PLASMA HEAT: WORLDWIDE DEVELOPMENTS USING A DEMONSTRATED, UNIQUE HEAT SOURCE FOR WASTE TREATMENT & INDUSTRIAL APPLICATIONS

Salvador L. Camacho and Clyde Z. Nunn
Plasma Technology Company,

Gary A. Benda
U S ENERGY Corp

ABSTRACT

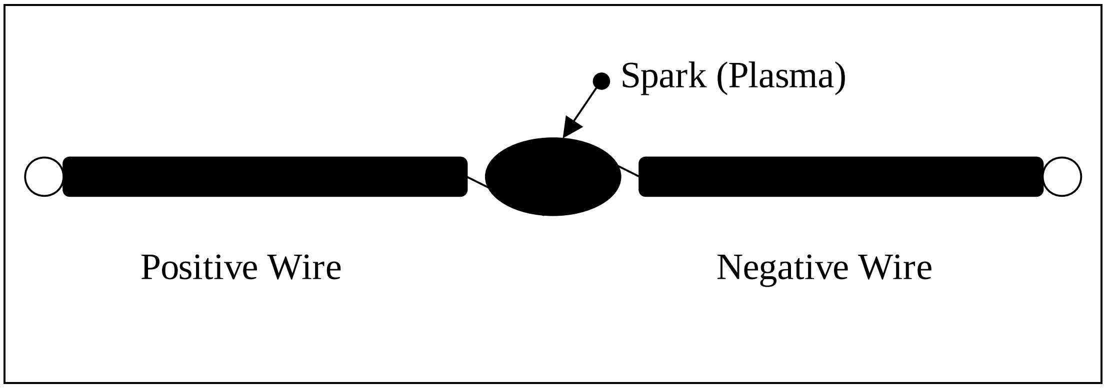
This paper gives a historical perspective and identifies recent developments of plasma technology and its many applications around the world. Although originally discovered in Germany in the 1800's, plasma-heating technology was virtually unknown in the United States until NASA developed it for test re-entry heat shield materials. As the technology progressed, various spin-off companies emerged to further develop plasma technology and apply it to industrial and environmental problems. After more than four decades, plasma technology is being utilized worldwide continuing to be a viable and effective means of not just reducing all kinds of wastes, but of converting residuals to a safe, and sometimes reusable byproduct.

INTRODUCTION

Plasma is considered by many to be the fourth state of matter, following the more familiar states of solid, liquid, and gas. Heat energy, when added to solid, converts the solid into liquid. Heat energy, when added to liquid, converts the liquid into gas. The addition of heat energy to a gas converts the gas into plasma. Lightning is an example of the plasma state of matter. Lightning is not a flame. Rather it is a very high-temperature beam of energy that radiates in three dimensions. Materials exposed to the plasma beam of energy is broken down into different components that are reformed into gaseous energy and molten inorganic byproducts that are safe to reuse for various purposes.

Knowledge of the existence of this fourth state of matter, plasma, has been around since 1878 in Europe. This knowledge, however, was not exploited until the early period of NASA's space program. Considerable improvements in plasma technology were achieved at NASA in a challenging effort to produce a heat source that would reliably test re-entry vehicle heat shield materials.

One of the advances that was made is a plasma torch that can produce this "lightning" on a sustained basis, rather than in the sporadic form we see in nature's lightning. A plasma torch generates a lightning discharge or "spark" between two solid metal electrodes that are connected to and alternating or direct current electric power source. This event is diagrammed on the next page.



Plasma Generation between Two Electrodes

The “spark” is plasma, a low-mass heat source with the highest sustainable temperature of any known man-made heat source. This “spark” or plasma can easily reach temperatures of 2000 to 5000 degrees centigrade or higher. The “spark” can even reach temperatures higher than the sun’s surface! Plasma, a beam of energy, is unique and thus has extraordinary capabilities.

This unique fourth state of matter, plasma, is a highly desirable heat source for environmental remediation and industrial processes. Its high temperature melts, not incinerates, materials and promotes rapid chemical reactions, converting organic matter into clean fuel gases and inorganic matter into a molten, glassy slag that is virtually unleachable and safe for numerous applications. Any known metals are merely melted. In other words, plasma essentially converts waste materials into recyclable byproducts. There is virtual 100 percent recycling of wastes without the cost and sorting of materials that recycling normally demands.

BRIEF HISTORY OF US PLASMA TECHNOLOGY DEVELOPMENTS & APPLICATIONS

Almost four decades after its successful development and employment during the NASA space program, plasma-heating technology is emerging as an ***efficient conversion/treatment technology.*** The decades of the 1960's and 1970's achieved safe travel into space by man with the help of plasma technology.

In the late 1970's and after playing a major role in this achievement at NASA, several scientists turned to the further development of plasma technology and to finding ways in which the technology could be applied for the benefit of the environment and as a cost effective enterprise. Dr. Salvador Camacho demonstrated that his plasma pyrolysis/vitrification technology is effective in converting municipal solid waste (MSW), used rubber tires, and combined MSW and medical wastes.

The US was leading the development of this technology for worldwide applications. Ebara-Infilco of Japan observed one of the tests at the plasma pyrolysis/vitrification (PP/V) system, which eventually led to Ebara-Infilco and several other Japanese firms incorporating PP/V systems at their incinerator plants for the safe, efficient treatment of hazardous fly ash and bottom ash.

The decade of the 1980's saw expanded plasma demonstrations taking place at universities, including the Georgia Institute of Technology in Atlanta. One of those Georgia Tech plasma demonstrations was with incinerator fly ash and bottom ash actually generated from Bordeaux, France, where the world-renowned wine country was facing serious problems cause by incinerator ash. After being convinced by the demonstration, Bordeaux is establishing a Plasma Pyrolysis/Vitrification plant to safely dispose of their incinerator ash.

The decade of the 1980's also witnessed very significant advances in the application of plasma heating technology in industrial processes. Prototype tests of plasma heating processes during the 1980's evolved in to actual construction and start-up of commercial-scale plasma plants. Plasma heating was poised for another quantum leap during the decade of the 1990's.

CURRENT WORLDWIDE APPLICATIONS OF PLASMA HEATING TECHNOLOGY

Plasma heating technology applications in metallurgical and waste treatment industries exist around the world and the non-transfer plasma torch design has been central to many of these applications. Listed are various examples of plants employing plasma technology:

> **West Germany.** The largest plasma facility in this country is located in Marl, West Germany. This facility is a 300 megawatts plant using fifty non-transferred plasma torches (graphite electrodes) to heat natural gas around the clock to produce acetylene for Europe.
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> **Sweden.** Sweden has two plasma facilities. One facility is in Lundskrona and treats approximately 600 tons per day of electric arc furnace (EAF) dust. It employs four non-transfer plasma torches to treat the dust from stainless steel and carbon steel furnaces. The plant recovers chromium, nickel, manganese, and iron from stainless steel dust waste, and primarily iron from the carbon steel furnace dust. This plant was the first to demonstrate that it can process and make useful a waste stream that the EPA now considers toxic because of the heavy metals contained in it.
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> A second facility in Sweden is located in Malmo. This plant has two furnaces, each heated by four plasma torches and processes chromite ore and produces chrome metal for use in making stainless steel.
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> **United Kingdom.** The largest plasma facility for making titanium dioxide pigments for titanium tetra-chloride is located here. Plasma heaters heat pure oxygen, which is reacted with the chlorinated titanium feed to produce titanium dioxide. With the plasma heating approach, the chlorine is recovered and recycled.

France. France has three industrial plasma facilities, in addition to the Bordeaux plasma facility already mentioned. The SFPO plant in northern France produces ferro-manganese using six to eight plasma torches of the non-transferred type. Similar torches, made by Aerospatiale are used in two cupola furnaces, one at Peugeot's plant in central France produces special iron for the automotive industry. The second torch is used for the same purpose in a different location.

Canada. About eight years ago, the Aluminum Company of Canada (ALCAN) commissioned a plasma heating process for the recovery of aluminum metal from aluminum dross.

United States. There are numerous facilities across the United States using plasma energy for various applications.

An aluminum waste-to-metal plasma plant was established in West Virginia. That plant is identical to the one mentioned in Canada.

Plasma heaters are also used in a new cupola design at Defiance, Ohio. This plasma heater cupola produces a special grade of iron for automotive engine blocks. The production rate of the cupola is more that 40 tons of iron per hour.

Plasma heaters are also employed in Holsapple, Pennsylvania and in Midlothian, Texas to heat molten meal in ladles and tundishes at steel-making plants. The Midlothian plant is equipped with a one megawatt non-transfer plasma torch designed by Dr. Camacho, as were the majority of the torches mentioned in this worldwide review.

In Nevada and Massachusetts, plasma heaters are employed to heat, melt and consolidate titanium scraps. The titanium ingots that are formed are cleaner and do not lose their alloying elements during melting.

Another plasma plant was established in Alabama to process automobile catalysts to recover platinum group metals.

Australia and South Africa. These countries have plasma-heated furnaces for chrome, iron, and manganese production.

Japan. Four plasma systems are used in Japan to treat incinerator ash, while others are used to heat molten metals in ladles and tundishes. Japan probably has more working plasma based systems than any other country.

PLASMA TECHNOLOGY CONTINUES TO BE DEVELOPED IN OTHER AREAS

Today, the currently defined potential for plasma heating technology includes some new areas of application. Some examples are:

(1) Volume reduction, treatment, and containment of radioactive and/or hazardous wastes,
(2) Safe, efficient conversion of hydrocarbons into gaseous and liquid fuels,
(3) The conversion of waste materials into energy and other useable products,
(4) The modification of local and national weather patterns,
(5) A process for drilling tap holes on furnace refractories,
(6) The manufacturing of composite materials,
(7) Production of lighter, yet stronger metals, and
(8) For reforming gases into desired compounds.

The USA and Canada are conducting tests of plasma pyrolysis of various types of wastes, including municipal solid waste, used automobile tires, used oil, medical waste, nuclear waste, hazardous waste, mixed waste and other types of waste. Examples of the broad range of developments in various countries include;

1) Switzerland is commissioning a plasma plant for the disposal of drummed liquid wastes

2) France is conducting tests to evaluate the technical and economic feasibility of disposing of medical waste by plasma heat.

3) In Italy, plasma heaters are being used to prototype a new process for recovering zinc from zinc wastes generated at galvanizing plants.

4) Japan is exploring the use of plasma in a variety of areas.

5) Russia is prototyping a plasma process for treating construction bricks in place, and

6) Also in Russia, in cooperation with Plasma Technology Corporation(PTC), the Kurchativ Institute of Russia is employing PTC's 300 KW Plasma Heating System at Radon, east of Moscow, for treatment of radioactive wastes.

7) The US Department of Energy has recently complete a multi-million dollar test at their Savannah River plant to determine the effectiveness of a patented process for in-situ plasma treatment of radioactive wastes. That test was successful and has the advantage of not requiring that the wastes be moved and the assurance that it would remain in tact and virtually unleachable.

CONCLUSION

Plasma heating technology has had four decades of history of development and actual applications to a variety of industrial heat and waste disposal problems. After providing the solution to the re-entry heat shield materials testing problem at NASA, to the great relief of the astronauts, scientists went beyond developments at NASA to make improvements to the hardware. Most notable, however, has been he persistent effort to apply the technology to the serious waste reductions and treatment problems around the world.

Although adoption of plasma heat-based waste treatment systems has been slower in the United States than in other parts of the world, rising costs of traditional treatment methods, both financially and environmentally, have made alternative technologies like plasma pyrolysis/vitrification systems much more attractive. New variations of plasma heating applications, such as in-situ application to hazardous or radioactive waste sites, are beginning to catch the attention of more end-users that face challenging treatment problems.

Plasma technology has the potential to revolutionize the way we deal with our ever-growing waste problems. Few technologies can claim the ability to first volume reduce wastes and then convert practically all of it into a safe, end-product, and for some wastes eliminate the need to fund a separate recycling program. Plasma heating technology can make this claim, and also claim that it achieves these goals without further exacerbating to our pollution problem.

REFERENCES

1. Camancho, S. L. " Industry Experience with the Reverse-Polarity Plasma Torch, ISPC-9, Pugnochiuso, Italy, September 1989.

2. Felnman, Jerome, Editor, "Plasma Technology in Metallurgical Processing, " A publication of the IRON AND STEEL SOCIETY, 1987.

3. Camancho, S.L. "Introduction to Plasma Arc Heating Technology," First INEL Plasma Waste Workshop on Low Level Nuclear Waste, January 1991.