Knowledge Management in Fast Reactors and related Fuel Cycles

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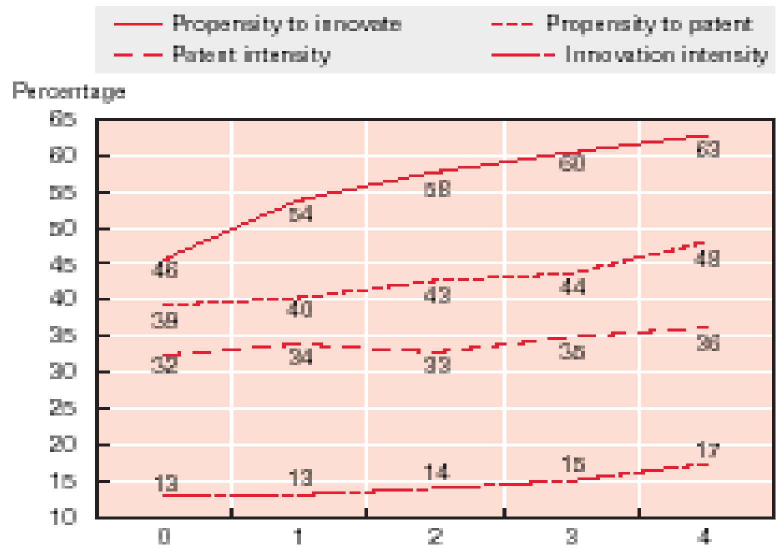
For Countries in the vanguard of the world economy, the balance between knowledge and resources has shifted so far towards the former that knowledge has become perhaps the most important factor determining the standard of living more than land, than tools, than labor.

-World Development Report 1998

Others' Experiences

- A French study which covered about 5500 firms shows that KM practices matter for innovation , productivity and performance.

Figure 3. Knowledge management intensity and innovation performance



Key: all things being equal, the companies without any KM policy have a 46% propensity to innovate compared to the companies rolling out the four policies that have a 63% propensity to innovate.

Source: *Measuring Knowledge Management in the Business Sector: First Steps*, OECD, 2003.

Nuclear Knowledge Management

- Like any other highly technical endeavor, the use of nuclear technology relies on the innovative creation, storage and dissemination of knowledge.

- The nuclear energy sector is characterized by long time scales and technological excellence.

- The early nuclear power plants were designed to operate for 30 years, but their service life is now expected to be 50-60 years. Decommissioning and decontamination of nuclear plants may take a few more decades, resulting in a life cycle in excess of 100 years.

- This gives rise to challenges like retention of existing skills and competences for a period over 3 generations and development of new skills and competences in the areas of innovative reactors, relevant open and closed fuel cycles, decommissioning and radioactive waste management.

- Then Director General of IAEA, Dr.Mohamed ElBaradei, in his statement to the 47th regular session of the IAEA General Conference in 2003 said, “whether or not nuclear power witnesses an expansion in the coming decades, it is essential that we preserve nuclear scientific and technical competence for the safe operation of existing facilities and applications.

- Effective management of nuclear knowledge should include succession planning to the nuclear workforce, the maintenance of the nuclear safety for operational reactors and retention of the nuclear knowledge accumulated over the past six decades”

- In the *"International Conference on Knowledge Management in Nuclear Facilities held in June 2007"*, Dr.Yury Soklov, Deputy Director General and Head of Nuclear Energy of the International Atomic Energy Agency, opined that managing, preserving and building on the knowledge that has been accumulated is ***both a short term and long term necessity and an important inter generational responsibility.***

- Nuclear energy is benefiting the human mankind in addition to contributions in the areas of human health, agriculture and industrial applications. Today, 1.6 billion people in the world are without access to electricity and 2.4 billion rely on traditional biomass for cooking and heating because they have no access to modern fuels.

- In recent years, there is a rising expectation for nuclear power as a source of electricity. This rise is driven by a number of factors. The rapid growth in energy demand becomes the main factor while climate change concerns have highlighted the advantages of nuclear power in terms of its minimal greenhouse gas emissions. The sustained nuclear safety and productivity records over the past twenty years have made nuclear operating costs relatively low and stable.

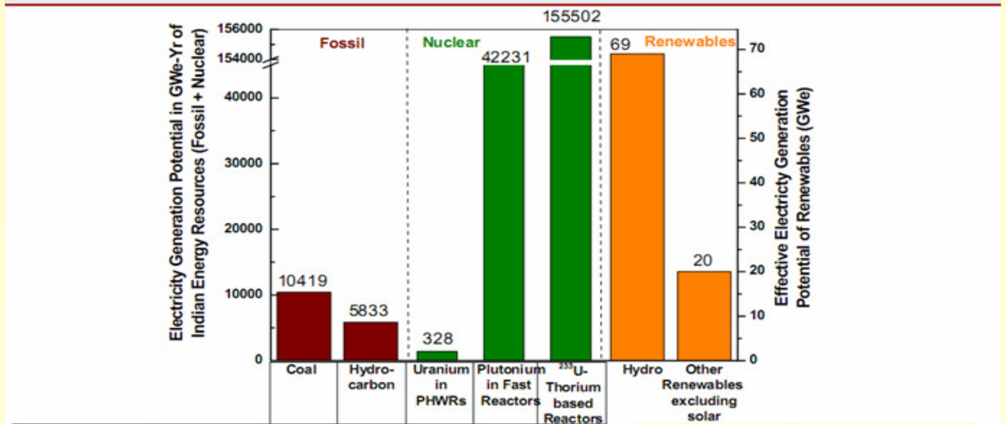
Need for KM contd..

- In order to assess innovative ideas objectively, it is essential to preserve scientific knowledge and historical experiences of a wide variety of reactor systems that have been designed and tested.

- Only a select few nuclear reactor types have survived to be commercially successful. There are many innovative concepts that are still awaiting commercial demonstration such as thorium fuel, heavy metal coolants, liquid fuel reactors etc. There is also a list of concepts that have been abandoned such as carbonic acid, organic and dissociating gas coolants.

- Knowledge related to why some concepts were considered attractive at different stages in the 60 year history of nuclear power and why some were dropped is of great value to the future designers and innovators of nuclear systems so that they need not have to relearn the hard way.

Indian energy resources and Nuclear Contribution



Years of depletion for electricity generation by single source		Coal	Hydro-carbon	Uranium in PHWRs	Plutonium in Fast Reactors	^{233}U-Thorium based Reactors
	Current rate (697 TWh)	130	*	4.12	211	>1950
	2052 rate (7957 TWh)	11.5	*	0.36	18.5	>170

Total Solar collection area required (based on MNES estimate 20 MW/km^2) :
At current rate- >>3900 sq. km
At 2052 rate- >>44650 sq. km

*: To be preferentially used in transport sector

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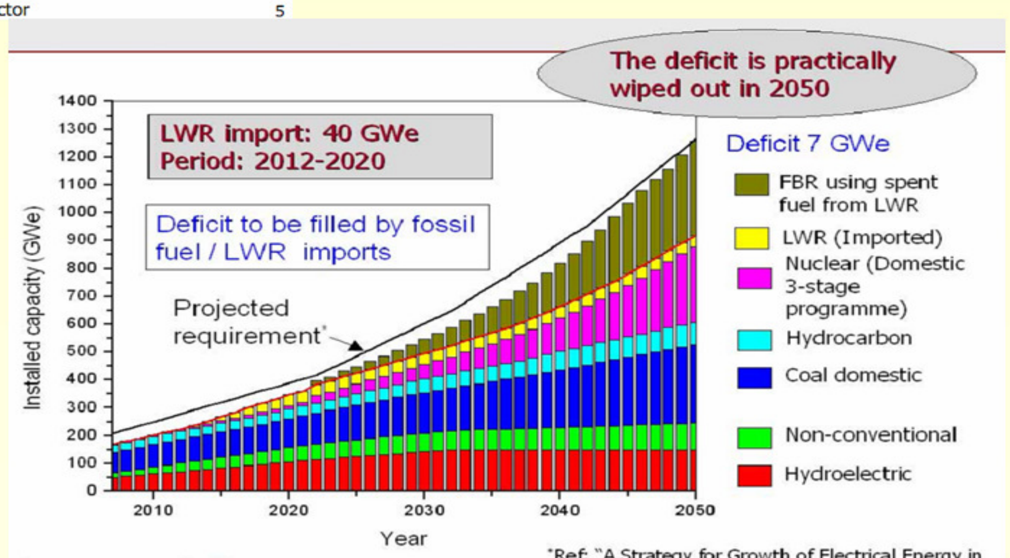
Current Indian Energy Resources

(Ref : A Strategy for growth of Electrical Energy in India, DAE, 2004; Coal data from Report of the Expert Committee on Road map for Coal Sector Reforms)

Strategies for

Long Term Energy Security



* - Assuming 4200 kcal/kg

*Ref: "A Strategy for Growth of Electrical Energy in India", document 10, August 2004, DAE

Mission of IGCAR

- ✓ *To conduct a broad based multidisciplinary programme of scientific research and advanced engineering development, directed towards the establishment of the technology of Sodium Cooled Fast Breeder Reactors (FBR) and associated fuel cycle facilities in the Country.*
- ✓ *The mission includes the development and applications of new and improved materials, techniques, equipment and systems for FBRs.*
- ✓ *Pursue basic research to achieve breakthroughs in fast reactor technology.*

Vision Statement

To be a global leader in sodium cooled fast breeder reactors and associated fuel cycle technologies by the year 2020 AD

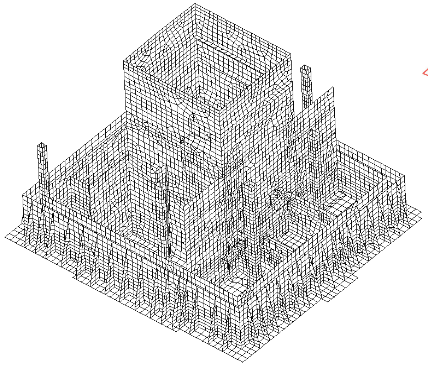
"Knowledge Management will never work until organizations realize, it's not about how you capture knowledge but how you create and leverage as one of the foundation blocks for defining and implementing knowledge management policy."

Knowing it's importance, at IGCAR, the stress has been on successful creation of knowledge through intense research and development and leverage it successfully to achieve Mission of the Centre through proper knowledge sharing and dissemination.

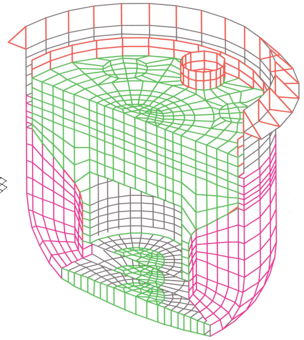
SEISMIC DESIGN

- Development of seismic design criteria
- Analysis of nuclear island connected buildings (NICB) and also extract floor response spectra at various component support locations
- Seismic analysis of reactor assembly to derive seismic forces
- Investigation of buckling of thin shells

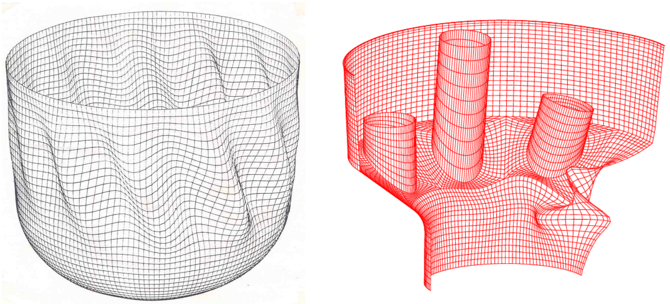
- Ensuring the reactor scramability
- Investigation of pump seizure
- Shake table testing for validation of analysis and qualification
- Long term R&D: behaviour of bearing, non-linear sloshing, parametric instability of thin shells, study of cliff-edge effects, fluid-structure interaction of perforated structures



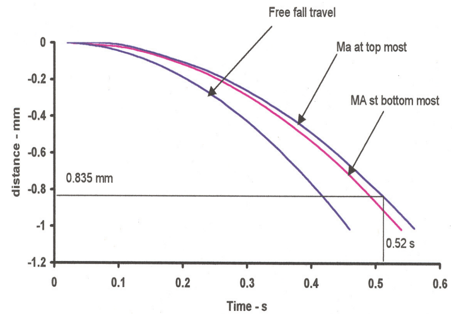
NICB model for seismic analysis



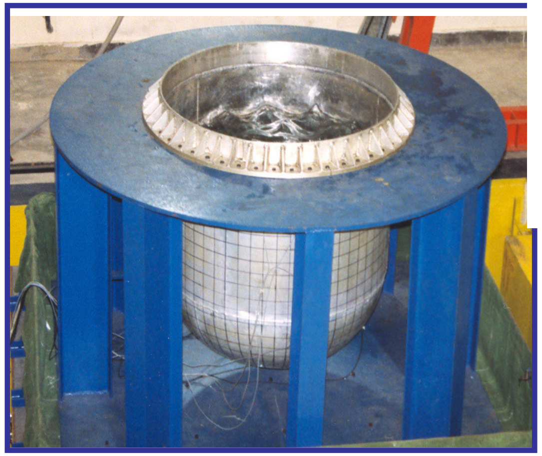
FEM model of RA



Buckling modes of thin vessels



Drop time of absorber rods

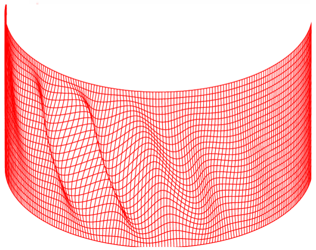


Shake table tests on RA model

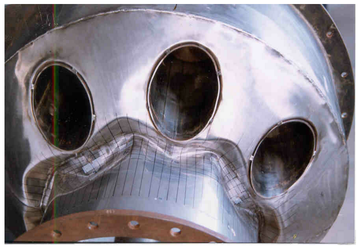
Thickness H - mm	No of tests	Imperfection δ/h	Buckling load - t	
			Test	FEM
0.8	4	2.2 - 3.8	33-54	28-32
1.0	4	1.1 - 4.2	50-69	42-56
1.25	4	1.2 - 3.4	60-73	72-99

Loading	Tolerance mm	Test	FEM	Test/ FEM
Pressure P MPa	-2.7 to 1.7	0.9	0.95	0.95
Axial force F- t	-2.9 to 2.5	1.61	1.40	1.15
P plus F	-1.8 to 1.4	0.175 & 1.18	0.151 & 1.18	1.16

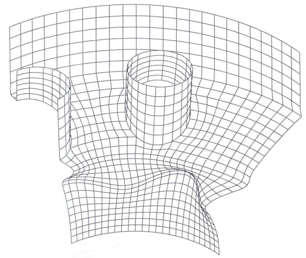
Experiment



Theory

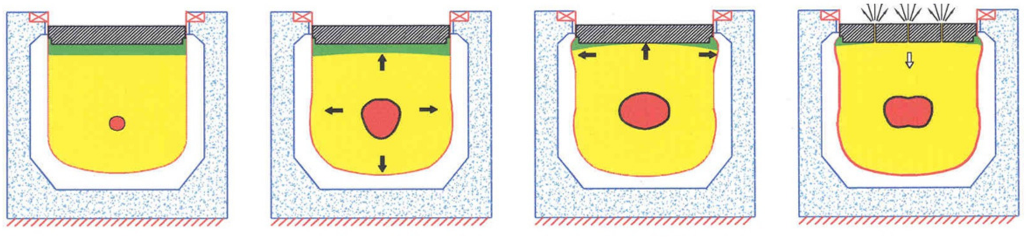


Experiment



Theory

ANALYSIS OF SHOCK-STRUCTURE INTERACTION: HIGHLIGHTS

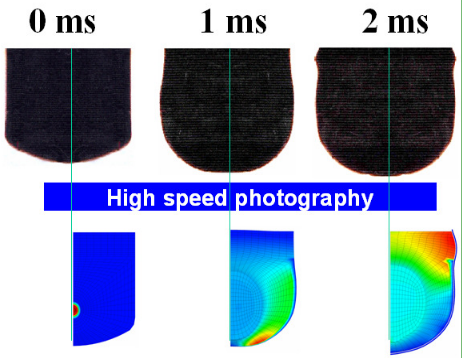


(a) Initial state : 0 ms (b) Vessel pulldown : 0 - 50 ms (c) Slug impact : 100 - 150 ms (d) Final state : 150 - 900 ms

Mechanical consequences of Core Disruptive Accident (CDA)

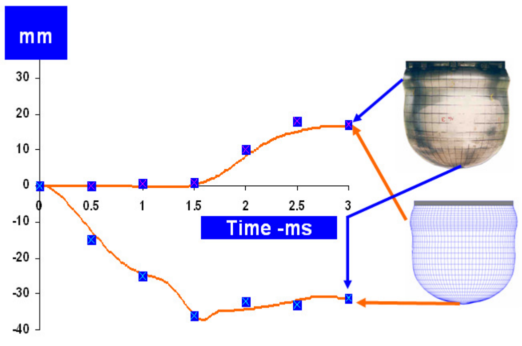
- Complicated loading scenarios on the vessel & top shield have been realistically simulated
- A series of ~65 tests have been conceived in a novel way and successfully completed at Terminal Ballistic Research Laboratory, Chandigarh over the period of 4 years
- Sophisticated instrumentations were deployed to derive extensive data for investigations.

Core Disruptive Accident (CDA) is a beyond design basis accident . Nevertheless, it is analysed in detail to meet the safety criteria postulated for PFBR



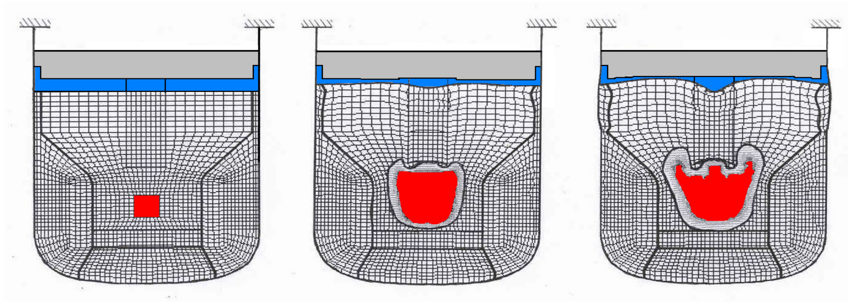
High speed photography

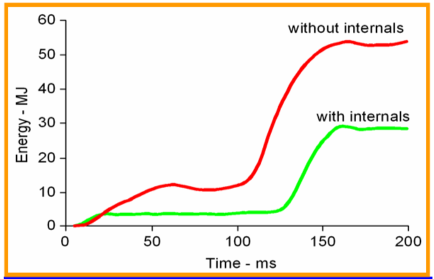
FUSTIN Prediction



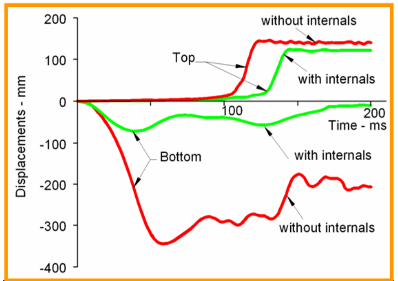
Main vessel deformation predicted by FUSTIN

Validation of computer code FUSTIN





Energy absorbed by main vessel



Main vessel deformations

Structural integrity analysis of PFBR RA under CDA

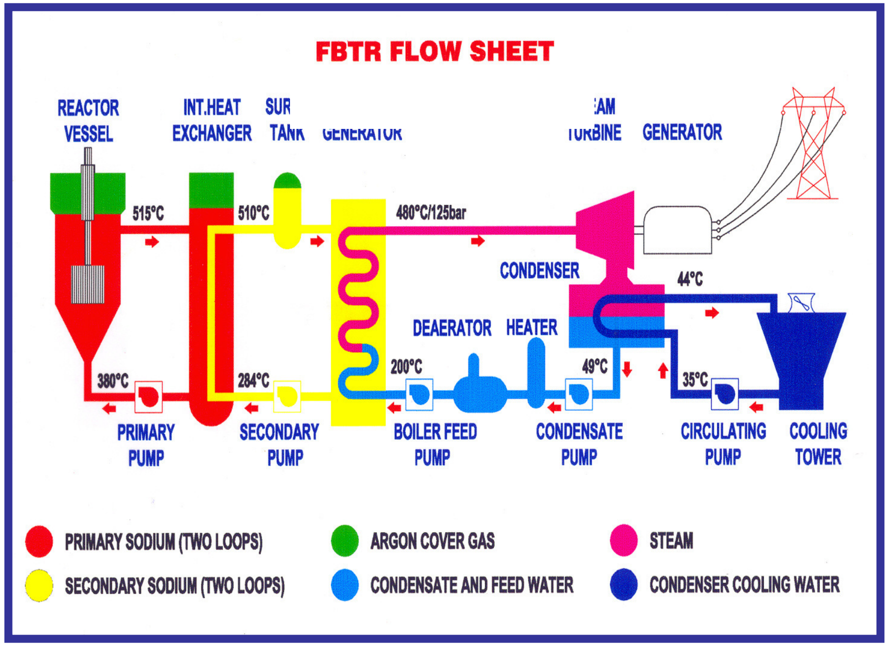
Before Test

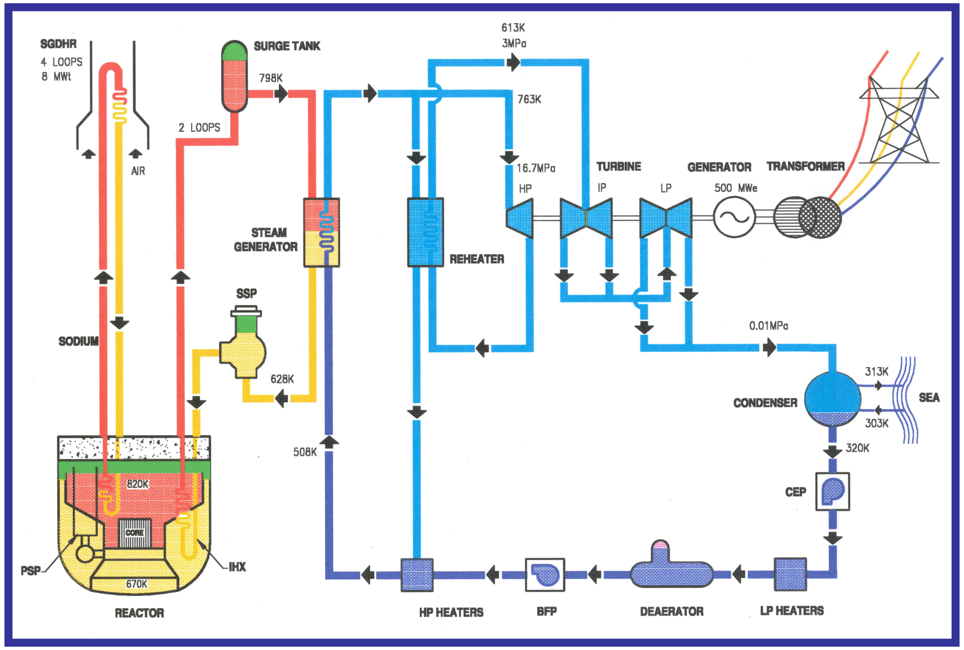
After Test

It demonstrates that MV can withstand 1200 MJ energy

Demonstration of structural integrity by tests

Approach to Big Leap in FBR Programme





FBTR

40 MWt

13.5 MWe

Loop type

Fuel: PuC - UC

- 400 r-y worldwide FBR operational experience
- Rich experience with MOX fuel
- 30 y of focused R&D programme involving extensive testing and validation
- Material and Manufacturing Technology development and demonstration
- Science based technology
- Peer Reviews
- Synergism among DAE, R&D Institutions and Industries

PFBR

1250 MWt

500 MWe

Pool Type

Fuel: UO_2-PuO_2

Incidents of Fast Breeder Test Reactor

- Fuel Handling Incident
- Na-K leak from secondary cold trap during commissioning
- Fall of capsule transfer gripper (TG) in Reactor Control Building
- Lightning induced Failure of Electronic Cards of various Systems
- Sodium leak from the sodium sampler in secondary sodium system
- Ruggedisation of Safety Critical Embedded System

- *The incidents have been analyzed, knowledge accrued, corrective action taken and disseminated so effectively that none of these incidents have recurred in more than 20 years of successful operation of FBTR.*
- *The knowledge has been disseminated in India and Internationally.*

Reflection of Guide Tube in Sodium

Guide Tube Cutting Machine Being Installed

Knowledge Management in Sodium Technology

Charging of Sodium Bricks in Melter Tank

Large Component Test Rig Cover Gas System

5.5 MWt Steam Generator Test Facility

Knowledge generated at IGCAR

- **Sodium handling was started in glove boxes, sodium transfer in small quantities to tanks, test loops for Electro Magnetic (EM) pumps.**
- **Initially sodium (150 t) was handled in brick form before purification for FBTR. Now 1750 t of sodium required for PFBR is handled in tankers.**
- **Technology for purification of sodium was developed.**
- **In the last three decades many sodium components and instrumentation have been developed like EM pump, magnetic flow meter, ultrasonic scanner, level sensors etc.**
- **A Large component test rig (with 80 t sodium) has been built for qualifying PFBR/FBR components in actual scale.**

- **Knowledge gained is used for development of sodium pumps & components, rugged sodium instruments & sensors, testing of critical components in sodium, sodium purification system for Prototype Fast Breeder Reactor.**

For the future fast reactors in the country, the sodium is the coolant

Knowledge Management in Fuel Reprocessing

Processing of Spent Nuclear Fuel (0.3%Pu) with 7 GWd/t Burnup (Existing Indian Experience)

Processing of Spent Nuclear Fuel (70%Pu) with 155 GWd/t Burnup (Current Experience)

Processing of Spent Nuclear Fuel with 200 GWd/t Burnup (Future Work)

Existing Knowledge

- Hot Cell
- PUREX
- Processes
- Operation
- Safety Aspects

Areas of Knowledge Enhancement

- Dissolver for high Pu Fuel
- Materials for dissolver & Evaporators
- Third Phase formation
- High Pu Concentration
- Criticality Aspects
- Novel Equipment
- Cost Minimization
- Process Optimization
- Modeling & simulation
- On-line Monitoring
- Increased Remotization
- Waste Treatment

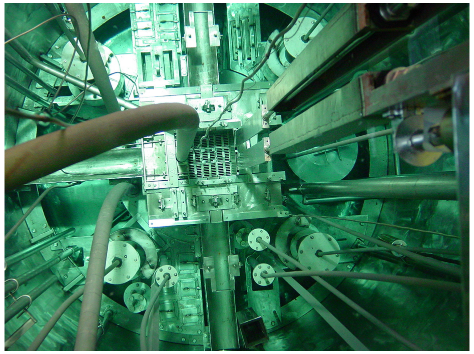
Application & Development of Knowledge

Creation of new knowledge

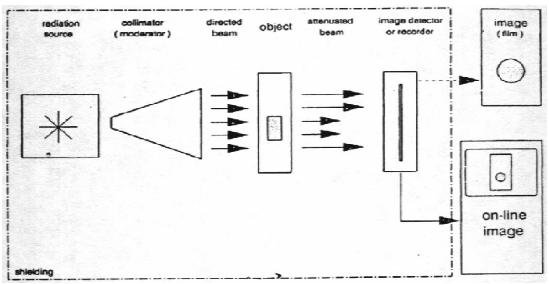
FBTR carbide fuel of 155GWd/t burnup has been successfully reprocessed

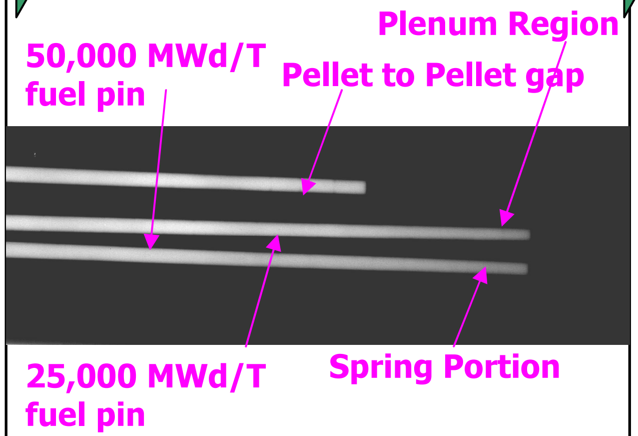
Knowledge Management in Non Destructive Evaluation Techniques

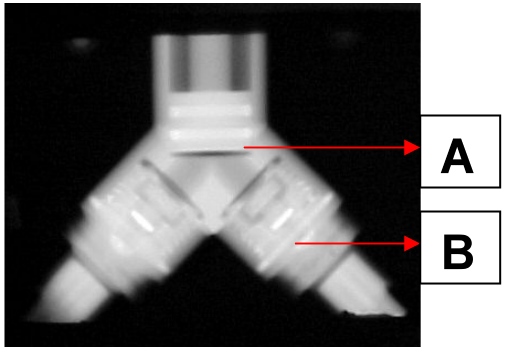
NDE Technique	Knowledge generated for in-house applications	Knowledge transferred to out-side agencies (strategic and core sectors)
Neutron radiography	Nuclear fuel pins, subassemblies and control rods	Pyrodevices used in launch vehicles and satellites of Indian Space Research Organisation and aeroengine blades for light combat aircraft



Kamini Reactor





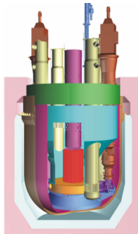


Pin pusher -- (A) O Rings and (B) Pyro charge

Knowledge Management for Safety Critical Real Time Computer Systems

System Requirement Specification

System Architecture Design



Requirements & System Architecture design are stable and evolve with slow pace

To be changed once in 5 years due to obsolescence & enhanced requirements by utility

Hardware Requirement Specification

Hardware Design Document

Software Requirement Specification

Software Design Document

Coding

To adapt to the new hardware

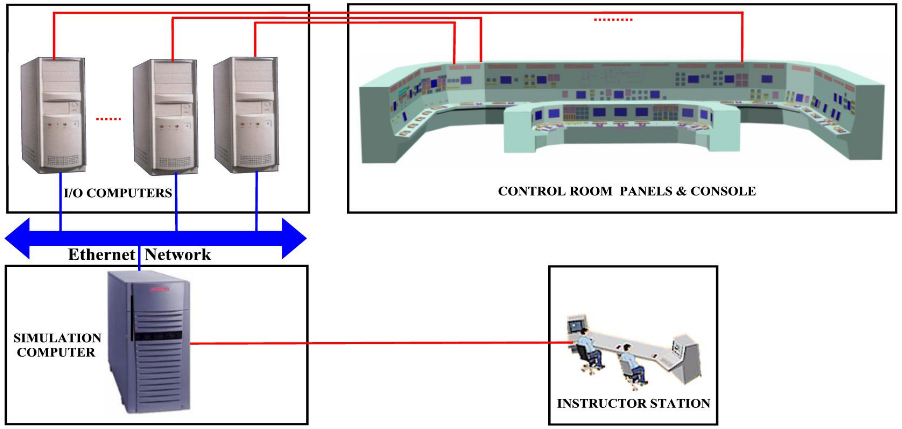
Integrated Testing

Commissioning

Procedures for testing & commissioning do not change except for feedback on real life experiences

Knowledge Management for managing High Obsolescence in Computer Systems

Full Scope Operator Training Simulator for Prototype Fast Breeder Reactor



- Knowledge corresponding to various sub systems of the total nuclear plant has been generated and managed in the simulator through mathematical models and is transferred in the form of training to operators.

- The important sub-systems that have been simulated are : neutronics, primary and secondary heat transport , electrical, fuel handling, instrumentation

- The incidents and malfunctions that have been simulated are: reactor shutdown , inadvertent withdrawal of control rod , plugging of fuel sub-assembly, trip, seizure of primary pump, slowing down, speeding up of one or two primary pumps, trip, seizure of secondary pump, leak in steam generator during operation, trip of main boiler feed water pump etc.

- New Knowledge is transferred for design of similar simulators for future fast breeder reactors and other high technology simulators. Feedback from simulator is used for enhanced design ,operation and safety.

Harnessing Tacit Knowledge of different disciplines is a Challenge

Advanced Simulator is a good example of delivering right information to right persons at right place

IAEA Fast Reactor Knowledge Preservation Initiative

- In September 2003,IAEA General Conference recognized that preserving and enhancing Nuclear Knowledge are essential.
- For three decades several countries had large and vigorous FBR development programmes.
  - Fast Test Reactors Rapsodie (France), KNKII (Germany), FBTR (INDIA), Joyo (Japan), DFR (UK), BR-10, BOR-60 (Russia), EBR-II, Fermi, FFTF(USA)
  - Commercial prototypes Phenix, Superphenix (France), SNR-300(Germany), Monju (Japan), PFR (UK), BN-350 (Khazakhastan), BN-600 (Russia)
  - By 1994 in USA Clinch River Breeder Reactor has been cancelled and FFTF and EBR-II have been shutdown.

- In 1998 Superphenix in France was shutdown.
- In Germany SNR-300 was completed but not taken to operation and KNK-II was shutdown.
- PFR in UK was shutdown in 1994.
- BN-350 was in Khazakhstan was shutdown in 1998.

- Fast Reactor Knowledge should not be lost because of these decisions as with the threat of Global Warming, Nuclear Renaissance is a compulsion and We require this knowledge sooner than later.

- IAEA’s initiative is to develop a Fast Reactor Knowledge Base based on the knowledge preservations of various countries. The IAEA contributes it’s own knowledge accumulated through working group on Fast reactors for over 35 Years.

Nuclear Work Force Succession Planning

- In many countries, large number of Nuclear work force is retiring.
- The Nuclear facilities can not function with out a "Critical Mass" of competent personnel.
- An effective succession planning is essential for the safe and continued operation of nuclear facilities.
- These new personnel have to be in place with an overlapping time along with the retiring people so that they can transfer their knowledge to their successors.

In IGCAR Succession Planning is inbuilt in to the system

Knowledge Loss Risk Assessment

- Every Organization has to periodically do Knowledge Loss Risk assessment.
- The total risk factor for each employee is based on the projected attrition date, the criticality of the knowledge and Skill (Position Risk factor) possessed by the employee.
- Once the Knowledge Risk assessment is done, the management has to device means by succession planning and by capturing the critical knowledge.
- The process has to be monitored and evaluated periodically.

Source: Risk Management of Knowledge Loss in Nuclear Industry Organizations : IAEA

Implementation of KM at IGCAR

- A written Knowledge Management policy has been formulated. A knowledge map is prepared.
- A web based Information Management Server Connected to IGCAR Intranet is commissioned.
- The Explicit Knowledge in the form of Design reports, Internal reports, Publications etc. are ported on to the server.
- The Tacit Knowledge is captured from the retiring and retired employees through exit interviews, reports, audio/visual presentations etc.
  A mechanism is evolved to validate the tacit knowledge.
- The Tacit Knowledge from the serving employees is captured through periodic lectures, internal reports etc.
- Access control mechanisms are adopted to protect confidential knowledge.
- Appropriate Motivations schemes are devised to enable employees to realize the paradigm shift that "*Knowledge is Power*" to "*Knowledge Sharing is power*". It is explained to the employees that knowledge sharing enhances iconic stature of the employee thus leading to higher recognition and possibilities in hierarchy.
- The policy is reviewed, audited periodically to correct inadequacies and plan improvements.

KM self assessment metrics

- IAEA has developed a self assessment metrics tool to identify the effectiveness of KM in the organization.
- The criteria have been grouped in to seven functional categories viz. a) KM policy/strategy, b) HR planning and HR processes, c) Training and human performance improvement, d) IT solutions, e) approaches to capture/use tacit knowledge, f) KM culture/workforce culture supporting KM.
- Based on this, self assessment metrics rating of 0 to 4 is calculated.

Source: Assessment of the organizations Knowledge Management maturity by James Edwin Boyles et al in IJNKM,Vol.3 No. 2 , 2009


IGCAR Information Management System - Microsoft Internet Explorer
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Back Search Favorites
Address http://igcims/
Go Links
Google Search Bookmarks Check Translate AutoFill Sign In
IGCAR INFORMATION MANAGEMENT SYSTEM
Search
DIRECTOR'S DESK
IGCIMS
ORGANISATION
BENCHMARKS
TEL &E-MAIL DIR
ISO 9001
ACCOUNTS
ADMINISTRATION
CG
EIG
ESG
FRTG
MMG
MSG
PLAN
REG
ROMG
RPG
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TACIT KNOWLEDGE
Our Primary Mission....
To conduct a broad based multidisciplinary programme of scientific research and advanced engineering development, directed towards the establishment of the technology of Sodium Cooled Fast Breeder Reactors (FBR) in the Country. The mission includes the development and applications of new and improved materials, techniques, equipment and systems for FBRs.
Dr. Baldev Raj
Director, IGCAR
MMG
150 keV GASEOUS ION IMPLANTER
Webstracts
India's Reactors
Annual Report 2008-DAE
FAST REACTORS FOR ENERGY SECURITY
Applet fprotate started
Local intranet

Manpower Training & Mentoring

- A training school is established at IGCAR to impart specialized training in Fast Reactors and related domains.
- The classes are taken by practicing engineers and scientists. This enables successful transfer of tacit knowledge of the senior scientists/engineers to the trainees.
- Mentoring is a continuous process at IGCAR.
- Officials are encouraged to participate in various National and International Conferences etc.
- Collaborations with many reputed educational institutions and R&D labs of national & international repute.

Conclusions

- Focus on Knowledge Management has enabled us to improve the availability factor of Fast Breeder Test Reactor from 20% to 90%
- Learning from :
  - Knowledge base of international operating experience of about 400 reactor years,
  - Knowledge accrued by successful operation of Fast Breeder Test Reactor for 24 years,
  - Major engineering experiments in Fast Reactor technology,

  has led us to indigenously design 500 MWe Prototype Fast Breeder Reactor with high confidence for success.
- Knowledge accrued from successfully reprocessing fuel at 7GWd/t burnup and related R&D has given vital inputs to reprocess FBTR carbide fuel of 155 GWd/t burnup.
- Knowledge accrued through extensive & intensive R&D is enabling us to build FRFCF.
- Knowledge generated in the areas of NDE, Materials has also been transferred to some strategic areas like Space & Defense.
- Hardware and Software Systems have been devised to capture & disseminate explicit and tacit knowledge within the Centre.

Acknowledgements

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  - Dr.Baldev Raj & Dr.P.Swaminathan for their constant guidance and encouragement.
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THANK YOU