EFFECTS OF AFTER-BURST ON HORN TIP STICKING IN ULTRASONIC WELDING

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Abstract - Ultrasonic metal welding for secondary cell battery is widely utilized. In ultrasonic welding, the tip of the horn is shaped with a knurl to fasten the weld material and transmit vibration efficiently. During this process, the material usually stick to the tip of the horn. This causes weld defect and additional processes will be required to separate the material from the tip. As a result, the development of the anti-sticking technology is necessary because production time and cost increase. In this study, the after-burst system of D9800 ultrasound welders developed by the Durasonic Corp. is used to find the minimum oscillating conditions under which materials are automatically separated from the tip. This minimizes production time and costs caused by weld defects and the shutdown of automated welding lines.

Index Terms - Ultrasonic Welding, Horn Tips, Anti-Sticking Technology, After-Burst Syste

I. INTRODUCTION

Ultrasonic metal welding is considered an economical and environmentally friendly technology because unlike conventional welding, heat sources, rods and solvents are not required and no hazardous materials are released [1]. Also, research on secondary batteries has also been actively conducted these days for the recent expansion of mobile devices such as smartphones, tablet PCs and the development of electric vehicles. These batteries are supposed to be small, lightweight, and high-capacity. Furthermore, the structure of the battery must be multi-layered. Ultrasonic metal welding has been used for efficient welding of multi-layer tabs [2]-[3]. From a practical applications standpoint, 'Sticking' have emerged that impede progress [4]. This occurs between the top part of the specimen and the tip of the weld horn. It is more serious for aluminum materials that are widely used in battery tabs in secondary batteries, this causes weld defect and additional processes will be required to separate the material from the tip. As a result, the development of the anti-sticking technology is necessary because production time and cost increase.

Related studies include micro-blasting to improve the deburring and surface properties of burr formed at the corners of an anvil tip to minimize sticking phenomena [5]. However, very little research has been done on techniques to prevent sticking situation of the horn and materials in ultrasonic welding.

In this study, the after-burst system of D9800 ultrasound welders developed by the Durasonic Corp. is used to find the minimum oscillating conditions under which materials are automatically separated from the tip. This minimizes production time and costs caused by weld defects and the shutdown of automated welding lines.

II. EQUIPMENT

D9800, the ultrasonic welder used in this experiment has a variety of weld modes that provide useful application. 10.4" size VGA touch screen is included and weld amplitude can be set digitally. In addition, the history of 200 welding results can be stored, and the welding condition can be pre-set, and the welding result graph is supported. Optional options include pre- and after-burst system. The pre-burst is a technology that approaches the sonotrode during vibration to develop weldability, and the after-burst is a technology that automatically separates the material stuck in the horn by vibrating the sonotrode during vibration. The applications of this machine include ultrasonic welding, cutting, staging and embossing of thermoplastic. Therefore, this machine is available in all industries [6].



Fig.1 Ultrasonic welding machine (D9800)

III. CAUSES AND CONDITIONS OF STICKING

A. Causes of Sticking and weld defect

Sticking is an important problem at the actual field, but few techniques are available for academic interpretation or its prevention. There are several causes of seizure. First, local scratches occur in the contact area between materials with insufficient press force. The second is the case of high affinity between the materials of the Horn/Anvil and the weld material. Finally, the weld material is pushed up by shear force, which is deposited on the tip [7].

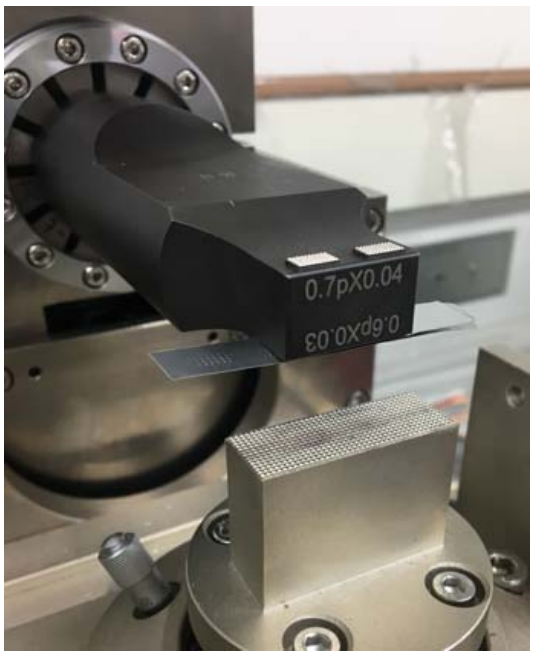
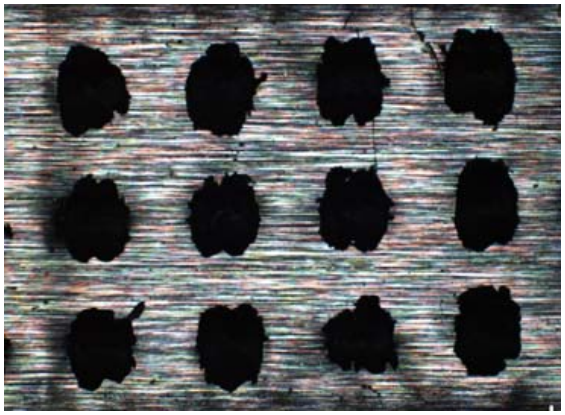


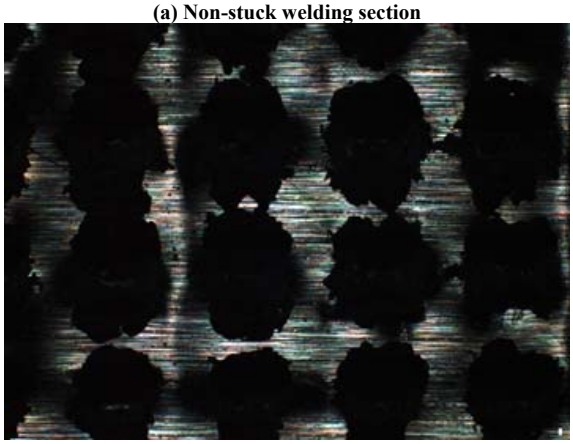
Fig.2 The material sticking to the horn of an ultrasonic welder



Fig.3 Weld defect caused by sticking



(a) Non-stuck welding section



(b) Non-stuck welding section

Fig.4 Using a microscope, comparison between when the sticking occurred and did not

Fig.2 shows the material sticking to the horn of an ultrasonic welder. It usually occurs when the knurl pattern of the horn tips is dense. Fig.3 shows weld defect caused by sticking and defect caused when material is removed directly from tip. Sticking during welding may cause the specimen to become excessively attached to the tip of the machine, causing tear. If this occurs in an automated welding line, it is necessary to separate the material from the tip, which can cause increased production time and cost. Fig.4 shows a comparison between when the sticking occurred and didn't using a microscope. From this, the pattern of the knurling when the stitching occurred is more uneven and larger. This results in a tear in the specimen [8].

IV. EXPERIMENT

A. Finding Welding Conditions when Sticking Occurs

As part of the experiment, the conditions under which sticking occurs were derived. The weld pressure was chosen as 0.2 MPa, 0.3MPa and 0.4MPa, the amplitude is set to 60%, 80% and 100% of the maximum amplitude, and the weld time is set to 0.3s, 0,4s, and 0,5s. Table. Ⅰ shows the welded results for each weld condition, and marked 'O' is the condition that aluminum sheets are adhered to the

Table. Ⅰ Results of Ultrasonic Welding
(O : Sticking to Horn, X : Sticking to Anvil or nothing)

Pressure (MPa)	Amplitude (%)	Welding Time (sec)		
		0.3	0.4	0.5
0.3	60	X	X	O
	80	X	O	O
	100	X	O	O
0.4	60	X	O	O
	80	O	O	O
	100	O	O	X
	60	O	O	X
	80	O	X	X
	100	X	X	X

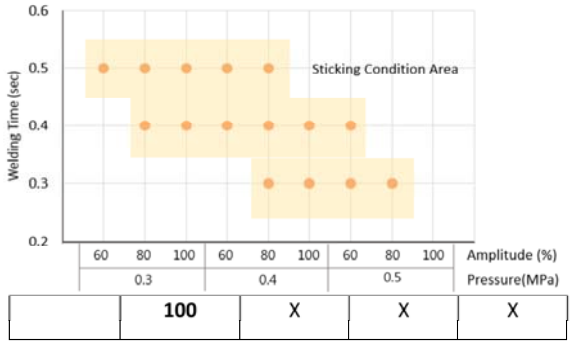


Fig.3 Sticking condition area

Ultrasonic horn. The parts marked 'X' are considered to have been no sticking or means that sheets are adhered to anvil. Therefore, it is deemed that Table. Ⅰ can be the basis for selecting welding conditions that will stick to the horn. Fig. 5 is a graph of the sticking condition area arranged in relation to Table. Ⅰ

B. After-Burst Technology

After-burst system, which was developed by Durasonic Corp. is a technology that automatically separates materials (mainly plastic) that are stuck in the horn. This technology automatically separates products stuck in horn by vibrating when cylinders rise after welding and reach a specified distance. For D9800 ultrasonic welders, the amplitude of the reversing motion can be set to a value of 50 to 100%, and the duration can be set to a value in the range of 0.01 seconds to 30.0s. In this experiment, the after-burst amplitude was set to its minimum size of 50%, and time was increased from 0.1 seconds to 0.5 seconds, and the minimum conditions were derived.

C. After-Burst Conditions

Based on Table.Ⅰ , the materials were separated from the horn by applying after-burst system after welding performed under each condition. At this time, the minimum condition for after-burst were derived and organized into Table. Ⅱ In order to derive the minimum condition, the amplitude was first set to the minimum size of 50% and the time was increased from 0.1 seconds to 0.5 seconds in increments of 0.05 seconds and the material was separated from the horn. If still not separated, the amplitude was increased to 60%, the time was increased again to 0.05 seconds from 0.1 seconds to 0.5 seconds, As a result, if the material was removed from the tip, the test of the condition was stopped and the experiment continued under the following conditions. Amplitude increased by up to 80%. In this process, it was possible to verify that increasing the time with the same amplitude did not separate the material. But increasing the amplitude with the same time could separate the material from the tip. Therefore, it can be concluded that the magnitude of amplitude is a more important factor than the time of after-burst system.

Table. Ⅱ Minimum conditions to be separated by after-burst per weld condition

Pressure (MPa)	Welding Time (sec)	Amplitude (%)	The Minimum after-burst condition
0.3	0.4	80	50%, 0.10sec
		100	50%, 0.30sec
	0.5	60	60%, 0.25sec
		80	70%, 0.35sec
		100	80%, 0.50sec
0.4	0.3	80	50%, 0.10sec
		100	50%, 0.25sec
	0.4	60	50%, 0.10sec
		80	60%, 0.25sec
		100	70%, 0.45sec
	0.5	60	70%, 0.35sec
		80	80%, 0.50sec
0.5	0.3	60	50%, 0.25sec
		80	60%, 0.25sec
	0.4	60	80%, 0.10sec

CONCLUSIONS

Research on secondary batteries has also been actively conducted these days for the recent expansion of mobile devices such as smartphones, tablet PCs and the development of electric vehicles. These batteries

are supposed to be small, lightweight, and high-capacity. Furthermore, the structure of the battery must be multi-layered. Ultrasonic metal welding has been used for efficient welding of multi-layer tabs. From a practical applications standpoint, 'Sticking' have emerged that impede progress. This occurs between the top part of the specimen and the tip of the weld horn. It is more serious for aluminum materials that are widely used in battery tabs in secondary batteries, this causes weld defect and additional processes will be required to separate the material from the tip. As a result, the development of the anti-sticking technology is necessary because production time and cost increase.

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There are several causes of sticking. First, local scratches occur in the contact area between materials with insufficient press force. The second is the case of high affinity between the materials of the Horn/Anvil and the weld material. Finally, the weld material is pushed up by shear force, which is deposited on the tip.

As part of the experiment, the conditions under which sticking occurs were derived. In order to derive the minimum condition of after-burst system, the amplitude was first set to the minimum size of 50% and the time was increased from 0.1 seconds to 0.5 seconds in increments of 0.05 seconds to observe if the material was separated from the horn. If still not separated, the amplitude was increased to 60%, the time was increased again from 0.1 seconds to 0.5 seconds in increments of 0.05 seconds. As a result, if the material was removed from the tip, the test of the condition was stopped and the experiment continued under the following conditions. Amplitude increased by up to 80%.

First, the after-burst amplitude was set to its minimum size of 50%, and time was increased from 0.1 seconds to 0.5 seconds, and the minimum conditions were derived. In this process, it was possible to verify that increasing the time with the same amplitude did not separate the material. But increasing the amplitude with the same time could separate the material from the tip. Therefore, it can be concluded that the magnitude of amplitude is a more important factor than the time of after-burst system.

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