CHAPTER – 6
6.1 DISCUSSION & CONCLUSION

Indian Atomic Energy programme has come of many successful milestones. The programme has delivered a self-reliant capability for design, construction, installation and operation of nuclear reactors such as Pressurized Heavy Water Reactors, Fast Breeder Reactor, etc. Activities on establishing an entire Nuclear Fuel Cycle have been very successfully accomplished. On the basis of achievements so far, this is a unique opportunity for us to move ahead with our own ideas of development of technology and various nuclear scientific works for an economical and successful nuclear energy programme. India has to fall back on its vast thorium reserves for its energy security.

Characterization of Special Nuclear Materials (SNM) in reprocessing plants are of paramount importance, since the input point in a reprocessing plant is first stage in entire nuclear fuel cycle, where the plutonium formed in a reactor is physically measured by chemical
analyses and confirmed with theoretical yields. The methods developed during above research works have been found very useful in characterizing SNMs.

Determination of trace quantity of uranium in plutonium product stream oxide samples by the above-developed method has been found very useful and simple with speed & cost effectiveness. Since major presence of macro quantity of plutonium is pre separated using TTA extraction, this technique makes use of only minimum resin quantity and less column waste volume during ion exchange separation works. The amplifier gain corrections applied have minimized the uncertainties over the mass ratios obtained. Indigenously built thermal ionization mass spectrometer (TIMS-III, BARC, India) has been successfully used for the above purpose by establishing optimum operating conditions and instrumental settings.

The development works also included the optimization of the indigenous TIMS-III for various applications in a reprocessing plant. The internal precision obtained for mass ratios are within acceptable level. External precision for replicate loading is still not to the level of 0.1 % but lies between 0.3% and 2 %. This is under constant review
with minor changes in the basic filament assembly design, ion source geometry and the sample introduction system.

In the field of High Resolution Gamma Spectrometry (HRGS) the above-developed methods are based on intrinsic properties of SNM such as plutonium and uranium, which are measurable in a non-destructive manner and any qualitative analysis can be performed for samples from unknown regions without any sample geometry. To make it quantitative, we have developed techniques with established sample-detector geometry and co-relation coefficients for non-destructive determination of plutonium in various streams. The results of isotopic composition is comparable to established techniques like mass spectrometry except for the isotopic content of Pu\(^{242}\)%. This may be due to computation of co-relation reactor constant developed for Pu\(^{242}\) content based on the formula \[ [242] = K \times [240] \times [241]/[239]^2. \] This ‘K’ factor can be achieved with better bias correction and narrow range correlation tables. The method for Pu content using 129.29 KeV is very fast and enables one to analyze concurrently both isotopics and plutonium content for a given sample in one shot analysis. This simultaneous method is very useful for plutonium product lots where the product information has to be roughly assigned before shipment of material to the end users. The gamma spectrometric method of
determining Europium in plutonium streams is found very useful for application of the technique on special requirements to optimize the process parameters during solvent extraction reprocessing process.

Alpha-particle spectrometry is a very suitable technique for the study of alpha emitting nuclides like uranium and plutonium. When several emissions interfere in the spectrum of a sample, deconvolution techniques and area stripping techniques can be used to obtain more realistic spectral data. Isotopic Dilution Alpha Spectrometry in conjunction with co-relation techniques can provide fast and reliable analytical method for accountability analysis of actinides in a radio-chemical plant. This developed CORAS method avoids the use of more sophisticated or expensive techniques such as mass spectrometry and represents an alternate technique to determine isotopic composition of samples containing alpha-particle emitting nuclides even in the case of very complex spectra such as those of uranium and plutonium samples. Co-relation combined with IDAS (CORIDAS) is regularly applied in our plant for day-to-day accountability analysis of plutonium in both input and product samples. The application of CORIDAS in product stream has been found very advantageous since this method makes use of sub microgram levels of sample and precise results are obtained [Table 4.2.5] with less risk factors of handling plutonium by
analysts. Characterization of SNM like uranium has been carried out for impurity analysis by Inductively Coupled Plasma Atomic Emission Spectrometer (ICPAES) and relevant data are included in the thesis.

6.2 Future Suggestions:

Mass spectrometric analyses need to be speeded up by reducing analytical duration. This is achievable by developing high speed/fast response electronic amplifiers and Secondary Electron Multipliers (SNM) with better multi-collector system. The sample evaporation mechanism on Rhenium filaments offers lot of scope for improvisation of neutral atom-ion chemistry with efficient ionization process. With availability of high end TIMS like MAT-262 and Quadra pole combined TIMS like TRITON one can go for more studies on isobaric interference oriented mass spectrometric determinations where one can completely circumvent the use of other techniques like alpha spectrometry and gamma spectrometry for isotopic determinations of Americium, Neptunium and Plutonium samples.

In future, once, better high resolution ALPHA detectors are available in market, the complex alpha spectrum of different actinides can be well deciphered by the resolved spectra in a more reliable manner with less
cumbersome data reduction techniques. The co-relation technique can be extended in the enrichment uranium field areas such as in enrichment plants and other reprocessing and other radio-chemical plants.

In the field of High-resolution Gamma Spectrometry (HRGS), use of Germanium / High Purity Germanium detectors are posing maintenance problems very often. The detectors need constant cryogenic support to make them functional for efficient use. Work on room temperature responsive semi conductor detectors need to be continued further and ultra high resolution gamma detectors offer solution for deconvolution of the complex X-ray/gamma spectrum of Special Nuclear Materials (SNM). There are spectral regions between 70KeV-110 KeV, 280-330 KeV & 700-900 KeV X-ray /Photon of gamma spectrum which have ample scope to be deciphered for quantitative analytical purpose. Some developments on use of CdTe (Cadmium Telluride) detectors are reported as room-temperature detectors, but still much works need to be pursued to validate the study for quantitative applications.