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1.5M ALUMINIZING PLANT OF THE INDIAN INSTITUTE OF ASTROPHYSICS

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ABSTRACT

The design and features of 1.5m vacuum coating plant an in house facility at the Kavalur Observatory for periodic aluminizing of astronomical optics are described. A typical performance data is given.

Key Words: aluminizing vacuum coating plant

1. Introduction

The 1.5 Metre aluminizing plant of the Indian Institute of Astrophysics, the largest of its kind in the country was commissioned by BARC in early 1978. This forms an in-house facility at the observatory at Kavalur for periodic coating of telescope mirrors. After several runs on the plant an optimised procedure of aluminizing was evolved and calibration for the thickness of the coating against aluminium evaporation time was ascertained. The first aluminizing of an astronomical mirror was done in the month of June the same year. Since then the plant has been in continuous operation and satisfactory aluminizing of many astronomical and other optical mirrors including a 1.2m primary mirror of Japal-Rangapur Observatory and 1.02m primary mirror of our Institute has been done. The plant can be used for aluminizing mirrors upto 1.3m in diameter and of weight not exceeding 700kg. This paper describes the operational features of the plant. Aluminizing procedure of the mirrors is also given.

2. Vacuum Chamber and Pumping System

The Aluminizing plant Fig.1 (a,b) consists of a vacuum chamber, a vacuum pumping system, an evaporation unit and ion discharge unit for substrate cleaning. The vacuum chamber is composed of a fixed main chamber and a movable lid constructed out of austenitic stainless steel. The lid is mounted on a trolley which can be tilted either to horizontal or to vertical position by a suitable mechanical drive system and can be retained in any desired position. Such a provision is suitable for loading and unloading of the mirrors.

The fixed chamber has two side ports of 406mm diameter for connecting the diffusion pumps and 300mm dia port on the dished end for mounting the low voltage high current feed - through for filament

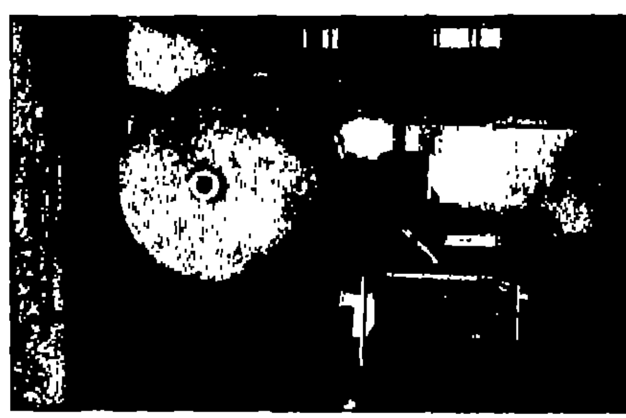

Fig. 1(a) Aluminizing plant

power supply. There are five other smaller ports for viewing windows, shutter drive feed-through as well as for mounting different gauge for heads for measuring the pressure in the chamber.

The vacuum pumping system comprises of two oil diffusion pumps DP-1 and DP-2 (Fig.2) of unbaffled speed 7,000 $l\,s^{-1}$ each. Electro-pneumatically actuated high conductance gate valves V_4 V_5 and refrigeration cooled chevron baffles CB-1, CB-2 are mounted on the diffusion pumps. The assembly is connected to the pumping port of the chamber through a short elbow. A 7,500 $l\,m^{-1}$ rotary mechanical pump R.P is used for roughing the chamber as well as for backing the diffusion pumps.

114mm electropneumatically actuated high vacuum gate valves VI, V2, V3 are incorporated in the vacuum

Fig. 1(b) Aluminizing Plant

plum lines to ensure remote and safe operation of the vacuum system. Three thermocouple gauges TC1, TC2 and TC3 have been used on the plum lines for monitoring pressure as well as for interlocking purposes. Hot cathode ionisation gauge and a discharge gauge are mounted on the chamber to monitor the degree of vacuum. A typical performance of the system is shown in Table 1.

Table 1 Typical of The Performance of 1.5 Metre Aluminizing Plant Vacuum System

Time in Minutes	Pressure in Torr	Remarks
0	Atmosphere	Engaging of R.P
15	2 x 10–2	As measured with Thermocouple gauge
30	3 x 10–3	Engaging of D P
60	6 x 10–5	Baffle cooling started
80	8 x 10–5	As measured with Discharge gauge
95	1.5 x 10–5	As measured with Discharge gauge
120	3 to 4 x 10–6 *	Measured with ionization gauge. Baffle cooling at -25° C.

* After a few discharge cleanings an ultimate vacuum of the order of 4x10 6 torr can be obtained in about an hour starting from 3x10 3 torr and Baffle temperature-25° C.

3. Evaporation Source Couflguration

The rear end of the fixed chamber houses the evaporation sources which are made of tungsten wire of 0.75mm dia and wound in helical shape. The 36 vaporation sources are arranged in a circular configuration and mounted on two concentric rings The entire filament ring assembly is mounted on a trolley so that the filament configuration could be brought forward for replacing burnt out filament as well as for loading with aluminium. The separation of 70cm between the ring structure and the mirror face has been found suitable for the uniformity of thickness on the mirror surface within ± 5 percent. This remains a little uncertain factor because all the filaments do not behave in similar manner during evaoration. The filaments are fixed in groups so

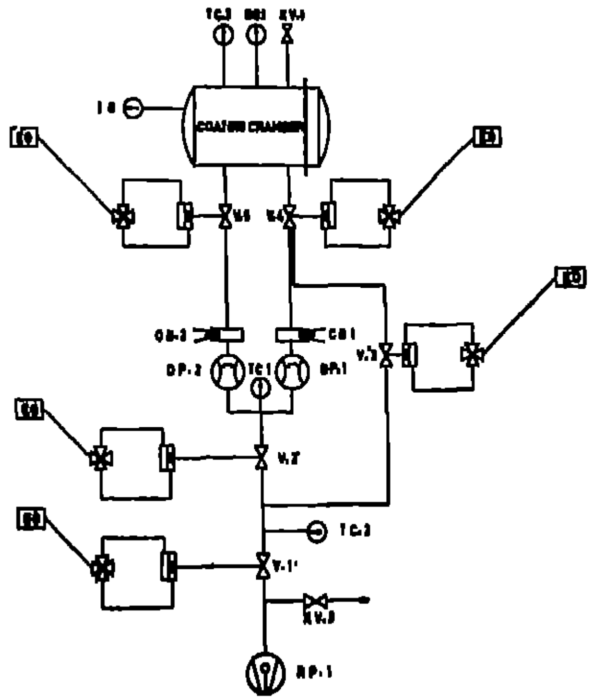

Fig. 2 Vacuum systems schematic diagram

as to reduce the size of the low tension supply unit providing power to the filaments. A shutter in front of the filament assembly masks the batch of filaments during prefiring operation when the evaporant aluminium is degassed and prefused to the filaments. The shutter can be moved to the desired positions with the help of a mechanical drive system operated manually from outside through a vacuum feed-through.

A 6v, 250 amp AC supply gives power to each batch of the filaments. Outer and inner rings need 6v, 250 amp and 6v, 125 amp supply respectively.

4. Ion Cleaning Arrangement

Discharge electrodes for ion cleaning are mounted near the open end of the fixed chamber with ceramic spacer between them. A continously variable high voltage supply of 0 to 5kv AC with a maximum current capacity of 500MA is provided for ion cleaning. It was found that to sustain discharge without arcing between the electrodes the H.T. transormer should have high reactance and electrodes need to be smooth.

5. Aluminizing Procedure

The aluminizing operation of the mirror is carried out as follows:

1. The surface of the mirror is subject to thorough chemical cleaning (see Appendix 1) to remove grease etc. and then washed with distilled water and dried. It is made sure that the surface is free from drying marks.

2. Precalibrated quantity of aluminium wire 9" length of 1mm dia of purity 99.99% is then wound on the helical tungsten filaments and these filaments are mounted in place. Utmost care is taken to keep these filament free from any contamination during loading and mounting.

3. The movable lid is tilted to horizontal position and the mirror is mounted inside and clamped. The lid is now tilted to vertical position and moved to bring its flange in contact with the fixed chamber flange, and locked with the G-clamps provided to hold both the flanges together. The chamber is then evacuated to a vacuum.

4. Dry nitrogen or air is admitted into the chamber through a needle valve mounted on to obtain a pressure of 10-20 microns in the chamber. Ion cleaning is now carried out for more than 30 minutes at 3 kv and 300m amp by striking adischarge obtained from the high tension unit. Extreme precautions are taken so that no arcing takes place between the electrodes. Subsequently the needle valve is closed and the chamber is again evacuated to high vacuum of the order 2×10^{-5} torr. To ensure better adhesion of film on the substrate the process is repeated again before deposition. Finally the chamber is evacuated to a vacuum of the order of 5×10^{-6} torr and evaporation is done.

5. The filaments are fired in four batches. They are first prefired by feeding only partial power (40%) to the filaments with the shutter masking them. As soon as the aluminium charge starts melting the shutter is moved away and the full power is fed to the filament to cause complete evaporation of aluminium on to the substrate.

6. After the evaporation of all the filaments, diffusion pump and refrigeration unit is switched off and the chamber is isolated from the vacuum system. Better results are obtained on durability of the coating if coated mirrors are left under vacuum for couple of hours. Dry air is then introduced through the admittance valve inside the chamber and it is brought to the atmospheric pressure. The dolly is moved out and aluminized surface can be inspected for their quality.

7. The quality of the reflective coating is checked on sample piece kept at suitable locations while loading mirrors. In order to get a total reflecting surface a calibration has been established in terms of length of the aluminium wire and evaporation time. It has been found that with the 9" length at 1mm aluminium wire gives coating thickness of about 1000Å. Ion cleaning at 3kv and 300 milliamps for about 30 minutes and suitable chemical cleaning of substrate as described in the Appendix 1 results in satisfactory adhesion of the coating. Coatings obtained from this plant adopting the procedure and precautions described in this paper have stood the standard scotch tape test very well.

Appendix 1

Chemical Cleaning Of Optical Mirrors Before Aluminizing

The cleaning is done in the following steps:

1. The Mirror is given a wash with distilled water and 1% teepol solution and dried.

2. The degreasing of the surface is done with Trichloro-Ethelene to the extent the dry marks on the surface are not seen.

3. Again, a distilled water and 1% teepol solution wash is given.

4. Cleaning of the surface with 6% H_2O_2 solution (by swabbing) and afterwards with distilled water.

5. Alternate cleaning (by swabbing) with 10% KOH and 10% HNO_3 with intermittent distilled water washes. The process is repeated through 10 to 12 rounds till the water flow on the surface is seen unbroken and uniform.

6. Finally, the surface is washed with distilled water about 5 to 6 times and dried with lint - free clean towels; full care is taken to ensure that after drying no dry mark is seen on the surface.

7. A breath figure testing of the mirror can also be done to make sure that the surface is uniformly clean.

8. The mirror is now ready for loading into the chamber.