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Plasma Nitriding Performed under Atmospheric Pressure using Pulsed-Arc Plasma Jet

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Plasma nitriding is one of the case-hardening technologies to elongate the lifetimes of mechanical components, dies, etc. The conventional plasma nitriding requires a low pressure plasma produced in a vacuum chamber. We believe that atmospheric-pressure plasma technologies have a potential to create novel nitriding without a vacuum system, leading to easy-to-operate, economical case hardening. Our basic idea is to spray the pulsed-arc plasma jet generated with nitrogen (N_2) gas onto the surface of steels.
The experiments are carried out in a closed container to purge residual oxygen (O_2) by N_2 introduction for preventing undesirable oxidization of specimens. The specimens are disk-shaped hot work steel of JIS SKD 61. The plasma jet nozzle is composed of coaxial cylinder electrodes made of stainless steel. Pulsed-arc discharge is generated between the inner and outer electrodes using a high voltage power supply (plasmatreat FG3001). The afterglow is spewed out through a jet orifice of 4 mm in diameter, producing the jet plume.
We found that only spraying the nitrogen plasma jet resulted in oxidization of the specimen surface owing to residual O_2. However, the continuous addition of H_2 gas to the N_2 atmosphere during the treatment, intended to the reduction of residual O_2, realized the formation of the nitrided layer [1]. The hardness profile and the thickness of the formed diffusion layer is very comparable to those for conventional nitriding. The thickness, however, is not uniform even in the radial range of 10 mm. We have discovered also that the addition of H_2 gas to the operating N_2 gas outperforms the above-mentioned H_2 addition to the N_2 atmosphere. In the former case the H_2 addition rate necessary for nitriding is one-tenth of that for the latter. Moreover, the thickness of the diffusion layer becomes more uniform. Spectroscopic study uncovered that the nitriding mechanism involves the production of NH radicals.
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Keywords
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