CHAPTER I

INTRODUCTION

1.1 General Remarks

In Thailand, we have monazite, which is the most important source of thorium. Analysis of a few sources of monazite as shown in Table 1.1 (1), shows that there are about 6 - 10 per cent.

In separating thorium from other components in thorium-bearing ores, the ores are first concentrated by a physical process. The next step is to break down the monazite sand and separate (from the gangue material) the thorium, rare earths and uranium contained in the thorium-bearing ores. The separation is accomplished by chemically decomposing the thorium-bearing ores and fractionally precipitating either the valuable elements or gangue. Once the valuable elements (thorium, rare earths and uranium) have been isolated, thorium must be separated from the latter two. The ultimate product is a thorium concentrate which is further purified.

The impurities (2) associated with the commercial concentrates of monazite sand are titanium, iron, silica and phosphate. These impurities are typically present in quantities of about 2 per cent, 1 per cent, 2 per cent, and 25 per cent, respectively. Rare earth content is usually 60 per cent, thorium 6 - 10 per cent and uranium less than 1 per cent. The actual composition of monazite sand depends upon their source and extent of concentration.

Table 1.1[1] Composition (%) of Samples of Monazite as Analysed by X-ray Fluorescene*

Element	Sample from	
	Phuket	Ranong
Ta	0.610	0.720
Th	6.600	8.350
Y	1,560	1.710
Zr	0,303	0.360
Sn	0,330	0.115
La	15.600	14.100
Ce	28.300	26,900
Gd	1.800	1,840
Dy	0,680	0,630

* The analyses were performed by The Physics Division, OAEP.

In separation process, monazite sand must be digested first. Because of trade secrecy, it is not known what method of digesting the monazite sand is now in use commercially, it is probably some variation of the sulfuric acid digestion process as shown in Fig. 1.1[2] which was developed for application in atomic energy program at Ames Laboratory, Iowa State College. On the other hand, the caustic soda digestion process which was developed by Battelle Memorial Institute, as shown in Fig. 1.2[2], has been used in large-scale industrial operation since 1949.

Thorium used in atomic energy must be of very high purity. So, the concentrate, obtained by extracting thorium from ores, containing up to 50 per cent rare earths, must be purified. The process must yield a

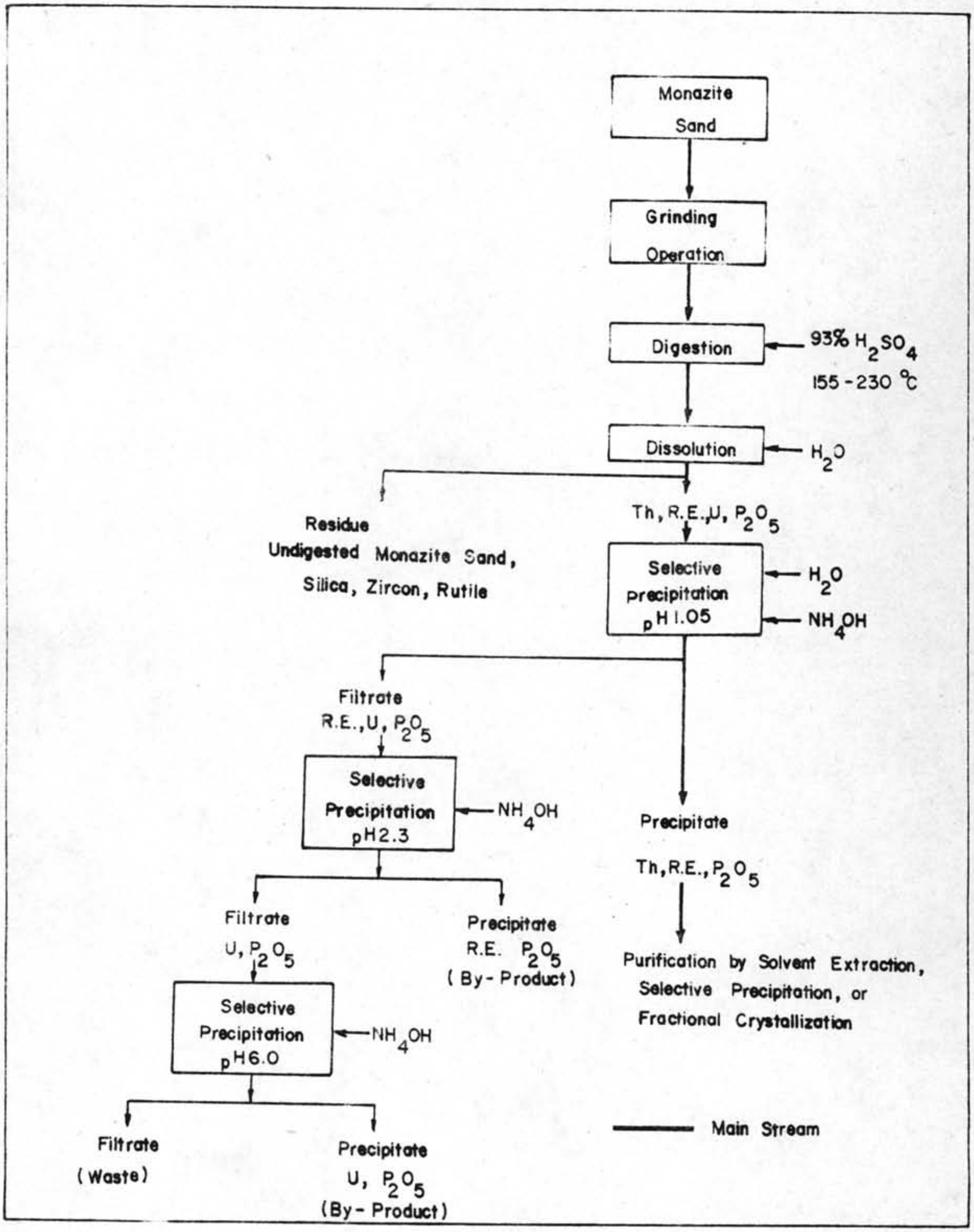

Figure. 1.1 Diagram of sulfuric acid digestion of monazite sand.

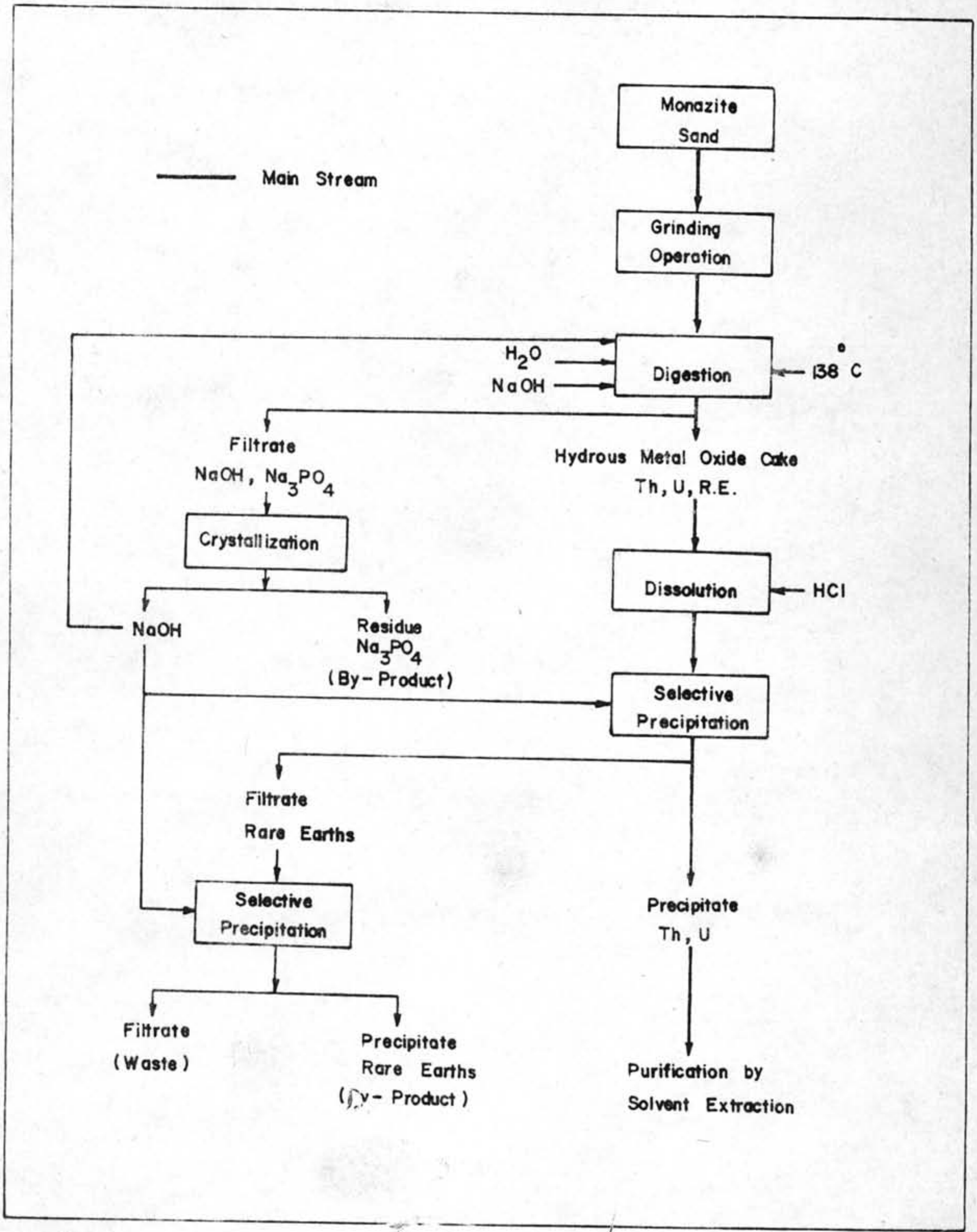

Figure 1·2 Diagram of caustic soda digestion of monazite sand very pure thorium concentrate and high recovery of rare earths and uranium.

Three major methods of purifying thorium concentrate are possible: solvent extraction, fractional crystallization and selective precipitation. According to the literature, fractional crystallization and selective precipitation method are the most common. Requirement of the atomic energy program for continuous, large-scale production of very high purity thorium metal, however, make the solvent extraction process more desirable.

In purification of thorium concentrate by solvent extraction, it is accomplished by bringing a thorium-bearing aqueous phase into contact with an organic solvent, having a strong propensity to dissolve thorium and weak propensity to dissolve the impurities. The thorium is thereby transferred from the aqueous phase into the solvent phase, leaving the majority of the impurities in the aqueous phase.

In a continuous countercurrent liquid-liquid solvent extraction process, the thorium-rich aqueous phase is fed into the operation at the middle or top stage of a vertical column, and the organic solvent phase enters at the bottom of the column. The heavier aqueous phase flows downward through the solvent phase, and leaves at the bottom of the column. The solvent phase rises and is removed at the top of the column. As the aqueous phase travels through the extraction process, it continuously gives up thorium to the solvent phase and continuously comes in contact with solvent containing less and less thorium until it reaches the point at which the fresh solvent is introduced to the operation. A more details may be found in the work by Treybal(3)

Practically(4), aqueous feed solution was prepared by dissolution of a thorium concentrate from the caustic soda digestion process in a concentrated (4N) nitric acid solution. The organic extractant used was 40 per cent tributyl phosphate (TBP) and 60 per cent diluent (kerosene)

The rate at which a component is transferred from one phase to the other depends upon a so-called mass transfer coefficient and upon the degree of departure of the system from equilibrium. The transfer stops when equilibrium is attained,

The mass transfer coefficients are of great importance, since, as they regulate the rate at which equilibrium is approached, they control the time required for separation and therefore the size and cost of the equipment used. In engineering practice, the diffusion coefficient enters into important parameters for mass transport correlations such as the Schmidt and Sherwood numbers.

1.2 Purpose of Research

The purpose of this research was to develop an equipment for measuring the diffusion coefficient. It was, then, used to measure the diffusion coefficient of thorium nitrate in nitric acid and in tributyl phosphate-kerosene solution.

1.3 Scope of Research

An improved capillary cell was to be designed and constructed. The diffusion coefficient of thorium nitrate in the solution would be determined as a function of concentration and temperature in the range employed in industry.