Article

An explosive bonding method performed by reflective action of underwater shock wave

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A new method of explosive welding is proposed. In the new method, an explosive put on a block of the thick steel is set on the one side of the specimen. The whole set-up is submerged in the water. When the explosive is detonated, underwater shock wave moves on the flyer plate from the near side to explosive to the far side. The shock wave holds a very high pressure, @so that the flyer plate is abruptly accelerated by pressure action and collides with a suitable velocity to the parent plate a slightly apart from the flyer plate. Thus explosive welding is achieved. Shock pressure decays with the distance from the explosive.

To make up the energy loss of shock wave, a reflector of thick plate is covered the passage of shock wave. To obtain an available reflection effect, the reflection is inclined to the bottom plate.

In the present paper, the availability of this method is at first claimed and the effects of the experimental conditions are investigated on the inclination of the reflector, the size and charge weight of explosive and the distance between the flyer plate and the parent one.

Key Words: Explosive Welding, Underwater Shock Wave, Underwater Explosion

1. Introduction

A usual explosive welding process is shown in Fig. 1. In the process, a flyer plate is accelerated by a detonation pressure of an explosive and collides with a parent plate at a high speed in a slanted state. In this process, the condition for successful welding are that the parameters, such as a moving velocity of collision point and a collision angle are held within suitable limits [1].

When the welding is done well, a weld interface is characteristically formed wavy.

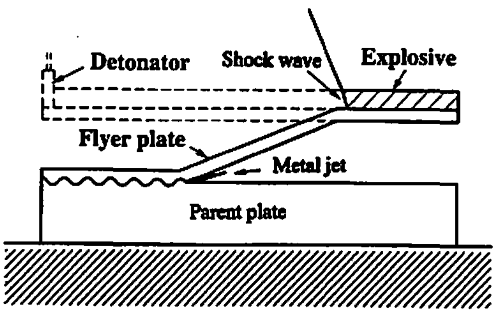

Fig. 1 Illustration of conventional explosive welding process

An explosive welding method using underwater shock pressure instead of the direct explosion pressure was proposed by Hokamoto and Fujita et al. shown in Fig.2.

In this method, the explosive covering over the area of the flyer plate was set with a suitable inclined angle against the flyer plate. However, the flying velocity reduced with the progress of collision point, because the explosive was apart from the flyer plate with the progress of welding process. Therefore, it is difficult to succeed in good welding

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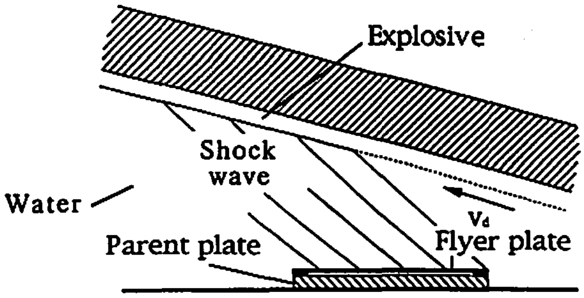

Fig. 2 An explosive welding method using underwater shock wave

over wide area by this method.

In a new method proposed here, the arrangement of the explosive is different from the method described above. The explosive does not cover the flyer plate but is set near the end of the flyer plate.

2. Experimental procedure

Fig. 3 shows a set-up for a new explosive welding method. The detonation is performed in the state that the whole set-up is submerged in the underwater. When an explosive put on a block of thick steel is detonated, an underwater shock wave generated propagates toward left side. When the shock wave moves on a specimen, it composed of a flyer plate and a parent plate, arranged on the way of the passage of shock wave, the shock pressure abruptly accelerates the flyer plate and collides it to the parent plate with a suitable high velocity. The collision moves from right side to left side on the specimen.

The energy of sock wave is presumed to reduce far from the explosive point. To make up the energy loss of shock wave, a reflector of thick plate is covered over the passage of shock wave. The reflector plate is set with a slight inclined angle against the bottom plate, so the passage of shock wave goes downhill. Thus the energy of shock wave is amplified by the refection from reflector and bottom plate. In practice, the energy loss dissipated during welding process must be added. Therefore the balance between the amplification and the dissipation of shock energy is important for the success of this method. In usual, some clearance is set between a flyer plate and a parent one.

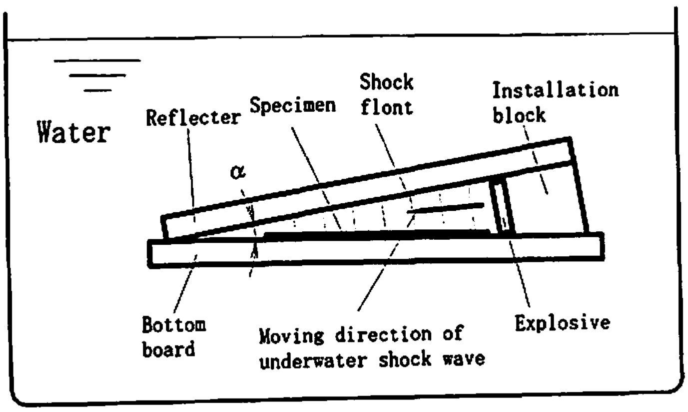

Fig. 3 Set-up for a new explosive welding

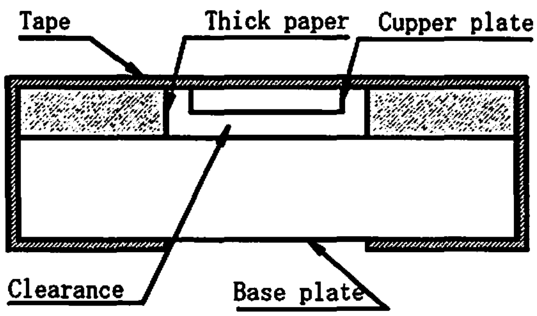

Fig. 4 A sample of setting up

Fig.4 shows a sample of setting up. The experiment is performed with two kind of clearance, one is 0.1 mm and the other is 0 mm (the flyer plate is put directly on the parent plate). Copper sheets of 0.1 mm thick used for the flyer plate and steel plates of 2 mm thick are used for the parent one. The high-explosive is SEP (a kind of plastic explosive, 1310 $kg \cdot m^{-3}$ in density and 6970 $m \cdot s^{-1}$ in detonating velocity) made in Asahi Chemical Co., Ltd.. The charge weight is 7 grams. The explosive is put on steel block of 25 mm in height, 50 mm in thickness and 50 mm in width (the width of shock wave passage). In addition, two sidewalls of steel plate 25 mm thick are used for the partitions of both sides of shock wave passage, in order to prevent the divergence of energy to side direction.

3. Experimental results

An experimental result done by setting of Fig. 4 is shown in Fig. 5, in which the clearance between the flyer plate and the parent one is 0.15 mm. In this side that is close to explosion, an effect of characteristic interfacial wave of an explosive welding appears on the surface of the flyer plate.

Fig. 5 Explosively welded sample

Fig. 6 Cross-sectional photo of explosively welded Cu/Fe

It suggests that the shock wave energy is too strong.

Fig.6 shows an enlarged sectional photograph of this part with an optical magnitude. It is clear that the influence of a weld interface formed wavy extends to the surface of the flyer plate. In this case, the part of last 1/4 was not welded, this suggested that the shock energy was insufficient there. It points out that a suitable energy distribution is important in this method.

Fig. 7 shows the experimental result in a case of no clearance between a flyer plate and a parent plate. The welding interface is wavy in this case, but the surface is flat, so welding state is good. In

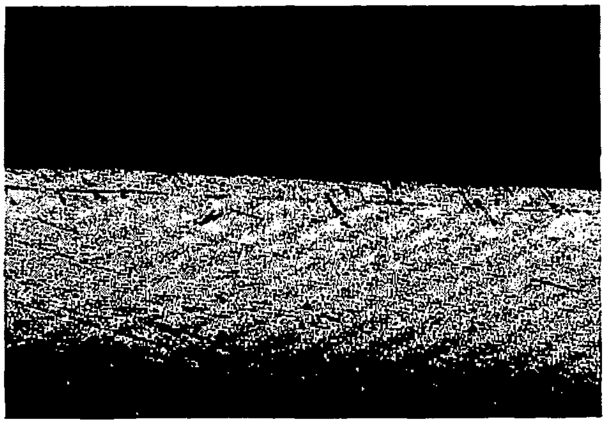

Fig. 7 Cross-sectional photo of explosively welded Cu/Fe without a gap

this case, however, only some part could be welded as shown in Fig. 7 weld interface was flat or no-welded in the rest part.

4. Conclusions

A new method for explosive welding, in which a specimen composes a flyer plate and a parent one is put on the passageway of underwater shock wave, was proposed. The experimental results according to the method showed a good weld though partially. And it was concluded that the shock wave energy must be suitably controlled by the arrangement of reflector and bottom plate for the success of this method.

References

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