Plasma Welding of Centrifugal Cast Steel Pipe (HK—40) (Report I)†

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Abstract

It was proven that the keyhole type plasma welding method is very effective to the high speed circumferential joint weld of centrifugal cast steel pipe (HK—40). In such a case, however, the proper programming is needed as to the start of weld, formation of back bead, crater treatment, etc. Such an optimum programming was examined.

1. Introduction

The plasma arc welding method can perform a high speed weld operation of 20—40 cm/min to the material with thickness of 10—20 mm, if the keyhole type process is employed. In addition, the even back bead can be obtained in a relatively easy way. Therefore, the study on its practical application was carried out. However, many problems are still open about the application of this welding method to the circumferential joint welding of pipe of such special material like HK—40 (A-567) (25Cr-20Ni-0.4C), and only few reports were published on the industrial application in this connection. The programming of **Fig. 1**[1] is so far known as the typical welding conditions for the circumferential joint of the thin wall pipe (AISI, 304 (18Cr-8Ni)). When, however, the authors applied this programming to the circumferential welding of HK—40 centrifugal cast steel pipe, following problems were found.

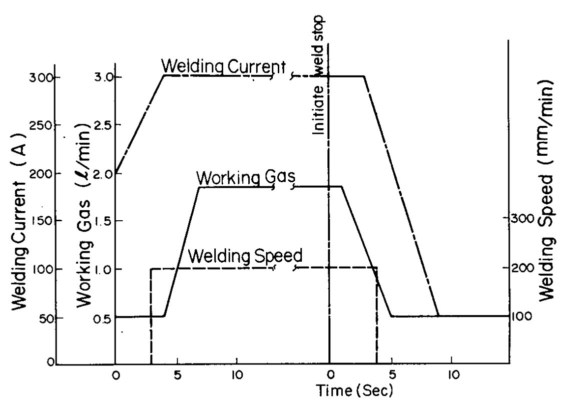

Fig. 1. Typical programming used for starting and stopping a circumferential keyhole weld. (Welding journal vol. 45, 166)

(1) Uneven formation of the back bead
(2) Defect in the start section and crater section

Apart from this applicability of this programming, it was found difficult to use this welding method for the thick wall pipe of more than 10 mm. These problems are believed to be attributable to the special property of the materials of HK—40 and also to the fact that the circumferential joint of pipe is to be welded.

In this regard, the experiment was conducted for the purpose to find the optimum programming for HK—40.

2. Experiment Method

The experiment was carried out with use of the plasma arc weld device by Thermal Dynamic Co. of the U.S.A. The weld conditions in this experiment were shown in **Table 1.** In this case, the weld object was rotated to the anti-clockwise direction, and the welding was made at the one o'clock point on.

Table 1. Fixed factors.

Plasma Arc Type	Transferred Type
rity	D.C.S.P
Electrode	Tungsten 3.0 mmϕ
Nozzle Diameter	3.2 mmϕ
Working Gas	5% H2+Ar

The control of the working gas is important and the control section was connected directly to the torch. **Table 2** and **Fig. 3** show the chemical composition and dimension/form of the test specimen respectively.

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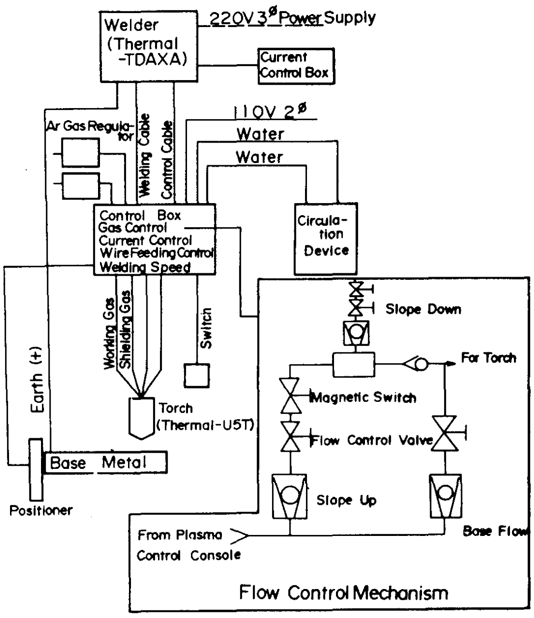


Fig. 2. Welding system.

Table 2. Chemical composition (wt. %).

C	Si	Mn	P	S	Cr	Ni
0.40	0.92	1.06	0.015	0.017	24.82	20.65

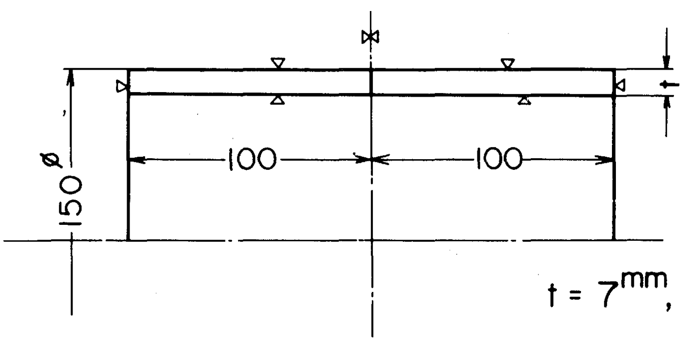


Fig. 3. Edge preparation.

3. Experiment Result and Examination

The results of the experiment was grouped and examined as to the three points, i. e., the formation of the back bead start of welding, and crater treatment in the following way:

3.1 Back Bead Formation Condition

The important factors to build up the back bead in the keyhole type plasma weld are the current density, weld speed, working gas flow rate, etc. These factors were taken as the variable factors, while fixing other various factors as constant. The result was compared with AISI 304[2), 3)], case, and the rearrangement of the data made in reference to the relation between the working gas flow rate and weld speed. Then, **Fig. 4** is obtained.

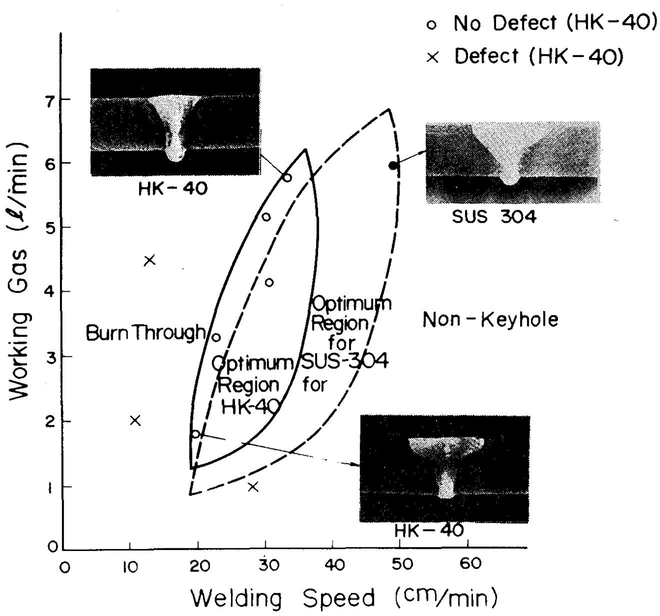


Fig. 4. Optimum welding condition for HK—40 and AISI–304.
Welding current 180 A
Nozzle diameter 3.2 mmϕ
Plate thickness 7 mm

The result of AISI 304 was obtained with the roll material and the difference is naturally expected from the result of our experiment on the centrifugal cast product. However, such factors cannot be ignored as the different chemical composition, evaporation, flow property, surface tension and such heat constant as thermal conductivity.

3.2 Start Condition

The timely relation between the arc start and the start of rotation of weld object is very important for the formation of keyhole. In this case, the weld current, weld speed and working gas are interrelated each other.

It is one of the most important tasks to get the best programming which regulates the above relation. When the Authors applied the programming of Fig. 1, the blow holes were formed. Therefore, a modified programming was applied, where the feeding was made at the same time with the formation of keyhole, as shown in **Fig. 5.**

Then, no blowholes were observed. Namely, the gas is not yet completely discharged during the process to build the keyhole and accordingly the blowholes are formed. Therefore, itsis necessary to start the feeding after the keyhole is built.

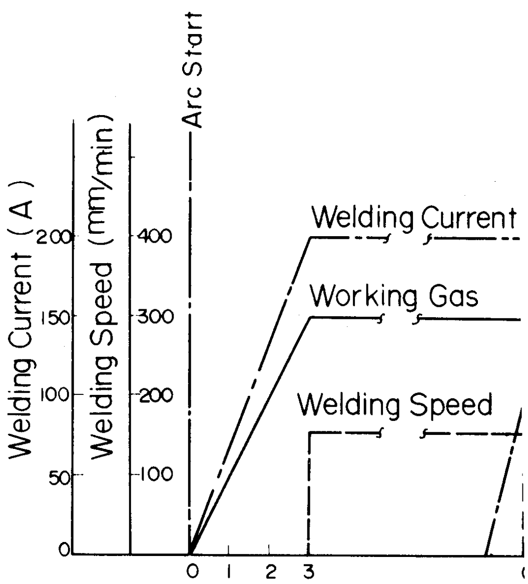


Fig. 5. Start programming of this experiment.

3.3 Crater Treating Condition

The most difficult problem in the application of the keyhole type plasma weld to the circumferential butt joint pipe lies usually in how to treat the crater.

The programming of Fig. 1 or **Fig. 6** was applied to the crater treatment of HK—40 centrifugal cast steel pipe butt joint. As indicated in the picture of Fig. 6., the surface apparently presents no problem. However, a large blowhole was formed in the center of wall thickness.

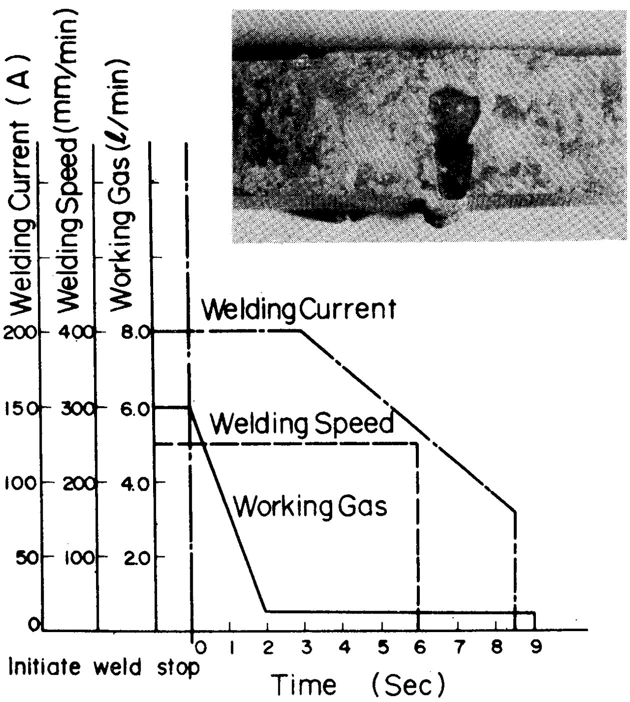


Fig. 6. Programming for crater treatment. (Similar programming to Fig. 1)

This blowhole is believed to be caused by the working gas, which could not be purged but was sealed in by the reduction of incoming heat amount. In the case of AISI 304 and the like, this type of blowhole hardly occurs, probably under the such influences as the different surface tension. Therefore, it becomes necessary to have such conditions as can avoid the sudden drop of the incoming heat so as to discharge the working gas completely. For the above purpose, the current reduction timing has to be delayed after the working gas flow rate is diminished. This delay time was set here at 3 seconds. The method tried in combination was to suspend the rotation of base metal temporarily so as to curb the reduction of incoming heat amount. However, the excessive back bead came out, as shown in **Photo. 1,** if the stop time was long. On the contorary, the pit which suggests the exhausting mark of the working gas was made on the outer surface of the bead, as shown in **Photo. 2.**

In order to prevent the formation of this pit, the programming of **Fig. 7** was applied to stop the feeding temporarily, and at the same time, a method was newly

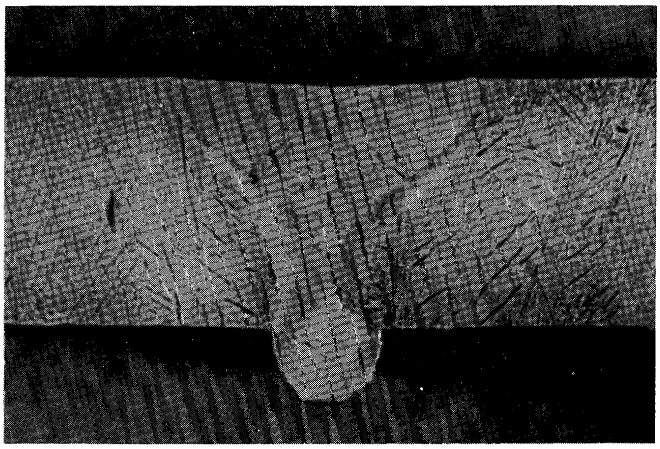
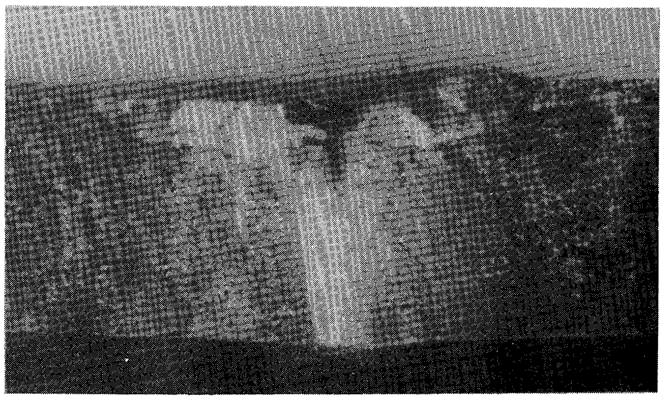


Photo. 1. The stop time is long.



Phot. 2. The stop time is short.

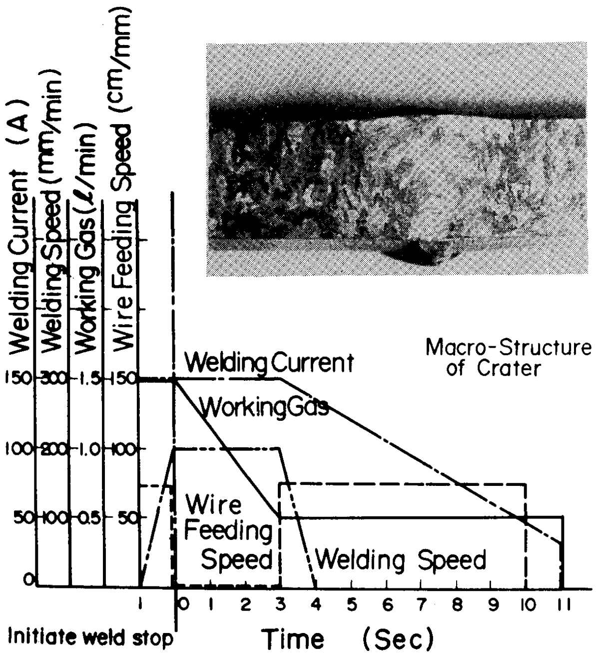


Fig. 7. Optimum programming proposed for crater treatment.

developed to insert the filler metal into the molten metal pot in order to obtain the effect similar to the casting riser.

As the result, the programming of **Fig. 8** was applied, and the keyhole type plasma welding was carried out to HK—40 centrifugal cast steel pipe. The outstanding seemed section was obtained thereby. The joint performance of the weld section will be explained in the following report.

4. Conclusion

The authers confirmed that by selecting properly the program which regulates the relation between the weld current, weld speed and working gas, it is posible to carry out the outstanding high speed welding to centrifugal cast steel pipe HK—40.

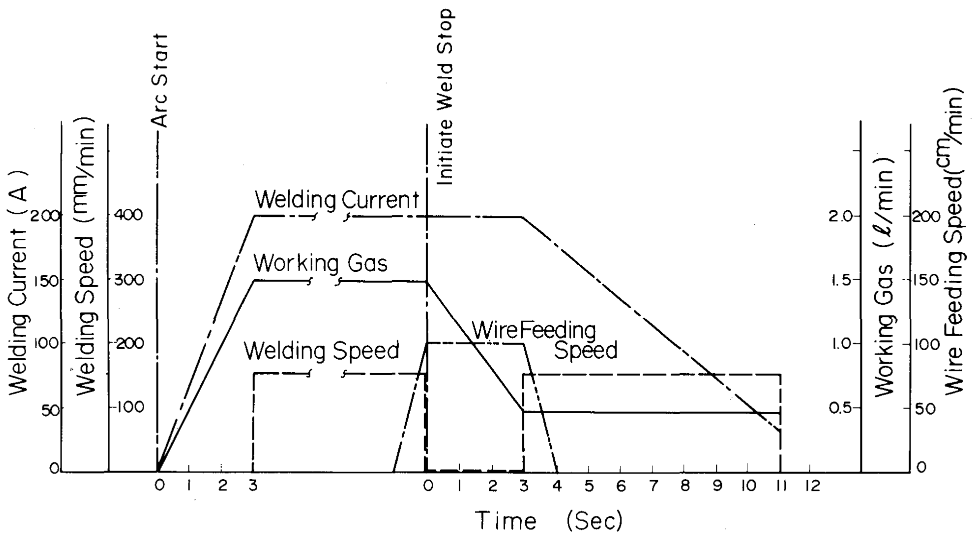


Fig. 8. Optimum programming used for starting and stopping a circumferential keyhole weld on HK—40.

References

1) L. J. Priroznik and H. R. Miller; Welding Journal, Vol. 45 (1966) 717.

2) K. Nishiguchi; Journal of the Japan Welding Society, Vol. 40 (1971) 1206.

3) Y. Arata and H. Maruo; JWRI, Vol. 1, No. 1 (1972).