## Hardfacing Overlay Welding by RP Plasma Arc
—Study on Hardfacing Process Using Extremely Hard Material (2nd Report)—

*by Masaki Nakojima, Masato Ueda and Akira Nohtomi*

In the previous report, the test results of the newly developed hardfacing process with transition metal carbide powder by the conventional DCSP plasma torch were described. In this study, bead-on-plate and multilayer overlay welding tests by the trial manufactured DCRP plasma torch have been carried out ot improve weldability of this process.

The results obtained are summarized as follows:

1) It is necessary to add a small amount of oxidizing gas ($CO_2$ or $O_2$) into the carrier gas in order to stabilize the arc. By the addition of oxidizinf gas, the weldability is improved due to increase of the wettability of overlay weld metal, though the penetration of overlay weld is increased.

2) The deposition efficiency is also improved, because the powder feeding rate can be increased exceedingly even at the lower heat input level than the case of DCSP welding.

3) In the case of high carbide content, the cathode flame is apt to occur due to fixing cathode spot of oxidizing gas is not added. Once the cathode flame occur, it will become impossible to carry out favorable overlay welding, because the shielding is disturbed and the cleaning action is gone out.

4) The occurrence of the cathode flame can be prevented by an addition of 0.2∼0.4 % $CO_2$ or $O_2$ in the one-layer overlay welding, but this preventing effect is not observed at the second and upper layers in the multilayer overlay welding. Therefore, in the multilayer overlay welding of carbide content above 80 %, it is hardly to obtain the sound overlay weld without any welding defects such as blowhole and lack of fusion.

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## Improvement of Stability and Self-Regulation of Welding Arc by Power Source with Nonlinear Characteristic

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A power source characteristic is proposed for improving the stability and self-regulation of the wleding arc in a constant feeding speed system. The welding system is described by nonlinear differential equations. The phase-plane analysis is used for the present investigation. The current and voltage of the arc constitute the coordinates of a representative point in the phase-plane. The steady solutions which are correlated with singular points in the phase-plane are first sought for various characteristics of the power source. The stability of steady solutions is discussed by considering the behavior of variations from the steady solutions. Our object is to improve the stability and self-regulation of the welding arc. These problems are investigated by studying the solution in the transient state, which, with the lapse of time, ultimately yields the steady solution. For this purpose, it is particularly useful to investigate the trajectory of the solution in the phase-plane and the time response of the solution in the transient state.

When the power source has a constant voltage characteristic, the time response of the welding arc may usually be quick. However, a slight deviation of the arc voltage from the singular point may produce such a large value of variation of the arc current that the spary arc cannot be sustained. When the power source has a drooping characteristic or a constant current characteristic, it may usually, but not necessarily, take a long time for the representative point to reach the vicinity of the singular point. From the analytical results, it will be deduced that a nonlinear characteristic of power source is useful for improving the stability and self-regulation of the arc.

We have developed a nonlinear characteristic power source consisting of transistors and function generators, and performed the experiments by making use of the power source. The arc phenomena are observed by means of the high speed motion pictures. The validity of the theoretical results is confirmed by the experimental investigations.

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## Underwater Automatic Oxy arc Curring of Thick Tubes at Water Depth up to 150 m

*by Masanobu Hamasaki, Yoji Ogawa Munehide Katsumura Yoshiro Matsukawa and Hiroshi Nakamura*

The authors have developed underwater automatic oxy-arc cutting method of tubes and this method was put into application to cutting of tubes of 1 m diam. and 16 mm thick used for construction of bridge pier at water depth of about 10 m. As a successful result was obtained, for the purpose of underwater cutting of beat-in-tube which is employed for preventing overturn of offshore platform, an experiment of underwater cutting using high pressure chamber was at this time carried out. Tubes used were 1 m diam. and 35 and 45 mm thick. Cutting at deep water depth was obtained the same result that at shallow water depth, however cutting oxygen pressure must be added 5–8 kg/mm² to water pressure corresponding water depth.

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