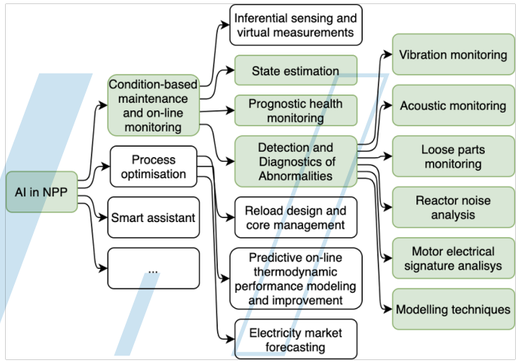
AI in Nuclear Power Plant Monitoring Systems

Problems

- Complex, versatile and large amount of information
- Unplanned shutdowns
- NPP equipment life extension



On-line condition monitoring of NPP equipment, systems and processes include the detection and diagnosis of abnormalities via long term surveillance of process signals while the plant is in operation.

Effects

- Safety
- Reliability
- Availability
- Cost optimization
- Technology enhancement
- Knowledge identification and capture

Loose parts monitoring system for Nuclear Power Plant

1. Events detection and classification

- Data preprocessing method[1] based on spectral whitening algorithm. This method provide extraction signals from background noise (fig. 1).
- Classification detected events (machine learning) by :
  - Loose parts
  - Technological events
  - False alarms
  - Hummer impacts

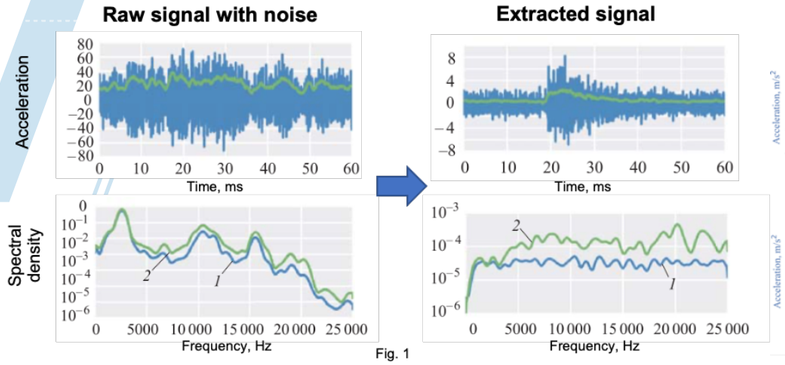


Fig. 1

2. Localization and mass estimation

- Impact localization method[2] is based on the representation of the surface, along which an acoustic wave travels, as a 3D model of the reactor plant main circulation circuit (fig. 3):
  - The algorithm to detect time of arrival impact signals (fig. 2)
  - Optimization model to estimate impact location using time of arrivals of the signal received by various sensors and mean speed of sound
  - Average error in the impact source localization is 600 mm
- Machine learning model mass estimation of loose parts. Used experimental data of impacts by different metal balls.

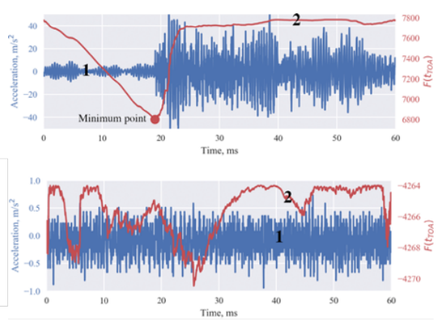


Fig. 2

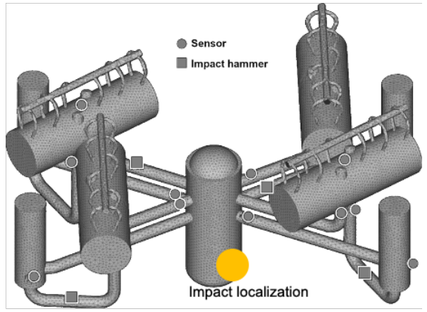


Fig. 3

1 - Maksimov I.V., Pavelko V.I., Perevezentsev V.V., Trykov E.L. Valid Signal Isolation Method for Loose Parts Monitoring System in the Main Circulation Circuit of WWER Reactor. Vestn. Mosk. Gos. Tekh. Univ. im. N.E. Baumana, Priborostr. 2018, no. 1, pp. 4–15 (in Russ.). DOI: 10.18698/0236-3933-2018-1-4-15

2 - Maksimov IV, Perevezentsev VV (2020) A localization method for loose parts monitoring system of VVER reactor plants. Nuclear Energy and Technology 6(1): 29-35. https://doi.org/10.3897/nucet.6.51252

3 - Katser ID, Kozitsin VO, Maksimov IV (2019) NPP equipment fault detection methods. Izvestiya Vuzov. Yadernaya Energetika 4: 5–27. https://doi.org/10.26583/npe.2019.4.01 [in Russian]

4 - Katser ID, Kozitsin VO, Maksimov IV, Larionov DA, Kotsoev KI (2021) Data pre-processing methods for NPP equipment diagnostics algorithms: an overview. Nuclear Energy and Technology 7(2): 111–125. https://doi.org/10.3897/nucet.7.63675