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Arc welding is a process in which steel is joined together by the solution-coagulation method. Typically， the process uses compatible filler materials. Before producing a well-bonded joint， the joint surface is heated above the melting temperature to allow complete fusion with the weld metal. Although metallurgical reactions involving melting， solidification and solid state transformation are not uncommon， the temperatures and cooling rates observed are severe.

Reactive gases are also present and can be dissolved in the molten steel. Flux is introduced to alloy with and protect the weld metal. In general， the joint is rigid and inhibits dimensional changes caused by shrinkage and solid state transformation， producing residual stresses of yield strength (YS) magnitude. Because metallurgical changes do not occur under equilibrium conditions and because stresses are high， many reactions may occur in the heat affected zone (HAZ) of the weld metal and steel and may produce defects that weaken its soundness.

Because of the great variability of the welding process， it is difficult to provide much detail about the stabilization mechanisms involved or the corrections that can be made. In addition， once most defects are explained， then many solutions are obvious. One problem， related to hydrogen (H2)， is not a simple one. The issue of hydrogen induced cracking (HIC) is very important as this problem becomes more and more important as more and more high strength， low alloy (HSLA) steels are welded.

Carbon (C) and low-alloy steels are being welded because they have most applications and good weldability. This practicality is mainly due to the metallurgical properties of iron

(Fe)-based systems. This property includes the ability to undergo anisotropic (microstructural) transformation， which allows the opportunity for hardening and strengthening through martensitic and bainitic transformation or precipitation mechanisms， in addition to the ability to easily alloy with a large number of elements. The weldability of carbon and low-alloy steels can generally be divided into (1) fabricating weldability and (2) using weldability.

Fabrication weldability is due to the possibility of joining C and low-alloy steels by welding without introducing harmful uninterrupted elements. The acceptability of these non-interruptible elements depends on the conditions of the specific welding application. The fabricating weldability of the steel is adequate for non-critical applications. However， the same steel may not be recommended for critical applications or may require special precautions， such as preheating， when welding. Fabrication weldability is mainly concerned with non-intrusive properties such as H2 assisted porosity， sheet tearing， cold cracking， hot cracking and reheat cracking.

Service weldability of C-beams and low-alloy steels means that the finished weldment has sufficient properties to achieve the desired function. An important feature of service weldability is a comparison of the performance of the HAZ with the performance of the unaffected base steel. Acceptability in service is also dependent on the planned application. For applications where corrosion is very important and toughness is of secondary importance， the service weldability of some steels is acceptable. However， in applications where toughness is very important， the same steel is unacceptable. In-service weldability relates to the effect of welding thermal cycling on hot zone properties. In-service weldability often determines the range of heat input allowed for certain steels. Low heat input can introduce undesirable low toughness microstructures and fabrication weldability problems associated with cold cracking. High heat input can introduce rough microstructures with low toughness and low strength. Heat input alone does not control the resulting microstructure and heat affected zone properties， but the resulting thermal cycling controls the microstructure and properties. Therefore， both the heat input and the thickness of the steel are important.

Classification of steels

Carbon and low alloy steels cover a wide range of compositions and properties. Steels are often classified according to their C and/or alloying element content. Different classifications have different designations， such as normal C steels， C-Mn (manganese) steels， medium C steels， low-alloy steels， high-strength low-alloy (HSLA) steels， and micro-alloy steels. Recently， a new classification of steels has introduced the method of steel processing as a classification factor. These are referred to by various names and are often described as thermomechanically controlled processing (TMCP) steels. The boundaries between all of the above classifications are often scattered， they often overlap， and they are sometimes subjective.

Low carbon steels contain up to about 0.30 % carbon and up to about 1.65 % manganese. The majority of rolled steels used for welding are low carbon steels. This category includes steels that vary considerably in their weldability. For example， it is possible to weld low carbon steels containing less than 0.15 % carbon in all welding processes. It is also possible to weld low C steels containing 0.15% to 0.30% C (often called mild steels) up to 25 mm thick. However， thicker mild steel sections may require additional action to weld successfully.

HSLA steels are designed to provide better mechanical properties than conventional C steels. This steel typically has a YS of 290 to 550 N/sqmm and is of the C-Mn type with very small amounts of niobium (Nb) and vanadium (V) added to ensure grain refinement and precipitation hardening. HSLA steels are often identified as microalloyed steels. The weldability of HSLA steels is similar to that of low carbon steels.

Recently， a new family of HSLA steels has been developed that have low C， copper (Cu) bearing age hardening. These steels are not truly low alloy because the total Cu， Ni