LABORATORY MANUAL

Delivering Excellence

Cold Atmospheric Plasma Pen

B-1 Jugal Apartment Near R.J Tiberwal College Vastrapur-380015, Ahmedabad, Gujarat

Email ID- directors.ets@gmail.com, Mobile No- 8511147496, 9825091974

Table of content

1. Introduction.....3
2. Technical Specification.....4
3. The Experimental Set Up.....5
4. How it works.....8
5. Few Suggested Measurement.....8
6. The Shutdown Procedure.....9
7. Precautions Do and Don't.....9
8. Test Report.....10

1. INTRODUCTION

Englert Technologies and Solutions Pvt Ltd (ETS) has indigenously designed and developed Cold Atmospheric Plasma sources commonly known as 'Cold Atmospheric Plasma Pen (CAP)'. Such set-ups are excellent experimental arrangements towards investigating weakly ionized plasma characteristics, non-thermal nature of cold plasma, ionization and energetics characteristics weakly ionized plasma and spectral characteristics of gases under excitations etc. The Cold Atmospheric Plasma Pen uses a high voltage and high frequency generator to convert inert gas into ionized gas, which is called Plasma. Nonthermal plasma jets (plumes) in atmospheric pressure discharges hold promising applications in medicine, biology, polymer etc. Interestingly such manifestations involve a significant fraction of basic plasma physics and measurement techniques also.

Fig 1: The Experimental Set-Up of Cold Atmospheric Plasma Pen.

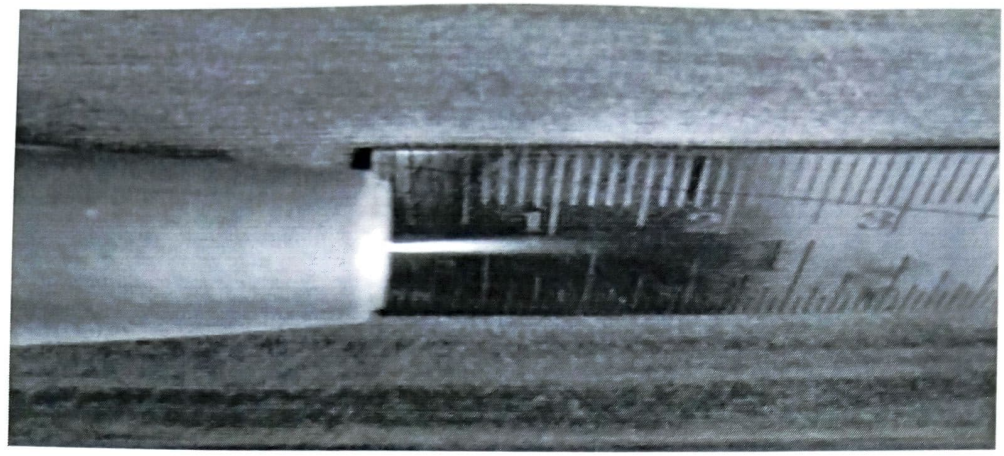


Fig 2: Cold Atmospheric Plasma Pen Plume

2. TECHNICAL SPECIFICATION:

1.	Features	• Simple and Safe Operation. • Neither vacuum or chamber required for versatile plasma chemistry. • Handheld, lightweight and Compact Size.
2.	Input power	• Standard AC 230 V and 50 Hz
3.	Plasma Plume	• One plasma plume size- 0.2 mm diameter and 15 mm long
4.	Plasma working pressure	• Flow rate 0-25 Lit/min
5.	Working Environment	• Plume Temperature is < 40°C • Air, N_2, Ar, He etc can be used as the gases. (No flammable or explosive gases are to be used)
6.	Overall Dimension	• 20 mm diameter and 135 mm long length.
7.	Net Weight	• ~20 kg
8.	Warranty	• 12 months from the shipment.
9.	Application	• Basic plasma physics • In Medical • In Biology • In Polymer Science

3. THE EXPERIMENTAL SET-UP (SCHEMATIC)

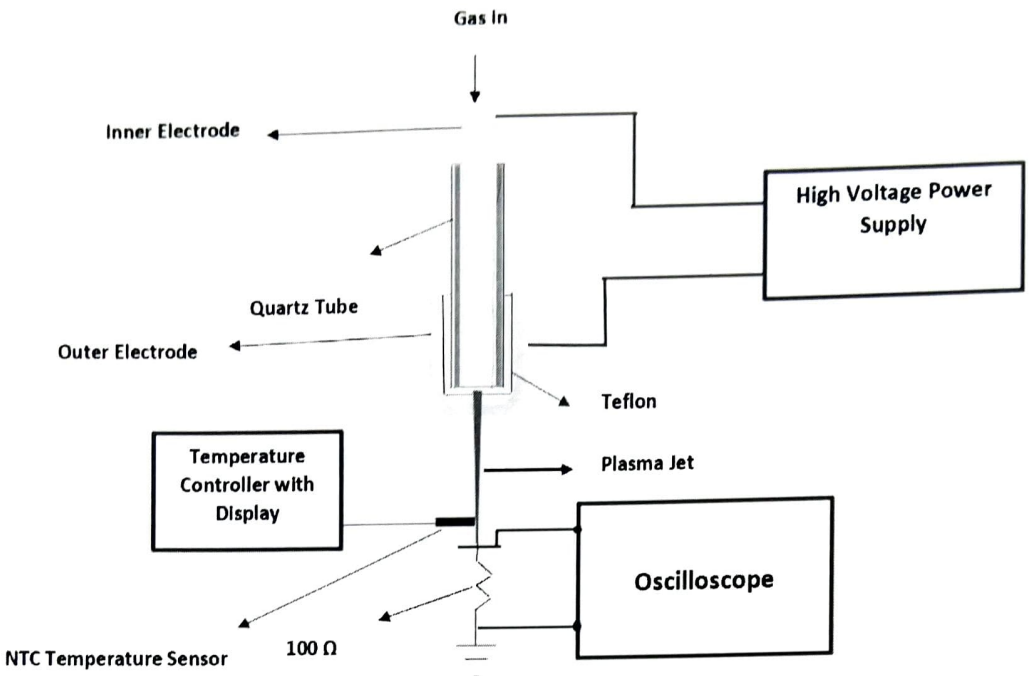


Fig 3: Schematic diagram of the Experimental system of Cold Atmospheric Plasma Pen

The Experimental system of Cold Atmospheric Plasma Pen are consisting of: -

1. Cold Atmospheric Plasma Pen with in-built electrical accessories
2. High Voltage Power Supply with controls
3. Gas cylinder
4. Gas supply system with regulation
5. Temperature Controller

(Measurement System is optional)

1. ***Cold Atmospheric Plasma Pen:*** A CAP Pen is embedded with high voltage Anode and ground Cathode configuration that is safe and housed inside in an insulator material with a leak tight configuration to flowing a carrier gas

Nitrogen, Helium, Air and Argon etc. Electrode Assembly and Gas connection has been housed in Teflon rod of outer length 135 mm and outer diameter 35 mm.

2. ***High Voltage Power Supply:*** A High Voltage Power Supply is complex power conversion circuit that convert the Low Voltage Potential to high Voltage Potential. It can generate the several thousand of volts at frequency of several hundred KHz. Discharge Voltage has been Supplied from the D.C Variable Power Supply. It is in the range of 0-15 KV maximum Output and 0-30 mA maximum current. An appropriate transformer has been used for high voltage and it has been regulated by a variac.

   (i) **Input Terminal-** The input termination is provided through a mains cable with a three -pin plug. Use of 3-core cables enables the cabinet of the unit to be properly grounded.

   (ii) **Output termination** – The Output termination are connected with the plasma Pen Internally.

   (iii) **Metering-** Separate 3-digit DPM is provided on the front panel for output voltage and 3-digit DPM for load current indication. The Voltmeter has a resolution of 1 V and ammeter has a resolution of 0.01 A. The meters monitor the output voltage & load current continuously. The regulated Output Voltage is 0-150 V and current 0-0.60 Amp.

   (iv) **On/Off Switch-** The Power On/Off switch Provided on the front panel.

   (v) **Panel Controls-** Controls are provided on the front panel for output voltage and current limit setting.

3. ***Gas flow system:*** **-** A gas flow arrangement with pressure tight fittings with coupling and PU connections, as per the design and requirements. Gas flow system consisting of followings: -

   i. Gas cylinder
   ii. High Pressure Gas Regulator
   iii. High Pressure Gas Flow meter
   iv. PU tube Connections

   (i) **Gas Cylinder:** A **Gas cylinder** is a pressure vessel for storage and containment of gases at above atmospheric pressure. High-pressure gas cylinders are also called gas bottles. A typical gas cylinder design is elongated, standing upright on a flattened bottom end, with the valve

and fitting at the top for connecting to the receiving apparatus. Gas cylinders have a stop angle valve at the end on top. During storage, transportation, and handling when the gas is not in use, a cap may be screwed over the protruding valve to protect it from damage or breaking off in case the cylinder was to fall over.

(ii) **High Pressure Gas Regulator:** A high pressure gas regulator is a valve to control the gas pressure to desired value. A pressure reducing regulator's primary function is to match the flow of gas through the regulator to the demand for gas placed upon it, whilst maintaining a sufficiently constant output pressure. If the load flow decreases, then the regulator flow must decrease as well. If the load flow increases, then the regulator flow must increase in order to keep the controlled pressure from decreasing due to a shortage of gas in the pressure system.

(iii) **High Pressure gas flow meter:** A gas flow meter is an equipment that measure the volumetric flow rate. The Flow meters are designed to operate in gases like Argon, Nitrogen & Carbon-di-oxide (CO_2) with Flow rating up to 25 m^3/hr. The Vertical flow gauge is shielded with outer tube for additional protection of Flow Gauge.

Size & Connections:

- Inlet Connection: 3/8' RH Internal Thread
- Outlet Connection: 3/8' RH External Thread.
- Type of Flow Control: Knob

(iv) **PU Pipe:** PU pipe is called polyurethane pipe. It is widely to transfer the gas from cylinder to system.

4. ***Temperature Meter***: A Temperature meter is used to measure the temperature of the any object. A temperature sensor is an electronic device that measures the temperature of its environment and converts the input data into electronic data to record, monitor, or signal temperature changes.
   - Measurement Accuracy: 0.1 C
   - Measurement Range: -50 C ~ 110 ℃
   - Dimension: 48 x 29 x 23 mm (LXWXH)
   - Working Environment: -40℃ ~ 65℃

4. HOW IT IS WORKS?

Step 1. switch on main supply

Step 2. Flow the gas into the pen by gas flow meter.

Step 3. Switch on the power supply

Step 4. Increase voltage till the plume come out from Pen

Step 5. Put these hand piece Plasma Pen on targeted area.

Step 6. Check the Temperature of the plume by temperature sensor.

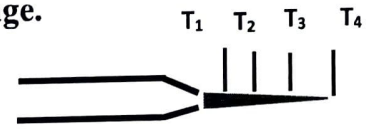
Step 7. Measure the shape and length of plasma plume at different input voltage and at different gas flow rate.

Step 8. Measure the Gas Temperature using thermocouple thermometer at different axial distance of the plasma jet column at some discharge conditions.

Step 9. Electrical parameter estimations such as discharge voltage using potential divider discharge current using the voltage across a resistor.

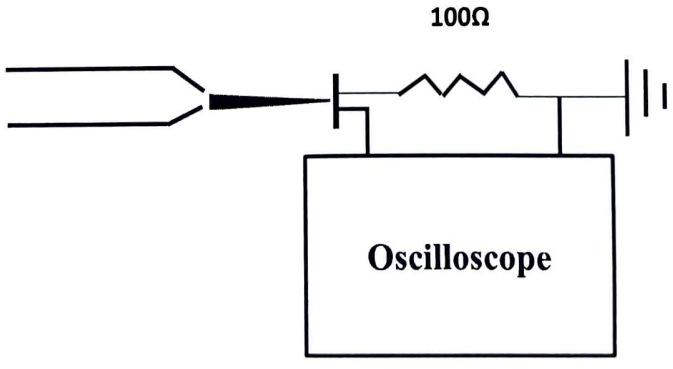
5. FEW SUGGESTED MEASUREMENT

(a) Measure the temperature Profile of Plume length for a given flow rate with applied voltage.



Here T_1, T_2, T_3, and T_4 are the temperature of the Plasma Plume at different distance from the plasma pen tip.

(b) Ionization current - Electrical parameter estimations such as discharge voltage using potential divider discharge current using the voltage across a resistor.



(c) Estimation of mean consumed power (P), Power efficiency and mean energy etc. in such discharges by Lissajous figure (V-Q) generation and calculating the accurate values of the mean power.

(d) Study of the emission spectrum of the particular gas-based plasma plume & their characteristics in discharge Physics.

6. THE SHUTDOWN PROCEDURE

Step 1 Decrease Voltage between electrodes by voltage regulator.

Step 2 At zero voltage switch off the power supply.

Step 3 Decrease the gas flow by gas regulator.

Step 4 Switch off the gas flow.

7. PRECAUTIONS DO & DON'T

1.You must always keep cylinders in a secure and upright position.
2. Before start the experimental system check the connection of experimental set-up.

3. Do not Put off the power supply directly. First, decrease the voltage and current into the Plasma Pen and then switch off the power supply.

4. Do not disassembles or repair the High Voltage Power Supply or touch the interior of the Power Supply.

5. Do not Touch the Product while Power is being supplied or immediately after power is turned OFF. Minor burns may occasionally occur.

6. Do not allows any pieces of metal or conductor or any clippings or cuttings resulting from installation work to enter the product. Minor electric shock, fire or product failure may occasionally occur.

7. Do not over regulate or over tight the gas regulator valve. It will damage the gas regulator valve.

8. When adjusting the flow rate, turn the dial clockwise to open the valve and counter clock wise to close it.

9. Never leave pressure in a regulator when it is not in use.

10. Close the cylinder valve and release all pressure before removing the regulator from the cylinder.

8. TEST REPORT

Measure the temperature Profile of Plume length for a given flow rate with applied voltage.
Flow Rate is 1 lit/min

Input Voltage	Input Current (Amp)	Temperature at 1mm distance (T_1)	Temperature at 4mm distance (T_2)	Temperature at 7mm distance	Temperature at 10 mm distance

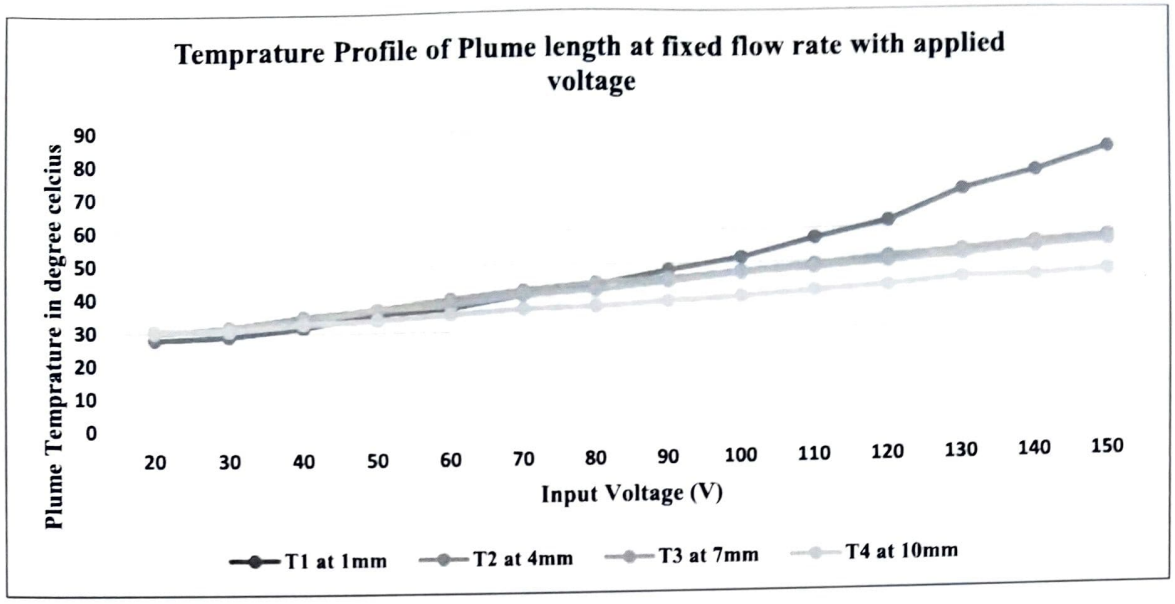


Fig 4: Variation of Plasma plume Temperature along the Plasma Plume length with applied Voltage

Measure the temperature Profile of Plume length for a given flow rate with Current.

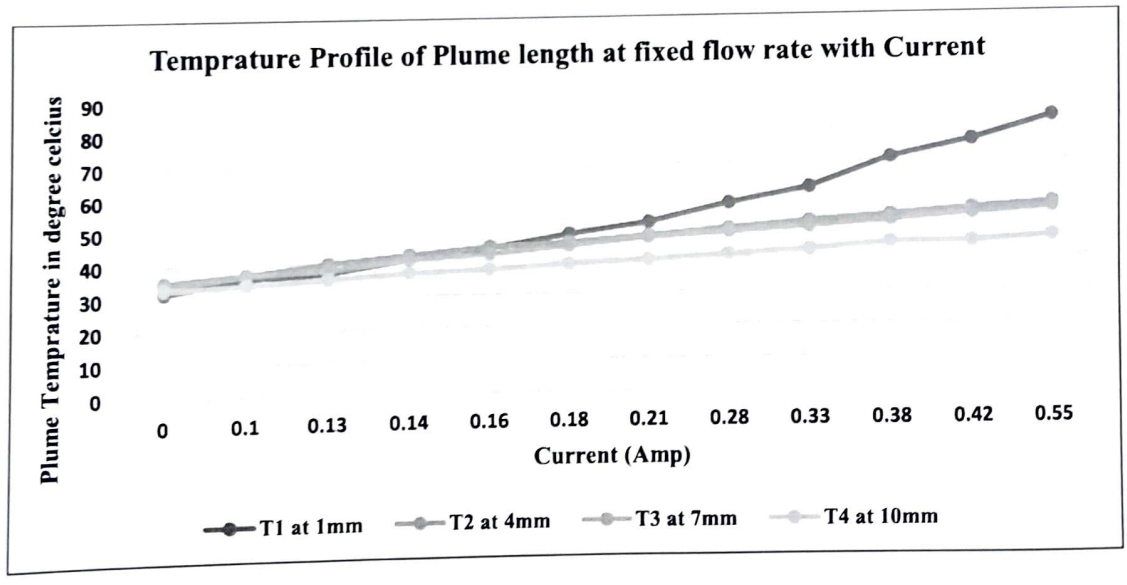


Fig 5: Variation of Plasma plume Temperature along the Plasma Plume length with Current