NASA TECH BRIEF

Lewis Research Center

Advances in Induction-Heated Plasma Torch Technology

The induction-heated plasma torch provides a means for electrical heating of a wide variety of materials to extremely high temperatures. In the space program, the induction-heated plasma torch is utilized to simulate the high temperature environment within a gaseous core nuclear reactor. NASA Tech Brief 69-10185, "Plasma-Heating by Induction," described the operation of an induction-heated plasma torch with pure hydrogen in which the exit-gas enthalpy was estimated to be at more than 2.3×10^6 J/gm (10^6 BTU/lb.). Continuing research has resulted in several significant advances in induction-heated plasma torch technology which extend and enhance its potential for a broad range of uses in chemical processing, materials development and testing, and the development of large illumination sources. These advances include:

High Pressure Induction Plasma Torch

An induction plasma torch was designed and operated at pressures up to 47 atm. Known prior work has been limited to 16 atm. The unique feature of the torch is the design of the plasma chamber which eliminates the detrimental proximity effects of the torch exit end on successful plasma operation wherein both the gas flow pattern and electrical stability were adversely affected. The design utilizes an extended plasma volume downstream of the induction coil which eliminates disturbance of the gas flow and electrical field in the vicinity of the plasma. This innovation has substantial impact on the possible use of plasma devices in chemical processing when high temperature, high purity gases are required at high pressure. It can also be used in basic reaction studies and in materials testing.

Solid-Feed Induction Plasma Torch

A technique has been developed for introducing solid material which is vaporized and forms the plasma core-gas material in an induction plasma torch. Previously, only gases had been introduced to form the plasma core. The technique developed involves introducing the solid material in rod form through a suitable probe directly into the plasma ball. The rate of injection and the exact position of injection can be varied to produce the optimum conditions for the specific material involved. This technique has a wide range of possible uses in chemical processing and materials development where complete and rapid heating of materials to extremely high temperatures is required. It is also possible that through the use of multiple injection devices controlled mixes or alloys of materials could be obtained by properly controlling the rate of injection of the various materials.

Permeable Wall Induction Plasma Torch

An induction plasma torch was designed and operated which utilizes permeable material for the wall of the torch through which the gas (other than the plasma core gas) is introduced into the torch. In previous designs, the gas which surrounded and stabilized the plasma was introduced through holes in the base of the torch surrounding the central plasma. Introducing this gas through the permeable wall has several advantages. It provides wall cooling, which is particularly necessary in high power operations. Also, this makes it possible to flow larger quantities of gas through the torch without extinguishing the plasma. For some applications, it is desirable to have little or no mixing between the plasma core gas and the surrounding gas; the permeable wall injection greatly reduces the amount of this mixing. Certain chemical reactions which may be carried out in a plasma torch produce finely divided powders which tend to deposit on the walls of the torch. With the permeable wall, it is possible to keep the wall clean by the constant flow of gas through it.

(continued overleaf)

Low Frequency Induction Plasma Torch Operation

An induction plasma torch was designed and operated at frequencies of 9600 Hz and 960 Hz using a motor-generator set as the power source. Previous work with induction plasma torches has been restricted to radio frequency power supplies with frequency outputs of 200 KHz and above. In this new design, a high frequency rf generator provides power for ignition, following which the system is switched to the motor generator set for sustained operation. These torches have been operated at pressures up to one atmosphere. This development is particularly important for applications of a plasma where high power (about one MW) is required. Motor-generator sets are more often available than high power rf supplies and the cost per unit of power is less. This availability makes possible the construction of larger devices, and may also make practical the use of plasmas for large light sources.

Notes:

1. The following documentation may be obtained from:
   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)

   Reference: NASA CR-1804 (N71-27023), Radiation Measurements, Low Frequency and High Pressure Investigations of Induction Heated Plasma

   Reference: NASA CR-1764 (N71-20142), Curved Permeable Wall Induction Torch Tests

2. Technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B72-10151

Patent status:

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act /42 U.S.C. 2457(f)/, to the TAFA Division, Humphreys Corporation, Bow, New Hampshire 03301.

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