UNIVERSITY OF SCIENCE AND TECHNOLOGY OF HANOI

DEPARTMENT OF SPACE AND APPLICATION

THERMODYNAMICS II

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LAB WORK REPORT

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Table of Contents

Hydrothermal Carbonization Reactor

1.1. Specifications

Model	KH
Reaction Volume	500ml
Working Pressure	<=3MPa
Working Temperature	<=220°C

1.2. Applications

Used in Hydrothermal Reaction with high pressure and high temperature in order to synthesize new materials or extract materials.

1.3. Mechanism and Applied Theory

The Reactor has 2 parts:

- The outer part is made of stainless steel jacket
- The inner part is made of Teflon liner or Teflon chamber

The reactor mechanism is based on **Ideal Gas Law**: PV=nRT, when the reactor's temperature increases, the pressure inside will also increase.

Furnace

2.1. Specifications

Model No.	LT 24/12/P330
Maximum Temperature	1200°C
Volume	24 L
Connected Load	4.5 Kw
Electrical Connection	3-phase
Weight	55 kg
Heating time	80 min
Inner Dimensions	w = 280mm d = 340mm h = 250mm
Outer Dimensions	W = 490mm D = 555mm H = 580+320mm

2.2. Applications

Modern furnaces employ technology and design to improve temperature uniformity control and isolate heated materials from combustion impurities. This makes muffle furnaces perfect for heat-treating applications, washing samples, and materials research.

Muffle furnaces are frequently used in industrial manufacturing facilities or in laboratories for high-temperature applications. These applications include:

- Chemical reactions
- Cremation

- Oil refining
- Glasswork

2.3. Mechanism

Blackbody radiation, convection, or conduction from electrical resistance heater components heats furnaces to the appropriate temperature. Because there is often no combustion involved in the system's temperature management, temperature uniformity may be managed considerably more precisely, and the item being heated is isolated from fuel combustion byproducts.

Operations:

Step 1: Turning on the Controller/Furnace. Turn on the power switch. After a couple of seconds, the temperature is displayed on the overview screen.
Step 2: Using the controller, set time for first process
Step 3: Set initial temperature T1
Step 4: Set time for process 2
Step 5: Set time for third process
Step 6: Set the final temperature T2
Step 7: Set time for the fourth process
Step 8: May press save button to save for later use
Step 9: Press start/stop button and hold for 2 seconds to operate.

Oven

3.1. Specifications

Model	UNB 500
Volume	108l
Size of container	560x480x400mm
Size of machine	710x760x550mm
Voltage	220V, 2000W
Mass	50kg
Adjustable Temperature	220℃
Temperature Accuracy	0.5℃

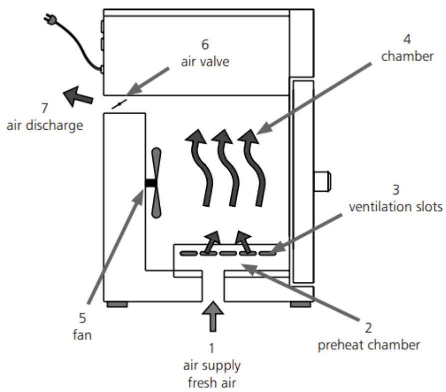
3.2. Applications:

In the laboratory, the oven can be used in preparing samples, sterilization, temperature testing, incubating temperature sensitive experiments, and drying instruments.

The drying oven has many use cases in both industry and civil:

- Materials testing
- In Pharmaceuticals, such as incubation and sterilization
- In Food and Agriculture Industries for determining dry content and humidity content

3.3. Mechanism and Applied Theory



The incoming air (1) is warmed in a **preheat chamber** (2) in both convection and fan-circulation ovens. The preheated air enters the **chamber** (4) through **ventilation slots** (3) in the chamber side wall. **The fan** (5) on the chamber back wall produces a large air throughput and a more intensive horizontal forced circulation compared with natural convection. **The air valve** (6) on the back of the oven controls the rate of air intake and **discharge** (air change) (7)

HVAC System

4.1. Specifications

Model	GCT/EV
Power Supply	230 VAC 50Hz-1500VA
Size	180x80x180cm
Weight	235kg

4.2. Applications

This HVAC system is designed for an exhaustive study of the thermodynamic transformations the air undergoes when crossing various stages of a modern air conditioning unit that serves a room where temperature and relative humidity must be checked.

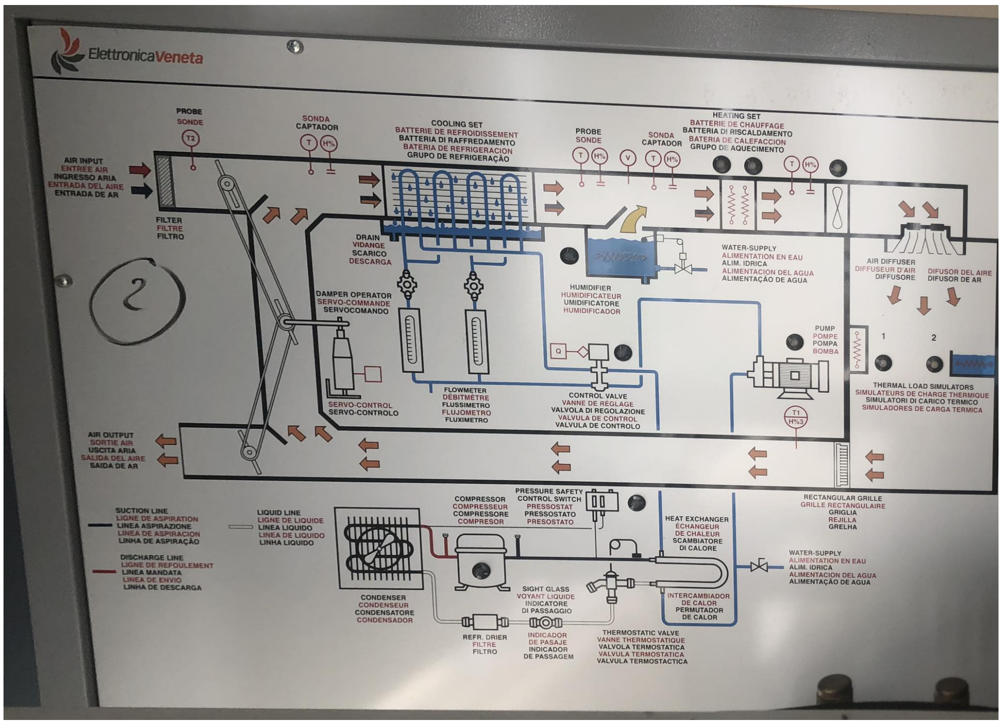
In real life, the HVAC system is essential in all the buildings for ventilation and to maintain comfortable temperature in the building, and clean the indoor air.

4.3. Mechanism and Principles

In the air intake process, the air will be filtered, then go to the cooling set. After that, the water supply will provide moisture for the air before it goes to the heating set. Then the air will be released to the room.

In the air exhaust process, the air will be taken out of the room and released into the environment.

The HVAC system uses First Law of Thermodynamics, the compressor adds energy to the refrigerant, making it hot. This heat transferred to the cooler air in the condenser. The HVAC system also uses the Second Law of Thermodynamics: Heat naturally flows from a body at a higher temperature to a body at a lower temperature.



HVAC system diagram

Air Compressor

5.1. Specifications

Compressor	Dr.Sonic 320-50V-ES-3M
Model No.	VKM 320
Max Air Flow Rate	210 l/min
Receiver Capacity	50 l
Max Pressure	116 psi
Noise Level	60 dB
Voltage - Phase	230 kV - 1
Operating R.P.M.	1400 R.P.M.
Dimensions (cm)	70L x 50D x 95H
Weight	73 kg
Nominal Power	2.2 kW

Feature:

- Oil free, Filtered, Corrosion protected, 100% moisture free.
- 50lt tank, with inner antioxidant coating.
- Double-column drier (ES).
- Dr Sonic silenced version with soundproof casing

5.2. Applications

Air compressors transform regular air into denser, higher-pressure air for use in a variety of consumer, professional, and industrial applications. Particularly:

- Construction: Construction sites use large air compressors to power drills, hammers, and compactors. Power from compressed air is essential on remote sites without reliable access to electricity, petrol and diesel as compressed air provides uninterrupted power.

- Manufacturing: Rotary screw equipment can simultaneously power the conveyor belts, sprayers, presses, and packaging.
- Agriculture: Tractors, sprayers, pumps, and crop conveyors are powered by air compressors to complete the farming and agriculture operations.
- Engines: Vehicle engines contain air compressors for heating and cooling, as well as in air brakes for larger trucks and trains.
- Spray Painting: Small air compressors are used in spray painting by powering airbrushes for personal and commercial use. Airbrushes range from delicate desktop brushes for artists to larger brushes for repainting vehicles.
- Energy Sector: Oil drilling relies on air compressors for functionality in the energy sector. Safe and dependable air compressed drilling equipment in oil rig operations is imperative to the safety of the crew.
- Pressure Washing: Compressed air is used to pump high pressured water through pressure cleaners and water blasters for more effective cleaning of concrete floors and brickwork, stain removal, and engine bay degreaser for pressure cleaning.
- Inflating: Air compressor pumps can be used to inflate vehicle and bicycle tyres, balloons, air beds, and other inflatables with compressed air.
- Scuba Diving: Scuba diving is reliant on compressed air with the use of tanks that store pressurized air allowing divers to stay underwater for longer.

5.3. Mechanism

The major steps in the air compression process are intake, compression, integrated storage, integrated cooling, and discharge, although not all compressors need integrated storage or cooling.

1. Intake

The first part of the compression process is air intake. During air intake, air is drawn into the compressor through an air inlet valve. The air inlet valve is often preceded by a filter, which protects the compressor by reducing the contaminants entering it.

2. Compression

The air then flows into the compression chamber where it is compressed. Compression is the conversion of the kinetic energy from the power source to potential energy in the form of pressurized air. Here are two fundamental concepts of a compressor.

Displacement

Compressors compress air through either positive displacement or dynamic displacement (also known as non-positive displacement).

- Positive displacement compressors increase the air pressure by reducing the volume of air.
- Dynamic displacement compressors (sometimes called non-positive displacement) increase the air pressure by first increasing the velocity of the air (directly increasing the kinetic energy of the air), then decreasing the velocity of the air.

Oil Lubricated vs. Oil Free Compressors

- Oil lubricated compressors (sometimes called oil flooded compressors) use oil in the compression chamber to act as a lubricant, a sealant, or a coolant, and often all three. One effect of this is to introduce a small amount of oil into the air stream itself during compression. This may not be desirable, depending on how the compressed air is being used.
- Oil free compressors (sometimes called oilless compressors) do not use oil in the compression chamber, so no oil enters the air stream. That does not necessarily mean no oil is used anywhere in the compression mechanism (e.g. parts like bearings need oil to work properly).

<u>3. Integrated Storage</u>

Depending on the compressor type, the air may flow into an integral receiver tank (sometimes called a storage tank or an air tank) after being compressed.

Many uses of integrated storage are tied to the compressor type and will be covered there. However, two common reasons are shared across multiple types.

- Limited duty cycle compressors, i.e. compressors not designed to run continuously, use integrated storage so that air is available even during the down time.

- Modulating compressors, i.e. compressors with controls allowing them to run below full capacity, use integrated storage so that air is available while running below capacity.

4. Integrated Cooling

Compressing air creates heat. While the air does not have to be cooled before leaving the compressor, most three-phase electric compressors and some diesel compressors come with integrated aftercoolers to lower the air temperature before discharge.

Compressors with aftercoolers will also have water separators to remove the excess moisture that drops out of the air stream during cooling.

5. Discharge

Finally, the air flows through the discharge valve, either directly to the point-of-use (e.g., a chipping hammer on a portable diesel compressor) or to a series of dryers and filters first (e.g., for instrument air in a manufacturing plant).

Macro Thermogravimetric Analyzer

6.1. Specifications

Reactor	Macro Thermogravimetric Analyzer
Model No.	Specific build
Max Temperature	1100℃
Temperature Accuracy	0.1℃
Heating Rate	5℃ / min
Max Flow Rate	150 g/h
Measuring Range	10mg - 320g
Balance Accuracy	0.1 mg

6.2. Applications

By measuring how much a material's mass changes as a function of temperature, TGA is primarily used to describe materials. TGA may be used to assess a substance's, by this procedure and the measurements that can be very precisely deduced from it:

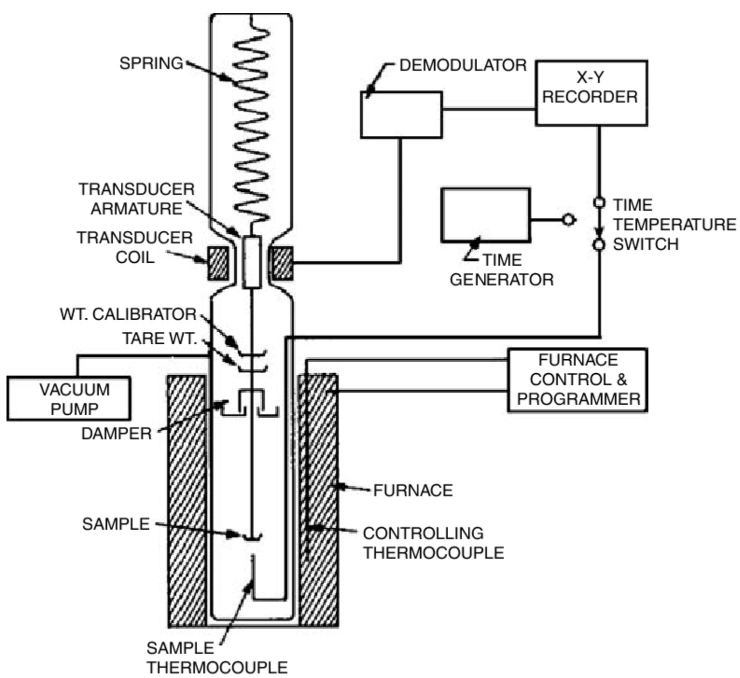
- Mass changes brought on by burning, evaporation, oxidation, or disintegration
- The amount of absorbed moisture
- The rate of material volatility
- The substance's basic fluids or formulations' thermal cracking point

TGA is most frequently used in business and industry to evaluate a product's heat resistance for quality control and safety reasons. For instance, TGA may be used in the following ways by the manufacturing of polymers, plastics, pharmaceuticals, and general goods:

- Quality control and assurance
- Thermal stability determination
- Oxidation and combustion research for product storage and use

6.3. Mechanism

The weight of the sample is recorded on an analytical balance that is retained outside the furnace as it is heated progressively throughout a TGA examination. Mass loss is picked up by TGA if a heat event causes the loss of a volatile component. While physical processes like melting do not cause mass losses, chemical operations like burning can. The weight of the sample is plotted against temperature or time to show thermal transitions in the material, such as solvent and plasticizer loss in polymers, water of hydration in inorganic materials, and eventually material disintegration.



Thermogravimetric Analysis System diagram

Operations:

Step 1: Prepare the sample
Step 2: Put the sample on the balance, use the remote to change the height of the sample in the furnace to get a better result.
Step 3: Creating an environment by pumping N2 gas to the machine through a N2 tank connected to a vault.
Step 4: Change the number on the control board to control the temperature, heat flow r

Parr 6200 Isoperibol Calorimeter

7.1. Specifications

Product Type	Isoperibol Calorimeter
Connector Types	Ethernet or USB
Depth	40 cm
Height	43 cm
Width	57 cm
Memory	Stores 1000 tests
Operation	Manual
Sample Range	52 to 12,000 calories

Compliance	ISO 9001:2008, CSA, CE, ASTM
Display Type	LCD
Operating Time	6 min./Test
Precision	0.05 to 0.1%
Temperature Resolution	0.0001°C
Equipment	Parr™ 1108 Bombs and Closed-circuit Water Handling Systems
Test Time	4 to 7 Tests/hr.

7.2. Applications

A calorimeter is a device used in calorimetry to gauge how much heat is produced or absorbed during chemical or physical processes. It is capable of measuring a substance's heat content, latent heat, specific heat, and other thermal parameters. It has several scientific applications such as:

- Analyze biochemical compounds in blood, plasma, serum, urine, etc.
- In thermodynamics study
- In the study of different materials, such as nanomaterials, zeolites and ceramics
- For assessing the thermal hazard potential of Li batteries
- For examining polymeric materials to determine their thermal transitions
- In solid and liquid fuel testing Waste and refuse disposal
- In the study of liquid crystals

- In the pharmaceutical and polymer industries
- To observe fusion and crystallization events and glass transition temperatures
- Food and metabolic studies
- For propellant and explosive testing
- In educational training

7.3. Mechanism and Applied Theory

A particular kind of constant-volume calorimeter are bomb calorimeters. Instruments are used to gauge the internal energy shift between reactants and products. Large pressures can be withstood by bomb calorimeters while the response is being monitored.

An outer and an inner vessel make up a calorimeter. There is little to no heat exchange between the interior of the inner vessel and the surrounding environment because the air between the two acts as a heat insulator. A fiber ring constructed of an insulating substance is used in lab calorimeters to hold the inner vessel in the middle of the outer vessel. A stirrer is used to agitate the liquid in the inner container in order to evenly spread the heat, and a thermometer is used to gauge the liquid's temperature.

The temperature rises if an exothermic reaction occurs in the calorimeter solution, which releases thermal energy as heat or light. Heat is lost and the temperature drops if an endothermic process occurs, one that takes thermal energy from the environment. The two liquids are in thermal equilibrium if there is no energy transfer between them. The amount of heat the reaction requires may be calculated using the temperature differential, mass, and specific heat of the solution.

The temperature change is used to calculate the enthalpy change per mole of substance A when substances A and B are reacted. The formula is:

$$Q = C_V \cdot (T_f - T_i)$$

Q: the amount of heat (J)
C_V : the calorimeter's heat capacity (J/K)
T_f: the final temperature
T_i: the initial temperature

ASAP 2060 Micromeritics

8.1. Specifications

Temp Range	Ambient to 250°C
Temp Accuracy	+/- 5.0°C
Ramp Rate	10°C
Electrical	100–240 VAC, 50-60Hz

8.2. Applications

Applications included hydrology, geology, chemical engineering, soil physics, and mineral physics. Particle size and form, packing, electrical, optical, chemical, and surface science were some of the characteristics covered. Particularly:

- Release and dissolution
- Absorption and drug action
- Physical stability
- Dose uniformity
- Purification, processing, blending, tableting and packaging of pharmaceutical products
- Ceramics
- Adsorbents
- Carbon black
- Fuel cells
- Catalysts
- Paints and coatings
- Projectile propellant
- Medical implants

- Electronics
- Cosmetics
- Aerospace
- Geoscience
- Nanotubes

8.3. Mechanism

Gas Sorption can be defined as the relative accumulation of mobile gas molecules due to the presence of a more or less static condensed phase, which may be a solid or a liquid. The molecules may accumulate on the surface, at an interface, or in the bulk of the condensed phase.

Molecules of gas arrive at the surface of a solid or a liquid. The molecules may :

- bounce directly off the surface.
- react chemically with the surface, and then
    - be trapped in position.
    - rearrange to make a new molecule, and be released.
- be held at the surface by a weak attractive force, characteristic of "physical adsorption", and then
    - move around on the surface.
    - be released again.
- molecules may meet, and react with each other.
- any molecules on the surface may absorb into the bulk, with a weak physical or a strong chemical interaction.

The number of molecules builds up, until it reaches equilibrium, when the rate of arrival of molecules equals the rate of loss. The time taken to reach equilibrium may depend on

- the arrival rate of gas molecules at the surface.
- the rates of any reactions with the surface, with the bulk, with other molecules.
- the rates of movement, or diffusion, of the molecules
    - across the surface.
    - through the bulk.
    - inside the pores.

All of these effects depend quite strongly on the temperature and the pressure.

Gas chromatography

9.1. Specifications

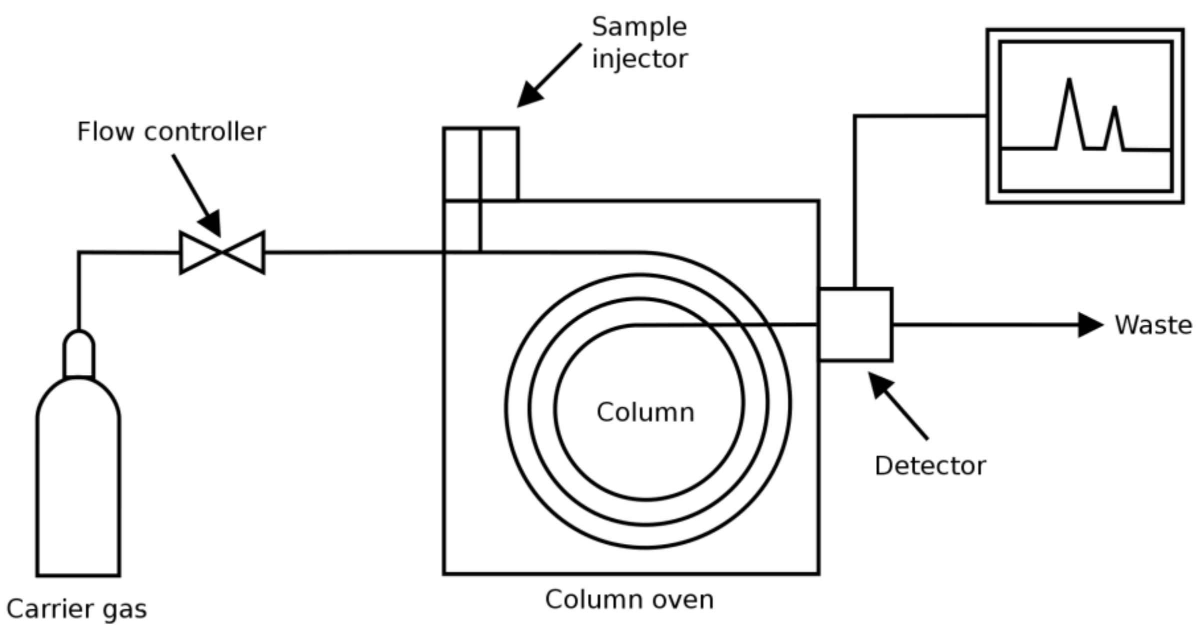
Model	990 Micro GC
Carrier Gas	He, Argon
Channels	4 channels
Detector	Micromachined TCD, dual-channel
Injection Range	1-10µL
Injection Temperature	110℃
Inlet Connection	3.2mm
Maximum Inlet Pressure	100kPa
Oven Temperature	Up to 180℃, isothermal
Sample Inlet	1.6mm
TCD Concentration Range	0.5pm to 100% level

TCD Linear Dynamic Range	10^5 (0.5 ppm to 5%)
Typical Detection Limit	0.5 ppm for WCOT capillary columns 10ppm for Micropacked columns 2 ppm for PLOT columns 10 ppm for Micropacked columns

9.2. Applications

Gas Chromatography is used in gas identification and measurement, testing purity of the sample, quantitative analysis, etc.

9.3. Mechanism



The gaseous or liquid sample is injected into the column by carrier gas (He or Ag). At the end of the column, the sample exits at different times because of the differences in physical and chemical properties as well as the stationary phase going through the column at different rates. This process allows for the separation of compounds in a mixture, separating different components of a mixture.

Conclusion

To conclude, as a result of this practical session, we now have a better knowledge of the basic thermodynamic principle that underlies various laboratory equipment, such as the compressor, thermal gravimetric analyzer, oven, furnace, etc. By doing so, we are better equipped to apply it and know how to use it in the actual world to support our future research.

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