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A REVIEW OF THE WALL PROBLEM AND
CONDITIONING TECHNIQUES FOR TOKAMAKS

BY

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PLASMA PHYSICS
LABORATORY

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Journal Paper at the 4th International Conference

on Plasma Surface Interactions in Controlled

Fusion Devices

Garmisch-Partenkirchen, F.R.G.

April 1986

 

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2. The second step is to

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1. *What is the main purpose of the text?*

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3. *How?*

4. *What are the main points of the text?*

5. *What is the author's attitude towards the topic?*

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7. *What is the conclusion?*

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22. *What is the conclusion?*

23. *What are the main points of the text?*

where k_1 and k_2 are the forward and reverse rate constants

$$\frac{d[M^+H]}{dt} = k_1[M^+][H_2O] - k_2[M^+H] = 0 \quad (2)$$

$$\frac{[M^+H]}{[M^+][H_2O]} = \frac{k_1}{k_2} = K_1 \quad (3)$$

where K_1 is the equilibrium constant for metal ion hydration.

$$\frac{d[M^+H_2O^+]}{dt} = k_3[M^+H][H_2O] - k_4[M^+H_2O^+] = 0 \quad (5)$$

where $[M^+]$, $[M^+H]$, and $[M^+H_2O^+]$ represent the concentrations of metal cation, metal cation-hydroxide, and metal cation-hydroxide-hydroxide in the near-surface region. Assuming that the rate of reaction (4) is negligible for the hydroxide formation, then the rate of reaction (1) can be written as

$$\frac{d[M^+H]}{dt} = k_1[M^+][H_2O] - k_2[M^+H] - k_3[M^+H][H_2O] \quad (6)$$

where

$$k = \frac{k_1 k_3}{k_2}$$

Leitz, et al. have examined the temperature dependence of the k_1

corresponding to the maximum of the curve is 1.44×10^{-4} mole/l. of hydrogen peroxide. This is in good agreement with Eq. (4) based on the formation of a complex between hydrogen peroxide and the polymer.

It has been reported that the average molecular weight of the polymer is approximately 100,000. The molecular weight of the polymer is important in determining the rate of the reaction. The rate of the reaction is expected to be proportional to the square of the molecular weight of the polymer. The rate of the reaction is expected to be proportional to the square of the molecular weight of the polymer. The rate of the reaction is expected to be proportional to the square of the molecular weight of the polymer.

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the frequency of electron bombardment and erosion of cathode surface. The plasma n_{pe} can be lowered to near zero by increasing the cathode surface area. A decrease in n_{pe} can be attributed for the reduction in electron density capability of the plasma. It is important to note that the electron density is listed in Table 1, which is a sufficient measure of the electron density of the plasma, while the cathode area is a measure of the electron density of the plasma.

In addition, the scattering effect of the cathode surface is also a factor in the plasma-wall and not the plasma-cathode interaction. The electron density is listed in Table 1, 1981, which is a sufficient measure of the electron density of the plasma. It is important to note that the electron density is listed in Table 1, which is a sufficient measure of the electron density of the plasma, while the cathode area is a measure of the electron density of the plasma. The electron density is listed in Table 1, which is a sufficient measure of the electron density of the plasma, while the cathode area is a measure of the electron density of the plasma.

The effect of electron bombardment on the plasma parameters is also a factor in the plasma-wall and not the plasma-cathode interaction. The electron density is listed in Table 1, 1981, which is a sufficient measure of the electron density of the plasma. It is important to note that the electron density is listed in Table 1, which is a sufficient measure of the electron density of the plasma, while the cathode area is a measure of the electron density of the plasma. The electron density is listed in Table 1, which is a sufficient measure of the electron density of the plasma, while the cathode area is a measure of the electron density of the plasma.

Surface analysis measurement of discharge cleaned surfaces of stainless steel (11 e.v., see Fig. 8), and residual gas measurements of the burning rate of oxygen-containing gases within discharge cleaned vacuum vessel (e.v.,

 

Acknowledgments

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19. TFR Group, J. Neukirchner, Mater. 26(1979)1581-1583.
20. TFR Group, 4th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (Garmisch-Partenkirchen, F.R.G., April 1990) paper E-3.
21. R. J. Taylor, R. E. Jamslah, and E. Schepfer, 4th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (Garmisch-Partenkirchen, F.R.G., April 1990) paper E-4.
22. L. J. Leisner, 4th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (Garmisch-Partenkirchen, F.R.G., April 1990) paper E-5.
23. L. J. Leisner and H. Grotzky, 4th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (Garmisch-Partenkirchen, F.R.G., April 1990) paper E-6.
24. Surface Contamination: Genesis, Detection, and Control, R. J. Taylor, Ed., Plenum Press, NY 1979.
25. L. J. Mathewson, in Plasma-wall Interactions (Proc. Int. Symp., 1977), Vol. 1, Gordon and Breach, London 1977, 117.
26. A. Borker, G. Ferro, G. Lippi, and L. Paoletti, J. Nucl. Energy, C23 (1979) 1017.
27. Princeton Plasma Physics Laboratory, vacuum chamber design and specification (unpublished data).
28. R. S. Barton and R. P. Govier, Vacuum 29 (1979) 1.
29. A. Mathewson and M. H. Achard in Proc. 7th Int. Vacuum Congress and 5th Int. Conf. Solid Surfaces, 1977 (P. Wobrowsky, et al., eds), Vol. 1, Vienna (1977) 1217.
30. L. M. Meade in Plasma-wall Interactions (Proc. Int. Symp., 1977), Vol. 1.

Parham, P. Press, Oxford, 1972, p. 113.

- [1] G. M. M. Harrison and R. E. Smith, *Phil. Mag.* **14**, 1073 (1964).
- [2] R. E. Smith and G. M. Harrison, *J. Phys. Chem.* **70**, 2310 (1966).
- [3] G. M. Harrison, et al., *J. Phys. Chem.* **74**, 2760 (1970).
- [4] G. Harrison, G. M. Harrison, and R. E. Smith, in *Electron Microscopy and Spectroscopy*, R. E. Smith, ed., Wiley, London, 1969, p. 107.
- [5] G. Harrison, et al., *J. Phys. Chem.* **74**, 2760 (1970).
- [6] G. Harrison, et al., *J. Phys. Chem.* **74**, 2760 (1970).
- [7] G. Harrison, et al., *J. Phys. Chem.* **74**, 2760 (1970).
 
- [15] Metallurgical Thermochemistry, R. E. E. Kohn, ed., Wiley, New York, 1967, p. 107.

$$f_{\text{eff}} = \frac{\pi}{2} \left(\frac{1 + \sqrt{1 - \frac{1}{n^2}}}{2} \right) \approx \frac{\pi}{2} \left(1 - \frac{1}{4n^2} \right)$$

1. The first group of 10 subjects had no previous experience with the apparatus and were naive to the purpose of the study. They were given practice trials before the first experimental session to become familiar with the apparatus and the procedure. The second group of 10 subjects had previous experience with the apparatus and the procedure. They were given practice trials before the first experimental session to become familiar with the apparatus and the procedure. The third group of 10 subjects had previous experience with the apparatus and the procedure. They were given practice trials before the first experimental session to become familiar with the apparatus and the procedure. The fourth group of 10 subjects had previous experience with the apparatus and the procedure. They were given practice trials before the first experimental session to become familiar with the apparatus and the procedure. The fifth group of 10 subjects had previous experience with the apparatus and the procedure. They were given practice trials before the first experimental session to become familiar with the apparatus and the procedure. The sixth group of 10 subjects had previous experience with the apparatus and the procedure. They were given practice trials before the first experimental session to become familiar with the apparatus and the procedure. The seventh group of 10 subjects had previous experience with the apparatus and the procedure. They were given practice trials before the first experimental session to become familiar with the apparatus and the procedure. The eighth group of 10 subjects had previous experience with the apparatus and the procedure. They were given practice trials before the first experimental session to become familiar with the apparatus and the procedure. The ninth group of 10 subjects had previous experience with the apparatus and the procedure. They were given practice trials before the first experimental session to become familiar with the apparatus and the procedure. The tenth group of 10 subjects had previous experience with the apparatus and the procedure. They were given practice trials before the first experimental session to become familiar with the apparatus and the procedure.

the behavior of the gas temperature components T_{H_2} , T_{He} and T_{Ar} during the afterglow of a typical high-power discharge in H_2 (the wall temperature $T_w = 115^\circ K$). For comparison, the time behavior of H_2 at the wall temperature only is also plotted. The indicated partial pressures were measured with a calibrated mass spectrometer; however, considerable variation in the absolute quantities of H_2 and He are noted with variations of plasma and wall conditions (36).

Fig. 4. Partial pressures of the residual gases CH_4 at 0.1 mm and C_2H_2 at 0.2 mm produced within the PDX torus during H_2 glow discharge conditioning (GOC) of the vacuum vessel before March 1, 79, and (b) after March 1, 79.

shows the second major configuration period which is characterized by the oscillation of the internal front. As shown in Figure 10, the time-integrated removal of ^{239}Pu was about the same for the two experiments, and for ^{241}Pu it was only about 10% greater for the first 100 days of the experiment. The results are shown in Figure 11. It is apparent that the removal of ^{239}Pu is about the same for both experiments, while the removal of ^{241}Pu is about 10% greater for the first 100 days of the experiment.

 

[illegible]

1990-1991 41* 105,194 25.00%

... the representation of the self appears to be...

*The 1971-72 series before and after 1971-72 are not available.

U.S. DEPARTMENT OF AGRICULTURE

15. $\bullet$ The spectrum of a stationary stochastic process is called the power spectrum.

1. The following information is being furnished to you for your information:

that the Fe is completely oxidized in a short time; i.e.,

^{II} and Fe^{III} oxidation states. After exposure to air, the color changed from green to brown. The color change was reversible after treatment with sodium dithionite. The color change was also observed in the presence of other metal ions such as Cu^{II}, Ni^{II}, Zn^{II}, and Co^{II}. The color change was attributed to the formation of a complex between the ligand and the metal ion. The complex was formed by the coordination of the ligand to the metal ion through the nitrogen atom of the imine group. The complex was stable in the presence of water and other metal ions. The color change was also observed in the presence of other metal ions such as Cu^{II}, Ni^{II}, Zn^{II}, and Co^{II}. The color change was attributed to the formation of a complex between the ligand and the metal ion. The complex was formed by the coordination of the ligand to the metal ion through the nitrogen atom of the imine group. The complex was stable in the presence of water and other metal ions.

conditioning (b) the Fe^{III} state disappears and the water-soluble

Fe^{3+} appears. Fe^{2+} is not observed (c) after Ar^+ ion bombardment.

is sufficient to remove the hydrocarbon contaminants.

appears (d) only when the fluence is sufficient: $\phi \geq \phi_{th}$.

partially remove the oxide layer by sputtering [11].

[illegible]

The following are the names of the persons who have been appointed to the various positions in the Department of the Interior, for the year ending June 30, 1901:

Position	Name
Secretary	John D. Smith
Assistant Secretary	John D. Smith
Chief of Bureau	John D. Smith
Chief of Division	John D. Smith
Chief of Office	John D. Smith
Chief of Section	John D. Smith
Chief of Branch	John D. Smith
Chief of Unit	John D. Smith
Chief of Detail	John D. Smith
Chief of Staff	John D. Smith
Chief of Adjutant	John D. Smith
Chief of Quartermaster	John D. Smith
Chief of Commissary	John D. Smith
Chief of Medical	John D. Smith
Chief of Veterinary	John D. Smith
Chief of Artillery	John D. Smith
Chief of Cavalry	John D. Smith
Chief of Infantry	John D. Smith
Chief of Engineers	John D. Smith
Chief of Ordnance	John D. Smith
Chief of Signal	John D. Smith
Chief of Transportation	John D. Smith
Chief of Communications	John D. Smith
Chief of Public Works	John D. Smith
Chief of Finance	John D. Smith
Chief of Legal	John D. Smith
Chief of Education	John D. Smith
Chief of Agriculture	John D. Smith
Chief of Commerce	John D. Smith
Chief of Labor	John D. Smith
Chief of Social	John D. Smith
Chief of Health	John D. Smith
Chief of Religion	John D. Smith
Chief of Art	John D. Smith
Chief of Science	John D. Smith
Chief of Literature	John D. Smith
Chief of Music	John D. Smith
Chief of Drama	John D. Smith
Chief of Poetry	John D. Smith
Chief of History	John D. Smith
Chief of Geography	John D. Smith
Chief of Mathematics	John D. Smith
Chief of Natural Science	John D. Smith
Chief of Social Science	John D. Smith
Chief of Political Science	John D. Smith
Chief of Economics	John D. Smith
Chief of Law	John D. Smith
Chief of Medicine	John D. Smith
Chief of Surgery	John D. Smith
Chief of Dentistry	John D. Smith
Chief of Pharmacy	John D. Smith
Chief of Veterinary Medicine	John D. Smith
Chief of Veterinary Surgery	John D. Smith
Chief of Veterinary Dentistry	John D. Smith
Chief of Veterinary Pharmacy	John D. Smith
Chief of Veterinary Medicine and Surgery	John D. Smith
Chief of Veterinary Medicine and Dentistry	John D. Smith
Chief of Veterinary Medicine and Pharmacy	John D. Smith
Chief of Veterinary Medicine and Surgery and Dentistry	John D. Smith
Chief of Veterinary Medicine and Surgery and Pharmacy	John D. Smith
Chief of Veterinary Medicine and Surgery and Dentistry and Pharmacy	John D. Smith

— Discharge

TIME

Figure 3. Average Response Functions

Figure 3

Reaction Mechanism of Iron

Reaction

1

2

3

4

5

6

7