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Gas forming of ultra-high strength steel hollow part using air filled into sealed tube and resistance heating

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Abstract

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A new gas forming process of ultra-high strength steel hollow parts using air filled into sealed tubes and resistance heating was developed to omit the subsequent heat treatment. In this process, a sealed quenchable steel tube was rapidly resistance-heated to improve the formability. By applying die-quenching ~~~~~~~~~ (50-100words, 9 pt., Times New Roman)

Capital

Keywords: Tube forming; Gas forming; Hot stamping (5-10 keywords, separated by semicolons ;)

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1. Introduction (Chapter:10pt., Times new roman, bold style)

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To improve the fuel consumption of automobiles, the reduction in weight of automobile parts becomes more demanding. ~~~~~~~~~~~~. Sorine et al. have improved the hydroformability of high strength steel tubes by optimising force for axial feeding. In hydroforming, tubes are bulged by high internal pressure and then formed with tools [1]. ~~~~~~~~~~~~~~. Ueno et al. have controlled the internal pressure without a booster for generating internal pressure by balancing decrease in internal volume of the tube and discharge in water from a high strength steel tube during hydroforming [2]. ~~~ The formed beams are generally heat-treated to obtain the required strength .~~~~.

Reference by the number square bracketed

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Nomenclature

A	cross-sectional area of tube
c	specific heat of tube
I	current of resistance heating
ΔT	temperature increment of the tube
t_e	heating time

2. Gas forming air filled into sealed tube and resistance heating

2.1. Experimental procedure (Section: 10 pt., Times new roman, italic style)

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A gas forming process of ultra-high strength steel hollow parts using air filled into a sealed tube and resistance heating was developed. A miniature V-shaped hollow torsion beam axle of about 1/4 the size of the actual ones was dealt with as an example of gas forming as shown in Fig. 1. The middle of a quenchable steel tube was formed into a V shape with the punch and die. The apparatus was composed of electrodes, a punch, a die and plugs, and was rvo press.

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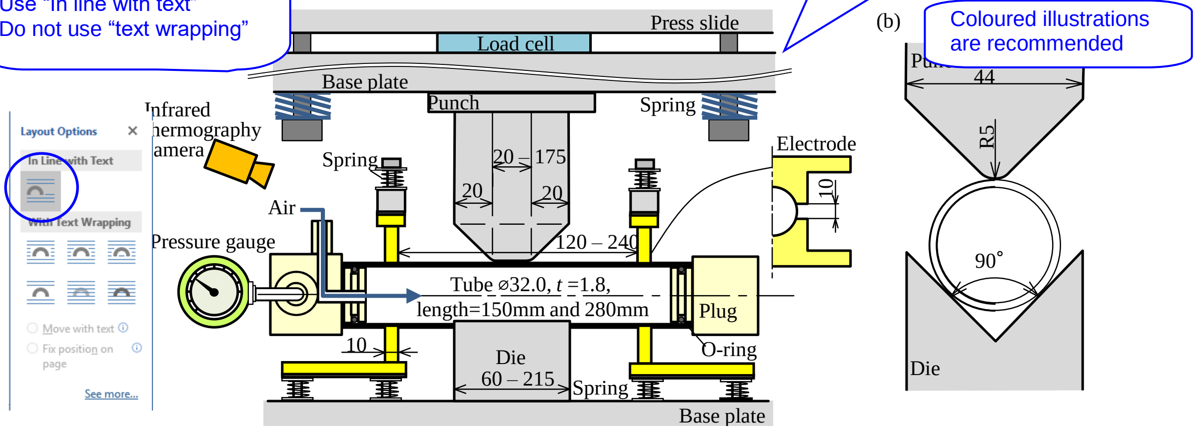

Fig. 1. (a) Experimental apparatus and (b) cross-section of die for gas forming of ultra-high strength steel hollow part using sealed tube and resistance heating. (Left justified [more than two-line], 8 pt., Times)

The distribution of temperature in the resistance-heated tube is shown in Fig. 2. The temperature is almost uniform inside 20 mm from the electrode, and thus the forming region was uniformly heated to 950 °C. ~~~~~~~~~ ~~~~~~~~~~

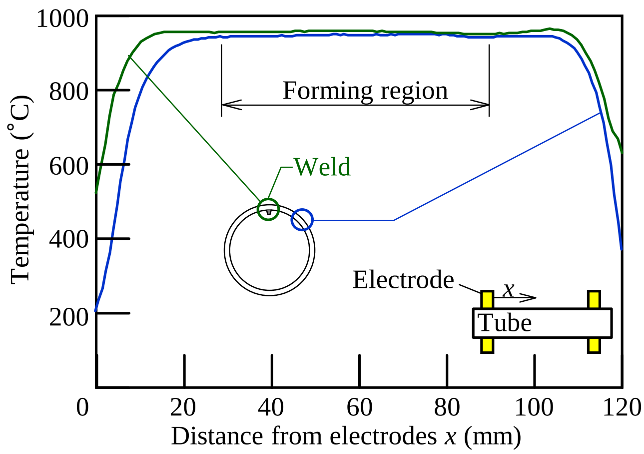

Fig. 2. Distribution of temperature in resistance-heated tube. (Centre [one-line], 8 pt., Times)

The conditions used for tube gas forming of the V-shaped hollow part are shown in Table 1. The current density of the resistant heating was fixed to be 33 A/mm^2, and the heating temperature in the forming region was controlled by the heating time.

Table 1. Conditions used for gas forming of V-shaped hollow part. (Left justified, 8pt, Times)

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	Current density J (A/mm^2)	Heating temperature of tube T (°C)	Internal air pressure p_0 (MPa)
Condition A	10 (Left justified, 8 pt., Times)	800	0.0
Condition B	20	850	1.0
Condition C	30	900	1.5

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To resistance-heat a steel tube having various ... the heat radiation, the input energy W for heating is given by

Math editor

Number of equation

$$W = cm\Delta T = c\rho AL\Delta T\,, \tag{1}$$

where c is the specific heat, m is the mass between the electrodes, ρ is the density, A is the cross-sectional area of the tube, L is the distance between the electrodes and ΔT is the temperature increment of the tube. The input energy is rewritten for the Joule heat by

$$W = RI^2 t_e = \rho_r \frac{L}{A} I^2 t_e\,, \tag{2}$$

where R is resistance of the tube, I is the current, t_{e} is the heating time and ρ_{r} is the electrical resistivity. By substituting Eq. (1) into the Eq. (2), the temperature increment is rewritten by

$$\Delta T = \frac{\rho_r}{c\rho}\left(\frac{I}{A}\right)^2 t_e = \frac{\rho_r}{c\rho}(J)^2 t_e\,. \tag{3}$$

The temperature increment is independent of the cross-sectional area and the distance between the electrodes.

2.2. ~~~~~~~~~~~~~~~~~~~~~~~ (Section: 10 pt., Times new roman, italic style)

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