I. The GTAW (TIG) Process

The necessary heat for Gas Tungsten Arc Welding (TIG) is produced by an electric arc maintained between a nonconsumable tungsten electrode and the part to be welded. The heat-affected zone, the molten metal, and the tungsten electrode are all shielded from the atmosphere by a blanket of inert gas fed through the GTAW torch. Inert gas is that which is inactive, or deficient in active chemical properties. The shielding gas serves to blanket the weld and exclude the active properties in the surrounding air. It does not burn, and adds nothing to or takes anything from the metal. Inert gases such as argon and helium do not chemically react or combine with other gases. They possess no odor and are transparent, permitting the welder maximum visibility of the arc. In some instances a small amount of reactive gas such as hydrogen can be added to enhance travel speeds.

The GTAW process can produce temperatures of up to 35,000° F/19,426° C. The torch contributes only heat to the workpiece. If filler metal is required to make the weld, it may be added manually in the same manner as it is added in the oxyacetylene welding process. There are also a number of filler metal feeding systems available to accomplish the task automatically. Figure 1.1 shows the essentials of the manual GTAW process.

Advantages of the GTAW Process

The greatest advantage of the GTAW process is that it will weld more kinds of metals and metal alloys than any other arc welding process. TIG can be used to weld most steels including stainless steel, nickel alloys such as Monel® and Inconel®, titanium, aluminum, magnesium, copper, brass, bronze, and even gold. GTAW can also weld dissimilar metals to one another such as copper to brass and stainless to mild steel.

Concentrated Arc

The concentrated nature of the GTAW arc permits pin point control of heat input to the workpiece resulting in a narrow heat-affected zone. A high concentration of heat is an advantage when welding metals with high heat conductivity such as aluminum and copper. A narrow heat-affected zone is an advantage because this is where the base metal has undergone a change due to the superheating of the arc and fast cooling rate. The heat-affected zone is where the welded joint is weakest and is the area along the edge of a properly made weld that would be expected to break under a destructive test.

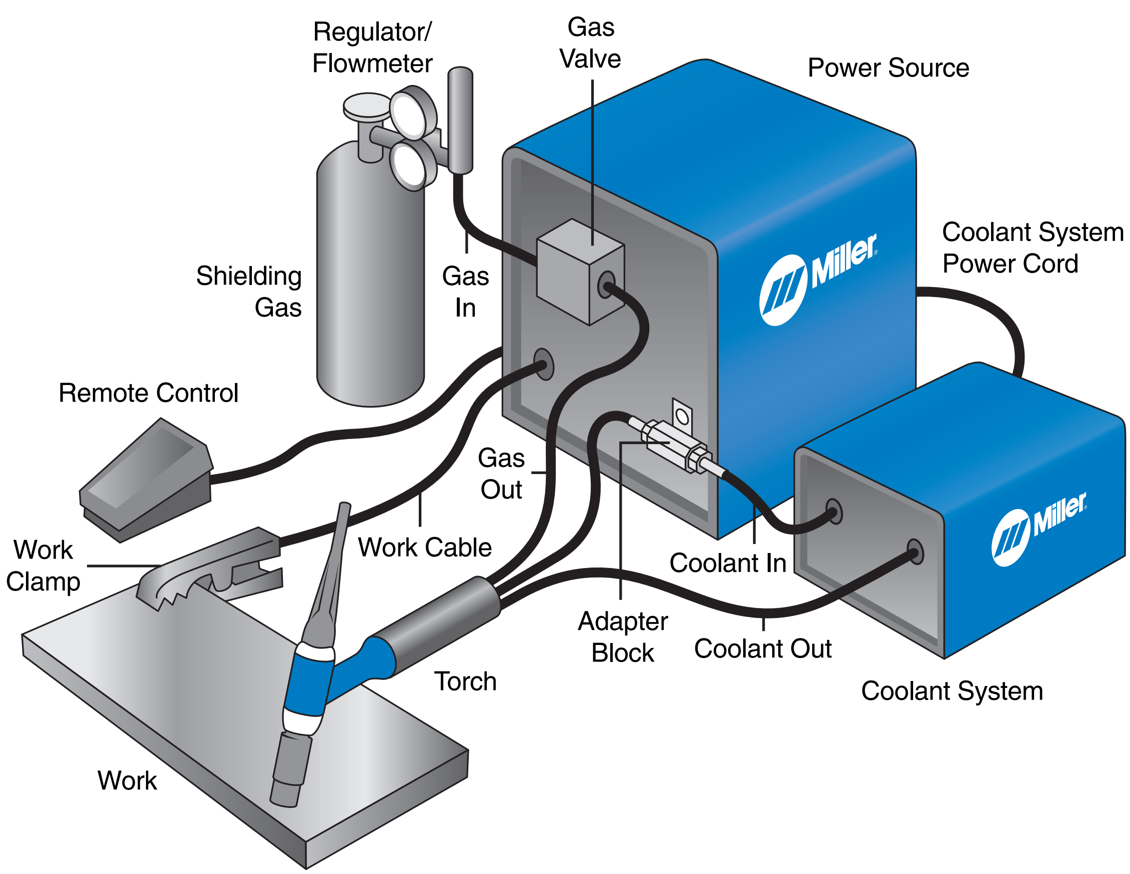

Figure 1.1 Essentials of the GTAW process (water cooled).

No Slag

There is no requirement for flux with this process; therefore, there is no slag to obscure the welder's vision of the molten weld pool. The finished weld will not have slag to remove between passes. Entrapment of slag in multiple pass welds is seldom seen. On occasion with materials like Inconel® this may present a concern.

No Sparks or Spatter

In the GTAW process there is no transfer of metal across the arc. There are no molten globules of spatter to contend with and no sparks produced if the material being welded is free of contaminants. Also under normal conditions the GTAW arc is quiet without the usual cracks, pops, and buzzing of Shielded Metal Arc Welding (SMAW or Stick) and Gas Metal Arc Welding (GMAW or MIG). Generally, the only time noise will be a factor is when a pulsed arc, or AC welding mode is being used.

No Smoke or Fumes

The process itself does not produce smoke or injurious fumes. If the base metal contains coatings or elements such as lead, zinc, nickel or copper that produce fumes, these must be contended with as in any fusion welding process on these materials. If the base metal contains oil, grease, paint or other contaminants, smoke and fumes will definitely be produced as the heat of the arc burns them away. The base material should be cleaned to make the conditions most desirable.

GTAW Disadvantages

The main disadvantage of the GTAW process is the low filler metal deposition rate. Another disadvantage is that the hand-eye coordination necessary to accomplish the weld is difficult to learn, and requires a great deal of practice to become proficient. The arc rays produced by the process tend to be brighter than those produced by SMAW and GMAW. This is primarily due to the absence of visible fumes and smoke. The increased amounts of ultraviolet rays from the arc also cause the formation of ozone and nitrous oxides. Care should be taken to protect skin with the proper clothing and protect eyes with the correct shade lens in the welding hood. When welding in confined areas, concentrations of shielding gas may build up and displace oxygen. Make sure that these areas are ventilated properly.

Process Summary

GTAW is a clean process. It is desirable from an operator point of view because of the reasons outlined. The welder must maintain good welding conditions by properly cleaning material, using clean filler metal and clean welding gloves, and by keeping oil, dirt and other contaminants away from the weld area. Cleanliness cannot be overemphasized, particularly on aluminum and magnesium. These metals are more susceptible to contaminants than are ferrous metals. Porosity in aluminum welds has been shown to be caused by hydrogen. Consequently, it is most important to eliminate all sources of hydrogen contamination such as moisture and hydrocarbons in the form of oils and paint.

II. GTAW Fundamentals

If you've ever had the experience of hooking up a car battery backwards, you were no doubt surprised at the amount of sparks and heat that can be generated by a 12 volt battery. In actual fact, a GTAW torch could be hooked directly to a battery and be used for welding.

When welding was first discovered in the early 1880s it was done with batteries. (Some batteries used in early welding experiments reached room size proportions.) The first welding machine, seen in Figure 2.1, was developed by N. Benardos and S. Olszewski of Great Britain and was issued a British patent in 1885. It used a carbon electrode and was powered by batteries, which were in turn charged with a dynamo, a machine that produces electric current by mechanical means.

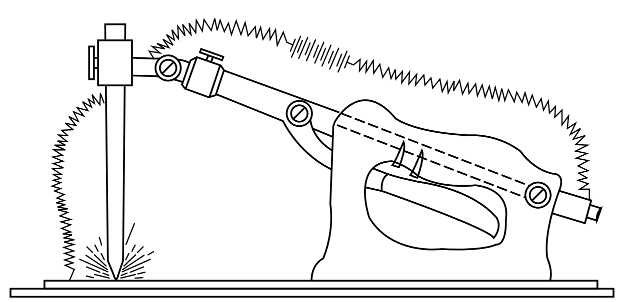

Figure 2.1 Original carbon electrode welding apparatus — 1885.