Uranium Enrichment Methods

The three important enrichment methods used for uranium enrichment.

1. Gaseous Diffusion
2. Gas Centrifuge
3. Thermal Diffusion

The input for all the three method is Uranium hexafluoride UF_6 and all the process uses the physical properties of molecules especially the one percent difference of the mass to separate the isotopes.

Uranium hexafluoride reconverted to produce enriched uranium oxide. The main aim is to make it as fissile material by increasing the proportion of fissile uranium U^{235} atoms within uranium.

The uranium to work in nuclear reactor it must be enriched to have 2% to 3% U^{235} .

Gaseous Diffusion

This works on the principle that as U^{235} is lighter will diffuse rapidly through porous barrier than heavier U^{238}

In the gaseous diffusion enrichment plant the solid uranium U^{238} and converted UF_6 is heated in its container till it changes to liquid form.

The container gets pressurised since the gas UF_6 above the liquid level U^{238} compresses. The UF_6 gas slowly fed into the pipelines from where it is pumped through special filter called barriers or porous membrane.

Through small holes in barriers enough room for UF_6 gas molecules to pass through. Isotopes enrichment occurs when lighter gas molecules diffuses faster than weigh molecules U^{238}.

It is not possible to do this diffusion completely with one Barriers. There are hundreds of such barrier are used one after another and gas diffused passing through all the barriers is collected at the end of the pipe lines is UF_6 which is an enriched U^{235} is collected. Thus collected enriched UF_6 is converted as liquid in a cylinder after condensing. These cylinders are than transported to fuel fabrication facilities. Then these converted in to fuel assemblies and served for nuclear reactor usage.

The UF_6 releases chemical and radiological hazards may lead to fatal deaths because of mishandling of radioactive elements. This is due to criticality accident called in advertent nuclear chain reaction.

Always the gas flow from high pressure side to low pressure side.

Whenever gas is separated from a vacuum by a porous barrier of microscopic holes, molecular effusion process occurs due to more collisions with the holes on the high pressure side than the low pressure side.

Gas Centrifuge

This is the common method in which Uranium hexafluoride gas is spun with high speed in a cylindrical chamber. The rotation creates a strong centrifugal force.

This centrifugal force makes the heaviest gas molecules to move towards outwards of cylinder and the lighter gas molecules to move towards inner section of cylinder at the centre.

The slightly enriched with less weight is U^{235} and the molecules collected outward is heavy U^{238} .

The U^{238} is recycled and processed further to extract U^{235}. Such process of completely extracting U^{235} from U^{238} and separating complete U^{238} completely called depleted Uranium.

The denser U^{238} isotopes separated from U^{235} and drawn towards the bottom of the chamber and extracted. The lighter U^{235} isotopes cluster collected at centre. Thus collected U^{235} is fed into the next higher stage centrifuge for further segregation. This process is repeated many times through a chain of centrifuges known as cascading process.

Always the gas flow from high pressure side to low pressure side. The Scottish Chemist Thomas Graham observed that the rate of effusion of a gas through porous barriers was inversely proportional to the square root of its mass. This shows the lighter molecules passes through the barrier faster than the heavier molecules.

Thermal Diffussion

Convection Current

Heat transfer across a thin layer (membrane) is used to separate isotopes . The layer may be liquid or gas. Thermal gradient is achieved by Cooling a vertical film on one side and heating on other side. Due to this thermal gradient convection current occurs. An upward flow of liquid or gas on the hot surface and the down ward flow of gas or liquid along the cooler side.

Diffusion

Under the existence of convection current **Lighter U^{235} UF_6** molecules will diffuses towards the warmer surface and **heavier U^{238} UF_6** diffuses towards the cooler side .

Extraction

The combination of diffusion and convection current causes(made) **Lighter U^{235}** molecules to concentrate on top of the film while the **heavier U^{238}** goes to the bottom. Both **U^{238}** extracted at bottom and **U^{235}** extracted at the top.

The thermal diffusion method was simple and low cost comparatively than gaseous diffusion.

But thermal diffusion method consumes much more energy than gaseous diffusion.