

Glossary

Alloy A substance having metallic properties and being composed of two or more chemical elements, of which at least one is a metal.

Alloying element The alloying element is an element added to and remaining in the metal, which changes its structure and properties.

Backing plate A layer of material that is placed below the joint interfaces of the materials to be welded. It provides a surface to oppose the vertical downward force on the material; and it protects the machine bed.

Bending stress If a beam is subjected to a bending moment, the fibres in the upper part are extended; and those in the lower part are compressed. Tensile and compressive stresses are thereby induced, which vary from zero at the neutral axis of the beam, to a maximum at the outer fibres. These stresses are called bending stresses.

Breaking load The load at which fracture occurs.

Brittleness The tendency of a material to fracture without first undergoing significant plastic deformation.

Brittle fracture Rapid fracture preceded by little or no plastic deformation.

Clamping System Is the device used to hold, locate and prevent the workpiece from moving during the large forces involved in the FSW process.

Coalescence The merging of two or more materials (metals) into one.

Defect A discontinuity or discontinuities that accumulate to render a weld or part thereof unable to meet the minimum acceptance standards or criteria of the design specifications.

Deformation Is a change in the form of a body due to stress, heat, or other causes.

Diffraction The scattering of electrons by any crystalline material, through discrete angles, and depending only on the lattice spacing of the material and the velocity of the electrons.

Ductility The ability of a material to deform plastically before fracture.

Dwell time The period of time after the rotating tool has been plunged into the work and for which it remains stationary, generating frictional heat and plasti-cizing the materials, before commencing the traverse along the joint (seconds).

EDM (Electrical discharge machining) This is a manufacturing process whereby a desired shape is obtained using electrical discharges (sparks).

Elastic region A material is said to be stressed within the elastic region, when the working stress does not exceed the elastic limit.

Elastic deformation This is the deformation of the material that is recovered when force is applied to it.

Elastic limit This is the greatest stress, which a material is capable of sustaining without any permanent strain remaining upon complete release of the stress.

Elongation The increase in gauge length of a body subjected to a tension force, referenced to a gauge length of a body. Usually expressed as a percentage of the original gauge length.

Elongation (%) The total percent increase in the gauge length of a specimen after a tensile test.

Engineering strain This is a dimensionless value that is the change in length (ΔL) per unit length of the original linear dimension (L_0) along the loading axis of the specimen; that is $e = \Delta L / L_0$, the amount that a material deforms per unit length in a tensile test.

Equilibrium A state of dynamic balance between the opposing actions, reactions, or velocities of a reversible process.

Etchant A chemical solution used to etch a metal to reveal the structural details.

Etching Subjecting the surface of a metal to preferential chemical or electrolytic attack to reveal the structural details for metallographic subsequent examination.

Extrusion The process whereby a material is shaped by force or squeezed through a die or nozzle.

Filler metal Metal added in making a welded, brazed, or soldered joint.

Force control A mode in the friction stir welding process, in which a known force from previous welds is added to other input process parameters, in order to produce a weld.

Fusion The melting together of filler metal and base metal, or of base metal only, which results in coalescence.

Fusion welding Any welding process that uses fusion of the base metal to make the weld.

Friction The force required to cause one body in contact with another to begin to move.

Friction stir welding and friction stir spot welding This is a process developed at The Welding Institute (TWI) that utilizes local friction heating to produce continuous solid-state seams. It allows butt and lap joints to be made, without the use of filler metals. The solid-state low distortion welds produced are achieved with relatively low costs, using simple and energy-efficient mechanical equipment.

Grain An individual crystallite in metals.

Grain growth This is a phenomenon, which occurs when the temperature of a metal is raised; the grains begin to grow and their size may eventually exceed the original grain size.

Grain size A measure of the areas or volumes of grains in a polycrystalline metal or alloy, usually expressed as an average when the individual sizes are fairly uniform. Grain size is reported in terms of the number of grains per unit area or volume, the average diameter, or as a number derived from the area measurements.

Grain boundary An interface separating two grains, whereby the orientation of the lattice changes from that of one grain to that of the other. When the orientation change is very small, the boundary is sometimes referred to as a sub-boundary structure.

Grinding Removing material from the surface of a workpiece by using a grinding wheel or abrasive grinding papers.

Hardness This is a term used for describing the resistance of a material to plastic deformation.

Hardness test This measures the resistance of a material to penetration by a sharp object.

Hardening Increasing the hardness by means of a suitable treatment.

Heat affected zone The portion of the base metal which has not been melted, but whose mechanical properties have been altered by the heat of welding or cutting.

Homogeneous The chemical composition and the physical state of any physical small portion, and one, which is the same as that of any other portion.

Hot working A deformation under conditions that result in recrystallization.

Indentation hardness This is the hardness, as evaluated from the measurements of an area of an indentation, made by pressing a specified indenter into the surface of a material under specified static loading conditions.

- Intensity (X-rays)** The energy per unit time of a beam per unit area, which is perpendicular to the direction of propagation.
- Interfacial region** A weld joint boundary of the workpieces indicating the positions of the pin and shoulder diameters during the welding process.
- Intermetallic compounds** These are any solid materials, composed of two or more metal atoms in a definite proportion, which have a definite structure, which differ from those of its constituent metals.
- Joint efficiency** The ratio of the strength of a joint to the strength of the base metal, expressed as a percentage.
- Keyhole** This is an exit hole, which is left behind by the friction stir spot welding process after the weld has been done.
- Lap Joint** A welded joint in which two overlapping metal parts are joined by means of a fillet, plug or slot weld.
- Macrograph** A graphic reproduction of a prepared surface of a specimen at a magnification not exceeding 25×.
- Macrostructure** The structure of metals, as revealed by macroscopic examination of the etched surface of a polished specimen.
- Magnification** The ratio between the length of a line in the image plane to the length of a line on the imaged material.
- Mechanical properties** These are the properties of a material that reveal its elastic or inelastic behaviour, when a force is applied, indicating the suitable mechanical applications.
- Microstructure** The structure of a prepared surface of a metal, as revealed by a microscope at a particular magnification.
- Oxidation** The addition of Oxygen to a compound.
- Parameter** The minimum and maximum parameters that would describe the operating range of a variable.
- Parent material** This is the sheet-metal plate in its 'as manufactured form', as supplied.
- Plastic deformation** This is the distortion of material continuously and permanently in any direction. The deformation that remains or would remain permanent after the release of the stress that caused it.
- Polished surface** This is a surface that reflects a large proportion of the incident light in a peculiar manner.
- Plunge depth** This is the maximum depth that the tool shoulder penetrates into the weld plates.

Recrystallisation This is a change from one crystal structure to another, such as that occurring upon heating and/or cooling through a critical temperature.

Residual stress This is the stress in a body, which is at rest, in equilibrium, and at a uniform temperature in the absence of any external force.

Retreating side The retreating side of the tool is where the local direction of the weld surface, due to tool rotation and the direction of the traverse, is in the opposite direction.

Rotation speed The tool rotation speed is the rate of angular rotation (usually specified in rpm) of the tool around its rotational axis.

Scanning electron microscope An electron microscope, in which the image is formed by a beam operating simultaneously with an electron probe scanning the object.

Solid phase A physically homogeneous and distinct portion of a material system in the solid state.

Spindle speed This is also referred to as the rotational speed; and it is the speed of the work holding device (chuck), measured in revolutions per minute.

Spindle torque This is the spindle torque required to rotate the FSW tool, when plunging it into and traversing through the workpiece along the joint (Nm).

Stress This is the load applied to a piece of material; and it tends to cause deformation, which is resisted by the internal forces set up within the materials, which are referred to as stresses. The intensity of the stress is estimated as the force acting on the unit area of the cross-section, namely: as Newtons per square metre, or as Pascals.

Tensile strength This is the maximum tensile stress, which a material is capable of sustaining. Tensile strength is calculated from the maximum load during a tension test carried out to rupture, and from the original cross-sectional area of the specimen.

Tensile test This measures the response of a material to a slowly applied axial force. The yield strength, tensile strength, modulus of elasticity and ductility are thereby obtained.

Tool displacement This refers to the offset of the tool at a certain distance from the weld centre line.

Tool shoulder This refers to that part of the welding tool, which rotates, and is normally disk-shaped.

Tool pin This refers to that part of the tool that rotates in contact with the surface of the workpiece.

Tool plunge This is the process of forcing the tool into the material at the start of the weld.

Tool tilt angle The angle, at which the FSW tool is positioned relative to the workpiece surface; that is, when zero tilt tools are positioned perpendicular to the workpiece surface (degrees).

Traverse speed This is also referred to as the feed rate; it is the speed at which the rotating FSW tool is translated along the joint line (mm/min).

Vickers hardness number This is a number related to the applied load and the surface area of the permanent impression made by a square-based pyramid diamond indenter.

Void This is the space that exists between the particles or grains. Normally, in welding, voids are associated with defects.

Unaffected material This refers to the bulk of the material, which is not affected by either heat or deformation, during the welding process.

Welding This is the process of joining, in which the materials are enabled to form metallurgical bonds under the combined action of heat and pressure.

Weld nugget or stir zone This refers to the recrystallized central area of the joint interface.

Welding speed This is also known as the traverse speed; this is the speed (usually specified in mm/min) of the tool traversing along the workpiece per specified time.

Workpiece The component to be welded.

Wormholes This refers to a defect in a FS weld, usually on the advancing side of the rotating tool, due to the lack of mixing and re-bonding of the plasticized material.