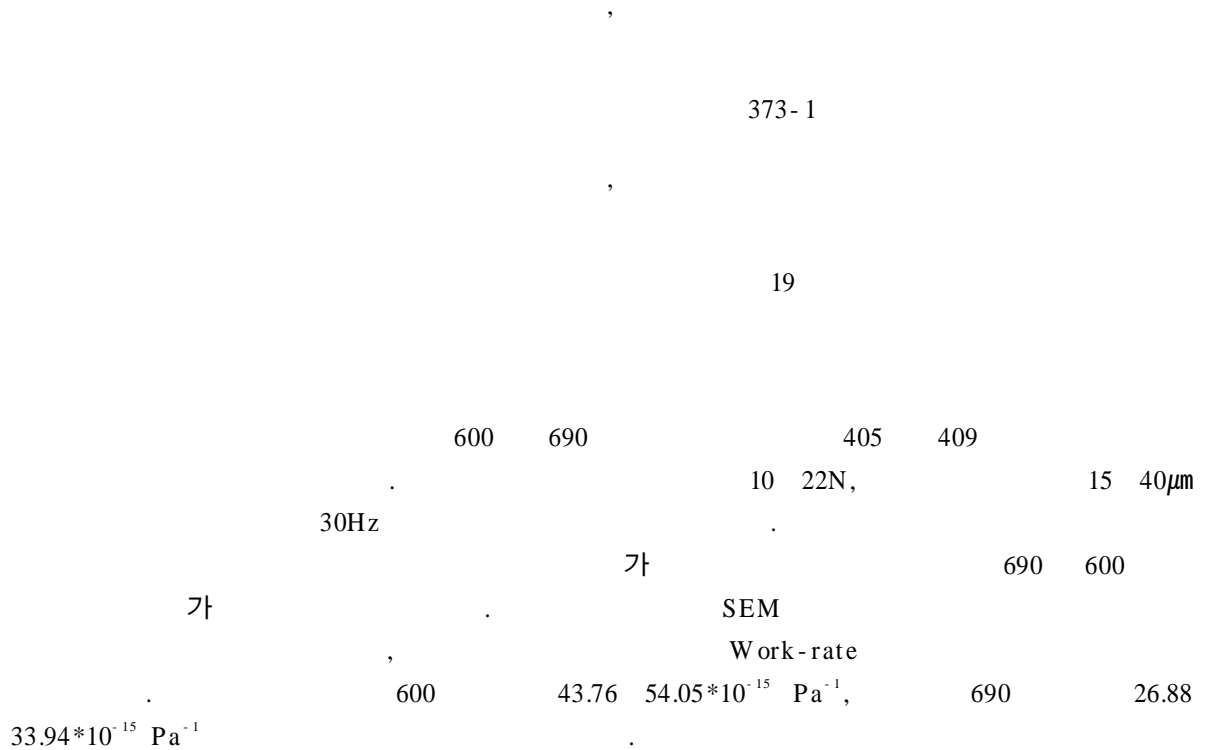


## Comparison of Wear Coefficients of Steam Generator Tube Materials



### Abstract

The wear resistance of SG tube materials against reciprocating loads in air environment has been compared by calculating wear coefficient of work-rate model for different tube and support material combinations. Wear testing of tube and support materials has been conducted at various loads and sliding amplitudes. The results showed a significant effect of normal load and sliding amplitude on tube wear damage. It also showed that, for a predominantly sliding motion, the wear rate is lower for Inconel 690TT compared with Inconel 600MA. From the examination of worn surface, it was found that there were different wear mechanisms between tube materials. Based on the work-rate model, average tube wear coefficients, for work-rates ranging from 4 to 30mW, wear calculated as  $43.76 \sim 54.05 \times 10^{-15} \text{ Pa}^{-1}$  for Inconel 600MA, and  $26.88 \sim 33.94 \times 10^{-15} \text{ Pa}^{-1}$  for Inconel 690TT against ferritic stainless steels.

(Flow-induced Vibration)

Palo verde Mihama

가

가

가

600

690

가

가

690

600

가

(Primary Water & Intergranular

Stress Corrosion Cracking)

가

[1].

690

가

가

가

690

가

가

600

690

405

409

Work-rate

2.

2.1

3/4

가

600

1

690

405

409

1

2

가

0.1mg

가

5

Ultrasonic

2.2

1

10 22N,

15 40μm

30Hz

Ultrasonic

2.3

(SEM)

가

가

가

2.4 Work-rate

Work-rate

Archard

가 Work-rate

3.

3.1

2

가

가

600

405

가

가

가

가

가

가

가

409

가

가 405

가

690

600

409

405

가

가

가

가

3.2

405

409

600

가

가

3

가

가

690

600

30 $\mu$ m

30 $\mu$ m

가

가

가

가



3.4 Work-rate

[5] Work-rate 5 가  
 600 , 409 405 가  
 가 409 가  
 , 405 600 409 405  
 409 690 , 600 가  
 690TT 가 , 405 409  
 690 409 600 405

4.

600 690 405 409  
 (1) 가 가 가  
 가 가 가  
 (2) 600 690 가  
 가  
 (3) 690 가 Delamination 가  
 Inconel 600MA 가  
 690 가  
 (4) 가 690 409 가  
 ,  $26.88 \times 10^{-15} \text{ Pa}^{-1}$  가  
 600 409  $54.05 \times 10^{-15} \text{ Pa}^{-1}$   
 가 600 405  
 690 409

5.

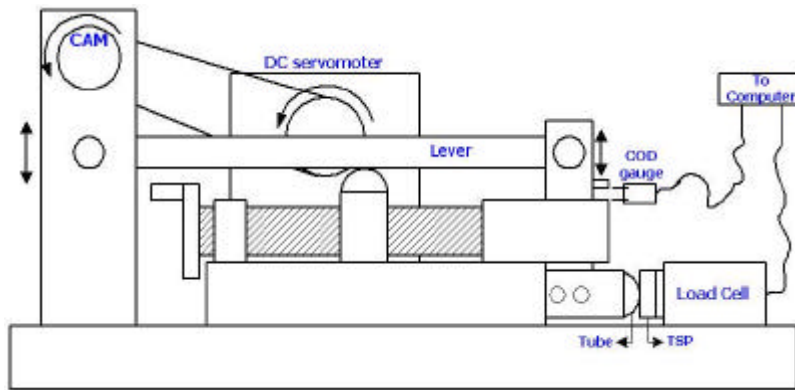
- [1] K. Stiller et al. " Structure, Chemistry and SCC of Grain Boundaries in Alloy 600 and 690. ", Metallurgical and Materials Transactions A, Vol. 27A, 1996
- [2] P. C. J. Gallagher, " The Influence of Alloying, Temperature, and Related Effects on the Stacking Fault Energy. ", Metallurgical Transactions, Vol. 1, 1970
- [3] J. M. Sarver et al. " Carbide Precipitation and SCC Behavior of Inconel Alloy 690. ", Corrosion, Vol. 44, 1988
- [4] K. Yamanaka " The Role of Grain Boundary Chromium Carbides on The IGA Resistance of Ni-base Alloy 600. ", Sixth Int. Sym. on Env. Deg. of Mat. in Nucl. Pow. Plants. 1993
- [5] F. M. Guerout et al, " Steam Generator Fretting-Wear Damage: A Summary of Recent Findings. ", Journal of Pressure Vessel Technology, Vol. 121, 1999

1. (wt%)

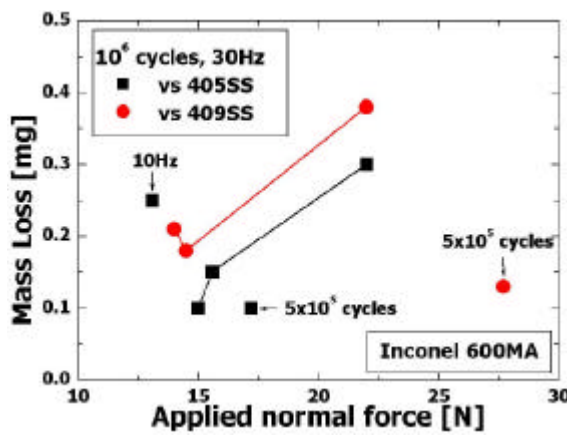
|            | Cr            | Fe   | C     | Si   | Mn   | Ti      | P     | S     | Co    | Ni   |
|------------|---------------|------|-------|------|------|---------|-------|-------|-------|------|
| <b>600</b> | 16.81         | 9.1  | 0.026 | 0.32 | 0.81 | 0.35    | 0.008 | 0.002 | 0.012 | Bal. |
| <b>690</b> | 29.5          | 10.4 | 0.02  | 0.33 | 0.26 | 0.32    | 0.004 | 0.001 | 0.012 | Bal. |
| <b>405</b> | 11.5<br>14.5  | Bal. | 0.08  | 1.00 | 1.00 | 0.1(A1) | 0.04  | 0.03  | -     | -    |
| <b>409</b> | 10.5<br>11.75 | Bal. | 0.08  | 1.00 | 1.00 | 6*%C    | 0.045 | 0.045 | -     | -    |

2. 600, 690 405, 409

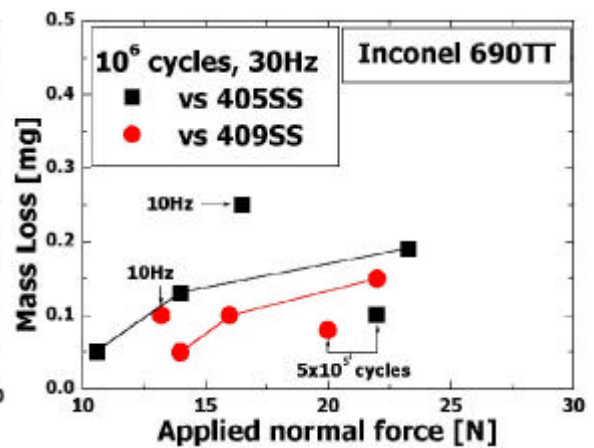
|              | (MPa) | (MPa) | (%)     | (HV) |
|--------------|-------|-------|---------|------|
| <b>600MA</b> | 283.5 | 682.6 | 47.3    | 194  |
| <b>690TT</b> | 316.5 | 708.7 | 46      | 193  |
| <b>405</b>   | 170   | 415   | 20(min) | 215  |
| <b>409</b>   | 205   | 415   | 22(min) | 229  |



1

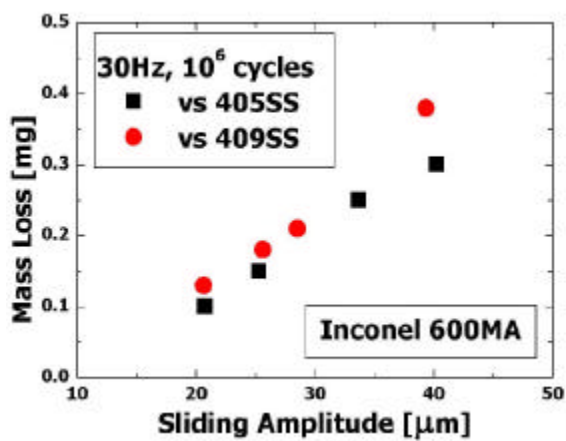


(a) 600

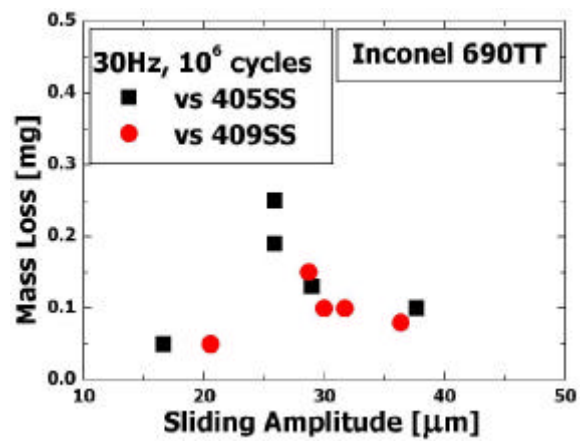


(b) 690

2.

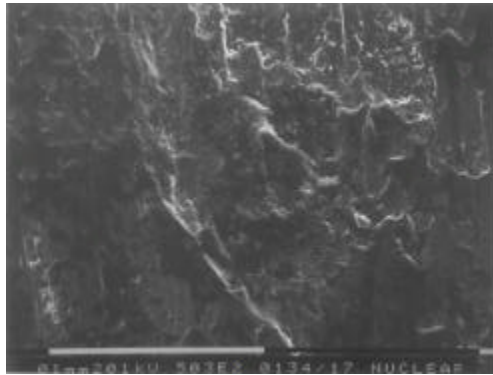


(a) 600

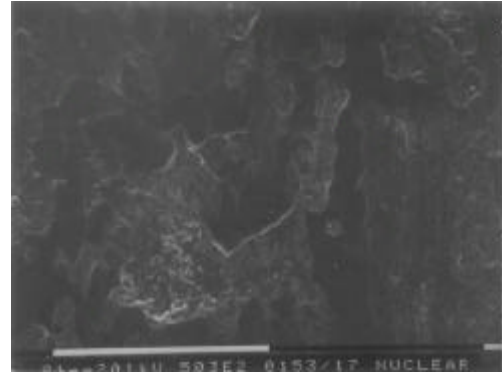


(b) 690

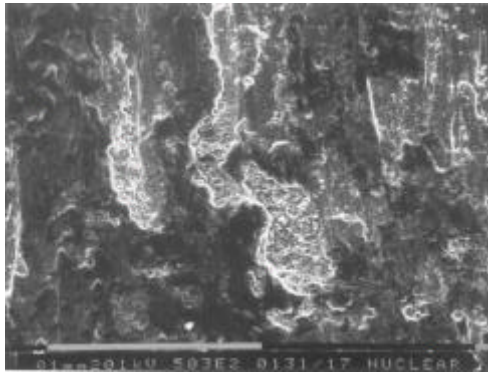
3



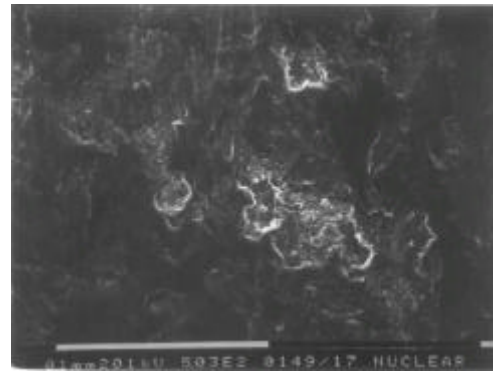
(a) 600 vs 405



(b) 600 vs 409



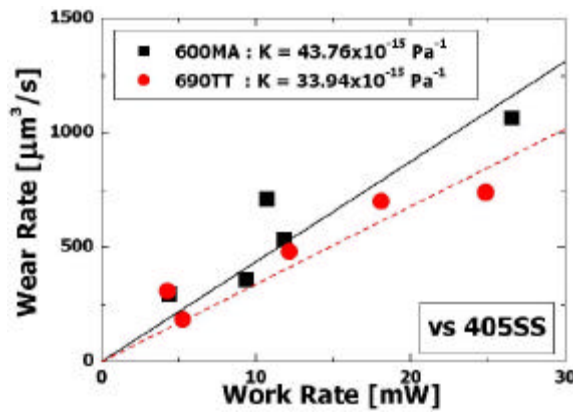
(c) 690 vs 405



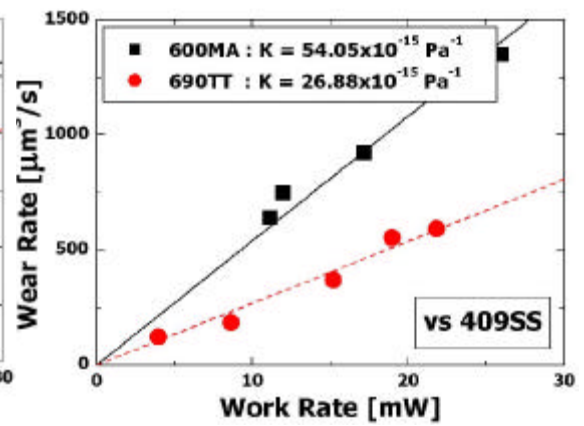
(d) 690 vs 409

4.

SEM



(a) 405



(b) 409

5 Work - Rate