An Overview on the Characteristics and Capabilities of the Jordan Research and Training Reactor (JRTR)

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1. Introduction

Jordan Research and Training Reactor (JRTR) is the first nuclear reactor in Jordan and the newest research reactor in the world. This university research reactor (located inside the campus of Jordan University of Science and Technology, Ar-ramtha-Irbid City, north of Jordan) is owned and operated by the Jordan Atomic Energy Commission (JAEC) and it is the first Korean nuclear reactor exported and built outside Korea. The JRTR, commissioned in 2016, is currently operational. The JRTR originally aims to play a unique role, regionally and internationally, in the near future as a scientific hub for education, training, utilization, and various applications as well as providing state of the art of various scientific research fields.

2. Characteristics and Capabilities

This section introduces the main design characteristics and capabilities of the JRTR taking into consideration the current status of the JRTR.

2.1 Main Characteristics

The JRTR is an open-tank-in-pool type, multi-purpose 5 MW_{th} (upgradable to 10 MW_{th}) with a maximum thermal neutron flux of 1.72 $x10^{14}$ n /cm^2.sec. Some of the JRTR main characteristics are listed in Table I with comparison to some other research reactors in the world. The JRTR was designed to have a neutron flux high enough to conduct various and advanced scientific research including materials testing. Proceeding to the safety aspects, it is worth to mention that the JRTR encompasses an inherent safety feature of maintaining the negative feedback effect under all conditions and circumstances. Generally, the JRTR possess the most advanced safety features (inherent & passive) which were developed by KAERI from HANARO experience along decades of development and operation.

As shown in Fig. No. 1 [1] which shows the reactor core plan configuration indicating all the facilities; 5 horizontal beams Standard Thermal Tubes (ST1&ST2), Neutron Radiography (NR), Cold Neutron (CN), and the Thermal Column TH, as well as 35 vertical holes.

2.2 Potential Capabilities

The JRTR was designed to join the nuclear community providing many scientific purposes and utilizations along its lifetime (40 years extendable to 60 years), mainly: Education and Training (E&T), Neutron Activation Analysis (NAA), Radioisotope Production (RIP), materials irradiation including, but not limited to, Neutron Transmutation Doping (NTD), and various Neutron Scattering Techniques (NST) applications after the installations of the planned beam instruments in the near future. As shown in Fig. 2, one of the most important potential capabilities of the JRTR, the experimental hall where planned to have a Neutron Imaging Facility (NIF) and a High Resolution Powder Diffractometer (HRPD) in the near future [3]. In addition to that, there is a plan to have some other additional instruments in the future. Such kinds of instruments will enable the scientists and researchers to perform various kinds of investigations, experiments and analyses as well as to provide the required support for the medical and industrial communities in their fields of interest.

Table I: The JRTR Characteristics and Comparison

	JRTR	MITR-II	HANARO	OPAL
Country	Jordan	USA	Korea	Australia
Power (MW)	5*	5	30	20
Criticality Date	2016	1958	1995	2006
Fuel	U_3Si_2 LEU Plate	UAl_x HEU Plate	U_3Si LEU Rod	U_3Si_2 LEU Plate
No. of Horizontal Channels	5	19	7	5
No. of Vertical Channels	35	6	32	45

*5 MW: The JRTR Power upgradable to 10 MW.

Further details regarding to the other main objectives of the JRTR, tables II, III, IV, and V show the current status and further potential capabilities concerning the fields of RI production, NAA activities, materials irradiation, in addition to the operational laboratories of the JRTR, respectively.

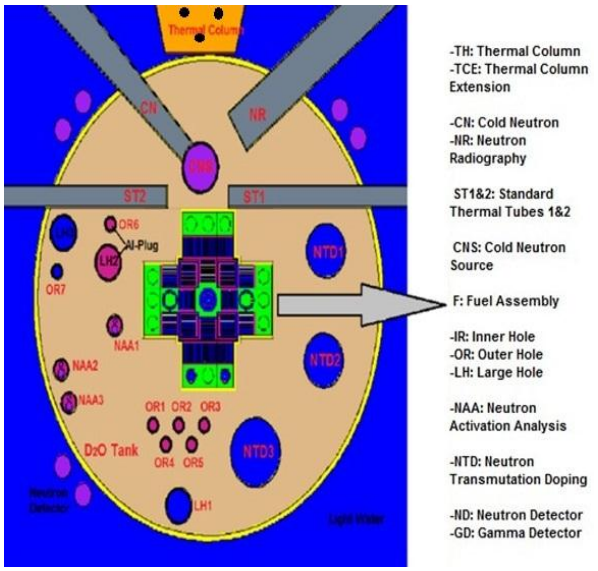

Fig. 1. A schematic drawing of the JRTR core configuration

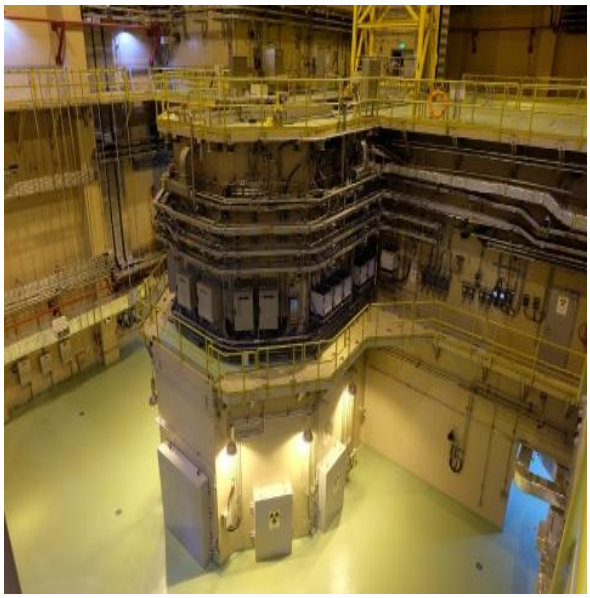
Fig. 2. The JRTR experimental hall view

One additional important point to mention concerning the (RI) production field that the JRTR has a distinguished feature of the on-power loading/unloading ability (OPLU) of the targets to be irradiated for medical purposes (especially, I-131 and Mo-99) which enables the JRTR to have (online) production without the need to wait until the reactor is in shutdown state.

Another important point to add, the JRTR possesses a great potential and ability to play a distinguished role of being the first scientific research hub locally and regionally, also by having as a starting point the unique collaboration in view of the existence of the only synchrotron-light source of the Middle East region in Jordan, namely, The Synchrotron-light for Experimental Science and Application in the Middle East (SESAME).

Table II: The capabilities of the JRTR's RI Production Facility

RI Production	
Facilities	3 Hot cells, fully equipped with all needed systems
Applications	Medical and industrial radioactive sources
Products	Mainly I-131 ^{99m}Tc Ir-192
Capacity	I-131 : 1 kCi/yr. Mo-99 : 240 Ci/yr. Ir-192 : 48 kCi/yr.
Main Current Clients	Jordan Royal Medical Services and King Hussein Cancer Center, and others

Table III: The JRTR NAA Facility Status

NAA Facility	
Facilities	3 Irradiation holes, equipped with three Pneumatic Transfer Systems (PTS) Gamma-rays spectroscopy
Applications	Various scientific research, forensics, agricultural studies, etc...
Main Current Clients	The JRTR divisions, Jordan universities, food and industrial sectors and others

Table IV: The JRTR materials irradiation Capabilities

Materials Irradiation	
Facilities	NTD holes, in addition to the in-core irradiation capabilities
Applications	Various Scientific Research Fields
Products	Silicon Doping

Table V: The JRTR operational laboratories status

Operational Laboratories	
Equipment and instruments	ICP-AES FT-IR HPGe Alpha-beta Counters Liquid Scintillator
Applications	The JRTR routine measurements and analysis for the camples
Main Current Clients	The JRTR Disciplinarians, Jordan universities, food and industrial sectors

3. Conclusion

This article concludes the JRTR design characteristics and features. The current status of the JRTR readiness and various potential capabilities are described as well as some future plans. This article highlights some cases of potential collaborations locally and internationally which will contribute to the nuclear community efforts to achieve higher degree of research reactors utilization in various categories of nuclear sciences to meet with the increasing global demand on the various nuclear applications and scientific research.

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