# Challenges in Developing Indigenous Technology

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**R.D. Kale , Formerly, Associate Director IGCAR, Kalpakkam**

Until late seventies there have been little emphasis and effort placed on developing critical technologies though know how transfer was already in existence in the Departments of Atomic Energy and Space for some time. With the advent of an ambitious programme of nuclear power reactors, that of satellite launch vehicles and the well known integrated guided missile development programme or IGMDP of DRDO “indigenisation” became a key Mantra in all above departments pursuing high technology areas. While this was fraught with many problems and challenges it was yet inevitable in key technological areas such as sodium cooled fast breeders where there was little choice if at all for importing such technologies. Having been associated with such projects as prototype fast breeder reactor from early eighties I would like to present my views on the indigenisation efforts on the then emerging high tech areas based on my own experience and that of my colleagues in IGCAR. The challenges to overcome in the indigenisation process can be broadly classified under three categories, viz technological, industry limitation and procedural, the last one refers in particular to tendering and contracting under government regulations. The nature of these challenges can be best understood by discussion of some examples in the technologies encountered.

# Technology of liquid sodium pumps

Fast reactors use liquid sodium as heat transport medium to convey the nuclear heat to steam generators by circulating sodium in their primary and secondary heat transport circuits. For the Prototype Fast Breeder Reactor or PFBR, gigantic sodium pumps are used to circulate 15500 CuM/h sodium flow consuming 3400 KW power at a high operating temperature of 400 in their primary circuit. Similar pumps are also needed in the secondary circuit. Such pumps are made by few select western countries and not available for import being deployed in sensitive/strategic technology. The major challenge in the pump hydraulic design lay in achieving high cavitation erosion resistance while keeping pump diameter as compact as possible. Here was a challenge never faced by Indian pump industry till then. A development project had to be conceived in collaboration with a reputed pump industry and hydraulic tests were initially conducted on smaller models initially to study parametric effects to arrive at a suitable impeller and diffuser before constructing a 1/ 2.75 scale larger model pump. For studying cavitation erosion effects not only visual observation of cavitation in the impeller was necessary but also a suitable paint had to be developed for the assessment of impeller erosion in short term water tests. Again the suitable paint developed in the western world could not be accessed a separate collaboration with BHEL had to be entered who were familiar with such processes for cavitation study in hydraulic turbines. Cavity lengths developed in the impeller were observed and later measured under stroboscopic light in transparent shroud model .This was carried out for varying suction pressures and was later correlated with eroded paint areas of the impeller to determine the point of maximum erosion and its exclusion from the operating states of the pump.

Another challenging aspect of the pump design was its ability to accommodate differential thermal expansion during its high temperature operation. A unique single point tilting pump rotor concept was evolved in which the vertical pump rotor assembly takes a small inclination of 0.4 degree supported by a spherical bearing as the pump passes through a temperature range until it reaches its operating temperature. A hydrostatic sodium lubricated bearing at the bottom of the shaft guides the rotor safely. The concept had to be validated on a near full scale rotor assembly measuring 7.5 meter before finalizing the pump mechanical design. The complete development of the primary and secondary pumps spanned over two five year plan periods with major participation from IGCAR, M/s KBL, FCRI Palghat among others.

# Steam Generator tube to tube sheet welding

A very different technological challenge was faced in procuring 23 meter long and slender seamless tubes in 9Cr. 1Mo ferritic steel. These seamless tubes are a must for the fabrication of sodium heated steam generator to avoid a weld in the middle of the tubes for improving the reliability of the unit against a violent sodium water reaction. The Nuclear Fuel Complex was till then producing shorter tubes but they successfully came through this challenge and produced these tubes which had to pass eddy current examination as one of the important specification to exclude any inclusion. The tube material was produced by vacuum induction melting and further refined by electro slag process. Then there was a further challenge of achieving high quality butt weld between the tubes and the tube sheet provided with machined spigots for the purpose. This weld had to meet 100% volumetric examination which could be carried out only by micro focal rod anode x ray equipment. The welding itself had to be performed by internal bore welding with pulsed TIG welding. The acceptance criteria specified for these 2.3 mm thick weld was isolated porosity of 0.4 mm maximum and a cumulative pore diameter of 5 mm over a weld circumference of 53 mm. The weld concavity and convexity both had to be limited to 0.3 mm, very challenging indeed. Special welding sequence with preheating and different high pulse levels of current had to be followed to achieve the first ever 25 m long 19 tube model steam generator. The unit has been thoroughly tested over nearly 10 000 hours in a specially constructed Steam Generator Test Facility.

# INDUSTRY LIMITATIONS

When the programme of sodium pump development was launched, it was clear that no Indian pump industry could take up the pump design and development in its entirety. This was because the pump design involved high temperature mechanical design and heat transfer considerations from hot sodium, besides a finely tuned hydraulic design. No pump industry was prepared to take up responsibility for an integral design and development. Attempts were also made by opening a dialogue with a reputed pump industry working with NPCIL projects as well as with SERENA/ FASTEC combination of European industries in the fast reactor field but to no avail. Hence the development programme was launched with Indian industry taking up hydraulic design to meet our specifications coupled with in house efforts (IGCAR) for the rest of the pump design and development. The in house efforts were devoted to design the ten meter long pump shaft for high operating temperature, the bottom hydrostatic sodium lubricated bearing among other components, and developing manufacturing technology for the long shaft of composite solid and hollow forgings, hard facing of bearing parts and a special float type non return valve , the last one being designed in collaboration with FCRI, Palghat.

Limitations were also recognised in the manufacture of the steam generator test model measuring 25 meter in height and 0.3 m in diameter. Here was necessary a close co ordination in procuring long seamless tubes from NFC, thick 9 Cr 1 Mo tube sheets and plates from Midhani, to supply in time bound manner all free issue materials to main SG supplier, L&T. Tremendous efforts on the part of designers were called for to coordinate with industrial groups as all above raw materials were being made to the stringent specifications for the first time here. The efforts placed in the steam generator did not stop here as considerable more work with industry was required to put in place a successful design of a conventional fired heater the major challenge being the heat transfer medium which was liquid sodium necessitating extra ordinary material surveillance and inspection e.g. helium tightness of all the welds.

# Challenges faced in awarding contracts

In the case of sodium pump a dialogue was initiated with pump industries both Indian and foreign for evolving suitable hydraulic design through a two stage process. The first step involved constructing a 1/ 3 model and the second consisted in building a full scale “hydraulic prototype” to cover adequately the scale up from successful model results. Considerable efforts were devoted in convincing the Department (non-technical) authorities to accept such a tender as the actual full sized pump was to be separately built for the project later. Positive replies to the communication from IGCAR were treated as prequalification bids after satisfactory bidder assessment. Following a three stage technology contract tendering (first time in the Department) bids were formally invited on a limited tender basis. The stages included a) technical b) commercial without price and c) price. The order placement was preceded by a detailed techno commercial dialogue and negotiation over a period of one and a half year, the order being approved by a high level committee that included secretaries in the department, in addition to Director and senior technical personnel. The whole process from the initial technical query to ordering stage took nearly four years where as the two stage development took another five years. A further period of five years became necessary for additional development contract subsequent to a revision in the pump design that had to be evolved with the number of pumps being halved and made as compact as possible to suit a revised primary circuit design from economic considerations. Much more canvassing and convincing act had to be carried out to pilot the project further.

In the case of steam generator technology it was equally important to design and construct in a time bound manner a test facility simulating all operating conditions of the actual plant. Towards this a 5.7 MW test facility was constructed on war footing in order to freeze the steam generator detail design for PFBR. The 25 meter tall, 0.25 meter diameter 19 tube unit was accommodated in a 36 meter tall high bay with rest of the systems located in a smaller building. The vendors for the fabrication of SG model, the fired sodium heater and the feed water pump of unique high head (170 bar) and low flow of 10 CuM/ h were selected after considerable pretender technical dialogue and careful deliberations during the tendering stage. Vendors’ reputation and their capability to effect timely deliveries were given enough importance. EPC packages for steam –water system, fired heater and control-instrumentation proved extremely useful even in this project of R&D nature. An important feature of the periodic project review was inclusion of accounts officer in every meeting to keep them abreast of importance and urgency of certain procurements and to effect expeditious release of payments in all works contracts. Emphasis on fast communications was a hall mark in running this project especially were used e mail communications introduced then recently(1998 onward) The steam generator facility was a success story of the task forces set up at different levels in IGCAR. All above considerations helped immensely in achieving this project without cost overrun though the project took six months more for its completion than the allotted five year period. This article has attempted to bring out the technological and other challenges met with in developing technology indigenously. The contributions of many of his former colleagues both junior and senior have been made use of in preparing this article and gratefully acknowledged.