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FRICTION STIR WELDING A METAL JOINING PROCESS OF GROWING IMPORTANCE

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Mechanical Engineers basically convert raw material to useful products. One of the basic requirements is to understand the material know it's properties, characters and it's strength to decide it's suitability for application for correct usage from cost, process adaptability and reliability. Forming and joining metals is one of the basic leanings that assisted in the advancement of products. Metal joining is useful in making gold, silver jewels, civil structures like grills, railings, buildings bridges, machines and boilers, condensers, evaporators, chillers, automobiles, aero planes, spacecrafts etc.

Joining processes vary, like in soldering brazing a filler material is used to join two base materials without changing the base material phase of solid state whereas in welding the base material is heated up to the melting point, When cooled the two base materials join because the common molten material rejoins as a single part. One of the basic welding processes is a metal arc welding, where the electrode is a consumable metal, MAW, where the heat of melting is obtained from an electric source. If the Arc is protected by an inert gas like Argon it is called Shielded Metal Arc Welding, SMAW, if the electrode used is a non consuming type like Tungsten, Then the welding process is called Tungsten Inert Gas, TIG welding. There are other advanced arc generation methods such as Laser or Electron or Plasma Which are useful in creating very thin weld beads. The requirements of a good weld is to have thin weld beads, should be able to weld thick members, create less residual stresses due to the welding process, have less distortions in shape from the original configuration Ultimately, form a stable strong and reliable joint. All the above mentioned welding processes require some external heat source to melt the two parts of the base metals before initiating joint.

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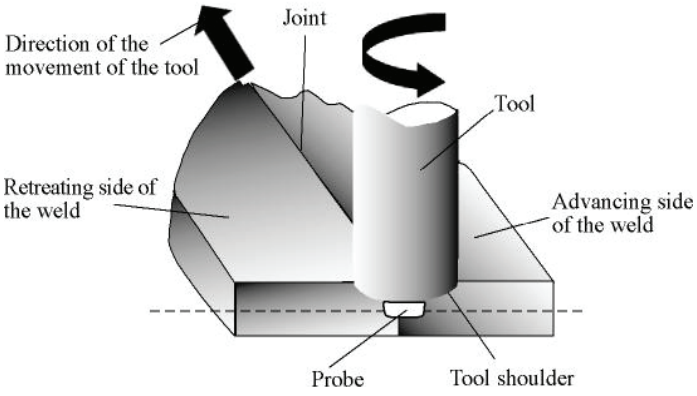
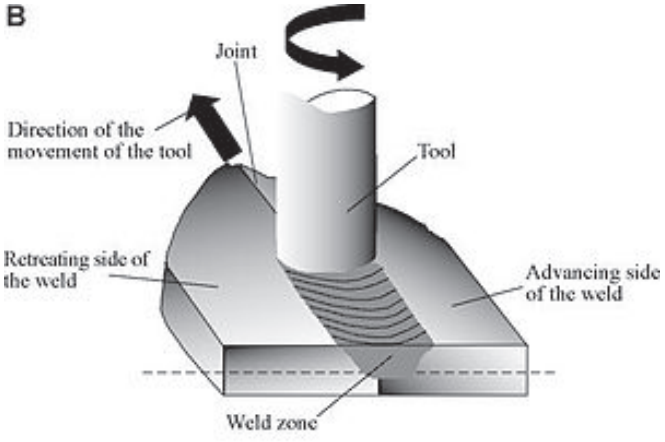
A



Friction stir welding was a new form of truly mechanical joining which was invented and Patented by TWI, UK Welding Institute in 1991. Using soft malleable materials like Aluminum the metal parts to be joined are kept side by side and a harder than the base metal stepped tool is pressed to the joint. Figure A, shows the tool which has a stem with a shoulder at the bottom and the probe which plunges into the metal. The vertical pressure of the tool and when it is moved with a speed along the weld joint will cause a friction force. The frictional heat could cause the metal of both the parts to be welded to soften and the semi solid metal is like dough which as the tool rotates, say anti clockwise, the metal flows in the anti clockwise direction too from the retreading side to the advancing side and mixes the two metals to be welded. On cooling serration weld lines formed joining the two parts. In Figure B, the tool rotation, tool movement in the direction of the weld and the metal flow to form the serrations and the weld joint is shown.

B



The micro structural changes which occur in the weld zone may be classified as

The stir zone is where the lines are formed also called Onion rings because of their shape. This portion of material has lower grain size than the parent material.

The flow arm zone is the region of material flow due to the shoulder transferring metal from the rear to the advanced parts of weld.

The thermo-mechanically affected zone (TMAZ) occurs on either side of the stir zone. This is a low temperature low strain effected material zone.

The heat-affected zone (HAZ) is common to all welding processes. As indicated by the name, this region is subjected to a thermal cycle but is not deformed during welding. The temperatures are lower than those in the TMAZ but may still have a significant effect if the microstructure is thermally unstable. In fact, in age-hardened aluminum alloys this region commonly exhibits the poorest mechanical properties.

Advantages limitations Challenges and Applications:

$$Q_{total} = \frac{2}{3}\pi P \mu \omega \left(R^3_{shoulder} - R^3_{pin}\right)$$

The heat generated $Q_{total\ is}$ a function of the Pressure applied P, coefficient of friction μ, speed of rotation ω, solder and pin radius. The heat requirement is less than a fusion welding as melting temperature is not reached. The advantages of no additional items like filler material, welding electrodes, heat generating equipment make this process interesting also this process is devoid of defects like blow holes and metal cracks. The challenge is designing the correct tool, it's material, it's shape it's movement control to generate enough frictional torque and metal flow for joining. The limitations cause new challenges for research and are an active topic. Where fusion welding or riveted joints where used in Aluminum parts of ships, aircrafts and automobiles are presently converted to FSW process. New areas of welding dissimilar metals are of active research study today.