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Direct Resistance Joule Heating of Al-SiCoated Steel Pipes in the Steel Tube Air Forming Process

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In recent years, various forming processes of automobile body parts are developed to increase the strength and reduce weight. Conventionally spot-welded assemblies of cold- or hot-stamped sheets or cold-hydroformed pipes are used for, however, difficulties such as weakness of spot welding difficulty of installing high-strength steel pipes for hydroforming lies. To improve these problems, the novel forming process of steel tube with high pressure air and direct resistance heating, Steel Tube Air Forming process, has been developed. It enables weight reduction of automobile parts by forming continuous closed section structure with flanges of 1500 MPa class. In this process, steel tube is heated by direct resistance heating to austenitize, then blow high pressure air into the tube to deform and quench it in dies[2].Generally AlSi-coated steel sheets are utilized for hot stamping to surpress the decarburization or oxidation, so that post-processes can be also omitted. However, AlSi-coated steel sheets are not been appliable for direct resistance heating, because of generation of coating bias made by Lorentz force. Meanwhile, there is no report about the resistance heating of AlSi-coated steel pipe. In this work, the effect of resistance heating condition affects to AlSi-coated steel pipe were reported.

Fig.1 shows the magnetic field distribution formed around the sheet and pipe when current is flowing through them obtained by 2D magnetic field analysis. The magnetic field distribution is more symmetrical for the pipe than for the sheet (shown as (a) and (b)). However, if a magnetic material such as a mold is in the vicinity, the magnetic field distribution around the pipe is disturbed (as (c)). When there is a pipe between the molds, the Lorentz force in the tangential direction is generated on the pipe surface. Fig.2 shows the appearance of the AlSi-coated steel sheet and steel pipe without die after direct resistance heating. There was no line-shaped trail of molten metal biased were observed. Fig.3 shows the height of coating bias on resistance heated pipes in each conditions of heating temperature and distance between dies. Although the bias of coating on the heated pipes could be observed in case inside dies, however the height of bias got decreased by making more distance between the die and the pipe. Therefore, it was confirmed that AlSi-coated pipe is available for direct resistance heating even between dies, by making appropriate distance between pipe and dies.

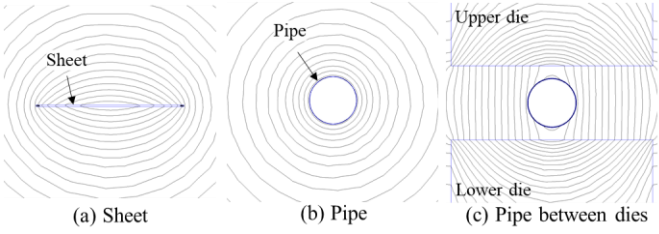

Fig.1 Magnetic field distribution around the sheet, pipe and dies

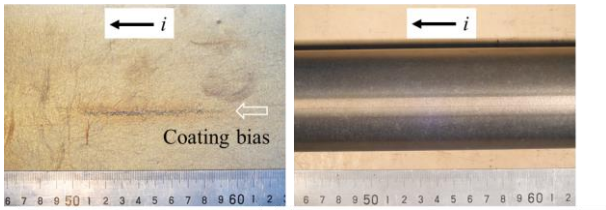

Fig.2 Comparison of the appearance of AlSi-coated steel sheet and pipe after direct resistance heating

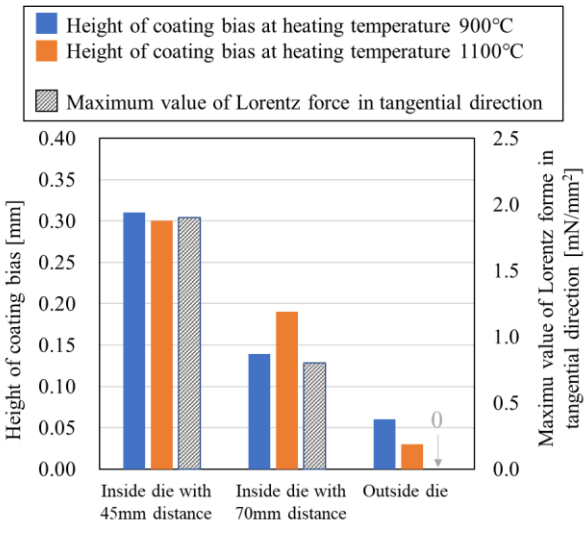

Fig.3 Height of coating bias on resistance heated pipes at 900°C and 1100°C, and maximum value of Lorentz force in tangential direction analyzed at the same condition