Self-Piercing Riveting

Process Summary

Self-Piercing Riveting (SPR) is a cold mechanical joining process used to fasten two or more sheets of material by driving a semitubular rivet piercing through the top sheet(s), but only partially piercing the bottom sheet. With the guidance of a suitable die, the rivet will spread inside the bottom material to form a mechanical joint. The SPR process and a joint cross-section can be seen in Fig. 1. A SPR system normally contains a driving system with a punch, a 'C' frame, a rivet feeding system and a controller. The main process parameters for different material stacks include different rivet setting force, different rivet (different geometry, materials, hardness, diameter, and length), and different die (different shape, diameter, and depth). Unlike solid, blind and semi-tubular rivets, self-pierce rivets do not require a pre-drilled or pre-punched hole.

Process Advantages

The main advantages of SPR include:

1. It is environmentally friendly: no fume, no spark and low noise;
2. Ability to join similar and dissimilar materials, including aluminium, steel, plastics and magnesium etc;
3. No requirement for pre-drilled holes and alignment;
4. No surface pre-treatment required;
5. Ability to join with lubricants and adhesives;
6. Low energy requirement;
7. Long tool life, >200,000 operations before replacement;
8. Easy for automation and process monitoring;
9. Short cycle time, 1-4 seconds;
10. Ability to achieve water tight joints;
11. As a cold process, no side effect on the heat treatment of the substrate materials;
12. High static and fatigue joint strengths.

HVM capability

The HVM Catapult SPR capability is located at WMG, the University of Warwick, which operates two SPR facilities, one Servo/Electric Henrob SPR system and one Servo/Electric Emhart Tucker SPR system. Details of the specifications are given in Table 1. The main difference between the Henrob

and Tucker SPR system is that for the Henrob system, the rivet is punched (in high speed) into the material stacks; however, for the Tucker system, the rivet is pushed (in low speed) into the material stacks. Currently, these systems are used to join aluminium or mixed material lightweight automotive body-in-white (BIW) structures.

Table 1 Specifications of Henrob and Tucker SPR systems

	Tucker SPR	Henrob SPR
Rivet diameter	5.3 mm	5.3 mm
Rivet length	4-12 mm	4-12 mm
Maximum stack thickness	6 mm (steel) 10 mm (Al)	6 mm (steel) 10 mm (Al)
Quality control	Stack thickness, rivet length and setting curve	N/A
Maximum setting force	80 kN	160 Henrob unit
'C' frame depth	Small (~150 mm)	Large (~440 mm)
Rivet hardness	250-600 Hv	250-600 Hv

Typical applications

SPR is widely used for joining lightweight aluminium BIW structures in automotive. Resistance spot welding has been the traditional joining method for steel automotive BIW structures for decades; however, when it is used to join lightweight aluminium or mixed material structures, it has some difficulty due to the high thermal conductivity, low electric resistance and stable surface oxide layer of aluminium alloys. As a result, SPR was developed as an alternative joining methods for these applications. Fig. 2 shows an example of a BIW structure joined by SPR. The other application of SPR include white goods, road signs, and construction.

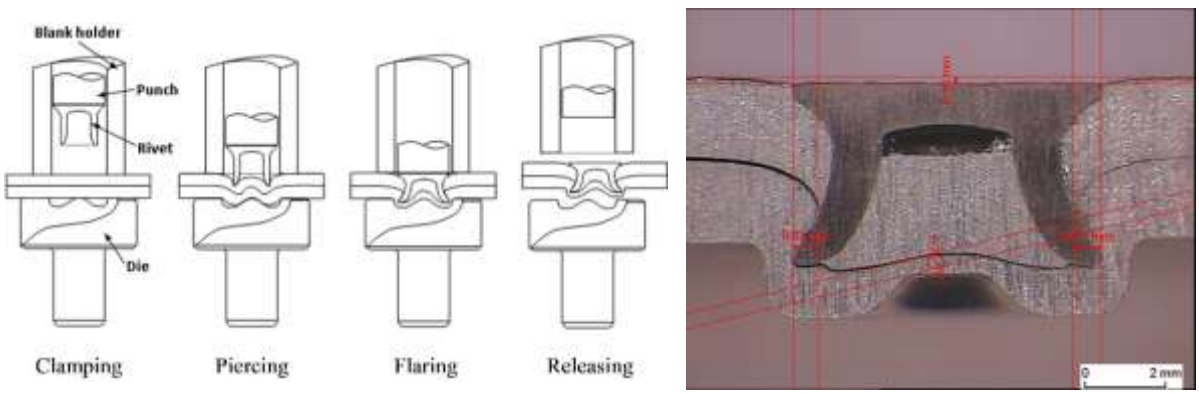

Figure 1 Illustrated SPR process and one cross-section of a SPR aluminium joint.

Figure 2 An all-aluminium automotive body-in-white structure.

Figure 3 WMG Tucker SPR system.

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