21.12 TUNGSTEN INERT GAS (TIG) OR GAS TUNGSTEN ARC WELDING (GTAW)

In this arc welding process, welding heat is produced from an electric arc established between the tungsten electrode and the job. A shielding gas (argon, helium, nitrogen etc.) is used to avoid atmospheric contamination of the molten weld pool. Filler metal, if required is fed separately.

Shielding Gases

Argon is normally preferred over helium because it requires a lower arc voltage, easier arc starting and provides a smooth arc action. It is also economical and heaviest.

Helium can withstand the higher arc voltage so it is used where higher heat input is required.

Sometimes active gas carbon dioxide is also used as it is more economical. It requires slightly higher current. It is normally used with only D.C. with +ve electrode. Whereas both argon and helium can be used with A.C. as well as D.C. welding power source.

Operation

This process uses a non-consumable tungsten electrode, which is mounted in a special electrode holder. This holder is also designed to furnish a flow of inert gas around the electrode and around the arc. Welding operation is done by striking an arc between the workpiece and tungsten electrode in an atmosphere of inert gas. The arc is struck either by touching the electrode with a scrap metal tungsten piece or using a high frequency unit. After striking the arc, it is allowed to impinge on the job and a molten weld pool is created. The welding torch and the filler metal are generally kept inclined at angles of 70-80 degree and 10-20 degree respectively with the flat workpiece. Filler metal, if required should be added by dipping the filler rod in the weld pool. When doing so, the tungsten electrode should be taken a little away from weld pool. However the heated end of filler rod as well as the electrode should be within the inert gas shield. Both D.C. and A.C. power source can be used.

Equipment

- Welding torch, tungsten electrode and filler metal.
- Welding power source, high frequency unit, D.C. suppressor unit and cable.
- Inert gas cylinder, pressure regulator and flow meter.
- Cooling water supply.
- Water and gas solenoid valves.

Polarities

DCSP (Direct Current Straight Polarity). Tungsten electrode (–ve), work (+ve) used for mild steel, stainless steel, copper and titanium.

DCRP (Direct Current Reverse Polarity). Tungsten electrode (+ve), work (–ve) used for welding aluminium and heavily oxidized aluminium castings.

ACHF (Alternating Current High Frequency). It is used for Al and Mg. High frequency also helps in oxide cleaning actions.

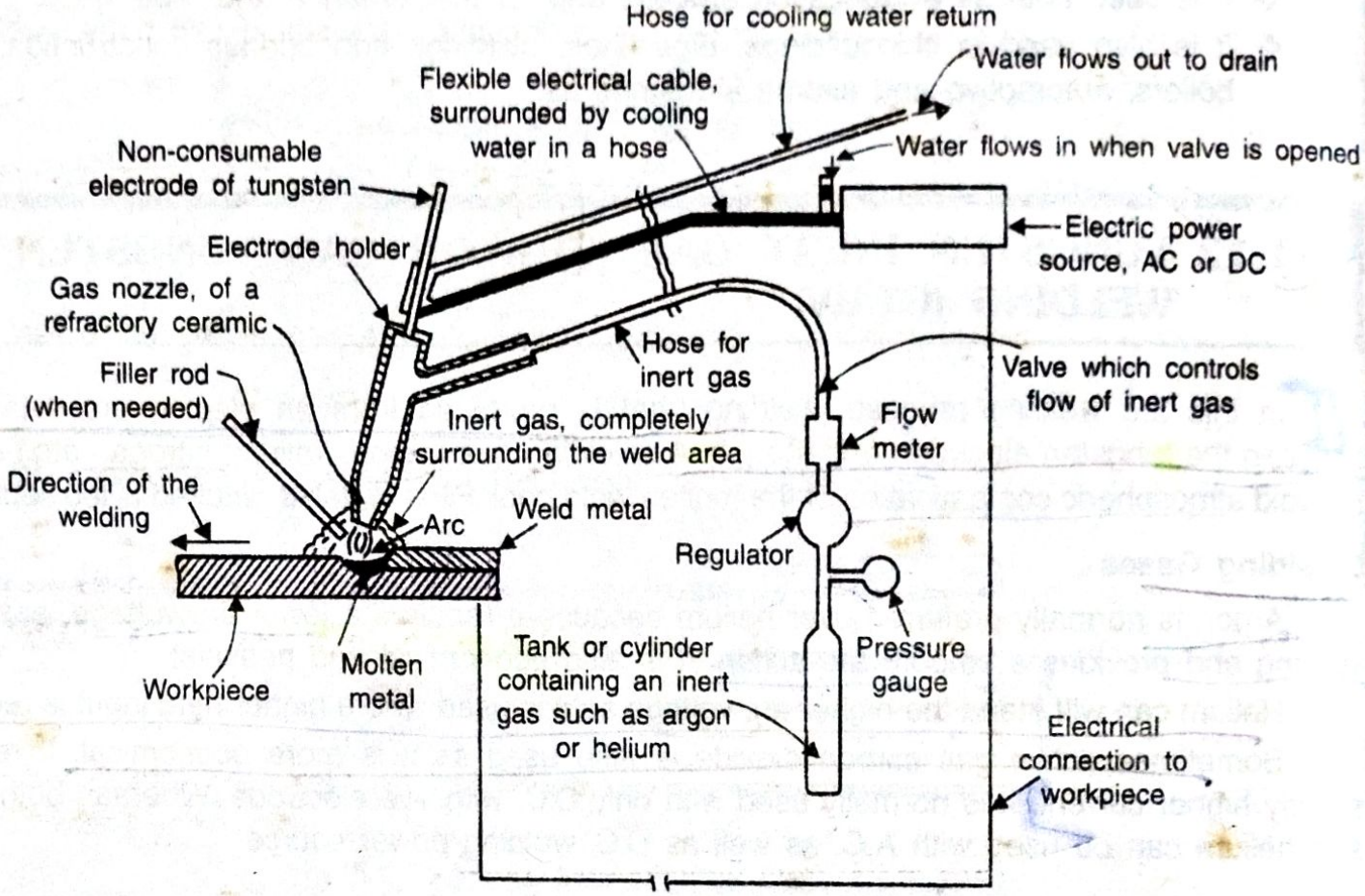

Fig. 21.8(*a*). *Principle of Tungsten Inert Gas (TIG) Welding.*

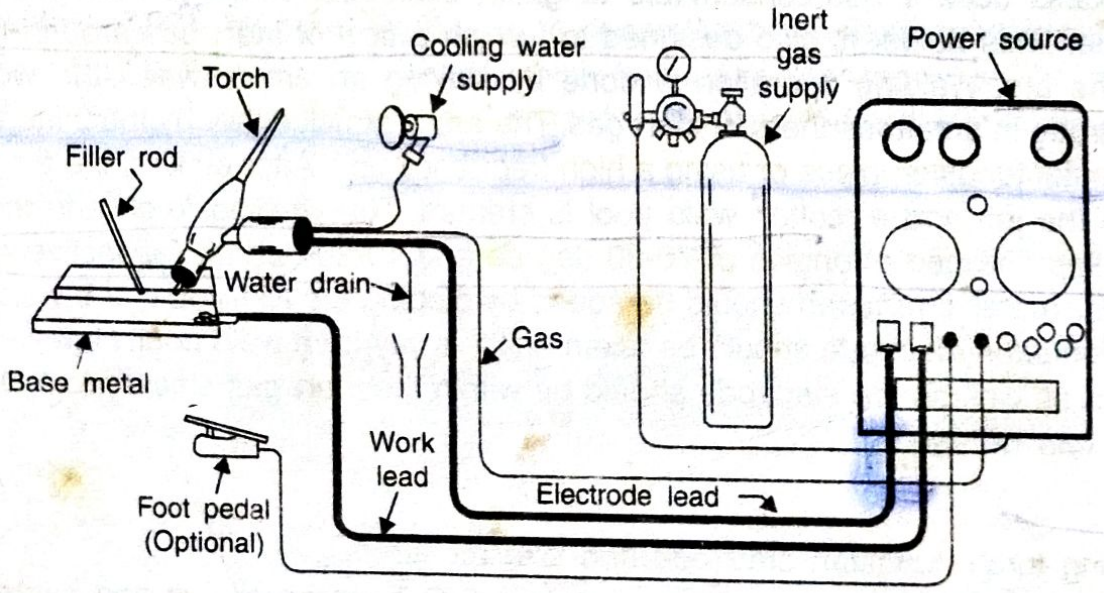

Fig. 21.8(*b*). *Setup of Tungsten Inert Gas (TIG) Welding.*

Advantages :

- No flux is used so no danger of flux entrapment.
- Clear visibility of the arc, so better control.
- It can weld in all positions.
- High quality welding of thin materials (as thin as 0.125 mm).
- Heat affected zone is very less.
- Unlike metals can be welded to each other like mild steel to stainless steel, brass to copper etc.

Disadvantages :

- Tungsten, if transfers can contaminate the weld pool.
- Filler rod end if by chance comes out of the inert gas shield can cause weld metal contamination.
- Equipment costs are higher than flux shielded metal arc welding.
- Electrode is non-consumable, so separate filler rod is needed, so there is decrease in welding speed.

Applications :

- Welding of carbon steel, stainless steel, nickel, aluminium, magnesium, brass, copper, bronze, titanium etc.
- Welding of sheet metal and thinner sections.
- Used in aircrafts, rocket motor chambers, transistor cases, and instrument industries.

21.13 METAL INERT GAS (MIG) OR GAS METAL ARC WELDING (GMAW)

In this welding process, welding heat is produced from an electric arc established between the continuously fed metal electrode and the job. Argon, helium, carbon dioxide or a gas mixture shields the arc and molten metal from atmospheric contamination.

Operation

The typical set up for GMAW process is shown in Fig. (21.9(*b*)). The consumable electrode is in the form of a wire reel, which is fed at a constant rate, through the feed rollers. The welding torch is connected to the gas supply cylinder, which provides the necessary inert gas. The electrode and the workpieces are connected to the welding power supply. The power supplies are generally of the constant voltage type only. The current from the welding machine is changed by changing the rate of feeding of the electrode wire.

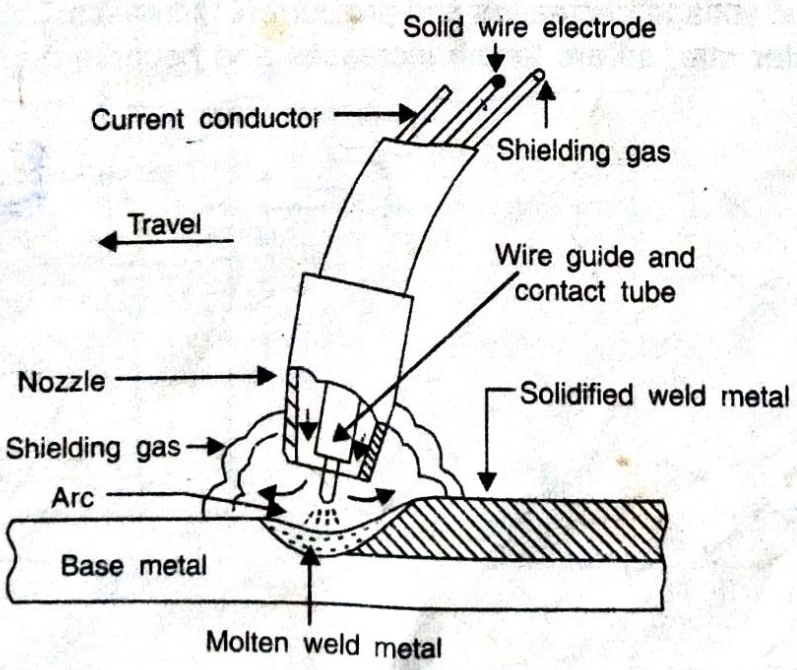

Fig. 21.9(*a*). *Principle of Metal Inert Gas Welding (MIG).*

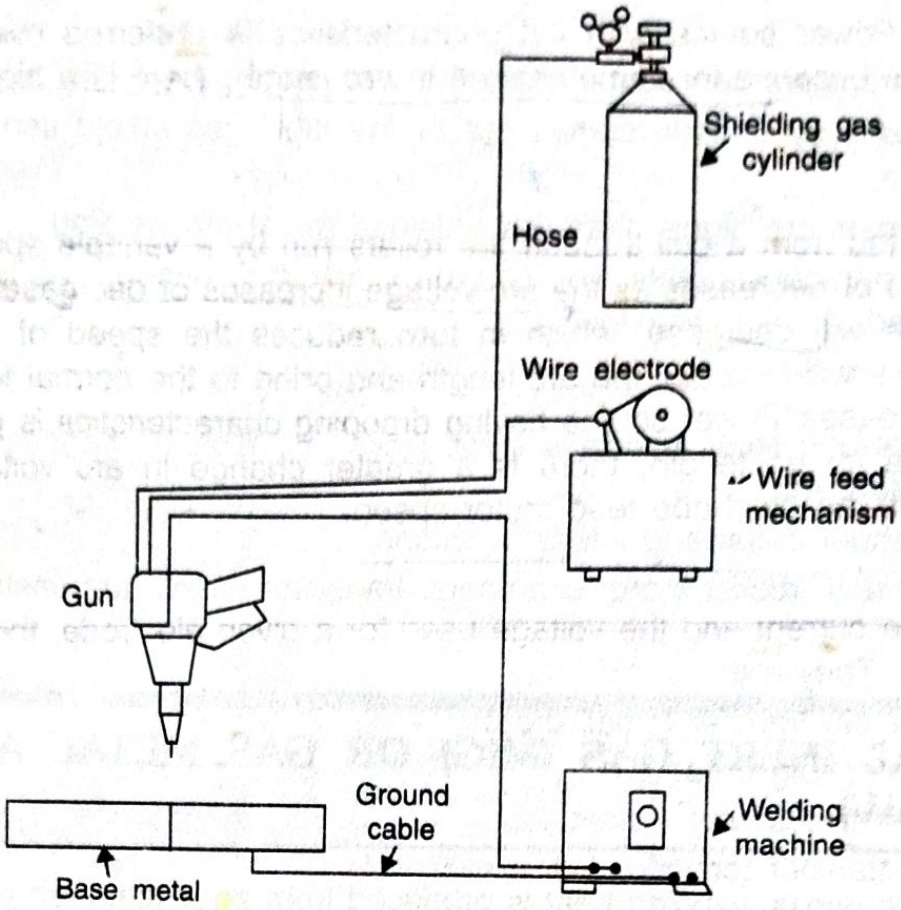

Fig. 21.9(*b*). *Setup of Metal Inert Gas Welding (MIG).*

Normally DC arc welding machines are used for GMAW with electrode positive (DCRP). The DCRP increases the metal deposition rate and also provides a stable arc and smooth electrode metal transfer.

For semi-automatic process, arc length is maintained constant by using the principles of self-adjusted arc or self-controlled arc.

Self Adjusted Arc

The electrode is fed from a coil through the grooved rollers run by a constant speed motor. If arc length decreases, voltage decreases and arc current increases. This increased current melts the electrode at a faster rate, so arc length increases and become normal. Reverse will occur if

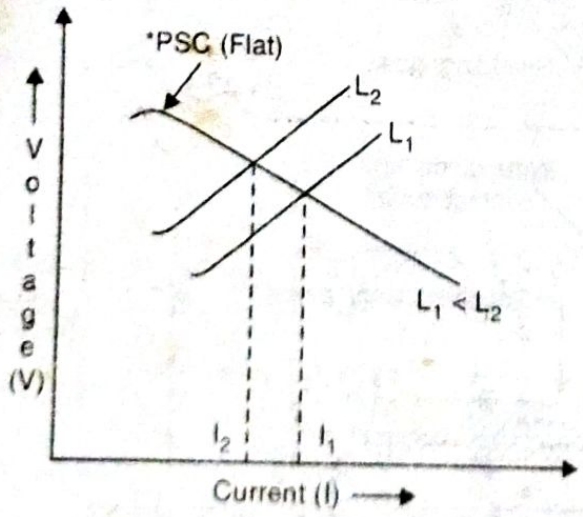

Fig. 21.10. *Self Adjusted Arc.*

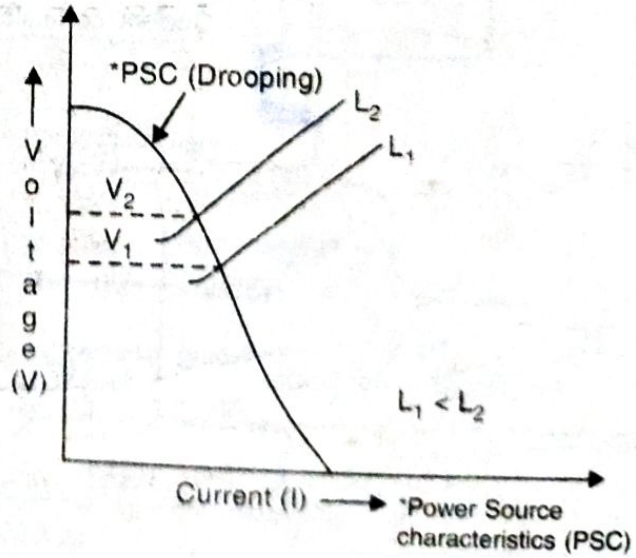

Fig. 21.11. *Self Controlled Arc.*

arc length increases. Power source with flat characteristics is preferred over another having drooping characteristics because for same change in arc length, there is a bigger change in arc current.

Self Controlled Arc

The electrode is fed from a coil through the rollers run by a variable speed electric motor whose speed increases or decreases as the arc voltage increases or decreases. If the arc length decreases, arc voltage will decrease, which in turn reduces the speed of eletric motor and electrode feed rate. This will increase the arc length and bring to the normal value. Reverse will occur if arc length increases. Power source having drooping characteristics is preferred because with the same change in arc length, there is a greater change in arc voltage, which inturn increases or decreases the electrode feed motor speed.

Metal Transfer

Depending on the current and the voltage used for a given electrode, the metal transfer is done in different ways. They are :

- Shot circuit or dip transfer (small drop)
- Globular transfer (big drop)
- Spray transfer (fine spray)
- Pulsed spray transfer (controlled droplet transfer)
- Rotating spray transfer (controlled droplet transfer and rotates in a helical pattern).

Equipments

- Welding power source and cables.
- Welding torch and wire electrode coiled on a spool.
- Wire feed mechanism and controls consisting of a pair of driving rolls, electric motor etc.
- Shielding gas cylinder, pressure regulators and flow meters.
- Controls.

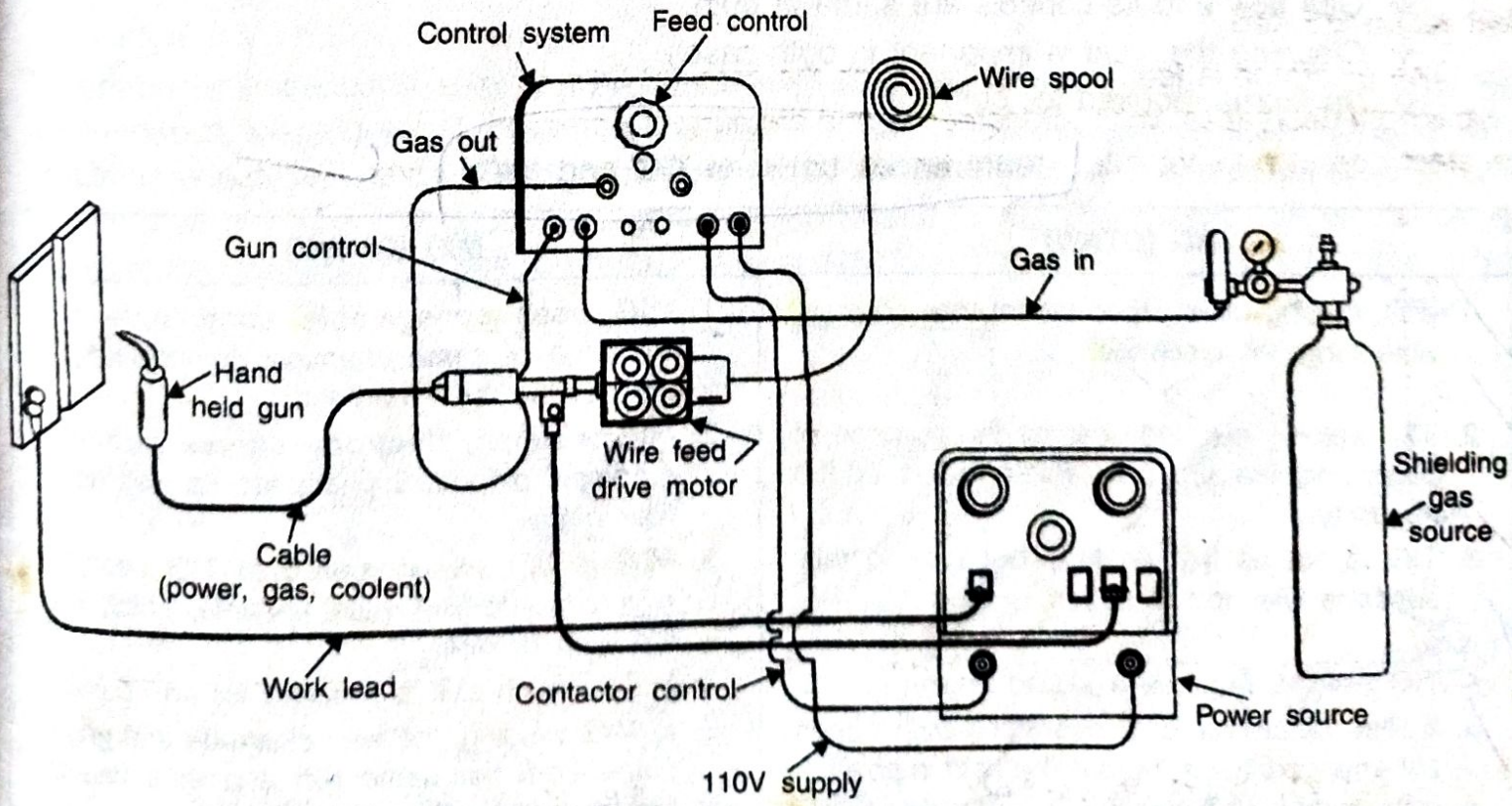

Fig. 21.12. *Equipment Needed For MIG Welding.*

Advantages

- ❖ GMAW does not require the high degree of operator skill.
- ❖ Continuous welding at higher speeds and in all positions with deeper penetration is possible.
- ❖ Thick and thin, both types of workpieces can be welded effectively.
- ❖ The process can be easily mechanized.
- ❖ Since no flux is used so more visibility, neatness, cleanliness, spatter free weld.

Disadvantages

- ❖ Welding equipment is more complex and more costly.
- ❖ The metallurgical and mechanical properties of the joint may be affected due to high cooling rate.
- ❖ It is difficult to weld in small corners.
- ❖ Process variables are more.

Applications

- ❖ It is suitable for welding variety of ferrous and non-ferrous metals.
- ❖ Metal fabrication industries, shipbuildings, automobiles, pressure vessel industries etc.
- ❖ Welding tool steels and dies.

21.14 COMPARISON BETWEEN TIG (GTAW) AND MIG (GMAW)

Common points of MIG and TIG are :

- ❖ Both use same gases for shielding depending on the metals to be welded.
- ❖ Both can be used for welding metals like stainless steel, non-ferrous alloys and aluminium.
- ❖ Gas flow and its controls are same in both.
- ❖ Cleaning the weld is important in both cases.
- ❖ No flux is required for both.

Differences between TIG and MIG

TIG (GTAW)	MIG (GMAW)
1. TIG welding uses a permanent, non-consumable tungsten electrode.	1. MIG uses consumable continuous coil electrode of same chemical composition as the material being welded.
2. TIG welding electrode serves the purpose of producing the arc only. Filler rod is added separately.	2. MIG welding electrode serves both the purposes of poducing the arc as well as of filler metal.
3. TIG is not as fast as MIG because in this, separate filler rod is added.	3. MIG is fast as compared to TIG because electrode and filler metal is same, which is in the form of wire.
4. TIG welding requires a skilled operator.	4. No so much skill is required for an operator.
5. If filler metal is added, operator's both hands are engaged. So work must be held in position with clamps or fixtures.	5. In MIG welding, the wire electrode and gases come from the same run and thus can be made easily automatic.

6. TIG welding usually uses DCSP (direct current straight polarity), but in case of welding thin sheets DCRP (direct current reverse polarity) is used.	6. MIG uses both types of polarities. Generally DCRP is used.
7. TIG welding torch is water-cooled.	7. Generally no water-cooling is necessary.
8. Tungsten if by chance comes in contact with the molten metal causes contamination of the weld pool.	8. No such problem is there with MIG (no tungsten electrode).
9. TIG welding is not used often for welding plates thicker than 6 mm.	9. It is best suited for thick (more than 6 mm) jobs.
10. Penetration is not so much deeper as with MIG.	10. Deeper penetrations can be obtained as compared to TIG.