POWER BEAMS & MATERIALS PROCESSING

PBAMP-2002

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PROCEEDINGS OF DAE-BRNS SYMPOSIUM ON

APPLICATIONS OF PLASMAS, LASERS AND ELECTRON BEAMS IN ADVANCED MATERIALS PROCESSING

DAE-BRNS

POWER BEAMS AND MATERIALS PROCESSING : PBAMP-2002

ORGANISED BY

LASER & PLASMA TECHNOLOGY DIVISION
BHABHA ATOMIC RESEARCH CENTRE

&

BOARD OF RESEARCH IN NUCLEAR SCIENCES
DEPARTMENT OF ATOMIC ENERGY

Mumbai-400 085

September 25 - 28, 2002

Multipurpose Hall, BARC Training School Hostel,
Anushaktinagar, Mumbai 400 094

Cover: The cover shows the three important Power Beams, namely, Plasma, Laser and Electron Beams being used for materials processing at various laboratories of The Department of Atomic Energy.

Plasma Cutting through High Density Beams

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Abstract

Hypersonic and high energy density Plasma beams combined with robotics and precision automation are poised to radically change the global fabrication industry. Dimensional cutting capabilities with minor finish cut edges allow plate, formed components and welded assemblies to be trimmed, contour-beveled and cut in the same setup. Environment friendly plasma torch features make the plasma cutting process practically unobtrusive on the shop floor.

Key Words : plasma cutting, hypersonic, profile cutting, robotics, automation

1. Introduction

What does the worldwide metal cutting industry need? *"cut it right the first time"*. This is now the Mantra for fabrication industry worldwide. The appetite for high accuracy, faster speed and lower cost is transforming the metal cutting industry worldwide. Metal cutting is no longer seen as the first step for machining. In most cases, profiles need to be cut to close tolerances to eliminate machining. The break-down of the barrier between machining and cutting represents a huge growth opportunity for the metal cutting industry.

Three technologies are fueling the growth of the plate / sheet metal cutting industry. They are Laser, Plasma and Water Jet cutting. The flexibility and ease of automation of the above processes are drastically reducing capital / operating cost with higher accuracy. This has created a tidal wave of demand for the best technology.

2. The Size of The Worldwide Plasma Cutting Industry

The Google Internet Engine search on Plasma cutting has shown 72400 sites. These many numbers of sites signifies that the Plasma industry has a World Wide importance

American Welding Society Conference held at Chicago mentions that *"For decades, the only plate cutting method was oxyfuel cutting, but recently, methods like Plasma cutting, high definition Plasma cutting & laser beam cu tting are more frequently used"*.

The entire oxy-fuel cutting market share can be taken over by Plasma cutting, only if it is cost effective. It is estimated that, the total hand cutting torch and consumables World market size is of approx. 2,50,000 torches valued at USD 750 Millions. Total machine cutting torch World market size is of approx. 25,000 torches valued at USD 250 Million.

3. How Patents Have Ruled / Driven The Plasma Industry?

Patents Chronology:

Technological excellence offering speed, accuracy and cost effective solution in Plasma Industry has ruled the market in the last 50 years. More than 460 patents are registered in this field up till now. (Refer Delphion patent search of U.S. Patent Office)

(1957) The Plasma jet generated by conventional "dry" arc constriction by Union: Carbides Linde Division. In the same year, Dr.Robert Gage obtained a patent, which for 17 years gave Union Carbide a Virtual Monopoly.This technique could be used to sever any metal at relatively high cutting speeds.

(1962) The dual flow technique was developed and patented by Thermal Dynamics Corporation and James Browning, President of TDC in 1963. This patent helped TDC to garner major business for many years.

(1968) Radial water injection arc constriction was developed and patented in 1968 by Richard W. Couch Jr., *President of Hypertherm Inc., US.*

(1972) In 1972, Hypertherm introduced and patented the water muffler and the water table pollution control systems, which controlled the potentially hazardous effect of Plasma arc cutting.

(1983) By early 1983, Thermal Dynamics launched the PAK3 and SAF introduced the ZIP cut. Both units were immensely successful in the business, one in the USA & other in Europe.

(1980-2001) Hypertherm introduced 65 Plasma cutting patents. This company's single point focus has guaranteed a virtual monopoly in the Plasma cutting industry. Today Hypertherm is the undisputed leader in the field of Plasma cutting worldwide.

(2001) India's first Patent for Plasma Torch Head is obtained by Plazma Cutting Equipment Pvt. Ltd. This fundamental method Patent was granted in 5 months by the US Patent office. Patents from all fields of Plasma processing have been sited as references, while granting this patent.

(2001) Further European and South African and other patents granted to Plazma Cutting Eqpt. Pvt. Ltd. for its Plasma Torch head.

The PLAZMA Patent is for a vastly improved method of electrode and nozzle centering and for minimal turbulence in Vortex gas flow. This is fundamental to any Plasma arc torch, which employs an electrode and nozzle. This simple and cost effective solution can revolutionize the global metal cutting industry by providing high-density beams at extremely low costs.

The rapid technological advances in high-density Plasma beams have opened a new era for Plasma arc cutting, which increased the world market size about 50 times.

4. Major Players

Major Players in the Plasma cutting world market are having commendable business are :

1. HYPERTHERM, INC.
2. LINCOLN ELECTRIC,INC.
3. MILLER ELECTRIC
4. THERMAL DYNAMICS
5. UNION CARBIDE - LINDE DIVISION

HYPERTHERM World Leader in Plasma technology has an impressive track record. This company uses only Plasma technology for metal cutting. LINCOLN ELECTRIC is the world

leader in design, development & manufacture of arc welding products, as well as Plasma and Oxyfuel equipment.

The PLAZMATorch :

The PLAZMA torch is the most important element of a PLASMA cutting system. Design and development of high quality Plasma torch is so difficult, that these are barely five to seven manufacturers world wide.

A pilot arc is initiated between the torch, electrode and nozzle tip. This arc is then transferred to the metal to be cut. The intense heat of the Plasma process causes an excessive heat build-up in the torch and consumables. This damages the torch and consumables during usage.

To counter the damages to the torch, there are two types of cooling technologies are being used :

1) Air cooling technology
2) Water cooling technology

How does plazma cutting technology answer this need ?

High density Plasma beams are now blurring the distinction between cutting and machining. In India, the latest machines from are already producing direct "to-be-welded" components for companies like BAJAJ, BHARAT FORGE, FOURESS, and others.

5. High Density Plasma Beams

Hypersonic and high-density Plasma beams combined with precision Automation are poised to radically change the global fabrication industry. These beams have enabled 3 dimensional cutting capabilities with mirror finish cut edges. This allows plates, formed components and welded assemblies to be trimmed, contour beveled and cut in the same set up. This Solution results in drastic cost reduction and increased productivity.

The characteristic of an ideal high density Plasma beams is:

High Current Density:

Current density is expressed as Amps per sq. inch = cutting current in Amps divided by nozzle orifice area in inches. Though the above formula does not represent the actual Plasma beam diameter, it is a good indicator of the same.

Normal plasma operates at a current density of 20,000 Amps / sq. inch. A high density Plasma torch generates a beam of around 35,000 - 55,000 Amps / sq. inch. To optimize this further, the PLAZMA torch operates in two modes, that is low intensity mode at 35,000 Amps / Sq. inch and high intensity mode at 55,000 Amps / Sq. inch on high intensity mode.

Hypersonic Velocity:

Higher current densities force the Plasma beam to exit out of a smaller orifice with an exponentially higher velocity. This high velocity is inherently prone to turbulence, resulting in a complete break down of the Plasma beam flow. There are many methods to tame this Plasma beam. In the PLAZMA torch a unique coherent flow technology works with the hypersonic velocity of the beam to form an extremely small kerf width, resulting in low cutting wastage.

High Arc Impedance:

The extent of constriction of these high-density beams is clearly indicated by higher arc voltages. These "fine-focus" beams have very high arc impedance. Normal plasma torches

operate at arc voltages of 120V to 150V. In comparison the PLAZMA torch operates at 180V to 220V. Finely focused high arc impedance beams generate extremely high cutting power. For example the PLAZMA torch cuts 12 mm plate at 2.7 meters per minute with just 180 Amperes.

Consumable Wear and Tear:

High current densities and inherently unstable beam flows can result in excessive wear and tear of plasma torch consumables. These beams are created with precision manufacturing for close tolerances of all torch components. This coupled with high efficiency cooling extends the consumables life. In a PLAZMA torch, unique thin film liquid cooling provides for rapid thermal transfer, which keeps torch components cool.

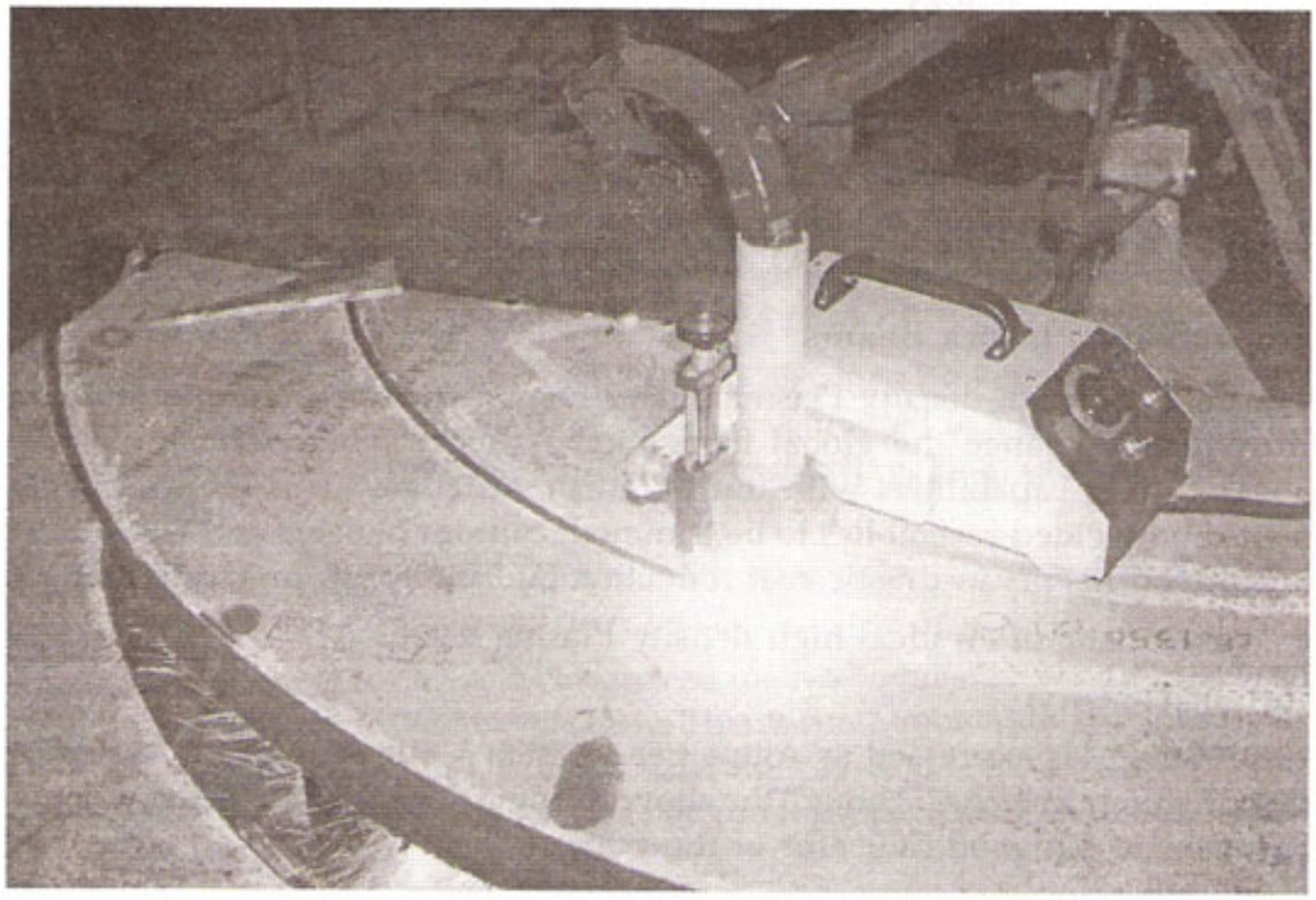

Fig. 1. With plazma make m/c & torch, continuous plasma cutting on 100mm stainless steel plate

6. High Density Beams Expand Plasma Cutting Applications

High-density Plasma beams combined with Robotics are changing the global fabrication industry. Plasma Robotic systems have 3 dimensional cutting capabilities with mirror finish cut edges. This allows plates, formed components and welded assemblies to be trimmed, contour beveled and cut in the same set up. This Solution results in drastic cost reduction and increased productivity. This solution enables batch manufacturing to supersede mass manufacturing. The possibility of flexible manufacturing enable smaller size companies to compete with larger Giants by offering just-in-time batch deliveries.

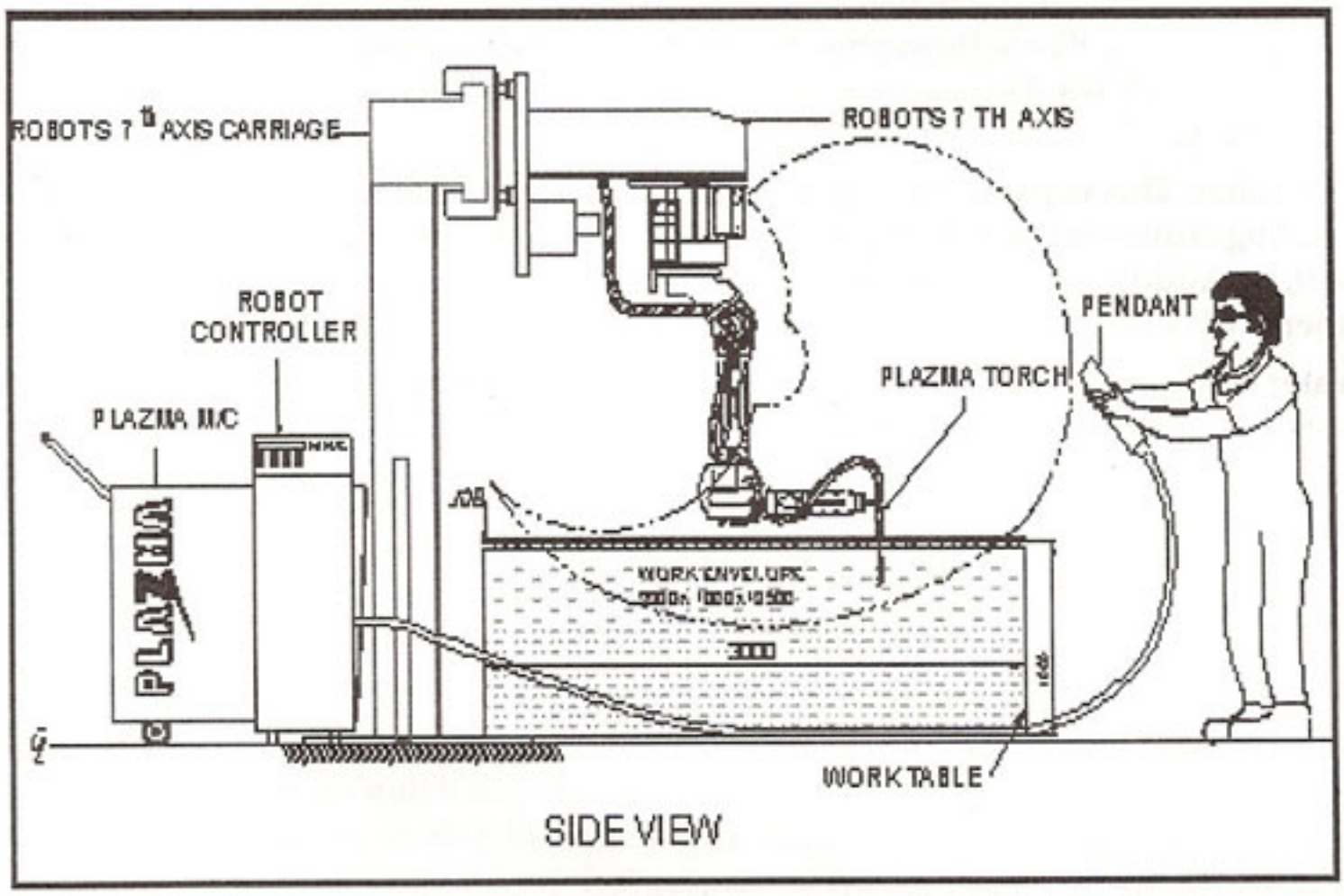

Fig. 2. Plasma robotic system

The Plasma Robotic Cutting System shown in the drawing is capable of:

a) 3D Cutting of formed components, castings and welded assemblies
b) Contour beveling for weld edge preparation
c) Positioning speeds of 20 Meters /minute
d) Cut Speeds of 9 meters / minute
e) Cutting of Small Batch Quantities
f) Minimum Cut Accuracy Of +/- 0.5mm
g) 3-side accessibility for Job Handling

7. Plasma Robotic Cutting System Hardware

To produce these high performance beams, the Plasma Robotic system components have to be finely matched.

The System Components are:

a) The Plasma Torch: The Torch should be capable of rugged duty with high precision quality. For example the plasma torch should remain cool even during cutting 100mm for a one-hour continuous operation. The resultant economics with high life, low cost consumables are highly competitive. High cutting speeds with lower currents multiply productivity and efficiency.

b) The Plasma Power Source: In India rugged simplistic solutions are essential. For example PLAZMA's advance magnetically controlled power sources give an extremely low ripple.

Unlike electronically switched Power sources approximately 94% of the D.C. Power is used for cutting. These Power Sources do not use high power electronic components and complicated PCB's. This ensures easy serviceability, low replacement cost and indigenous availability.

c) The Robot: This expands the capabilities of cutting from simple plate cutting to contour beveling, 3 dimensional cutting of formed components, welded assemblies and sheet metal cutting. Additionally the Robot can also be used for machining, welding, drilling, and other such operations.

d) Water muffler / Shielding systems: The new generation of water muffler / shielding systems drastically reduce noise, fume and light pollution.

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