0.775(T - 600) & \text{if } 600^\circ\mathrm{C} < T < 1000^\circ\mathrm{C} \\ 345.5 - 0.25T & \text{if } T > 1000^\circ\mathrm{C} \end{cases}$$

The material parameters listed above are primarily sourced from the referenced literature, with some modifications based on experiments conducted by the Nuclear Power Institute of China.

[1] Fink J K. Thermophysical properties of uranium dioxide[J]. Journal of nuclear materials, 2000, 279(1): 1-18.

[2] Williamson R L, Hales J D, Novascone S R, et al. Multidimensional multiphysics simulation of nuclear fuel behavior[J]. Journal of Nuclear Materials, 2012, 423(1-3): 149-163.

[3] Carbajo J J, Yoder G L, Popov S G, et al. A review of the thermophysical properties of MOX and UO2 fuels[J]. Journal of Nuclear materials, 2001, 299(3): 181-198.

[4] Martin D G. Thermal expansion of solid UO/sub 2/and (U, Pu) mixed oxides-a review and recommendations[J]. J. Nucl. Mater.;(Netherlands), 1988, 152(2/3).

[5] Hagrman D L, Reymann G A. MATPRO-Version 11: a handbook of materials properties for use in the analysis of light water reactor fuel rod behavior[R]. Idaho National Lab.(INL), Idaho Falls, ID (United States), 1979.

[6] Hales J D, Williamson R L, Novascone S R, et al. BISON theory manual the equations behind nuclear fuel analysis[R]. Idaho National Lab.(INL), Idaho Falls, ID (United States), 2016.