Basic Plasma Theory

The following article outlines some of the basic theory surrounding plasma torches, oxy-fuel cutting and plasma in general.

In order to properly set up a plasma cutting machine, it is important to understand plasma in general. The process of plasma cutting involves using plasma - a state of matter that arises at extremely high temperatures. In plasma cutters, this involves sending a stream of gas (usually air) and adding heat to it, ionizing the gas. This electrically charged gas is called plasma.

Because this superheated gas has a current carrying capacity, it can be used to create an arc between the machine producing the gas flow and the metal part (which can conduct electricity) on which the user is working on.

The plasma torch serves as a holder to consumable parts and cooling setups for these parts, while the nozzle and the electrode setup are responsible for creating and maintaining the plasma flow from the torch to the metal sheet.

In order to properly set your plasma cutting procedure, four major areas need to be understood and set up correctly:

- power supply setup
- circuit start (ignition)
- gas flow control
- torch

Power Supply Setup

The power supply houses the connections to the plasma torch and produces a constant current DC output for them. The power supply also holds the cooling system for the torch.

RHF Console

The Remote High Frequency console houses the water and gas plumbing, along with other control devices. It also holds the starting circuit for the plasma torch, which allows the operator to start the plasma torch from a large distance (up to 200 feet in Hypertherm plasma cutter setups).

Gas Flow Control

The gas console houses the metering and the solenoid (coiled wire) valves for the shield and plasma gases. It interfaces the gas supply, the motor valve, the RHF console and the power supply of the machine. This console panel should be mounted in a convenient position for the operator (usually above the power supply).

Torch

The torch holds the consumable parts and is responsible for the actual arc generation between the machine and the metal that needs to be cut.

Sequence of operations

In order to create the cutting arc between the torch and the metal, the following sequence of actions will be performed:

- the start signal will be sent from the operator input to the torch
- the torch mechanism will start
- gas flow will be established
- the pilot arc will be created
- the arc transfer to the metal will occur

Starting the torch

The two methods for torch starting are High Frequency and Touch (Contact) Start.

High Frequency

High frequency current of 5000-10000 volts forms an electric spark between the nozzle and the electrode that are housed by the torch. Gas is then 'pushed' through the spark, raising its temperature and ionizing it.

This is a method that is suitable for a wide variety of applications. However, the user may want to choose another starting method in the presence of sensitive electronic equipment due to the large amounts of generated electrical noise. This is especially important when using a standard PC as the controller machine for the CNC setup.

Contact Start

In this scenario, the electrode and the nozzle are shorted **before** the gas reaches the torch. The gas flow upon reaching the torch causes the electrode and the nozzle to move apart, creating a spark between them. As the gas passes through this spark, its temperature rises to its ionization temperature.

This process is usually done at power levels below 100 Amps. Thus, it is well-suited to be used around sensitive controller equipment that may otherwise be subject to electrical interference from the High Frequency torch start method.

Torch Shielding

Some of the issues with non-shielded parts include double arcing and nozzle damage. Double arcing arises from tiny drops of molten metal flying outwards from the piercing of the metal sheet. These droplets can form a path for the current to flow through, making the nozzle be at a positive potential. In result, this can create a path for the electrical charge to flow through and make a second arc. This issue also arises due to the creation of current flow path if the nozzle touches the metal part during the cutting process.

Nozzle damage arises from contact of the nozzle with the work piece, as well as blowback from the metal splatter as described above. Due to such damage, the orifice of the nozzle can change its shape from a perfect circle to an oval hole, leading to reduced performance.

Shielding the nozzle with an electrically isolated copper shield helps extend the nozzle lifetime and prevents double arcing. This allows for lower costs by prolonging the parts life, as well as allowing for a thicker piecing capacity and increased ease of operation.

Introduction to terms used in plasma cutting

Kerf

Kerf is the opening created by the gas that is cutting the metal. This metal is removed, with the width of the removed metal dependent upon the particular setup used, including parameters like amperage, the gases chosen, the orifice size of the nozzle, and the distance of the nozzle from the working part.

A kerf value (for plasma cutting) or tool diameter offset (for milling) specifies the offset value. In order for the offset to actually be activated within the program, the G-codes must contain the kerf ON/OFF codes (G41, G42, G40). Most CAM software packages designed for plasma cutting take the tool diameter compensation into account when generating the control program automatically. In those cases, the offset (kerf or toll diameter) compensation must be turned off in myCNC software.

Dross

Dross is the residual material that remains on the working part after it has been cut. This metal is concentrated at the bottom/top of the cut and the amount and distribution of dross is dependent on things like travel speeds, gasses used, and type of metal.

Lag lines

Cut lines are the lines on the surfaces of the cut. They are more consistent when the power supply is consistent as well, and are usually curved and slightly slanted.