INTRODUCTION TO
CNC Plasma Arc Cutting

LINCOLN ELECTRIC
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Introduction

The Torchmate Curriculum

It goes without saying that today’s manufacturing industries face many inherent challenges, such as global competition, rising material costs, and even more importantly, a lack of skilled workers. In order to remain competitive in an ever-changing market, employers are demanding higher skill levels in the positions they offer. Consequently, experience with Computer Numeric Controlled (CNC) machines is a basic requirement for many of the current manufacturing positions now available. Employees with CNC skills often have greater computational skills and an enhanced understanding of modern manufacturing processes. In turn, these individuals are more valuable to their employer and can demand higher salaries.

Torchmate CNC Cutting Systems has been marketing superior plasma cutting systems to manufacturers worldwide for over 30 years. Affordability, quality, service and commitment to its customers are the cornerstones upon which the Torchmate brand has been built. Having a multitude of options and accessories available allows each CNC cutting system to be personalized, based upon the customer’s individual production requirements. With the recent purchase of Torchmate by Lincoln Electric Co., a growing segment now exists within educational institutions. The flexibility and affordability of the new Torchmate “Growth Series” has enabled programs at university, community college, and career tech institutions alike to consider adding CNC Plasma cutting to their training programs. However, within each institution, instructors face common challenges that may impede the success of incorporating CNC plasma cutting within their programs. For example, instructors may have limited or no experience with CNC machines or perhaps students may have little or no experience with CAD software. Consequently, the new CNC plasma cutting table may sit in the corner collecting dust, until the instructor has time to figure out how to program and operate the CNC cutting system well enough to provide effective instruction.

Torchmate has designed this reference material with the educator in mind by providing comprehensive chapters crafted by practicing welding & fabrication educators. In addition, a comprehensive glossary is included that provides standard terms and definitions used in industries that use CNC CAD/CAM. While programs at each educational institution vary in the level of instructional rigor, it is Torchmate’s intent to streamline the process of incorporating CNC Plasma Cutting into existing welding and/or metal fabrication programs at levels of instruction by using this new curriculum.
How to use this text

This student reference material contains 11 chapters plus an index. To make sure you get the most out of this material, we’ve included the following in each chapter:

» Vocabulary words are formatted in red italic text to denote their first occurrence. If you have questions or want to know more about these terms, you can find them in the index.

» Information that we think will be helpful or important to you is formatted in bold or italic text. Bold text generally denotes an important word or phrase, while italic text is used to highlight an important concept.

» Each chapter begins with a preview that tells you what you can expect to learn, how you can evaluate your learning, and what new vocabulary words you may want to look up before you proceed.

» Each chapter includes either a chapter review or performance-based assessment, or both. Complete these independently or as directed by your instructor.
Chapter Preview

Chapter 1: History of Plasma Cutting

You will learn:

- What is plasma?
- How plasma arc cutting has changed since its inception to the present day.

You can review what you’ve learned by:

- Completing the chapter review.

New vocabulary words (in alphabetical order):

- CAM (Computer Aided Machining)
- CNC (Computer Numerical Control)
- PAC (Plasma Arc Cutting)
- plasma
Certain types of plasma occur in nature, such as stars, auroras, static electricity, and lightning. Other types of plasma are manufactured, such as neon lights, fluorescent bulbs, and plasma televisions.

As you read, look for words in *red italics*. This indicates a word whose definition can be found in the glossary at the end of this text.
Chapter 1

History of Plasma

WHAT IS PLASMA?

When defining the distinct forms that various states of matter take on, it is common to group them into three distinct stages: a solid, a liquid, or a gas. However, there is a fourth state of matter, called plasma, which can occur under certain circumstances. Figure 1-1 depicts the four states of matter. When considering the various stages of matter of water, for example, there would be the form of ice (solid), water (liquid), and steam (gas). If heat is applied to the ice, it will simply change from a solid to a liquid, and when additional heat is applied, the liquid will change to a gas (steam).

Through continued addition of heat energy to the steam, the subsequent gas molecules become electrically charged (ionized), creating plasma (see diagram below). Certain types of plasma occur in nature, such as stars, auroras, static electricity, and lightning. Other types of plasma exist in our daily lives, such as neon lights, fluorescent bulbs, and plasma televisions, all of which are manufactured.
HISTORY OF THE PLASMA ARC CUTTING PROCESS

TIG Welding Process Developed

During the World War II era, a Union Carbide engineer named Bob Gage developed an arc welding process in an effort to improve the joining of aircraft materials. The process used a protective barrier of inert gas (helium) around an electric arc carried by a non-consumable electrode (tungsten) to protect the weld from oxidation. By forcing the ionized gas through a nozzle, the arc and the plasma exiting the nozzle reached high velocities, with super-heated temperatures that facilitated welding metals such as aluminum and stainless steel. The arc itself was transferred from the torch to the workpiece through a non-consumable made of tungsten.

This metal joining process was formally named Tungsten Inert Gas (TIG) welding and later trademarked with the name “Heliarc” by Union Carbide’s Linde division. Today, the TIG welding process is formally referred to as Gas Tungsten Arc Welding (GTAW) by the American Welding Society.

PLASMA CUTTING INVENTED

Over the course of the next decade, Union Carbide engineers discovered that by sending an electric arc through a gas passing through a constricted opening, the temperature of the gas could be elevated to the extent that the gas became a plasma. These extreme temperatures were possible because the high gas flow in the plasma torch nozzle created a cool layer of un-ionized gas along the nozzle wall, which facilitated a higher level of arc constriction and consequently allowed temperatures up to 36,000º F to be reached. As the metal being cut became part of the circuit, the electrical conductivity of the plasma caused the arc to transfer to the work. Additionally, the restrictive orifices in the nozzle caused the flow of gas to speed up and swirl. This caused a “jet-effect,” which in turn blew the metal away, leaving a narrow kerf behind in the workpiece. From this fundamental discovery, the very foundation of the Plasma Arc Cutting (PAC) process was born. Figure 1-2 depicts a basic plasma torch.

Figure 1-2.
Cutaway of a plasma torch
INTRODUCTION TO CNC PLASMA ARC CUTTING

Chapter 1

EARLY PLASMA CUTTING

The plasma-arc cutting process saw its first commercial application in the early 1960s. Early plasma cutters were large, slow, and expensive. Consequently, common applications for PAC consisted of repeating cutting patterns in a “mass-production” mode. It was not uncommon to see early plasma cutters run continuously to help amortize the high cost of the related equipment. However, the cut quality of plasma-cut steel at this time was poor. Further development was needed for plasma cutting to compete against other widely accepted metal cutting processes.

DUAL FLOW AND AIR PLASMA CUTTING SYSTEMS

Over the course of the next few years, several other developments took place in an attempt to improve PAC efficiency and cut quality. For example, the Dual Flow Arc Plasma, developed in 1962, used nitrogen as the primary (plasma) gas in addition to a secondary shielding that was added around the plasma nozzle. The secondary gases commonly used included air or oxygen for steel, argon/hydrogen for aluminum, and carbon dioxide for stainless steel. While the dual flow plasma arc cutting process improved the life of the torch consumables and increased the potential cutting speeds for steel, it had no additional benefit over conventional plasma arc cutting in regard to stainless steel and aluminum.

About a year later, the air plasma cutting process was developed, which used common air instead of nitrogen as the plasma gas. The addition of the available oxygen in the air created a higher level of heat energy, which in turn allowed for substantial increases in cutting speeds. Special electrodes made entirely of hafnium or of alloys of hafnium and zirconium were developed, and they proved more resistant than tungsten electrodes to the adverse oxidation effects of the oxygen. However, the additional available oxygen in the plasma stream continued to have an adverse effect on the life span of the electrodes. It also caused an increased chance of porosity in the base metal being cut when welded. Plasma system manufacturers remained challenged to improve the lifespan of their consumables.

One of the earliest patents for a “shape cutting machine” was issued in 1919. The machine utilized a pivoting column, rolling carriage, and horizontal torch head to trim the flanges on boilers.
Answer each of the questions below either by writing a short answer or by discussing with a group as directed by your instructor.

1. Describe how the advent of the Internet has affected PAC; then, predict one way in which PAC might be affected in the future due to advancements in technology.

2. Explain how World War II affected the development of PAC. Interdisciplinary connection: Identify one other manufacturing technology that was developed as a result of World War II.

3. PAC and other technologies are causing manufacturing to become increasingly hi-tech. Do you think this changes the nature of careers in manufacturing? Why or why not?