27pC07

大気圧プラズマジェットを用いた低級鋼の高速表面硬化処理
Rapid Hardening of Low-Class Steel Surface using Atmospheric-Pressure Plasma Jet

永松寛和、市來龍大、井上貴史、赤峰修一、金澤誠司
H. Nagamatsu, R. Ichiki, T. Inoue, S. Akamine, S. Kanazawa
大分大工
Oita Univ.

Plasma nitriding is one of the surface-hardening technologies utilized for a number of mechanical products such as automobile components, dies, etc. We have succeeded in nitriding using atmospheric-pressure pulsed-arc (PA) plasma jet without vacuum system [1]. However, low-alloy steel is not hardened by nitriding because hardening by nitriding requires precipitation of nitrided rare metals. On the other hand, "nitriding/quenching" invokes the martensitic transformation of ion to harden steel surface without rare metals. Moreover, treatment time is shorter than nitriding time. Here, we report the first trial of nitriding/quenching using atmospheric-pressure PA plasma jet.

The jet nozzle is composed of a coaxial cylindrical electrode system and the nozzle tip is covered by a simple container made of quartz for reducing O_2 gas in the treatment atmosphere as shown in Fig. 1. N_2-H_2 mixture gas (N_2:20 slm, H_2: 220 sccm) is introduced into the jet nozzle. The low-frequency voltage pulse (4–5 kV in height and 21 kHz in repetition) is applied using a high voltage power supply. The maximum of the discharge current is ca. 1 A. The afterglow of the generated PA plasma is spewed from the jet nozzle tip.

The sample is a square plate (20×20 mm^2 and 1 mm in thickness) of low-alloy steel JIS SPCC (C:0.02%). The treatment temperature is maintained at 900 °C by plasma jet itself for transforming steel from ferrite to austenite. The treatment time is 30 min. Subsequently, the sample is dropped into distilled water for quenching. In this way, sample steel is transformed from austenite to ion-nitrogen martensite.

The hardness profile of cross-section of nitrided/quenched sample is shown in Fig. 2(a), where the vertical axis is the depth from the sample surface and the horizontal axis is the radial position of the sample, the origin of the horizontal axis corresponding to the center of jet spraying. Near the radial position of 0 mm, the sample is uniformly hardened in depth direction and the hardness is increased from 150 $Hv_{0.01}$ of the base material to 400 $Hv_{0.01}$. On the other hand, near ±10 mm, the hardness is increased to 650 $Hv_{0.01}$. For comparison, Fig. 2(b) shows the hardness profile of only nitrided SPCC cross-section. This figure proves that the hardness is not considerably increased only by nitriding. As a result, we succeeded in hardening low-alloy steel which does not include rare metal by nitriding/quenching.

[1] R. Ichiki, H. Nagamatu, Y. Yasumatu, T. Iwao, S. Akamine, and S. Kanazawa, Mater. Lett. **71**,134 (2012).

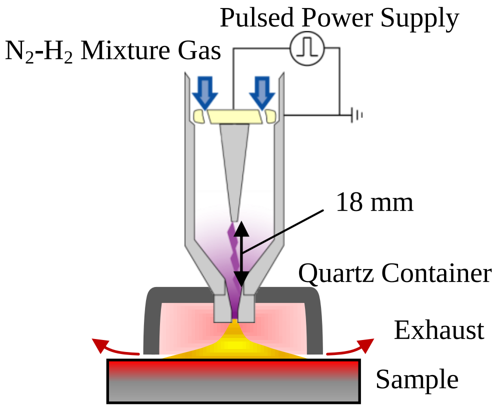

Fig.1. Schematic of the experimental equipment.

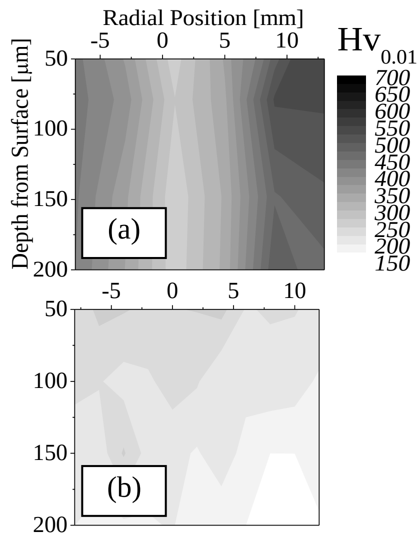

Fig.2. (a) Hardness profile of cross-section of nitrided/quenched sample.
(b) Hardness profile of cross-section of nitrided sample.