PLASMA
PROCESSING UPDATE

A newsletter from the

Facilitation Centre for Industrial Plasma Technologies
Institute for Plasma Research

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Contents

Editor's Note

Though it has got the potential to offer great opportunities for the graduate and postgraduate students to carry out basic research, plasma science is not so popular amongst the students, in India. However, the trend is changing of late, and certain universities and NITs have started offering specialized courses in plasma physics. Nevertheless, these institutes are lacking in facilities and expertise to offer the complimentary practical knowledge through carrying out lab scale experiments. In a significant move in this direction, recently FCIPT has signed an MOU with Delhi University (DU), to set up two laboratory scale plasma experimental systems at DU. Mr. R. S. Rane, explains in detail.

Mr. S. Kanojiya elaborates about the performance of the plasma nitriding system installed at Indo German Tool Room (IGTR), Ahmedabad. This system was funded by DST, New Delhi, and designed, developed and installed under the technical guidance of FCIPT. The objective is to allow the industry to take advantage of this advanced plasma surface treatment system as IGTR does job work for them. Efforts are on to install plasma nitriding systems in all the tool rooms across India.

An atmospheric pressure plasma processing unit, for treatment of 1 m wide fibres and fabric in a continuous mode, has been developed and successfully demonstrated at FCIPT. Ms. Nisha Chandwani explains the details of this system and its applications.

Editor : ***Alphonsa Joseph***
Co-editor : ***A. Satyaprasad***

Conference Presentations from FCIPT

Name of the Author	*Topic*	*Date*	*Place*	*Conference*
Mr. A. Satyaprasad	Deposition of Zinc coatings using Plasma Enhanced Jet Vapour Deposition	14-17, November 2009	Kolkata, West Bengal	NMD-ATM 2009
Mr. Kishor Kumar	Co-sputter Deposition Setup with three Magnetrons for depositing Nano-composite Coatings	14-17, November 2009	Kolkata, West Bengal	NMD-ATM 2009
Dr. S. Mukherjee	Plasma Surface Engineering	8-10, December 2009	NIT, Hamirpur, Himachal Pradesh	24th National Symposium on Plasma Science and Technology
Dr. S. K. Nema	Environment friendly disposal of solid organic waste using Plasma Pyrolysis Technology	8-10, December 2009	NIT, Hamirpur, Himachal Pradesh	24th National Symposium on Plasma Science and Technology
Dr. G. Ravi	Non-thermal Plasma Fuel Reforming and Cracking	8-10, December 2009	NIT, Hamirpur, Himachal Pradesh	24th National Symposium on Plasma Science and Technology
Ms. J. Alphonsa	Plasma Nitrocarburising Process for Corrosion resistance of Valves used in Steam Turbines	6-8, December 2009	Baroda, Gujarat	MICMEP 2009

About FCIPT

Facilitation Centre for Industrial Plasma Technologies

The Institute for Plasma Research (IPR) is exclusively devoted to research in plasma science, technology and applications. It has a broad charter to carry out experimental and theoretical research in plasma sciences with emphasis on the physics of magnetically confined plasmas and certain aspects of nonlinear phenomena. The institute also has a mandate to stimulate plasma research activities in the universities and to develop plasma-based technologies for the industries. It also contributes to the training of plasma physicists and technologists in the country. IPR has been declared as the domestic agency responsible in INDIA to design, build and deliver advanced systems to ITER (International Thermonuclear Experimental Reactor), to develop nuclear fusion as a viable long-term energy option.

The Facilitation Centre for Industrial Plasma Technologies (FCIPT) links the Institute with the Indian industries and commercially exploits the IPR's knowledgebase. FCIPT interacts closely with entrepreneurs through the phases of development, incubation, demonstration and delivery of technologies. Complete package of a broad spectrum of plasma-based industrial technologies and facilitation services is offered. Some of the notable achievements of FCIPT are: plasma nitriding of industrial components to increase wear resistance and hardness, coating of quartz-like films on brassware to inhibit oxidation and tarnishing, thermal plasma technologies for waste treatment, plasma processing for textile industries, deposition of TiN coatings to increase abrasion resistance, deposition of amorphous silicon coatings for anti-reflection properties, etc. The Centre has process development laboratories, jobshops and material characterisation facilities like Scanning Electron Microscope, X-ray Diffractometer, Microhardness testing facilities, which are open to users from industry, research establishments and universities.

This newsletter is designed to help you keep abreast with the developments in the important field of plasma assisted manufacturing and to look for new industrial opportunities. We would be very happy to have you write to us on ways of improving this service or visit us for further discussions.

Please visit our website: *http://www.plasmaindia.com* or *http://www.ipr.res.in/fcipt*

Development of Lab scale Glow Discharge Experimental Systems for Delhi University

Mr. R. S. Rane is a scientist at FCIPT, and is an expert in magnetron based PVD coatings.

Introduction

Plasma is the fourth state of matter and more than 99% of the universe is known to be present in this state. Plasma is highly exotic in nature and finds applications in various fields ranging from simple surface modification to nuclear fusion. The field of plasma offers excellent opportunities for the students, researchers, technologists to undertake interest in the basic research, and technology development. However, the plasma science has not been so popular in India, hitherto, so that it could become part of the graduate and post graduate curricula. Nonetheless, the scenario is changing of late, as the importance of the plasma science is being recognized by one and all, and even in India certain universities, NITs, and other educational institutes have started to introduce the academic courses on plasma physics. Nevertheless, the universities and institutes are lacking the facilities and expertise to offer the complimentary practical knowledge to the students by the way of carrying out small lab scale experiments pertaining to plasma physics.

In a significant move in this direction, a MOU was signed between FCIPT and Delhi University (DU), so that FCIPT will develop small lab scale experimental systems and devise a set of experiments which could be routinely carried out by M.Sc. level students. To start with, the experiments would be restricted to the study of glow discharge only, as it is relatively easy to create and diagnose these discharges.

Two experimental systems have been developed at FCIPT for this purpose. The first one is equipped with facilities to carry out the following experiments: To study a) Paschen curve, b) various regimes of glow discharge, c) normal-abnormal glow discharge transition characteristics, and d) striations in the glow discharge plasma. In the second system, experiments to measure the plasma properties like electron temperature, plasma density, plasma potential could be carried out using Langmuir probe. Other experiments like the study of ion acoustic waves, anode glow etc. can also be carried out in the same set up. The description of the experimental systems and a few example experiments are given below.

Experimental System 1

A schematic picture of the first experimental system is shown in figure 1. It is a cylindrical stainless steel (SS) chamber of approximately 20 cm diameter and 50 cm length. It is connected with a rotary pump of 350 lpm capacity. As it is clearly seen, there are two disc electrodes (cathode and anode) which are connected to a floating dc power source. The operating parameters like pressure (p), inter electrode distance (d), applied voltage (V), discharge current (I) can be varied to study the various characteristics of the glow discharge plasma. The table 1 gives the list of variable operating parameters and the range in which they can be varied during the experiments.

Table 1 : The list of variable operating parameters and their ranges

Sr.No	Parameter	Range
1	Electrode dimensions (cathode & Anode)	10 cm diameter
2	Inter electrode gap	1 cm to 40 cm
3	Pressure	0.05 to 10 mbar
4	Voltage	20 to 1000 V
5	Discharge Current	Max. up to 1A
6	Current limiting resistance	20 to 1000 Ω

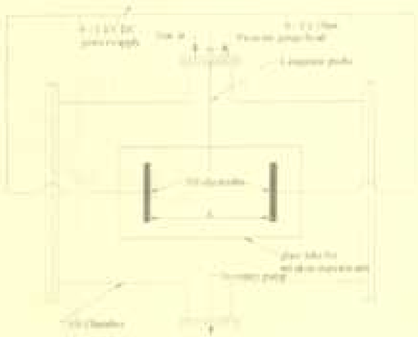

Fig. 1: Schematic of the experimental system 1

The following are the details of a few example experiments that could be carried out in this system.

The objective of the first experiment is to study the Paschen curve. The Paschen curve gives important information regarding the dependency of breakdown voltage (V_b), for a given gas, on the product of the operating pressure (p) and the distance between the electrodes (d). This is a simple experiment and allows the students to get a feel of producing the glow discharge plasma, the breakdown voltage etc. The experimental procedure is as follows.

The experimental system is evacuated down to a base pressure of 5 X 10^{-3} mbar. Then the required operating pressure (ranging from 0.05-10 mbar) is obtained by introducing the appropriate gas into the system. The inter electrode distance is set at a particular value. Then the voltage is applied across the electrodes, using a variable DC power source, and the voltage is slowly increased. The students have to note down the voltage at which the breakdown of the gas occurs, which can be seen by the presence of a glow across the electrodes. The same exercise should be repeated by changing the inter electrode distance (d), at the same pressure (p). The above set of experiments should be repeated at different pressures. After obtaining sufficient number of points, a graph can be plotted between breakdown voltage and the product of *p* and *d*, which is the Paschen curve for that particular gas.

Figure 2 shows the Paschen curve for air, and it is plotted with the help of the data points generated by carrying out the experiments in the above mentioned experimental setup.

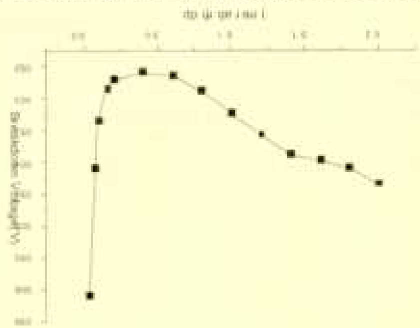

Fig. 2: Paschen curve for air

The above setup can also be used to carry out the experiments related to the study of striations in the glow discharge plasma. Striations are those alternative bright and dark regions formed in the positive column of the glow discharge, along the direction of the discharge current. Striations can be seen, in a limited range of discharge current values, operating pressures, tube radii etc. for a given gas. Creation of striations, the amplitude, frequency and wave length of the luminosity oscillations, velocity of the striation propagation depend on the operating parameters like discharge current, operating pressure, type of gas used, and tube radii. To see under which circumstances these striations form, and to study the effect of operating parameters on the number and width of dark and bright regions of the striations is part of the experiment. A typical photograph of the striations, generated in the above mentioned experimental system is shown in figure 3.

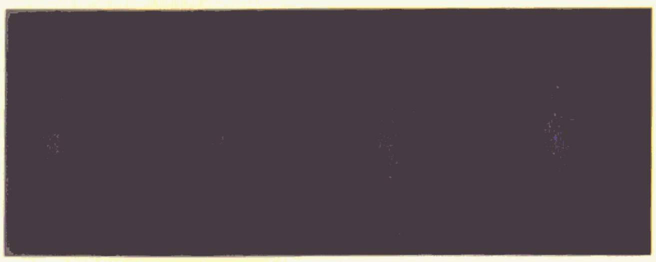

Fig. 3: A photograph of typical striations

Further, the above system can also be used to carry out the experiments concerned with the study of I-V characteristics of the glow discharge plasma which includes (a) normal glow to abnormal glow transition, (b) finding out various regions of the plotted I-V graph viz. Townsend dark region, normal glow region, abnormal glow region etc.

Experimental System 2

The schematic of the second experimental system is shown in figure 4. This setup also uses a cylindrical SS chamber, with 30 cm diameter and 50 cm length. However this system is connected with a combination of diffusion and rotary pumps to obtain the necessary low base pressures. A gas dosing valve is used to control the gas flow in to the system and by that way to control the operating pressure.

This setup is meant for carrying out the experiments with objectives of (a) estimating the plasma parameters like plasma density, electron temperature, floating potential, plasma potential etc. in a low density glow-discharge plasma, (b) understanding the propagation properties of ion acoustic waves in low pressure plasma etc. These experiments would give accurate results if they are carried out at low operating pressures like of the order of 10^{-4} to 10^{-3} mbar. However it is very difficult to generate plasma at such low pressures with conventional techniques. Hence a hot cathode filament method is used to generate the plasma. As shown in figure 4, four numbers of wire type tungsten filaments are held across two strips, bent in the form of a ring. These filaments act as hot cathodes (source of electrons). A DC power supply is used to apply the power across these filament resistors. These filaments

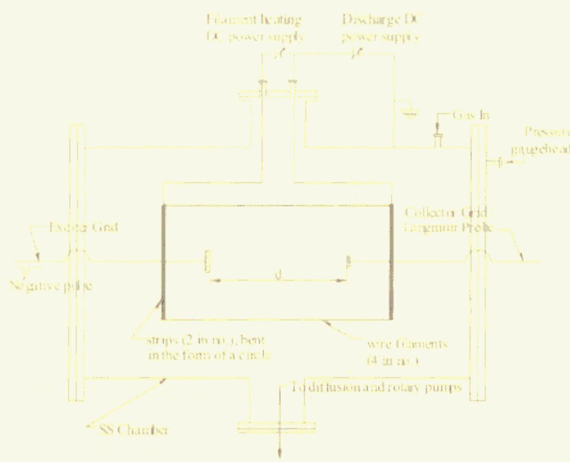

Fig. 4: Schematic of the experimental system 2

start emitting electrons, due to thermionic emission, once their surfaces reach very high temperatures. These electrons are accelerated towards the wall of the ss chamber (anode), as the chamber is maintained positive (and grounded) with respect to the filament setup. These accelerated electrons ionize the background gas and generate plasma.

As shown in figure 4, the system has a provision to introduce diagnostic tools like Langmuir probe, collector and exciter grids/plates, coaxially into the hot cathode filament setup, where the plasma is generated. These tools can be moved axially to diagnose the plasma at various points. The following are the details of typical experiments that could be carried out in this system.

The objective of the first experiment is to understand how to estimate the plasma parameters like plasma density, electron temperature, plasma potential, floating potential etc. using a single Langmuir probe. The experimental procedure is as follows. The system is evacuated down to a base pressure of 5 X 10^{5} mbar. Argon gas is then introduced into the system to raise the pressure to 2 X 10^{3} mbar. The filaments are heated by putting on the 'filament heating DC power supply' (typically 10 V, 20 A). The discharge power supply is now switched on (typically 100 V, and 0.5 A) and the plasma is generated. Experimental parameters such as operating pressure, discharge voltage and discharge current are kept constant – in a given experiment – and the values are noted down. The Langmuir probe is now externally biased to collect current from the plasma. The bias voltage is varied from -60 V to +40 V (with respect to ground) using a ramp circuit, and the complete I-V characteristics of the plasma are traced out. Ion saturation current and floating potential are directly deduced from the I-V plot, whereas the parameters like electron temperature T_e, plasma density n_e, plasma potential are calculated through data analysis of the I-V plot. A typical I-V graph plotted using the above experimental setup is shown in figure 5. This I-V graph was obtained from an experiment in which Argon was used as the background gas, the operating pressure was maintained at 2 X 10^{3} mbar, and the discharge voltage and discharge current were 90 V, and 0.04 A respectively. The ion saturation current, and the floating potential are figured out to be 0.2 X 10^{4} A, and -3 V respectively. Further analysis of the plot has shown that the plasma density, plasma potential and the electron temperature are approximately 3-4 X 10^{15} /cc, 3-4 V, and 1.2 eV respectively.

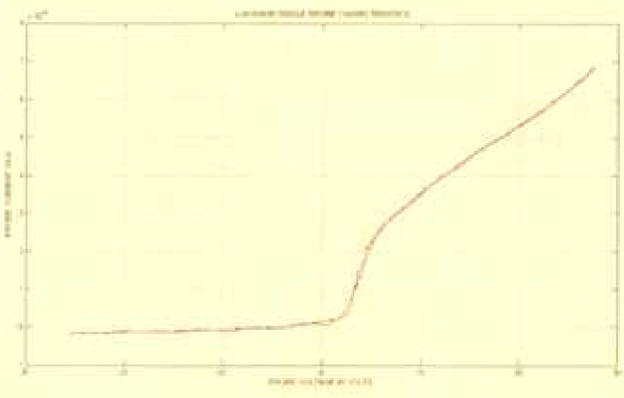

Fig. 5: A typical plot of I-V characteristics of a Langmuir Probe in the glow discharge

The objective of the second experiment is to understand the propagation of the ion acoustic waves in low pressure glow discharge plasma using time of flight techniques. The exciter and collective grids/plates are used as diagnostic tools in this experiment. The experimental procedure is same as the one explained in experiment 1, till the plasma production. As shown in figure 4, the exciter and collector grids/plates are facing each other and the distance between them is kept at a pre-decided value. Electrostatic perturbations will be excited in the plasma by applying a negative pulse voltage using a simple low frequency signal generator to a metallic exciter grid, immersed in the plasma and detecting the perturbations using a receiver plate (collector) kept at a distance ***d*** away from the exciter grid. Waveforms of exciter and receiver signals have to be recorded. Time (*t*) taken for the arrival of oscillations at receiver plate can be measured, and the velocity of the propagating oscillations can be calculated using $v = d/t$, clearly bringing out the travelling wave nature of the oscillations. Experiments can be performed with two different gases, such as, Argon and Helium and dispersion relation for ion acoustic waves, [illegible] is solved to bring out the dependency of velocity on ion mass.

Performance Evaluation of Plasma Nitriding System at Indo German Tool Room

Mr. Shivkumar Kanojia is a Graduate Engineer in Metallurgy from M. S. University of Baroda, and has 22 years of experience in Heat Treatment, Material Testing and in allied fields. Presently working as In-Charge of Heat Treatment Section with Indo German Tool Room, Ahmedabad. He is also a facu lty for the subject of Material Technology and Heat Treatment in the same institute.

Plastic processing is considered as one of the fastest emerging segments of manufacturing industries. In plastic processing industry, wear of the machinery components has been one of the persistent problems for years. The most critical components that are subjected to wear during plastic processing are injection moulds, plastic moulds, screws and barrels. Also, the contact surfaces that are of highest concern includes ejector plates, support column rails, gates, leader pins, hot runners, surfaces directly opposite to the gate and cavity and core sets. Moving pieces such as valve gates, shut-off nozzle, threaded cores, ejector pins, core pulls and slides may present problems of galling or abrasive wear. The life of parts like slides and ejector pins is becoming a bigger issue. These concerns have led to the development of materials with such surface characteristics as low surface energy and low coefficient of friction. As a result, molders are realizing that a proper coating for these components is necessary to achieve productivity gains and higher quality parts. Service life of these components can be improved significantly by carefully modifying the microstructures of the material to give high surface hardness and tough core.

Plasma nitriding process is widely accepted by the plastic industry, as it offers high surface hardness and provides thick nitride layers. Plasma Nitriding is a case hardening technique used on a variety of mould steels and is performed in a vacuum chamber at temperatures from 450 to 580° C. Most pre-hardened steels have hardness in the range of 28-40 HRC, and these steels are ideal for the fabrication of the above mentioned parts. It is so because; this hardness range is excellent for machining. However, these values are not enough, on the surface, for the extended mould life. The hardness values on these surfaces could be increased by case-hardening them through plasma nitriding. The results of the plasma nitriding can be evaluated by nitriding a test coupon of like material, and then measuring the surface hardness and the case depth. The increased haredness is due to the presence of alloying elements like chromium, molybdenum, vanadium and aluminum, in the pre-hardened steel, which form stable nitrides. Further, plasma nitriding also results in a surface with low coefficient of friction, to allow the parts to be easily released from the injection moulds and other components. It also imparts excellent corrosion resistance properties. Certain resins like PVC, result in abrasive wear during operation, and this can also be prevented by forming a hard layer by plasma nitriding process.

Indo German Tool Room (IGTR) has recently installed a Plasma Nitriding system (shown in figure 1) for surface hardening the components from various industries in and around Gujarat. This system was funded by Department of Science and Technology (DST), New Delhi and technically supported by Facilitation Center for Industrial Plasma Technologies (FCIPT) and Gujarat Council of Science and Technology (GUJCOST). This system can nitride components having sizes of up to 700 mm height and 800 mm diameter. The system is installed at IGTR, primarily to provide service to the nearby industries, by offering them to use this modern technique of surface hardening in this competitive era of globalization.

IGTR, Ahmedabad is an organization, set up by a bilateral agreement between government of India and government of Federal Republic of Germany with cooperation from the state government of Gujarat, with the aim of providing services to the industries with the help of latest technologies, and is also engaged in the area of training in tool and die making, CAD/CAM and CNC technology.

Fig. 1: Photograph of the plasma nitriding system installed at IGTR, Ahmedabad

During the tenure of about 15 years of tool making at IGTR, Ahmedabad, various molds were manufactured, where plasma nitriding was applied to mold components and these molds were running satisfactorily. Following are the names of some plastic components, fabricated using injection molding process, and the mold parts were plasma nitrided.

- Starter Seat Body
- MCB Switches
- Domestic switches
- Pin socket
- Fan regulators
- Disposable Injection syringe
- Tooth paste cap
- Mineral water bottle cap
- Rivet button
- Connector
- Mirror angle
- Roller body
- Plastic container
- Coaster set
- Tumbler
- Drip cap
- Gears, etc.

Apart from plastic industries, other industries like textile industries, automobile industries, electrical/electronic industries, machine manufacturers have also shown their interest for plasma nitriding. As of now, more than 40 different industries have benefitted from this process.

Not only the industries, but majority of students from universities and colleges have also taken training and have been exposed to this technology. IGTR continues to cater to all the industries by providing quality surface hardened components, thereby disseminating the environment friendly plasma nitriding technology.

Development of Industrial scale non-thermal Aatmospheric Pressure Air Plasma Processing System

Ms. Nisha Chandwani is a Scietific Assistant at FCIPT, and is working on atmospheric pressure plasma processing.

Introduction:

Surface treatment of woven fabric and

non woven fibers is necessary to improve, dye-uptake, hydrophilicity and adhesion characteristics. Traditional liquid chemical processes used by the textile industry involve high consumption and pollution of water resources. Further, waste water processing costs are high and drying the wetted fibers is energy, time and cost-intensive. Therefore, the textile industry has a great interest in alternative dry processes, such as plasma based processing techniques for the surface treatment of textile materials.

The textile industry requires such a process, which can be integrated in a continuous production or finishing line. Earlier, due to the limitations concerned with a vacuum based plasma processing system, an appropriate system for the textile industry could not be designed. However, this problem is now solved with the development of a non-thermal atmospheric pressure plasma processing system. The dielectric barrier discharge (DBD), is one of the cold plasma sources which can generate non thermal plasma at atmospheric pressure. Commonly, a homogenous DBD can be obtained under certain conditions using Helium and other gas mixtures. However, Helium – being expensive – is not suitable for mass production in textile industry.

In order to solve this problem, FCIPT has developed a unique atmospheric pressure air plasma processing system, which uses atmospheric air as the plasmagen gas. A prototype system was developed at FCIPT, and was successfully installed, commissioned and synchronized with roller worster card at M/s Shivaco Weavers, Kullu, Himachal Pradesh. This system is being used to surface treat the angora wool, in order to improve its surface gripping properties.

Atmospheric pressure air plasma processing system at FCIPT

Since the system that was installed at Kullu is only a prototype, and as the results obtained are encouraging, at FCIPT efforts were made to scale up the prototype into an industrial scale system. The efforts were paid off and the system was developed at FCIPT and it can be used for the surface modification of 1 m wide fibers/web/fabric in a continuous mode.

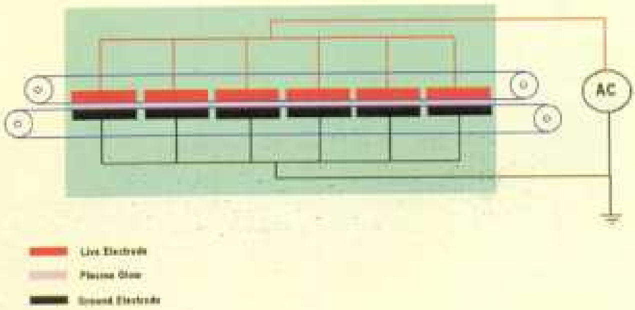

Fig. 1: Schematic diagram of industrial scale atmospheric pressure plasma processing system

The schematic of the atmospheric pressure air plasma processing system is shown in figure 1. It is driven by a high voltage AC power supply with a rated capacity of 10 kW. As shown in figure, the plasma output of this unit is distributed over 6 pairs of specially designed electrodes of 1 m length and 0.5 m breadth. The working surfaces of all the electrodes were affixed with a thin dielectric sheet. The separation between the electrodes is kept between 3 and 6 mm. The system is equipped with a pair of conveyor belts and a motor drive. The sample to be treated is placed in between the pair of conveyor belts, and the speed of the belt can be optimized in concurrence with the other operating parameters, as per the requirements.

The photograph of the developed system is shown in figure 2. The overall dimensions of the system i.e. 4 m length, 1.5 m width and 0.8 m height, makes it a suitable system for the textile industry. A special feature of this system is that it can be used in-line, i.e. can be integrated with the existing process workflow. Further, it is also a user friendly system and requires only air and electric power as consumables.

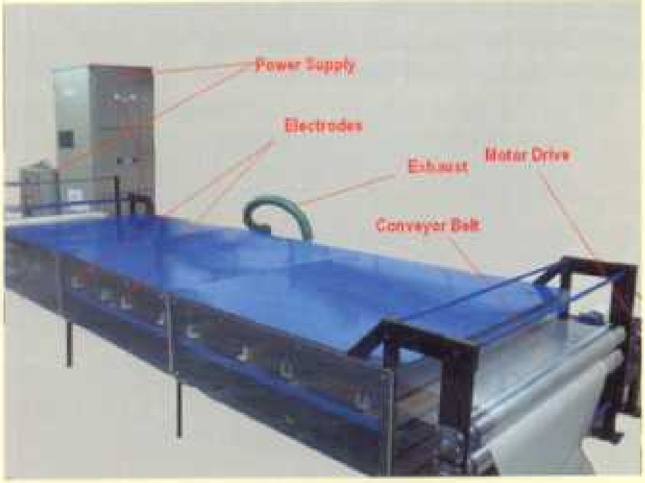

Fig. 2: Photograph of the industrial scale atmospheric pressure plasma processing system

The functioning of the system has been successfully demonstrated at FCIPT, IPR. The angora wool was treated in the system, and the results obtained are as good as those obtained in the prototype system.

At FCIPT, we strongly believe that there is a lot of scope for the eco-friendly plasma processing techniques to play a vital role in the textile industry. Hence, we are working out a plan in conjunction with textile industries, textile machinery manufacturers and textile and plasma research organizations to see the possibility of getting the textile industry benefitted from the user friendly plasma based technologies. In this direction, steps have already been taken to form a national level consortium, the details of which are provided elsewhere in the same issue.

OTHER NEWS

National Workshop on Eco-friendly Plasma Applications in Textile – A Brief note

A National Workshop on Eco-friendly Plasma Applications in Textile, sponsored by Industries Commissionerate, Government of Gujarat and IPR (Institute of Plasma Research) was conducted at the IPR campus in association with Plasma Science Society of India (PSSI) on 10^{th} and 11^{th} November 2009. The objective of the workshop was to deliberate on possible Plasma applications in textile in different fibre sectors and draw up a Plan for National Plasma Textile Program with the formation of a consortium. The consortium formation as well as the consortium itself will have active participation of all players in the area – textile industries, textile machinery manufacturers and textile and plasma research organizations.

Participation in the workshop was by invitation only and consisted of experts (numbering around 50) from the field of plasma (IPR, IIT-Delhi), textile research associations (BTRA, CSTRI, NITRA, SASMIRA, NITRA, MANTRA, WRA), academic institutes like PDPU, DKTE, MSU etc. as well as top textile industrialists from Reliance Industries, Raymond Ltd., Arvind Mills, Global Pacific and Prashant Group. Delegates from Government agencies like Industries Commissioner, Govt. of Gujarat, TIFAC (DST) also participated and gave valuable inputs regarding the framing of a National Programme on plasma applications in textile and how to go about it.

The two day workshop was inaugurated by Shri. Sujit Gulati, IAS, Industries Commissioner, Government of Gujarat and others on the dias included Prof. P. K. Kaw, Director, IPR, Shri. Anand Parekh, President, Textile division, Reliance Industries, and Prof. P. K. Barhai, President, PSSI. The two day meet consisted of presentations under different sessions like Plasma applications in textile (given by R&D centres), views from textile industries (given by textile industrialists), views from textile machinery manufacturers. The problems faced by the industry and their expectations from research organizations were put forth by the industrial units. Industry needs were broadly on three points : Value addition to the textile products, Eco-friendly processes, and Energy/Cost saving mechanisms.

It was realized by all that such a National Programme should culminate in the formation of a consortium which will consist of textile industries, Government agencies, textile research associations and academia. An exhaustive session on deliberations about the consortium formation took place and a core team formed to draft a document on the status of textile research both in India and abroad as well as formulate guidelines with inputs from CEOs of textile industries. Finally, a proposal for the formation of consortium will be submitted to TIFAC, DST in the coming months. A follow up meeting is scheduled to be held later this month at IIT Delhi to proceed with the status report preparation and also formulate finer aspects of the consortium formation.

Photo 1: Release of the Proceedings booklet during the inaugural function

Photo 2: Prof. P. K. Kaw lighting the lamp and Inaugurating the Workshop

Installation of a Lab scale Plasma Glow-Discharge System at STAS, Kottayam, Kerala

Facilitation Centre for Industrial Plasma Technologies (FCIPT) has commissioned a lab scale plasma glow discharge system at School of Technology and Applied Sciences (STAS) at M. G. University, Kottayam, Kerala. The photograph of the system is shown in figure1. This system is equipped with a plasma reactor of 300 mm diameter and 300 mm height, and a 5 kW pulsed DC power supply. A project team, from FCIPT, lead by Mrs. Keena Kalaria, has successfully installed and commissioned the system at STAS, Kottayam in August 2009. This system will be used by the students of M. G. University for doing some basic research work on plasma surface engineering of different types of steels.

Fig. 1 : Photograph of the plasma glow-discharge system installed at STAS, Kottayam, Kerala

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