PLASMA PROCESSING UPDATE

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Facilitation Centre for Industrial Plasma Technologies,
Institute for Plasma Research

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Contents

Editor's note

Plasma nitrocarburising, a variant of plasma nitriding process has been used to improve both wear and corrosion properties of steels. Ms. Alphonsa Joseph emphasis on the benefits of this process when used on control valves.

Plasma pyrolysis is mostly used for safe disposal and energy recovery of organic waste. Since this technology converts electrical energy into heat efficiently, it has been used to pyrolyse petroleum waste to get valuable by-products like syn gas and other lighter gases. This work was done in collaboration with M/s BPCL, Noida and Mr. Adam Sanghariyat discusses about the results.

Mr. Nirav Jamnapara cites many applications of aluminized coating and presents some results of plasma assisted aluminized coating experiment carried out in FCIPT.

Editor: Dr. S. Mukherjee
Co-Editor: Alphonsa Joseph

Conference presentations from FCIPT

Name of the author	Topic	Date	Place	Conference
Ms. Alphonsa Joseph	Comparison of Corrosion Resistance Properties after PN and PNC Process.	February 2012	IIT, Mumbai	ENGGCOAT-2012
Ms. Alphonsa Joseph	Low Pressure Plasma Technologies For Industrial Applications.	March 2012	BESU, Calcutta	SEMA-2012
Dr. Mukesh Ranjan	Plasmonic coupling in nanoparticles arrays.	March 2012	S. P. University	CMMP-2012
Dr. Mukesh Ranjan	Plasmonics for plasmonic solar cell.	March 2012	Shibpur, Kolkata.	DST workshop on Plasmonics solar cell.
Dr. Mukesh Ranjan	Plasma surface Engineering possible applications in harnessing solar energy.	March 2012	Bhavnagar, Gujarat	CSMCRI 2012
Dr. C. Balasubramanian	Thermal plasma process for synthesis of nano aluminium tungstate (poster presentation).	February 2012	Kochi	International Workshop on Nanotechnology in solar and energy storage applications
Dr. Suryakant B. Gupta	An Overview of Spacecraft charging research in India: Spacecraft Plasma Interaction Experiments	Jan 2012	Kitakyushu, Japan	SCTC-2012
Dr. Suryakant B. Gupta	An emerging role of plasma technology in biological sciences	Jan 2012	Nagoya University	Guest lecture
Dr. Suryakant B. Gupta	ISO design overview of SPIX-II system for Spacecraft ESD experiments	February 2012	Albuquerque, USA	Guest Lecture
Dr. S. Suryakant B. Gupta	Spacecraft Plasma Interaction eXperiment (SPIX): Current status and future activities	February 2012	California, USA	Guest Lecture
Dr. S. Nema	Surface modification of Polymers using Non-Thermal Plasmas	February 2012	CIPET, Ahmedabad	APM-2012
Dr. S. Nema	Surface modification of Polymers using Non-Thermal Plasmas	March 2012	P.G college of Science	NCAP -202

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 and 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 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 important areas in which FCIPT has been working on include Plasma Surface Engineering, Plasma Pyrolysis/ Gasification/ Energy Recovery, Plasma Diagnostics, Plasma Based Nano Patterning and Nano Synthesis, Textile Engineering, Solar Cell Development, etc. The Centre has process development laboratories, jobshops and advanced material characterisation facilities like Scanning Electron Microscopy, Microhardness Testing facilities, which are open to users from industry, research establishments and universities. For further information, please visit our website.

This newsletter is designed to update the readers with the latest developments in the important field of plasma processing and plasma based technology development and to look for new industrial opportunities.

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

Plasma Nitrocarburizing process for improving the corrosion resistance of control valves

Ms. Alphonsa Joseph

Control valves play a central role in the control and optimal performance of a myriad of flow processes in oil, gas and power industries. In “severe service” applications, control valves are equally crucial for safely dissipating high process fluid energy levels to avoid valve and piping damage from acoustic noise, vibration, cavitation and erosion. Two most common problems of wear and corrosion have been attacking these control valves for many decades. Solutions have been adopted by using high strength and corrosion resistant material like austenitic chromium-nickel steels (e.g. SS316). Since these steels have low hardness values it is necessary to produce high hardness values. In the present study an attempt has been made to improve both wear and corrosion resistance of materials used in making control valves by using plasma nitrocarburising process.

Plasma nitrocarburising process was carried out in the plasma nitrocarburising system present in FCIPT using optimized process parameters. After plasma nitrocarburising it was observed that there was an increase in surface hardness from 288 HV0.1 to 753 HV0.1. This increase in hardness is due to carbon-nitrogen incorporation in to the surface of these steels

The X-ray Diffraction results indicate that there is presence of expanded carbon nitrogen saturated austenite phase. This phase is responsible for improvement in corrosion resistance properties. With increase in processing time chromium nitrides are formed which reduce the corrosion resistance properties of the steel. These results were reflected after carrying out the corrosion studies on untreated and treated austenitic SS 316 stainless steel samples using potentiodynamic and salt spray tests.

In order to understand the corrosion behaviour of the control valves used in steam turbines which are exposed to marine environment, two electrolytes were selected. They are 3.5% NaCl solution and tapwater. The tap water has a TDS value of 600ppm, COD of 70mg O_2/ltr and conductivity of 0.75mohms. Figure 1 shows current density versus voltage for both treated and untreated samples of AISI 316 in 3.5%NaCl and tapwater.

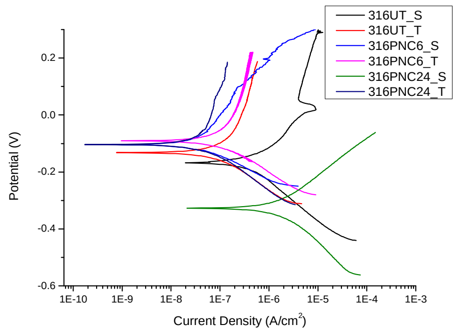


Fig.1 : Polarization curves for untreated and treated AISI 316 austenitic stainless steels tested in 3.5%NaCl and tapwater solutions.

Table 1: Electrochemical results of austenitic stainless steels tested in 3.5%NaCl and tapwater solutions.

Material	**Treatment**	**Ecorr (mV)**	**(Icorr) (μA/cm^2)**	**Corrosion rate (mpy)**
AISI 316 3.5% NaCl	Untreated	-168	0.705	0.113
	Treated for 6 hrs	-104	0.040	0.006
	Treated for 24 hrs	-327	1.96	1.141
AISI 316 Tap water	Untreated	-132	0.269	0.043
	Treated for 6 hrs	-90.60	0.163	0.026
	Treated for 24 hrs	-103	0.087	0.051

The polarization curves and electrochemical results shown in Figure 1 and Table 1 indicate that the corrosion resistance is better for samples treated for 6 hours compared to samples treated with 24 hours. This improvement is due to the presence of expanded carbon-nitrogen austenite phase. After processing for longer duration, the expanded austenite tends to dissociate in to chromium nitrides and ferrite phase along with iron nitrides. As a result the corrosion rate increases compared to untreated sample.

Salt spray tests were conducted as per ASTM B117 standard in 5% NaCl and tapwater for 96 hours. After 96 hours the samples were taken out and photographs were taken using a high resolution camera. From Table 2 it is seen that the AISI 316 austenitic samples treated for 6 hour did not corrode compared to samples treated for longer durations. The loss of corrosion resistance is due to the presence of chromium nitrides.

Material	**Untreated samples**	**Treated for 6 hrs**	**Treated for 24 hrs.**
AISI 316 Tested with 3.5% NaCl solution			
AISI 316 Tested with tap water			

Table 2: Photographs of untreated and treated samples after exposing to 5% NaCl solution and tapwater

Hence, we can conclude that plasma nitrocarburising process has indeed improved the corrosion resistance of AISI 316 austenitic stainless steels, due to carbon and nitrogen incorporation into the surface of the material. The low corrosion rate, low current density and high potentials obtained after conducting potentiodynamic tests on treated samples indicate better corrosion resistance properties compared to the untreated samples. Since most the steam turbines components made of these steels are damaged due to high service and corrosive conditions, surface modification method like plasma nitrocarburising can be used as one the solution to decrease corrosion problems.

Plasma pyrolysis of petroleum residue

Mr. Adam Sanghariyat

Petroleum waste includes petroleum residue, pet coke, petroleum sludge, etc. Safe disposal of petroleum waste is a serious concern for petroleum refineries. Refiners need special methods and techniques to extract valuable products from these products viz. (i) Tank Sludge, (ii) Vacuum Residue and (iii) Pet Coke. Except tank sludge, the other two by-products have substantially higher concentration of carbon and therefore have more potential to release higher calorific value gas mixture and can be processed to maximize the production of syn gas through energy efficient processes viz. pyrolysis or gasification process. A technology that can make use of these low value petroleum products or end waste to produce valuable and usable products such as syn gas (mainly H_2 and CO) or fuel gas for power plant in an environmental friendly process will be a boon for the refineries. Gasification using thermal plasma is rapidly becoming a popular method for attaining high temperatures in a short duration. There is better process control and better utilization of carbon in the fuel through this process.

In this context Institute for Plasma Research (IPR) and Bharat Petroleum Corporation Limited (BPCL) initiated a combined study to develop and demonstrate an environmental friendly plasma gasification process, which can be applied on the petroleum products or waste to produce valuable syn gas (mixture of Carbon monoxide and Hydrogen) and other lighter useful gases like in smaller fractions like methane. Plasma gasification is state of the art technology for safe disposal and conversion of organic waste into commercially useful products in an environment friendly manner. In plasma gasification, the most likely compounds that form from carbonaceous matter are carbon monoxide, hydrogen, and carbon dioxide. The gases formed have high calorific value and therefore, can be used to recover energy or used directly to run an engine or produced syn gas can be converted into chemicals.

By designing an appropriate waste feeding mechanism for individual petroleum waste having different physical and chemical properties FCIPT carried out the plasma gasification in the plasma pyrolysis set up shown below:

Fig. 1: Image of the plasma gasification system with the arrangement to feed Tank Sludge

The plasma gasification of the FEED material was carried out at (i) at different oxygen flow rate and (ii) at different steam flow rate and (iii) keeping the steam flow fix (optimised value obtained from previous experiment) and varying oxygen flow rate. All the experiments were carried out at constant power. In addition, the quantity of the individual feed was also kept constant during the experiments. The results clearly indicate that vacuum residue provides higher quantity of syn gas and other hydrocarbon gases in comparison to tank sludge and the pet-coke. The results obtained at FCIPT were checked for a few representative samples with BPCL, Greater Noida. Both the results are closely matching. The optimised conditions for Syn gas formation are mentioned in the Table 1.

Mass energy balance data clearly reveals that vacuum residue provides higher quantity of syn and other hydrocarbon gases thus provides greater increase in water temperature when it was circulated through copper coil present in the combustion chamber. The temperature rise was minimum in the case of pet-coke. We observed approximately 40-50% unconverted pet-coke remains in the process chamber, which is possibly due to less residence time of pulverised coke particles in the hot zone of plasma. The tank sludge also carries significant water therefore provides relatively less quantity of combustible gases, which is reflected through moderate rise in water temperature circulated through the coil.

Table 1:

FEED	**Para-meters**	**With O_2**	**With H_2O**	**With Mix. of O_2 and H_2O**
Vacuum Residue	Flow rate	90 LPM	8 Kg/hr	H_2O –8Kg/hr O_2– 80LPM
	Syn Gas %	85.4 %	67.63%	73.8%
Tank Sludge	Flow rate	30 LPM	6 Kg/hr	H_2O –6Kg/hr O_2 – LPM
	Syn Gas %	70.5 %	71.8%	66.4%
Pet-Coke	Flow rate	70 LPM	10 Kg/hr	H_2O -10Kg/hr O_2– 100LPM
	Syn Gas %	68.5 %	70.81%	77.5%

For the fixed flow rate of different feed material the quantity of combustible gas produced from gasification process is tabulated below in Table 2.

Table 2:

FEED material	**Feed rate Kg/hr**	**Gas mixture flowrate Kg/hr**	**Calorific value of gas mixture KJ/mol**
Vacuum Residue	8	12.87	568.24
Tank Sludge	8	7.42	475.92
Pet-Coke	8	23.89	219.67

From the study carried out at FCIPT using petroleum FEED, we see there is enormous potential to recover valuable gaseous products rom the plasma gasification of FEED and it is possible to control concentration of hydrogen of CO in syn gas by adjusting temperature of primary chamber and steam or oxygen flow rate.

Applications of aluminized coatings

Mr. Nirav Jamnapara

Intermetallic aluminides such as FeAl, NiAl, CoAl etc. have been extensively used owing to their high temperature stability and protective properties. However, they are brittle in nature and hence their use as structural material is limited. These aluminides have been found to yield excellent results in surface engineering applications. Some applications of aluminide coatings in various industrial sectors are discussed below:

Coatings for Metal-dusting resistance in petrochemical plants:

Metal dusting (MD) [1] is a type of corrosive disintegration of metals and alloys into fine particles. Fe, Ni, Co based alloys are prone to MD. Metal dusting occurs in the temperature range of 400 – 800 °C in a carbon supersaturated gaseous environment. The common gases that cause MD are CO and hydrocarbon gases (viz. CH4 etc.) and such gases are mostly handled in petrochemical plants. Thus petrochemical plants are more prone to MD type of corrosion. The C from CO or CH_4 type of gases reduces to C and deposits on the surface of metal. Mostly Fe based alloys are used in industries and hence Fe reacts with C to form Fe_3C. The C in this Fe_3C close to the C rich surface becomes unstable and dissociates into Fe and C. The C of this dissociated Fe_3C again reacts with the substrate and this way ‘Fe’ dust gets generated. This type of corrosion leads to thinning of sections and need to be prevented.

Diffusion of C needs to be prevented and a barrier layer would be ideal to resist MD. Aluminides (FeAl / NiAl) have the capability to generate Al_2O_3 protective layer which has been found to be a diffusion barrier for C and H atoms. Below mentioned aluminide coatings can be an effective solution to reduce metal dusting.

Hot corrosion resistant coatings for power plant applications:

The sulphur content in fossil fired boilers and gas turbine fuels are primary reasons for hot corrosion of structural components. The SO_2 and SO_3 gases react with Na and K in the fuels to form low melting point eutectics on the structural material such as gas turbine vanes or boiler tubes, which then accelerates the grain boundary corrosion [2].

Bond coats in thermal barrier coatings in gas turbines:

Bond coats in a thermal barrier coating (TBC) are the interface intermetallic coating zone comprising of aluminides. The purpose of this aluminide is to continuously supply Al to generate Al_2O_3 and thus become self healing. This also imparts bonding strength to the TBC layer which is mostly oxide. The role of bond coat is thus important and decisive for the performance of the TBC coating. In gas turbines and high temperature reactors where Ni-base super alloys are used, NiAl bond coats are used, while FeAl based bond coats are used with Fe base substrates.

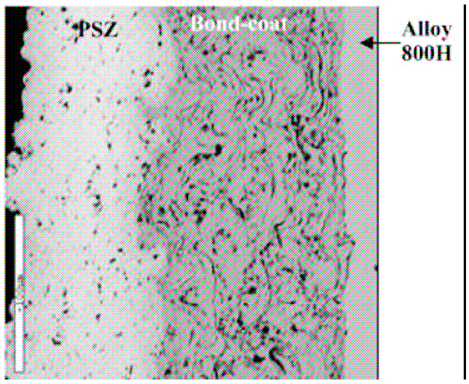


Fig. 1: Illustrative microstructure of thermal barrier coating with bond coat on alloy 800H [3]

Intermetallic aluminides are key to performance enhancement of thermal barrier coatings. Such bond coats also support in hot corrosion at high temperatures during service. Fig 1 is an illustrative example of the microstructure of thermal barrier coatings by plasma spray technique (overylay type) and location of the bond coat [3].

Fretting wear coatings in fission reactors:

P91 tubes are used in steam carrying tubes of steam generators in prototype fast breeder reactor (PFBR). The flow induced vibrations of these tubes immersed in liquid sodium needs to be damped and are done by clamping them using inconel 718 strips. However, due to the flow induced vibration damping, fretting wear takes place on inconel 718. A reduction in the friction co-efficient through a lubricating film and a wear resistant surface is an effective solution to the fretting wear problem. Nickel aluminides have been known as a stable intermetallic phase and good in wear resistance. The self generated alumina helps in reducing the friction co-efficient by formation of Na-Al-O complex and thus helps in reducing the fretting wear. In this direction, a project on plasma aluminizing of inconel 718 alloys under funding from BRNS, Mumbai is being pursued.

Liquid metal corrosion coatings in nuclear reactors:

Both nuclear fusion and fission reactors use liquid metal coolants which result in corrosion of structural materials. Pb-Bi and Pb-Li eutectic alloys are used as coolants for fission and fusion reactors respectively. A typical erosion-corrosion type mechanism has been reported [4] for such liquid metal induced corrosion of steels. Fig. 2 indicates mechanism of such corrosion by liquid metals.

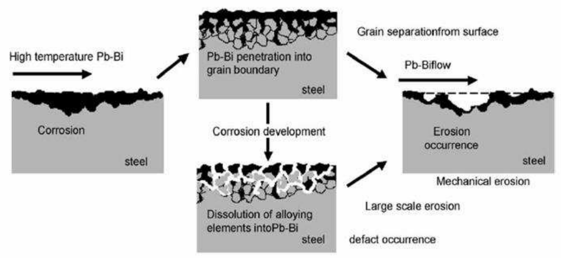


Fig. 2: Schematic of erosion-corrosion mechanism of Pb-Bi on steel [4].

Protective coatings in fuel cells

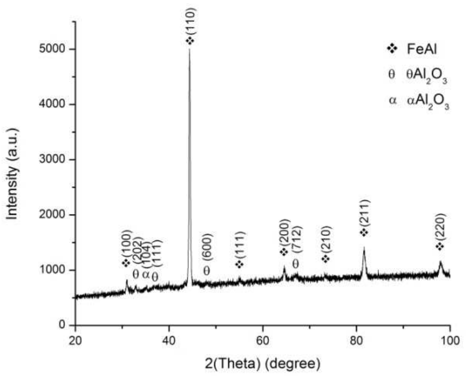
In molten carbonate fuel cell systems, a wet seal technique is applied on bipolar plate for gas sealing and retention of fused electrolyte. Since the wet seal environment is very corrosive, only Al containing alloys show good corrosion resistance for wet seal applications [5]. Aluminides can be generated by aluminizing SS316 or by deposition techniques (overlay type).

Plasma based aluminide coating processes:

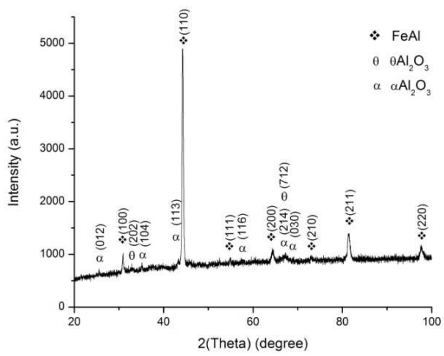
Aluminide coatings in general can be classified into either 'overlay' type or 'diffusion' type. The overlay coatings (e.g. thermal spray type), are deposited over the substrate and have a mechanical bonding with the substrate. The diffusion type coatings have a chemical / metallurgical bond with the substrate and are hence are more adherent and desirable. These diffusion coatings can be generated by various techniques viz. pack aluminizing, hot dip aluminizing, gas phase aluminizing, plasma assisted aluminizing etc. In all of the above processes, either Al or Fe-Al intermetallic phases are formed. Subsequent oxidation treatment needs to be conducted to form a protective Al_2O_3 film on the aluminide coatings. This alumina films protects the substrates from further oxidation, hot corrosion, carburization etc. Conventionally the oxidation heat treatment is conducted in muffle furnaces or other type of furnaces as the application demands. It has been observed that plasma (non-thermal, glow discharge type plasma) assisted heat treatment results in considerable benefits as compared to the thermal treatment.

Role of plasma in aluminizing:

Glow discharge plasma has been known to accelerate diffusion processes owing to the active species generated in the glow discharge. Plasma is also known to reduce activation energies of various phases at lower processing temperatures. Recently, it has been observed from the work done at FCIPT that change of allotropic form of alumina takes place when subjected to glow discharge plasma treatment. After hot dip aluminizing, when samples were subjected to heat treatment at 750 °C for 1 hour, it was observed that the metastable θ-Al_2O_3 present on the surface before treatment, got converted to stable α-Al_2O_3 phase [6]. The θ phase visible in fig 3 (a) got transformed to α in fig 3 (b).



(a)



(b)

Fig 3: X-ray diffractograms of (a) thermally treated and (b) plasma treated aluminized 9Cr-1Mo steels.

In another experimental observation, it was found that heat treatment under plasma treatment (Ar + O2) results in larger diffusion case depths as compared to the coatings generated by thermal treatment. The thermally treated samples yielded an Fe-Al diffused case up to 65 µm, while the plasma oxidized samples yielded an Fe-Al diffused case up to 98 µm [6].

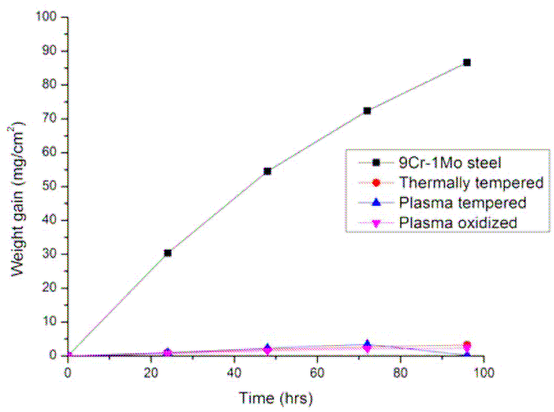


Fig. 4: Thermal cycling test for bare 9Cr-1Mo steel, thermally and plasma aluminized steels.

The cyclic oxidation tests conducted on the bare 9Cr-1Mo steels in comparison with the thermal and plasma treated samples revealed that the plasma treated aluminized samples showed excellent oxidation resistance. Fig 5 indicates a weight gain plot as a function of time when exposed to 900 °C temperature upto 96 hours.

Summary:

Plasma processing can yield better coatings & coating processes in terms of stable phases, larger case depths, shorter processing times etc. The performance evaluation tests under oxidation and liquid metal corrosion have revealed that plasma processed samples yield longer service life and are resistant to high temperature corrosion. Industries are welcome to explore applications pertaining to similar problems with FCIPT.

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OTHER NEWS

Installation of a plasma pyrolysis system at Shree Chitra Tirunal Institute, Trivandrum.

A Plasma Pyrolysis system was installed and commissioned at Shree Chitra Tirunal Institute for Medical Science and Technology, Biomedical Wing, Trivandrum in March 2012. The fabrication and installation of the system was carried out by M/s Bhagwati Pyrotech Pvt. Ltd. along with FCIPT, IPR. This system is meant for disposing bio-medical waste and has a waste disposal capacity of 20 kg/hour. The photograph of the actual installed system is shown in figure below.

Fig. 1: Plasma Pyrolysis system installed in Trivandrum

Photograph of the Plasma Pyrolysis system that was installed at Shree Chitra Tirunal Institute for Medical Science and Technology, Trivandrum hospital.

Installation of Washer Gun Plasma System at Delhi University.

A washer gun plasma system (WGPS) as shown below was installed and commissioned at Delhi University in the month of January 2012, for studying the plasma properties formed by this source as part of the curriculum for the post graduate students.

Fig.1: Washer gun plasma system installed at Delhi University.

In this system, the washer gun plasma source is installed at one end of the vacuum chamber and the plasma produced by this source is ejected in to the vacuum chamber so that experiments can be carried out in a moving plasma. The system consists of a stainless steel vacuum chamber (500 mm diameter and 600 mm length) which is evacuated using rotary and diffusion pumps, to a base pressure of ~ 5x10-6 mbar. The gun consists of a stack (~ 12 cm diameter, 15 cm length) of alternating metal and insulator discs having a 3 cm diameter hole at the centre where Ar gas is introduced to a pressure of ~ (1-10) x 10^{-2} mbar. The end metal discs of the washer gun form the electrodes across which the high voltage stored in the capacitor bank is discharged. The power source consists of a capacitor bank consisting of two parallel capacitors (10 μf each), that can be charged to 15 KV (maximum) using a 15 KV, 20 mA DC power supply. Thus energy of ~ 2 KJ maximum can be stored in the capacitors. The voltage discharge across the washer gun is accomplished through an ignitron switch driven by a driver circuit. The ignitron is connected in series with the load (plasma gun) through a resistor (~ 1 Ohm). The value of this resistor is so adjusted as to keep the circuit under critically damped condition, to avoid ringing in the discharge voltage / current. There is a pneumatic bleeding set up to discharge the capacitor in case of failure in plasma formation.

The diagnostic set up installed includes high voltage probe for discharge voltage measurement, current transformer for discharge current measurement and several Langmuir probes, for measuring density, temperature, floating potential and plasma potential measurements. There are 8 numbers of I-V cards that enable simultaneous measurement of density at desired locations in plasma. Two oscilloscopes are provided to enable capturing of signals. The system has an additional facility of producing DC plasma using a conventional set-up, with a filamentary discharge. This can be used for cleaning the probes and also for calibration.

Installation of Industrial Scale Plasma Processing unit for treating Angora Wool at Uttarakhand

An Industrial scale atmospheric pressure air plasma processing system for surface modification of Angora wool was installed at Himalayan Institute for Environment Ecology & Development (HIFEED), Ranichauri, Uttarakhand on 6th June 2012 as shown in Fig. 1 below. Plasma treatment facilitates spinning of Angora by increasing its coefficient of friction. The plasma system can treat 1m wide Angora web at the processing speed of 4.5m/min. The treatment cost is very less as only consumable is electricity. The system has been fabricated by M/s. Inspiron Engineering Pvt. Ltd, licensee for this plasma processing technique. The project has been funded by Department of Science & Technology (DST).

Fig. 1: Industrial scale Plasma processing unit installed at Uttarakhand

Angora Web fed into plasma system

Procurement of Potentiodynamic set up and Salt spray Chamber.

FCIPT has recently installed a potentiodynamic and salt spray chamber for determining the quantitatively the corrosion rate of coatings on metals in the month of February 2012 as shown in Fig. 1 and Fig. 2. The potentiodynamic set-up as shown below consists of a three electrode cell with counter, reference and working electrode connected to the power supply. This set-up is equipped with software's to determine the open circuit potential, corrosion rate and resistance to polarization. This set-up is also equipped with Electrochemical Impedance Spectroscopy to determine the impedance of the coating to corrosion.

Fig. 1: Potentiodynamic set-up supplied by M/s Gamry Instruments, USA.

The salt spray chamber shown below has a capacity of 450 ltrs and has a automatic continuous salt spray. This system is conducted as per ASTM B117 international standard, and can be used with pH neutral salt solutions (NSS) and also with Acetic Acid (ASS) or Cupric Acid (CASS). This system is mainly used to detemine the weight loss after exposure of the material to salt fog for hours for qualitative determination of corrosion resistance of the material.

Fig. 2: Salt Spray Chamber supplied by Ascott Analytical Equipment Ltd.

Plasma Treated Angora wool coming from sliver unit installed at Uttarakhand

Facilitation Centre for Industrial Plasma Technologies

Institute for Plasma Research

A-10/B, Sector-25,
GIDC Electronic Estate,
Gandhinagar, Gujarat-382 044
INDIA

Phone *:(079) 23269000/23269002*
:23962000
Fax *:(079) 2326901/23962001*
E-mail *:fcipt@ipr.res.in*
Website :www.plasmaindia.com
:www.ipr.res.in/fcipt