

## Joining Forces

*Gary White*

In future, manufacturing lightweight cars will be a lot simpler and faster, thanks to a groundbreaking invention by AutoCRC's Advanced Rivet team. The team has invented a rivet that makes its own hole and cleans up afterward, eliminating drilling and cleanup operations, while making a stronger joint in less time.

Supported by GM Holden and AutoCRC, CSIRO researchers have made a leap forward in blind rivet technology. The blind rivet, so named because the user cannot see the other side of the joint, is extensively used in automotive, aerospace and general manufacturing, where access is only possible to one side of the components to be joined. Blind riveting usually involves five steps; clamping parts to be joined, drilling a precise hole through both parts, cleaning up the drill "swarf", inserting a rivet and finally, locking the joint by expanding or "upsetting" the rivet in the hole. Using the concept of friction stirring, Dr Sri Lathabai's team has invented a highly effective Friction Stir Blind Rivet (FSBR) for use in joining light alloy components. The FSBR system makes it possible to rivet quickly with minimal waste and maximum joint strength.

Blind or "pop" rivet technology has been in use since early in the 20<sup>th</sup> century. Initially developed by a shoe manufacturing company, blind rivet designs proliferated and found application in almost every

manufacturing industry including automotive and high-tech aerospace manufacturing. Common blind rivet types range from cosmetic non-structural hollow types to structural internal locking rivets. A blind riveted joint is convenient, but variations in the drilling operation can lead to several problems including loose joints, swarf and capture of swarf in the joint. These issues with the blind riveting process



Typical riveted panel and stiffener

often prevent its use in applications where swarf cannot be removed and may cause damage to the product. Hollow structural sections and tanks are such examples, where the swarf can rattle about, find its way into critical parts like an engine, or corrode and spread corrosion within the part.

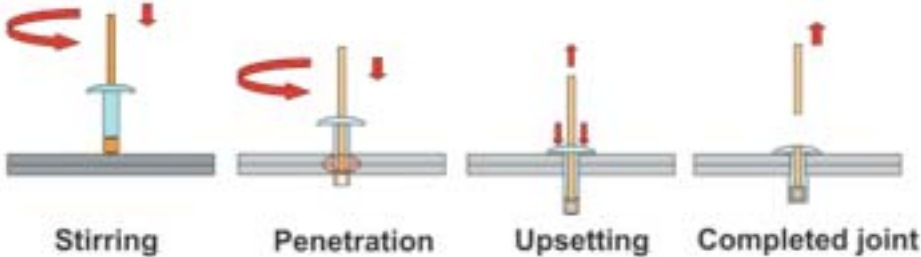
In safety critical applications, aerospace and automotive manufacturers have devised elaborate cleaning systems as part of their blind riveting process. The drill swarf is vacuumed, magnetically attracted or washed out prior to rivet insertion and upsetting. In the aerospace industry, this is a significant time and cost penalty necessary to avoid catastrophic

failures in service. In automotive applications, similar cleaning operations are necessary, primarily to avoid loose joints and noise from loose swarf.

If the joint is not adequately clamped swarf may find its way “between” the components of the joint. This usually results in a loose joint as the swarf is compacted or is worked out of the joint during service.

The quality of a blind rivet joint is highly dependent upon the quality of each operation, and to avoid problems, manufacturers add cost and time in pre-drilling processes to minimise this risk. In some cases, additional rivets are used to ensure a solid joint, adding further cost and time in the process.

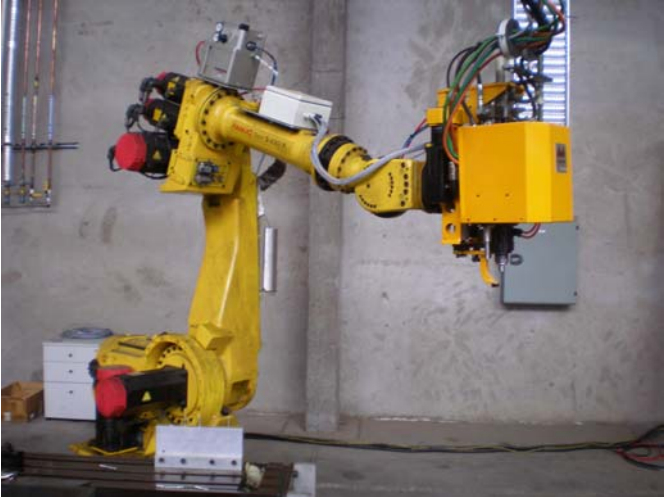
Learning from earlier work by GM researchers, Dr Lathabai’s team overcame these shortcomings by inventing a new rivet that uses friction stir blind riveting (FSBR) to eliminate the need for pre-drilling and cleaning holes in the parts. FSBR is a new process for joining light alloys like aluminium and magnesium. During FSBR, a blind rivet, rotating at high speed, is brought in contact with the part. The frictional heat generated between the rivet and the part softens the material so that the rivet can be pushed completely into the parts to be joined.



The friction stir blind rivet (FSBR) process

To complete the joining process, the rivet is upset by pulling on the mandrel, (that just created the hole) using a conventional blind riveting tool. The FSBR process has all the one-sided accessibility of conventional blind riveting, but without the extra pre-drilling steps.

To prove the effectiveness of the FSBR process and patented rivet design, the project team designed, constructed and programmed a remote-controlled FSBR tool for production line robots. CSIRO scientists worked with production line experts Marand Precision Engineering to create the unit, which is being used for tests on components.



The FSBR system on a production robot

The new FSBR invention offers many benefits for manufacturers. Because

the friction stir process heats and plastically deforms the material around the rivet mandrel, the resulting hole is exactly sized for the rivet body, improving joint strength and durability. The rivet mandrel is designed for low insertion force, and to capture the metal plug created during the friction stir process. When the rivet is upset, the mandrel end contracts and this material is held in place. Finally, the friction stir process plasticises the metal around the hole, and creates a smooth bore with no loose material or gaps between the parts at the joint. Because of the smooth bore, it is unlikely that hole material will end up between the joined pieces.

Manufacturers using the new FSBR system can expect faster, cleaner, stronger and more durable blind riveted joints over standard blind riveting. These benefits will reduce costs and improve competitiveness enabling the increased use of light alloys in vehicles. The new FSBR system is suited to use on automated production line, and has definite possibilities for use by robots. The low forces and temperatures needed to create the joint are especially attractive, and in some cases, FSBR will eventually replace spot welding as the most effective joining system. FSBR has potential for other applications because it is not a cutting process, and the heat generated is low and very localised. This means a wider range of materials can be joined, including composites and textiles.

### **Publications**

Lathabai, S. et al. "Friction Stir Blind Riveting - A Novel Joining Process for Automotive Light Alloys." SAE World Congress 2011.

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