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बीएआरसी न्यूज़लैटर

BARC NEWSLETTER

IN THIS ISSUE

In the forthcoming issue :

Silicon Sensors for the Compact Muon Solenoid Experiment at the Large Hardon Collider, CERN

The world's largest and the highest energy accelerator ever built, the Large Hadron Collider (LHC) will become operational at CERN, Geneva, by mid 2008. The article presents an overview of the R&D undertaken by BARC, to develop the technology for 32-strip silicon sensors, for the Compact Muon Solenoid (CMS) experiment at the LHC, as a part of DAE-CERN Collaboration programme.

Studies on Response of Structures, Equipment and Piping systems to Earthquake and its Mitigation

The article identifies three major areas of research in earthquake engineerings:- Design and development of passive devices to control the seismic response of Structures, Systems and Components (SSCS) non linear behaviour of piping systems subjected to loading and non linear behaviour of RCC Structures under seismic excitation. The work undertaken by the Reactor Safety Divn. in these three major areas in described.

बी एआरसी न्यूज़लैटर
BARC NEWSLETTER

CONTENTS

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बीएआरसी न्यूज़लैटर
BARC NEWSLETTER

CPA Nd:GLASS LASER SYSTEM FOR INTENSE LASER MATTER INTERACTION RESEARCH

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Introduction

There is a strong motivation to develop powerful ultra- short pulse generators, due to their diverse applications in areas of fundamental research. In order to achieve very high peak intensities to focus on gaseous or solid targets, in high field Physics studies, a laser source capable of producing intensities $> 10^{18}$ W/cm^2 is necessary. Interest in the study of interaction of matter with ultra-bright and ultra-short light pulses is increasing all over the world. High power short-pulsed laser systems have to be developed as a new tool, to investigate advanced Physics in extreme conditions. Ideally, such a laser system should be compact and reliable. In order to make the system as compact as possible, it is desirable to use solid state amplifier material because of their energy storage capabilities. Nd:glass laser systems, built earlier for amplifying nanosecond pulses were very large, where each amplifier stage was pumped with more and more energy, so that extraction could be high. Each stage of the amplifier rod had to be of greater diameter than the previous one, so as not to cause intensity dependent damage or nonlinear effects like self focusing or filamentation, in the amplifier rods. The advent of Chirped Pulse Amplification [1] technique (CPA), has made the entire laser system more compact, so that lasers of even tens of terawatts of peak power can be accommodated in a single room. Over the last fifteen years, CPA has become the technique of choice, for producing high peak power, ultra-short pulse duration pulses in the femtosecond range.

In Chirped Pulse Amplification (CPA) the oscillator pulse is a transform limited pulse with sufficient bandwidth to support the desired pulse duration. This pulse is temporally stretched in a pulse stretcher setup, where the pulse is chirped or in other words there is a variation in frequency with time [2]. The duration of the stretched pulse is adjusted, so that the pulse intensity in the amplifier remains below the limit imposed by non- linear distortions in the amplifier medium. The stretched pulse is amplified to the desired value and then compressed back almost to the original pulse duration, by folding back all the spectral components of the pulse. In the amplification process, the regenerative amplifier is the first step where the nano Joule level energy of the oscillator is boosted up to the milli Joule range in one stage, before linear amplifiers are added to the system. So the key to obtaining ultra short pulse and high peak powers in a compact system, is the stretcher/compressor unit and the regenerative amplifier. Nd:Glass based linear amplifiers have been designed and built at BARC. The regenerative amplifier and stretcher for a CPA system, is designed and demonstrated for the first time at BARC.

Femtosecond range Oscillator

The oscillator is a passively mode-locked system with an Nd:glass (fluoro – phosphate) active medium and a saturable absorber providing an intensity dependent loss in a cavity. When a saturable absorber is inserted into a laser cavity, the natural, small fluctuations of the laser are continually enhanced, until a pulse is formed after a build-up time. The system relies on diode pumping of the active medium (Nd:glass) and uses a SEmiconductor Saturable Absorber Mirror (SESAM) to start and stabilize the pulse forming process. The propagation of the pulse inside the oscillator cavity can be described by the non linear Schrodinger equation. A pulse with a $sech^2$ intensity profile is an exact stable solution of the non linear wave equation. This is a soliton pulse and it propagates without changing its duration. So soliton propagation occurs when the nonlinearity in the medium is balanced by the dispersion in the cavity. These pulses form a pulse train of mode-locked, transform-limited 200 femtosecond pulses, with a centre wavelength of 1056 nm. The spacing between the pulses is set by the length of the oscillator cavity, resulting in a repetition frequency near 100 MHz.

The Stretcher / Compressor system

For setting up a stretcher or compressor system, estimation of group velocity dispersion plays the most important role in the design. Group Velocity Dispersion (GVD) [3] is the result of different fourier components of a pulse traveling at different phase velocities. The optical path length of different wavelengths varies either because an optical material actually disperses the wavelengths, or because the wavelength components are made to travel different path lengths. One observable consequence of GVD is that, different frequency components of an optical signal will propagate at different speeds through a dispersive medium and this leads to changes in the temporal profile of an optical signal, though it does not change the spectral profile. Ever since the time Martinez [4] showed that a pair of gratings can generate both positive and negative second order GVD, gratings have generally been used in chirped pulse amplification , both for stretching and compression of pulses. Our interest lies in the extent to which a pulse can be stretched or compressed in time. The physical origin of group velocity dispersion can be attributed to angular dispersion. Gratings are used to generate the angular dispersion. The transit time dispersion increases as the pulse propagates away from the first grating of the pair. After the desired dispersion is obtained, a second grating is used to recollimate the beam. An anti-parallel grating pair with a telescope in between, can produce positive GVD and therefore a stretched pulse is produced in time.

The extent of pulse compression or stretching is determined by the orientation of the gratings and the distance between them. In the case of a stretcher

Fig.1: Layout of the stretcher using two gratings of 1800 lines / mm or 1200 lines /mm. Two achromatic lenses of focal length 60 cm form the unit magnification telescope. The 107.6 fs, 100 MHz oscillator (GLX – 200) is seen in the backdrop

where a unit magnification telescope is used, the respective distance of each grating from the nearest focal point, the sum of the focal lengths and the effective distance between the gratings need to be optimized to get the best results. Fig. 3 shows the schematic of a double pass stretcher. Generally, the stretcher configurations are a double pass configuration, that not only give a larger dispersion but also eliminates spectral walkoff at the end of the double pass. The gratings are placed in near littrow arrangement, therefore optimized value for angle of incidence has to be calculated. Four experimental setups of CPA systems were studied and comparison of experimentally measured pulse widths and calculated ones were made. Table 1 compares the results along with the parameters of the configuration. The parameters are incident pulse width, wavelength of incident beam, the bandwidth, number of grooves on the grating used, angle of incidence on the first grating and focal length of the lenses used in the stretcher. Changes in pulse length may be accomplished by adjusting the beam incident angle on the grating and the distance between the gratings. Fig. 1 is the stretcher setup in our laboratory. The design parameters are included in Table 1 (marked with *). The incident pulse is a transform limited pulse of 200 fs, incident at an angle which is 8^0 more than Littrow angle on holographic gratings. Two types of gold coated holographic gratings were considered and in both the cases, the compressed pulse is about 307 fs. In case of the 1800 lines/mm grating, the stretched pulse is about a nanosecond long. Here the angle of incidence is large, and then not only do we get spectral clipoff at the lenses, but we also have spectral clip off at the grating. This of course can be avoided by using large sized lenses and longer gratings. Another way to avoid spectral clip off is to use gratings with 1200 lines/mm grooves. Here the angle of incidence need not be large and so the grating size can be smaller and at the same time because the spectral spread is less , the lenses of the telescope too can be smaller in diameter.

Table 1: Comparing the stretcher and compressors of four CPA systems based on Cw dye, Ti:Sapphire KrF and Nd:Glass. The * indicates the stretcher/compressor parameters for Nd:Glass based system at BARC

Input Pulse Width	λ in nm.	Δλ In nm	Gratings (lines/ mm)	Angle of incidence	Effective grating separation in cm	Focal length of lenses in cm	Stretched pulse (Cal/Meas)	Compressed Pulse (Cal/Meas)
[5]83fs	617	4.8	1700	41.68°	72	50	108 ps/85 ps	168 fs/91 fs
85 ps	617	4.8	1 700	29.12°	66			
[6]110fs	800	8.4	1800	54. 6°	65	50	136 ps/120 ps	203.8 fs/220 fs
120ps	800	7.2	1800	46.05°	70			
[7]372 fs	249	1.3	3600	39°	76	72	25.5 ps/37 ps	185 fs/150 fs
37 ps	249	0.7	3600	5°	78			
[8]70 ps	800	24	1800	56°	47	60	420 ps/500 ps	67.9 fs/70 fs
500 ps	800	20	1800	62.25°	100			
*200 ps	1056	9	1200	47.31°	75	60	157 ps	307 fs
*I57ps	1056	3.8	1 200	47.31°	75			
*200 fs	1056	9	1800	79.8°	75	60	1.5 ns./1.26 ns	307 fs
*1.5ns	1056	3.8	1800	79.8°	75			

The spectral bandwith is important and maximum effort is put to preserve the oscillator bandwidth, because we know that retaining the entire bandwidth ensures that the compressed pulse can be reduced to a minimum possible. The performance of the stretcher is also governed by finite beam size, divergence, lateral walkoff of different components and the aperture of the telescope. Though in an ideal double pass stretcher there should be no spectral walkoff at the end of two passes, a real stretcher always gives rise to an elliptical beam, due to introduction of astigmatism and spectral walkoff. Therefore, alignment techniques have to be directed towards the reduction of ellipticity. Fig. 2 shows the near field and far field spatial profile of the pulse after the stretcher. The beam has to pass through a pulse selector while it remains a near circular beam of Fig. 2. Before it enters the regenerative amplifier some corrective measures on the elliptical beam need to be done. This has been rectified by the use of two cylindrical lenses with focal length of 70 cm and 50 cm as shown in the schematic diagram of Fig. 3.

Regenerative Amplifier

A variety of regenerative amplifiers reportedly in use [9,10] till today, have a spectrum of output characteristics and operating conditions. The pulse width, energy and possible repetition rates of the amplifier depends on the properties of the material being used as the active medium, such as, bandwidth, thermal conductivity and radiative lifetime. In recent years, many diode pumped regenerative amplifier systems based on Colquirite crystals [11] have been made, where the emission bandwidth is large and the extracted energy is a few tens of micro Joules. Ti: Sapphire too has a large bandwidth and the extracted energy from a regenerative amplifier reaches the milli Joule level and it is the most common material for chirped pulse amplification systems. For many high field Physics studies, a laser system capable of producing intensities of $10^{18} - 10^{20}$ W / cm^2 use Nd:Glass as amplifiers [12]. This is because Nd:Glass has a higher saturation fluence and longer upper state life time as compared to Ti:Sapphire. Ideally, such a laser should be compact and

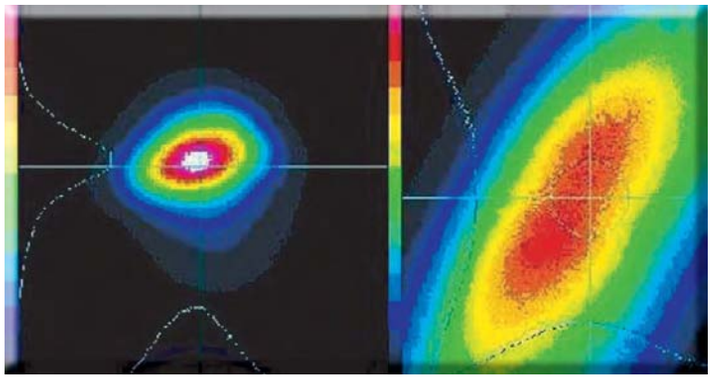


Fig. 2: The near field and far field spatial profile after a double pass stretcher setup. The elliptical profile is a consequence of the beam passage through the stretcher assembly

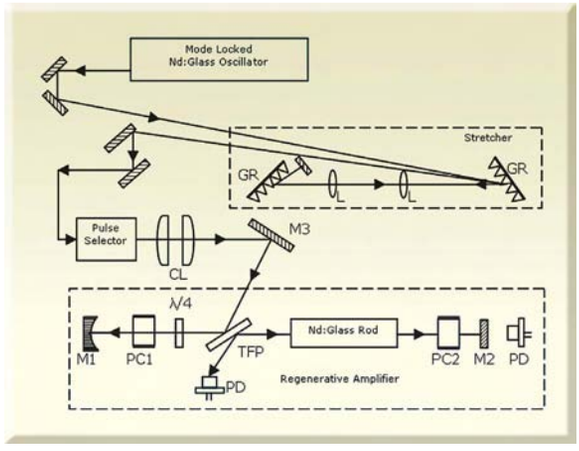


Fig. 3: Experimental configuration of the regenerative amplifier: PC1 & PC2- Pockels cell, TFP– Thin Film Polarizer, M1& M2- 100% reflecting regenerative cavity mirrors, M3- 100 % reflecting deflecting mirror for seed pulse injection. GR -holographic gratings, CL – cylindrical lenses, λ/ 4–Quarter wave plate. PD – Avalanche photodiode

reliable. Spectral gain narrowing is one of the main issues in a high power laser chain which results in larger pulse durations after compression. Ti:Sapphire has a much larger amplifying bandwidth than does Nd: Glass so that Ti: Sapphire regenerative amplifiers operating in the 1060 nm wavelength range does not exhibit much spectral narrowing. Therefore, these amplifiers have been used as a front end for high power Nd:Glass systems [13]. Spectral narrowing, however, sets in the subsequent power amplifiers too. If the spectral narrowing can be limited and more energy extracted in one stage, then the total system could become compact. Here we designed and built an Nd:Glass based regenerative amplifier, that has a larger emission bandwidth and the energy extracted is more than that reported previously in literature.

Design of the Nd: Glass Regenerative Amplifier System

The regenerative amplifier design is essentially a multi-pass amplifier with a cavity geometry such that, the injection of a chirped laser pulse and the ejection of the amplified pulse can be controlled, by two optical switches. Such a system is necessary to reach the milli-joule level of energy with one amplifier stage. Fig. 3 shows the regenerative amplifier setup along with the oscillator and stretcher. The oscillator (GLX200 from Time Bandwidth Products, Switzerland) is a 200 fs, 100 MHz Nd:fluoro phosphate glass oscillator with a spectral bandwidth of 9 nm FWHM and a peak at wavelength 1056 nm. The average output power from the oscillator is 55 mW. The regenerative amplifier cavity consists of two KDP Pockels cell, a quarter wave plate, a thin film polarizer and an Nd: Silicate glass rod (10 mm diameter, 150 mm long) placed between a curved mirror (6 m radius of curvature) and a plane mirror separated by 1.5 m. This pulse train is stretched in a double pass stretcher.The stretcher output is a 200 ps, 100 MHz pulse train with an average power of 7 mW and a spectral bandwidth of 9 nm FWHM. A single pulse is selected from the pulse train, by a pulse selector. The pulse selector is a home- built device that uses two glan polarizers and two electro – optic light modulators (KDP crystals) that are optically in series and electrically in parallel and are driven by a quarter wave voltage of 3.5 KV with a very fast rise time of about 2 ns (Fig. 4). The single pulse of 200 ps duration and 70 pJ energy is then injected into the regenerative amplifier cavity. Before injection, the pulse is collimated by two cylindrical lenses. This is because the spatial profile is slightly elliptical as a consequence of the astigmatism introduced by the stretcher. This collimation increases the intensity of the input pulse and also avoids cutoff at the Nd:Glass rod in the cavity. The Nd:Silicate glass rod is flash lamp pumped with an electrical energy of 600 J. The Pockels cell, PC1 is triggered and a quarter wave voltage of 3.5 KV is applied for the required retardation, to trap a pulse inside the cavity.

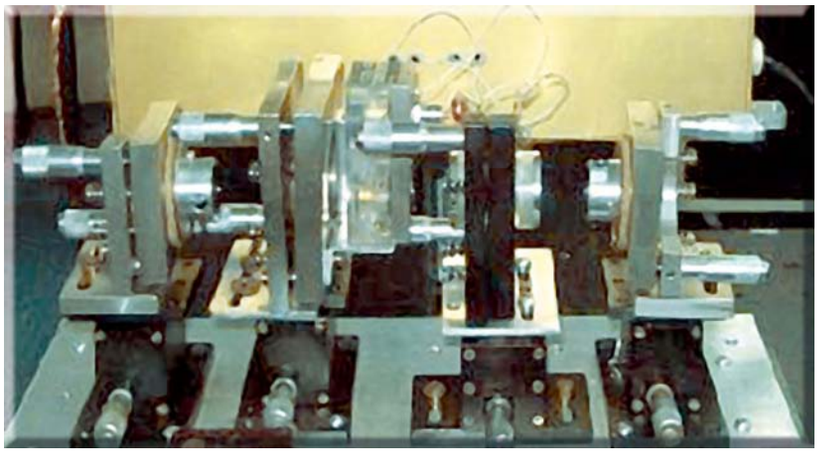


Fig. 4: The single pulse selector with two Glan polarizers on either end and two KDP crystals between the polarizers. The power supply, generating a 6 ns trigger pulse of quarter wave voltage to the crystals

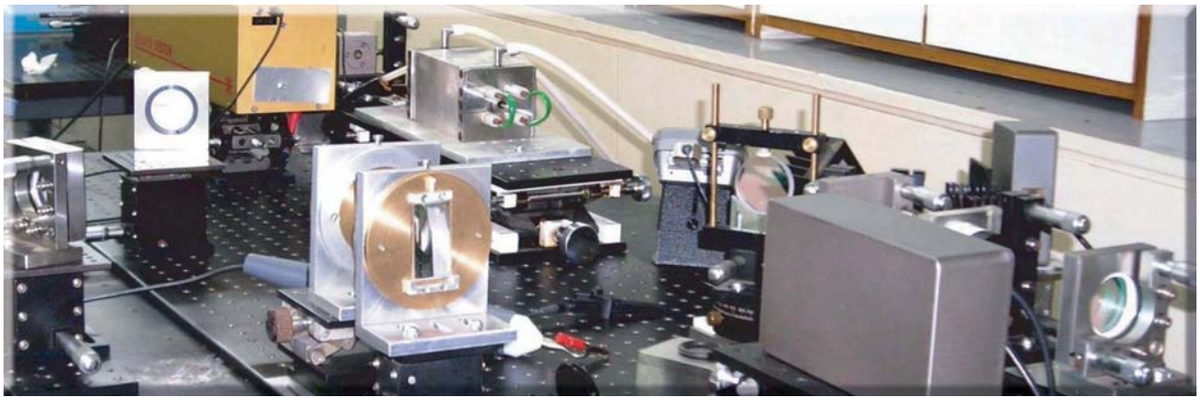


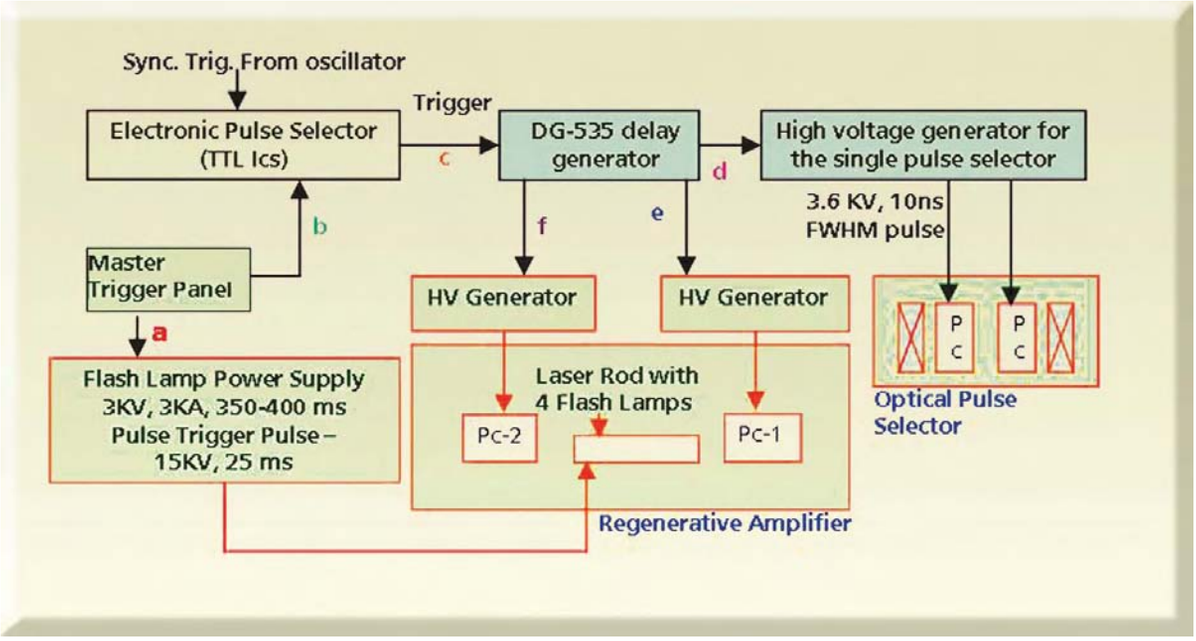
Fig. 5: The regenerative amplifier assembly with two cylindrical lenses in the foreground. The Nd:Glass rod enclosed in an aluminium reflector, the two pockels cells with their respective 3.5 KV pulse generators

The evolution of the pulse is monitored on an avalanche photodiode, where a leak pulse from mirror M2 is detected. After the necessary number of round trips, the pulse is ejected out by switching on Pockels cell PC2, witah a quarter wave voltage of 3.5 KV. The ejected pulse is monitored and measured after the thin film polarizer with an avalanche photodiode. A pyroelectric joulemeter was used at this position to measure the energy of the ejected pulse. The synchronization of the various electro-optic switches, firing of flash lamps and single seed pulse selector was an important part of the working of the regenerative amplifier as shown in Fig. 5.

Trigger Synchronization systems

The optimized working of the regenerative amplifier setup revolves around the precise timings of the trigger signals that drive the various high voltage pulse generators. The two electro – optic modulators of the single pulse selector, the two modulators of the regenerative cavity and the four flash lamp firings have to be synchronized , in order to extract a single clean optical pulse with maximum extracted energy.

The flash lamp optical pulse is a 400 μs pulse with a peak at 220 μs when the population inversion in the Nd: Glass amplifier medium should be at its maximum. Therefore, the regenerative amplifier flash lamps are fired first and all other triggers are timed so that the seed pulse injected into the amplifier cavity is some where around the peak period of the population inversion. Just as Fig. 3 depicts the optical schematic of the regenerative amplifier with all associated optical systems, Fig. 6 is the schematic of the modules that synchronize the timings of all the electro – optic devices and the flash lamps of the amplifier. The timing sequence for various trigger pulses of different stages is shown along side in Fig. 6. From the master trigger panel , two trigger signals (marked as a & b), one for the flash lamps and one with a delay for the electronic pulse selector is taken. The electronic pulse selector, which is a gating circuit also uses a synchronizing trigger from the oscillator, so that, a single trigger pulse can activate the high voltage generator of the Pockel's cells of the optical pulse selector. The Pockel's cells are driven by high voltage pulsar of 10 ns duration and 3.5 KV quarter wave voltage. This pulse has to be perfectly synchronized with the laser pulse and should be of precise duration, i.e not more than 10 ns because the separation of two consecutive optical pulses is 10 ns. A slight change in the electrical pulse length can reduce the contrast ratio of the selected optical pulse. To obtain a clean, sharp, ripple-free electrical pulse, stray capacitances and impedances were



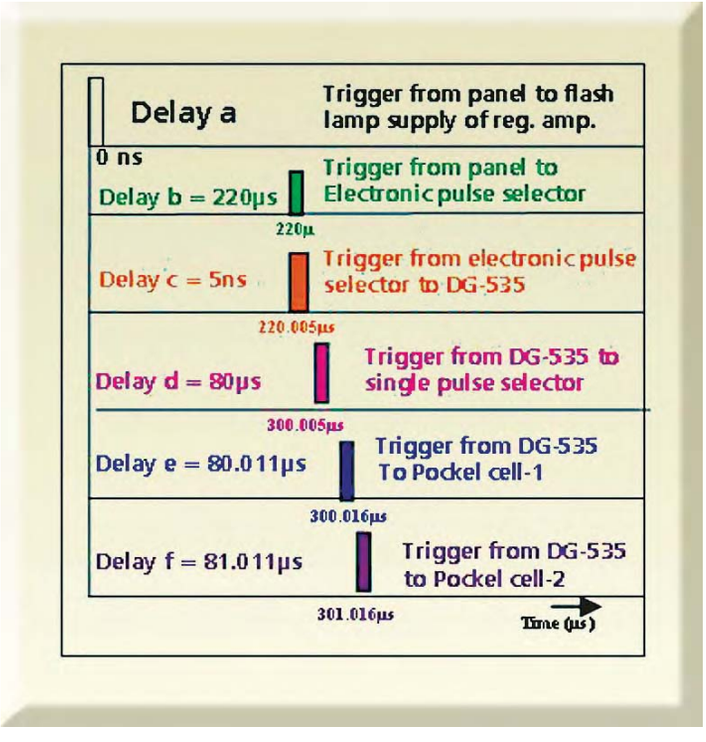


Fig. 6: Delay and control setup for regenerative amplifier setup and timing sequence for various trigger pulses

countered by choosing the right connectors, right cable lengths and resistances. Since in the above setup high frequency circuits are used, time delay introduced by cables and modules themselves have to be taken into account, along with jitter. Since delay and timings of the order of nanoseconds are involved, a delay generator that could precisely control the delays and jitter in the picosecond range was used (DG535 Delay Generator of Stanford Research Systems). This provides TTL level signals that activate the pockel's cells of the single optical pulse selector as well as the high voltage generators for the two pockels cells, within the regenerative cavity (marked as d, e and f). Here again, the injection timing of the seed pulse can be manipulated to picosecond levels with the help of DG535. The ejection of the amplified pulse when it has reached its maximum amplification can also be

timed, with the help of the delay generator.

Measurements on the Regenerative Amplifier

The regenerative amplifier cavity was first optimized in the Q- switched operation and then the seed pulse was directed into the amplifier. The cavity had to be then adjusted for complete seeding i.e no Q- switched signal noted underneath the circulating pulse recorded on the avalanche photodiode, detecting the leak pulse from the mirror M2. In most previously reported regenerative amplifier construction, mode matching is carried out by using intra cavity or extra cavity aperture or lenses in order to obtain complete seeding. In this case, we have used a new technique where the alignment of the cavity is changed slightly to partially suppress the buildup of the spontaneous emission into a Q- switched pulse. Simultaneously the seed pulse injection alignment is shifted proportionately (by mirror M3) so that it is in perfect alignment with all the components of the cavity. In this way the seed pulse has an initial advantage of exploiting the gain of the Nd: Silicate glass medium as compared to the cavity spontaneousemission buildup. Fig. 7 shows the circulating amplified pulse as detected from the leak pulse of mirror M2. It shows complete seeding with a fully modulated structure giving no indication for a Q- switched background. The adjustments in the seed pulse injection timing (i.e. triggering the Pockels cell PC1.), the energy dumped into the flash lamps and the seed pulse intensity (by adjustment of the cylindrical lens pair) were all aimed to get complete seeding with no Q- switched signal. In the best operating condition we could eject out a single pulse with an energy of 15 mJ. The amplified pulse is ejected out after 100 round trips when the amplification reaches its maximum. The inset of Fig. 7 indicates the ejected pulse when the Pockels cell PC2 is switched on with a quarter wave voltage. The regenerative amplifier provides a net gain of $2.1X10^8$. The amplified pulse spectrum is also recorded with the help of the leak pulses from mirror M2, using a McPherson spectrometer. The spectral bandwidth was measured to be 3.8 nm FWHM. This bandwidth of the output pulse from the regenerative amplifier is much more than that achieved earlier from Nd:Glass based amplifiers. The reduction of the spectral bandwidth from 9 nm FWHM of the seed pulse to 3.8 nm of the amplified

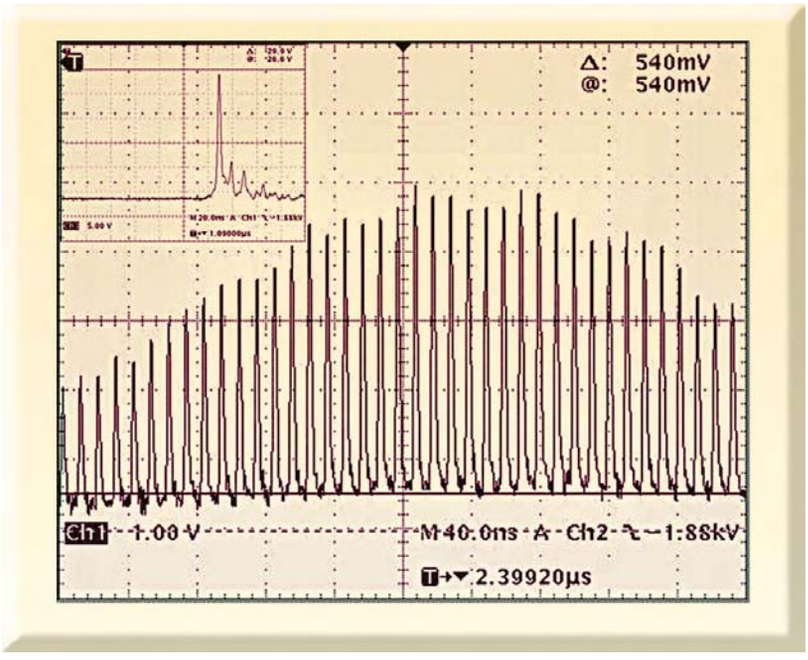


Fig. 7: Leak signal through the plane mirror M2 of the regenerative amplifier cavity, showing the evolution of the seed pulse amplification in the cavity. The inset depicts the switched out amplified pulse of 15 mJ energy detected after the thin film polarizer

pulse is due to the well known gain narrowing, where different spectral components experience different gains.

The availability of different kinds of glass with shifted fluorescent curves, opens up the possibility of enlarging the emission bandwidth. Mixing two or three types of Nd:Glass rods (silicates and phosphates) in a chain of amplifiers provides a feasible solution for limiting gain narrowing [14,15] and getting shorter pulses after compression. The seed pulse wavelength has a significant influence on the amplification. In the present setup the centre wavelength of the seed pulse is 1056 nm and the fluorescence peak of the Nd: Silicate glass gain medium is 1060 nm. With the new technique it was possible to get complete seeding in spite of the 4 nm mismatch in peak wavelength. With more initial photons of 1056 nm, a good extraction was obtained, though the gain of the amplifying medium is less at this wavelength. Though the initial photons of 1060 nm wavelength are less, it uses the larger gain at this wavelength in the amplifying medium as compared to 1056 nm. These two factors balance out and this has made it possible to limit the gain narrowing to 3.8 nm. Gain narrowing is more pronounced in regenerative amplifiers and any gain narrowing caused by subsequent linear amplifier chain is negligible. Therefore, getting a very good spectral bandwidth at the regenerative amplifier stage is important. Fig. 8 is the comparison of the change in bandwidth as the oscillator pulse evolves through its passage from the stretcher to the output of the regenerative amplifier. With a bandwidth of 3.8 nm the smallest possible temporal pulse width is about 310 fs after compression.

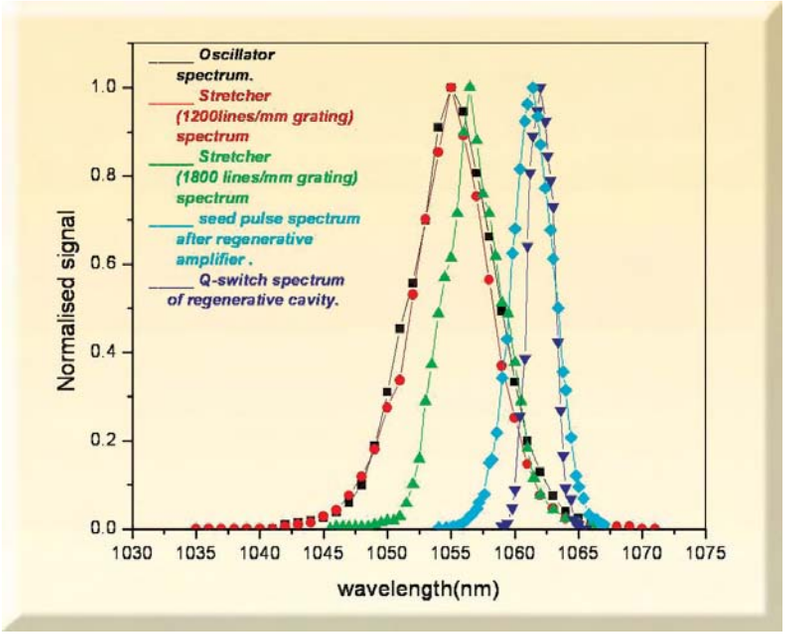


Fig. 8: Comparison of the spectrum from the oscillator, stretcher, regenerative amplifier and the Q- switched pulse

With the present alignment technique we found that we could pump the Nd:Glass medium with large electrical energy, without loss of the stored energy in the gain medium to a Q- switched pulse buildup. The stored energy is extracted by seed pulse only. Thus the energy output from the regenerative amplifier was more. Therefore, if the energy extracted and the spectral bandwidth of the output pulse from the regenerative amplifier (the first stage of the total amplifier chain.) are more, then tremendous peak powers can be obtained with modest total energy requirements of the whole system. This makes the total system compact too. The linear amplifiers that will follow the regenerative amplifier are designed with increasing Nd:Glass rod diameters until an energy of 1 J is reached, before the pulse is compressed to obtain about a TW level power.

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ANNOUNCEMENT

Forthcoming
Discussion Meet on ElectroAnalytical Techniques and Their Applications
"DM-ELANTE-2008"

Under the auspices of the Indian Society for ElectroAnalytical Chemistry (ISEAC), the above Discussion Meet would be held at Tea County, Munnar, Kerala (www.teacounty.com) during February 25-28, 2008. The Discussion Meet would cover recent advances in various ElectroAnalytical Techniques and their applications in Chemistry, Physics, Biology, Material Science, Nuclear Technology etc. The Scientific Programme of this Meet would include Tutorial Lectures, Invited Talks, Panel Discussions, Oral Presentations by Research Scholars as well as Contributed Papers as Posters. Further updates about this Discussion Meet are available on www.iseac.org.

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बीएआरसी न्यूज़लैटर
BARC NEWSLETTER

POTENTIAL AND PROSPECTS OF ULTRAFILTRATION

D. Goswami, S. Prabhakar and P. K. Tewari
Desalination Division

Membrane Processes

Membrane processes are selective separation processes, that require two bulk phases physically separated by a third phase - the membrane. In fact, the membrane is a selective interphase between the two bulk phases, the term 'selective' being inherent to the membrane or the process. Membrane processes are characterized by less energy consumption and less chemical intervention. They are eco-friendly as they mostly operate on physical or physico-chemical mechanisms. A membrane may be eithert homogeneous; or heterogeneous, transport through the membrane may be active or passive; passive transport may be driven by pressure, concentration or temperature differential; membranes may be natural or synthetic; they may be organic or inorganic in nature and they may be neutral or charged. The membrane phase may be any one or a combination of – nonporous solid, microporous or macroporous solid with a fluid in the pores, a liquid phase with or without a second phase or a gel. Solid synthetic membranes can be symmetric, asymmetric and composite.

The utility of membranes in reverse osmosis desalination and water recovery has been well established. With the advancement of membrane preparation methods and techniques, a variety of membranes can be tailor-made to bring about specific separation goals.

Classification of Membrane Processes

The membrane phase interposed between two bulk phases controls the exchange of mass between the bulk phases in a membrane process. The movement of any species across the membrane is caused by one or more driving forces as shown in Table 1. These driving forces arise from a gradient of chemical, thermal or electrical potential. A gradient in chemical potential may arise due to a concentration gradient or pressure gradient or both.

Table 1: Classification of membrane processes according to their driving forces

Pressure Difference	Activity Difference	Temperature Difference	Electric potential Difference
Microfiltration	Pervaporation	Thermo-osmosis	Electro-dialysis
Ultrafiltration	Gas separation	Membrane distillation	Electro-osmosis
Nanofiltration	Dialysis		
Reverse Osmosis	Liquid membranes		
Piezodialysis			

Pressure-driven Membrane Processes

Various pressure-driven membrane processes as shown in Table 1 are used to concentrate or purify a dilute (aqueous) solution. The particle or molecular size and chemical properties of the solutes determine the structure of the membrane to be employed e.g., pore size and pore size distribution. Because of the driving force, the applied pressure, the solvent and various solute molecules permeate through the membrane, whereas, other molecules or particles are rejected or retained to various extents. As we go from microfiltration through ultrafiltration to reverse osmosis, the size (molecular weight) of the particles or molecules separated reduces and consequently, the pore sizes in the concerned membrane must become smaller. This implies that the resistance of the membranes to mass transfer increases and hence the applied pressure (driving force) has to be increased. A schematic drawing of the separation range involved in the various processes is given in Fig. 1, though a sharp demarcation is not practicable.

Ultrafiltration

Ultrafiltration is a process which lies in between microfiltration and reverse osmosis. It is primarily a size-exclusion based, pressure-driven membrane separation process. The pore sizes of the UF membranes range from 0.05 micron (500 Angstrom) on the microfiltration side to 1-2 nm (10-20 Angstrom) on the reverse osmosis side and are capable of retaining species in the molecular weight range of 300 to 5,00,000 Daltons. Ultrafiltration membranes can be considered as porous membranes where rejection is determined mainly by the size and the shape of the solutes relative to the pore size on the membrane and where the transport of solvent is directly proportional to the applied pressure. Most ultrafiltration membranes are characterised by their Nominal Molecular Weight Cut-Off (MWCO), which is defined as the smallest molecular weight species for which the membrane has more than 90% rejection.

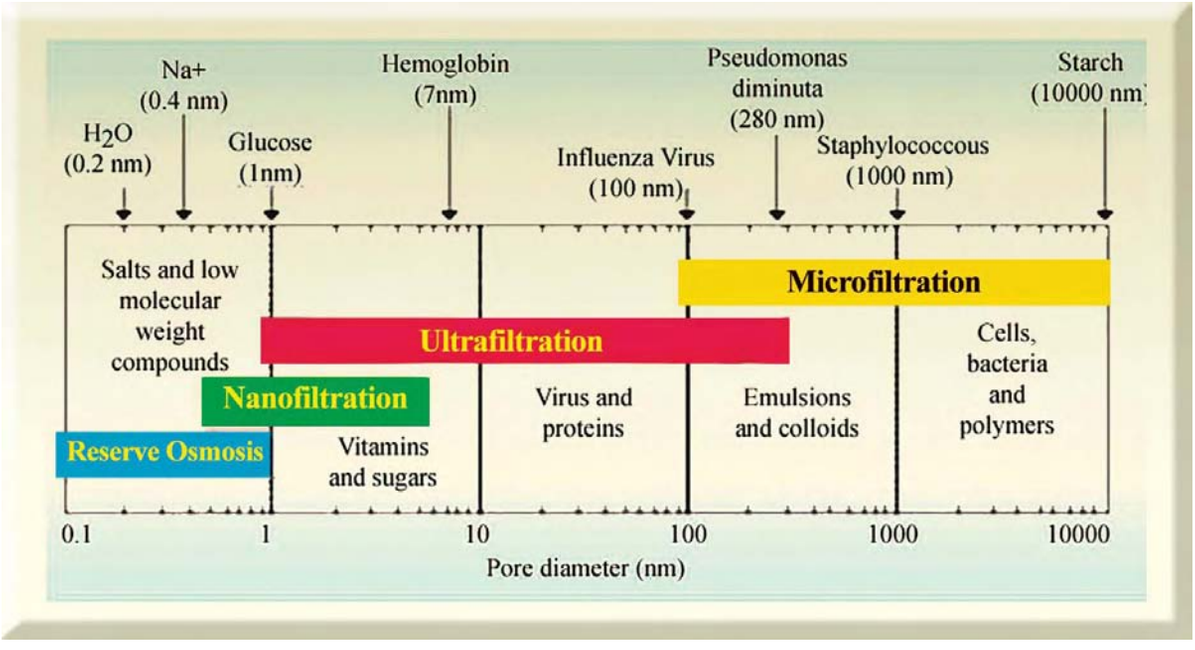

Fig.1: Range of pressure-driven membrane separation processes

Ultrafiltration membranes

Most ultrafiltration membranes are polymeric in nature, though inorganic membranes are also available. Ultrafiltration membranes have an asymmetric structure, i.e., an upper thin, dense skin that is permselective and a more porous substrate for mechanical support. The hydrodynamic resistance of the membrane is mainly determined by the skin of the membrane and is of the order of about 1 micron thick. Table 2 lists typical ultrafiltration membrane materials.

Table 2: Typical Ultrafiltration membrane materials

Polymeric	
	Polysulphone (PS)
	Polyethersulphone (PES)
	Cellulose acetate (CA)
	Regenerated cellulose
	Polyamides (PA)
	Polyvinylidine fluoride (PVDF)
	Polyacrylonitrile (PAN)
Inorganic	
	Alumina – alpha/gamma
	Borosilicate glass
	Pyrolysed carbon
	Zirconia/ SS

Polymeric ultrafiltration membranes are typically made by the phase inversion method in which, the homogenous polymer solution is converted to a porous polymer framework through exchange of the solvent with the precipitating non solvent. Hydrophobic polymers such as polysulphone or PVDF sometimes may need to be modified to obtain higher fluxes, less fouling etc. by incorporating hydrophilic groups by sulphonation, surface grafting and polymer blending. Surface modification is important in view of the fact that as ultrafiltration membranes reject larger molecular weight species, their liquid phase back diffusivity is lower, leading to membrane fouling and concentration polarization.

Membrane configuration

Several membrane configurations are available. Polymeric membranes can be cast or extruded, as either flat-sheet or in cylindrical geometry. Flat-sheet membranes are used in spiral-wound or plate and frame modules whereas cylindrical geometry is available for tubular or hollow-fiber type. Inorganic membranes are used only in tubular or monolith form. The choice of configuration depends on the ability to handle the fouling or plugging characteristics of the retentate stream. Other criteria are hold-up volume and cost of the module. Modules can be classified as turbulent flow wide-bore tubular membranes or as laminar flow thin channel devices like spiral-wound, hollow-fiber

Table 3: Comparison of UF module configurations

Type	Feed channel height (mm)	Packing density (m^2/m^3)	Feed velocity (m/sec)	Reynold's Number	Hold-up Volume
Hollow-fiber	1.0-2.5	1200	0.5-3.5	10-1000	Very low
Tubular	10-25	60	2-6	10000-30000	High
Plate & Frame	0.3-1.0	300	0.7-2.0	100-6000	Moderate
Spiral-wound	0.5-1.0	600	0.2-1.0	100-1000	Low

or plate and frame. The feed channel clearance has to be sufficient to resist plugging by suspended solids. Table 3 gives a fair comparison of different module configurations.

Ultrafiltration phenomena

The most important membrane properties are the membrane productivity (flux) and the extent of separation (rejection of various feed components). The volumetric flux (permeate volume/membrane area/ time) is given by

$$J_v = P(\Delta p - \Delta \Pi) / l \ldots\ldots \text{(i)}$$

where, P is the permeability coefficient, Δp isthe hydrostatic pressure difference, $\Delta \Pi$ is the osmotic pressure difference between feed and permeate phases and l is the membrane thickness. Osmotic effects are generally very small in UF and can be neglected.

The observed solute rejection R_i for a given species I is given by

$$R_i = 1 - c_{ip}/c_{ir} \ldots\ldots\ldots\ldots \text{(ii)}$$

Where, c_{ip} is the concentration of species I in the permeate and c_{ir} is in the retentate.

In the simplest view, UF membranes can be considered to reject larger molecules through a sieving mechanism with solvent flowing in pores and solute molecules having sizes less than the pore diameter being carried convectively. Assuming a uniform pore size and laminar flow through these pores, the volumetric flux J_v can be expressed in terms of Hagen-Poiseulli equation. If the membrane is considered as an aggregate of cylindrical pores per unit area, n_p , with diameter d_p and length l, the flux of permeate having viscosity η can be expressed as

$$J_v = [n_p . d_p^4 / 128\eta] \ X \ \Delta p / l \ldots\ldots \text{(iii)}$$

This equation predicts that the flux will be proportional to the fourth power of the pore diameter.

The observed solute rejection R_i can be related to the ratio of molecular diameter of the species and the pore diameter by the equation of Ferry as

$$R_i = [\lambda(2-\lambda)]^2 \text{ for } \lambda < 1$$

$$R_i = 1 \text{ for } \lambda \geq 1$$

Where λ is the ratio of the species diameter d_i to the pore diameter d_p.

However, the flux through a pore as in equation (iii) does not incorporate any membrane characteristics other than the pore diameter. Features such as solute size, solute/membrane interaction etc. need to be incorporated into the equation. This has lead to the proposition of various models of Ultrafiltration.

Concentration Polarization / Fouling

It is observed that the flux in UF process does not increase linearly with pressure after a critical pressure is reached. Also, the flux of even moderately concentrated solutions such as 1% dextran is far lower than the pure solvent as shown in Fig. 2. Initially, the flux increases linearly with applied pressure (section OA). After a certain pressure is reached, no increase in flux is obtained (section BC). This observation indicated the importance of liquid phase mass transfer effects. The build up of the rejected species at the membrane surface is known as concentration polarization.

Flux reduction in UF is usually ascribed either to an increase in osmotic pressure at the membrane surface or a decrease in hydraulic permeability due to formation of a gel layer. The flux through an ultrafiltration membrane can be written as

$$J_v = (\Delta p - \Delta \Pi) / (R_m + R_c) \ldots\ldots\ldots \text{(iv)}$$

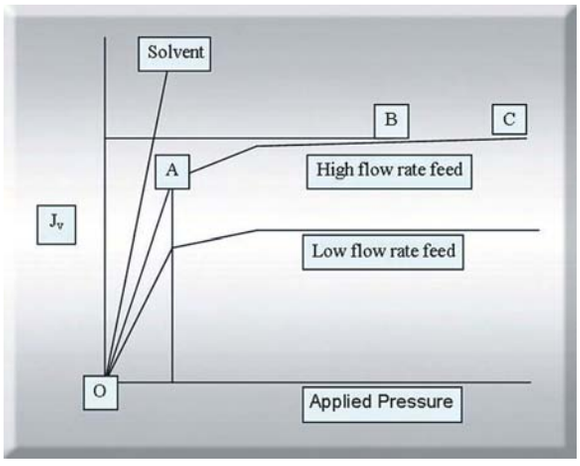

Fig. 2: Flux vs applied pressure

Where, R_m is the resistance due to the membrane, R_c is the resistance offered by the deposited cake and $\Delta\Pi$ is the osmotic pressure difference that builds up as a result of solute rejection.

Flux decline as per Film theory model is ascribed to the additional resistance, offered by two layers on the membrane feed side surface – the boundary layer and the gel or cake layer. Boundary layer analysis is shown in Fig.3, where, δ is the distance over which the concentration changes from bulk feed c_f to membrane surface c_w.

δ is controlled by the module flow and diffusion conditions. Solute is transported to the membrane surface by the convective flow of permeate and this is balanced by the back diffusion of the solute to the bulk as given by equation (v)

$$J_v (c - c_p) = - D (dc/dx) \quad \text{.....(v)}$$

Integrating this equation across the boundary layer, the flux can be expressed as

$$J_v = k \ln [(c_w - c_p) / (c_f - c_p) \quad \text{.....(vi)}$$

Where, $k = D/\delta$) is the mass transfer coefficient. As the flux increases with increasing applied pressure, the value of c_w relative to c_f also increases. As c_w reaches the solubility limit, further increase will cause a precipitate or thixotropic gel to be deposited on the membrane surface. Further increase of pressure will not give any more improvement in flux. When c_p is assumed to be small, this limiting flux can be approximated as

$$J_{vg} = k \ln (c_g / c_f) \quad \text{.....(vii)}$$

This equation can be used to predict the limiting flux in various UF systems if the gel concentration c_g is known and the approximate correlations for mass transfer coefficient k are used. C_g is mainly a function of the solute-solvent system and the operating temperature but is independent of membrane characteristics, feed concentration, flow conditions and operating pressure. Values of c_g have been found to be around 25% (weight basis) for macromolecular solutes and an average of 65% for colloidal dispersions.

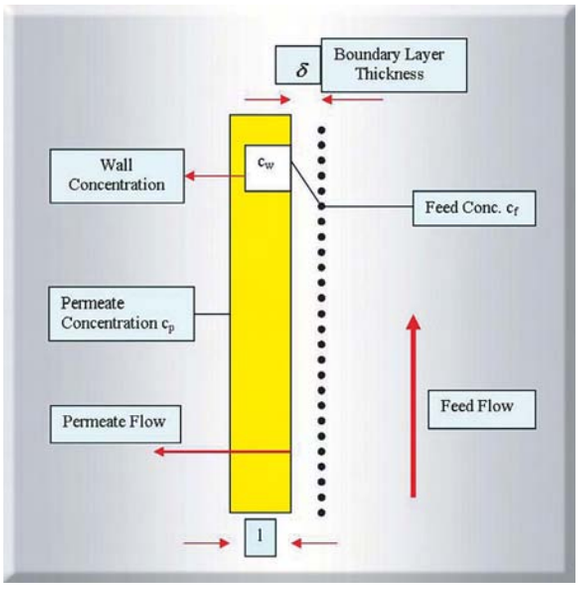

Fig. 3: Boundary layer model for cross-flow ultrafiltration

MaCs transfer coefficient k can be estimated from correlations of Sherwood number ($Sh = kd_h/D$) in terms of Reynolds number ($Re = d_h v_f/\nu$) and Schmidt number ($Sc = \nu/D$) where, ν refers to kinematic viscosity, d_h is the hydraulic diameter of the device through which the feed flows in contact with the membrane and v_f is the velocity of the feed flow. The correlation for turbulent flow is

$Sh = 0.023\ Re^{0.8}\ Sc^{0.33}$ .....(viii),

Those for fully developed and for developing flow in laminar region are

$Sh = 1.62\ [\ Re.\ Sc\ (d_h/l)]^{0.33}$.....(ix)

$Sh = 0.664\ Re^{0.5}.\ Sc^{0.33}\ (d_h/l)^{0.5}$....(x)

Equation (x) is valid only if the device channel length is of similar magnitude as the length L^* required for flow profile to be developed ($L = 0.029\ Re.d_h$).

Control of membrane fouling

The choice of membrane material, module configurations and process configurations are all important to achieve a high degree of separation, without the membrane productivity being hampered by fouling and concentration polarization. Various strategies have been adopted to control fouling and concentration polarization namely, membrane material selection, flow manipulation, providing additional force field and cleaning procedures. Adsorption effects of the particular solute with the membrane can be avoided, by proper surface treatment of the membranes. Commercial membrane modules are designed to control polarization phenomena by either increased shear at the membrane surface (thin channel devices, high flow rates) or turbulence inducers (feed spacer design, static mixers). Use of an additional force field like electrical field to supplement feed flow or convection as a way of control is an attractive possibility though it is still restricted to laboratory levels. Cleaning of foulants by clean-in-place minimizes the down-time of a process. Cleaning protocols may or may not involve external chemicals. Sometimes periodic reversal of flow direction may help to prevent particulates from plugging up the membranes. Back-flushing from the permeate side is possible with some modular configurations to remove gross foulants.

Process configurations

The most common ultrafiltration process configurations are: batch concentration in dead-end mode and feed and bleed system in cross-flow or tangential flow mode as shown in Fig. 4.

In both the modes of operation, the driving force for the flow of permeate, is the pressure drop across the membrane, that results from the hydrostatic pressure of the feed and the permeate. In dead-end filtration, the retained particles buildup with time as a cake layer, which results in an increased resistance to filtration and causes the permeate flux to drop at a constant pressure drop or causes pressure drop to increase at a constant flux. As a result, dead-end filtration requires to be stopped periodically in order to remove the settled particles. As such, dead-end filtration is a batch process. In the cross flow filtration, the feed is made to flow tangential to the surface of the membrane. The imposed trans-membrane pressure drop, causes a cross flow of permeate through the membrane to occur. As shown in Fig. 3, permeate flow carries the particulates to the membrane surface where they are rejected or retained to form a thin cake layer. Unlike dead-end mode, this cake layer does not buildup indefinitely thus blocking the flow altogether.

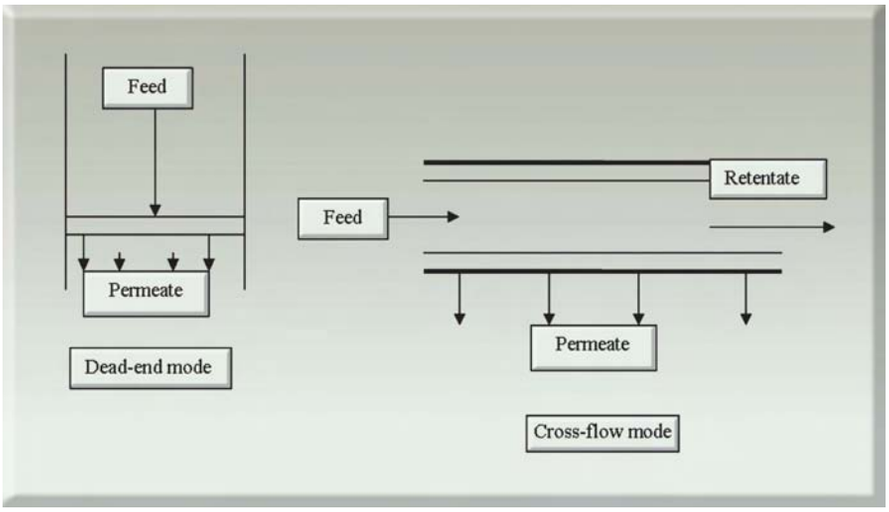

Fig. 4: Modes of operation of ultrafiltration system

Instead, the high shear exerted by the feed flowing tangential to the membrane surface, sweeps the deposited particles toward the filter module exit, so that, the cake layer remains thin. This also helps to prevent building up of concentration polarization and hence fouling and relatively high fluxes can be maintained over prolonged time periods. The rejected species along with some of the feed are bled from the module continuously.

Application potential of ultrafiltration

Many ultrafiltration applications are already being practiced in industry: the most prominent use being in the food industry where it is used, for example, to recover lactalbumin and lactoglobulin from cheese whey, to preconcentrate milk before cheese making and for fruit juice clarification. These applications use polysulphone membranes, the first two in spiral-wound form and the third with tubular modules.

Other important applications are recovery of electrocoat paint and purification of water for the pharmaceutical industry. Recovery of vaccines and antibiotics from fermentation broth in pharmaceutical industry, is an area of increasing importance.

Effluent treatment by ultrafiltration is being practiced actively in the industry. Various difficult waste streams are successfully recycled.

BARC's achievement in ultrafiltration

Domestic water purifier

Domestic water purifier based on ultrafiltration membranes has been developed in the Desalination Division and the technology is transferred to 17 private vendors for commercial exploitation. Vendors have successfully developed the domestic purifier product with add-on features and these are now available in the market at affordable price ranges under license to BARC. A good number of these products made under BARC license have been already deployed on the BARC campus also.

Successful deployment of ultrafiltration for running desalination plants

Ultrafiltration is a size exclusion based process. Therefore, it is perceived, that the use of ultrafiltration is of definite advantage, so far as pretreatment of creek sea water, to the existing sea water desalination plant is concerned. Published literature supported the use of ultrafiltration as an ultimate barrier for pathogens, for municipal water supply in other developed countries. This is also evident from the pore size range of ultrafiltration as shown in Fig.1.

Feed water for sea water desalination has a necessary prerequisite of very low turbidity of the order of 0.5 NTU and a very low pathogen content to safeguard the reverse osmosis membranes, which are sensitive

Fig. 5: The ultrafiltration pretreatment plant at the Desalination Division, BARC

to settleable colloids and microbial fouling and are also costly. The existing sea water desalination plant was initially put up with conventional coarse and fine filtration processes. But the seasonal and daily variations of turbidity levels of the incoming creek sea water, from 50 NTU to more than 1000 NTU, was forcing the plant to be shut down for want of achieving the desired NTU level in the conventional pretreatment scheme.

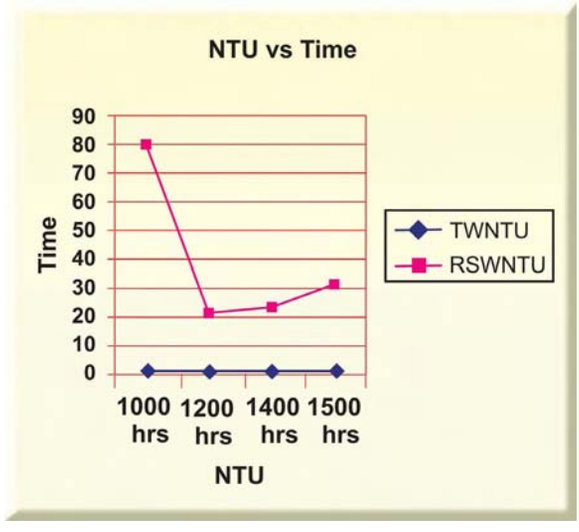

Fig. 6: Feed and treated water turbidity vs time in a day

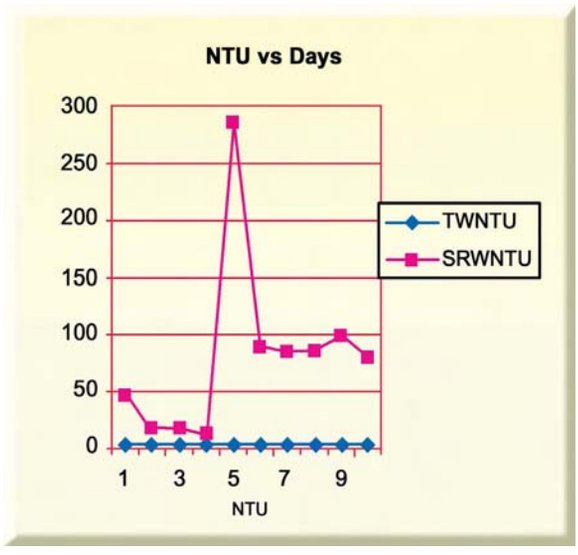

Fig.7: Feed and treated water turbidity vs days

With proper design and installation of an ultrafiltration pretreatment plant, ahead of the reverse osmosis plant in the year 2004, has seen the desalination plant running continuously without shut down. The ultrafiltration membranes are of hollow fiber configuration and are imported. Fig.5 shows a pictorial view of the ultrafiltration plant at the Desalination Division, BARC. The stable output quality of the treated water (TW) vis-à-vis Raw Sea Water (RSW) is shown in Fig. 6 and Fig. 7.

Conclusion

Having ascertained the efficacy of the UF pretreatment in the existing RO pilot plant, a 200 m^3/day UF-RO plant is proposed in the XIth Plan to assess the techno-economic viability of the ultrafiltration process, in the field of desalination.

ULTRA-HIGH PRECISION SLIT ASSEMBLY

Centre for Design and Manufacture

The Centre for Design and Manufacture (CDM) has designed and developed a motorized ultra-high precision slit assembly for use in synchrotron beam lines. The purpose of this instrument is to precisely define the shape and size of the synchrotron beam. The shape of the opening of the slit can be made either square or rectangular, as needed and its range is from '0 x 0' micron(completely closed) to 200 micron x 200 micron, with a resolution of 0.06 micron and repeatability is nearly zero.

The design of this system is based on flexure design, so there is no sliding motion and hence no friction between mating parts, which makes the system very accurate. Slit assembly has two identical four bar mechanisms as shown Fig.1. These are designed and manufactured and the sides of the slit opening are exactly parallel to each other. The direction of the applied force is at right angle to the direction of opening of the slit. In one mechanism force is applied vertically, accordingly its four bar mechanism elongates horizontally and in the other mechanism, force is applied horizontally, accordingly its four bar mechanism elongates vertically. All the deflections are within the elastic limit of the material of construction, so after the force is removed the mechanisms regain their original shape. Two slit edges, made of tungsten carbide are fitted on each four bar mechanism in such a way, that when there is no force, both the edges remain in contact and provide '0 x 0' (No gap) opening.

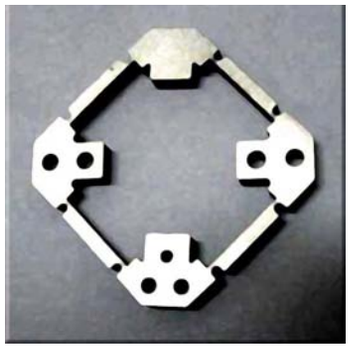

Fig. 1: Four bar mechanism

Combination of movements of these two four bar mechanisms, provide square or rectangular opening as desired. Both the four bar mechanisms are mounted inside a small housing and the actuating force is applied from outside, through a fine pitch screw and a stepper motor (Fig. 2 & Fig. 3). An Encoder is also mounted for feedback on the size of the opening.

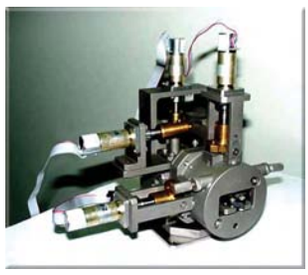

Fig. 2: Precision slit assembly

One slit assembly consists of four stepper motors; two motors are for controlling the opening size in horizontal and vertical direction respectively and other two motors are for providing the tilt and the rotation to the slit opening, for alignment with respect to the beam.

Three slit assemblies of this type have been manufactured, tested and delivered to RRCAT for use in EDXD synchrotron beam-line, installed at INDUS-II, RRCAT, Indore.

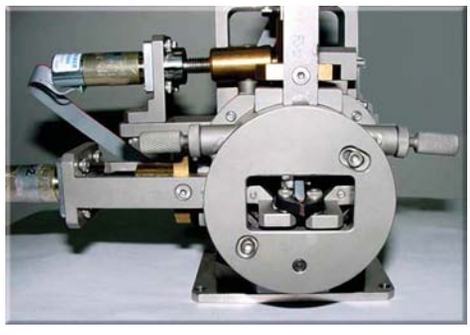

Fig. 3: Enlarged view of slit assembly

GRADUATION FUNCTION OF BARC TRAINING SCHOOL: OCES - 2006 AND OCDF - 2006 BATCHES

The Graduation Function of the 50th batch of BARC Training School (OCES-2006) and 3rd Batch of Orientation Course of DGFS Fellows (OCDF-2006) was held on 31st August, 2007 at the Central Complex Auditorium, BARC. The Hon'ble Prime Minister of India, Dr. Manmohan Singh was the Chief Guest for the function. H.E. Mr. S.M. Krishna, Governor of Maharashtra, presided over the function. The occasion was graced by Mr. Vilasrao Deshmukh, Hon'ble Chief Minister of Maharashtra, Mr. Prithviraj Chavan Hon'ble Mnister of State, PMO and Mr. M.K. Narayanan, National Security Advisor.

This was also an occasion on which the toppers of batches 1- 45 were honoured with the Homi Bhabha Medal. The toppers from 46th batch onwards are being honoured with the Homi Bhabha Medal on their respective graduation days.

Welcoming the gathering, Dr. A. Kakodkar, Chairman, AEC, paid tributes to the contribution of BARC Training School in the success of our atomic energy programme which has led to our R&D centres being 'Technology Powerhouses' in all spheres of the Department's activities. Admiring the vision of Dr Bhabha in setting up the Training School, he said that the unique multidisciplinary approach coupled with commitment to excellence which the BARC Training School nurtures, has given rich dividends in the area of power generation and added strategic strength to our country. This has given a boost to the path of self-reliance which has been the touchstone of our nuclear policy. He promised the young graduates an exciting and challenging career and thanked the Prime Minister for his constant support and encouragement to the scientific community of DAE. He presented a painting and a memento to the Prime Minister as a mark of appreciation.

Sitting on the dais from left to right are: Mr. Prithviraj Chavan, Hon'ble Mnister of State, PMO, H.E. Mr. S.M. Krishna, Governor of Maharashtra, Dr. Manmohan Singh, Prime Minister of India, Mr. Vilasrao Deshmukh, Hon'ble Chief Minister of Maharashtra, Mr. M.K. Narayanan, National Security Advisor and Dr. S. Banerjee, Director, BARC. Dr. Anil Kakodkar, Chairman, AEC is seen delivering the welcome address

Dr. R.R. Puri, Head, Human Resource Development Division, BARC, mentioned that 105 trainees graduated this year from the Training School. They would all be also enrolling for the M Phil/ M Tech Degrees of the Homi Bhabha National Institute, a deemed to be university.

The Prime Minister gave away the Homi Bhabha Medals to the toppers of OCES-2006 and OCDF-2006 batches and to the Toppers of Batches 1- 45 of the BARC Training School.

The Prime Minister in his speech lauded the efforts of the BARC Training School faculty in training over 7500 scientists and engineers who laid the building blocks of self reliance in the field of Nuclear Science and Technology. The BARC Training School, he said, is recognized internationally as a model institute of excellence.

He urged the scientific community to create a culture of excellence and to develop role models so as to attract the best talent. The PM appreciated the efforts of the faculty of the BARC Training School for their contributions to the technological developments of the country, in building and operating indigenously designed nuclear reactors. He reiterated the government's commitments to strengthening the autonomy of the nuclear R&D programmes. The unique three stage programme to utilize the thorium reserves and the setting up of the Fast Breeder Reactors and designing of an Advanced Heavy Water Reactor and other reactor designs are steps in the right direction, he added. The contributions in the areas of agriculture, food preservation and health care are of equal significance, he said.

Prime Minister Dr. Manmohan Singh addressing the gathering of Homi Bhabha Awardees, Training School Officers, Senior Scientists and other distinguished invitees

He appealed to the young graduates and youth across the country

"Be bold, be brave, be innovative, be curious and be open to new ideas, new ways of thinking and new ways of doing things. This is the scientific method. The nuclear renaissance taking place will place a high premium upon your skills and knowledge".

He acknowledged the role of visionaries such as Dr. Homi Bhabha, Dr. Homi Sethna and Dr. Raja Ramanna in building this great national institution largely due to their boldness and openness to new ideas. They were perhaps inspired by the words of the Father of our Nation, Mahatma Gandhi, who said

"I do not want my house to be walled in on sides and my windows to be stuffed. I want the cultures of all lands to be blown about my house as freely as possible. But I refuse to be blown off by any".

He urged the gathering to imbibe these qualities and benefit from the two way flow of ideas, goods, services and peoples between India and the rest of the world. In conclusion, quoting J.R.D Tata on the qualities of Homi Jehangir Bhabha

"Scientist, engineer, master-builder and administrator, steeped in humanities, in art and music, Homi was a truly complete man".

Dr. Anil Kakodkar, Chairman, AEC, receiving the Homi Bhabha Medal from the Prime Minister, Dr. Manmohan Singh

The PM urged everyone to develop such a holistic personality, combining a scientific temper with modern outlook.

Dr. S. Banerjee, Director, BARC, proposed the vote of thanks. It is indeed a very special day, he said, the gathering spawning across generations - our predecessors who shaped the destiny of our programme, the present day achievers who are responsible for realizing some of the dreams of our earlier generation and the trainees of the current batch in whose hands lies the future. The BARC Training School has been the source of talent pool driving the multifarious activities of DAE. He thanked the PM for his encouraging and inspiring words and the other dignitaries on the dais and the distinguished gathering of guests who assembled for this function. Special words of appreciation were reserved for the training school faculty numbering about 300 for imparting high quality education to the trainees. He also thanked Dr. A. Kakodkar, for his close involvement in the TS activities and all the award winners for accepting the invitation to be present to receive the award. He then warmly welcomed the fresh graduates to the BARC fold.

The award winners of the individual disciplines were honoured in the afternoon session. Medals were conferred on them by Dr. H.N. Sethna, Dr. P.K. Iyengar,

Dr. S. Banerjee, Director, BARC delivering the vote of thanks

Dr. M.R. Srinivasan, former Chairman, AEC and Dr. A. Kakodkar, Chairman, AEC. The awards function was followed by reminiscences by some former alumni of the BARC Training School. A scintillating entertainment programme with a message of national integration by the trainees of the 50th Batch brought the day's proceedings to a fitting finale.

NATIONAL FIRE SERVICE WEEK OBSERVED AT BARC

The Fire Service Week – 2007 was observed at BARC from April 14-20, 2007. in accordance with the directive issued by the Ministry of Home Affairs, Government of India. On this day in the year 1944, fire service personnel displayed exemplary courage and devotion to duty as they fought the huge fire that had erupted following an explosion on a Ship S.S. Fort Sticken berthed at the docks of Mumbai Port Trust. Many fire fighters lost their lives, leaving behind their names etched in the minds of Mumbaites forever. Even after this accident, while fighting fire, many fire fighters have lost their lives. On 14th April, due respect and homage is paid to those brave fire fighters.

Dr. S. Banerjee, Director BARC being offered Pin Flag by Mr. A.K. Tandle, Chief Fire Officer at the function

Several programmes were organized by the Fire Service Section, BARC. during the fire service week from April 14-20, 2007, to create fire safety awareness among the employees in BARC, Trombay and Anushakti Nagar.

On behalf of BARC, Mr. A.K. Tandle, Chief Fire Officer placed wreaths on 14.4.2007, at the memorials erected on the grounds of Mumbai Port Trust and at the headquarters of Mumbai Fire Brigade, Byculla.

Dr. S. Banerjee, Director, BARC was offered pin flag on 16.4.2007 to start the fund raising campaign in BARC. Dr. Banerjee appreciated the continued participation of BARC Fire Service personnel in various state level fire drill competition and in securing 2nd and 3rd positions and conducting fire safety awareness programmes in BARC and Anushakti Nagar. Mr. B.P. Sharma, Associate Director, Materials Group, BARC appreciated the fire emergency work carried out by FSS in BARC and hoped that they to do the wished to continue same in future also.

Two crews from BARC Fire Service Section participated in Tactical Medley Drill Competition on 17.4.2007 organized by the Govt. of Maharashtra at Civil Defence Headquarters. Thirteen teams belonging to various organizations viz. Mumbai Fire Brigade, BPCL, Mumbai Port Trust, State Fire Training Center etc. participated in competition. Team 'A' from this section was awarded Second prize and Team 'B' was awarded Third prize. Mr. S.N. Kadam, Fireman and Mr. S.J. Ghadshi, Fireman were awarded 1st and 1st consolation Prizes respectively in individual ladder Drill Competition.

Mr. D.K. Gulati, Station Officer and Mr. V.A. Sayed, Sub Officer received prizes in quiz competition organized by MARG at BPCIL.

Fire Fighting and Rescue demonstration in a building was held at Varsha 'B', New Mandala on 19.4.2007. Fire safety posters and banners were displayed at the location and also cards on Fire safety in residential

The live "Demonstration of Rescue" by using rope at "VARSHA SQUARE, New Mandala

area were distributed to residents who were present to witness the programme. Around 600 residents of Anushakti Nagar witnessed the programme.

At PP/FRD also live demonstration on fire safety and exhibition was arranged on 18.04.2007. Mr. A.K. Tandle, CFO briefed the significance of fire service week. Mr. S.D. Mishra, Group Director addressed the gathering and inaugurated the "Fire Safety Equipment Exhibition". Fire fighting and rescue demonstrations were held after inauguration. PP staff members witnessed the programme. Mr. Mishra emphasized that NRG project should be free from fire accidents and assured that NRG will work in co-ordination with FSS to achieve fire accident free project sites. He also appreciated timely dewatering carried out by FSS in Waste Tank Farm area during 26th July 2005.

Mr S. K. Ghosh, Associate Director, ChEG. requested employees to attend fire safety training programme and ensure fire safety at the work places while speaking during the inauguration function.

On 15.04.2007 a film on "Fire in high rise building", "Aag ka Niyantran" were screened through cable network at Anushakti Nagar to increase the fire safety awareness among the residents of Ansuhakti Nagar.

This year during fund raising campaign for fire service welfare activities totaling Rs.16, 907/- were collected

Mr. S.D.Mishra, Director, NRG., Mr. S.K. Ghosh, Associate Director, ChEG. & Head, ChED. and others taking keen interest in the exhibition on "Fire Safety Equipment" displayed at FRD. Complex.

Director, Fire and Emergency Services, Maharashtra, Chief Fire Officer, Mumbai Fire Brigade, Chief Fire Officer, BARC and winning team of BARC Fire Services in the "Tactical Medley Drill" along with the two trophies for second position and third position

through voluntary donations and the same amount was deposited in the office of Fire advisor to Govt. of Maharashtra.

Dr. Jayraj Phathak, Secretary, Urban Development, Government of Maharashtra, Mr. Jalota, CEO, MIDC, Government of Maharashtra and other dignitaries were present at the closing ceremony of the Fire Service Week on 20.04.2007 at Cross Maidan, Dhobi Talao, Mumbai. BARC Fire Service personnel contingent participated along with Emergency Rescue Tender & Equipments. Dr. Jayraj Pathak, Secretary Urban Development and Mr. Jalota, CEO, MIDC distributed the prizes to the winners of various competitions held during fire service week.

Demonstration of "Emergency Rescue Tender" showing electrical mask in operation

BARC TRANSFERS TECHNOLOGY OF MANUAL LIQUID SCINTILLATION COUNTING SYSTEM

The technology of Manual Liquid Scintillation Counting System developed by the Electronics Division has been transferred to M/s. Nucleonix Systems Pvt. Ltd., Hyderabad on 04.10.2007.

The Liquid Scintillation Counting System with USB Interface is a PC-based system for detecting even small amounts of beta and alpha radioactivity. It has manually operated light tight sample chamber shielded with lead housing. Usage of excellent quality high efficiency matched pair of photo multiplier tubes, precision fast and slow preamplifiers, high speed analog electronics design, USB based spectroscopy quality MCA, rugged manually operated sample chamber with lead shield, allow the system to offer high efficiency even for low energy beta emitters such as tritium and also a very low background. It has wide range of applications in Biology, Medicine and Environmental studies. Salient features of the system are: (i) advanced photo multiplier design (ii) Nanosecond pulses coincidence detection (iii) USB-based high-resolution spectroscopy quality Multi-channel Analyzer (1K–8K) (iv) Excellent performance in terms of efficiency and background (v) Simple to install, operate, handle and easy to manufacture and maintain.

The Technology Transfer and Collaboration Division coordinated all activities related to this technology i.e. preparation of leaflet, technical brochure, technology document, advertisement of the technology, technology transfer agreement preparation and the technology transfer agreement signing formalities.

After signing the technology transfer agreement with M/s. Nucleonix Systems Pvt. Ltd., Hyderabad. seen sitting from right to left are Ms. Smita S. Mule, TT&CD, Mr. A. M. Patankar, Head, TT&CD, Mr. J. N. Reddy, MD, M/s Nucleonix, Dr. R. B. Grover, Director, KMG, Dr. P. P. Vaidya, Head, Nuclear Systems Section, ED, Ms. R. K. Gurna and Ms. Molly Paulson, ED. Standing from right to left are Mr. Murali Krishna, and Mr. K. V. Panchal, from ED, Mr. T. H. Salunke and Ms. Soniya S. Murudkar, from TT&CD and Mr. S.R. Jadhav, Mr. M. Vinod, Mr. D.M. Nikhare from ED.

भा.प.अ. केंद्र के वैज्ञानिकों को सम्मान
BARC SCIENTISTS HONOURED


Amit Kunwar


Dr. K.I. Priyadarsini


Himanshi Narang


Dr. Malini Krishna

श्री अमित कुंवर विकिरण एवं फोटोरसायनिकी प्रभाग को लोनावला में दिनांक 8-11 जनवरी, 2007 के दौरान सोसाइटी ऑफ फ्री रैडिकल रिसर्च, इंडिया द्वारा आयोजित इमर्जिंग ट्रेंड्स इन फ्री रैडिकल्स एण्ड ऐंटीऑक्सिडॅन्ड रिसर्च पर अंतरराष्ट्रीय सम्मेलन में माडुलेशन आफ गामा -रेडिएशन इन्ड्यूस्ड रेडॉक्स सिग्नलिंग इन स्प्लीन लिंफोसाइटसबाइ Cu(II)-करकुमिन (1:1) कांप्लेक्स नामक उनके पोस्टर के लिये गौरवशाली युवा अन्वेषक पुरस्कार प्रदान किय गया। पुरस्कार में सोसाइटी ऑफ आर्काइव्स ऑफ बायोकेमिस्ट्री एण्ड बायोफिसिक्स द्वारा प्रमाणपत्र एवं नकद पुरस्कार है। इस पत्र के सह लेखक हैं डॉ.के.आई. प्रियदर्शिनी, आरपीसीडी, सुश्री हिमांशी नारंग एवं डॉ. मालिनी कृष्णा, विकिरण जैविकी एवं स्वास्थ्य विज्ञान प्रभाग। श्री अमित कुंवर को दिनांक 6 अक्तूबर, 2006 के दौरान स्पेटसस द्वीप, ग्रीस यूरोप में आयोजित इंटरनैशनल फ्री रैडिकल समर स्कूल में शामिल होने हेतु सोसाइटी ऑफ फ्री रैडिकल रिसर्च, यूरोप एवं फेडरेशन ऑफ यूरोपियन बायोलाजिकल सोसाइटी द्वारा आमंत्रित किया गया ।

Mr. Amit Kunwar of Radiation & Photochemistry Division was awarded the prestigious young investigator award (Archives of Biochemistry & Biophysics award) for his poster entitled "Modulation of gamma-radiation induced redox signaling in spleen lymphocytes by Cu (II)-curcumin (1:1) complex" at the International Conference on "Emerging Trends in Free Radicals and Antioxidant Research" organized by the Society of Free Radical Research, India at Lonavala, 8-11 January, 2007. The award consists of a certificate from the Society of Archives of Biochemistry & Biophysics and a cash prize. Coauthors of this paper are Dr. K.I. Priyadarsini of RPCD, Ms Himanshi Narang and Dr. Malini Krishna of Radiation Biology & Health Sciences Division. Mr. Amit Kunwar was also awarded previously with participation grant from Society of Free Radical Research, Europe and Federation of European Biological Society for attending the "International Free Radical Summer School" held at Spetses Island, Greece, Europe during 30th September to 6th October 2006.


S.P. Srivastava

श्री. एस.पी. श्रीवास्तव, अभिकल्पन एवं विनिर्माण केंद्र को इण्डियन सोसायटी फॉर नॉनडिस्ट्रक्टिव टेस्टिंग, मुंम्बई अध्याय द्वारा दिनांक 28/09/07 को, वार्षिक आम सभा के दौरान आयोजित एक कार्यक्रम में एन.डी.टी. एचिवमेन्ट पुरस्कार - 2007 (शोध एवं विकास) से सन्मानित किया गया। यह पुरस्कार श्री. श्रीवास्तव को पराश्रव्य ध्वनी निरीक्षण के क्षेत्र में उनके विशिष्ट योगदान जैसे चैनल ग्रोथ मेझरिंग डिवाइस तथा ऑटोमेटेड मेकानिकल स्कैनर के विकास के लिए प्रदान किया गया ।

Mr. S.P. Srivastava of Centre for Design and Manufacture has been awarded the NDT Achievement Award – 2007 in the Research and Development category by the Indian Society for Non- Destructive Testing, Mumbai Chapter for his outstanding contributions in the field of Ultrasonic Testing such as 'Channel Growth Measuring Device' to predict the remnant life of TAPS fuel channel and 'Automated Mechanical Scanner' for Ultrasonic C-scan imaging of End Fitting Forgings. The Award was presented to Mr. Srivastava on 28/09/07 in a function organized during the Annual General Meeting of ISNT Mumbai chapter.


Dr. V.K. Manchanda

उनकी उत्कृष्ट उपलब्धियों एवं निपुणता को देखते हुए डॉ.वी.के. मनचंदा, अध्यक्ष, विकिरण रसायनिकी प्रभाग, भापअ केंद्र को सॉल्वैंट एक्सट्रैक्शन एण्ड आयन एक्सचेंज, मार्सल एण्ड डेक्कर, इन्क, पब्लिकेशन, न्यूयॉर्क की पत्रिका के संपादक मंडल में शामिल होने का आमंत्रण दिया गया है । यह एक मात्र ऐसी पत्रिका है जिसमें इस क्षेत्र के संबंध में व्यापक चर्चा होती है। डॉ. मनचंदा वर्ष 2004 से नाभिकीय विज्ञान एवं प्रौद्योगिकी की रासायनिक पहलुओं हेतु एक अंतरराष्ट्रीय पत्रिका रेडियोकिमिका ऍक्टा के सलाहकार मंडल के सदस्य के रूप में कार्य कर रहे हैं। वे अनेक अंतरराष्ट्रीय पत्रिकाओं के पुनरीक्षकों के पैनल में रह चुके हैं। उन्होंने अंतरराष्ट्रीय पत्रिकाओं में लगभग 170 पुनरीक्षित लेखों को प्रकाशित किया है एवं 15 विद्यार्थियों को उनकी पीएचडी के लिए गाइड किया है । अध्यक्ष, आईएएनसीएएस के रूप में वे नाभिकीय विज्ञान संबंधी ज्ञान को बढ़ावा देने में सक्रिय रूप से जुड़े हुए हैं। वे भारतीय पृथक्करण विज्ञान एवं प्रौद्योगिकी संस्थान (आइएनएएसएटी) के अध्यक्ष के रूप में भी कार्य कर रहे हैं।

In view of his distinguished achievements and expertise Dr. V.K. Manchanda, Head, Radiochemistry Division, BARC has been invited to join the Board of Editors of the Journal, Solvent Extraction & Ion Exchange, Marcel and Dekker, Inc, Publication, New York. This is the only journal to exclusively address the leading issues across the breadth of this field. Dr. Manchanda is also working since 2004 as Member, Advisory Board of *RadioChimica Acta*, an International Journal for Chemical aspects of Nuclear Science and technology. He has been on the panel of reviewers of several international journals. He has published about 170 peer reviewed papers in International journals and guided 15 students in their Ph.D. work. As President, IANCAS, he is actively involved in disseminating knowledge related to Nuclear Sciences. He is also the working President of the Indian Association of Separation Science and Technology (INASAT).


Dr. A. M. Shaikh

डॉ. ए.एम. शेख, घनावस्था भौतिकी प्रभाग (एसएसपीडी) को न्यूट्रान रेडियोग्राफी के क्षेत्र में उत्कृष्ट योगदान के लिए इंडियन सोसायटी फॉर नॉन डिस्ट्रक्टिव टेस्टिंग द्वारा "आईएसएनटी-एनआरडब्ल्यूजी स्वर्णपदक-2007" प्रदान किया गया । श्री टी. शंकरलिंगम, अध्यक्ष, नेशनल थर्मल पॉवर कारपोरेशन, भारत सरकार ने दिनांक 28 नवंबर 2007 को एम.एस. यूनिवर्सिटी, वडोदरा में आयोजित "एनडीई 2007" के उद्घाटन समारोह में उक्त पदक डॉ. शेख को प्रदान किया ।

Dr. A.M. Shaikh, Solid State Physics Civision (SSPD) has been awarded the " ISNT-NRWG gold medal 2007" by the Indian Society for Nondestructive Testing, for his outstanding contribution to the field of Neutron Radiography. Mr. T. Shankarlingham, Chairman, National Thermal Power Corporation, Government of India presented the medal to Dr. Shaikh at the inaugural function of "NDE2007" at the M.S. University, Vadodara on 28th November 2007.

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