Plasma Remediation of Environmental Problems

Technical, Commercial and Regulatory Issues in Plasma Treatment of Medical Waste

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Bhagwati Pyrolysis Systems

Environmental concerns are powerful drivers for new plasma-based technologies

- Hazardous solid waste (industrial, medical)
- Air pollution (vehicular, power plant, voc)
- Water (purification, dry processes)
- Decarbonisation (fuel reforming)
- Decontamination (organic, sterilization)
- Recycling (waste to value, zero emission)

Technology is a small component in the environmental remediation field

- Process R&D
- Prototype
- Commercial viability
- Regulatory Issues
- Environmental Action Groups

Plan of the Talk

- Introduction
- Medical Waste problem
- Plasma Pyrolysis of Simulated Waste
- Product Definition
- Development Issues
- Pyrolysis Prototype
- Commercialization
- Future Plans

Ahmedabad City

- Population 3 Million
- 6 large hospitals
- 786 private nursing homes
- 1000 bed civil hospital
- 700 gm waste/bed

- The total hospital waste generated in Ahmedabad is estimated 5,124 kg/day accounting for 2.4 percent of the total solid waste generated in the city

There are no standards for hospital waste composition

Paper and Cloth	50 – 70 %
Plastics	20 - 60
body parts	20 – 60
Glassware	10 – 20
Fluids	10 - 30

- 50% carbon
- 20% oxygen
- 6% hydrogen
- numerous other elements

Pyrolysis is the process of decomposition of organic matter without Oxygen

Polyethylene: 400 – 600^{0}C

Polyvinyl Chloride: 400 – 600^{0}C

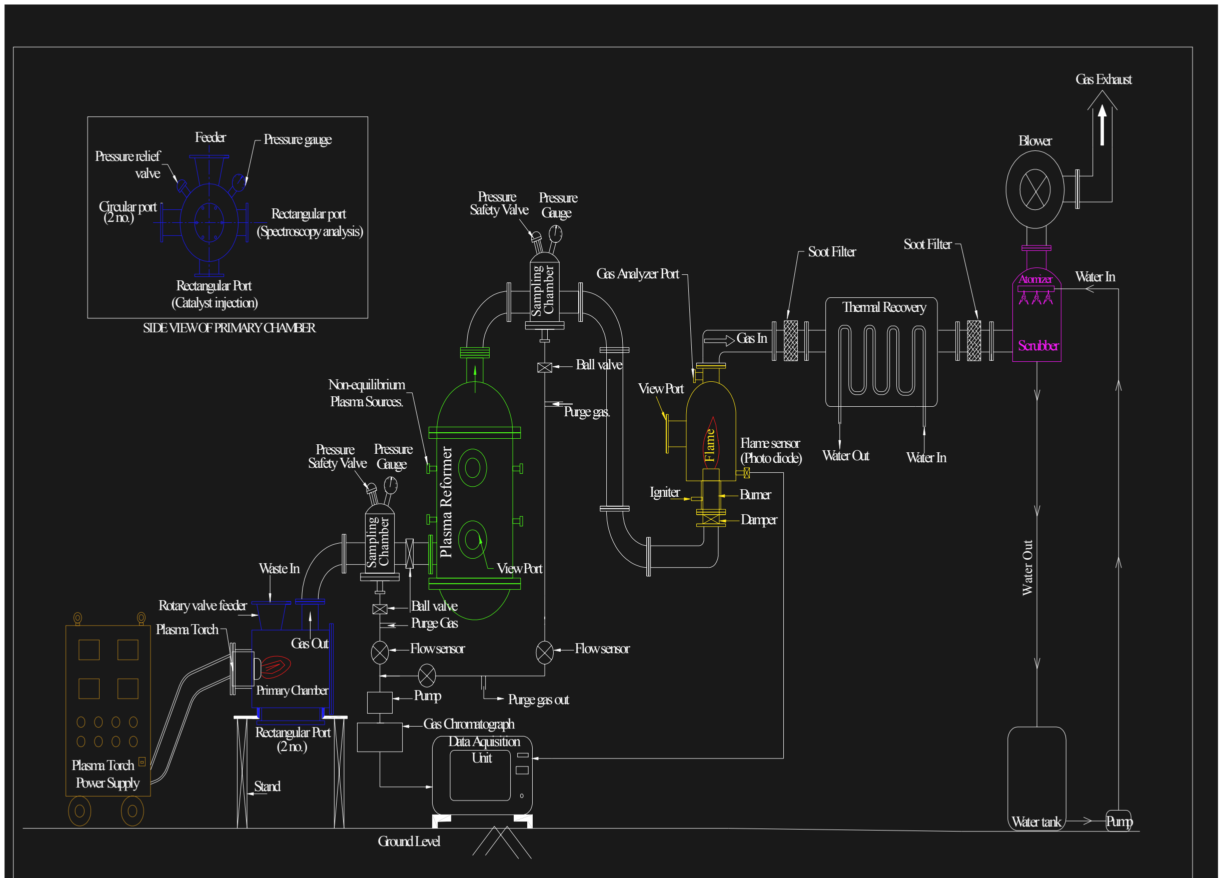
Polypropylene: 387 - 600^{0}C

Cellulose (Cotton): 300-700^{0}C

Cellulose: $C_6H_{10}O_5$ + Heat $\Rightarrow$ CH_4 + 2CO + $3H_2O$ + 3C

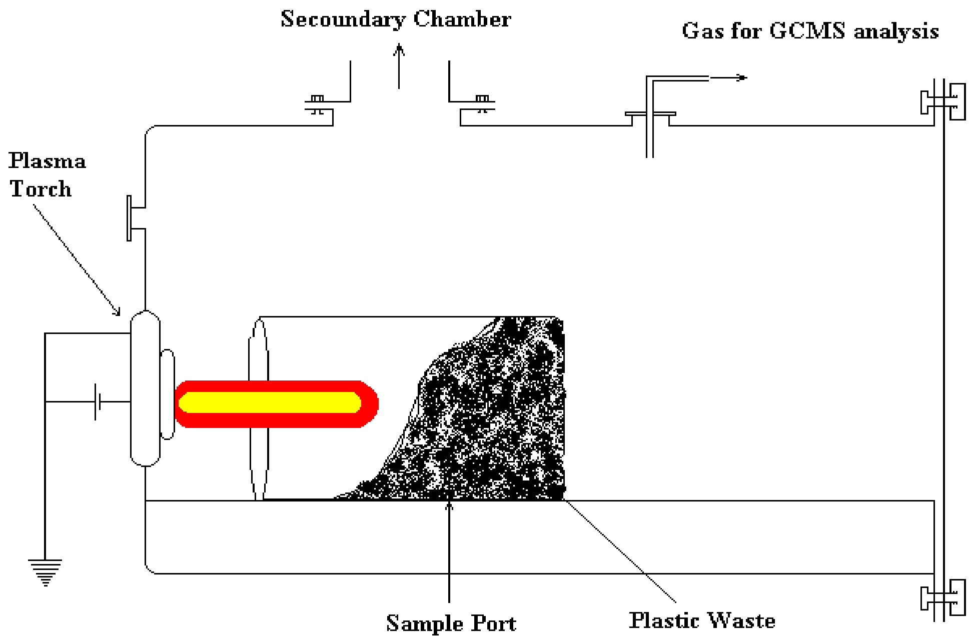
Polyethylene: $[-CH_2-CH_2-]_n$ + H_2O + Heat $\Rightarrow$ xCH_4 + yH_2 + zCO

Controlled experiments on simulated medical waste generated the basic data for design

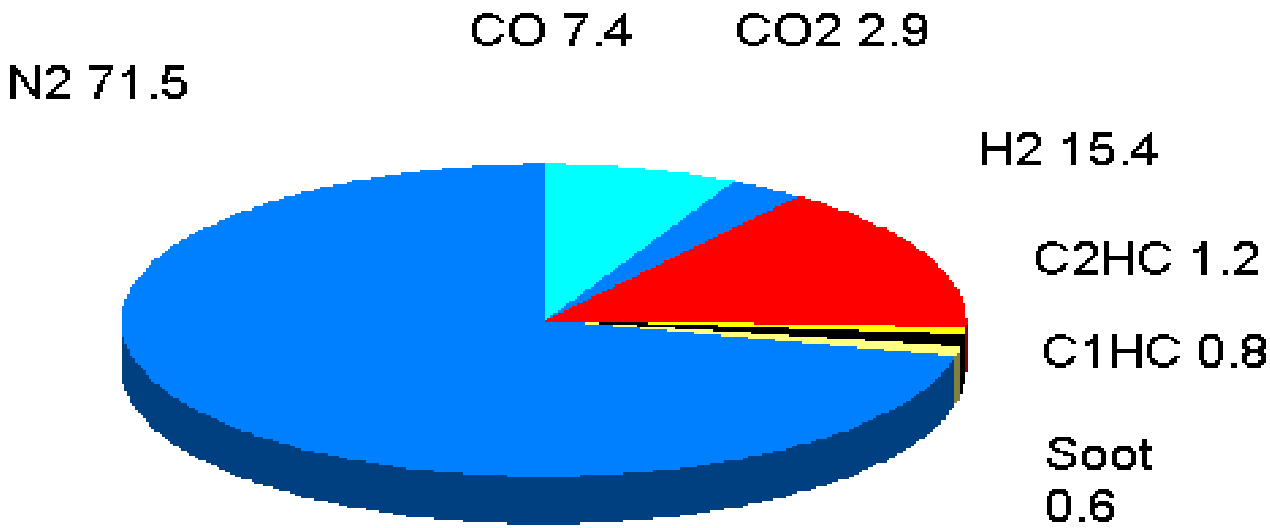


Schematic of Energy Recovery Experiment

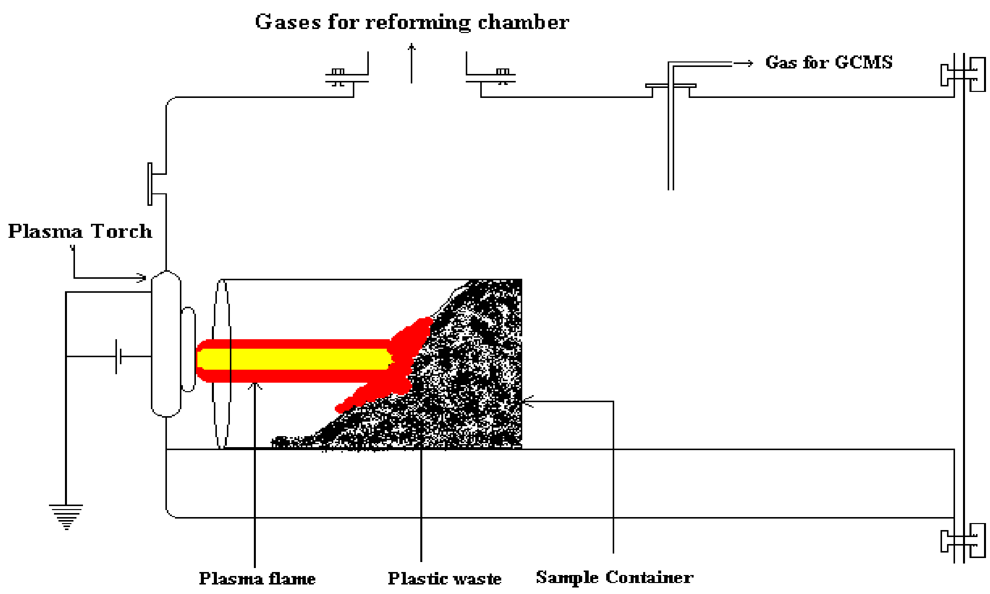
Slow pyrolysis produces heavy hydrocarbons and low amounts of hydrogen



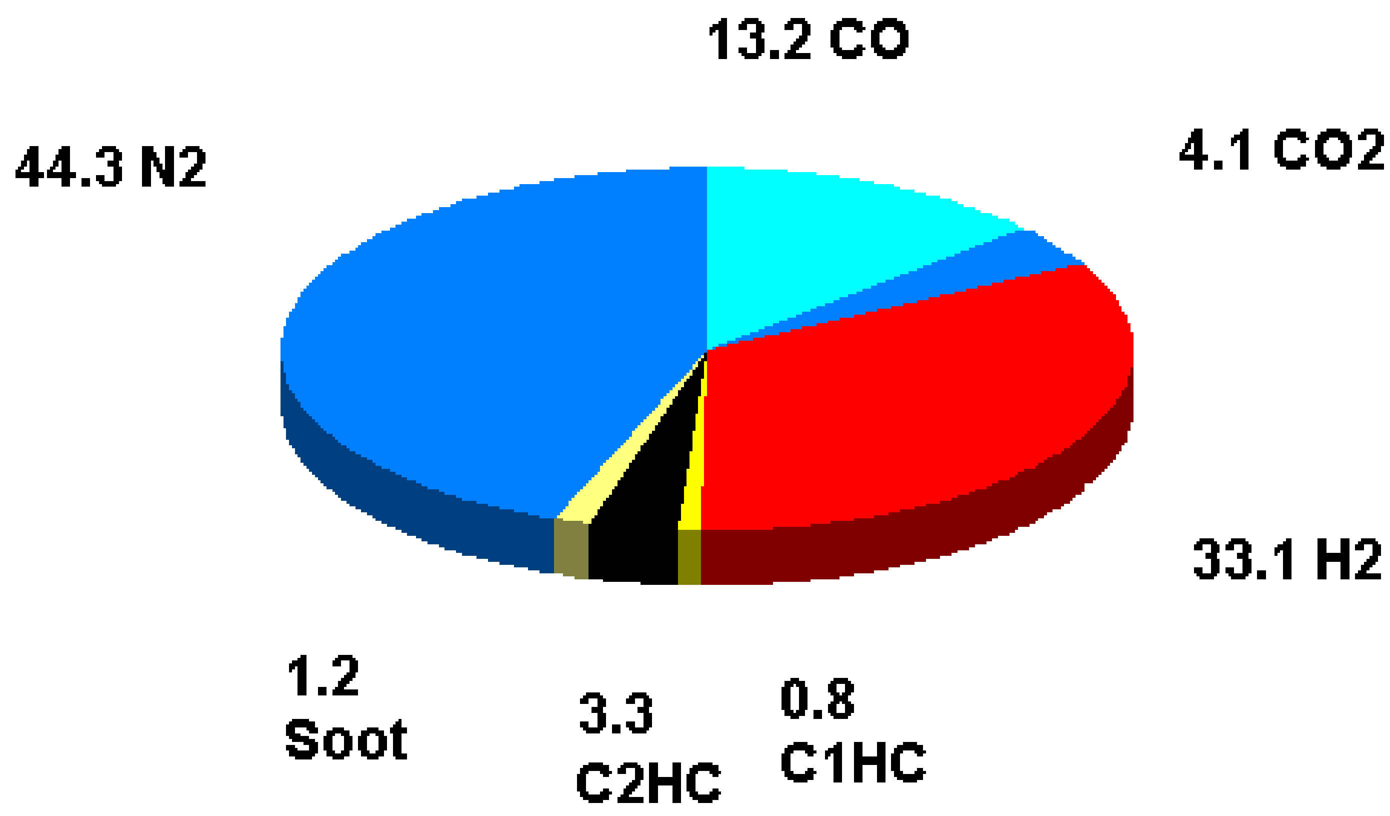
Composition of slow pyrolysis gases



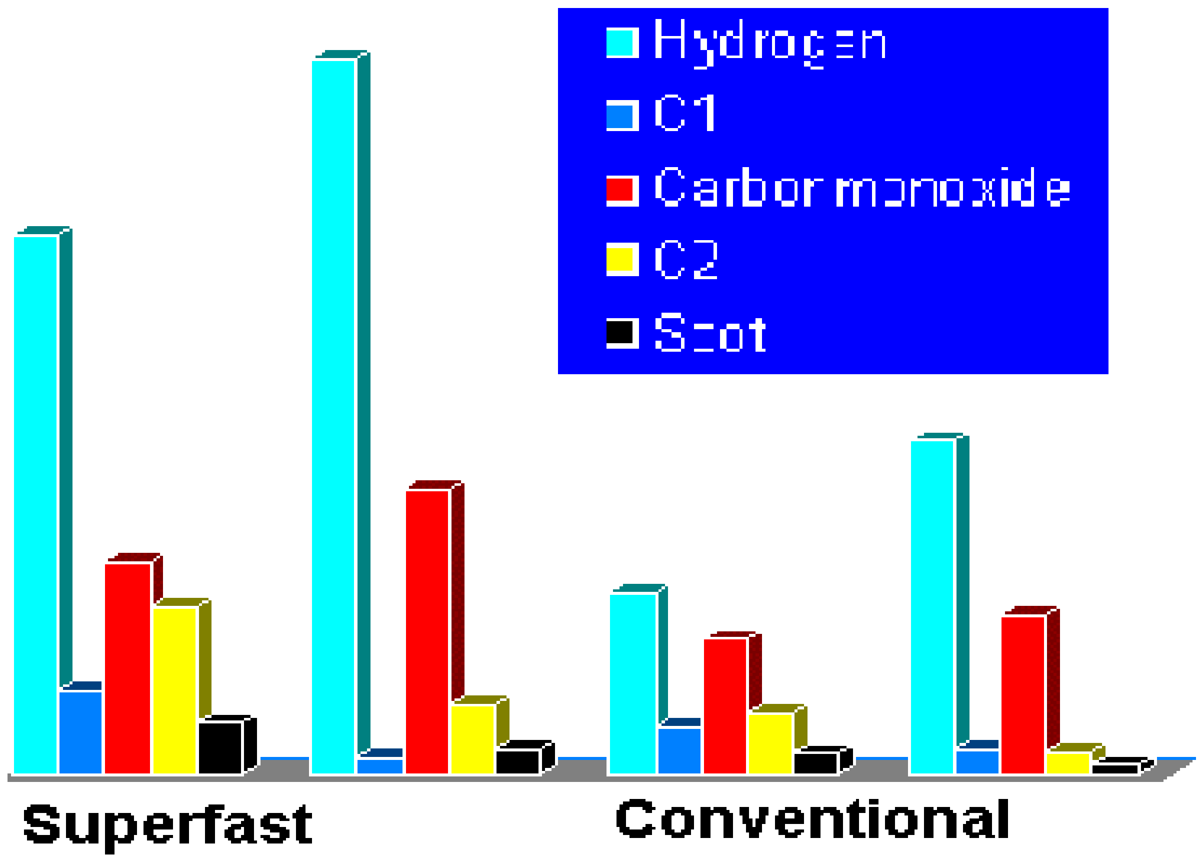
Fast pyrolysis exploits direct plasma-waste interaction improving H2/CO production



Fast Pyrolysis improves fraction of energy gases



Comparative advantage of fast pyrolysis to produce energy gases and reduce soot



On the road to commercialization, product definition is very important

- Technical issues
- Intellectual property issues
- Commercial viability concerns
- Regulatory norms

Technical issues in product definition

- Plasma Torch for 8 hour operation
- Non-standard waste composition
- Fast pyrolysis configuration
- High current power supply
- Load-lock waste feeder

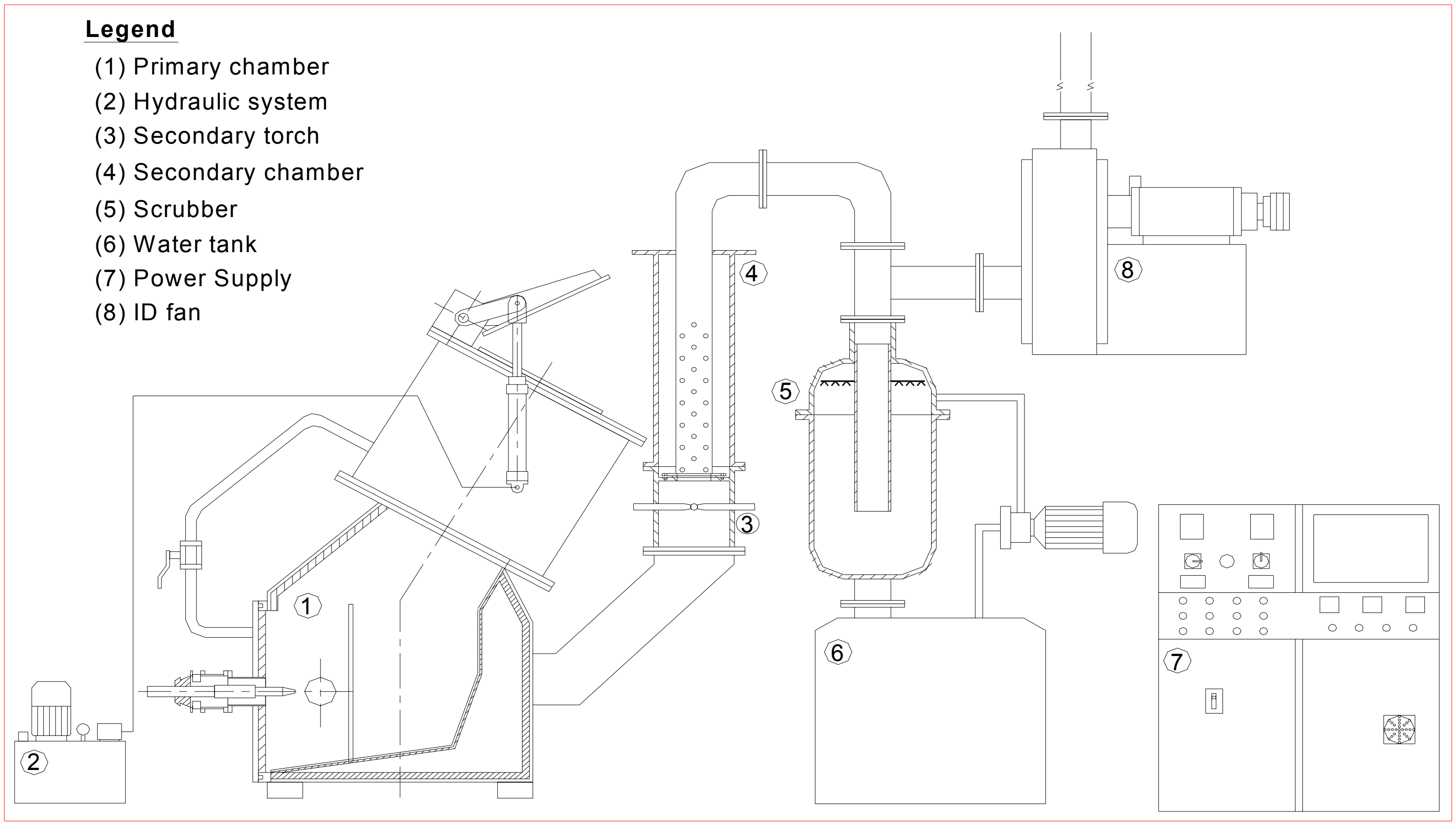
Commercial issues

- Torch with air or no gas feed
- Automated fail-safe operation
- Portable
- 20 Kg/Hour capacity
- operating cost ~ Rs. 12/Kg (25 cents)
- Capital cost ~ $ 25,000

Regulatory issues

- + 1100 degree in combustion chamber
- 800 degree in pyrolyser
- 2 Second residence time
- NO_x <
- CO <
- Hydrocarbons <

Pyrolysis System Concept



Development of a Torch with no Gas Injection

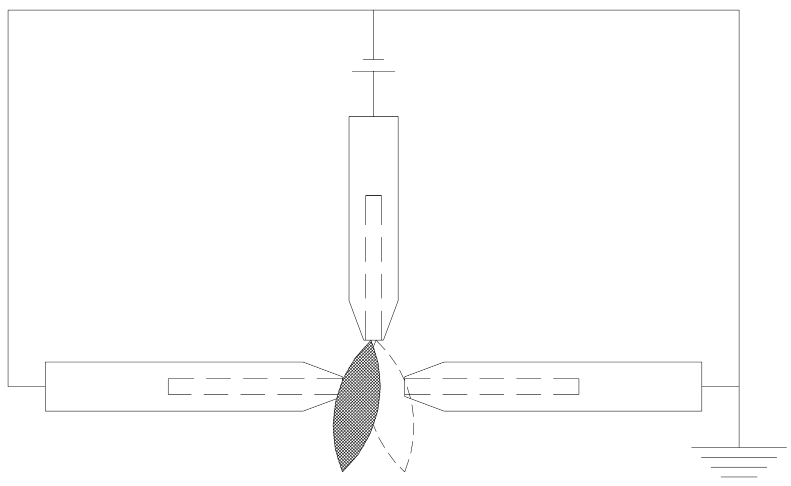


Fig.2 Typical Flame structure of Graphite Plasma Torch

spectroscopic diagnostics to characterize the torch plasma

- line width of $H\beta$ and $H\alpha$ lines for measuring density
- 1.62×10^{17} cm^{-3}

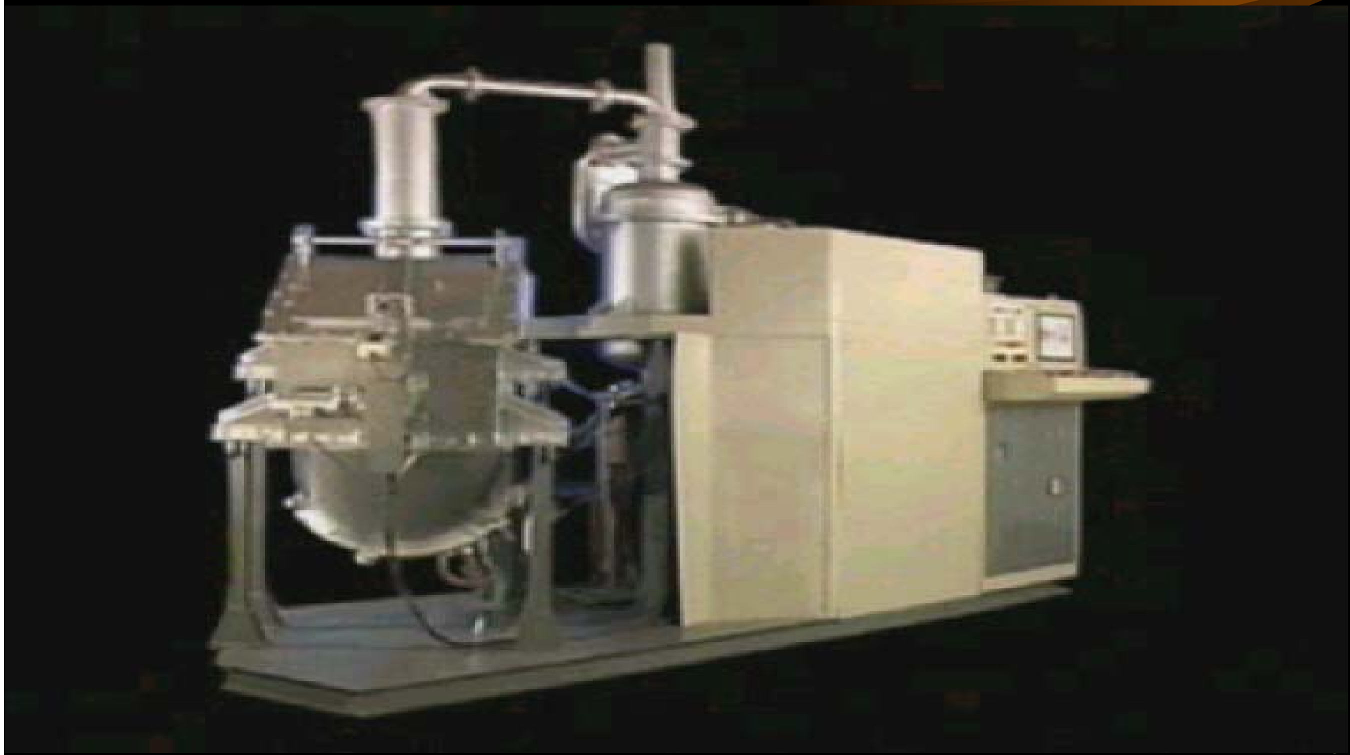
- LTE model: The intensities of five NII lines (3995, 4621, 4630, 5001 and 5005 A^{o})
- Cathode : 16000 ^{o}K
- Anode : 12000 ^{o}K
- Melt : 10000 ^{o}K

The Emitted Gases Meet the CPCB Norms

Emissions: Comparison with CPCB Norms

Gas	CPCB Limit ppm	Measured
CO	100	40-85
NOx	450	7 -2 5
SOx	50	1-20
Hydrocarbons	100	10 -95
HCl	50	--

Research Prototype



Under a DST initiative, demonstration systems for medical and plastic waste pyrolysis are being set up at dispersed locations

Energy recovery options: feasibility of using the product gas for direct fuelling of IC engines

N_2	45.03%
H_2	22.63%
CO	26.65%
CH_4	1.50%
CO_2	4.20%
Hydrocarbons	0.45%

- pyrolysis of 1 kg polyethylene can produce 3200 litres of 100% combustible gases which can generate 3 kWh energy