INTERNAL FRICTION DURING STEADY STATE CREEP OF 25Cr-20Ni AUSTENITIC STAINLESS STEEL

T. Yamane, Y. Takahashi, K. Hatano

To cite this version:


HAL Id: jpa-00221115
https://hal.archives-ouvertes.fr/jpa-00221115
Submitted on 1 Jan 1981

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
INTERNAL FRICTION DURING STEADY STATE CREEP OF 25Cr-20Ni AUSTENITIC STAINLESS STEEL

T. Yamane, Y. Takahashi and K. Hatano

Department of Materials Science and Engineering, Osaka University, Yamadakami, Suita, Osaka 565, Japan

Abstract. Internal friction was measured to know the changes in the dislocation density and loop length during the steady state creep. Main experimental results are (1) Internal friction of fine grain specimens (d=30μm) is constant during the steady state creep. (2) The decrease in internal friction is observed in medium (d=150μm) and coarse (d=600-850μm) grain specimens, and it is remarkable at high creep stress. The decrease is considered to correspond to that of Al₁⁴.

1. Introduction. Changes in the dislocation distribution and density during creep are known by the direct observation of an electron microscope. No change is in them at low stress⁴ where the vacancy creep occurs, but they are changed during the steady state creep in the region of the power law creep.⁵ These changes can be investigated by the measurements of internal friction too. During deformation, the internal friction Q⁻¹ corresponding to dislocations can be expressed by the following equation:

\[ Q^{-1} = \frac{\mu^2 E A \varepsilon}{kT \omega} + \frac{8\mu^2 E b^2 B}{\eta_0^2 E^2 L} A_1^4 \omega \]  

where each symbol means that shown in Table 1. The first term in the right of Equation (1) is constant during the steady creep for constant ε and the second term corresponds to a kind of Granato-Lücke relaxation.⁵ The equation can be applied at small strain amplitude and in the lower resonance vibration frequency than kHz.

In this study, the change in A₁⁴ during the steady state creep is guessed by the measurements of the internal friction.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>dislocation density</td>
</tr>
<tr>
<td>B</td>
<td>quasi viscous constant</td>
</tr>
<tr>
<td>l</td>
<td>average loop length</td>
</tr>
<tr>
<td>b</td>
<td>Burgers vector</td>
</tr>
<tr>
<td>µ</td>
<td>orientation factor</td>
</tr>
<tr>
<td>T</td>
<td>absolute temperature</td>
</tr>
<tr>
<td>E</td>
<td>line energy</td>
</tr>
<tr>
<td>ε</td>
<td>strain rate</td>
</tr>
<tr>
<td>ω</td>
<td>frequency</td>
</tr>
<tr>
<td>E</td>
<td>elastic modulus</td>
</tr>
<tr>
<td>v</td>
<td>activation volume</td>
</tr>
<tr>
<td>k</td>
<td>Boltzmann constant</td>
</tr>
</tbody>
</table>

Table 1 Symbols in Equation (1).
2. Experimentals. Electrolysis iron, nickel and chromium were melted in the vacuum of $10^{-4}$ torr. A cast ingot was hot-forged and cold-drawn to 2mm diameter wire. The chemical compositions of the wire are Cr 22.77, Ni 21.39, C 0.005, Mn nil, Si 0.02, P 0.004 and Fe bal. in weight %. The grain size of the creep specimens was controlled by recrystallization heating at various temperatures and for various time length. The gauge length of the creep specimens was 45mm. The grain size was measured by the grain intercept method. Internal friction was obtained by the natural decay of torsional resonance vibration during creep, and the vibration frequency was 0.8-2Hz.

3. Results. Figs. 1 and 2 show examples of creep curves and internal friction measured during creep. These specimens have the average grain size of 30 and 850μm respectively. Changes in internal friction are summed up in Figs. 3 and 4. From these figures, following results can be recognised.

(1) Internal friction decreases independently of the grain size in the transition creep region.

(2) Fine grain specimens (d=30μm) have constant internal friction during the steady state creep.

(3) Medium (150μm) and coarse (600 and 850μm) grain specimens have the decrease in internal friction during the steady state creep. The decrease is remarkable in the high creep stress over 20MPa., but no decrease in low stress such as 14.7MPa.

In the steady state creep region, a strain rate is constant, but internal friction is not always constant. This cause can be considered that it corresponds to the change in Al as seen in Equation (1).

4. Discussion. The deformation mechanism of this experimental condi-
Fig. 2 Creep curves and internal friction. 
($d=850 \mu m$, $\sigma_a=34.3$ MPa)

Fig. 3 Changes in internal friction during creep.
Fig. 4 Changes in internal friction during creep.

tion corresponds to the dislocation creep region as shown in Fig. 5.\(^7\)
At the initial stage of the creep, there is a following relation between \(l\) and \(\Lambda\),
\[
1 \sim \Lambda^{-1/2} \quad \text{-------- (2)}
\]
and \(\Lambda l^4 \sim l^{-1}\) can be introduced. This means internal friction decreases with dislocation density during only initial creep.\(^3\) After the middle stage of the transition creep, the annihilation and rearrangements of dislocations and the formation of substructures must be considered;\(^3\)\(^8\) but the main cause of the decrease of the internal friction may owe to that of \(\Lambda l^4\).

5 Conclusion. Internal friction corresponding to \(\Lambda l^4\) was measured in the steady state creep region where the creep is controlled by the dislocation-recovery. The main experimental results obtained are as follows,

(1) Internal friction of the fine grain specimens (30\(\mu m\)) is constant during the steady state creep. (\(R_1\) region in Fig. 5)
(2) The medium (150\(\mu m\)) and coarse (600-850\(\mu m\)) grain specimens have
Fig. 5 $\sigma/G - d/b$ diagram for steady state creep.

$\sigma$: creep stress
$G$: shear modulus
$d$: grain size
$b$: Burgers vector
$T$: creep temperature
$T_m$: solidus temperature

The decrease in internal friction. (R2 region in Fig. 5)

6. References.
3) A. Orlova, M. Pahutova and J. Cadek: Phil. Mag. 25(1972) 865,
4) G. Kaiser and W. Pechhold: Act. Met. 17(1969) 527,