



# Development of cold spot joining method for high strength and lightweight metal structures

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## Abstract

Our research group has developed a “cold spot joining method” that promotes local deformation at the joint interface through welding pressure, enabling arbitrary control of the welding temperature. This welding method leads to spot welding of various steels without phase transformation, fabricating joints with no change in hardness from the base material. Specifically, it completely eliminates cracking, hardening at the joint, and softening in the heat-affected zone. This allows the properties of the base material to be fully utilised in the structure, regardless of the type of metal. Furthermore, its ability to join at low temperatures makes it particularly suitable for applications such as welding dissimilar materials such as aluminum alloys and steels, or welding galvanised steel plates. Furthermore, as it enables spot welding without melting the aluminum, not only are high-strength joints obtained, but welding current can be reduced by approximately 40%, significantly extending electrode life. This non-melting welding technique is also highly advantageous for welding cast materials such as the recently noted giga-cast materials.

development constraints arising from weldability and joint characteristics. Furthermore, the welding equipment is equivalent to conventional resistance spot welders, except for the joint pressure application mechanism, making replacement straightforward. Its application is expected to expand to various structures made from thin metal plates, such as those in automobiles and railway vehicles. Enhancing joint strength and enabling multi-material construction in metal structures significantly contributes to weight reduction and improved reliability.

## Background & Results

Resistance spot welding is an indispensable technology for manufacturing various metal structures, particularly within the automotive industry. However, the welded area typically exhibits a solidification microstructure, resulting in lower strength and toughness compared to the base material (the material being welded). Furthermore, a softened zone, known as the heat-affected zone, forms at the periphery of the welded area. With the rapid advancement in the high strength of materials such as steel plates in recent years, the reduction in the mechanical properties of the welded area has become a serious issue. Furthermore, aluminum materials, whose usage is increasing for the purpose of vehicle body weight reduction, have low electrical resistivity and high thermal conductivity. Consequently, resistance spot welding requires extremely high currents, and the shortened electrode life due to contact with molten aluminum is also a problem. In contrast, it has been demonstrated that the cold spot joining method enables high-strength welding of high-tensile steel plates, various galvanised steel plates, and aluminum alloy plates. Even in dissimilar material welding between steel plates and aluminum alloy plates, satisfactory joints have been achieved in tensile shear tests and cross-tensile tests, where the base material fractures.

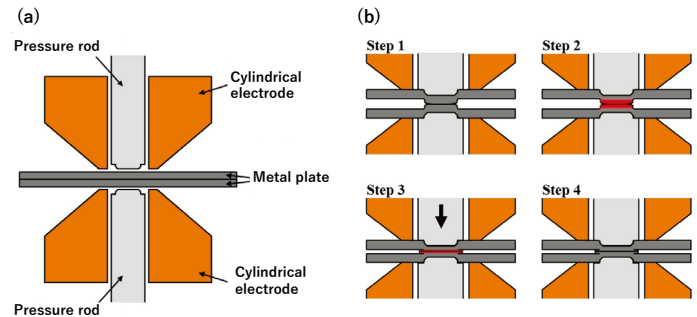


Fig. 1 Schematic drawings of a dual electrode (a) and welding process (b) in cold spot welding.

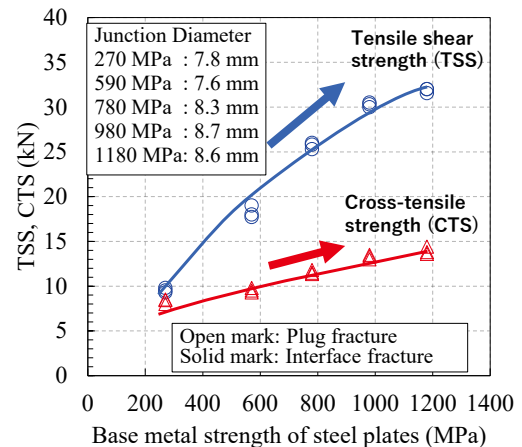


Fig. 2 Relationship between base metal of steel plates and strength of joints. In conventional resistance spot welding, as the base material strength increases, the effects of softening in the heat-affected zone and embrittlement in the solidification zone become more pronounced, leading to a saturation in the increase of joint strength. However, it is evident that by using cold spot joining, the joint strength continues to increase.

## Significance of the research and Future perspective

The use of cold spot joining not only allows the full potential of existing metal materials to be utilised, but also removes material

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**Keyword** solid-state welding, dissimilar welding, high-tensile steel, aluminum alloy, weight reduction