Source: RAGHUNATHAN, S.: „*Novel Technologies for Repair and Refurbishment in the Power Industry and Case Studies*“; Contribution on the 8th International EPRI Conference on Welding and Repair Technology for Power Plants; 18-20 June 2008, Fort Myers Florida

Friction Processes

The recorded use of frictional heat for solid-phase joining techniques dates back over a hundred years. The friction welding process, however, to a large extent has been restricted to round, square, or rectangular bars. In addition to the applicability of these techniques to form attachment to structures, TWI has been working on techniques which now allow solid-phase friction welding as a viable option for plate fabrication in a range of materials. Solid phase welding is thought to be less sensitive to Helium cracking than conventional arc welding, which affects repair of irradiated stainless steels. Of particular interest are three techniques that have potential for the repair of defects, friction taper stitch, friction hydropillar processing and friction stir welding. Friction processes have been successfully applied to produce sound welds underwater.

Friction taper stitch welding (3)

Friction taper stitch welding is particularly suited to repair of cracks. This is a solid phase welding process and involves drilling a tapered hole through the full thickness of a plate at the location of the defect. A tapered plug with a similar included angle is then friction welded into the hole. By using a series of inter-linking holes long defects can be repaired. The process is portable and will run from power supplied by mobile generators. The hole plugging weld cycle time in 8mm thickness stainless steel is ~0.5 seconds. The principle of friction taper stitch welding is shown in Fig.5.

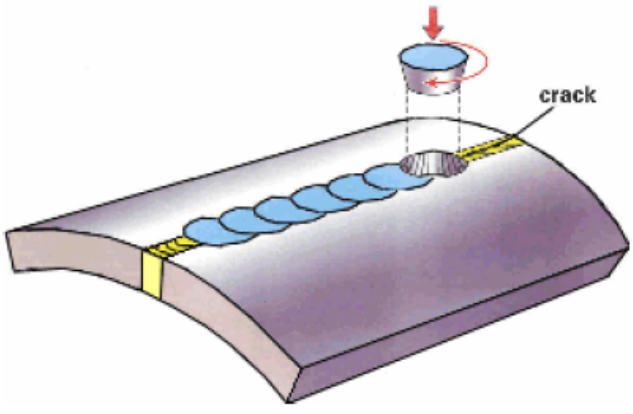

Figure 5. Principles of friction taper stitch welding for crack repair.

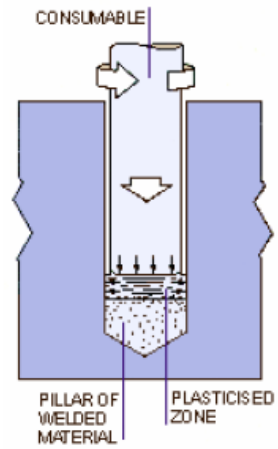

Figure 6. Friction Hydropillar Processing

Friction hydro pillar processing (FHPP) is a comparatively recent solid-phase welding technique. Invented at TWI, this technique is the focus of considerable R&D interest because of its potential in fabrication and manufacturing where it offers a number of novel production routes. The FHPP technique is still under development, but already shows promise for joining and repairing thick plate in ferrous and non-ferrous materials. Conventional fusion welding of thick section fabrications involves lengthy processing sequences and with some process large volumes of consumable material. In contrast, use of the FHPP welding technique should provide a reduction in joint preparation and weld filler metal, which will lead to significant cost savings.

Friction Stir Welding and Processing

Friction Stir Welding (FSW) is a continuous hot-shear process involving a non-consumable, rotating probe of harder material than the substrate itself. The basic principle of the process is shown in Fig.7. Essentially, a portion of a specially shaped rotating tool is entered between the abutting faces of the workpiece (i.e. the joint). The tool's rotary motion generates frictional heat which creates a plasticised region (a local active zone) around the immersed portion of the tool, the contacting surface of the shouldered region on the tool and the workpiece top surface. The shouldered region provides additional friction treatment to the workpiece as well as preventing plasticised material from being expelled. The tool is then steadily moved along the joint line, with the plasticised zone cooling behind the tool to form a solid-phase joint as the tool moves forward.

The FSW is being considered as material reprocessing technique, which would repair surface breaking, or near surface defects and has been applied to the manufacture of copper canisters for encapsulating high level nuclear waste and storage in deep level depositories.

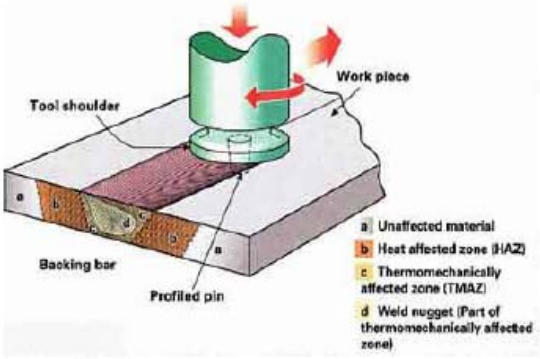

Figure 7. Principle of FSW

Figure 8. Friction stir processing trial - stainless steel

Friction Stir Processing Being Developed for On-Line Repair of Nuclear Plant - As nuclear plants around the world grow older there are increasing incidences of stress corrosion cracking (SCC) problems. In PWRs such cracking is well known and often associated with reactor pressure vessel parts (eg: primary water SCC at reactor nozzle locations). However SCC also occurs in the secondary circuit and auxiliary parts of the plant which are also safety-critical. This repair development is aimed at relatively thin-walled Type 304 stainless steel water storage tanks which have experienced SCC cracks at the external surface. Friction stir processing is a technique which has grown out of TWI's friction stir welding expertise and essentially provides a high integrity smooth repair of shallow surface breaking defects. For this particular application, the utility customer considered it offers advantages for on-line application particularly in terms of its controllability and lower risk of through-wall penetration when compared with conventional weld repair methods. A typical friction stir process trial weld in stainless steel is shown in Fig.8.