

Both-Sides Welding Technology for Resin Fuel Tubes

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ABSTRACT

This study developed technology for simultaneously welding heterogeneous resin tubes in order to weld and integrate resin tubes with two different specifications (low temperature and high temperature). The aim of integration was cost and weight reduction. The cost reduction due to reducing the number of parts exceeded the increase in material cost due to a change to resin materials.

Base material fracture of the resin tubes was set as the breaking format condition, and the welding parameters of the joint part rotations and the friction time between the joint part and the resin tubes were specified as the weld strength judgment standard. In addition, the fused thickness determined by observing the cross-section after welding was specified as the weld quality judgment standard. The range over which weld boundary peeling does not occur and weld strength is manifest was clarified by controlling the welding parameters and the fused thickness.

The use of this technology made it possible to reduce the part cost by 10% and the part weight by 50%.

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INTRODUCTION

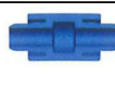
Conversion of metal parts to resin parts is an important technology for reducing vehicle weight. Honda uses a fuel tube structure consisting of a metal fuel tube in the long under-floor section with short resin tubes joined to both ends. The resin tubes on both ends have used resin materials with different specifications (high temperature and low temperature) due to the 120°C environment inside the engine room at the front of the vehicle and the 80°C environment around the fuel tank at the rear of the vehicle. The long under-floor metal tube has a high specific weight and has been an obstacle to weight reduction. In order to reduce weight by replacing this metal tube with a resin tube that has low specific weight, it is necessary to join resin tubes with two different specifications (low temperature and high temperature). The thermoplastic resin used in the resin tubes has the property of melting when heated to the melting point or more, and technology for fusing and welding different thermoplastic resins is widely known.[1,2,3] This study focused on welding the thermoplastic resin used in resin tubes. The outermost layer of the resin tubes and the joint part used the same material, and this material is heated by friction and fused to achieve a structure that integrates resin tubes with different specifications. The welding parameters are the joint part rotations and the friction time between the joint part and the resin tubes. In addition, the both-sides welding method welds the resin tubes simultaneously from both sides of the joint part, which is rotating at a constant speed. Therefore, the impact of the contact time lag between the right and left sides was confirmed.

The weld strength and weld quality judgment standards were the part breaking strength and the fused thickness determined by observing the cross-section of the weld part.

EXPERIMENTAL METHOD

Table 1 shows the specifications of the resin tubes and the joint part used in this study.

Table 1. Specifications of the resin tubes and joint part.

Operating environment		Engine side(<120℃)	Fuel tank side(<80℃)	
Structure				
Name		Tube X	Joint	Tube Y
Material layer configuration	1(Inner layer)	Conductive ETFE	PA12	Conductive PA12
	2	ETFE		PA12
	3	PA12		EVOH
	4(Outer layer)			PA12

The resin tubes have dimensions of outer diameter 8 mm × inner diameter 6 mm (plate thickness 1 mm), and the joint part has grooves for inserting the resin tubes. The grooves of the joint part have a tapered shape so that the resin tubes expand outward when the resin tubes are inserted into the joint grooves during press fitting.

Figure 1 shows a schematic of resin tube and joint part welding. The resin tubes and the joint part were fixed by separate jigs, the joint part was spun together with its jig and the resin tubes were pressed simultaneously from both sides over the outer circumferences of the joint part grooves and fused by frictional heat. Spinning was then stopped to allow the fused resin to cool and harden, thus welding the resin tubes and the joint part. The resin tubes have a multi-layer structure with a barrier layer to suppress permeation. Nylon resin (PA12) was used as the material for the outermost layer of the resin tubes and the joint part material to achieve the same melting points and fuse the parts at the same timing.

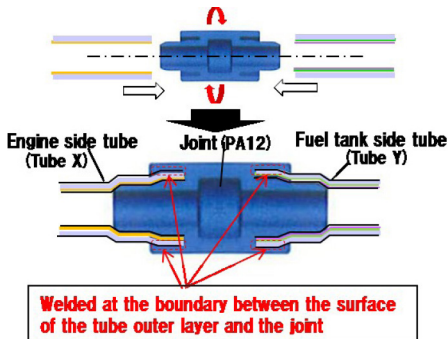


Figure 1. Schematic of resin tube and joint part welding.

The welding parameters evaluated in this study were the ① rotations, ② friction time and ③ time lag. Table 2 shows a matrix of the test conditions A, B, C and D that combine these parameters.

Table 2. Welding parameter matrix.

	①	②	③
① Rotations(rpm)	A	B	C
② Friction time(sec)	C		
③ Time lag(sec)	D	Non	D

Tests were conducted to confirm the weld strength when the various welding parameters were changed. The weld strength was evaluated by the resin tube breaking strength, which is the part breaking format, or the weld boundary surface peel strength. A and B show the impact of the individual welding parameters, and C and D show the compound impact of multiple characteristic welding parameters during both-sides simultaneous welding. Figure 2 shows the relationship between the rotations and the breaking force when the friction time is constant at 3 (sec) and the rotations are varied (condition A).

Figure 3 shows the relationship between the friction time and the breaking strength when the rotations are held constant at 1100 (rpm) and the friction time is varied (condition B). This study simultaneously welded resin tubes with different specifications to a single joint part from both the right and left sides, so it is important to confirm the effects when multiple welding parameters are changed.

Figure 4 shows the resin tube breaking strength when both the rotations (rpm) and the friction time (sec) are varied (condition C).

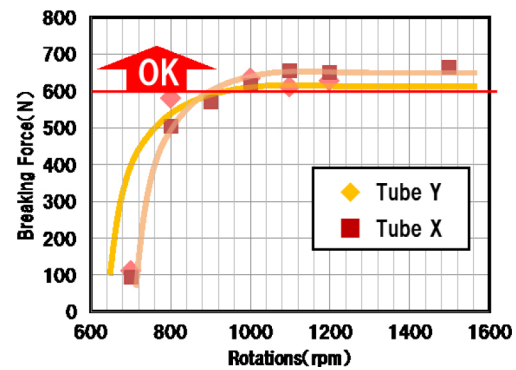


Figure 2. Relationship between rotations and breaking force.[Friction time constant at 3sec]

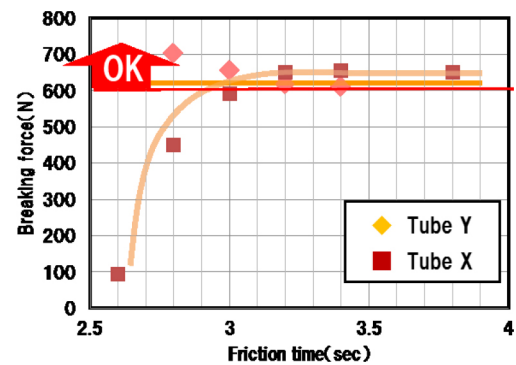


Figure 3. Relationship between friction time and breaking force.[Rotations constant at 1100rpm]

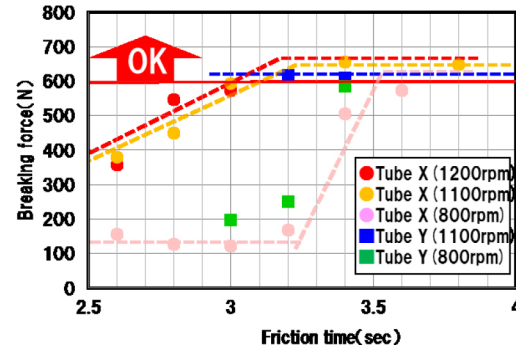


Figure 4. Relationship between breaking force and different combinations of rotations and friction time.

Figure 5 shows the resin tube breaking strength when both the rotations (rpm) and time lag (sec) are varied (condition D).

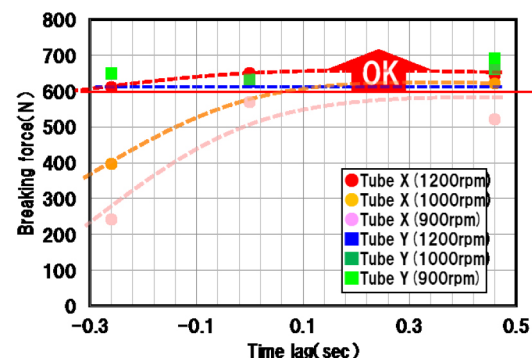


Figure 5. Relationship between breaking force and different combinations of rotations and time lag.