Relation between Results of X-ray Testing of P. V. C Welds and Their Mechanical Strength

Hiroshi KIMURA,* Takuzi YAMAGUCHI,* Masakazu UEMATU,*

(Received Sep. 30, 1969)

X-ray radiography and penetrant inspection have been applied in nondestructive testing of P. V. C welds. The relation between the image of defects and the static strength has been examined.

INTRODUCTION

Plastics being used as a strength member of the welding constraction, there is necessary to check, if the welding is efficient or not, and the request for nondestructive inspection test of the welded portion has come up. In this report, we are examining the relations of X-ray inspection and mechanical strength by experiment of the defects of welded P. V. C which was made at random.[1~4] We have made heat plate and hot jet welded specimens, made be 5 mm thickness clear P. V. C plates, which has nine steps of void from 0.26 mm up to 1.79 mm in diameter. We have made the specimens which have included Cu powder from 65～270 mesh and Fe powder from 150～270 mesh and coal powder. Also specimens which the welded surface is over heated than the welding temperature. Specimens under heated or over heated were made freely. These specimens were set under X-ray penetrant inspection and the pattern of defect were microphotometry. We check the intensity and studied the efficiency of X-ray penetrant inspection. On the other hand, by autograph, we searched the mechanical strength, we are searching for the relation between void and strength of these defect specimens.

EXPERIMENTAL RESULTS AND CONSIDERATION

Figure 1 shows the results of X-ray penetrant photograph on microphotometry of P. V. C plates at 5 mm thickness which has channel pattern of 0.5 mm up to 3.0 mm every 0.5 mm. This specimen profile size was by the penetrant meter of the Lloyd Register of Shipping. We utilized the 4 mA-25 KV-10 min X-ray irradiated conditions.

Figure 2 shows the microphotometry curve from the X-ray penetrant photograph using specimen with drill holes from 0.5 mm up to 2.5 mm on 5 mm P. V. C plates rather than channels like Figure 1.

By this result, we have become clear that by character of pattern and contrast of the X-ray, we could make some estimate indirectly.

Figure 3 & 4 shows the microphotometry curves of specimens of drill holes from 0.26 mm up to 1.79 mm with pianowires inserted on the centre line of the welding surface

* Dep. of Textile Eng.

and after welding pulling out the pianowire to make voids.

The intensity shows big on the 0.81 and 0.54 mm drill holes, but this was because when pulling out the pianowires, the P. V. C around the pianowires was strongly bonded

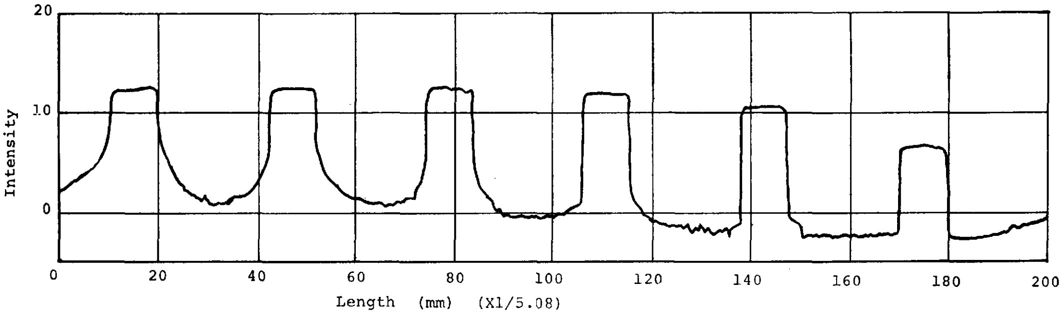

Fig. 1 Pattern of intensity (miller slit)

where, 1) Scanning speed 10mm/min.
2) Chart speed 2 ×25.4mm/min.
3) Bristol's microphotometer.

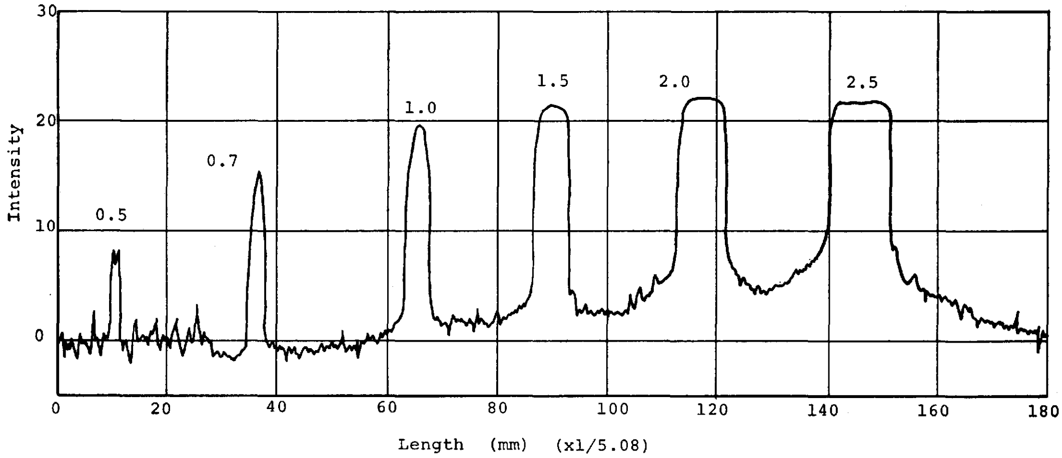

Fig. 2 Pattern of intensity (Drill hole)

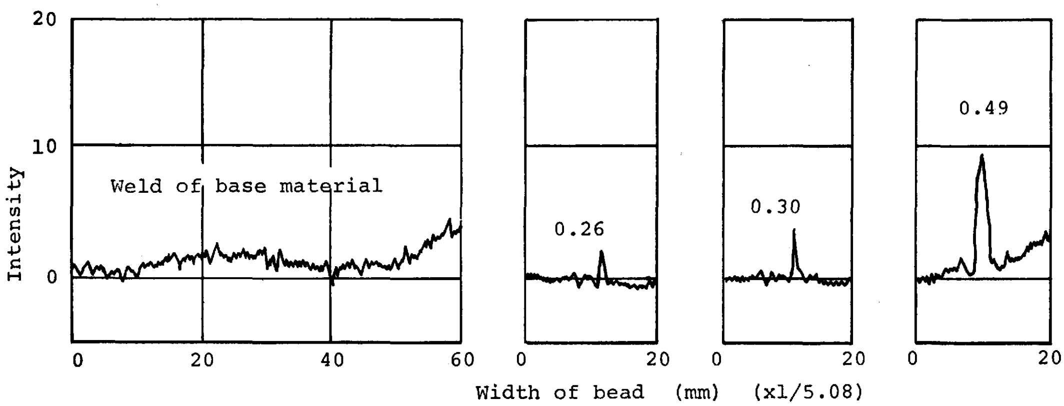

Fig. 3 Intensity on the holes of the each size

and made voids larger than the pianowire diameters. The others, the diameter of the void and the intensity are in proportion.

Table 1 shows the strength of these defected weldings and the joint efficiency. By this result, when the void is small the joint efficiency is good and when the void is between 0.49~0.96 mm the results is very poor, but when if comes up to 1.20~1.79 mm, the joint efficiency recovers. At this size, we do not have to think about notch effect. At 0.26 mm, the strength is large, and 0.81 mm welded area comes small and the welding is unstabilized. Near 1.79 mm, size effect makes it recover. According to this, it has come clear that between void diameter and strength, it has non linear relation.

Figure 5 & 6 shows the microphotometry curve of specimens welded with Cu powder mesh #65, #100, #150, #−270 : 0.1 grams and 0.3 grams diffused to make defects and welded. The mesh of the Cu powder has 2nd order curve relation with the X-ray intensity and mesh #100 shows the maximum value. When the mesh is large, the resin

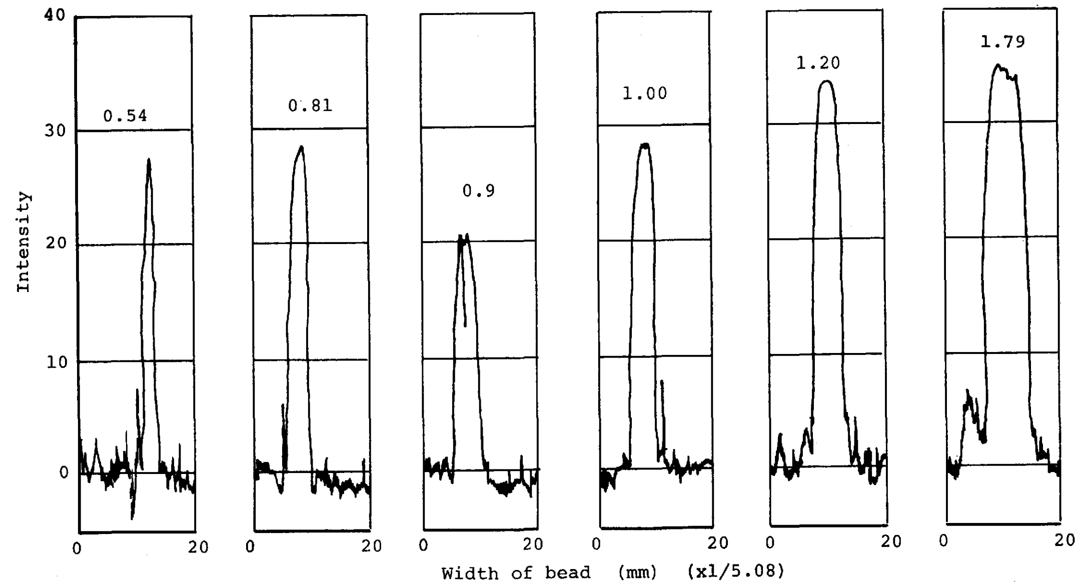

Fig. 4 Intensity on the holes of the each size

Table 1 Tensile strength and joint efficiency

Hole dia	a				b				c			
	T.S	J.E	True t.s	True j.e	T.S	J.E	True t.s	True j.e	T.S	J.E	True t.s	True j.e
0.26	5.27	73.2	5.57	77.4	5.40	77.1	5.71	79.3	5.50	76.4	5.82	80.8
0.30	4.39	61.0	4.67	64.9	3.83	53.2	4.06	56.4	4.00	55.6	4.17	57.9
0.49	1.97	27.4	2.23	31.0	2.27	31.5	2.52	35.0	2.82	39.2	3.13	43.5
0.54	1.31	18.2	1.54	21.4	1.75	24.3	1.96	27.2	1.70	23.6	1.90	26.4
0.81	1.00	13.9	1.18	16.4	1.03	14.3	1.22	16.9	1.26	17.5	1.50	20.8
0.96	1.42	19.7	1.73	24.0	3.93	54.6	4.73	65.7	3.42	47.5	4.15	57.6
1.00	2.77	38.5	3.45	47.9	3.53	49.0	4.26	59.2	2.89	40.1	3.60	50.0
1.20	3.18	44.2	4.21	58.5	3.76	52.2	4.93	68.5	3.16	43.9	4.16	57.8
1.79	2.67	37.1	4.11	57.1	1.40	19.4	1.92	26.7	2.78	38.6	4.24	58.9

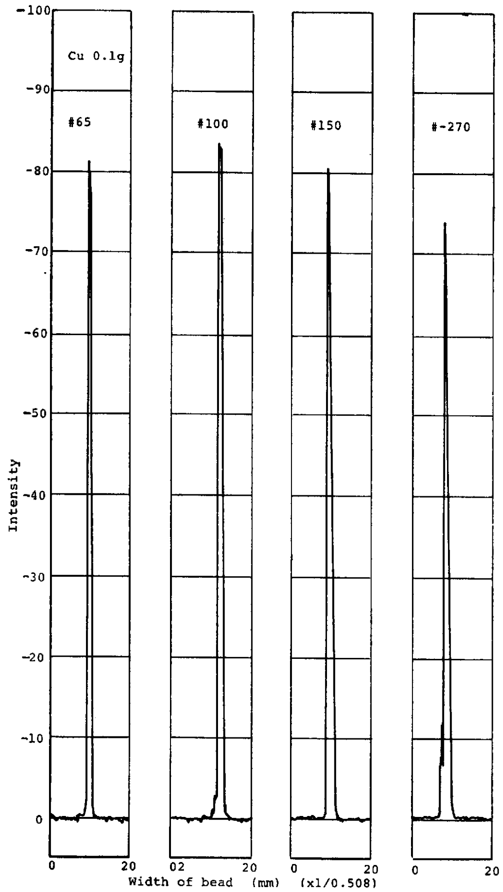

Fig. 5 Intensity on the interposed of Cu powder

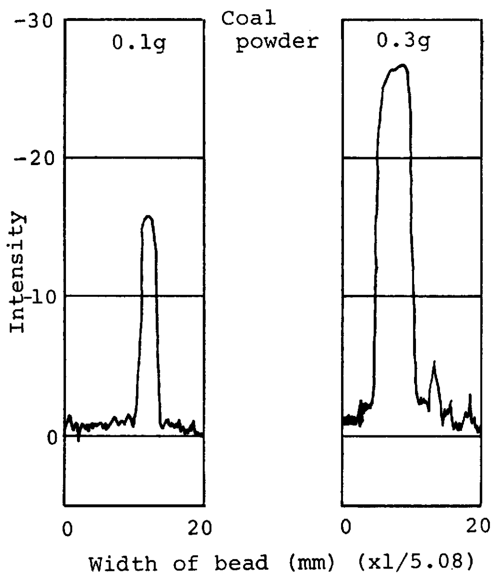

Fig. 7 Intensity on the interposed of coal powder

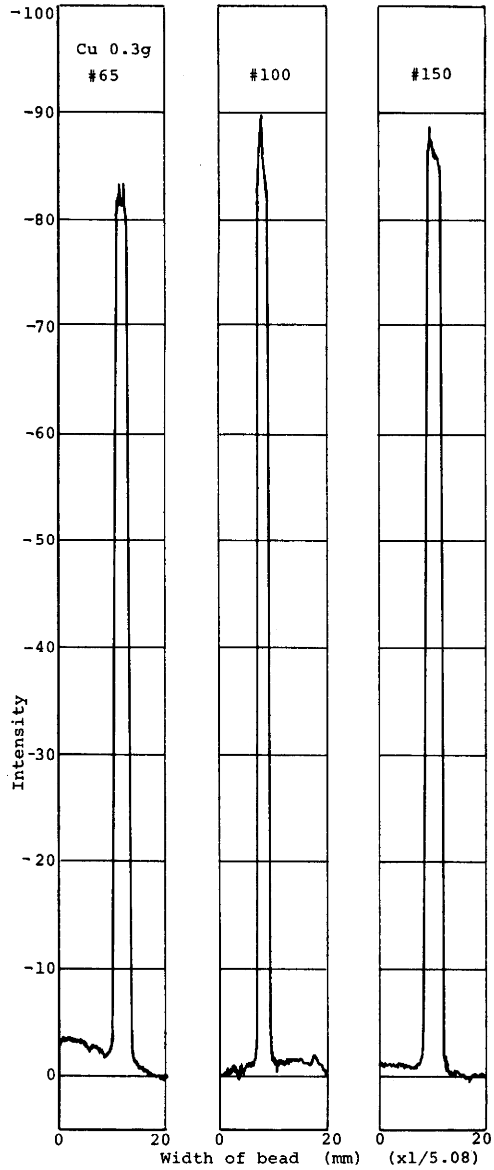

Fig. 6 Intensity on the interposed of Cu powder

can easily pass thru the Cu powder grain, and when the mesh is small, we think that the X-ray absorbed capacity is small.

Figure 7, 8 & 9 shows the same experimental results with Fe powder and coal powder. Figure 7 shows that intensity and X-ray absorbed area is large according to the distributed density of the coal powder and also shows distributed depth is large.

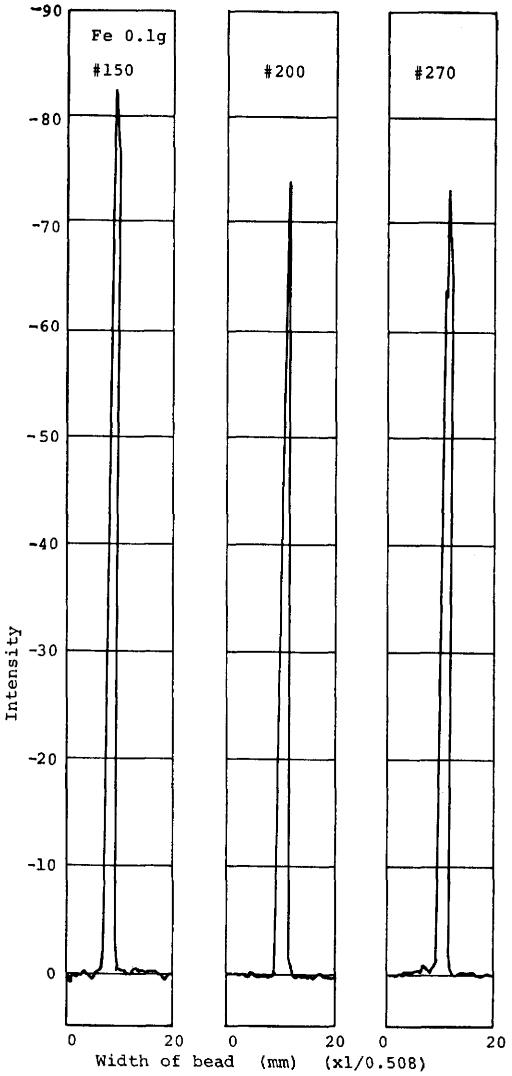

Fig. 8 Intensity on the interposed of Fe powder

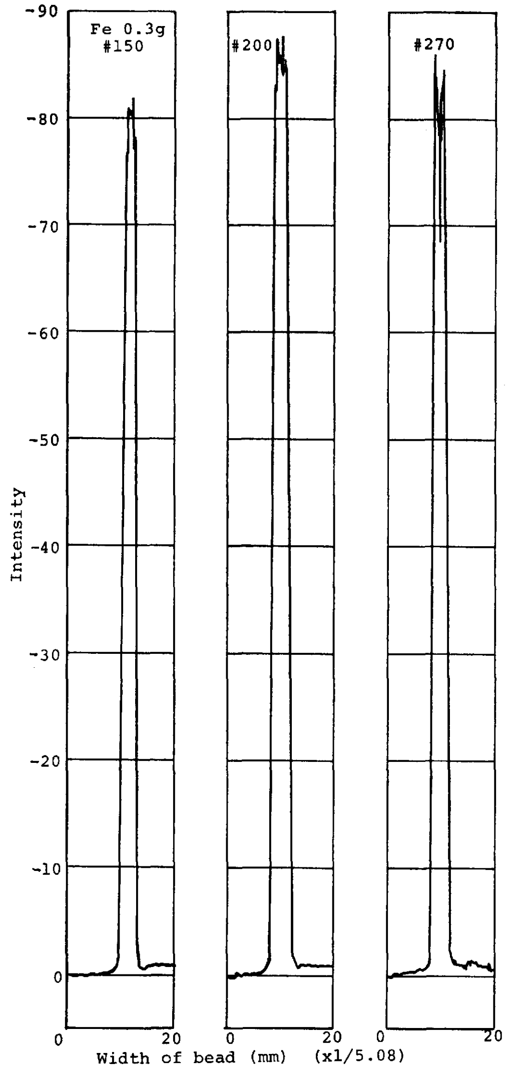

Fig. 9 Intensity on the interposed of Fe powder

Table 2 Tensile strength and joint efficiency

		0.1g						0.3g					
		T.S	J.E	T.S	J.E	T.S	J.E	T.S	J.E	T.S	J.E	T.S	J.E
Cu powder	# 65	2.24	31.1	2.10	29.2	2.09	29.0	2.35	32.6	2.19	30.4	1.94	26.9
〃	#100	1.63	22.6	2.17	30.1	2.09	29.0	1.74	24.2	1.66	23.1	1.50	20.8
〃	#150	2.56	35.6	2.27	31.5	1.71	23.8	1.57	21.8	1.61	22.4	1.43	19.9
〃	#−270	1.14	15.8	1.69	23.5	1.47	20.4	2.52	35.0	2.43	32.5	2.41	33.5
Fe powder	#150	2.00	27.8	1.84	25.6	1.96	27.2	2.21	30.7	2.09	29.0	1.90	26.4
〃	#200	2.91	40.4	2.67	37.1	1.85	25.7	2.30	31.9	2.07	28.8	2.06	28.6
〃	#270	1.59	22.1	1.55	21.5	1.53	21.3	1.32	18.3	1.71	23.8	1.18	16.4
Coal powder		0.84	11.7	1.05	14.6	1.15	16.0	2.53	35.1	1.77	24.6	1.87	26.0

Figure 8 & 9 shows the same results of F_e powder.

Table 2 shows the results of these tension test and the welding joint efficiency. This shows that when the distributed density of coal powder is large, it does not always mean that the welding joint efficiency is small. Also concerning the other Cu powder and Fe powder, we could not make clear the relation of N. D. I and joint efficiency.

Figure 10 shows the microphotometry curves of standard, over and under heated specimens. Under heated ones, the welding under the root edge is unsatisfactory and on the overheated ones, you can acknowledge carbide.

Figure 11 is same experimental results of heat plate welding. In heat plate welding, when too much overheated, the overheat portion is pressured and flows out to the surrounding and defects can not actually intervention.

Table 3 shows the welded joint efficiency of these defected specimens.

It shows that over heat is rather better than under heat and too much over heated

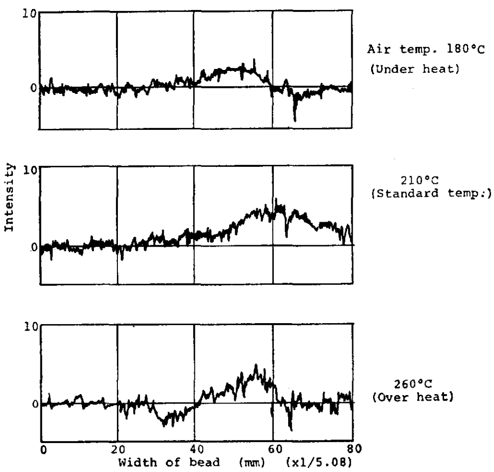

Fig. 10 Intensity on the weld the by Hot-Jet welding

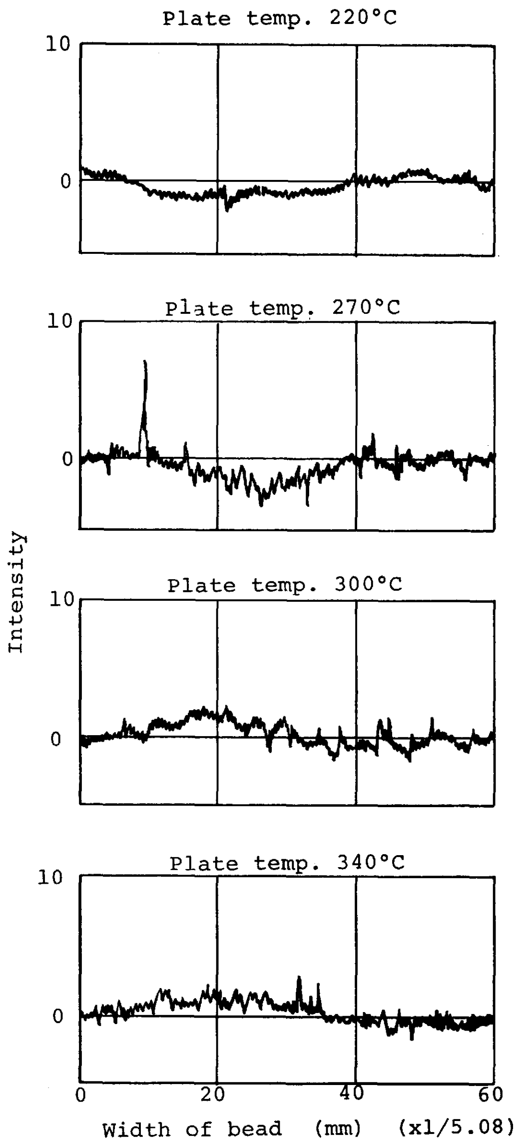

Fig. 11 Intensity on the over heat weld (Heated plate weld)

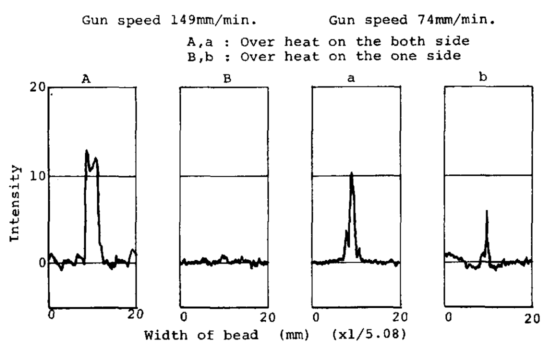

Fig. 12 Intensity on the over heat weld

Table 3 Tensile strength and joint efficiency

Welding temp.		a		b		c	
		T.S	J.E	T.S	J.E	T.S	J.E
A	180°C	0.88	12.2	1.42	19.7	0.57	7.90
	210°C	3.71	51.5	4.31	59.9	4.97	69.0
	260°C	4.52	62.8	4.77	66.3	3.56	49.4
B	220°C	6.69	92.9	6.60	91.7	6.63	92.1
	270°C	6.11	84.9	6.64	92.2	6.57	91.3
	300°C	4.04	56.1	3.66	50.8	3.08	42.4
	340°C	1.78	24.7	3.17	44.0	0.47	6.50

A : Hot-Jet welding
B : Heated plate welding

Table 4 Tensile strength and joint efficiency

	Gun speed 74mm/min.						Gun speed 149mm/min.					
	T.S	J.E	T.S	J.E	T.S	J.E	T.S	J.E	T.S	J.E	T.S	J.E
A	0.45	6.25	0.20	2.80	0.25	3.60	0.82	11.4	0.79	11.0	0.86	12.0
B	1.30	18.1	1.51	21.0	1.76	24.4	2.17	30.1	2.12	29.4	2.02	28.1

A : Over heat on the both side
B : Over heat on the one side

is not good.

Figure 12 shows the microphotometry curves of heat welding under standard conditions, over heating one surface or both surface by hot jet gun. At the speed of 74~149 mm/min, and the hot jet temperature of 300°C.

Over heated both welded surfaces show clearly high intensity. Among over heating one surface, the intensity is rather high when the gun speed is slow.

Table 4 shows the welding joint efficiency of these. The strength of over heat of both surface is very poor, and the joint efficiency of one surface over heat is under 30%.

CONCLUSION

The following summary can be made from the results of the present experiment.

1) The transmission of X-ray in P. V. C is very good, and contains heavy metal element such as Pb and the transmission in very near Al.
2) The intensity of defect pattern of X-ray differs by the mesh of the inclusions, and seems to have some relation between mesh and intensity.
3) In hot jet welding, when the depth of penetration is unsatisfactory by under heat, and when over heated and can acknowledge carbide, this may be detected by the X-ray microphotometry curves.
4) The may be some non linear relation between welding joint strength and the size of void which is a defect of the welding.
5) The welding strength may be very poor by the including of the metal or non metal

pulverized powder, and when smaller the mesh of the including is, the more larger the effects.

6) The effect to the strength is larger when under heated or over heated, but especially under heating lower the strength.

ACKNOWLEDGMENTS

This work was partly supported under contact No. 24, for the Scientific Research, Japanese Scientific Promotive Association.

The authors would like to express sincere thanks to Mr. Nagamasa KATAYAMA of national Osaka Industrial experimental Station for preparing the experimental apparatus.

Part of this work was present at the Annual Meeting of the Japan Welding Society, Tokyo, April 1969.

REFERENCES

1) Hiroshi KIMURA : Welding of Plastics, Publication of Nikkan Kōgyo Press Co. Ltd., p. 68 (1967)
2) Yugoro ISHII, Others : Relation between Results of Nondestructive Testing of P. V. C Welds and their Mechanical Strength, J. N. D. I., Vol. 14, No. 1, p. 3~9 (1965)
3) Yugoro ISHII, Others : On the Relation between the Nondestructive Testing Information of Steel Welds and their Mechanical Strength, J. N. D. I. Vol. 16, No. 8, p. 319~343 (1967)
4) Yugoro ISHII, Others : On the Relation between the Nondestructive Testing of P. V. C Welds and their Mechanical Strength, J. N. D. I, Vol. 17, No. 7, p. 271 275 (1968)