Application of Two-Dimensional Discrete Cosine Transform to Coefficients of Bailey-Norton Creep Law

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Introduction Bailey-Norton creep law which is one of the power law is mainly used to express the transient creep and the steady creep of high temperature materials such as boiler and turbine materials. This time we have found out that the two-dimensional discrete cosine transform (2D DCT) can express well both stress and temperature dependence of the coefficients of the creep equation at the same time(1).

Two-Dimensional Discrete Cosine Transform If the 2D DCT coefficient is $F[k, l]$, the discrete cosine transform and the inverse discrete cosine transform (IDCT) for the 2D discrete signal $f[i, j]$ with a size of $N \times N$ are expressed by the following equations(2).

$$F[k, l] = \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} f[i, j] \phi[k][i] \phi[l][j]$$

(1-1)

$$f[i, j] = \sum_{k=0}^{N-1} \sum_{l=0}^{N-1} F[k, l] \phi[k][i] \phi[l][j]$$

(1-2)

$$\phi[k][i] = \frac{1}{\sqrt{N}}, k = 0$$

$$= \sqrt{\frac{2}{N}} \cdot \cos\{(2i+1)\pi/2N\}, k = 1, 2, \ldots, N-1$$

(1-3)

Coefficients of Bailey-Norton Method Expressed by 2D DCT We selected the transient creep curve data from Fujimoto et al.’s paper(3). The used data are the reading values by the author. The equation of Bailey-Norton method is as follows;

$$\varepsilon = A \cdot \sigma^n \cdot t^m$$

(2)

We calculated $A, n, m$ of Eq.(2) from the above data by using the least square method. The used data are 400, 425, 450, 475 °C in temperature and 15.0, 17.5, 20.0, 22.5 kg/mm² in stress (4×4). Then we expressed the obtained $A, n, m$ respectively by using the 2D DCT. The results are shown in Fig.1, Fig.2 and Fig.3. The values at 412.5, 437.5, 462.5 °C under 16.25, 18.75, 21.25 kg/mm² were interpolated by the 2D DCT. As shown in Fig.1, 2, 3, it is found that the 2D DCT can express well both stress and temperature dependence of $A, n, m$ respectively. Moreover, the 2D DCT curved planes pass through all the measured $A, n, m$ values.

Conclusion As shown in Figure 4, it is possible to estimate unknown creep curves using interpolated coefficients of Bailey-Norton equation extracted from the 2D DCT curved planes.

