WHAT TO KNOW BEFORE SELECTING A MANUAL PLASMA UNIT
Understanding Size, Power, Components, and Cost

By David Cook

The first plasma arc cutting (PAC) systems, developed in the Sixties, were thousand amp monsters designed to blast through 6 inch thick stainless steel. Their mechanized torches were moved by XY cutting machines and powered by DC units the size of refrigerators. Surprisingly, the PAC industry evolved from high to low amp systems, water to gas cooled, and from gas to air cooled. Today’s handheld air PAC systems are lightweight, portable, and relatively powerful for their size. They are used for cutting everything from thin gauge metals to 1 inch plate. More traditional console PAC systems also are available to handle cutting tasks up to 2 inches and more. Handheld PAC systems are now the fastest growing segment of the PAC market because they offer a fast, efficient, and affordable way to cut. This article offers an overview of manual PAC technology from the early days to the present, including an explanation of different power supplies, recommendations for selecting and sizing a system, and other functions and features to look for in a handheld system. Regardless of the size, all PAC systems contain the same basic components, including a gas supply, DC power supply, and plasma torch. The torch requires a circuit to initiate an arc and a cooling system.

Gas Supply
Most older plasma systems used nitrogen as the plasma gas and air or CO2 as the secondary gas, which required expensive bottles or bulk containers. Now, most handheld systems use clean, dry shop air to cool the torch and provide the necessary plasma gas. Shop air currently is the most affordable and versatile plasma gas. It is readily available and provides good cut edge quality on mild and stainless steel and aluminum. With the exception of special applications, such as thick stainless steel and aluminum cutting or plasma gouging, almost all handheld systems today use air plasma. Several manufacturers even have developed air plasma systems with small, onboard air compressors.

Power Supplies
PAC power supplies are direct current electrode negative (DCEN). The process requires a constant source of DC and a high open circuit voltage (OCV) to initiate the arc. The following is a summary of some basic differences among PAC power supply types.

<u>DC Droopers</u>**.** Early plasma systems included “drooper” power supplies, named for their drooping output power curves. These units provided a high OCV and relatively stable current and operating voltage. They used a fixed output DC rectifier bridge consisting of a series of diodes to convert AC power from a transformer into usable DC for the cutting process. These simple systems created a lot of power but wasted energy and had too much “ripple” (a fluctuation in DC output that causes a rough cut and short part life) in their output power. To further regulate power output, multiple transformers could be used, each providing a higher level of output current.

<u>Reactors</u>**.** Reactor power supplies were the next step in power regulation. These used a reactor device to control the amount of AC voltage supplied to the bridge rectifier. The reactor consisted of a group of AC coils with a DC winding around it. The current in the DC

winding controlled the amount of AC that passed through the reactor, which created an adjustable transformer that allowed variable DC output from the bridge.

<u>SCRs</u>**.** Silicon controlled rectifiers (SCRs) are another type of continuously variable output power supply. SCRs convert three phase AC power from a transformer directly to DC. They require huge capacitor banks and large transformers. SCRs are large and powerful and are used for high amp PAC systems but are not well suited for handheld systems.

<u>Switchmode</u>**.** Switchmode power supplies use transistors to modulate DC power after the rectifier.

<u>Choppers</u>. Choppers are a type of switch mode power supply that use power semiconductor devices such as isolated gate bipolar transistors (IGBTs)—which take raw DC with ripple and chop it up, rapidly switching the power on and off to smooth the output characteristics. IGBTs can be fired much faster than old reactor type power supplies. The result is a very smooth output power curve.

<u>Inverters</u>. Inverters are another type of switchmode power supply. They use devices such as transistors on the input side of the power train to raise the frequency of the AC into the transformer. Higher frequency input allows a much smaller transformer to be used. Because a smaller transformer is used, inverters are much lighter and more portable than conventional power supplies, making them ideal for handheld applications. Early inverter power supplies were limited by low output current and complicated design and poor reliability. When problems occurred,sophisticated techniques and troubleshooting were required to solve them. Today's inverters are more reliable, robust, and powerful. Most manual PAC systems now use inverter or switchmode technology. These sophisticated, electronically or microprocessor controlled devices are better able to tolerate variations in line voltage, take more abuse in the field, and deliver better cutting performance while consuming less power.

Torches

All plasma torches contain the same basic elements, including:

- Electrode to carry the negative charge from the power supply
- Gas distributor, or swirl ring, to spin the plasma gas into a stable, swirling vortex
- Nozzle to constrict and focus the plasma jet

The torch is primarily a holder for the consumable parts. Torch improvements have been aimed at optimizing the torch and consumable designs to improve cooling, enhance starting characteristics, and increase cutting capacity. Improvements also have been made in material selection for consumables and torches to improve durability, such as using high temperature durable plastics in place of ceramics. Ergonomics have improved

BUYING BASICS

When looking for a new handheld system, consider answers to the following questions:

- What type of power supply does the system have? What is its capacity?
- Will the system generate enough power to meet my needs?
- How much will it cost to operate?
- Is the torch durable and ergonomically designed? Does it have the latest safety features?
- How long is the warranty?
- How easy is it to add technical support once the warranty is expired?
- Can I try before I buy?

with features such as trigger torches, better handle designs, and options for torch angle or adjustable torchheads. Safety improvements include parts in place (PIP) circuits and switches or triggers to prevent the torch from firing without the parts properly installed and the operator ready. Most handheld systems on the market today use one of two methods to initiate the plasma arc. The tried and true method is a high frequency (HF) starting circuit built into the power supply. This system uses a high voltage transformer (similar to a bug zapper), capacitors, and spark gap assembly to generate a high voltage spark at the torch. The spark ionizes the plasma gas, enabling current to flow across the air gap between the nozzle and electrode. The resulting arc is called the pilot arc. High frequency starting systems are simple, relatively dependable, and require no moving parts in the torch. However, they do need periodic maintenance to prevent hardstarting problems. Another potential problem is that high frequency radiates from the system, creating electrical noise that may interfere with sensitive electronic equipment. Contact start torches use a moving electrode or nozzle to create the initial spark that enables the pilot arc. When the torch is fired, the electrode and nozzle are in contact in a short circuit, something called a “dead short”. But as the gas enters the plasma chamber, it blows the electrode back or the nozzle forward, creating a spark. This process is similar to the spark created when you quickly yank an electrical plug out of a live outlet. Contact start torches produce much less electrical noise than HF systems. These also are “instant on” torches, which reduce cycle time because of the lack of pre-flow.

Sizing a System

The machine should have sufficient power to handle typical cutting tasks with ease, and it should be able to cut the material at about 20 inches per minute (IPM) or faster. When an operator becomes accustomed to the speed of PAC, it is possible to hold line profiling at 70 to 80 IPM. Even faster speeds are possible with template cutting or cutting accessories such as circle cutters and rolling plate followers. Before purchasing a system, the three material considerations are:

- Types of materials to be cut
- Thickness of materials to be cut
- Most commonly cut material thickness

The third consideration is the most important when selecting a plasma system. Often, errors are made in sizing a system for an application, and too little or too much power is acquired for the most common cutting task.

Underpowering, or trying to cut at the high end or over the system’s cutting capacity, will lead to poor cut quality, low cut speeds, and high torch and part consumption. Over powering can lead to cut quality problems, such as heat distortion, wide kerf, and low speed dross. Generally, more power is better, especially because most systems now allow variable output so that the power can be dialed down for thinner materials. Figure 1 includes some basic cutting capabilities for a range of different amperages.

Equipment manufacturers rate the cutting power of a PAC system with a thickness or capacity rating. These ratings are based on carbon steel and list the thickest metal that the system will cut with reasonable speed and cut quality, from an edge start. In an edge start, the operator fires the torch with the nozzle just over the edge of the plate, then begins cutting. For a pierce start, the operator fires the torch over the plate and blows a hole through the material before cutting. Piercing through material requires more power and operator skill

Metal Thickness	Minimum Recommended System Size	Approximate Cutting Speed*
18 ga.	12 amps	35-100 IPM
⅛ in.	12 amps	10-20 IPM
¼ in.	25 amps	15-20 IPM
⅜ in.	40 amps	25-35 IPM
½ in.	55 amps	25-40 IPM
¾ in.	80 amps	10-25 IPM
1 in.	100 amps	10-15 IPM

*Ranges shown are based on claims of several manufacturers. Speeds are based on carbon steel cutting. Actual cutting speeds vary, depending on torch and power supply design.

Figure 1 *Material thickness determines the system size.*

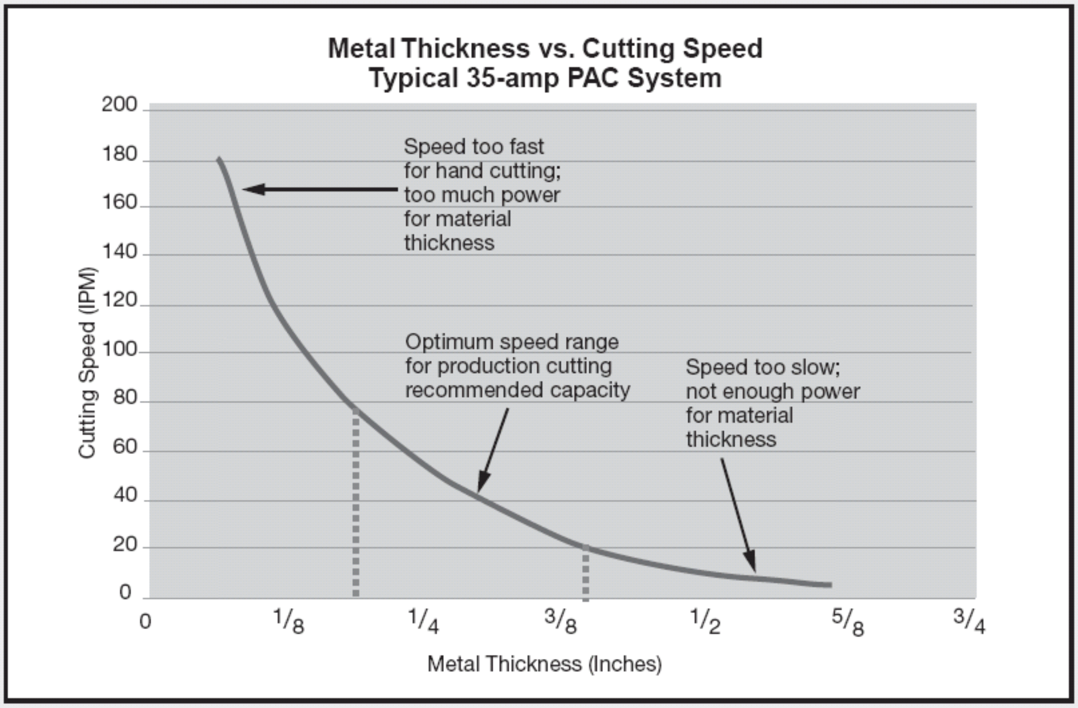

Figure 2

If the system doesn't have a recommended capacity rating, an analysis can be made by referencing the cut charts or a cut speed curve.

than edge starting. For these reasons, the pierce rating, or piercing capacity, usually is half the cutting capacity. For example, most 100 amp systems will cut 1 inch plate from an edge start, but can only pierce ½ inch plate.

Some manufacturers also offer a recommended capacity, which is a more useful specification than maximum capacity. The recommended capacity is the optimum thickness for the machine in terms of quality, parts life, cut speed, duty cycle, overall productivity, and cost of operation. If the system doesn’t have a recommended capacity rating, an analysis can be made by referencing the cut charts or a cut speed curve as shown in Figure 2. The regularly cut material should fall somewhere in the middle of the cut chart, and the corresponding speed should be at least 20 IPM.

Cost of Operation

Many variables contribute to the overall cost of operation for PAC, including labor, power, duty cycle, gas, shop air maintenance, consumables, consumables life, speed of cut, and the amount of cleanup or secondary operation required. The two most important factors to consider when purchasing new equipment are consumable cost and consumable life. Because the part life of different systems varies, consumable cost alone is not the best measure of a system’s cost of operation.

Consumable Cost. The total consumable cost divided by the consumable life in hours of arc on time per hour, is the most useful measurement. For example, if the cost of a nozzle is $4, the cost of the electrode is $6, and together the set lasts 2.5 arc hours, then the cost per hour, or CPH, is $10 ($4 + $6) divided by 2.5 for a total CPH of $4. Just the nozzle and electrode are used for this calculation because the other consumable parts are designed to last much longer. To calculate CPH for all torch components, a weighted average should be used based on usage ratios. Typically, shields, swirl rings, and caps outlast nozzles and electrodes in a minimum 20 to1 ratio.

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