From the Director's Desk...

It is my privilege to bring to you this year's issue of RRCAT Newsletter, highlighting the progress made by the Centre during July 2019 – June 2020. The unprecedented situation arising due to outbreak of COVID-19 in March 2020 and the nationwide lockdown thereafter till May 2020 brought the vibrant on-going activities of our Centre to standstill for a while. Nonetheless, substantial progress has been made by the Centre during this period on advanced technologies, scientific research, societal applications and education, adhering to preventive measures of COVID-19 spread. The editorial team has worked meticulously to present to you fair glimpses of the progress on all these fronts.

The national facility of indigenous synchrotron radiation sources, Indus-1 and Indus-2, continued to operate in round-the-clock mode till 22nd March 2020 and were abruptly brought to safe shut down state in compliance to Government of India guideline to contain the spread of COVID-19. Operations began to be resumed slowly by the end of June 2020 following the elaborate start-up procedure. During the period July 2019 – March 2020, the facility operated for 231 days, with beam availability of ~22 hours per day in Indus-1 and ~16 hours per day in Indus-2. Beam lifetime of 84 h 48 m was recorded at 100 mA of stored current in Indus-2, which is the highest lifetime achieved so far. A major upgrade accomplished in Indus-2 during this period is the successful installation of an indigenously developed vertical pinger magnet; this is an important diagnostics tool for carrying out advanced beam dynamics studies. The successful development of Non Evaporable Getters (NEG) coating technology for coating of small aperture vacuum chambers for insertion devices is a significant step towards technology capacity building for the Centre. In recent years, several of such important upgrades on various sub-systems, such as injector microtron, high power RF and microwave systems, ultra-high vacuum system, magnets, power converters, control system, beam diagnostic system and coolant system have taken place in Indus-2, using the indigenously developed technologies. Majority of these are comprehensively described in one of the Theme Articles.

Utilizing the Indus-1 and Indus-2 accelerator beamlines, a total number of 518 user experiments were performed using EXAFS and XRD beamlines. The users from the industry also used these beamlines for their R&D programmes. Novel experimental studies have been carried out on material research for energy as well as device applications, and also on biology research using the protein crystallography beamline. Based on these user experiments, nearly 175 research papers were published in peer reviewed journals. During the recent past, very useful experiments on nuclear materials like uranium and thorium oxides, doped oxides, reactor grade graphite, zircaloy etc., have been performed using the x-ray fluorescence microprobe beamline BL-16 and Angle Dispersive X-ray Diffraction (ADXRD) beamline BL-12 on Indus-2, which are described in one of the Theme Articles.

On the front of industrial electron linac for societal applications in the area of irradiation of medical and food products, appreciable progress has been made on design and development of Linac-3 (with beam power of 10 kW), which is an upgrade of the earlier developed Linac-2 (with beam power of 6 kW) that is operating at Agricultural Radiation Processing Facility. Linac-3 has a pre-buncher RF cavity in order to improve the electron beam transmission efficiency and also to reduce the energy spread of accelerated beam; and a 270 degree bending magnet system, to limit the maximum electron energy within allowable limit. Beam trials of Linac-3 have been carried out up to 1 kW at beam energy of 9.5 MeV during this period, and attempt to progressively increase the beam power to 10 kW is underway.

Towards the efforts to develop the advanced technology of superconducting proton accelerators, notable progress has been made on indigenous development of a welding glove box, which has been successfully used for dressing of a HB 650 MHz β=0.92 five-cell SCRF cavity for the first time under the PIP-II project. An end lever tuner has been developed and integrated with the dressed five-cell cavity, and successfully characterized for its operation. For the Horizontal Test Stand (HTS), which will be an important facility to characterize the indigenously developed and dressed SCRF cavities, the control system has been successfully developed and integrated; the commissioning trials will soon begin.

Noteworthy progress has been made in the area of technology development of a variety of lasers for various applications. An engineered version of 500 W all-fiber single transverse mode Yb-doped cw laser at 1080 nm has been developed. This core development will be used to build a multi-kW fiber laser for a wide range of industrial applications. A fiber-optic front end laser system with a pulse energy of 20 nJ, required for development of Nd:Glass based high energy laser system, has been developed and tested. A Nd:YAG laser operating at 1320 nm wavelength, that is different from the usual operating wavelength around 1064 nm, has been developed. This 1320 nm laser has potential applications in laser medicine and dental surgery. In the ongoing activity of building a fast capillary discharge based soft x-ray laser, progress has been made in terms of an enhancement of output energy from the existing 2 μJ to 70 μJ per pulse through enhancement in its discharge current. This development has potential applications in nano-imaging and plasma diagnostics.

Laudable contribution from the Centre continued to be made towards applications of laser. Laser cutting of pipelines of emergency core cooling system of the 1000 MWe reactor of Kudankulam Nuclear Power Station Unit-2 (KKNPS-2) was urgently required for replacement/repair of one of the injection valves of the system. This critical job of cutting the pipe with coolant present in the system was successfully completed by RRCAT, using an indigenously developed 500 W average power of 10 kW peak power fiber coupled pulsed Nd:YAG laser system. In another application, the zircaloy-4 tubes used as cladding material for thermal reactor fuels were coated with > 100 µm of SiC, using Laser Additive Manufacturing based on Directed Energy Deposition (LAM-DED). The SiC coating avoids high temperature oxidation and hydrogenation, and the coated samples have been sent to Reactor Engineering Division (RED), BARC for further qualification tests. Using the RRCAT based LAM facility, mesh type spacers for fuel bundles required for new 540 MWe PHWR fuel cluster simulator built at RED, BARC were manufactured. A comprehensive description of various application of high power solid state laser developed at RRCAT for the nuclear reactor program in India is described in one of the Theme Articles. Another important application of high-power laser is in the area of charged particle acceleration to make a compact accelerator, and some of the recent studies performed at the Centre using the 150 TW laser are described in another Theme Articles. An interesting study have been performed on laser atom cooling, where it has been shown that the Magneto-Optical Trap (MOT) loading data can be used as an alternative method for measurement of Ultra-High Vacuum (UHV) pressure.

Different dimensions of scientific research on materials continued to be explored at the Centre. Interesting and useful studies have been performed towards development of GaAs based spin-Hall devices, where it has been shown that performance is enhanced in terms of improved signal to noise ratio and at low power consumption by using optical excitation of spin polarized hot electron in L-valley, instead of conventional G-valley excitation. Studies have been performed on preparing an organic scintillator Trans-Stilbene (TSB) in a composite form with Poly-Methyl Methacrylate (PMMA), and exploring its suitability for x-ray imaging using the imaging beamline BL-04 of Indus-2. Interesting work has been done on development of x-ray detection screen by depositing cerium-doped YAG nano-powder on glass substrate through sedimentation method. For investigating electronic trap states in Methyl Ammonium Lead Iodide (MAPI), which is an organic inorganic hybrid perovskite based photovoltaic material used for solar cell applications, a Thermally Stimulated Current (TSC) measurement set up has been developed. A prototype version of hand-held arc-flash and fire/flame detector has been successfully demonstrated using the in-house developed $Mg_xZn_{1-x}O$ based visible blind UV photodetectors. Extensive work has been performed at RRCAT in recent years on development and deployment of radiation resistant GaAs based PIN photodetectors, which is described in one of the Theme Articles.

Scientific activities carried out at the Centre have resulted into 222 publications in peer reviewed journals and several publications in conference proceedings. Technology transfer to industry has taken place for 60 kW RF broadband dual directional coupler. The third batch of Trade and Apprenticeship Scheme at RRCAT (TASAR) was started to impart education and training to 57 apprentices. National Science Day and RRCAT Foundation Day are some of the important events that were organized at RRCAT, which also serve as an important forum for our outreach activity. RRCAT hosted the biennial joint conference "ISO-ISMPO 2019 Conference" on the theme “Cancer in Indian sub-continent – how to manage better”, under the aegis of the Cancer Society of MP and Indian Laser Association (ILA). RRCAT staff club continued to carry out various activities in the area of sports, music, culture, yoga and health for its members and their families. HBNI Research Scholars Day and mini marathon are some of the important activities organized by RRCAT HBNI, which keep the campus vibrant with student activities.

All the necessary steps have been taken at the Centre premises for prevention of COVID-19, in compliance to the guidelines and advisory notes issued by Ministry of Home Affair, Ministry of Health and Family Welfare and Indian Council of Medical Research including local administration. This has enabled us to bring back the pace of all the on-going activities of the Centre slowly, and cautiously.

My hearty congratulations to the winners of various individual and group achievement awards for the year 2018 under the DAE Excellence in Science, Engineering and Technology Awards Scheme. I also congratulate those who have been awarded the Ph. D. degree by HBNI and won Best Thesis / Best Poster awards during the last one year.

I sincerely express my appreciation to chairman, convener and members of the Editorial Board for their efforts in showcasing a wide spectrum of activities of our Centre under the present situation of COVID-19, and bringing out the combined issue of the Newsletter in time.

With best wishes,

November 26, 2020

Debashis Das
Director