ISSN 0972-5741 Volume 98 October 2013

IGC Newsletter

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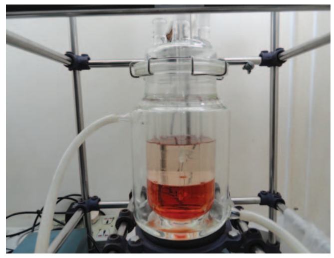

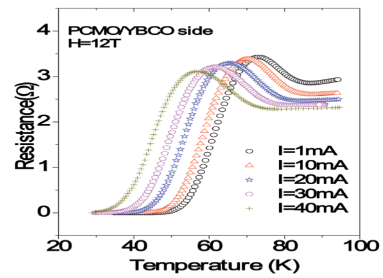

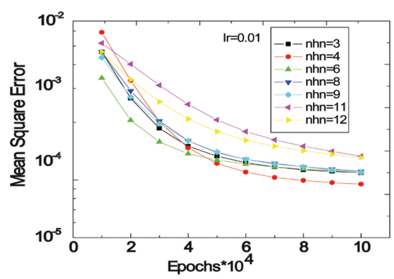

INDIRA GANDHI CENTRE FOR ATOMIC RESEARCH

http://www.igcar.gov.in/lis/nl98/igc98.pdf

From the Editor

Dear Reader

It is my pleasant privilege to forward a copy of the latest issue of IGC Newsletter (Volume 98, October 2013 issue).

In this issue we have had the privilege of Dr. R. Chidambaram, Principal Scientific Advisor to the Government of India, Chairman of the Scientific Advisory Committee to the Cabinet and former Chairman, Atomic Energy Commission, sharing his experiences with a team of young officers.

In the first technical article Shri N.K. Pandey and colleagues have discussed the extraction kinetics of ruthenium with tri n-butyl phosphate/dodecane system.

In the second technical article Shri Dipak Kumar Baisnab and colleagues have described the experimental studies of the effect of external perturbation such as substrate induced strain, applied current and magnetic field on $Pr_{0.5}Ca_{0.5}MnO_3$ on $YBa_2Cu_3O_7$ thin film heterostructures.

In the Young Officer's forum Shri Ankit Kumar has detailed the design and development of novel fault tolerant system for universal signal conditioning system architecture. He has also discussed the performance features of the architecture and its typical application.

In the young researcher's forum Ms. Subhra Rani Patra has described the development of computational intelligence systems for estimation of parameters such as temperature and identification of events for Fast Breeder Reactors.

This Newsletter carries reports on the "Graduation Function of the Seventh Batch of Trainee Scientific Officers of BARC Training School at IGCAR", "Summer Training in Physics and Chemistry (STIPAC - 2013)", "BITS Practice School" and "Quality Circle Annual Meet (QCAM) - 2013".

Dr. R. Chidambaram, Principal Scientific Adviser to the Government of India, Chairman of the Scientific Advisory Committee to the Cabinet and Former Chairman, Atomic Energy Commission visited the Centre during the last quarter.

We are happy to share with you the awards, honours and distinctions earned by our colleagues.

We look forward to your comments, continued guidance and support.

With my best wishes and personal regards,

M. Saibaba

(M. Sai Baba)
Chairman, Editorial Committee, IGC Newsletter
&
Associate Director, Resources Management Group

Interaction with Dr. R. Chidambaram

Dr. R. Chidambaram interacting with the team of young officers and Dr. M. Sai Baba, AD, RMG

What is the secret behind your energy? is it nuclear energy!

I don't think I am in any way special in this context. Intellectual pursuits are, of course, strengthened by good physical health. In 1957, I read a book by Swami Yogananda - "Yogasanas Simplified" – and, on the cover page was written: "It has been selected by the Crypt of Civilization to be buried along with many other books so that this knowledge is not lost, in case the world gets destroyed". From 1957 onwards, I do yoga and it has helped me a lot. One must understand that yoga is not aerobic and must be combined with other aerobic exercises. Earlier I used to play tennis, now I go for a walk. You must do physical exercise regularly, particularly at your age, and I am sure many of you are doing that already.

The type of contributions you are making and the type of change you are bringing in also sometimes gives you energy. When you have passion to do things you want to do, that automatically increases your energy levels. You must feel that what you are doing is important.

What were the challenges you faced when you transformed from Chairman AEC to Principal Scientific Adviser?

It was not too difficult because the Department of Atomic Energy has practically everything. A lot of my work was in basic research, DAE is very much in applied research, is interacting with industries, and also many of our things have gone for rural applications. The weakness in the Indian S&T system is inadequate interaction between the academia and industry, except in fields like nuclear, space and defence research; but it is going to go up sharply in the next ten years in my opinion. One of the focal areas of my office is on enhancing academia-industry interaction. When the Indian industries move up in technology and their products become more and more globally competitive, nobody is going to give you technology and allow you to compete. At that time, industry will have to lean heavily on Indian academia.

In India youngsters are reluctant to take up research, is the scenario same in other countries too?

It is a global phenomenon not limited to India. The haemorrhage of talent occurs at two places: after the +2 level, students interested in basic research take up professional courses, engineering or medicine, either because of parental pressure or because of peer behavior. A student, who has won a gold medal in the physics olympiad, instead of pursuing research in physics, joins IIT and becomes an electrical engineer; if he likes electrical engineering it is a different issue and there is no questioning of his choice. I feel parental pressure creeps

Dr. Rajagopala Chidambaram is the Principal Scientific Adviser to the Government of India and Chairman of the Scientific Advisory Committee to the Cabinet. He joined BARC in 1962 and became its Director in 1990. He established the High Pressure Physics Group that has done extensive work on equation of state and phase transitions at high pressures. He played a leading role in the design and execution of the Peaceful Nuclear Explosion experiment at Pokhran in 1974 and also led the DAE team, which designed the nuclear devices and carried out the five Pokhran tests in 1998 in cooperation with Defence Research and Development Organisation. Dr. Chidambaram is a Fellow of all the major Science Academies in India and also of the Third World Academy of Sciences, Trieste (Italy). He has received many awards and honours, notable among them are the C.V. Raman Birth Centenary Award of the Indian Science Congress Association in 1995, the Distinguished Materials Scientist of the Year Award of the Materials Research Society of India (MRSI) in 1996, R.D. Birla Award of the Indian Physics Association in 1996, Padma Vibhushan from Government of India (a civilian honour -1999), Homi Bhabha Lifetime Achievement Award of the Indian Nuclear Society (2006), the Lifetime Achievement Award of the Indian National Academy of Engineering(2009) and the C.V. Raman Medal(2013) of the Indian National Science Academy.

in here. If you join IIT or any leading professional institution, at the end of four years, your career is made, whereas if you pursue basic science, it takes five years to complete your post graduation and another five years to complete your Ph.D. and after that "parkalam- dehka jayaga". So at present it is a very unequal battle. I am convinced that if you want to attract talented young people into pure science or into engineering research and development for that matter, we must assure them a good career. One reason for the success of the BARC Training School is the assurance of a good career after graduation. Talented young people are not wanting to make money like a businessman, but they just want to have a reasonable quality of life. As a first step, recently DST has launched the INSPIRE programme, and one aspect of the programme is that, after your Ph.D., it guarantees you a job for five years. We need to wait and see the impact of this programme. In the case of engineers in general, after completing their B.E/B.Tech programme, an engineer who has obvious talent for engineering research and technology development, often either goes for a job, joins IIM or goes abroad. Myself and Dr. JJ Irani from Tata Steel suggested to industry leaders many years back, after a brainstorming session in our office, that when they hire human resource through placement interviews, let the creamy layer among the selected candidates be paid job salaries and allowed to pursue engineering research in a broad area of interest to the company, not just problem solving. He or she – the research fellow - will be subconsciously loyal to the company and keep looking for information valuable to the company. Two professors from different countries, when they talk generally tell each other almost everything and the research fellow is listening. But when two company scientists talk, they tell each other nothing useful, because of commercial secrecy and IPR issues.

At the end of four years, after finishing the Graduation programme, we are inclined to earn money for our family, do you think that the remuneration for higher education is not at par with other countries?

Foreign countries also have a problem. I read in the Journal "Nature" a few issues back that they are overproducing Ph.D.'s, particulary in the U.S. When you overproduce Ph.D's in a particular field, their market value goes down, hence we need to strike a balance between attraction of young talent and over production of Ph.D's in every area of science and engineering.

After graduating with an engineering degree we aspire to join IIT and IIM, but since the stipend is very low, many of them do not opt for higher studies. What is your comment on this?

It is better than earlier. When I joined for research in IISc in 1956, the fellowship from the Institute was Rs.56/- a month, the next year I became a junior DAE fellow at Rs.250/- a month, a big jump; then I became a senior DAE fellow at a (then) whopping Rs.400/- a month and then I joined BARC. I have always been fed by BARC/DAE.

What was your first reaction when Buddha smiled at you?

It was a great sense of excitement, we were doing it for the first time in 1974 and we had access only to published information when designing the fission device. When we send a shock wave through a material, its density increases. When we send a spherical shock wave through a ball of plutonium, it implodes and its ‘k’ value goes up and the system goes from a subcritical state to a supercritical state; then you initiate the chain reaction. The designs tested in 1998 were more complex, including a thermonuclear device and the subkiloton devices. Of course, we did have great excitement and happiness, both in 1974 and in 1998, because of the perfect match between design and achieved yields of all the devices.

Was it that you all had been making a world-wide storm, which they never expected?

Yes, they never expected the tests, both in 1974 and 1998, but we had been indicating to them that we are going to do it. Eisenhower (former U.S. President) started the Peaceful Nuclear Explosion (PNE) programme, - "Swords into Ploughshares", he called it. Applications suggested included stimulation of a hydrocarbon reservoir by an underground nuclear explosion. Suppose you drill into a hydrocarbon reservoir, oil or gas comes out; but if you fracture the rock around the reservoir, more oil and gas comes out of it. U.S. had done such PNE experiments in Colorado. In case you want to dig a canal, you can blast it using nuclear explosives. Different applications need different kinds of nuclear explosives. For example, to stimulate a hydrocarbon reservoir, one cannot use a hydrogen bomb because tritium will get exchanged with hydrogen in the hydrocarbon, so they used a fission device and, in the name of this application, they designed fission devices that can go up to 100 kilotons. When you want to cut canals or make water reservoirs you don’t want to spew out too much fission products, so they designed devices that have a very low fission trigger and most of whose yield comes from the thermonuclear part. We were interested in underground copper mining; in fact I presented a paper in IAEA in 1970 to indicate our interest in copper mining using underground nuclear explosions; break the underground ore, pour acid into it, extract the solution and recover the copper. IAEA held a series of Conferences on Peaceful Nuclear Explosions between 1970 and 1975, all of which I attended. Dr. Raja Ramanna and I presented the results of our 1974 PNE test in the 1975 IAEA meeting on PNEs. But after we did our 1974 test, they said there is nothing called peaceful nuclear explosives! Of course, the physics of nuclear explosives is same for a PNE device and a nuclear weapon, but the way in which they are packaged is different. I wrote a paper entitled “The May 1998 Pokhran tests – Scientific Aspects” which had been put on the net by the South Asia Analysis Group in 2000; and in 2008, the journal "Atoms for Peace", published in Europe, reproduced this paper.

Our spending on the R&D sector, as % of GDP is 0.9%, which is somewhere around eigth position in the world; do you think that we need to improve on that and how do we go about that?

Yes, we need to improve on that, ours is less than 1% and is hanging around it for many years; our Prime Minister has said that it should be made 2%. In South Korea it is almost at 3% but there is a major contribution from industry there. In India, 80% of the R&D funding comes from the Government and mostly it tends to be for Basic Research except in the mission-oriented agencies and CSIR. You know, there is a thermodynamic equilibrium between the knowledge in the academic system and the knowledge which has been transferred to (or generated within) the industry system in a developed country like the U.S.; the two are very close to one another. Industry is therefore, waiting for new knowledge to come out of the academic system. In India, academics want our knowledge to be at par with the knowledge in the western system so that we can publish in high impact factor journals. Knowledge in industry in India is a couple of notches lower in many sectors (nuclear, space, knowledge chemicals, etc. are exceptions) and that is what has caused the disconnect between academia and industry. If you are willing to live with yesterday's technology, where is the need for research and development? In nuclear and space, partly because of the technology denial regime, we had to do it on our own; they did not even give us computers, so we developed our own parallel-processing super-computers. In fact, in a way, that was a blessing in disguise to strengthen our self-reliance in the nuclear field.

Is it that Government is not relying on Indian Scientists? There is an organization, Defence Research & Development Organization, but still it is spending a lot of money for buying aircrafts, etc. from other countries?

DRDO is doing very well in many sectors like missiles. Forget about aircrafts, what about X-ray diffractometers and electron microscopes, we do buy it from other countries. The same is true for advanced medical therapeutic and diagnostic instilments. The Co-60 radiation therapy machine BHABHATRON designed by BARC is an exception. I would say that the problem is that doctors and scientists get accustomed to brands, and that is a major hurdle to indigenization efforts.

Why not the money spent on procuring from other countries, be diverted for research in order to produce indigenous products?

Indigenization is a complex process. I will give you an example. We have built neutron diffractometers. When we can build a neutron diffractometer, we can as well build an X-ray diffractometer. The Physics Group and the Reactor Control Division in BARC showed enough interest in the 1980's and, under a DST project, we built an X-ray diffractometer, almost as good as the one available in the market. But, the foreign exchange situation had improved and people opted for branded products rather than the indigenously developed X-ray diffractometer. One cannot force scientists today to buy the indigenous products. On the contrary, they say we want to pursue top class research, how can we do that unless we have the best equipment. Our missiles are indigenous. We have started working on R&D towards coal based, advanced ultra supercritical thermal plants; here steam is required at 700 °C + and we are developing the technology. IGCAR is involved in designing the boiler tube materials. The coal based advanced ultra supercritical thermal plant, nobody in the world has built one yet and hopefully we will reach the target early.

Once the Advanced ultra supercritical thermal plants (AUSTP) are operational, are we going to replace the existing ones?

This is not likely. These plants are for the future. We will start and NTPC will build a 800 MWe advanced ultra supercritical thermal plants prototype. As I said, there is a consortium, nucleated by our office, consisting of IGCAR, BHEL and NTPC to pursue the R&D for this project. Take the case of PHWR. Initially we started with 220 MW, then 540 MW and now 700 MW PHWR. All future PHWRs would be 700 MW. If we are successful, all the future thermal plants will also be advanced ultra supercritical thermal plants, because the coal consumption comes down. This is a relatively cleaner carbon technology, not zero carbon like nuclear, but for every MW, we will be emitting less carbon dioxide, and also using up less coal.

Do you think that the industry funding on the R&D should be made mandatory, to increase the flow of funds for research?

You see it is very difficult to force this, as each industry has its own stakeholders and shareholders. They will invest a rupee in R&D if and only if they get a good return.

But, in the long run, doesn't that be really beneficial to them?

Yes, of course. But for that, a long term vision is necessary. If it is beneficial for them in the short term, they will definitely go for it, you don't have to tell them. For instance, we started the Core Advisory Group for Automotive Research (CAR) in 2004. Any sector, which is booming, has got cash to invest in research. We thought at that time that the automotive sector is going to boom and formed the Core Advisory Group for this sector for what we call "pre-competitive applied research". If it is proprietary applied research, a company wants to improve its proprietary product, it is the business of the company and they can ask any academic institution to help them do it. In case, it is a pre-competitive generic problem in any industry - for example, in the automotive sector, problems such as alternate fuel, combustion, hydroforming, light weight alloys etc., which are generic issues - then it becomes the business of the Government and the results are available to all the automotive companies. Those are the ones we started under "CAR". What was noted was that the industries were not even aware of what academia can do for them, now the interaction between the industry and academia has increased in this sector. We also encourage international collaboration. Fraunhofer Group of Institutes in Germany is more for applied research just like Max Planck Institutes are for basic research. They focus on very specific topics, so we have started one collaboration with Fraunhofer Group for joining of dissimilar materials. Things are beginning to happen.

Now we face a severe energy crisis, our industries want to grow but we have no power. How do we address this issue?

There is no simple solution. We have to increase the availability of power manifold; for that, we need to build all kinds of power plants based on coal, nuclear, hydro and renewables.

Do you think that the concept of "Brain Drain" is still prevalent in India, that talent is moving out of India and that we are unable to retain the talented people?

When I was a student in Madras University, the Vice-Chancellor Dr. A. Lakshmanasami Mudaliar called it not 'brain drain' but 'brain overflow'. I was in Chicago last month for a Global Conference organised by the Indian Institute of Science Alumni association of North America. They all want to collaborate with India. I visited Oak Ridge National Laboratory and Argonne National Laboratory during this visit and , they are also very keen to collaborate with India. I have been saying that we must leverage international cooperation to strengthen our own initiatives. Dr. Homi Bhabha did that with great success and today we are a nuclear-developed country. Let the other country leverage its cooperation with us in a similar fashion. Then we have the foundation for a sustainable mutually beneficial cooperation. I mentioned about the Nanoelectronics initiative that started after a brainstorming session in our office to create Centres of Excellence in Nanoelectronics in IISc., Bangalore and IIT Bombay. The DIT provided the startup money Rs. 100 crores to these two institutions; now more funds have started flowing in from the industry also. Because the facilities that they have set up are world class facilities, a lot of young faculty are coming back. Prof. Rudra Pratap, a dynamic professor at the Indian Institute of Science and in-charge of the nanofab lab, gave a talk at Chicago and was confidently saying that we now have a facility "equal to or even better than what you have there".

We want international collaboration today, on an 'equal partner' basis. We are not looking for handouts, those days are over. Our National Knowledge Network (NKN) is on par with 'Internet2' of the U.S. and the E.U. Grid and so NKN can connect with them. Things are changing, you are the people who must change it faster; change will not happen by itself. To paraphrase what Swami Vivekananda once said, "Don't only think of what the Prime Minister should do or other leaders should do; think of what you can do within your own immediate environment". As you become senior and more powerful, you can start changing a larger environment, that is how one must bring about the change.

What is your role as Principal Scientific Adviser?

It is a multi-departmental role. The Principal Scientific Adviser is also ex officio Chairman of the Scientific Advisory Committee to the Cabinet (SAC-C). SAC-C has as members all the Scientific Secretaries, Presidents of the Science/Engineering/Agricultural Academies, Presidents of Industry Associations and some other leading scientists and intellectuals.

The scientific business of the Government has been divided into many Scientific Departments - Atomic Energy, Space, Defence Research, CSIR, DST, DBT, Medical Research, Agricultural Research and so on. But there are things which fall in nobody's territory, e.g. attracting young people to careers in science, which has been a major focal point of our Office since some years back. And there are many things, bits and pieces of which fall in many territories, e.g. Rural Development. We started a programme called Rural Technology Action Group "RuTAG", based on the principle that active scientists are not the best people for grassroots intervention, their Karma is different! I am sure that if you go and work for rural development programmes you will do as good a job as any other person, but who will do the scientific work you are doing here, which is equally important. Our Office works with rural voluntary organizations led by scientists, or which have a strong scientific component. The voluntary organization is the one that understands and knows the exact requirements of the rural people they regularly interact with and the scientists who lead them talk my language as well. I said my weakness is in grassroots intervention but my strength is my connectivity with all the knowledge institutions across the country. In case one wants something, I request for it from the universities, IITs, BARC, etc and that is the principle of RuTAG. It is working pretty well. The RuTAG centres are located in eight IIT's and now two NITs have also been included. When we want to scale successful rural innovations, we work with state governments. After the first isotope hydrology technique, introduced by BARC, succeeded in improving the recharge of aquifers in the hilly area of Gaucher in Uttarakhand by an average factor of 3, the Government of Uttarakhand and Himachal Pradesh are implementing it in ten other places.

Some solar power plants were installed in remote villages to meet the energy requirement, but later were dropped due to lack of maintenance, what should be done to avoid such things.

We must encourage local leadership to avoid problems like this, that is why the structure of RuTAG is what it is. An example in agriculture is a project from TIFAC(DST); Dr. S.K. Sinha, former Director of ICAR, went into eastern Uttar Pradesh and Bihar and tripled agricultural productivity in two years! Nothing great, just guaranteed good seeds, and ensured they followed good agronomical practices. But the moment they go away, things begin to slide. That is why local leadership is so important.

Sir, is it that we should have probably identified and trained some farmers in all these aspects?

Yes, we should do that but scaling of rural innovations is a problem in our country. Instead of penetrating 20 km in UP, with a great deal of effort, you can penetrate maybe up to 100 km, but how can you extend it to Odisha. You have to identify a competent person in Odisha. Skills, raw materials and even life styles changes in India in maybe even 100 km. Technology transfer works only in three situations. Suppose you design a new advanced reactor, you can do technology transfer very easily because the cost of redeveloping the technology is very high. They are not going to redo the entire exercise again but just pay and use. If it is a spectacular rural innovation, like the dwarf variety of wheat, that is not affected by high winds unlike the tall varieties that get easily destroyed, this technology spreads like wild fire. Third is the power of television advertisement; if our actors or cricketers drink something, we also tend to drink the same. We never stop to think whether the celebrity in the advertisement drinks it in his or her real life or not. In rural innovations, the perceived benefit is often only marginal, that is why technology transfer does not work in general for rural innovations. A rural innovation travels a distance of 50-100 km and stops. The reasons are change in raw materials, local skills and even tastes. The way a Tamilian woman cooks is different from how a Uttarakhandi woman cooks. There is such diversity in our country, which is of course a good thing. We also don't want one innovation centre to take over the whole of India, we want thousands of innovation Centres, wealth creating centres in India. That is why I have been recommending not just "Technology Transfer", but "Concept Transfer" followed by "Reinnovation"- for rural development. For example, IIT Kharagpur scientists asked why are you using your hand in the Ambar Charka to spin the wheel, instead you can use your foot as in the Sewing Machine; the foot doesn't get fatigued as fast as the hand. Both your hands are free and you can increase the number of spindles and thereby productivity goes up. The core concept here is that when you want rotary motion, use your foot; if you are smart enough, the same concept can be utilized by potters and others when they want rotatory motion. Some concepts that are common to several applications can go very far. Re-innovation would involve adapting the concept to suit local needs, local raw materials, local skills and local manufacturability.

Do you think we lack in entrepreneurship skill as a whole, we don't tend to be entrepreneurs and commercialize our products?

The first thing about India is nobody knows India fully. No simple statement holds for India. How do you say we lack entrepreneurship skill? Take for example, Shri Dhirubhai Ambani, he built an empire from nothing, there are so many other examples. The system is slowly falling into place. It takes time, particularly in a democratic society, that is why I say we should have optimism. We must also individually contribute to the development of our Nation, within the limits of our capability.

What is your opinion on the education system of India?

We must make teaching profession more respectable and better salaried. After completing your education, when you look out for careers, where do you place the school teacher's career, it is often seen as the last option. We must first change this scenario. Finland comes number one in the OECD's "PISA test". On investigating, it came to light that, they respect their school teachers the most. We should push for better emoluments for teachers and try to use also the electronic connectivity for teaching. BARC is trying a project at Pandharpur Engineering College, essentially for rural development. I consider DAE as a knowledge hub. In case a rural group wants some technology, he goes and approaches the Pandharpur Engineering College, either directly or through some voluntary organization. Pandharpur Engineering College in turn approaches BARC; BARC may or may not have the technology. In case BARC has the technology, it is delivered to the rural group through the National Knowledge Network, in case BARC doesn't have the technology, it gets in touch with some other DAE organization where it is available and delivers it. Thus, BARC acts as a national knowledge hub. We can have similar Knowledge hubs in CSIR, DRDO, Department of Agriculture etc. One of the things they tried there was school teaching. There are a number of rural schools around Pandharpur; they give lectures from Pandharpur Engineering College site. Wifi is good enough to reach out, optical fibre is not required for the last mile. Even among the group of rural schools, good teachers are identified and invited to deliver lectures which can reach the other schools in the group.

I would like to mention another related idea. The spouses at our remote nuclear project sites are a huge resource that has not been effectively utilized; they can reach out to the rural population in various areas like education, health, legal matters etc. If the project authorities give them logistic support, ensure security and provide transport, they can reach out to the rural people around the project site, make friends and create an awareness among them about our nuclear programme. I was very impressed by the way BHAVINI and IGCAR are reaching out to people around Kalpakkam.

In manufacturing technology, particularly steel-related manufacturing technology, what are the upcoming technologies such as hydroforming, semi solid forming etc.

Hydroforming technology is more associated with the automobile industry. I feel manufacturing is an area, where we have somehow missed out so far. Now we feel that we must have concentrated much more in that area. National development and national security depend heavily on manufacturing skills, across the board. We must also focus on "additive manufacturing (3D-printing)", which is an important component of the on-going Third Industrial Revolution, driven by the internet.

In India we have capitalized on the IT boom and Nanotechnology. What do you think the future will be?

IT services (export-oriented) was a good business concept, it created a lot of wealth for the country and this should continue. We must move on to electronics hardware. Now we have good R&D labs for nanoelectronics, hopefully one day a mega fab will come and in between we must have a prototype fab. India's strength is in design. That is why in Bengaluru and other places, we have excellent chip design groups. But they are designing chips mostly for other nations and not for India. Indian electronic companies must first get interested in fabricating chips for their products. We had a Core Advisory Group for Electronics Hardware co-chaired by Shri Ajai Chowdhry, former Chairman, HCL Infosystems Ltd. and Shri G.P. Srivastava from BARC, the Indian Electronics and Semi-conductor Association was also very much involved in it. There are some killer applications where we need large quantities of chips, for e.g. set top boxes for TV - what is there in a set top box that India can't make and we import it from China and South Korea. Next tablets; MHRD has brought out the Akash tablet and there are other tablets available in the market. These must be improved continuously, particularly in educational content. Smart energy meters and smart phones are also expected to have huge markets. We must concentrate on electronics hardware, telecom equipment such as routers and switches. My focus is currently on the network-related area. In Chennai, our office has established the Society for Electronic Transactions and Security (SETS). Shri R. Balasubramanian, Director of MatScience is also the Director of SETS. The location of SETS is unique, it has IIT Madras on one side and the Institute of Mathematical Sciences (MatScience) on the other. If we take a field like Cryptology, it is part number theory and part computer science. We are pushing on indigenization of electronics products and cyber security products.

Recently there have been a lot of attack on the Government websites, What is your opinion on the issue of cyber attacks?

Cyber attack can be at various levels; cyber attack for profit, cut into credit card or bank account, somebody loses money, in case he or she is really careless. Next is the attack on critical infrastructure such as the power grid or water grid; the Government is taking action for critical information infrastructure protection. We have an Integrated Threat Management Appliance designed by SETS and ECIL, that doesn't allow anything malicious to go into the main Network from an edge institution. Secure Network Access System(SNAS), designed by BARC and ECIL, is there; somebody tries to do something in the LAN, inconsistent with the security policy of the organization and he is cut off. One thing about these devices is that they have to be continuously upgraded as viruses and worms become more and more complex. This is a never-ending process. The question basically is - who is smarter than whom? We must fight this but without getting paranoid about it. The extreme cyber attack which we must be really careful about is cyber warfare. The former U.S. Defence Secretary Leon Panetta, said that the next Pearl Harbor for the U.S. will be cyber-based, which many people think was just hyperbole.

Do we have a forum where young people can give their ideas which can be looked or worked upon.

Nobody prevents you from sending me an e-mail for example. Creating an organization for this purpose across India is not so easy, as selecting the best out of the several thousand ideas from young brilliant minds scattered over a multitude of areas is not an easy task. The best thing would be to have small and then slightly higher and higher concentric rings. If you are convinced that your idea is very important, first write to the Head of your Institution. The proper route would be for you to approach your institution Head and request him to a raise this issue at the next higher level.

Would you like to share with us something regarding your school and college days.

My school education was at Meerut, UP. My mental arithmetic I still do in Hindi. I have never studied Tamil, though I know Tamil well. Then I joined Presidency College at Chennai, and pursued my post graduation in IISc Bangalore with specialization in Analogue Computers. I later switched to NMR, and from NMR moved to Neutron Scattering, from Neutron Scattering to High Pressure Physics and also to some aspects of Nuclear Technology.

Sir, what is your expectation from younger people like us. What can we do at our age to address some of the national issues?

You are the people who are going to take India on a fast-growth track. First and foremost, you should not lose your optimism, don't get carried away by what you see in the newspapers and electronics media. You see many negative things because negative things make news, though the media do present positive things also, but not to the extent I would like. India runs the way it runs, because many good people are here doing good work. Of course, you must try to improve the system. Einstein was once asked," what is it that makes a great scientist"? His reply was very interesting. He said "People think it is the intellect, they are wrong, it is the Character". Not that anybody can do great science, but unless you have integrity and feel for societal equity, no scientist can become great. This is true not only for scientists, but also administrators, bureaucrats, businessmen, politicians, lawyers. "Character" is the first thing one must develop. So my expectation from young people is "Optimism and Character"! I wish you all the best in your careers in the Department of Atomic Energy.

The team:
Shri Anindya Bhattacharyya, Shri Ashish Shukla,
Shri Avik Kumar Saha, Ms. Diptimayee Samantray and Ms. K. Saipriya

Kinetics of Extraction of Ruthenium with Tri n-Butyl Phosphate/Dodecane

In the reprocessing of the spent fuels discharged from Fast Breeder Reactors (FBRs), fission product ruthenium (noble metal) contributes significantly towards the radioactivity. For a fast breeder reactor fuelled by 28% plutonium containing mixed oxide, with an average burn-up of about 80 GWd/t and after a cooling period of six months, ruthenium contributes to the extent of 20% of the total radioactivity observed. As the half-life of ^{106}Ru isotope is nearly one year, the decontamination factor (DF) required for ruthenium is high even for the fuels with about two years cooling period. The inability to effect the separation of uranium and plutonium from ruthenium lies in the diversity of ruthenium compounds and their distribution coefficients in nitric acid solutions and the sensitive equilibria among its compounds/complexes. Most of the Ru(IV) ions produced during the dissolution of the spent fuel in nitric acid are quickly converted to Ru(III). Ruthenium with the oxidation state as +3 forms extraordinarily stable $Ru(NO)^{3+}$ species, resulting in the formation of a series of nitro-nitrato complexes which are extractable. Hence, it is necessary to understand the extraction kinetics of ruthenium with the solvent, tri-butyl phosphate /dodecane (TBP/DD) system.

Ruthenium nitrosyl nitrate ($Ru(NO)(NO_3)_3$) with ruthenium content of 1.5 wt.% in 8 M HNO_3 solution, TBP and dodecane were used for the extraction experiments. Since ruthenium is present predominantly as ruthenium nitrosyl ($Ru(NO)^{3+}$) species in nitric acid in the dissolver solution, ruthenium nitrosyl nitrate solution was employed in the extraction studies to simulate the chemical state of ruthenium in the dissolver solution. The extraction experiments were conducted in a Lewis cell comprising an impeller, baffle and stirrer (range: 60 to 1000 rpm). A double beam UV visible spectrophotometer was used for determining the concentration of ruthenium.

Approximately 1 g/L of ruthenium nitrosyl nitrate solution in 1, 2, 3 and 4 M HNO_3 was prepared from the ruthenium stock solution (15 g/L). 20 and 30 % TBP in dodecane (V/V) solutions were prepared by diluting TBP with dodecane in their corresponding volume ratio. Variety of contacting techniques like rotating diffusion cell, centrifugal contactor, rising and falling of single drop technique and Lewis cell are in use for determining the mass transfer coefficients and kinetics of extraction. Among these, Lewis type stirred cell of constant interfacial area is a convenient apparatus for studying the rate of mass transfer and measuring the individual phase mass transfer coefficients because it allows both constant area between two phases and a variance of the rate of stirring in a sufficiently broad range. 500 ml of ruthenium nitrosyl nitrate solution in 1 M nitric acid was taken in the Lewis cell (Figure 1). To this solution, 500 ml of pre-equilibrated 30 % TBP/DD (500 ml of 30 % TBP/DD and 200 ml of 1 M HNO_3 were mixed thoroughly in a separating funnel for about 20 minutes and the aqueous phase was separated out) was added gradually without disturbing the interface. Organic and aqueous phases were mixed with a double impeller using stirrer at the speed of 100 revolutions per minute. Samples were taken out at every 30 minute intervals of time (up to 300 minutes) from both aqueous and organic phases for determining the acidity and ruthenium concentration. Ruthenium was estimated spectrophotometrically using 1,10-phenanthroline as the chromogenic agent and acidity was determined by volumetric titration with standardized NaOH solution. Experiments were conducted with nitric acid concentrations: 1, 2, 3 and 4 M; TBP concentrations: 20 and 30%; impeller speeds: 100, 120 and 140 revolutions per minute and aqueous to organic (A/O) ratios: 0.6, 0.8 and 1.0.

Extraction of ruthenium is generally second order with respect to TBP concentration, with the formation of the complex $(Ru(NO)(NO_3)_3).(H_2O{\cdot}TBP)_2$. The complex that is more extractable in TBP is tri-nitratonitrosyl ruthenium, while tetra-nitrato is less extractable and Ru(IV) is inextractable. Extraction of ruthenium can be represented by the reaction,

$$\underbrace{RuNO(H_2O)_2^{3+} + 3NO_3^-}_{} + 2TBP \rightarrow Ru((NO)(NO_3)_3){\bullet}(H_2O{\bullet}TBP)_2 \quad (1)$$

$$\text{Aqueous (B)} + \text{Organic (A)} \rightarrow \text{Products} \quad (2)$$

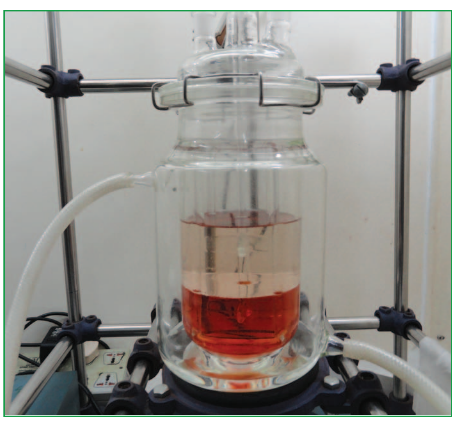

Figure 1: Lewis cell with double impeller

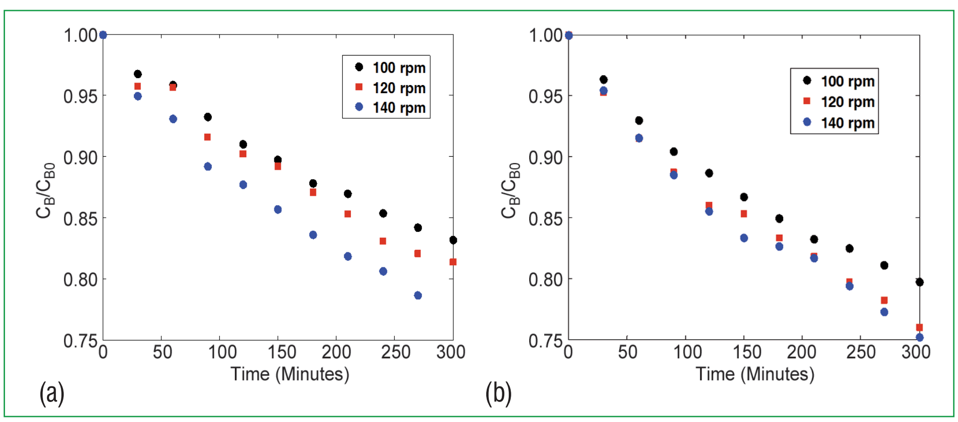

Figure 2: Extraction of ruthenium from (a) 1 M and (b) 2 M HNO_3 by 30% TBP

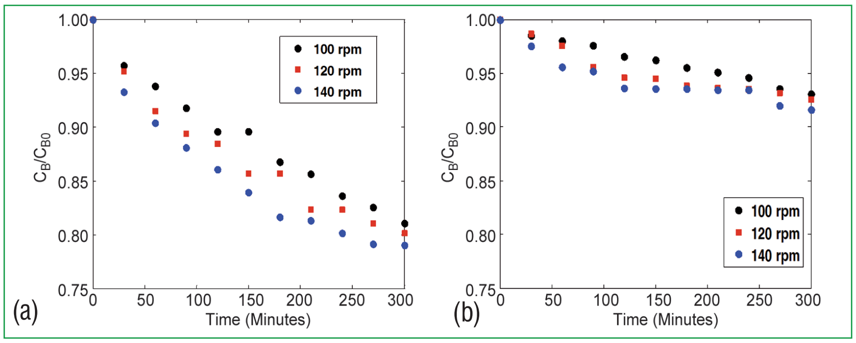

Figure 3: Extraction of ruthenium from (a) 3 M and (b) 4 M HNO_3 by 30% TBP

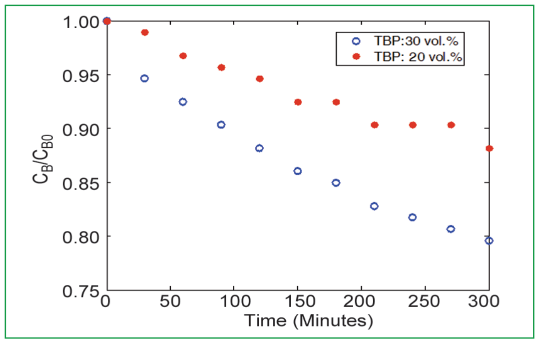

Figure 4: Extraction of ruthenium from 2 M HNO_3 by 20 and 30% TBP

Variation in the concentration of ruthenium with time at 1, 2, 3 and 4 M acidity using the impeller speed as 100, 120 and 140 rpm, for the extraction with 30 % TBP/DD is plotted in Figures 2 and 3 respectively.

The concentration of ruthenium against time in the extraction with 20 and 30 % TBP at 120 rpm from 2 M HNO_3 is given in Figure 4.

According to two film theory, it is assumed that close to any fluid-fluid interface, there is a stagnant film through which transport process takes place by simple molecular diffusion. In the present context, solute B diffuses into the thin organic film adjacent to the interface of both phases and reaction takes place to form the ruthenium complex with TBP. Concentration profile for this case is shown in Figure 5, in which most of the reaction between A and component B takes place in the aqueous phase.

Analysis of the experimental data indicated the extraction kinetics of ruthenium with TBP to follow slow reaction regime (reaction regime between 1 & 2). In this regime, diffusional rates of mass transfer are comparable to chemical reaction rates (i.e., both diffusional and kinetic factors are important). The governing equation for slow reaction regime is

$$R_A.a = K_1.a.(C_A^* - C_{A0}) = l.k_{mn}.C_{A0}^{\ m}.C_{B0}^{\ n} \quad (3)$$

On rearrangement and assuming m = n = 1, Equation 4 is obtained.

$$\frac{C_A^*}{R_A.a} = \frac{1}{K_1.a} + \frac{1}{l.k_2.C_{B0}} \quad (4)$$

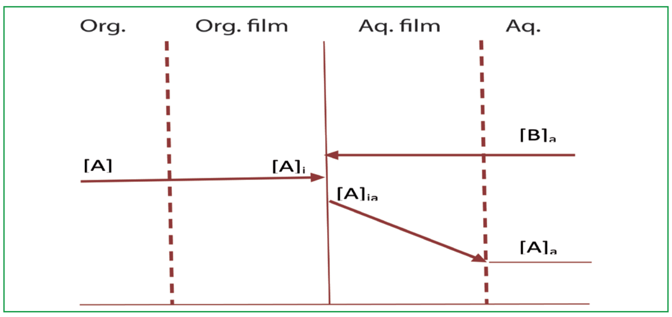

Figure 5: Schematic representation of the concentration profiles during the extraction of ruthenium

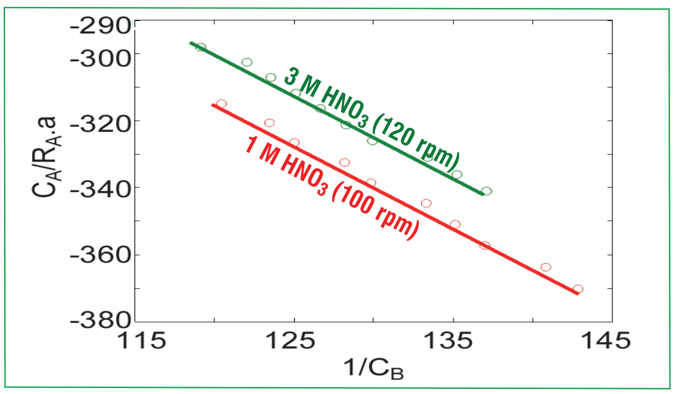

Figure 6: Plots based on Equation 4 for the data generated with 1 M and 3 M HNO_3

Figure 6 shows the plots based on Equation 4 for the experimental data generated in the extraction of ruthenium from 1 M (100 rpm) and 3 M (120 rpm) nitric acid respectively, using 30 % TBP. The values of k_La and k_2 could be derived from the respective intercept and the slope of plots in Figure 6.

In the slow reaction regime, the conditions to be satisfied are:

I. Solute concentration in the bulk liquid is not zero and it has some finite value, as shown in Figure 5.

II. $k_L a \approx \ell k_2 C_{B0}$

III. Hatta number $(H_a) = \sqrt{\frac{D_A k_2 C_{B0}}{k_L}} \ll 1$

IV. $H_a \ll q \qquad (q = \frac{D_B C_{B0}}{z D_A C_A^*})$

The kinetic parameters calculated using plots in Figure 6 are (a) Rate constant: 10^{-3} L/mol.s; (b) Mass transfer coefficient: 10^{-4} - 10^{-5} m/s; (c) Hatta number: 10^{-3} - 10^{-4} and (d) q value: 18 - 30. The results of this study satisfied the conditions for the slow reaction regime between 1 & 2 i.e. $H_a \ll 1$ and $H_a \ll q$; thus, implying that the rate of extraction of ruthenium is low. Since diffusional rates of mass transfer are comparable to chemical reaction rates in the slow reaction regime, significant amount of ruthenium will not get extracted using centrifugal extractor as the extraction equipment.

Since the rate of extraction of ruthenium is slow, the decontamination factor with centrifugal extractor as the extraction equipment would be better than with the pulse columns, as the residence time for extraction is less in centrifugal extractors.

Reported by N.K. Pandey and colleagues,
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Effect of External Perturbation Induced Charge Order Melting of $Pr_{0.5}Ca_{0.5}MnO_3$ on $YBa_2Cu_3O_7$ Thin Film

The antagonism between ferromagnetism and superconductivity was recognised very early by Ginzburg. Nevertheless, not much attention has been paid to investigate the behavior of thin film heterostructures comprising ferromagnetic and superconducting thin films. However, recent development of artificially fabricated thin film heterostructures has made it possible to bring the ferromagnetic phase in close proximity to the superconducting phase. A number of exotic phenomena such as oscillation of superconducting transition temperature (T_c) as a function of ferromagnetic layer thickness, spin triplet superconductivity, domain wall superconductivity, depression of superconductivity because of proximity to a ferromagnetic layer, superconducting spin-switch effect, Josephson effect involving two spin singlet superconducting layers separated by a half-metallic ferromagnet etc. have stimulated further scientific research on such systems. The first study on heterostructures involving thin films of unconventional superconducting materials and ferromagnetic materials were reported in late 1990s. The use of high temperature superconductors and ferromagnetic manganites unveiled a rich potential for possible application in devices based on injection of spin polarized quasiparticles from the manganite into the superconducting layer.

Soon, novel phenomena based on proximity effect were discovered, which operated at a much larger scale than the ones observed in conventional heterostructures. Detailed experimental and theoretical investigations and discovery of several exotic interfacial phenomena attracted more researchers to this field to further investigate the properties of such heterostructures. Charge ordered manganite like $Pr_{0.5}Ca_{0.5}MnO_3$ (PCMO) can be used for the fabrication of such heterostructures in conjunction with high T_c superconductors like $YBa_2Cu_3O_7$ (YBCO) with a view to investigate such effects.

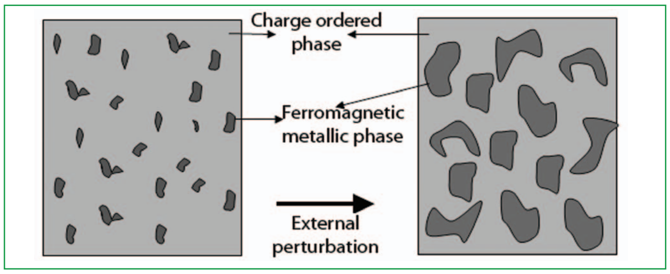

Figure 1:Schematic illustration of the ferromagnetic metallic clusters dispersed in a charge ordered background of the $Pr_{0.5}Ca_{0.5}MnO_3$ film, which are expected to grow under the application of suitable external perturbation

PCMO undergoes a phase transition from charge ordered antiferromagnetic insulating state to charge delocalized ferromagnetic metallic state under an external perturbation like magnetic field, electric field, substrate induced strain etc. (see schematic diagram in Figure 1).

This ferromagnetic metallic state of PCMO can then be judiciously used as a source of spin injection into the high T_c superconductors. A variety of bilayer and trilayer thin film heterostructures of PCMO and YBCO have been fabricated on different substrates like MgO, $SrTiO_3$ and $LaAlO_3$ to demonstrate the spin injection effect in these heterostructures. Thin film of YBCO with a thickness of ~100 nm has been grown on (100) oriented $LaAlO_3$ substrate by the pulsed laser deposition technique. A second layer of PCMO film with a thickness of ~100 nm was grown in situ on top of the YBCO layer. Magnetoresistance (MR) measurements were carried out on the bilayer sample under magnetic fields upto 12 T with different applied current (10 μA to 40 mA). Applied current (I) has been used here as an external perturbation to induce localized clusters of ferromagnetic metallic state inside the matrix of charge ordered PCMO layer. Based on the results of these measurements (shown in Figures 2a, 2b and 2c),

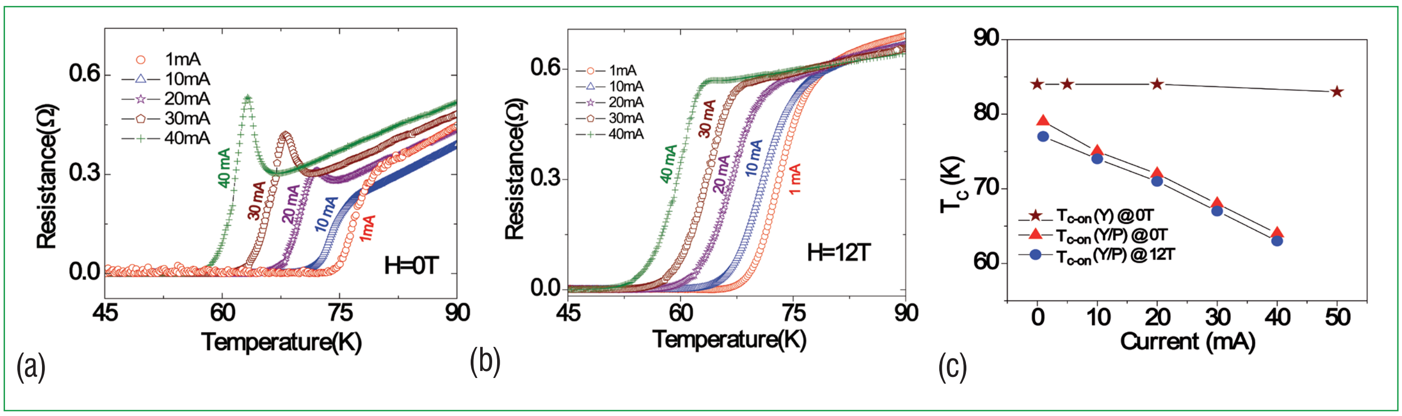

Figure 2: (a) & (b) Resistance vs. temperature behavior for different measuring currents ranging from 1 to 40 mA at two different magnetic fields on YBCO/PCMO film (c) T_c vs. applied current for a single layer YBCO (denoted as Y) and PCMO/YBCO bilayer (denoted as Y/P) for H=0 T and H=12 T field

it is inferred that the charge order melting is initiated in PCMO for I>1 mA at H=0 T leading to the formation of isolated tiny clusters of the ferromagnetic phase. The size of these ferromagnetic metallic clusters increases with increase in the magnitude of applied current. The T_c of the underlying YBCO layer is thus suppressed by injection of quasi-particles emanating from the top PCMO layer.

It is seen that the direct proximity of the ferromagnetic metallic phase can also reduce the T_c of YBCO layer and thus the proximity effect can play a crucial role in determining the overall behavior of the system. This fact can be cleverly used to control the T_c of the superconductor even without the direct electrical contact with the ferromagnetic metallic phase. To investigate these effects further, another PCMO/YBCO heterostructure has been deposited on $SrTiO_3$ substrate where about half of the bottom YBCO layer was deliberately not covered by the PCMO film by suitable masking techniques. The magnetoresistance measurements on this film and related analysis (shown in Figures 3a, 3b and 3c) reveal that the suppression of T_c is higher on the bilayer side of the sample compared to that on the YBCO side. This is due to the proximity effect and the quasi-particle spin injection effect from the top PCMO layer into the adjacent YBCO layer. But on the YBCO side, the proximity effect associated with the ferromagnetic metallic clusters in the PCMO layer may be excluded; superconducting properties on the YBCO side may, however, be affected by injection of spin polarized charge carriers. The results show a possibility of using these effects in spin injection devices where the superconductivity in a part of the YBCO thin film may be controlled by using spin injection effect arising from the ferromagnetic clusters in an adjoining YBCO/PCMO bilayer using a control variable such as applied current or magnetic field.

In recent years, there is an increasing effort to use these charge ordered melting phenomena to control the spin injection into the high temperature superconductor and thereby control the superconducting properties of high temperature superconductor. While it would be interesting to investigate the behavior of high temperature superconductor/manganite heterostructures when simultaneously subjected to several of these external perturbations, there is no report in the literature on the effect of simultaneous use of several such external perturbations to effectively control the spin injection into the high temperature superconductor. This concept can create a new possibility to effectively control the spin injection effect into the manganite/superconductor hetero-structure. Detailed investigations on PCMO/YBCO/PCMO tri-layer heterostructures have been used to demonstrate this concept of simultaneous use of two or more external perturbations to influence the formation of ferromagnetic metallic regions in PCMO. PCMO/YBCO/PCMO trilayer heterostructures with different thicknesses of the individual layers have been grown on MgO substrate using the pulsed laser deposition technique. There is a 9.2% lattice mismatch between the MgO and PCMO and thus PCMO film with thickness (~40 nm) lower than a threshold experiences a substrate induced strain. Therefore, in one trilayer (designated as "strained film"), the thickness of the bottom PCMO layer was selected to be relatively low compared to that in the other trilayer (designated as "relaxed film"). The experimental data on the strained and the relaxed films may be accounted for by invoking the nucleation and growth of ferromagnetic metallic clusters in the PCMO film promoted by experimental variables such as strain, magnetic field and applied current. Near the "hump" region, the magnetoresistance was observed to be negative for the

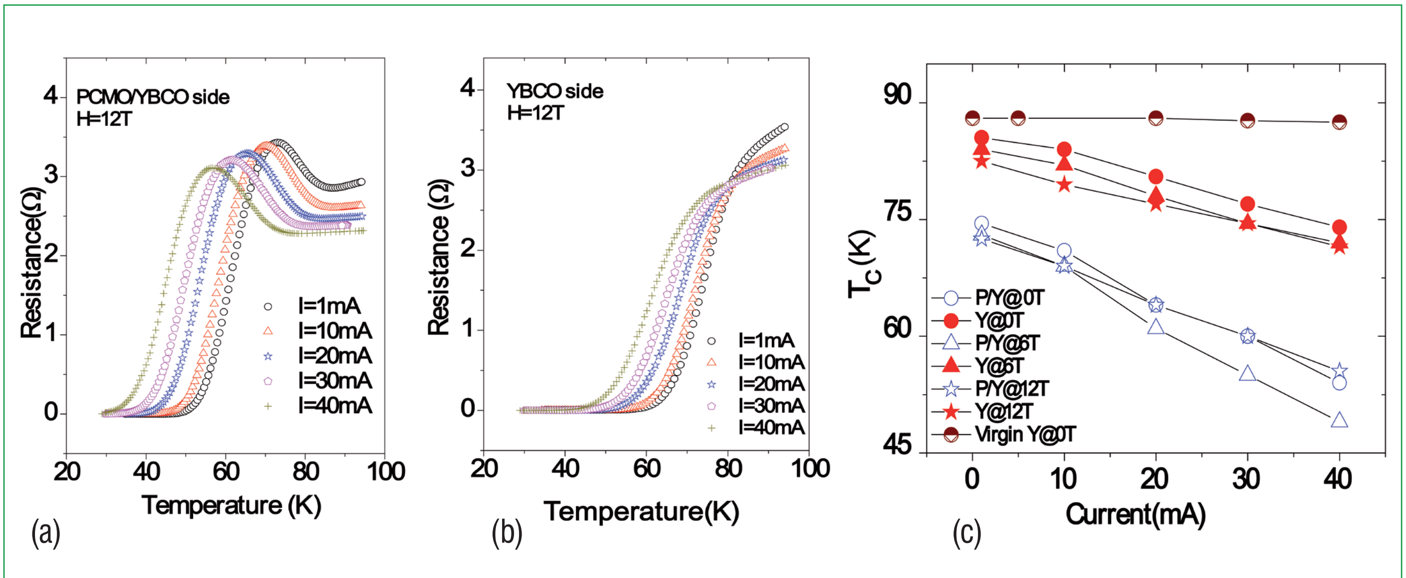

Figure 3: Resistance vs. temperature behavior for different measuring currents ranging from 1 to 40 mA at 12 T magnetic fields on (a)YBCO/PCMO side and (b)YBCO side (c) Variation of T_c with applied current in masked bilayer heterostructure for the YBCO side not covered by PCMO and for the YBCO side covered by PCMO at H=0, 6 & 12 T field. Also the T_c variation for virgin YBCO film is shown for comparison purpose

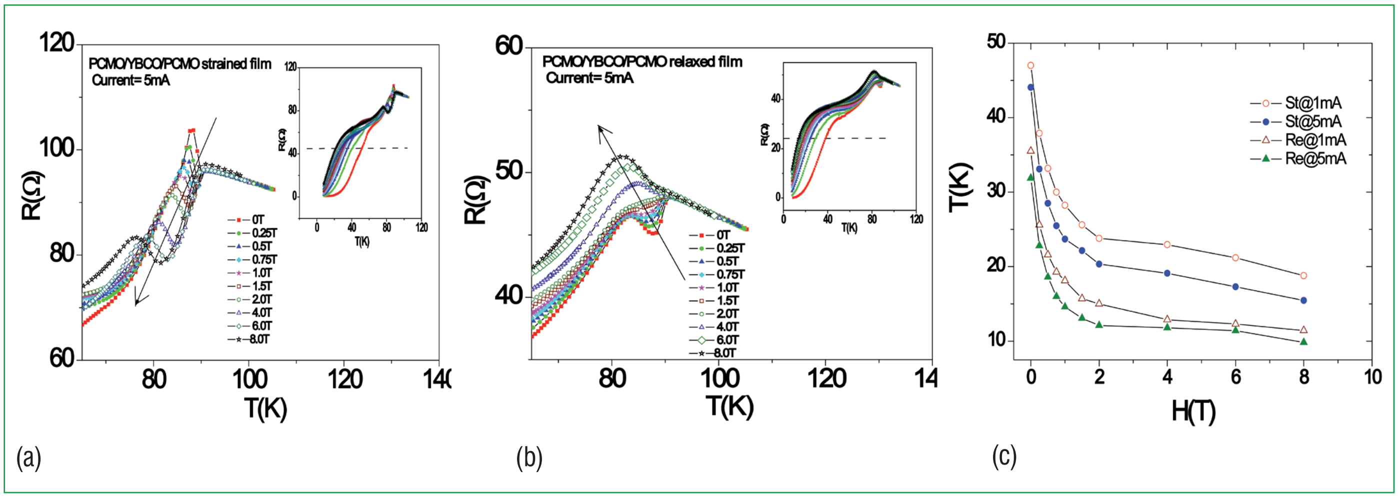

Figure 4: Temperature dependent resistance behaviour near the hump region for different applied magnetic fields ranging from 0 to 8 T for (a) strained film and (b) relaxed film at 5 mA applied current. Insets of figures (a) and (b) show the corresponding temperature dependent resistance for a wider range of temperatures (from 4.2 to 100 K). (c) variation of T_c for trilayer heterostructure at applied currents of 1 mA and 5 mA

strained film and positive for the relaxed film which are shown in Figures 4a and 4b. The suppression of the superconducting transition temperature T_c of the YBCO layer was found to be relatively higher for the strained film compared to that for the relaxed film shown in Figure 4c. This was ascribed to the spin injection and proximity effects due to the growth of ferromagnetic metallic clusters inside the PCMO layer. The trilayer was deposited on MgO substrate. This lattice strain can assist the formation of ferromagnetic metallic clusters in PCMO. Magnetoresistance measurements have been performed on the trilayers using two different sets of current (1 mA and 5 mA) applied to the top PCMO layer. The investigations on the T_c for this trilayer for different values of applied magnetic fields and currents (see Figure 4c) reveals that the suppression of T_c is much higher for the trilayer compared to that for the bilayer (where strain as a parameter was absent). The suppression of T_c due to the applied current has been measured to be ~0.8 K/mA for the trilayer whereas the value was only ~0.35 K/mA for the bilayer. Both substrate induced strain and electric field (current) are responsible for the nucleation of the FM clusters in bottom and top PCMO layers respectively and this results in a higher quasiparticle spin injection effect as well as the direct proximity effect of ferromagnetic metallic phase on the superconducting YBCO layer. These results demonstrate that strain can be used to control the formation of ferromagnetic metallic clusters just like applied current.

The experimental studies on PCMO/YBCO thin film heterostructures unveil the potential of using external perturbations such as substrate induced strain, applied current and magnetic field as control variables to influence the superconducting transition temperature T_c of the superconducting YBCO layer in a thin film PCMO/YBCO heterostructure. These experimental investigations open up a new opportunity to use these properties for the realization of novel spin injection devices by suitable choice of materials of charge ordered manganites and high T_c superconductors. It may be noted that controlled growth of these multilayer heterostructures and the related interface studies are required to realize these devices. There is a scope to further promote the melting of charge ordered phase of manganites by choosing substrates with even higher lattice mismatch (~10 %). There is also a possibility to use a number of external perturbations simultaneously to create a situation inside the charge ordered manganites where a small value of applied current or external magnetic field can bring about drastic changes in the physical properties. There are possibilities to induce 0 to π transition in superconductor/manganite/superconductor multilayer heterostructures, a phenomenon of considerable contemporary interest. In general, it is known that the thickness of ferromagnetic metallic layer governs the nature of coupling of the superconducting order parameters of the two superconducting layers in SC/FM/SC trilayer structures. Once the thickness of ferromagnetic metallic layer is fixed in a multilayer, it cannot be used to induce the transition from 0 to π phase. However, in SC/manganite/SC heterostructures, it may be possible to use external perturbations to influence the sign of the coupling of order parameters in the two superconducting layers separated by a manganite layer. In these heterostructures, the size and density of ferromagnetic metallic clusters inside the manganite layer can be varied by the external perturbations without changing the thickeness of the deposited manganite layer. Thus by fabricating and depositing of these heterostructures one can effectively contribute towards the goal of achieving various spin injection devices.

Reported by Dipak Kumar Baisnab and colleagues,
Condensed Matter Physics Division
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Young Officer's FORUM

Design and Development of Universal Signal Conditioning System for I&C of Future FBRs

Ankit Kumar, obtained his Bachelor of Technology in Electronics and Communications Engineering from Inderprastha Engineering College, Ghaziabad, Uttar Pradesh in 2009. He is from the 4th batch of BARC training school at IGCAR campus and currently working as Scientific Officer in Fuel Handling Control Section (FHCS) of ICD/PPG/RDG. His current area of interest is Design of I&C for Fuel Handling Systems used in FBRs and development of I&C data acquisition and control systems.

Universal Signal Conditioning System (USCS) is a compact field/ machine mountable fault tolerant 3U modular system which directly interfaces all types of analog/digital/discrete/special purpose sensors of a particular I&C system. It performs signal conditioning with high resolution & accuracy and transmits data over dual redundant RS485 links to control & monitoring systems.

Novel fault tolerant 3U modular system architecture has been developed for USCS for its safety critical and safety related I&C applications, targeting simplification of I&C architecture of future FBRs while maintaining the safety features of PFBR architecture in compact manner.

USCS architecture innovatively utilizes simplest multi-drop serial bus called Inter Integrated Circuit (I^{2}C) Bus for system operation with simplicity, fault tolerance and online maintainability (hot swap). System backplane uses only passive components, dual redundant I^{2}C buses, data consistency checks (CRC) and geographical addressing scheme (with 2 bit hamming distance) to tackle with bus lock ups/stuck buses and bit flips in data transactions. Dual CPU active/standby redundancy architecture with hot swap implements tolerance for CPU card software stuck up conditions and hardware faults. System cards implement hot swap for online maintainability, power supply fault containment and isolation, local communication buses fault containment and isolation and I/O channel to channel isolation and independency. I^{2}C bus failure mode analysis was done and system design was hardened for possible failure modes.

Figure 1: (a) Conceptual active backplane, (b) industrial prototype passive backplane with 3U bin and (c) backplane field I/O connectors

Various fault tolerance and performance features of USCS architecture and its typical applications for pure hardwired (without real time software) core temperature monitoring system for FBRs, as a universal signal conditioning system for safety related I&C systems and as control system for non-nuclear safety applications are discussed.

Design of USCS Backplane

3U single-height Euro card mechanical standard was adopted for system to achieve compactness. Backplane slot connector is a 96 pin DIN41612 Type C female which is mating connector to 96 pin DIN41612 Type C male (with 6 First Mate Last Break Pins) card edge for hot swap. For each slot/card, all fields' I/O are through 34 pin FRC (flat ribbon cable) connector mounted at backside of backplane which is mapped to the center row of 96 pin DIN41612 female slot connector. Stripline traces (Embedded Traces) are used for I^{2}C buses which provide self shielding and protection. Stripline also results in lower emissions and crosstalk.

The rise time of I^{2}C signals (300 ns for 400 Kbps) is very large (15 times) as compared to time of flight of I^{2}C signals on backplane (20 ns), so no termination resistor has been used on backplane. CPU card uses rise time accelerators i.e. dynamic current pull ups which help improve rise time and low state margins together. 5 V power plane can handle 50 A current and 12 V power plane can handle 20 A current safely. Backplane has twenty slots, but if required, two backplanes (or 2 bins) can be wire-linked to support twenty more slave cards without degrading backplane bus performance.

Tolerance for permanent loss of communications (due to bus lockups/ stuck buses) or inconsistent data transfers (due to bit flips) has been implemented. A 3U 19 inch 20 slots 400 Kbps fast I^{2}C bus serial backplane shown in Figure 1 was developed which uses only passive components like resistors and capacitors to achieve high reliability. This minimizes the probability of permanent stuck up (high/low) faults on I2C bus due to backplane components failures.

Backplane uses dual redundant I2C0 buses as system utility bus (SUB) and dual redundant I2C1 buses as system data bus (SDB) (Figure 2). Bus redundancy helps to tackle permanent bus stuck up faults (at low/high) due to passive component failures on one I2C bus. SUB (I2C0 bus) is used as system geographical addressing bus (SAB), card power monitoring & control bus (PMC) and system fault monitoring bus (FMB). SDB (I2C1 bus) is used for sensor data transactions. SUB bus of a particular card gets enabled automatically when the card is hot plugged in the backplane slot provided the card passes the built in heath tests after insertion event. SDB is normally disabled for a particular card and gets enabled only when a particular card is addressed on SUB. Once data transaction with a particular slave card is over, the CPU card issues a command to disable the SDB buffers of that card using SUB.

All card slots and on-card power hot swap controllers are geographically addressable on SUB. A bit flip while addressing on SUB or SDB may modify actual 7 bit I2C address to an address used by another IC on bus which may result in undesired operations and inconsistent data flow. To avoid such failures, a hamming distance of two is used among allocated slot geographical addresses i.e. slots geographical addresses on SAB differ from each other by at least two bits. As after the card is addressed successfully, further transactions on backplane are on SDB between the CPU card and the addressed card only; addresses of all ICs of the card on SDB also implement a hamming distance of two.

There is an acknowledgment for each byte transmission on backplane I2C buses. This helps in detecting/avoiding the failure due to bit flips in start condition, R/W bits, stop bit, acknowledgement bit etc. A bit flip in data bytes is detected using cyclic redundancy check implemented in backplane card interface with hot swap (BCI-HS) and inconsistent data is rejected. As the backplane is passive, all its features are implemented using BCI-HS residing on each card.

Design of Backplane-Card Interface with Hot Swap

On-card BCI-HS which implements communication buses fault containment which ensures automatic disconnection of card's local I2C buses from backplane buses if load card side I2C lines are low for ≥30 ms and also ensures generation up to 16 clock pulses on card load side SCL to attempt to free the bus and re-establish the connection when the bus becomes free. Card edge connector is staggered 96 pin DIN41612 Type C with six first mate last break pins for implementing 1 V precharge and ground contact for hot swap. It ensures generation of 1 V precharge on serial data and serial clock lines at the time of insertion and removal of card from backplane. Precharging minimizes the worst-case voltage differential these pins will see at the moment of connection, therefore minimizing the amount of disturbance caused by the I/O card.

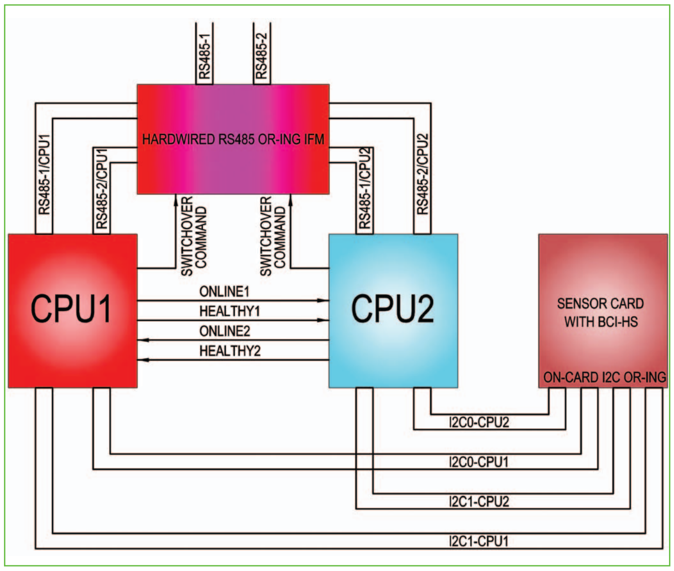

Figure 2: Dual redundant I2C buses on backplane

BCI-HS implements buffering of each I2C bus entering on card in order to isolate the card side capacitance from backplane side capacitance. This results in effective capacitance load of 10 pF by any card on each I2C bus and total capacitive load of 200 pF maximum by all 20 cards of the backplane. This value is 50% of the maximum capacitance load of 400 pF allowed by I2C bus specifications. Redundant I2C bus OR-ing is implemented using high reliability 2:1 I2C controlled I2C MUX.

Card's power can be controlled and monitored using commands on I2C0 bus using current ramp power hot swap controller (PHSC) which also has a geographical address on SUB. Additionally, the power of cars can be controlled using toggle switch provided on 'fascia'. Power fault containment ensures that the faulty card's power planes are isolated from the backplane power planes in case of any power supply fault on card so that the system power supply remains unaffected.

A unique on-card I2C0 bus accessible EEPROM based card ID helps CPU to detect the type of card and an I2C0 controlled 8 bit GPIO port reads the fault statuses of card. CPU will not get acknowledged merely from the card on SUB if either the card is unhealthy or if it is not present at all or 'fascia' switch is OFF. When CPU gets acknowledgement on SUB from card, it shall put a command on SUB to enable the card SDB buffers.

Dual CPU Active/Standby Redundancy Architecture

System uses dual CPU active/standby redundancy architecture with identical hardware and software on both CPU cards along with hot swap. The view of a typical 3U CPU card is shown in

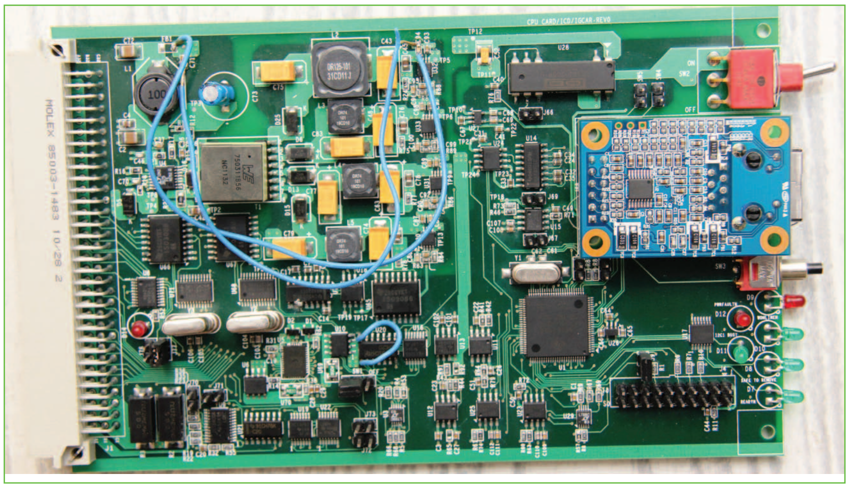

Figure 3: 3U CPU card

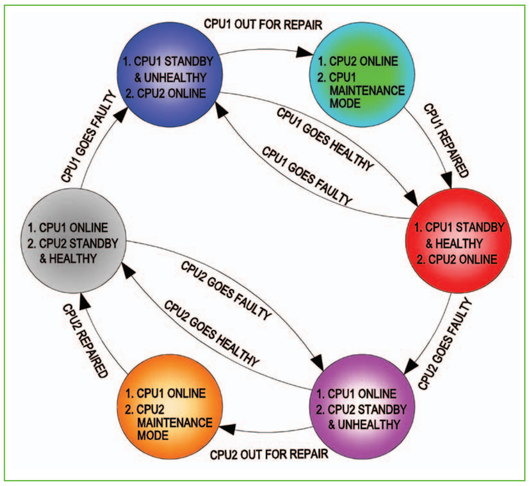

Figure 4: State diagram for active/standby redundancy

Figure 3. State diagram for active/standby redundancy is shown in Figure 4. I2C & UART ports loopback facility, power monitoring using BCI-HS and hardware watchdog timers with manual reset for software health are used for CPU card health. Each CPU generates two signals, one is HEALTH to communicate status of its health to other CPU and one is ONLINE for communicating online/standby status. Switchover logic ensures that only healthy CPU has control of system and faulty CPU card is silent.

Hardware watchdog timers have been used to keep the faulty/standby CPU silent and to tackle stuck up situations on ONLINE/STANDBY status lines. If at a time both CPUs are healthy, it is ensured that only one is online and other is standby. Online CPU continuously reports health of standby CPU to initiate a repair if latter becomes faulty. Maintenance of standby/faulty CPU can be done without affecting the online CPU due to hot swap facility. CPUs synchronization is not required due to real time availability of field inputs and only isolated RS485 outputs of online CPU are routed. CPU switchover was tested by disabling the power on one CPU using 'fascia' switch, by inserting infinite software loops on one CPU, keeping one CPU in long reset using reset button on fascia, and by pulling I2C bus to low on one card.

Design of typical Analog Front End

Front end of analog card uses digital galvanic isolation after ADC which reduces digital noise coupling to analog ground plane, avoids inaccuracies of analog isolation amplifiers, ch-ch isolation eliminates cross channel couplings.

To reduce EMI/EMC issues, 4 channel fly back DC to DC converters are implemented on board using 400 KHz switchers and 1:4 SMD transformers. There is a continuous background offset and gain calibration of the complete analog front end and continuous background sensor open/short detection. Dedicated analog front end per channel (No MUX) has been used in order to implement ch-ch independency and continuous parallel conversion of all channels. Typical analog specifications are given in the Table 1.

Applications & Improvements

Core Temperature Monitoring System (CTMS)

Block diagram of PFBR core temperature monitoring system is given in Figure 5. Dedicated 3-port galvanic isolated SCM has

Table 1: Typical Analog Specifications

Specifications	Description/Value
DC CMRR	120 dB typical
50/60 Hz CMRR	117 dB typical
NMRR 47 Hz to 63 Hz	78 dB minimum
PSRR	112 dB
INL	±15 PPM of FSR
Offset Error	8.25 uV max
Offset Drift with Temperature	0.125 nV/°C
Offset Drift over time	100 nV/1000 hours
Gain Error	100 PPM
Gain Error drift with Temperature	0.5 PPM/°C
Gain Error drift over time	1.6 PPM/ 1000 hours

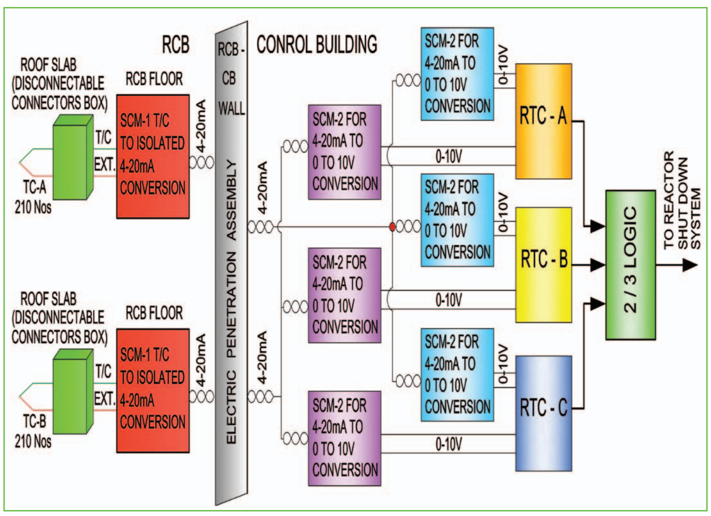

Figure 5: PFBR core temperature monitoring

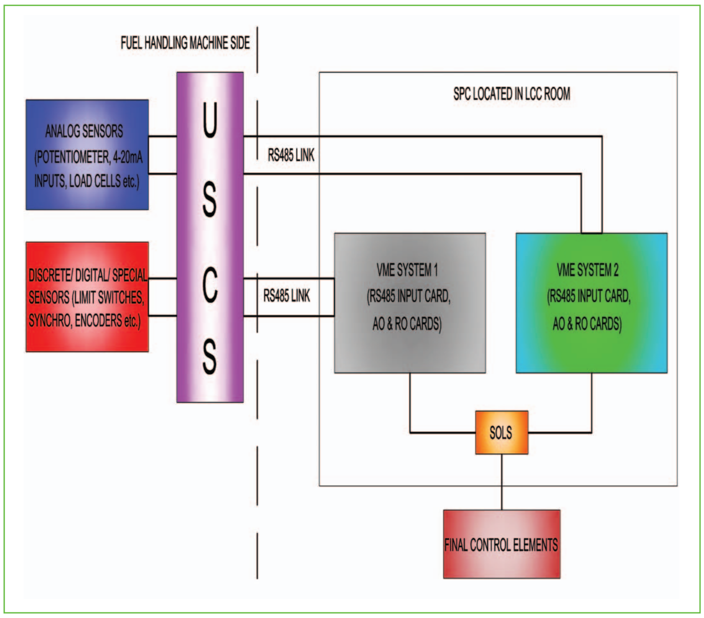

Figure 6: Safety related applications

Figure 7: USCS industrial prototype

been used for each T/C channel and failure of one channel does not affect healthy T/C channels i.e. channel to channel isolation has been implemented. Maintenance/ replacement of faulty SCM can be done while other sensor channels are online i.e. T/C channel hot swap facility is implemented. PFBR architecture is robust and proven, but there is scope for improvements with respect to size, cost and complexity.

The CTMS architecture reduces size, cost and complexity while maintaining the safety and maintainability features of existing architecture. USCSs directly interfaces all thermocouples directly over roof slab and replace multiple components in signal chain like junction boxes, SCMs (sensor to isolate 4-20 mA converters) along with their panels, dedicated long cables for each sensor, SCMs which convert 4-20 mA to isolated 0-10 V along with their panels and VME RTCs.

Cabling complexity and number of leak tight electric penetration assemblies (EPA) are also reduced drastically due to RS485 transmission as opposed to 4-20 mA transmission which requires two wires per T/C. Reduction in RCB/CB wall penetrations increases reliability of containment and also reduces cost, as EPAs have been imported at very high cost.

Along with cost, size and complexity reduction, this architecture increases reliability also due to its pure hardwired operation as compared to PFBR architecture which uses software based RTCs. Each hardwired FPGA controlled USCS transmits raw ADC data of thermocouple cards over RS485 and also FPGA based CPU cards are dual redundant to avoid single point failures in system control or RS485 communications. Total T/C to digital conversion time is independent of number of core thermocouples. This is possible because each T/C channel of USCS has a dedicated ADC running in continuous conversion mode whose conversion time is 2.5 ms.

A triple redundant FPGAs (operating in 2oo3 (2 out of 3) mode) based trip/alarms generator module (TAGM) receives raw ADCs data for a particular group over RS485. Three such TAGMs (one for each group A/B/C) also operating in 2oo3 mode along with 2/3 logic generate trip outputs for reactor shutdown system.

Safety Related Systems Applications

In safety related or safety class-2 applications, a field/ machine mounted USCS directly interfaces all types of analog/digital/ discrete and special purpose sensors in field, carries out processing and transmits data over dual redundant RS485 links to dual redundant VME based systems. This results in significant reduction in cabling and size for sensors and signal processing cabinets (Figure 6).

Non Nuclear Safety Applications

For NNS applications, USCS shall replace the PLC and VME based RTC from the architecture and interface all the field instruments, valves and motors etc. After processing all the inputs from field, it shall update the process computer on Ethernet link.

Extremely simple yet robust fault tolerant 3U modular system architecture has been developed which results in simplification of I&C architecture of future FBRs while retaining the safety features of the existing architectures in compact manner. A USCS industrial prototype shown in Figure 7 was developed and design was validated successfully along with software. The system architecture shall be deployed in non-nuclear safety applications first and after gaining sufficient confidence, shall be deployed for safety critical and safety related applications.

Reported by Ankit Kumar
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Young Researcher's FORUM

Development of Computational Intelligence Systems for Parameter Estimation and Event Identification in Fast Breeder Reactors

Ms. Subhra Rani Patra, did her Masters in Electronics from Berhampur University, Odisha. She joined IGCAR as a DAE research fellow in Computational Sciences in July 2007 and carried out her doctoral work in the Electronics, Instrumentation and Radiological Safety Group, under the guidance of Dr. M. Sai Baba. She obtained her doctoral thesis titled "Development of Computational Intelligence Systems for Parameter Estimation and Event Identification in Fast Breeder Reactors " to Homi Bhabha National Institute, Mumbai. She has worked as a Research Associate for one year at Indian Statistical Institute, Bangalore during July 2012-July 2013. Presently she is a Research Associate at IGCAR.

Computational intelligence is an area of research involving the study of adaptive mechanisms to facilitate intelligent behavior in a complex environment. It is a methodology of computing that exhibits an ability to learn and deal with new situations. Some of the attributes of computational intelligence are generalization, discovery, predictions and decisions. The main building blocks of computational intelligence are: artificial neural network, fuzzy logic, evolutionary computing as presented in Figure 1. Computational intelligence techniques can be applied in many fields like: pattern recognition, image processing, detection of medical phenomena, stock market exchange, credit assignment, process modeling, monitoring the condition of machinery engine management etc. An example is of neural network recognizers which are made to learn from a Chinese type written letter training set initially. The trained network then makes the character identifications. Each neural network uniquely learns the properties that differentiate training images. It then looks for similar properties in the target image to be identified.

In recent past, computational intelligence has also been applied in nuclear reactors to predict the parameters and detect the anomalies of subsystems accurately and consistently, which will be an aid to operators for maintenance of the reactor.

Nuclear power plant is a very complex arrangement of machinery consisting of a large number of control and support systems exhibiting nonlinear behavior. Accurate assessment of the operational characteristics in a nuclear power plant is of paramount importance. In real time, it is possible to implement intelligent systems in the form of artificial neural network, data mining, expert system etc., for modeling the nuclear power plant. Artificial neural network model, being nonlinear, data driven and having black box approach, is a powerful tool for identification of relevant physical parameters. A less understood system with large input and output datasets can be modeled using artificial neural network without having much knowledge of its internals.

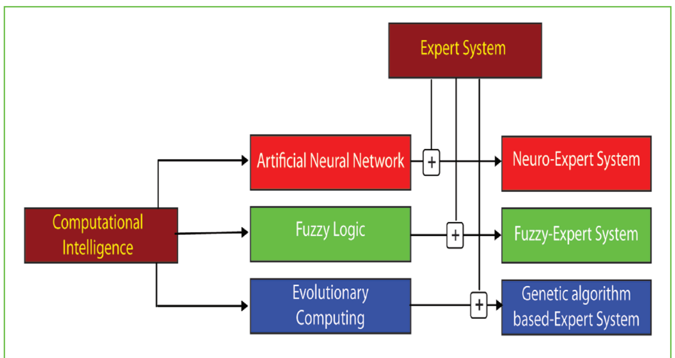

Figure 1: Computational intelligence hierarchy

In this work, computationally intelligent models are implemented for parameter estimation and event identification in nuclear reactor.

The subsystems taken here for case studies are:

- for FBTR: Intermediate heat exchanger
- for PFBR: Neutronics system and Primary sodium circuit

A neural network model has been proposed to estimate the value of temperature parameters in fast breeder reactor subsystems. Supervised back propagation algorithm has been implemented and fine-tuned for this purpose. The significant parameters used for prediction of the temperature of sodium are: primary inlet temperature, primary flow, secondary inlet temperature and secondary flow. The desired output parameters to be predicted are: primary outlet temperature and secondary outlet temperature. Input data for intermediate heat exchanger has been generated from the Quadratic Upstream Interpolation for Convective Kinetics (QUICK) code. After fine tuning, the neural network is trained for 10^5 iterations using back propagation algorithm and the achieved error convergence is of the order of 10^{-4}. From the results obtained, it is shown that this algorithm shows faster convergence and takes less computation time compared to models developed based on physical relations. The network is also trained with radial basis function algorithm. A comparative study of back propagation and radial basis function algorithm, is also carried out. The training results show that radial basis function algorithm are much faster compared to the standard back propagation as the network got converged to mean square error 8.9 x10^{-6} in 10^4 iterations itself.

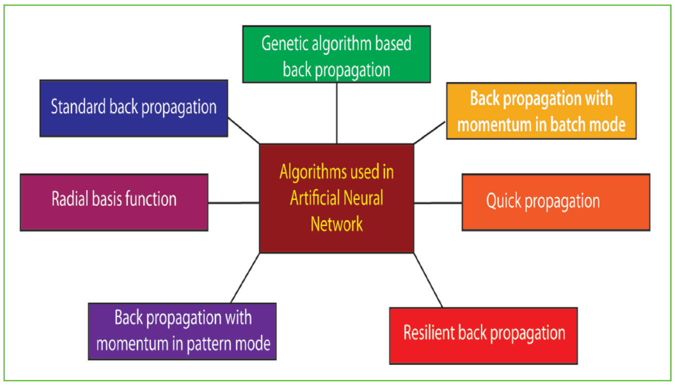

Figure 2: Various algorithms used for parameter estimation and event identification in nuclear reactor

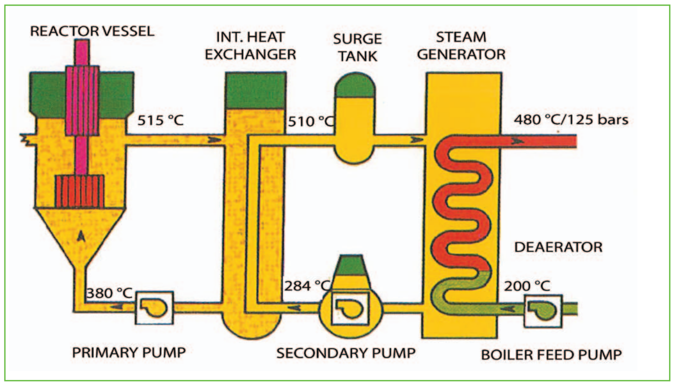

Figure 3: FBTR flow sheet for intermediate heat exchanger

Reactor power estimation has also been carried out using back propagation algorithm using multilayer perceptron model. The input parameters to the neural networks are the positions of nine control and safety rods and the output parameter is reactor power. Back propagation algorithm along with its variants namely standard back propagation, back propagation with momentum in pattern mode, back propagation with momentum in batch mode, quick propagation and resilient back propagation algorithm are also applied for process modeling of neutronics system. Among those algorithms resilient algorithm has converged faster with less number of epochs and an error convergence of 4.9×10^{-7} and produces the target output which is well agreement with the desired output.

Neural network model has also been implemented for identification of events or unsought occurrence of plant conditions which affect the safe operation of plant. In nuclear reactor, thousands of alarms are generated within a fraction of a second. So, the operator has to take immediate as well as appropriate action which can prevent occurrence of any abnormal plant conditions. Neural network is a tool that helps in predicting plant behavior in a fast and reliable manner. The neutronics system and primary sodium circuit related events of PFBR have been monitored using neural network algorithms. The event related input data have been generated from in-house developed thermal hydraulics code and has been validated as per the event analysis reports of PFBR. Four different events are taken together in a single neural network and back propagation algorithm and its variants are implemented. The events are: uncontrolled withdrawal of control and safety rod and primary sodium circuit related events, primary sodium pump trip, and primary sodium pump seizure. The significant parameters for these four events are reactivity (ρ), linear power (Lin P), central subassembly outlet temperature (θ_{CSAM}), increase in the central subassembly temperature ($\Delta\theta_{CSA}$), increase in the mean core temperature ($\Delta\theta_M$), power to flow ratio (P/Q) and pump speed (N_p). These are used to represent as input nodes to the neural network. The network is trained using BIKAS (Bhabha Atomic Research Centre – Indian Institute of Technology Kanpur-Artificial Neural Networks Simulator) with variants of back propagation algorithms. Among these algorithms, resilient back propagation algorithm shows least mean square error convergence of 4.29×10^{-4} providing better performance compared to other algorithms. From the obtained test results, it is observed that the neural network could identify the events successfully.

A hybrid genetic algorithm based neural network model has been developed for sodium temperature parameter estimation of intermediate heat exchanger of FBTR and the results are compared with standard back propagation algorithm. From the results obtained, it could be observed that genetic algorithm based neural network has faster convergence with less time of computation in comparison with standard back propagation algorithm. The various algorithms used in this work are presented in Figure 2. One case study that has been implemented for parameter estimation of intermediate heat exchanger is explained here in detail.

Neural network model for Intermediate Heat Exchanger using Quadratic Upstream Interpolation for Convective Kinetics (QUICK) scheme

Artificial neural network model has been developed for intermediate heat exchanger to study its behavior at transient conditions. Intermediate heat exchanger is a very crucial component of the reactor which transfers heat from primary side to the secondary side of a fast reactor and the heat in turn is used for electricity generation. Heat goes to the steam generator to produce superheated steam which rotates the turbine to generate electricity. The flow sheet of intermediate heat exchanger of FBTR is presented in Figure 3.

Quadratic Upstream Interpolation for Convective Kinetics scheme is a higher order up winding numerical scheme which takes care of strong convective flow. With the help of QUICK scheme primary and secondary outlet and inlet temperatures have been evaluated for given mass flow rates of intermediate heat exchanger in shell and tube side. Using simulated data generated from QUICK code, a three layer artificial neural network is trained using both back propagation algorithm and radial basis function algorithm.

Back Propagation Algorithm

Back propagation is the method for computing the gradient of the case-wise error function with respect to the weights for a feed-forward network, a straightforward but elegant application of the chain rule of elementary calculus. The steps involved in back propagation algorithm are presented below.

1. Present a training sample to the neural network
2. Compare the output of network with the desired output. Calculate the error in each output neuron
3. For each neuron, calculate what the output should have been, and a scaling factor, how much lower or higher the output must be adjusted to match the desired output. This is the local error
4. Adjust the weights of each neuron to lower the local error
5. Update the weights and repeat from step 3 on the neurons at the previous level
6. Save the weights and outputs

It is a steepest gradient descent algorithm. The output is calculated using transfer function. The multi layer perceptron is having a nonlinear transfer function known as sigmoid activation function. The activation function has been modified as follows in order to have better convergence and is presented by equation 1.

$$f = \left[\frac{2}{1+e^{-x}}\right] - 1 \qquad (1)$$

Subsequently fine tuning of the algorithm is required, in order to make mean square error as small as possible. To achieve this, different number of hidden nodes (*nhn*) and learning rate (*lr*) parameters are used and the network is trained so as to fix their values where mean square error is least. The formula for mean square error is given in equation 2.

$$\text{Mean square error} = \frac{1}{TSN}\sum_{t=1}^{TSN}\sum_{k=1}^{NON} * \left((d_{out})_{kt} - O_{kt}\right)^2 \qquad (2)$$

Where *TSN* is the number of training samples and *NON* is the number of outputs nodes, $(d_{out})_{kt}$ is the desired output and O_{kt} is the actual output. One more parameter known as momentum can also be used which filters out high-frequency changes in the weight values. By iterating the algorithm, the desired weight parameters can be found.

The weight parameters can be calculated using equations 3a and 3b.

$$W_{kj} = W_{kj} + \delta W_1 \qquad (3a)$$

$$W_{ji} = W_{ji} + \delta W_2 \qquad (3b)$$

Where W_{kj} is the weight vector from hidden to output layer, W_{ji} is the weight vector from input to output layer and δW_1, δW_2 are the respective changes in weight parameters. When the testing data is given to the algorithm, using the above weight parameters the neural network will be able to generate outputs almost matching with the desired outputs. This can be represented as the ability to generalize.

Radial Basis Function Algorithm

Radial basis function approach is designed as a curve fitting problem in high-dimensional space that provides the best curve fit for the applied dataset during training. A general radial basis function network consists of three layers, each of the layers having different utilities. The input layer consists of nodes where the datasets are applied (during training and testing). The second layer is the hidden layer of the network and unlike multilayer perceprton back propagation network radial basis function network contains a single hidden layer. The hidden layer applies a nonlinear transformation to the applied data to bring it to a hidden space of higher dimensionality. The set of functions that the hidden layer provides, constitute an arbitrary 'basis' for the input pattern when they are expanded into hidden space. These functions are called 'radial basis functions'. The third layer is the output layer of the network and it gives a linear transformation to the hidden space contents that forms the response of the network to the applied dataset.

The different radial basis functions used are:

Gaussian Functions:

$$\varphi(r) = exp\left(\frac{r^2}{2\sigma^2}\right) \quad \text{width parameter } \sigma > 0$$

Multi-Quadratic Functions:

$$\varphi(r) = (r^2 + \sigma^2)^{\frac{1}{2}} \quad \text{parameter } \sigma > 0$$

Generalized Multi-Quadratic Functions:

$$\varphi(r) = (r^2 + \sigma^2)^{\beta} \quad \text{parameter } \sigma > 0,\ 1 > \beta > 0$$

Thin Plate Spline Function:

$$\varphi(r) = r^2 \ln(r)$$

where,

$\varphi(r)$ = basis function

σ = width parameter

r = centre

β = multi-quadric function with values ...-3/2, -1/2, 1/2,3/2....

The radial basis function is similar to the Gaussian density function which is defined by a 'centre' position and a 'width' parameter. It is a real valued function whose value depends only on the distance from its receptive field center μ to input x. The Gaussian function gives the highest output when the incoming variables are closest to the centre position and decreases monotonically as the distance from the centre increases. The width of the radial basis function unit controls the rate of decrease; for example, a small width gives a rapidly decreasing function and a large value gives a slowly decreasing function. When the distance between x and μ,(denoted as $\|x-\mu\|$), is smaller than the respective field width σ, the function has an appreciable value. Once the normalized center and training data are available, the width of the basis functions is found by the formula represented in equation 4.

$$\sigma = \frac{d_{\max}}{\sqrt{2 * nhn}} \qquad (4)$$

where,

- σ = fixed width of all basis functions in the net
- d_{max} = maximum distance between centre
- nhn = number of hidden nodes

The non linear transfer function used here is Gaussian basis function whose output is inversely proportional to the distance from the center of the neuron and that is stated in equation 5.

$$Z_j = \exp\left[-\frac{\| x - \mu_j \|^2}{2\sigma_j^{\,2}} \right] \qquad (5)$$

where x is the input vector μ_j and σ_j and are the center and width of the basis function and Z_j is corresponding activation function. In multilayer perceptron, the network is trained with single global supervised algorithm, whereas radial basis function is trained one layer at a time with first layer unsupervised.

The output expression for the network is computed by the formula given in equation 6 with $y=[y_1, y_2, \ldots, y_k]$ and y_i as the output of the i^{th} neuron given in equation 6.

$$y_i = \sum_{i=1}^{nhn} w_{ji} * Z_j + b \quad \text{for i=1,2,...,k} \qquad (6)$$

where,

- nhn = number of hidden layer nodes (radial basis function)
- Z_j = output value of node in hidden layer for the i_{th} incoming pattern
- w_{ji} = weight between j_{th} radial basis function unit and i_{th} output node
- b = biasing term

Radial basis function neural networks are classified as universal approximators, as this type of network structure, using basis functions for mapping the network neurons can approximate virtually any function of interest to any desired degree of accuracy, provided sufficient number of neurons are represented in the hidden layers of the network.

Results and Discussion

The coding has been performed in C. Primary sodium inlet temperature, secondary sodium inlet temperature and primary sodium flow and secondary sodium flow are the inputs to the neural network. Primary sodium outlet temperature and secondary sodium outlet temperature are output of the neural network. Out of 77 sets of data generated from the QUICK code for prediction of temperature of intermediate heat exchanger, the network has been trained with 70 sets. A set of seven distinct test cases have been chosen within the range of inputs already trained, for testing the network. The time taken to generate the data set using QUICK code is 10 minutes.

Different trials have been carried out using back propagation algorithm in the training phase, to get the optimal values for different number of hidden nodes and learning rates. Figure 4 shows mean square error parameter with respect to the number of iterations for various learning rates and number of hidden nodes. At first the value of learning rate is varied keeping number of hidden nodes constant. Then the number of hidden nodes is varied keeping learning rate constant. The optimal learning rate and number of hidden nodes are nhn= 4 and learning rate lr= 0.01 showing least mean square error of $9.5\text{x}10^{-5}$ for 10^5 iterations.

After fine tuning, the network is further trained for 10^6 iterations using back propagation algorithm. Finally the network is again trained using the radial basis function algorithm. The number of centers used for radial basis function network is four. Both back propagation algorithm and radial basis function algorithm are employed. Variation in the graph plotted between the total number of training sample sets of primary and secondary outlet

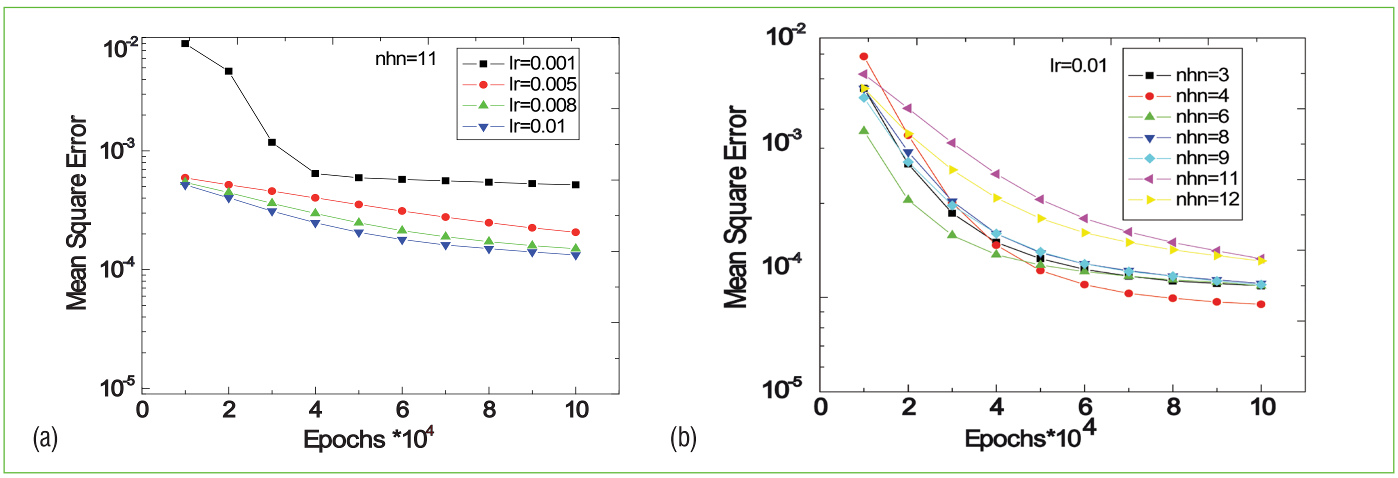

Figure 4: Mean square error with respect to number of epochs for (a) various learning rates (b) number of hidden nodes for intermediate heat exchanger

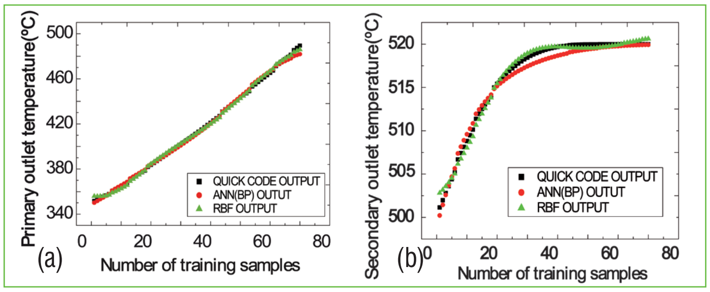

Figure 5: Estimation of (a) primary outlet temperature (b) secondary outlet temperature of intermediate heat exchanger for training sample index

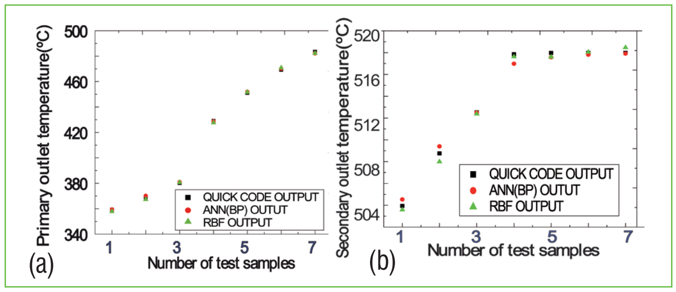

Figure 6: Estimation of (a) primary outlet temperature in (b) secondary outlet temperature of intermediate heat exchanger for test sample index

temperatures for desired and actual outputs are presented in Figure 5. It can be seen that the actual outputs achieved from back propagation algorithm and radial basis function algorithm agree with the desired output.

The training results show that radial basis function algorithm is much faster compared to the standard back propagation algorithm as the network got converged to 8.9×10^{-6} within 10^4 iterations. In Figure 6 the graph for testing samples using the back propagation algorithm and radial basis function algorithm is plotted. The testing samples are not present in the training set but these are taken from the range of training samples. This is the validation phase. The graph shows that the testing samples for desired and actual output of primary and secondary outlet temperatures overlap with each other and their difference (set to be ± 2 °C) is also not very large. From the results given above it can be observed that, compared to the conventional methods used for the prediction of intermediate heat exchanger temperature, the standard back propagation algorithm shows better results and compared to standard back propagation algorithm, radial basis function algorithm shows better convergence.

Figure 7 depicts scatter plots between desired and actual outputs for testing samples. The data treatment yielded the correlation coefficient of 0.99995 (for standard back propagation network), 0.99975 (for radial basis function network) for primary outlet temperature and 0.99849 (for standard back propagation network) and 0.99852 (for radial basis function network) for secondary outlet temperature. The correlation approaching to unity indicates that the desired and the actual data lie on a 1:1 straight line when plotted against each another. The standard back propagation has certain drawbacks as it can get trapped in local minima instead of reaching the global minima. This is overcome by radial basis function algorithm which uses Gaussian function as transfer function. Once trained, the network gives the output in few milliseconds with expected accuracy.

To conclude, the case study has been taken in which the network is trained and tested using back propagation algorithm for estimation of temperature parameter of intermediate heat exchanger and is again trained with radial basis function algorithm. The results of radial basis function algorithm are compared with standard back propagation algorithm. It is seen that the radial basis function algorithm is better as compared to standard back propagation network having faster convergence. From the results of the work carried out, it is found that the neural network model is able to generalize and produce satisfactory results for a wide range of data with faster response than the conventional methods.

Reported by Subhra Rani Patra
Electronics, Instrumentation and Radiological Safety Group

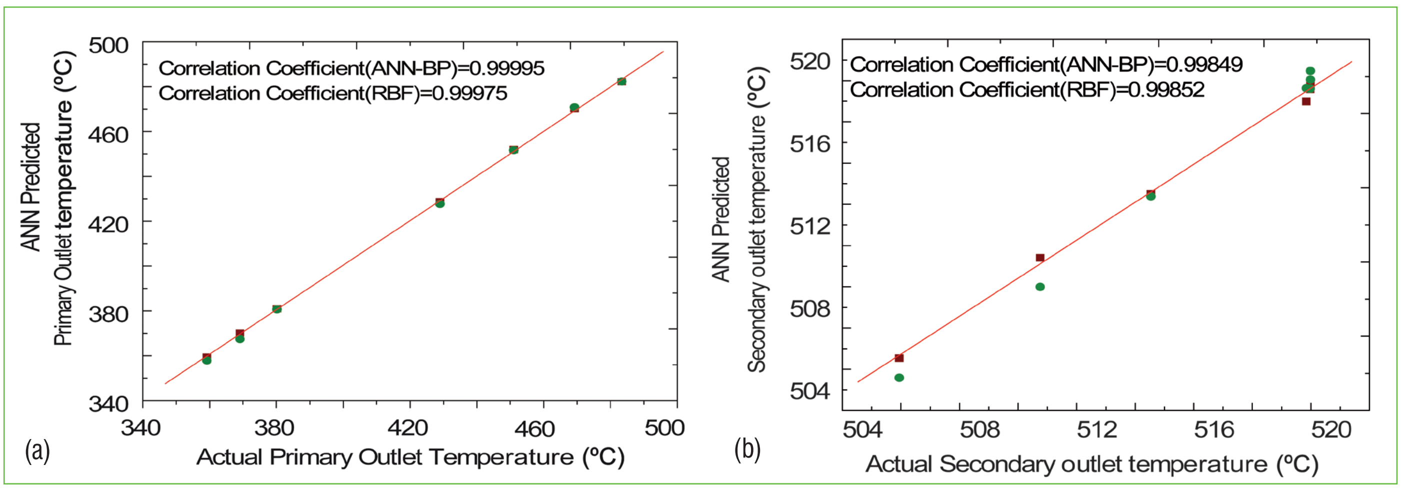

Figure 7: Scatter plot between desired and predicted output values for QUICK code, back propagation and radial basis function for (a) primary outlet temperature (b) secondary outlet temperature for intermediate heat exchanger

News & Events

Graduation Function of the Seventh Batch of Trainee Scientific Officers of BARC Training School at IGCAR
July 29, 2013

Prof. K. Kasturirangan, Member (Science), Planning Commission, Government of India and former Chairman, Indian Space Research Organization addressing the gathering while Dr. P. R. Vasudeva Rao, Director, IGCAR, Dr. M. Sai Baba, Associate Director, RMG, Shri R. V. Subba Rao, Head, OCES-TS, RMG are seated on the dais during the graduation function

The seventh batch of fifty TSOs from the BARC Training School at IGCAR have successfully completed their training and were graduated in a special ceremony that took place on July 29, 2013 in the Sarabhai Auditorium, Homi Bhabha Building, IGCAR. Prof. K. Kasturirangan, Member (Science), Planning Commission, Government of India and former Chairman, Indian Space Research Organization was the Chief Guest. Dr. M. Sai Baba, Associate Director, RMG welcomed the gathering. Dr. P. R. Vasudeva Rao, Director, IGCAR delivered the presidential address. Prof. Kasturirangan released the souvenir featuring the training school programme in the previous academic year and Dr. P. R. Vasudeva Rao received the first copy.

Prof. Kasturirangan gave away the prestigious 'Homi Bhabha Prize' comprising of a medallion and books worth Rs. 5000 to the meritorious toppers from all the disciplines. He also gave away the course completion certificates to all the graduates passing out. A few of the Trainee Scientific Officers passing out shared their experience, gave a feedback on the academic programme and their stay at hostel. Prof. Kasturirangan gave a very inspiring and motivational lecture to the students. Shri R. V. Subba Rao, Head, OCES-TS, RMG proposed the vote of thanks.

Reported by M. Sai Baba, AD, RMG

Seventh Batch of Graduates of BARC Training School at IGCAR with Prof. K. Kasturirangan, Member (Science), Planning Commission, Government of India and former Chairman, Indian Space Research Organization, Dr. Prabhat Kumar, CMD, BHAVINI, Shri T. J. Kotteeswaran, Station Director, MAPS, Shri Amitava Roy, Facility Director, BARCF, Dr. P. R. Vasudeva Rao, Director, IGCAR, senior colleagues of the Centre and members of RMG

Summer Training in Physics and Chemistry (STIPAC - 2013)
May 27 - July 5, 2013

STIPAC students with Dr. P. R. Vasudeva Rao, Director, IGCAR & senior colleagues during the inaugural function

Group photograph taken after the valedictory function

Summer training course in Physics and Chemistry (STIPAC), an annual event of IGCAR was conducted during the period May 27 - July 5, 2013 for the pre-final year M.Sc. students from all over India. The intention of STIPAC is to motivate young students to pursue a scientific research career by providing them the opportunities to take part and become familiar with scientific research through lecture courses and hands-on laboratory experiments in selected areas. A total of forty students attended, twenty each from Physics and Chemistry discipline, respectively.

The theme of this year's summer training in physics (STIP) was on "Structure and Properties of Materials". The lectures addressed the sub-themes of symmetries and crystalline order, XRD and structure determination, optical, transport & thermodynamic properties of solids, electronic structure of materials, cooperative behavior, superconductivity, phase transitions, defects & disorder in solids, soft matter, micro and nano structured materials, surface and interface phenomena, interaction of radiation with matter and basics of quantum & statistical mechanics. There were also introductory lectures on current topics such as graphene, porous solids, multiferroics, topological insulators, quasicrystals, etc. The STIP students were also given individual specific projects under a supervisor.

Summer training in chemistry (STIC) involved lecture courses in the following areas: nuclear chemistry, solid state chemistry, thermochemistry, analytical chemistry, surface chemistry, electrochemistry, quantum chemistry, spectroscopy, coordination chemistry, computational chemistry etc. Areas of laboratory work in the STIC course included thermal analysis, high performance liquid chromatography, super critical fluid extraction, electroanalytical chemistry and infrared spectroscopy.

During the inaugural session, Dr. K. Nagarajan, Associate Director, CG, Dr. C. S. Sundar, Director, MSG and Dr. P. R. Vasudeva Rao, Director, IGCAR emphasized the need for such motivating summer training programmes to enthuse the students into research career. The Chief Guest Prof. Krishan Lal, President, Indian National Science Academy, New Delhi gave a lucid lecture on "A Century of Crystal Structure Determination".

Special evening lectures were given by Prof. E. Prasad, IIT Madras, Ms. Shyleswari M. Rao, Director, Ved Vyas Inner Space, Chennai, Prof. K. S. Viswanathan, IISER, Mohali, Dr. S. Banerjee, DAE Chair Professor and Former Chairman, Atomic Energy Commission of India, Mr. S. Rathakrishnan, Ms. R. M. Nachammai, Dr. K. Hari Krishna, MAPS, Dr. M. Sai Baba, Associate Director, RMG, Dr. C. S. Sundar, Director, MSG, Dr. P. R. Vasudeva Rao, Director, IGCAR, Dr. S. K. Deb, Head, ISUD, RRCAT, Indore, Dr. Saibal Basu, BARC, Dr. A. K. Tyagi, BARC and Dr. M. V. N. Murthy, IMSc, Chennai.

The concluding function on July 5, 2013 had the valedictory address by Dr. Vijayamohanan Pillai, Director, CSIR - Central Electrochemical Research Institute, Karaikudi, a brief session on students response and the lecture by Dr. Pillai entitled "Impact of Molecular Nanotechnology on Materials Research".

Reported by Coordinators, STIPAC-2013

BITS Practice School
May 22 - July 13, 2013

Dr. P.R. Vasudeva Rao, Director, IGCAR interacting with the students from BITS Practice School

Twenty five students from BITS Pilani, Hyderabad and Goa campuses underwent BITS Practice School at our Centre during May 22- July 13,2013. The course aims at exposing the students to industrial and research environments, how the organizations work, to follow and maintain work ethics, study the core subjects and their application in the organization and to participate in some of the assignments given to them in the form of projects.

The students were from various engineering disciplines like, Mechanical, Chemical, Electrical, Electronics & Instrumentation, Computer science and Electronics & Communication Engineering. Dr. R. Natarajan, Director, Reprocessing Group and ESG(M&E) inaugurated the Practice School at IGCAR on May 22, 2013. Students carried out challenging projects in various Groups of the Centre in line with their discipline. During the period of their stay, they visited various facilities at IGCAR, BHAVINI and MAPS. As a part of the curriculum, Quiz, Project work presentations, group discussions and report writing were done in the Practice School. Dr. P. R. Vasudeva Rao, Director, IGCAR interacted with the students on July 4, 2013. The valedictory function was held on July 11, 2013. Dr. T. Jayakumar, Director, Metallurgy and Materials Group delivered the valedictory address and distributed the certificates to the students.

Reported by M. Sai Baba,
Coordinator-BITS Practice School

Dr. R. Natarajan, Director, RpG & ESG(M&E) interacting with the students from BITS Practice School

Dr. T. Jayakumar, Director, MMG delivering valedictory address

Conference and Meeting Highlights

Quality Circle Annual Meet (QCAM) - 2013
August 23, 2013

Quality circle is a small group of employees doing similar or related work who meet regularly to identify, analyze, and solve work related problems usually led by a senior team member. After completing their analysis, they present their solutions to management for implementation and to improve the performance of the organization. Thus, implemented correctly, quality circles can help the organization to reduce cost, increase productivity and improve employee morale.

In IGCAR, every year Quality Circle Annual Meet (QCAM) is conducted and the QC case studies are presented by the QC teams. QCAM – 2013 was conducted on August 23, 2013 at Sarabhai Auditorium and Raja Ramanna Auditoriums in parallel sessions. Welcome address was given by Shri G. Srinivasan, Director, ROMG. The Presidential address was given by Dr. R. Natarajan, Director, RpG & ESG (M&E). Inaugural Address was delivered by Dr. K. Narashiman, Director, AU TVS CQM & IQAC, Anna University, Chennai and vote of thanks by Shri G. Kempulraj, Head, Central Workshop Division.

Totally twenty nine Quality Circles (about 200 members) from IGCAR, schools from Kalpakkam and neighborhood presented QC case studies in a wide spectrum of topics covering Technical, Research & Development, Services and Education. Professional judges from Quality Circle Forum of India, Chennai chapter, adjudged the QC case study presentations. Under the Mechanical and Manufacturing' stream, the Moon QC Team bagged 'Dr. Placid Rodriguez memorial trophy',

Dr. R. Natarajan, Director, RpG & ESG(M&E) delivering the presidential address

while Rainbow QC & Excel QC teams won and shared the 'Shri M. K. Ramamurthy memorial trophy' for Plant Operation and Services category. Valarpirai Nila QC, Government HSS, Vengappakkam won the 'Dr. Sarvepalli Radhakrishnan memorial trophy' in School category.

During valedictory function, the events were summed up by Shri A. Jyothish Kumar, Associate Director, Engineering Services Group (M&E). The programme was concluded with the valedictory address and the prizes were distributed to the participants by Shri G. Srinivasan, Director, ROMG, IGCAR. Vote of thanks was proposed by Shri T. V. Maran, Member Secretary, Organising Committee.

Reported by G. Kempulraj,
Member Secretary, Apex Steering Committee
on Quality Circles, IGCAR, QCAM 2013

Forthcoming Meeting and Conference

Recent Advances in Information Technology (READIT)

Scientific Information Resource Division (SIRD) in collaboration with Madras Library Association Kalpakkam Chapter (MALA-KC) is organizing the 9th National Conference on the theme "Towards Semantic Digital Library Infrastructure" during December 18-19, 2013 at IGCAR, Kalpakkam. This Conference forms a part of the series "Recent Advances in Information Technology (READIT)". READIT series is being conducted from 1995 onwards. The previous Conferences were well received by professionals engaged in IT and Library & Information services and Academic institutions. This Conference will be preceded by a one-day Tutorial on " Creating Content Portals " on December 17, 2013.

The Conference will have invited talks as well as contributed papers on the following sub-themes:

- Virtualized Digital Library Infrastructure
- Cloud Computing Techniques
- E-books & Enabling Architecture
- Semantic Metadata Creation & Retrieval
- Knowledge Dissemination Techniques
- The Changing Role of Library

Address for correspondence

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Visit of Dignitaries

Dr. R. Chidambaram, Principal Scientific Adviser, Government of India, Chairman of the Scientific Advisory Committee to the Cabinet and former Chairman, Atomic Energy Commission during his visit to the Centre on August 12, 2013 delivered the Vikram Sarabhai Memorial Lecture on "The Third Industrial Revolution and India"

Vikram Sarabhai Memorial Lecture on "The Third Industrial Revolution and India" was delivered by Dr. R. Chidambaram, Principal Scientific Adviser, Government of India, Chairman of the Scientific Advisory Committee to the Cabinet and Former Chairman, Atomic Energy Commission on August 12, 2013.

Awards & Honours

Indira Gandhi Centre for Atomic Research had been chosen by St. John Ambulance (India), Tamil Nadu State for a Special First Aid Award in recognition of its contribution towards imparting training on First Aid to departmental employees

Dr. P. Chellapandi has been awarded the 2009 VASVIK Award by Vividhlaxi Audyogik Samshodhan Vikas Kendra, Mumbai for his contributions in the field of Mechanical & Structural Sciences and Technology

Dr. U. Kamachi Mudali has been conferred with prestigious "Fellow Honour" of National Association of Corrosion Engineers (NACE), USA, for his outstanding contributions in corrosion science, engineering and technology of materials used in nuclear and allied industries including academic contributions

He has been appointed as Member of Journal of Coating Science and Technology

He has been elected as “Honorary Fellow” by Electrochemical Society of India 2013

Dr. Shaju K. Albert has been elected as “Fellow of IIM” by the Council of Indian Institute of Metals

MOON Quality Circle of Fast Reactor Technology Group, IGCAR with members Shri A. T. Loganathan, Shri D. Kuppuswami, Shri K. Mohanraj, Shri T. V. Maran, Shri A. Clement and Shri B. Babu has won Gold Medal in the Chapter Convention for Quality Circles (CCQC-2013) held at Easwari Engineering College, Chennai during October 5-6, 2013. Shri K. Mohanraj and Shri D. Kuppuswami won the First prize in debate. Shri A.T. Loganathan won the Second prize in QC Poster Competition Award

Best Paper/Poster Award

Internal Gelation Studies for the Preparation of TiO_2 Microspheres
Shri Dasarath Maji, Dr. R. Venkata Krishnan and Dr. K. Ananthasivan from CG
Theme meeting on Recent Trends in Materials Chemistry 2013 (RTMC – 2013), July 25-27, 2013, VIT University, Vellore
Best Poster Presentation Award

Tahina Spectabilis

Published by Scientific Information Resource Division, IGCAR, Kalpakkam-603102