Investigation on local formation of expanded austenite phase by atmospheric-pressure plasma jet

A. Maeda[1], R. Ichiki[1], R. Tomizuka[1], H. Nishiguchi[2], T. Onomoto[3]
S. Akamine[1], S. Kanazawa[1]

[1] *Faculty of Engineering, Oita University, Oita, Japan*
[2] *Research Promotion Institute, Oita University, Oita, Japan*
[3] *Fukuoka Industrial Technology Center, Kitakyushu, Japan*

We succeeded in forming expanded austenite phase (S phase) of stainless steel locally by atmospheric-pressure pulsed-arc plasma jet using N_2/H_2. We confirmed the formation of S phase from metallographic structure and XRD patterns. We found that surface hardness increases. This indicates that reduction of passivation film on stainless steel by hydrogen is successful.

1. Introduction

Austenite stainless steel is widely used for food processing equipments and chemical plants due to its good corrosion resistance. However, this steel does not have high hardness and wear resistance. Therefore, the wider application has been limited. To overcome the shortcoming, studies to form S phase on austenite surface has been carried out all over the world [1]. S phase is austenite phase that contains dense nitrogen. This phase has not only good corrosion resistance but also high surface hardness and wear resistance.

We need remove the passivation film of stainless steel surface to diffuse nitrogen. This film is removed by sputtering in low-pressure plasma nitriding. On the other hand, We have developed atmospheric-pressure plasma nitriding as unique technology [2]. However, it is impossible to sputter it in atmospheric-pressure plasma. Therefore, we attempted the use of hydrogen to reduce passivation film to form the S phase by the atmospheric-pressure plasma.

2. Experimental setup

JIS SUS304 ($25\times25\times5$ mm^3) was used as a sample. A ceramic heater was used to control treatment temperature to 425°C. N_2/H_2 mixed gas (N_2 97%, H_2 3%) is used as the operating gas. The pulsed voltage of 5 kV and 21 kHz was applied to the inner electrode and the generated jet plume is sprayed onto the sample surface. The duration is 2h.

3. Results and discussions

Metallographic structure of sample cross-section is shown in Fig. 1. The thin film is formed on the outermost surface.

XRD patterns of sample surface is shown in Fig. 2. Here, r is the distance from irradiation center. S and γ indicate the S phase and the base metal, respectively. We can obviously see S from r = 0 to 12 mm. The position of S shifts toward low 2θ with increasing r. This indicates that nitrogen concentration increases with r. This is probably attributed to that surface temperature and diffusion coefficient decrease with r. Moreover, intensity of S decreases with increasing r. This corresponds to that thickness of S phase decreases with r. Additionally, hardness test proved that surface hardness increases.

In conclusion, we succeeded in forming S phase by atmospheric-pressure plasma for the first time. This indicates that reduction of passivation film by hydrogen is successful.

This work was supported by JSPS KAKENHI Grant Number 15K17482.

4. References

[1] Y. Sun *et al*., J. Mater. Sci. **34** (1999) 4793.
[2] H. Nagamatsu *et al*., Surf. Coat. Technol. **225** (2013) 26.

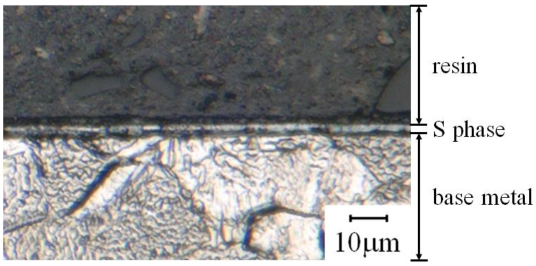

Fig. 1 Metallographic structure of sample cross-section.

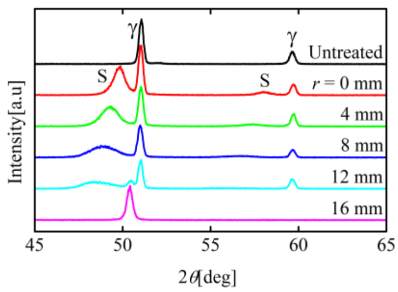

Fig. 2 XRD patterns of sample surface.