KAWASAKI STEEL TECHNICAL REPORT
No.1 (September 1980)

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Evaluation of Thermal Shock Resistance of Refractories by Using Acoustic Emission Technique*

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Theoretical and experimental problems encountered in evaluating thermal shock resistance of refractories are summarized and a newly developed evaluation method using acoustic emission for detection of cracking is explained.

It has been clarified that thermal shock conditions, specimen dimensions and restraining conditions, which were ignored in the previous studies, have a great influence on the thermal shock damage behavior. [illegible]

Sufficient propriety for the evaluation is also given by the calculation of thermal

in this case is called thermal shock fracture resistance parameter, and various parameters are proposed ac- tion is given below on the assumption that disk-shaped Griffith cracks with a radius l exist uniformly

tions. Among these, following three equations assum- between them.

used.

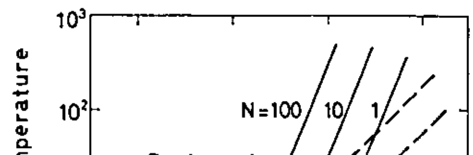
During rapid heating:

$$R = \frac{\sigma_f \cdot (1-\nu)}{E\alpha} \quad \cdots\cdots (1)$$

During slow heating:

$$R' = \frac{\sigma_f \cdot k(1-\nu)}{E\alpha} \quad \cdots\cdots (2)$$

$$\Delta T_c = \left[\frac{\pi\gamma(1-2\nu)^2}{2E\alpha^2(1-\nu^2)}\right]^{1/2} \times \left[1 + \frac{16(1-\nu^2)Nl^3}{9(1-2\nu)}\right] l^{-1/2} \quad \cdots (6)$$



above may be effective in providing target property values for material development and making com-

theoretical evaluation. According to their results obtion method of crack initiation and propagation include the possibility of monitoring in real time, high sensitivity and high accuracy. On the other hand, there has been some demerits such as under-development in quantitative elucidation of AE mechanism and a difficulty in the calibration of the measurement system. In the following section, the authors will present these experimental results and discuss the capabilities of the evaluation for thermal shock resistance of refractories.

3 Thermal Stress Produced in Refractories during Experiment by Panel Method

sional plane model, and derived the following relation on the assumption that a crack extends when the thermal stress exceeds the tensile stress of the refractory.

$$\frac{d^2T}{dx^2}\left(\frac{b^2}{16 + 3b^2/x^3}\right) \geqq \frac{\sigma_f}{E_\alpha} \qquad \cdots\cdots\cdots\cdots (8)$$

b: Refractory width
x: Distance from hot face

He also demonstrated that the crack position corresponds to that predicted by equation **(8)**.

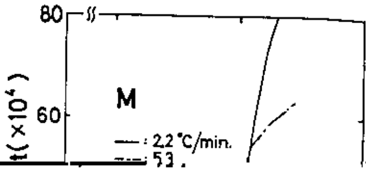
Such thermo-elastical analytical calculation involves the hot face increases further. Although moving away from the hot face. As shown in **Fig. 7**, the magnitude of σ is scarcely affected by the restrain-

ing stress in the direction parallel to the hot face. On

powerful guide to a thermal shock experiment by the panel method

Table 2 Typical properties of refractories

	Sample					
	M	D-1	D-4	A	MC-1	MC-2
Porosity (%)	13.8	15.0	13.9	16.4	14.9	14.8



[redacted]

condition in actual service conditions and the experimental conditions in evaluating the thermal shock resistance may result in an incorrect decision. Application of the AE technique to the panel method has such merits as changeability of thermal shock conditions and capability of high sensitive monitoring of crack propagation behavior, and it gives a result with better correspondence with the actual service performance than conventional experimental evaluation methods.

4.2 Refractory Materials

[redacted]

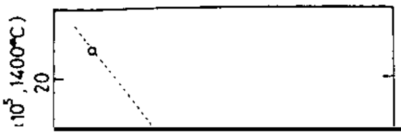
tion.

4.3 Specimen Size

Fig. 12 shows the test results for different cross sectional size of D-1 refractories. To eliminate the simple influence of the cross sectional area, the relation between the total ringdown count per unit cross sectional area and the hot face temperature is shown here. As the cross sectional area size decreases and the cross sectional shape approaches a square, the AE count and damage decrease. This result corresponds

[redacted]

step-like AE characteristic implies that the fracture



advanced evaluation is possible as compared with the conventional experimental evaluation. The quantitative relationship between the degree of damage and the ringdown count is yet to be studied because of