Editorial

Friction stir welding and processing has come a long way since the heady days of the pioneering work done at TWI in Cambridge some two decades ago. The FSWP 2010 conference held in Lille, France, during January, had the brief to cover in this context, the process, structure–property relationships, simulation and applications. Of the large number of papers presented at the conference, a selection which dealt with welding are included in this special issue of STWJ. All of these papers went through the usual independent refereeing and editorial procedures of the journal.

It is interesting that nearly 30% of research papers on FSW published since 2008 are on dissimilar metal joining; this is a large increase when compared with the average over the last two decades. It is possible that with aluminium alloys at least, the joining of similar alloys is so well established that the *research* focus is now shifting to the more difficult joints between materials which may have vastly different physical properties. This topic was of course covered in a recent special issue of STWJ (Volume 15, Issue 4, described in Ref. 1), and it is not surprising that the Lille meeting contains some interesting contributions in this context.

The paper by Chen and Lin[2] deals with the optimisation of operating conditions for joining of certain aluminium and iron alloys, with the objective function for the optimisation based on elementary measures of impact toughness. Apart from the specific achievements, there are two generic points which emerge. In a recent critical assessment,[3] it was emphasised that there is a difficulty in defining what constitutes a good weld when it comes to joining steels or dissimilar FSW joints involving steels. The mechanical characterisation is usually more comprehensive when arc welds are studied. This may be because the difficult joints are as yet far from serious technological exploitation.

The paper[2] also underlines the fact that models of FSW are not sufficiently advanced, or are not sufficiently widely available, to deduce the optimum parameters without simply embarking on experiments. The models are not yet capable of predicting mechanical properties so that optimisation must be based on an intuitive understanding of what is good in a stir weld. What is needed is simple calculations (cf. the tremendous success of the ‘carbon equivalent’ concept in fusion welding). Some progress is being made in this area.[4]

Friction stir spot welding is likely to contribute to the design of better automobiles because the method leads to the possibility of joining different metallic alloys in a mass production scenario.[5] Conventional resistance spot welds are assessed in a variety of ways including cross-tension and lap shear testing. It is natural then to expose friction stir spot welds to similar tests even though the geometry of the ‘nugget’ is dramatically different. The paper by Tran and Pan[6] has some particularly good metallography to show the failure modes, together with an interpretation of load bearing capacity.

A fascinating study by Chen and Nakata[7] shows that when joining steel to magnesium alloys using friction stir welding, it is advantages if the steel has a zinc coating. The reason is beautifully simple, that the zinc promotes the formation of a low melting point eutectic with the magnesium, which enhances interdiffusion, breaks oxide films and results in a cleaning action when the liquid is expelled from the joint due to tool pressure.

In a similar study on the friction stir spot welding of aluminium and magnesium alloys, Sato *et al.*[8] find no difficulty in producing defect free welds, although the mixing leads to substantial formation of intermetallic compounds. The presence of the compounds does not in itself lead to deterioration in the lap shear strength as long as their distribution is optimised.

In an alternative approach to spot joining, Miles *et al.*[9] use a consumable tool to penetrate overlapping steel and aluminium alloy sheets, followed by rotational friction heating, and finally the separation of the part of the tool which does not lie within the sheets. In this so called friction bit joining process, the lap shear strength is found to be similar to that associated with self-piercing rivets, whereas the latter process is restricted to ductile materials.

The experimental modelling of metal flow during FSW, pioneered by Reynolds and co-workers,[10,11] is reported by Kumar and Kailas[12] in an effort to understand the factors that control the vestige of the joint surface which existed prior to welding. It appears that this remnant can be avoided by locating the surface on the advancing side of the stir weld. Park and co-workers[13] also report

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advantages in the control of mixing when it comes to the joining of dissimilar aluminium alloys, and explain how the fracture position in tensile testing is determined by the mixing.

The use of FSW in the stiffening of sheet is important in the fabrication of decks and other engineering applications where reinforcement is achieved without a substantial increase in weight. Tavares *et al.*[14] report on T-joints produced using FSW without overlapping the web and skin other than where the these two components touch. Studies of the fatigue, hardness and residual stress patterns of such joints show reasonable promise.

In summary, an exciting and imaginative set of papers which show the vitality of this field of research.

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