Residual Heat Estimation by Image Processing Using Cherenkov Radiation in TRR

M.Arkani
Department of Nuc. Eng.
Azad University, Tehran, Iran

M.Gharib
Tehran Research Reactor
Nuc. Research Center
AEOI, Tehran, Iran

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AIM

- Initial Approach
  - Using existing CCTV camera system
  - Derive a relationship between core light intensity vs. power
  - Later, due to saturation problem & auto iris, another approach employed
- Present Approach
  - PC-camera to look after shutdown glow
  - Check if Cherenkov light fits with decay heat

INSTRUMENTATION

- CMOS sensor at the heart of camera
- Core image formed on an array 640 x 480
- Each color of RGB : 0-255
- Pixels are scanned : bit-map-format
- Output signal : total intensity of core image
  - If all pixels are ON,
  - If all colors at peak,
  - Then $(\text{signal})_{max} = 3 \times 255 \times (640 \times 480)$

    $= 235{,}008{,}000$
- All numbers are normalized WRT total intensity right after shutdown

Imaging System prior to deployment

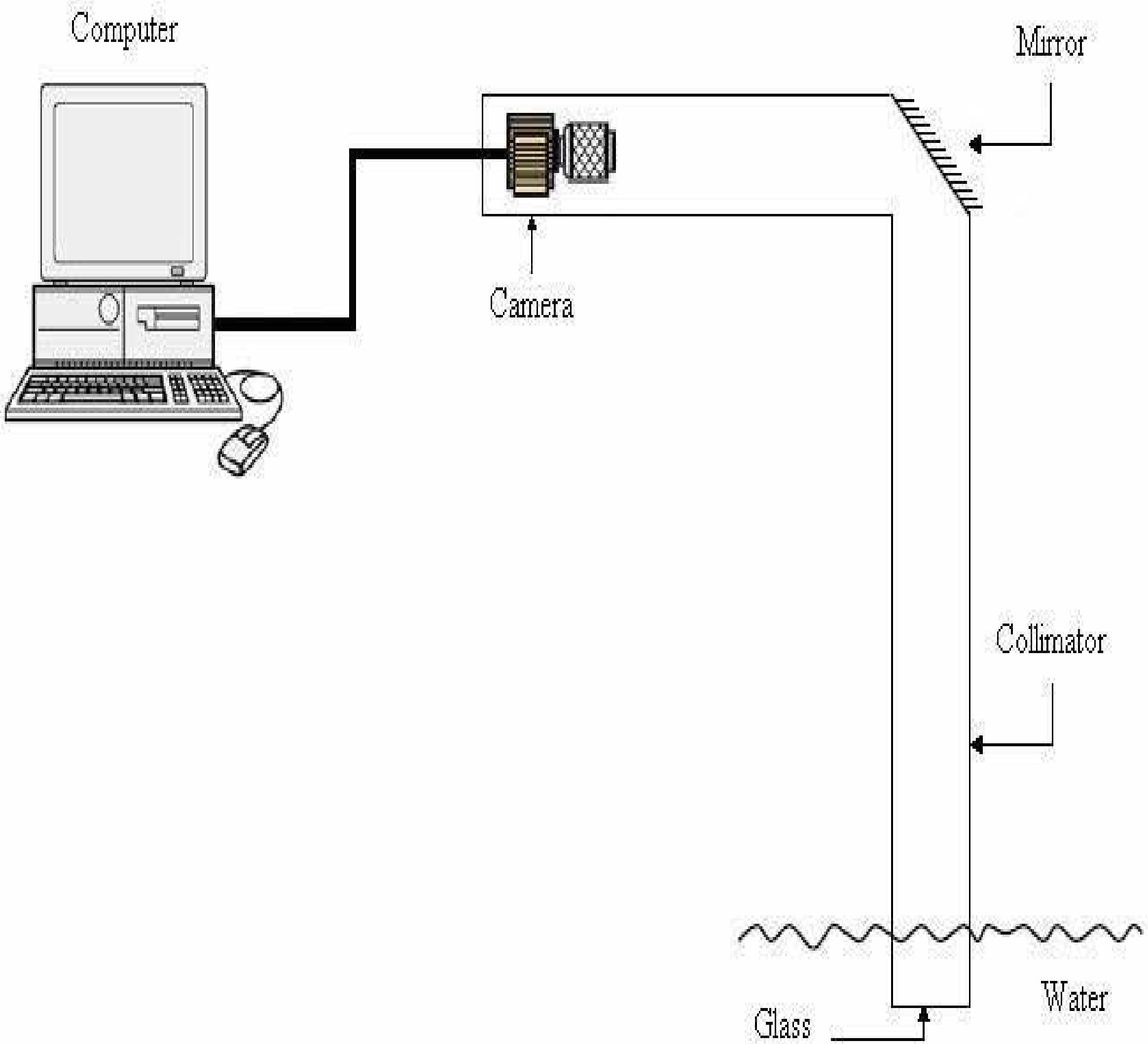
Collimator length ~ 1.4 m

Imaging System prior to deployment

(within wooden frame)

Housing to protect camera & circuit

Experimental Setup



Technical Specification of Setup

CAMERA

- High-quality VGA CMOS sensor
- Manual control (no auto Iris)
- Video capture: 640 480 pixels
- Frame rate: 15 frame /sec at QVGA resolution
- USB port

PC SYSTEM

- Windows 2003,XP
- Pentium IV 2.8 GHz, full cash, Intel
- 512 MB RAM
- Programming environment: Delphi 7

TRR core configuration #23

Core Configuration 23

	1	2	3	4	5	6	7	8	9
A	GR BOX	GR BOX	GR BOX	IR BOX	A121	A146	A135	A67	IR BOX
B		GR BOX	N.S	A62	A70	AS 27 SR1	A150	AS 26 RR	GR BOX
C	GR BOX	GR BOX	A64	A147	AS 25 SR4	A75	A112	A111	GR BOX
D	GR BOX	GR BOX	A136	A66	A63	IR BOX	A115	AS 23 SR2	GR BOX
E	GR BOX	GR BOX	IR BOX	A148	A149	AS 28 SR3	A137	A144	IR BOX
F	GR BOX	GR BOX	GR BOX	IR BOX	A145	A151	A139	Fresh A65	GR BOX

TRR core top view

Core ~ 8 m below pool level

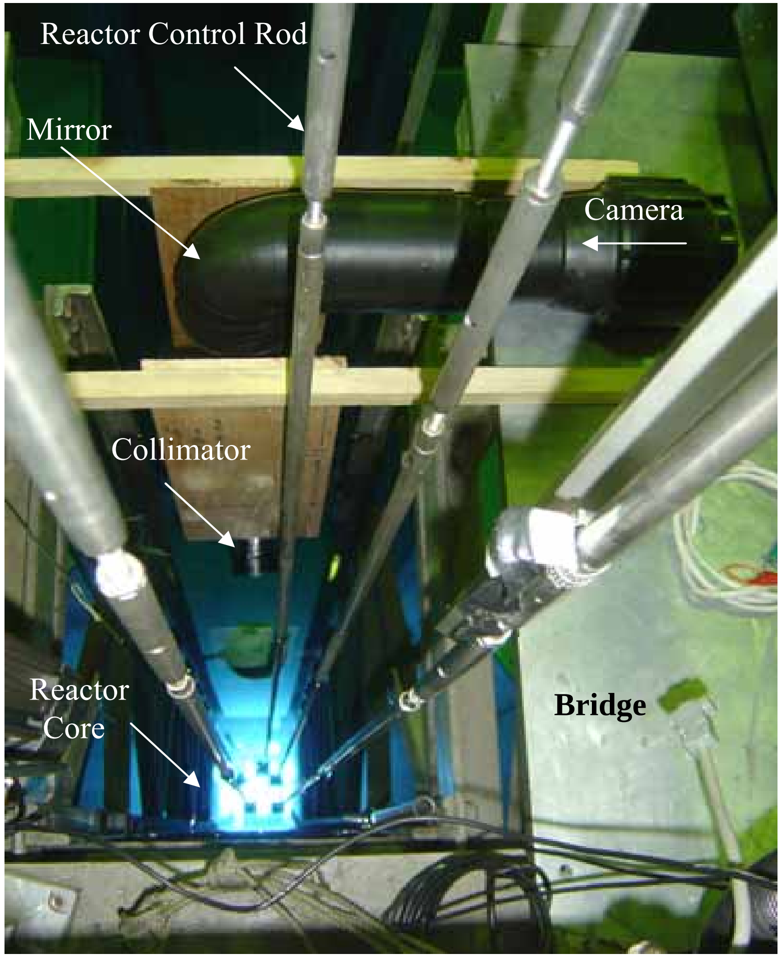
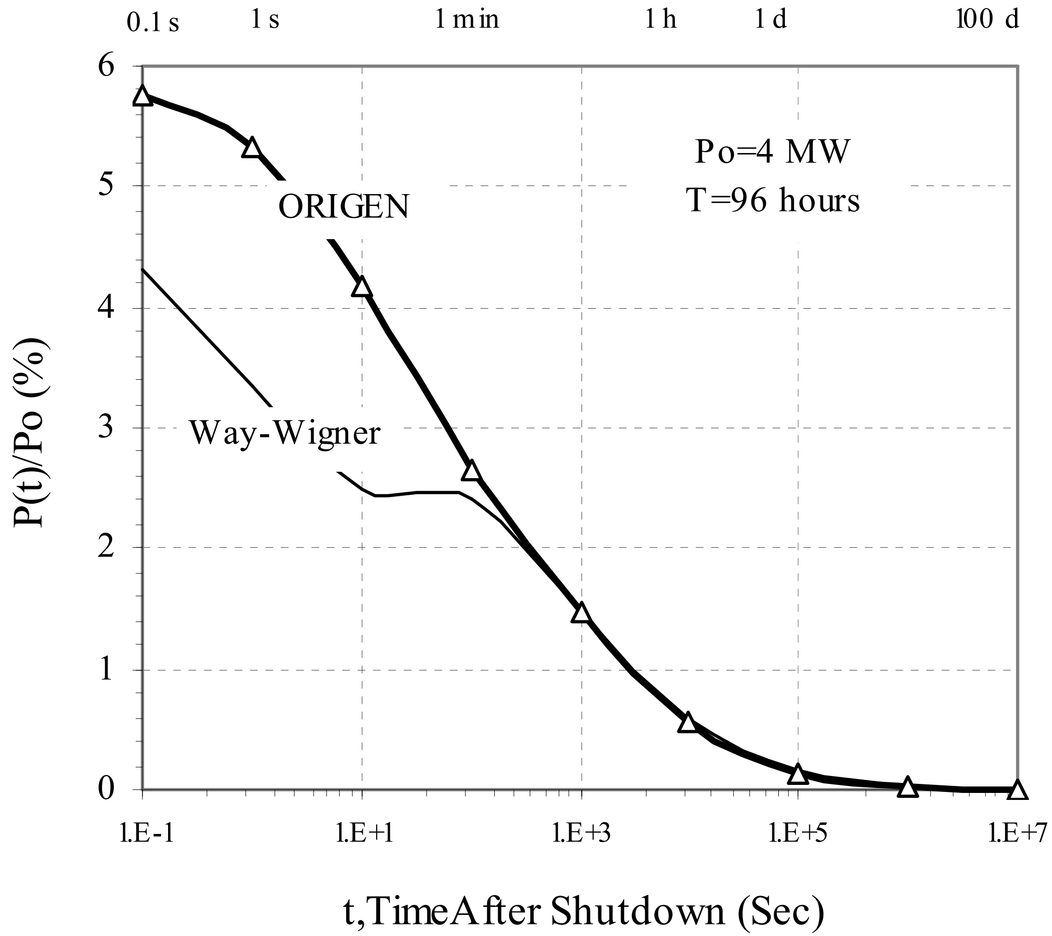


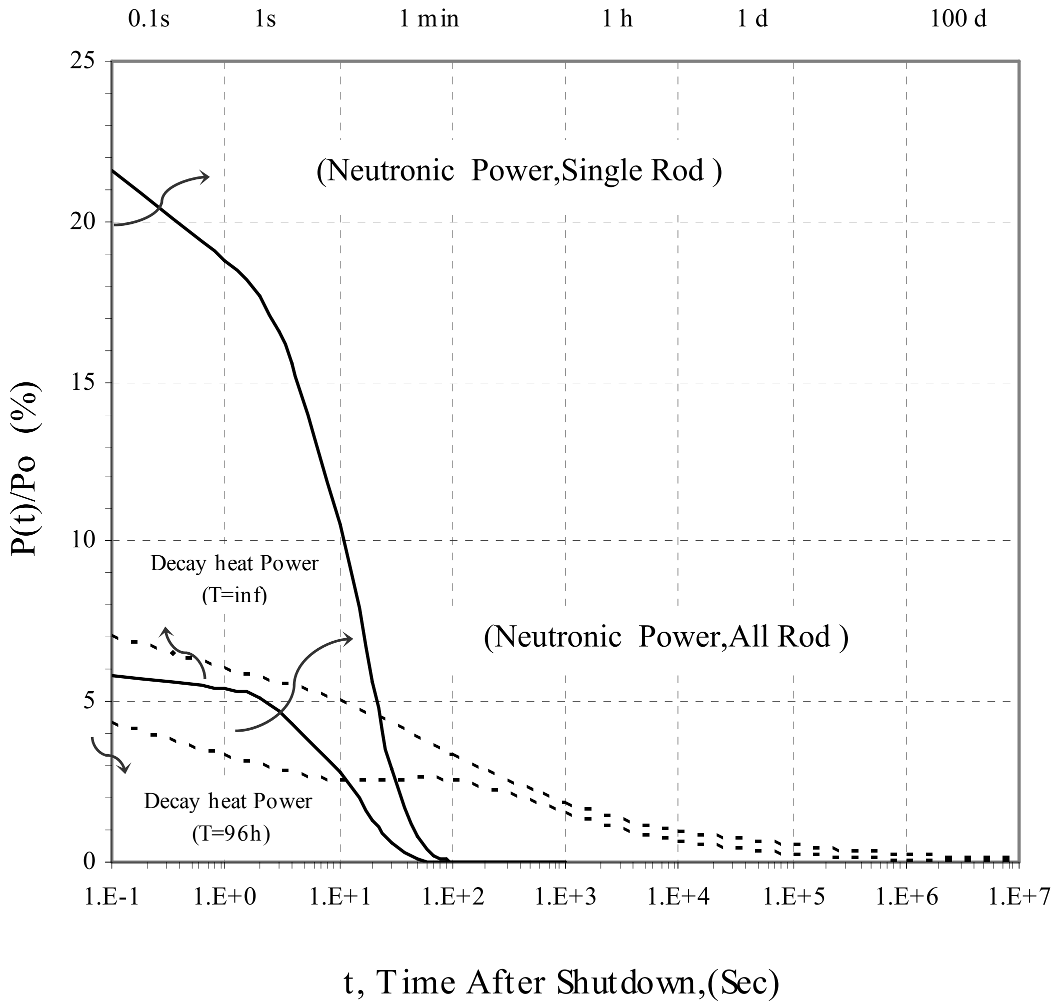
Image of core seen by PC-camera

Decay Heat After Shutdown

Way-Wigner Vs. ORIGEN



Heat Rate After Shutdown
Delayed Neutronic Vs. Decay Heat

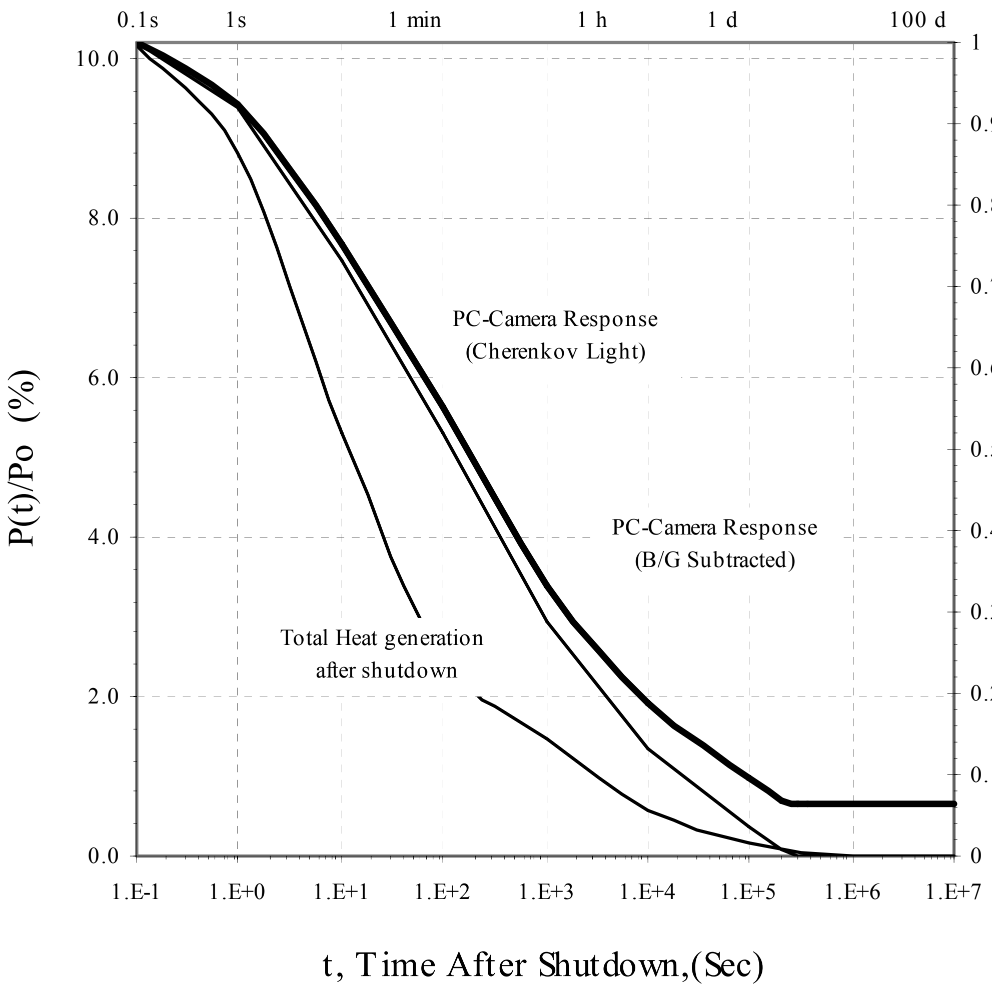


Po=4 MW

Λ=45 μsec

β=0.0077

Measured Cherenkov Light Vs. Total Heat Rate Release in TRR



RESULTS & DISCUSSIONS

- Continuous run of 96 hours at Po= 4 MW
- Reactor scram with all 4 shim rods
- Cherenkov radiation monitored after shutdown up to 100 hours
- Total heat rate estimated:

  Decay heat + Neutronic power
- PC-camera response are recorded by computer
- General trends are satisfactory
- Contribution of gammas to heat are NOT the same for : Neutronic & decay heat

CONCLUSIONS

- Real time monitoring for open pool reactors
- Independent channel for post shutdown
- Indirect measurement for decay heat
- Long distance from core
- Out of water system
- Low price