Practical Work Book

MY-401: Vacuum Metallurgy

Name _____
Roll No_____
Batch_____
Year_____
Department_____

Department of Metallurgical Engineering
NED University of Engineering and Technology

Practical Workbook

MY-401: Vacuum Metallurgy

PREPARED BY

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This is to certify that this practical book contains _____ pages.

Approved by:

Chairman
MYD

Department of Metallurgical Engineering
NED University of Engineering and Technology

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His/her performance is reflected by index/contents of his/her practical workbook. This overall performance of the student is Excellent/Very Good/Good (satisfactory)/Not Satisfactory

_____
Course Teacher

PRACTICAL 1

OBJECTIVE: To study the working principle of Rotary Vacuum pump

APPPRATUS:

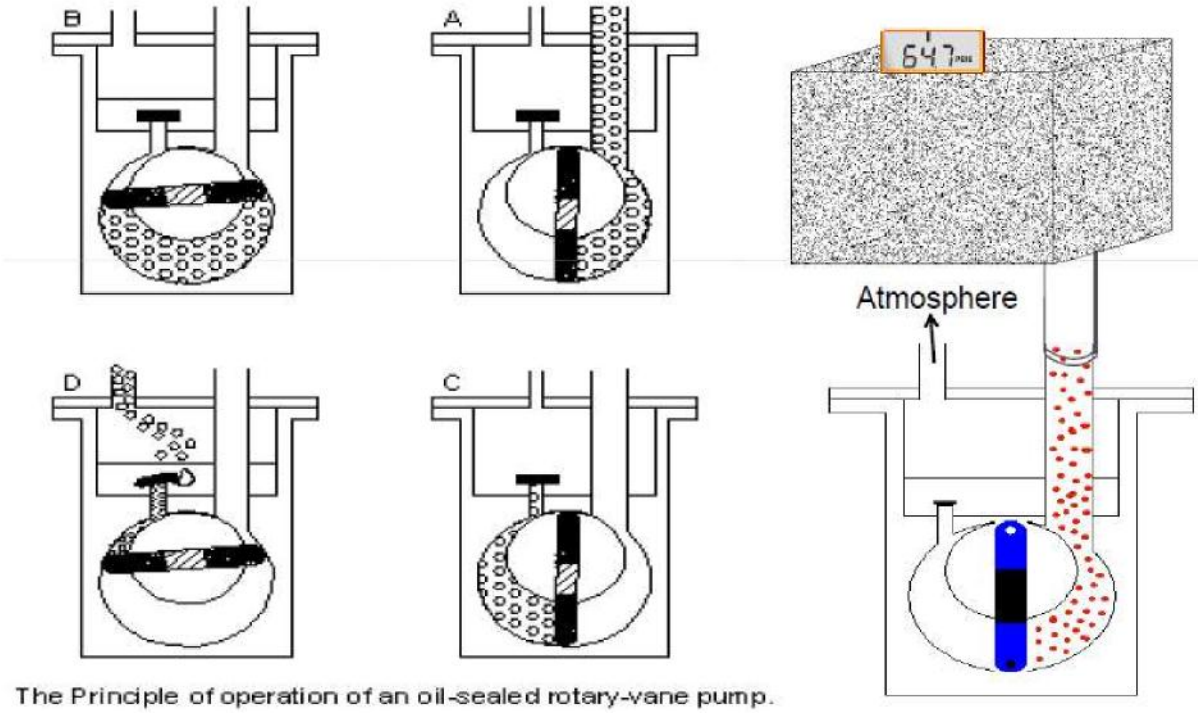
Rotary vane vacuum pump, vacuum gauge, Leak tight Chamber

THEORY

Rotary Vacuum Pump:

A displacement vacuum pump is generally a vacuum pump in which the gas which is to be pumped is sucked in with the aid of pistons, rotors, vanes and valves or similar, possibly compressed and then discharged.

The Rotary vane pump is defined as "A device which entraps the gas in a space, compress and then delivers to atmosphere."
The pumping process is affected by the rotary motion of the piston inside the pump.
Differentiation should be made between oiled and dry compressing displacement pumps.



The Principle of operation of an oil-sealed rotary-vane pump.

Working principle of a Rotary vacuum pump

PRINCIPLE OF OPEATION:(write in your own words)

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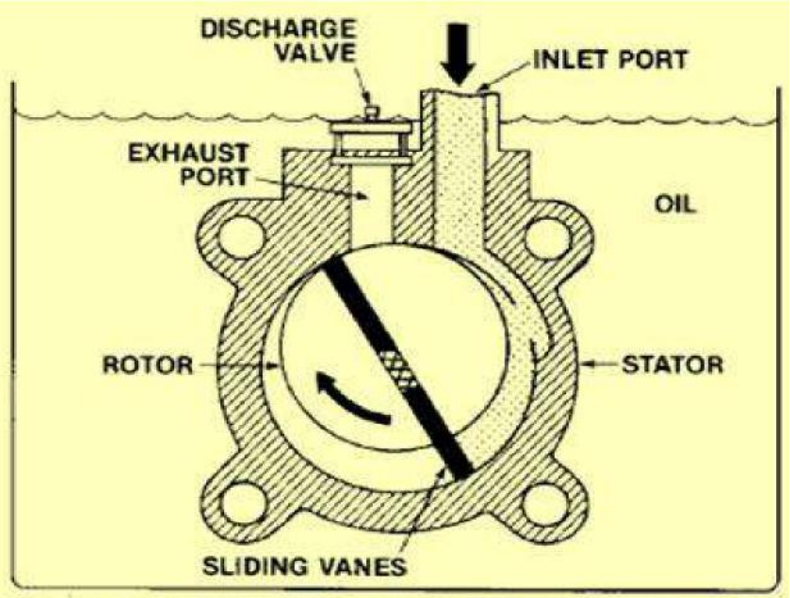
CONSTRUCTION



ROTARY OIL-SEALED MECHANICAL PUMP MODULE

OBSERVATIONS:

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EXERCISE

Q1. Why vacuum pump falls in a category of displacement pump?

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Q2. What is the vacuum range of Rotary vacuum pump?

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Q3. What is the function of oil in rotary pump?

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Q4. Give few applications of Rotary vacuum pump?

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Q5. What is the function of gas ballast valve?

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PRACTICAL 2

OBJECTIVE: To study the working principle of Diffusion pump.

APPRATUS:

Diffusion pump, vacuum gauge, leak tight chamber, backing pump (Rotary pump).

THEORY

These pumps consist basically of a pump body with a cooled wall and a three- or four-stage nozzle system. The oil serving as pump fluid is in the boiler and is vaporized from here by electrical heating. The pump fluid vapor streams through the riser tubes and emerges with supersonic speed from the ring-shaped nozzles. Thereafter the jet so-formed widens like an umbrella and reaches the wall where condensation of the pump fluid occurs. The liquid condensate flows dow nward as a thin film along the wall and finally returns into the boiler. Because of this spreading of the jet, the vapor density is relatively low. The diffusion of air or any pumped gases (or vapors) into the jet is so rapid that despite its high velocity the jet becomes virtually completely saturated with the pumped medium. Therefore, over a wide pressure range diffusion pumps have a high pumping speed. This is practically constant over the entire working region of the diffusion pump because the air at these low pressures cannot influence the jet, so its course remains undisturbed. At higher inlet pressures, the course of the jet is altered. As a result, the pumping speed decreases until, at about 10^{-1} mbar, it becomes immeasurably small.

WORKING PRINCIPLE (In your own words)

CONSTRUCTION

1. Heater
2. Boiler
3. Jet A ssembly
4. Pump body (condenser)
5. Copper coiling Coil Port
6. for backing pump
7.

PRECAUTIONS:

- Care must be taken while the pump is on, because it can generates hazardous fumes. -
Backing pump must be used for initial evacuation.
- Proper mounting of gauges must be checked.

OBSERVATIONS:

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EXERCISE

Q1. Why diffusion pump falls in the category of momentum transfer pump?

Q2. What sort of problems can occur in diffusion pump?

Q3. What is the function of oil in diffusion pump?

Q4. Give few applications of Diffusion vacuum pump?

Q5. How to overcome backstreaming?

PRACTICAL 3

OBJECTIVE: To study the working principle of Turbo molecular pump

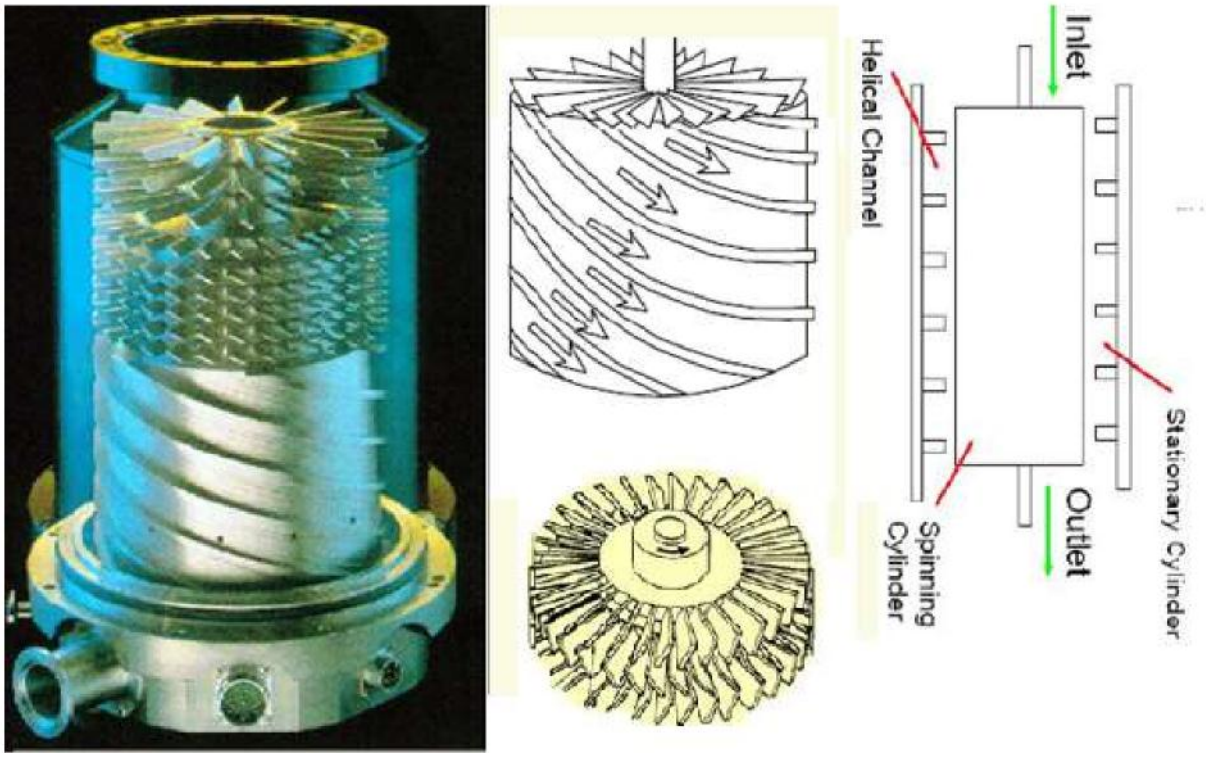
APPRATUS:
Turbomolecular pump, vacuum gauge, leak tight chamber, backing pump.

THEORY

The principle of the molecular pump well known since 1913 is that the gas particles to be pumped receive, through impact with the rapidly moving surfaces of a rotor, an impulse in a required flow direction. Blade angle decreases from high vacuum to fore-vacuum side Blades near inlet have high pumping speed. Blades at the foreline side have low pumping speed. At the end of the Fifties, it became possible through a turbine-like design and by modification of the ideas to produce a technically viable pump the so called **turbomolecular pump.** The spaces between the stator and the rotor disks were made in the order of millimeters, so that essentially larger tolerances could be obtained. Thereby, greater security in operation was achieved.

WORKING PRINCIPLE (In your own words)

CONSTRUCTION



PRECAUTIONS

- Avoid any vibrations while the turbo molecular pump is on.
- The valve between turbomolecular and backing pump must be open operation of TM P.
- Proper mounting of gauges must be ensured for accurate readings.
- Chambr must be leak tight.

OBSERVATIONS:

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EXERCISE

Q1. What should be the minimum gap between rotor and stator

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Q2. What sort of problems can occur in Turbomolecular pump?

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Q3. Give advantages and disadvantages of TMP?

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Q4. Give few applications of TM P?

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Q5. What is the rotational speed of TM P?

PRACTICAL 4

OBJECTIVE: To understand the vacuum system of the Scanning Electron M icroscope.

APPRATUS:

Scanning electron microscope equipped with turbomolecular and backing pump with vacuum gauges

THEORY:

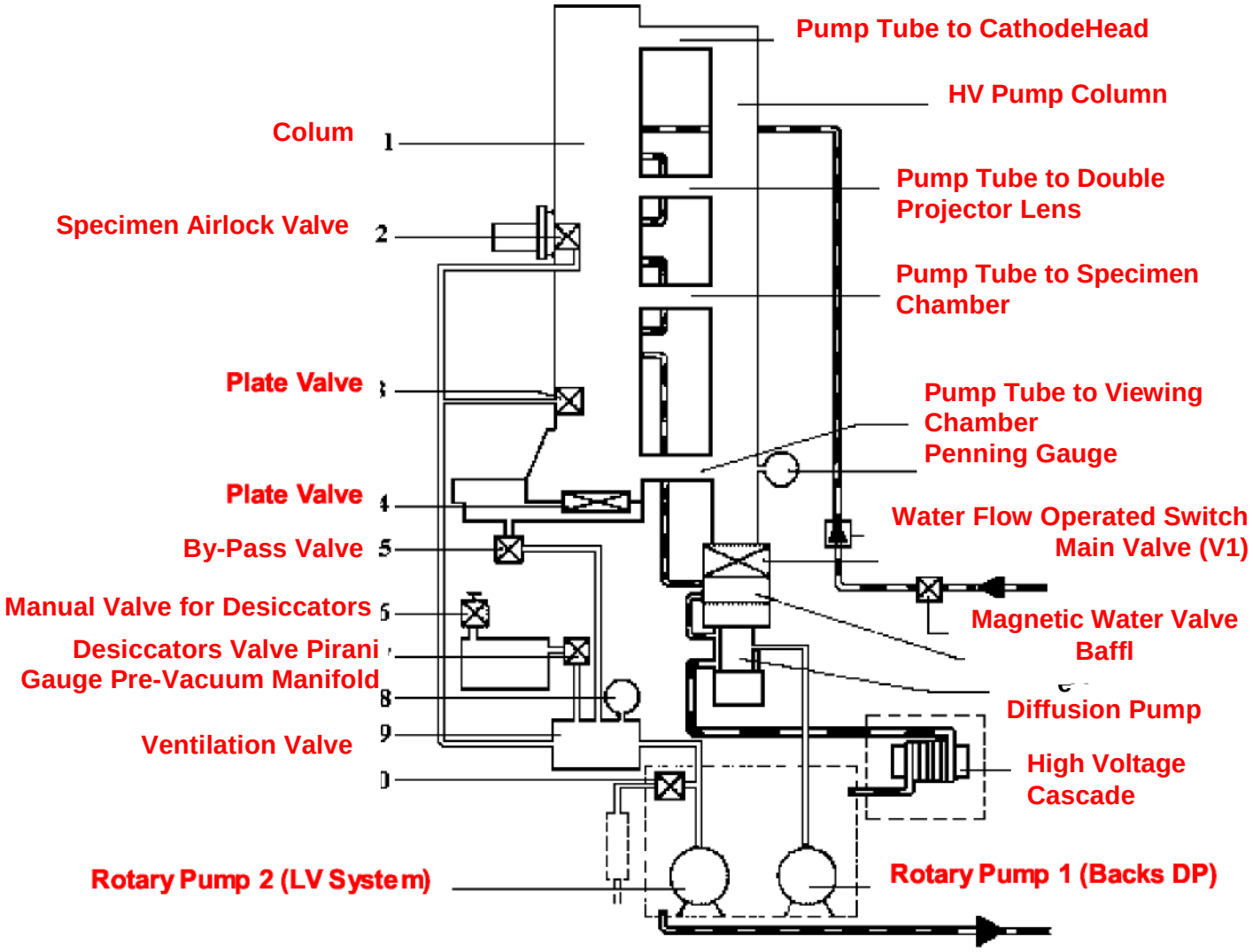
The environment within the column is an extremely important part of the electron microscope.

- Without sufficient vacuum in the SEM , the electron beam cannot be generated nor controlled.
- If oxygen or other molecules are present, the life of the filament will be shortened dramatically.
- Molecules in the column will act as specimens.
- When these molecules are hit by the electrons, the beam will be scattered.
- When changing samples, the beam must be shut off and the filament isolated from atmospheric pressure by valves.
- Attempting to operate at high pressures, will result in expensive repairs and periods of prolonged shutdown.

Therefore vacuum is a basic requirement for the general operation of the SEM is the control and operation of the vacuum system. A vacuum is obtained by removing as many gas molecules as possible from the column. The higher the vacuum the fewer molecules present. Atmospheric pressure at sea level is equal to 760 millimeters of mercury. A pressure of 1 millimeter of mercury is called a Torr. The vacuum of the SEM needs to be below 10^{-4} Torr to operate, although most microscopes operate at 10^{-6} Torr or greater vacuum. The higher the vacuum (the lower the pressure), the better the microscope will function. To pump from atmospheric pressure down to 10^{-6} Torr, two classes of pumps are used in SEM : a low vacuum or roughing pump (atmosphere down to 10^{-3}) and a high vacuum or pump (10^{-3} down to 10^{-6} or greater depending on type of pump).

For roughing vacuum rotary vane pump is used and for further vacuum any of the following vacuum pumps can be used

- Oil Diffusion Pumps
- Turbomolecular Pumps -
Ion-Getter Pumps an - Cryo
Pumps



Typical schematic diagram for SEM

OBSERVATIONS:

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EXERCISE

Q1. Why vacuum is necessary for SEM ?

Q2. What level of vacuum is essential for SEM ?

Q3. Can SEM analysis be obtained without vacuum?

Q4. Give few applications SEM?

PRACTICAL 5

OBJECTIVE: To study the Thermal evaporator system for thin film deposition

APPARATUS:

Thermal evaporator system, different metals (Al, Cu, N i, A g), silicon wafer, vacuum system

THEORY:

Thermal evaporator system:

Thermal evaporator system is a machine that is used to make metallic thin film deposition on susbstrates by thermal means where by heat is produced by electric means. This operation is carried out at high vacuum so as to provide the thin film free of impurities.

WORKING PRINCIPLE: (write in your own words)

Precautions:

1. Care must be taken as there is very high voltage at the base of the machine.
2. Don't open the machine door until unless the vent is done.
3. If the required thickness is high then do not use small boat as it may lead to the damage of the boat and metal.
4. A lways wear gloves and face cover while operating the machine
5. Run the specific program in digital panel as per the metal to be coated.
6. The system should be leak tight for better quality coating.

Observations:

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EXERCISE

Q1. What is the function of boat?

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Q2. Boat should be made of which material and why?

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Q3. Why and how we treat wafer before coating?

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Q4. Where the wafer is placed in the thermal evaporator? Sketch?

PRACTICAL 6

OBJECTIVE: To understand the working principle of Vacuum Induction furnace.

APPARATUS:

Induction furnace, vacuum system

THEORY:

Vacuum Induction Melting (VIM) is the melting of metal via electromagnetic induction under vacuum. An induction furnace containing a refractory lined crucible surrounded by an induction coil is located inside a vacuum chamber. The induction furnace is connected to an AC power source at a frequency precisely correlating to the furnace size and material being melted.

M aterial is charged into the induction furnace under vacuum and power is applied to melt the charge. Additional charges are made to bring the liquid metal volume to the desired melt capacity. The molten metal is refined under vacuum and the chemistry adjusted until the precise melt chemistry is achieved. Impurities are removed by chemical reaction, disassociation, flotation and volatilization. When the desired melt chemistry is achieved, a preheated tundish is inserted through a valve isolated hot tundish insertion lock. This refractory tundish is positioned in front of the induction furnace and the molten metal is poured through the tundish, into the awaiting molds.

VIM is a process used to make superalloys, stainless steels, magnetic and battery alloys, electronic alloys, and other demanding high value alloys.

WORKING PRINCIPLE: (write in your own words)

CONSTRUCTION:

A- Overmelt Charger
B- Control Room
C- Isolation Valve
D- Isolation Valves (2)
EF- Melt C hamber
G- Hot Tundish Charger
HI- Induction Furnace
J- Induction Power Supply
Mold Chamber Ingot M
olds

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EXERCISE

Q1. What level of vacuum is required in VIM ?

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Q2 What do you mean by induction?

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Q3. Why Vacuum induction furnace is preferred over normal induction furnace?

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