iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** VIII **Month of publication:** August 2017

DOI: http://doi.org/10.22214/ijraset.2017.8249

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, August 2017- Available at www.ijraset.com

Review: Self Piercing Riveting in Automotive Industry

Chirag Sarda [1], Ruchira Srivastav [2]
[1]Mechanical Department, Amity University, Greater Noida, India
[2]Assistant Professor, Mechanical Department, Amity University, Greater Noida, India

Abstract:* SPR or self piercing riveting is a cold mechanical joining process in which the sheets of materials are joined by driving a rivet piercing through the top sheet or top and middle sheets and eventually lock under the guidance of a suitable die into the bottom sheet. SPR is currently the main joining method for mixed-material lightweight automotive structures and aluminium. SPR was originated half century ago, but it only had significant progress in the last 25 years due to the requirement of joining light-weight materials, such as aluminium alloy structures, aluminium-steel structures and other mixed-material structures, from the automotive industry. Compared with other conventional joining methods, SPR has many advantages including no pre-drilled holes required, no fume, no spark and low noise, no surface treatment required, ability to join multi-layer materials and mixed materials and ability to produce joints with high static and fatigue strengths. In this paper, research investigations that have been conducted on self-piercing riveting will be extensively reviewed. The current state and development of SPR process is reviewed and the influence of the key process parameters on joint quality is discussed. The tests and relevance of SPR joints, the advantages and possible disadvantages, applications and futuristic trends of SPR are reviewed.
***Keywords*: Self-Piercing Riveting (SPR), automotive industry, SPR joint strength characterisation, aluminium sheets, lightweight materials**.

I. INTRODUCTION

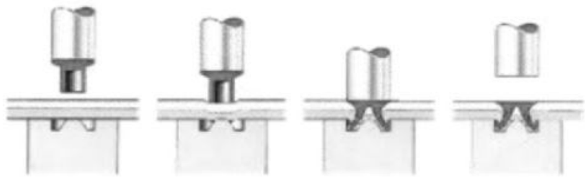
In order to reduce fuel consumption and vehicle emissions, the use of lightweight materials has always been of interests to the automotive industry. Much of the focus of weight-saving has centered on the vehicle body as this accounts for about 30% of the total vehicle weight. The industry has also replaced the traditional mild steel in body application from new steels of high strength and thinner gauge. Introduction of new materials like aluminium has presented new challenges to automotive industry with resistance Spot-Welding method because of its low melting point, high thermal conductivity, reacting and contaminating welding tip, aluminium oxide layer makes the spot weld weak and metal surface with low fatigue resistance. But the answer lies in the development of a combination of adhesive bonding and SPR. This joining technology have been introduced to automotive manufacturing to achieve weight reduction goals and joining body panels and structures, particularly for aluminium parts and dissimilar metal parts.SPR joint strength characterisation and performance behaviour is also evaluated in this review.

II. SELF- PIERCING RIVETING

As discussed before, the process is to fasten two or more sheets of materials mechanically with a rivet. The process is schematically illustrated in Fig.1.1.The technique is divided into following distinct stages:

A. The sheets to be joined are fasten together between an upset die and a blank holder.
B. Through a feeding system, a semi-tabular rivet is driven under a punch and is driven down using electrical system or hydraulics, forcing the rivet down into the material stack.
C. At piercing stage, the rivet shank acts as a shearing punch that pierces into the entire thickness and the lower sheet is partially pierced until the rivet reacts against the influence of the die.
D. At flaring stage, the rivet spread into the die and forms a mechanical-interlock. The force applied causes the lower sheet flow into the die cavity, due to plastic deformation and the lower sheet confirms the cavity shape to form a buttonhole at the bottom.
E. The last stage is the releasing of the joined sheets.

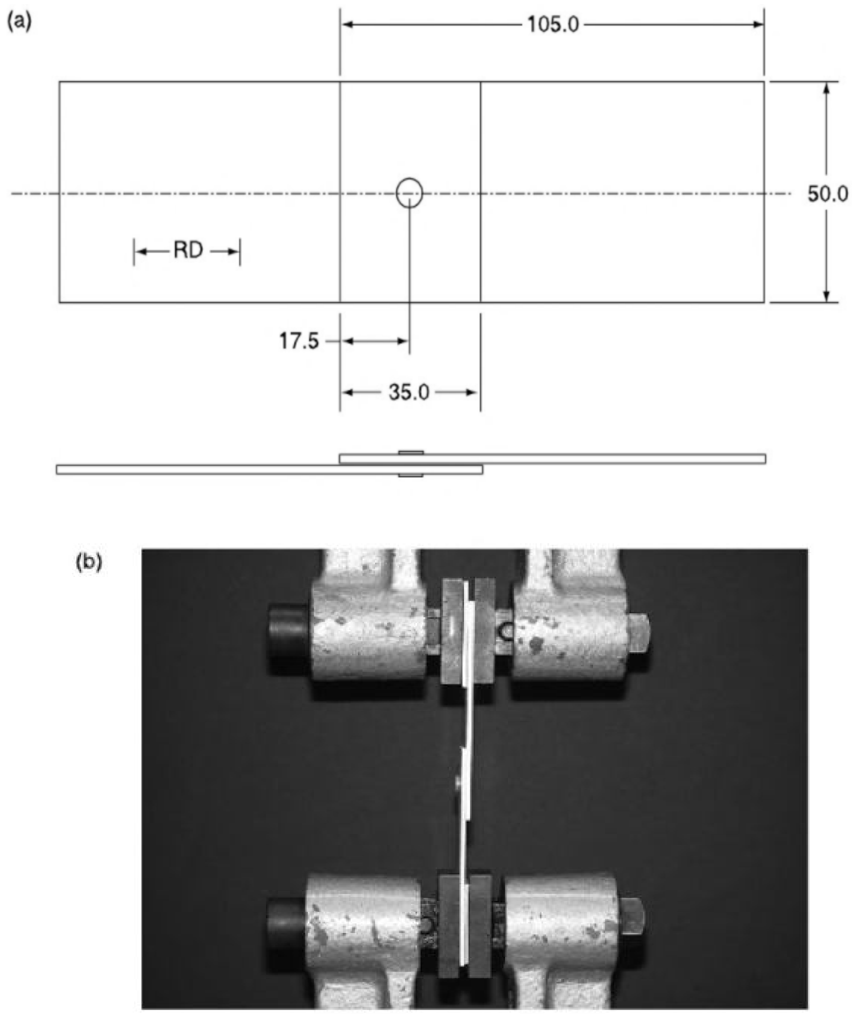
International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, August 2017- Available at www.ijraset.com



1.1 The self-piercing riveting process.

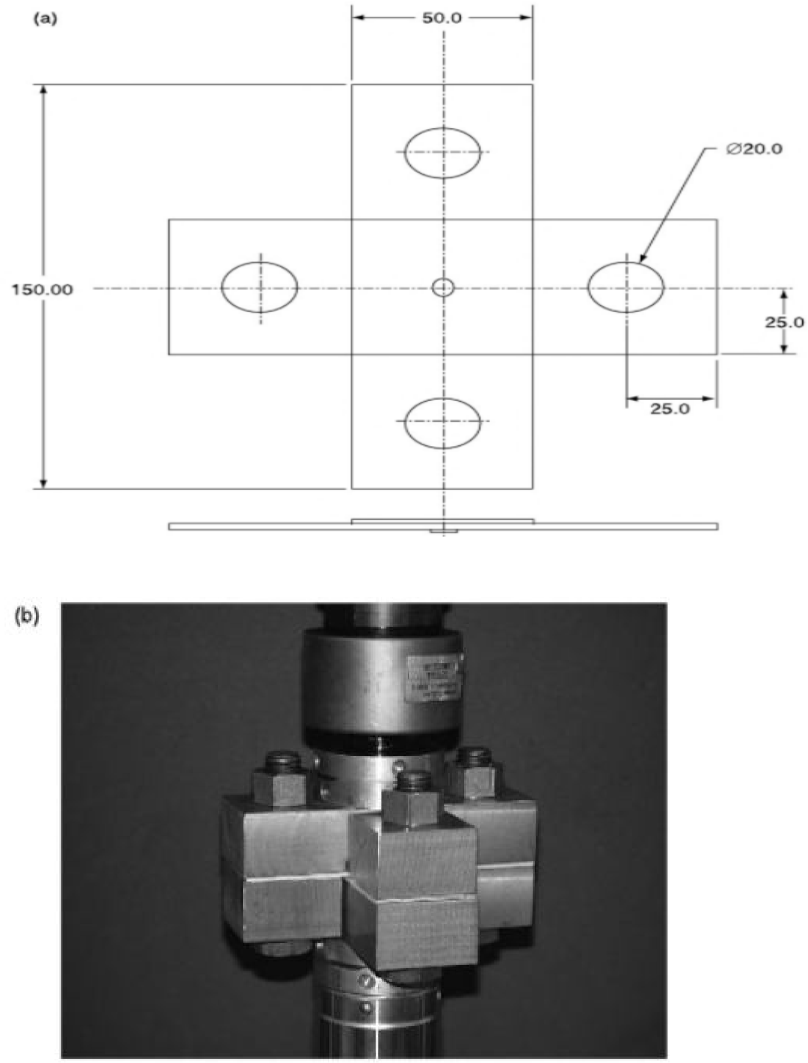
III. TEST TYPES AND THIER RELEVANCE

Test like uniaxial tension are performed for static joint strength and energy absorption of both similar and dissimilar combination of SPR joint. Common specimen configurations like lap shear, cross tension and coach peel used to test the joints in one directional loading condition. For the work that is reviewed in this paper, lap shear specimen are typically 105mm in length and 50mm in width with a 35mm overlap of the materials of interest. Cross tension specimens are also 105mm in length and 50mm in width, joined perpendicular to each other crossing in the centre of each material. Coach peel specimens are 105mm in length and 25.4mm in width. Figures 2.1, 2.2 and 2.3 illustrates the coupon design assemblies and each respectively assembly in a test fixture.

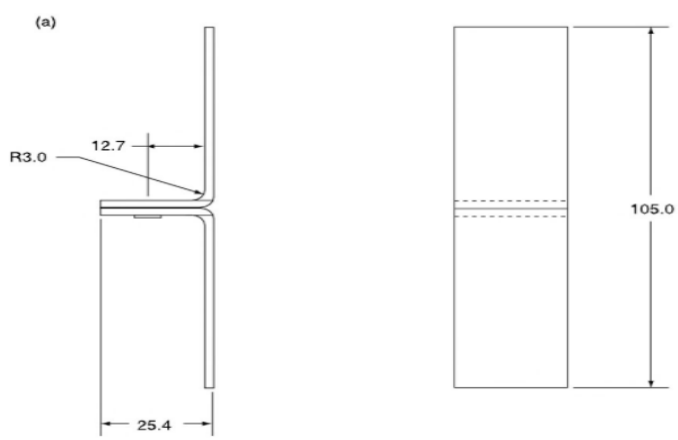


2.1 The lap shear coupon assembly drawing (a), and test fixture (b), used to conduct static tests. All dimensions are in millimeters.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, August 2017- Available at www.ijraset.com

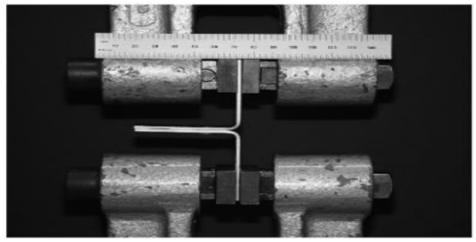


2.2 The cross tension coupon assembly drawing (a), and test fixture (b), used to conduct static tests. All dimensions are in millimeters.



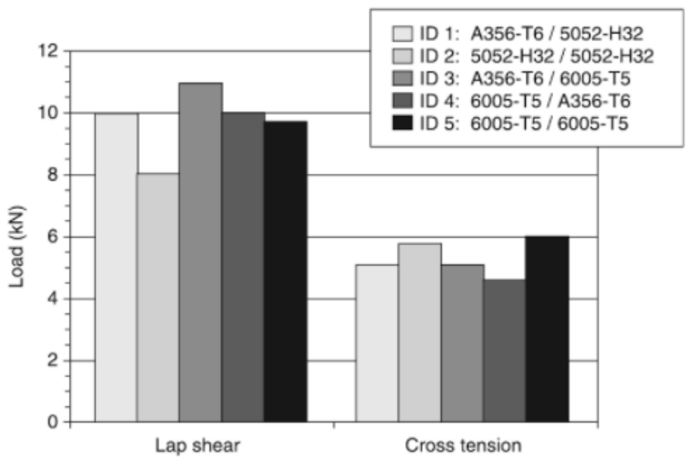
International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, August 2017- Available at www.ijraset.com

(b)



2.3 The coach peel coupon assembly drawing (a), and test fixture (b), used to conduct static tests. All dimensions are in millimeters.

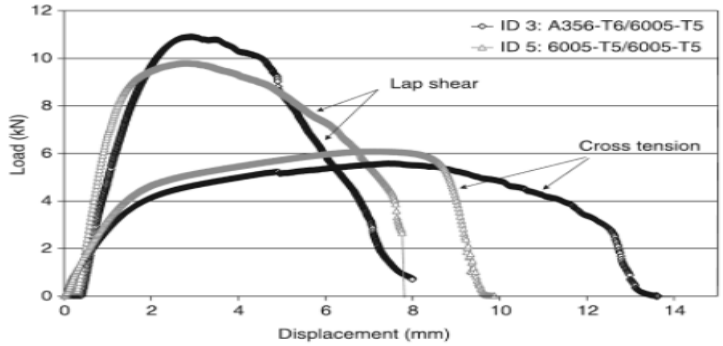
Test parameters for quasi-static test of each assembly design include a closed-looped servo-controlled hydraulic test frame at a rate of 10mm/min for lap shear and 25mm/min for both cross tension and coach peel loading condition. For varying material combination .Fig.2.4 shows the lap shear and cross-tension test results of single joint SPR of 3mm thick AA6005-T5 wrought flat stock extrusion, AA5052-H32 wrought steel and A356-T6cast flat stock in various combination as described in Table 2.1.
Illustrating the load-displacement graph in Fig.2.5, of Joint ID 3(6356-T6/6005-T5) and ID 5(6005-T5/6005-T5) lap shear and cross tension results are shown.



2.4 An illustration of the average static strength results for varying heavy vehicle aluminum cast and wrought alloy SPR joint combinations under lap shear and cross tension loading.

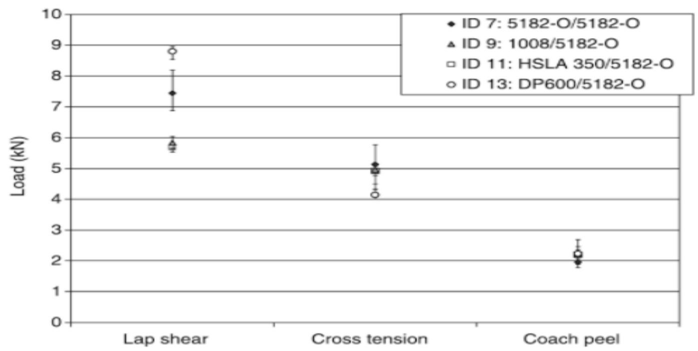
Table 2.1 Joining parameters for single joint SPR specimen assemblies of similar and dissimilar material combinations

SPR joint ID	Top material	Top thickness (mm)	Bottom material	Bottom thickness (mm)	Joint stack (mm)	Rivet length (mm)	Henrob die	Clamp pressure (bar)	Setting pressure (bar)
1	A356-T6	3.0	5052-H32	3.0	6.0	9	A	120	235
2	5052-H32	3.0	5052-H32	3.0	6.0	9	B	120	210
3	A356-T6	3.0	6005-T5	3.0	6.0	9	B	120	235
4	6005-T5	3.0	A356-T6	3.0	6.0	9	A	120	235
5	6005-T5	3.0	6005-T5	3.0	6.0	9	B	120	235
7	5182-O	2.0	5182-O	2.0	4.0	7	C	120	210
9	1008	1.4	5182-O	2.0	3.4	6.5	D	120	210
10	5182-O	2.0	HSLA 350	1.0	3.0	6	D	120	230
11	HSLA 350	1.0	5182-O	2.0	3.0	6	D	120	240
12	5182-O	2.0	DP 600	1.6	3.6	6	D	123	230
12L	5182-O	2.0	DP 600	1.6	3.6	6.5	D	120	240
13	DP 600	1.6	5182-O	2.0	3.6	6.5	D	120	240



2.5 Uniaxial test results for aluminum cast to wrought (ID 3) and wrought alloy (ID 5) SPR joints.

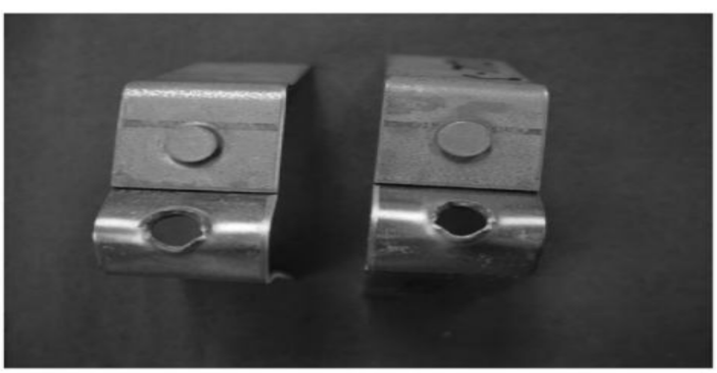
Figure 2.6 illustrates the different strength observed for dissimilar metal combination used in automotive application. This fig. shows importance of testing different design configuration because trends observed under one conditions may not be observed in other loading conditions.



2.6 An illustration of the static strength results for various dissimilar material SPR joint combinations where the bottom material of the joint is 5182-O aluminum.

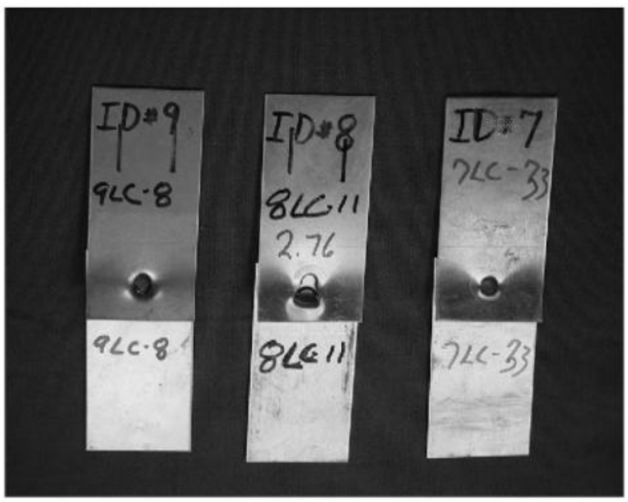
IV. FAILURE MECHANISM

Basically, there are two primary failure modes that are observed under static loading: rivet head pullout and rivet tail pullout. In rivet head pullout, the rivet head is pulled out from the top material substrate (Fig.2.7) and rivet tail pullout occurs when rivet tail is pulled out of the bottom material (Fig.2.8). Sheet bending may be observed under static loading in thin substrates on the rivet head side causing tearing or shearing of the top sheet substrate which allows the rivet head to pull-through as shown in Fig.2.9.



2.7 Representative image of SPR joint assemblies exhibiting rivet head pullout. Images shown are coach peel coupon assemblies after testing.

2.8 Representative image of SPR joint assemblies exhibiting rivet tail pullout. Images shown are lap shear coupon assemblies after testing.



2.9 Representative images of SPR joint assemblies exhibiting sheet tearing (outer specimens) allowing rivet head pull-through and sheet shearing (center specimen). Images shown are lap shear coupon assemblies after testing.

V. ADVANTAGES

New automotive industries use SPR as a joining method for several reasons, including:

A. Joining together unweldable or difficult to weld materials.
B. It does not required pre-drilled holes and exact hole alignment unlike conventional riveting.
C. No damage to protective coatings.
D. It produces joints of good fatigue resistance and high resistance.
E. The process can be fully automated and robot mounted to operate in a flow-line.
F. The cycle time for a joint is short and does not increase significantly for thicker materials or stacks.
G. The processing tools have a long life.
H. Low energy requirement.
I. It is available in a variety of forms: robot-mounted, portable and multi-head machines.
J. This process is environmentally as well as user friendly as no fume emissions during production.
K. No material waste, little noise and low processing cost.

VI. DISADVANTAGES

Summarised below are the possible disadvantages of the process:

A. spite of low processing cost, the equipment and tooling costs are higher.

B. This process is not for brittle materials, it is limited to deformable materials.

C. As a result of SPR, there are some concerns about potential corrosion problems such as (i) the potential use of dissimilar materials causing galvanic corrosion;(ii) causing differential aeration corrosion due to overlap joint and gap between the rivet and pierced sheet, and (iii) surface irregularities .

D. As the process is double-sided, so access to both sides of stacks is required.

VII. APPLICATION

A. Self piercing riveting are used to assemble automotive sunroofs, which require high durability and strength.**]**

B. Self piercing riveting no work hole are used for roof trusses, which require long-term durability and strength.

C. Plastic rivets are used to assemble returnable plastic containers, which require high durability against repeated use. This rivet allows products to be made entirely of plastic thereby making them recyclable.

D. Self piercing riveting high in strength and durability are used for assembly of large work piece like wing roof truck.

E. Self piercing riveting are used to assemble storage sheds, which are typically used under bad weather condition for long periods of time. This rivet ensures both self piercing riveting, which eliminates the need to drill pilot holes in work piece and high sealing performance after fastening.

VIII. FUTURE RESEARCH

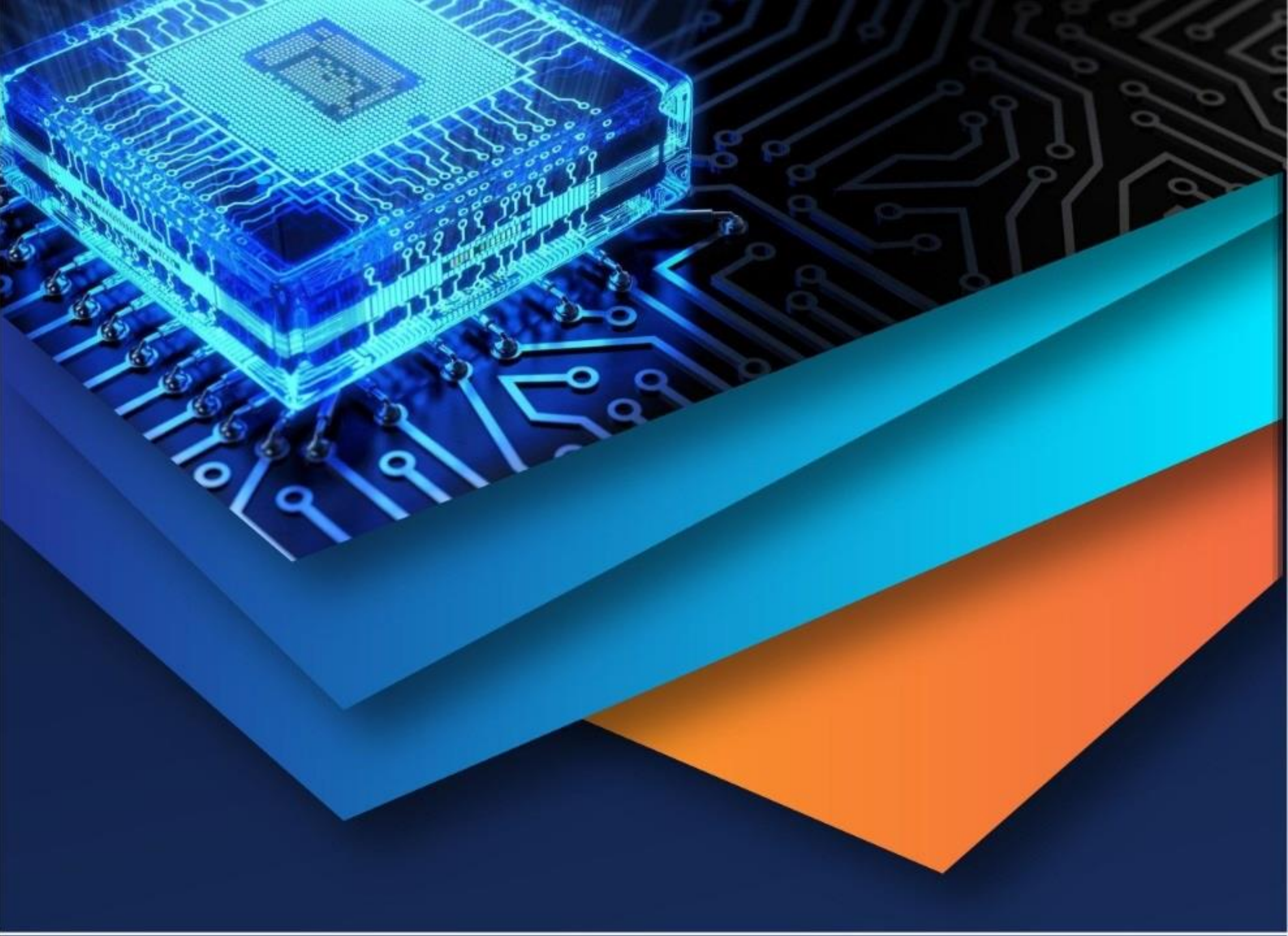
Based on current SPR developments, future research efforts are likely to focus on (1) SPR of new materials and mixed materials, including very high strength steels, press hardened steels, casting materials and fibre reinforced composite; (2) further understanding of the mechanical performance and (3) modelling of the SPR process and behaviour. Due to the complexity of the process, the modelling of SPR process and SPR joint performance remains the main challenge. The development and future research is likely to address the speed of joining which dependent several factors including the rivet pitch length, materials to be joined and their geometry. The current joining speed is roughly 1m/min which is comparable to welding process and the industries will likely to develop a speedier SPR process.

IX. CONCLUSION

SPR is a given basic standard reference for the designers and engineers of aerospace welding automotive materials etc. as well as the metal manufacturers. Due to its low speed and low energy requirement it is been increasingly adopted by many industries, for high speed mechanical technique for sheet joining components. It reviews the process, the equipments and behaviour of SPR by describing the process of modelling and evaluation.

REFERENCES

[1] PondJ B (1972), 'What's new in automotive fastening', Automotive Ind, 147, 32-37.
[2] Bollhoff Fastening Ltd, http://www.boellhoff.de.
[3] LaPensee M L (2003), 'Self-pierce riveting technology: a joining solution for light metals', Light Met Age,61,32-34.
[4] The Welding Institute, TWI, http://www.twi.co.uk.
[5] He X, Pearson I and Young K (2008), 'Self-piercing riveting for sheet materials: state of the art', JMater. Process Technol., 199, 27-36.
[6] Fu M and Mallick P K (2003), 'Fatigue of self-piercing riveted joints in aluminium alloy 6111', Int.J. Fatigue, 25(8),183-9.
[7] Booth G S, Oliver C A, Westgate S A, Liebrecht F and Braunling S (2000), 'Self-piercing riveted joints and resistance spot welded joints in steel and aluminum', Proceedings of the International Body Engineering Conference, Detroit, MI, SAE Paper No. 2000-01-2681.



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY