I.1: Plasma arc cutting of metals for manufacturing of components

Cutting of metals in the desired profile is the first stage in any manufacturing process. A metal can be cut by thermal cutting or water jet cutting process depending upon the type, thickness and size of the raw material. Thermal cutting techniques can be any one of oxy-acetylene gas cutting, laser cutting, Electrical Discharge Machining (EDM) wire cutting or plasma cutting. Plasma Arc Cutting (PAC) is a versatile and the most commonly used cutting process for cutting of electrically conductive materials, due to fast and reliable cutting process. The Centre has successfully setup an air based Computerized Numerical Control (CNC) PAC cutting facility for cutting of ferrous and non-ferrous metals, as shown in Figure I.1.1.

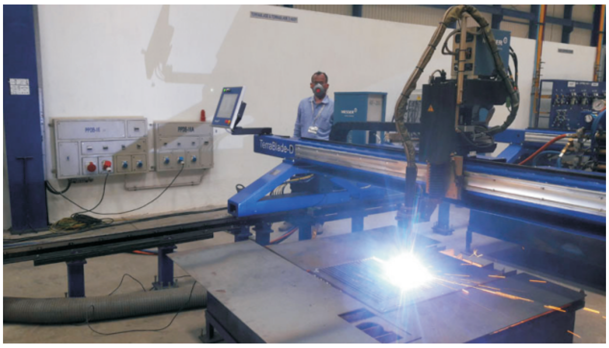

Fig. I.1.1: CNC plasma arc cutting machine.

Following is a brief description of the plasma cutting process, its cutting capabilities, the quality of the cut surfaces and the various associated issues:

Plasma cutting process: In PAC process, a high-velocity jet of ionised gas (termed as plasma) originating from constricting orifice of plasma cutting torch melts and severs a localized area of a work-piece. This is achieved by heating a compressed gas by using a plasma arc. The arc is heated rapidly and attains very high temperature, typically ~15300K, at the central core of arc. At the nozzle orifice, plasma gas expands and velocity of plasma gas increases which may go typically up to 2-3 times higher than the sonic velocity. The heat intensity of the plasma depends on the type of gas used, gas pressure, arc current, internal contour and opening of the orifice. A typical electrical circuit of plasma cutting is shown in Figure I.1.2.

Cutting capabilities: The cutting capability of machine depends on the type of material being cut, the thickness of material, cutting velocity of plasma cutting torch and plasma gas pressure.

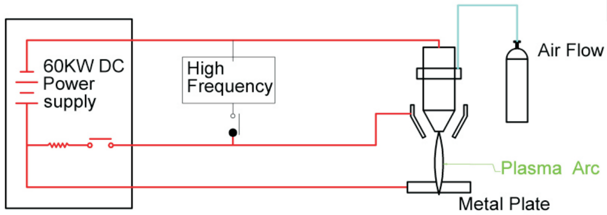

Fig. I.1.2: Schematic diagram of electric circuit of PAC.

The average enthalpy of the plasma jet is given by the following equation:

$$H = \frac{\eta VI}{G}$$

where

H = Average enthalpy of plasma jet in J/g
η = Process efficiency
V = Arc voltage in V
I = Arc current in A
G = Gas mass flow rate in g/s.

Quality of cut surfaces: The quality of cut surfaces is defined by degree of striations, kerf width, taper in the cut thickness and dross adherence to the cut plate. It depends mainly on speed of cutting, arc current, thickness of material and type of cut i.e. linear or contour cut. A typical kerf width in 25 mm thick stainless-steel plate is approximately 5 mm. A typical bevel angle in a linear cut of 50 mm thick stainless-steel plate is 2-3 degrees. Dross at the bottom edge of the cut face is almost nil in CNC PAC. The cutting parameters are optimised to get optimum quality of the cut. This leads to saving of raw material, minimisation of Heat Affected Zone (HAZ), lesser cutting margin, which in turn reduces machining time and the cost. The better surface finish also reduces the consumption of precision cutting tools/ inserts.

Metallurgical effects: Since it is a thermal cutting process, the cut pieces have HAZ adjacent to the cutting edges. The degree of HAZ in the cut plate is inversely proportional to cutting speed.

The power source of machine operates at a maximum operating current of 300 A at a duty cycle of one hour at 40 °C. Gantry size of the machine is 3000 mm x 2000 mm x 150 mm. Materials are being cut by optimizing the process variables to minimise the heat input and the degree of bevel in the cut surfaces. This facility is being used successfully for cutting of raw materials for development of components for laser and accelerator projects of the centre.

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