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REPROCESSING CONSIDERATIONS FOR A DEVELOPING COUNTRY

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1. Introduction

During the discussions in the Sub-Group A Meetings of INFCE Working Group 4, papers on base case and national reference case reprocessing plants have been presented which essentially deal with large size pertaining to developed countries taking advantage of economy of size. During the meeting of the Sub-Group 4A at Tokyo, it was decided that the Indian delegation should be invited to contribute a paper describing how a reprocessing plant in a developing country differed from the base case. Accordingly this paper has been prepared which, among other aspects, discusses the circumstances which may favour smaller plants in other countries. Technical information with respect to a 100 t U/yr national plant, on similar lines as indicated in the paper Co-Chairmen/WG.4/33A Rev.2 entitled "Summary Table of Base Case and National Reference Case Reprocessing Plants" is also presented in the table annexed to this paper. Perhaps this information could be included in that Co-Chairmen paper to serve as a comparison.

2. Reprocessing Alternatives

During the deliberations of the Working Group 4 of INFCE, various alternatives for treating the spent fuel have been suggested significant among which are :

(i) Store indefinitely without reprocessing;

(ii) Reprocess but do not separate uranium from plutonium (coprocessing);

(iii) Reprocess to obtain separated uranium and plutonium;

(iv) Reprocess to obtain partially decontaminated plutonium.

The first alternative may be ruled out primarily on the consideration of limited storage capacity for spent fuel and resource utilisation. In addition, sufficient experience in the long term storage of spent fuel is yet to be derived. From considerations of radiological health and safety, it may be preferable to manage the high active fission product wastes in solid form after reprocessing the spent fuel.

The second and third alternatives are similar in the chemical processing approach, but differ only in the end products. Coprocessing of uranium and plutonium with a view to obtaining desired end products has not been established as yet commercially. In addition, the main constraint for this alternative is the amenability of the end products for manufacture of fuel to required specification, as most of the present fuel fabrication plants prefer to take well characterised UO_2 and PuO_2 powders for this purpose. Also tight tolerances on the fissile content have to be achieved to prevent power peaking in the reactor.

In the case of the fourth alternative the contaminated plutonium end product will be highly radioactive. This would require the development of sophisticated remote handling technology for fabrication of plutonium fuels. This will result in heavy economic penalties, which may be difficult to justify.

3. <u>Considerations for plant sizing and location.</u>

The optimum capacity of a reprocessing plant is a function of the parameters specific to the country in which it is located, prominent among them being the quantity of spent fuel from the installed nuclear capacity, transport network and environmental conditions. The scope for sizing and siting of the reprocessing plants extends from small plants attached to each power station to large scale central plants catering to many power stations. It may not be always feasible to have package plants at every reactor site due to limitations associated with the capacity of the environment to accept discharge of liquid and gaseous radioactive wastes from reprocessing plants in addition to those discharged from nuclear power stations. However, wherever possible an on-site plant would be preferable because it obviates the necessity of transporting irradiated fuels over long distances and will also enable better utilisation of infrastructure. As an example, while India has a fairly extensive railway network, the existence of different gauges of railways imposes limitations for rail transport due to transhipments involved. This is further aggravated by the already heavy goods and passenger traffic on existing railway lines. Similarly, though there is a wide network of roadways existing, its development is not uniform all over the country and cannot be relied upon for long distance transportation of spent fuel. Even sea transport to coastal sites presents problems in view of the crowded harbour facilities.

It, therefore, becomes necessary that in each instance a feasible mode of transport needs to be worked out. These factors, coupled with the growth of installed capacity of nuclear power stations planned, make it necessary to consider smaller capacity reprocessing plants in the range of about 100 to 200 tonnes per year located at reactor sites to the extent possible.

It should be realised that economy of scale has its limits and optimum size varies from one country to another. With smaller plants there is scope for better utilisation of reprocessing capacity. Also by constructing such plants sequentially, operational experience could be ploughed back to effect technological improvements in the new plants which would otherwise impose significant cost penalties in the case of larger plants. Further smaller plants built on different sites would reduce the quantities of radioactive wastes generated at one site which is more easily manageable.

4. Reprocessing need in Indian nuclear power programme

The need for tapping power from nuclear fuel in India is urgent and its contribution to the total electrical power generating capacity in areas away from coal fields will have to be substantial in the coming years. However, the limitations in the extent of natural uranium resources available call for efficient utilisation of the same within the constraints of economy and technological capability. The Fast Breeder Reactor which is known to enhance the utilisation of uranium by orders of magnitude, therefore, seems to be an obvious choice under such conditions. In view of the modest resources of uranium and large reserves of thorium in India, to extract maximum energy possible, the strategy of nuclear power development has been to instal natural uranium, heavy water moderated reactors to start with, followed by fast breeder reactors in the next phase. To pursue this objective, it is essential to produce adequate quantities of plutonium in natural uranium reactors to make it available for fuelling the fast breeder reactors.

Thus, the development of reprocessing technology is essential for India. Expertise in this field exists in the country and two reprocessing plants have been built with indigenously developed knowhow.

5. Reprocessing experience in India and future plans

In India, the first fuel reprocessing plant at Trombay to process aluminium clad natural uranium metallic fuel from research reactor, was commissioned in 1964. This plant is undergoing partial decommissioning at present for effecting modifications to increase its capacity. It is also encouraging to note that the effluent discharges to the environment from the operation of this plant at Trombay have been small compared to the allowed safe recipient capacity of the environment. Another plant capable of reprocessing oxide fuels of light water and heavy water reactors of a nominal capacity 100 t U/yr has been built at Tarapur which is undergoing initial trial runs. The end products of the plant are uranium and plutonium oxides. The conversion facilities are built as integral parts of the reprocessing plant. The experience with these two plants so far has shown that it is possible to construct smaller capacity plants economically with costs, both with respect to initial investment as well as operating costs, much lower than the indicative reprocessing costs elsewhere in the world. A reprocessing plant of size similar to the Tarapur plant is being designed for construction at Kalpakkam near Madras in southern India.

Since a substantial portion of the expenditure on the Tarapur plant has been incurred before the steep rise in costs during 1973-74, the overall capital costs have been considerably lower. The cost of reprocessing per kg of uranium in this plant works out to about US $ 90, including the conversion of uranium and Pu to their respective oxides, but excluding spent fuel transport and waste management. It is estimated that an updated plant of similar capacity built taking 1978 costs will result in a unit reprocessing cost including conversion which is about double that for the Tarapur plant. It could be seen that these unit reprocessing cost figures are much lower than those indicated for large size plants in developed countries.

Major factors which contribute to such comparatively lower cost figures in India even for smaller plant could be (1) basic differences in the capital as well as operating costs arising out of wide differences in the skilled labour cost which is lower in India by an order of magnitude and the appreciable difference in construction cost; (2) difference in engineering and commissioning costs; and (3) differences in the type of financing - lower fixed charge rate corresponding to government financing.

6. General remarks

From the above it will be clear that the considerations that govern the decisions regarding the capacity of reprocessing plants are basically different, at least for the time being, between developing countries and the developed countries. The lower or even comparable unit reprocessing cost may be achievable with plants of lower capacity compared to plants of much larger capacity in developed countries. For example in India it is expected that in the near future it will not be either economical or technically advantageous to set up reprocessing plants larger than 100 to 200 t U/yr.

In the context of the argument that services of large facilities available in developed countries should be utilised taking advantage of economy of size, it is pertinent to point out that this is not universally applicable. The Tarapur reprocessing plant has been built specifically to reprocess the spent fuel from the Tarapur and Rajasthan Atomic Power Stations. As the cost figures indicate, this plant can reprocess these fuels economically and there is no need to avail of the larger facilities available in other countries.

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Annexure

National reference case reprocessing plant

(For inclusion in paper: Co-ch/WG.4/33A. Rev 2)

TOPIC		INDIA
1.	Process	Chop/leach, Solvent Extraction
2.	Design Capacity	0.5 t/d
3.	Plant availability	200 d/y
4.	Commercial programme	100 t U/y
5.	Maximum fuel burn-up	20,000 MW d/t
6.	Fuel cooling time	0.5 y (minimum)
7.	Mode of operation	Continuous on shift
8.	Spent fuel reception buffer storage	100 t U
9.	Uranyl nitrate buffer	Stored as oxide
10.	Plutonium nitrate buffer storage	Stored as oxide
11.	HA Waste concentrate storage	1000 m^3
12.	MA aqueous waste storage	2000 m^3
13.	MA organic waste interim storage	200 m^3
14.	Cladding and structural material	0.6 - 0.8 m^3/t U
15.	Ion exchange resins and iodine absorbers	1 m^3/y
16.	Off gas and exhaust air filters	100 m^3/y
17.	Pu contamination materials eng. wastes and decontamination materials	-

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TOPIC	INDIA
18. Services Cooling water Electricity Steam	 8×10^4 m^3/yr 1×10^7 kwh/y 5×10^4 t/y
19. Maintenance philosophy	Remote maintenance for highly active mechanical equipments. Contact maintenance for chemical process units.
20. Selection of major equipment	Element bundle shear Batch dissolver Pulse column extractors Mixer settlers for solvent treatment
21. Ventilation philosophy	Areas classified and held under negative pressure. Pressure gradient ensures airflow pattern from lowest contamination region to higher contamination region. Iodine and Krypton levels are monitored.
22. Safeguards and physical protection	Material accountancy, containment a nd surveillance measures applied, Strict control of movement of materials.
23. Safety philosophy	Same as base case.