

## Physics of accelerator-driven sub-critical systems for energy and transmutation\*

In 2003, the Department of Atomic Energy, under the X plan had started a new project on 'Physics Studies and Technology Development for Accelerator Driven Sub-critical Systems'. The first formal workshop on the subject was held recently in Jaipur.

Anil Kakodkar (Chairman, Atomic Energy Commission) in his message sent to the convener of the workshop pointed out that the ADS technique is a forerunner amongst the hybrid techniques for nuclear power generation which can sustain growth of the Th-U<sup>233</sup> system and it can also be useful for the transmutation of the long-lived nuclear waste so to make nuclear energy more acceptable to the society.

S. Banerjee (BARC, Mumbai) in his inaugural speech on 'Physics of ADS for energy and transmutation' pointed out that like many other nations who are using nuclear power, there is a need to reshape our energy resources either because of fast receding resources of uranium fuel or due to the serious problem of nuclear waste. In this context, Banerjee described the three-stage Indian nuclear programme having application of thorium at the central stage. This emphasizes the need of carrying out studies related to the thorium fuel cycle, production of U<sup>233</sup> and future need of high power reactors based on thorium fuel. By adopting this three-stage nuclear power programme, India can sustain power generation for centuries by making use of its own vast reserves of thorium only. ADS can be used in the third stage. S. S. Kapoor (formerly of BARC) in his keynote address on 'ADS – Relevance and overview', talked about the problems posed by the critical reactors, such as nuclear waste, safety issues and requirement of the nuclear fuel every 5–10 years and compared them with

ADS. He pointed out that not only does the ADS provide solution to many problems, but also provides the freedom of choice of nuclear fuels, more burn-up and reduced requirement of reprocessing fuel, etc. More importantly, it is best suited to application of thorium fuel. The major challenge before the country in working for the ADS technology is to build a 'high current proton accelerator'.

Besides these two special talks, 13 scientists from abroad and 17 from India delivered lectures on the following theme-subjects of the workshop:

(a) Thorium fuel cycle (two talks): A. G. Gerasimov (ITEP, Moscow) pointed out that the CANDU power reactor can use thorium fuel. V. Jagannathan (BARC) described a reactor design using thorium fuel that has scope of application in the ADS.

(b) Nuclear waste transmutation (four talks): V. V. Seliverstov (ITEP) talked on parameters and conditions of 'burners' for incinerations of long-lived waste. B. P. Kochurov (ITEP) spoke on the transmutation of higher actinide americium in a fast lead-cooled system. Yuri A. Korovin (Technical University, Obninsk) talked about the need of data for incineration of nuclear waste. J. Adam (JINR) presented results of simulation and experiments conducted at the Nucleotron accelerator of JINR, on transmutation rates of minor and higher actinides by the spallation neutrons.

(c) Nuclear data, benchmark and role of (*n, xn*) reactions for ADS (five talks): Requirement of new nuclear data like that of (*n, xn*) reactions, high energy fission and shielding, shortcomings of old data, preparation of formats of data, process of design and modelling and settling questions of benchmarks, suggestions for new experimental set-ups for study of physics of new reactions initiated by high energy neutrons that affect the design of hybrid reactors like ADS, were the important points of discussion related to the work element of design and modelling of ADS. S. Ganesan (BARC), V. Kumar (University of Rajasthan), J. Blomgren (Neutron Laboratory, Uppsala), A. K. M. Moinul

Haque (Bangladesh) and Ashok Kumar (BARC) were the speakers in this session covering the aforesaid points. It was stressed that there is a need for cross-checking old data of the seventies and eighties and to produce new data with high-energy neutrons. New materials suggested for these studies were Pb, Bi, Zr, Nb, V, Cr, Mg, Ni, etc. along with the study of thorium for settling the question of the Th-cycle. Setting up a new database in the country for ADS work was another important suggestion that surfaced in this session.

(d) Radiation safety, computer codes and method of calculation (six talks): Hybrid reactor for the ADS is supposed to have its own source of high-energy neutrons and that makes it different from the critical reactor. Almost the whole reactor mechanism including safety aspects have to be redefined. Talks delivered by S. B. Degweker (BARC) and P. K. Sarkar (VECC) covered these aspects of reactor calculations and safety analysis. Talks by B. P. Kochrov (ITEP), H. Kumawat (University of Rajasthan), and V. K. Senecha (CAT) covered methods of simulation codes for ADS. K. Arulprakash (IIT Kanpur) discussed heat mapping of the spallation target system of ADS.

(e) Experimental methods and facilities for ADS (nine talks): Different experimental methods including activation and solid-state track detectors up to the fabrication of accelerators, their application in advancing the ADS technology and even the critical and sub-critical facilities that are being used for physics experiments for ADS were discussed in this session. The experimental data provided in the talks by Yuri E. Titarenko (ITEP), Manish Sharma (Jaipur), and V. Wagner and M. Majerle (Czech Republic) have application in design and modelling of the ADS. In a talk by P. Singh (BARC), the plan of accelerator development for ADS in India was described along with the challenges before the Indian scientists to give it shape. Talk by A. M. Kozodaev (ITEP) on neutron generator in use at ITEP, another talk by R. Srivenkatesan (BARC) on the critical facility at BARC for experimental studies related to ADS

\*A report on the Workshop on Physics of Accelerator-Driven Sub-critical Systems for Energy and Transmutation, held at Jaipur during 23–25 January 2006. The Board of Research in Nuclear Sciences (DAE), ILTP programme of the Department of Science and Technology, Government of India and University of Rajasthan, Jaipur jointly sponsored the workshop.

and a review talk on experiments using 14 MeV neutron source by T. K. Basu (BARC) showed the involvement and preparedness of big teams of scientist world over in the development of several techniques for studies related to ADS. Besides, S. K. Gupta (University of Rajasthan) delivered a talk on time-of-flight technique for measurement of neutron cross-sections.

(f) Spallation target and technologies (four talks): Development of a spallation target for ADS, particularly that in the liquid phase is a matter of developing a special technology of Pb + Bi eutectic.

Russians have got expertise in this technology so far. P. Satyamurthy (BARC) delivered two talks on this aspect presenting preparations being done by Indian scientists for the eutectic technology. R. M. Vadjikar (CAT) discussed heat dynamics of solid targets. K. Kobayashi (Kyoto University, Japan) presented a theoretical talk on the issue of interpretation of sub-criticality coefficient in case of neutron source-driven systems like the ADS.

The workshop ended with a concluding session emphasizing the need for experimental facilities that should be set up

on priority for data collection and preparing the Indian database for ADS. The organizers have released powerpoint presentations of all the speakers in a CD. The Abstract Booklet of the workshop will be available on a CD. The text of full papers will be published shortly in *Pramana – J. Phys.*

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## MEETING REPORT

### New developments in rapeseed mustard\*

Oilseed crops in India account for almost 5% of Gross National Product (GNP) and 10% of the value of agricultural products. Rapeseed mustard (*Brassica*) contributes 32% of the total oilseed production in India, and it is the second largest indigenous oilseed crop. Despite many changes in the rapeseed mustard sector, such as development of improved varieties, region-specific production and practices, India is not self-sufficient in this crop. Agricultural scientists, policy makers, field botanists, biotechnologists and the industry are gearing up to the challenge to bring back the lost glory to this crop by enhancing the yield per hectare, developing improved hybrids, improved farm mechanization methods and post-harvest management strategies. In view of recent research carried out in the above-mentioned methods and research in health and dietary aspects, a one-day national conference was organized. The conference received infrastructural and financial support from NAFED. The conference was attended by 200 delegates from various parts of India. Research scholars, teachers from various

colleges, university departments, scientists working in NGOs, Indian Council of Agricultural Research laboratories and entrepreneurs from the oilseed industry attended the conference.

The one-day deliberations consisted of four technical sessions and a panel discussion for drafting recommendations to the Government and various agencies involved with the improvement of this crop. The four technical sessions focused on (a) health and nutritional aspects, (b) crop improvement, (c) quality and value addition, and (d) processing and storage.

A. K. Bhatnagar (Department of Botany, University of Delhi) while delivering his welcome address, focused attention on the uses of mustard and added that 'the golden crop with strong aroma needs serious attention from all quarters and cross-sections of society associated with this crop'. He added 'scientific institutions, marketing managers and industry need to work together and carry out collaborative research with inputs from farming community to make the elusive "Yellow Revolution" a reality'. The seminar was inaugurated by Kailash Jyani (Additional Director General, NAFED) who emphasized the need of region-specific research in this crop. He cautioned the scientific community about loss in yield of crop due to pests and pathogens in the field as well as after harvest. He also stressed on the need of more proactive

research in all frontiers so that aspirations of farmers to gain better market prices for their produce are assured.

S. C. Manchanda (All India Institute of Medical Sciences (AIIMS), New Delhi) in an interesting lecture on 'Role of Indian mustard in controlling coronary heart diseases', stated that the use of mustard oil could contribute significantly to check increasing epidemic of coronary heart diseases (CHD), which are the leading cause of death in the developing countries. Discussing the properties of mustard oil, Manchanda emphasized that it is a healthy cooking medium because of low saturated fatty acids (8%), high monosaturated fatty acids (70%) and alpha linolenic acid (10%). According to the recently published study by the Harvard Medical School of Public Health, USA; AIIMS, New Delhi and St. Johns Medical College, Bangalore, it has been demonstrated that use of mustard oil as a cooking medium reduces CHD risk by almost 70%. M. S. Ganesh (Fortis Hospital, Delhi) shared his views on anticancer properties of mustard oil. He elaborated on the role of various components of oil, such as curcumin, antioxidants, and isothiocyanates in preventing malignancy. In the second technical session, Deepak Pental (University of Delhi) spoke on the recent developments in hybrids and transgenics in mustard. He stressed on the need of modern biotechnological innovations *vis-à-vis*

\*A report on the National Conference on 'New Developments in Rapeseed Mustard', organized by the Mustard Research Promotion Consortium, an autonomous organization, and the Delhi University Botanical Society at the New Conference Centre, University of Delhi, Delhi on 21 January 2006.