The various needs of customers in the automotive industries have created a recent trend in metal parts production toward the small production of a variety of parts at lower cost and with a shorter delivery period. As a method to meet these needs, incremental forming is demanded and has been actively studied, in which the parts are formed by a series of local deformations using general-purpose tools, for forming the parts produced in a small quantity. The incremental forming technique includes, for example, moving cylindrical tools along the parts shape and pressing or hammering the sheet metal blank using general-purpose tools\(^{1-3}\).

For automobile sheet metal parts, backward stretch forming would be the most suitable because it can easily form complicated shapes; however, it has difficulty in obtaining an accurate form and cracks may occur because of the significant decrease in sheet thickness in sections with a steep incline. To overcome the insufficient accuracy, a supporter method (Fig. 1) has been examined, by which forming of complicated and large panels such as quarter panels has become possible\(^{4}\).

For further improving the accuracy and suppressing the crack generation in the supporter method, we have devised a multi-head revolving tool with a special design at the tip of a cylindrical tool (Fig. 2). By using this tool, an improvement in shape fixabilities and a reduction in crack generation have been confirmed (Table 1, Fig. 4).

As another forming method without using a supporter, we propose a counter tool method using a counter tool together with the multi-head revolving tool (Fig. 3). In this method the parts are formed by drawing, thus resulting in remarkable suppression of the thickness decrease (Fig. 5).

An outline of these methods is described below. In both methods, the contour line tool locus system using the NC milling machine is adopted for the forming.

(1) Supporter method: A multi-head revolving tool and a supporter in the shape of the parts are placed on either side of the blank, and the parts are formed by revolving the tool, with a clearance of thickness \( +\alpha \) retained.

(2) Counter tool method: A round sheet metal blank is supported with its center fixed, and the multi-head revolving tool and a counter tool placed on either side of the blank are used in combination to form the parts.

References

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**Table 1** Deviation of shape formed by supporter method (mm).

<table>
<thead>
<tr>
<th>Position</th>
<th>Forming tool</th>
<th>Multi-head with revolution</th>
<th>Semi sphere Non revolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>c</td>
<td>0</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>d</td>
<td>1.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

**Fig. 1** Schematic diagram of supporter method.

**Fig. 2** Multi-head tool.

**Fig. 3** Schematic diagram of counter tool method.

**Fig. 4** Comparison of breakage in supporter method.

**Fig. 5** A sample formed by counter tool method and its thickness.