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FITT .. tramping ahead

After a few years of its existence, a Technology Transfer Organisation (TTO) may often come to a crossroad where it becomes important for it to self-assess its' roles and operating model, the value it has created for its stakeholders and its' prospects / relevance going forward. Typically, a TTO evolves from a simple office performing services for the faculty scientists to a more mature one managing IP/license portfolio, administering IP policy, contract R&D, spin-outs etc. As a foremost TTO from academia in India, FITT can be considered at some such inflection point in its' 25th year of maturity. Designed to be a self-sustaining entity from day one, it calls for a great deal of robustness in the operating model of FITT to be able to sustain, and also decide to look at newer avenues of growth. In most of the academic institutions, the various TTO functions like industry partnerships, IP management, entrepreneurship, consultancy etc. are spread out over different entities. At IIT Delhi, FITT was created as a comprehensive body to address varied technology transfer activities entailing a single-window platform to usher in seamless and efficient delivery process. Having built its credentials in the area of IP management, professional development and incubation programs in a steady manner, FITT has embarked on the next leg of its journey to further IIT Delhi's vision of greater industry outreach, high value and inclusive innovations, enhanced IP creation and augmentation of start-up ecosystem. With its persistent lean and flexible structure layered with commercial ethos, FITT has been quick to take up the responsibility of organizing Research Parks for IIT Delhi at its various campuses. Thus, there is an increasing shift from an administrative to a strategic direction for FITT. While it looks at new growth drivers, the task of building its' own capacity to perform and also continue to serve as the benchmark TTO in the country, FITT is boldly looking forward to busy yet exciting times with a wide repertoire of projects and programs. With active support and cooperation from the Institute's academics, FITT hopes to strike it big in the foreseeable future.

Wish everyone a glorious 2018 !

Anil Wali

Felicitation of awardees of Smartathon 2017 organised by FITT in association with Samsung at LHC, IIT Delhi on December 1, 2017

UK India Roundtable discussion on Innovation Campuses, Science Parks and Incubators organised by FITT at the Senate Room, IIT Delhi on November 1, 2017

WEE Awardees being felicitated by Prof V Ramgopal Rao, Director IIT Delhi during the award ceremony on December 27, 2017

Contents

Aeration by drops and jets: how bubbles come into action

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Aeration is used to remediate polluted rivers contaminated with waste products, petroleum, sediments and chemicals. It is the process of increasing the oxygen saturation. In water treatment, the goal is to transfer a part of the 21% of oxygen found in ambient air to the bottom sediment level where it disperses via bubbles into the water column while scrubbing out accumulated noxious gases at the same time. For improving any aquatic environment, dissolved oxygen in water is very critical to keep the treatment process aerobic; nutrient consuming microorganisms like bacteria thrive in aerobic environments. Aeration reduces the concentration of volatile organic compounds like Trihalomethanes (THMs) which are formed from the reaction between natural organic matter in raw water and chlorine disinfectant. It also removes dissolved gases such as carbon dioxide, hydrogen sulfide, methane, and radon. Aeration can be achieved through the infusion of air into the bottom of the lake, lagoon or pond or by surface agitation from a fountain or spray-like device to allow for oxygen exchange at the surface and the release of noxious gasses.

(a) Fountains

(b) Floating surface aerators

(c) Paddlewheel aerators

(d) Subsurface aeration

Figure 1. Different types of aeration techniques
[Pictures from differerent sources]

Any surface aeration [shown in Fig. 1 (a), (b) and (c)] process utilizes air-water contact to transfer oxygen. As the water is propelled into the air, it breaks into small droplets. Collectively, these small droplets have a large surface area through which oxygen can be transferred. Upon return, these droplets mix with the rest of the water and thus transfer their oxygen back to the ecosystem. A motorized device churns the water and air together, allowing THMs to transfer from water into the air. In case of surface aerators, as the name suggest, aeration takes place just for the water near the surface. The water at depths cannot be aerated properly.

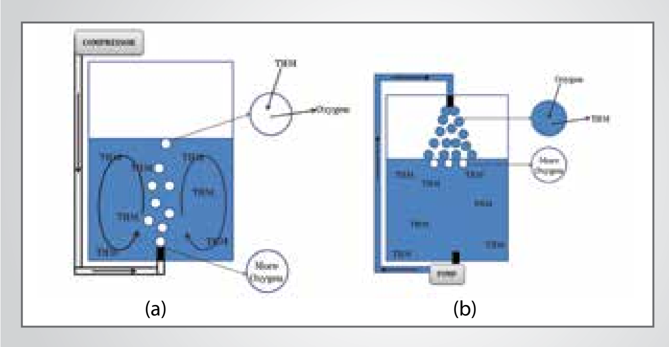


Figure 2. Schematic of (a) Bubble aerator, (b) Spray aerator. Blue and white color indicates water and air respectively. Black arrows indicate the direction of flow.

Subsurface aeration [as in Fig. 1(d)] seeks to release bubbles at the bottom of the water body and allow them to rise by the force of buoyancy. When compressed air is released at the bottom it will naturally begin to migrate towards the surface of the water. As it travels up the water column the pressure surrounding the bubbles slowly decreases causing the bubbles to expand in size. Due to the fact that larger bubbles displace more water than smaller bubbles a slight current begins to develop [shown in Fig. 2(a)]. This current draws oxygen-depleted water from the bottom, oxygenates it and transports it to the surface. This action mixes stratified water while increasing dissolved oxygen levels and protecting fish, aquatic organisms and beneficial microbes from suffocation. Mixing enhances aeration, where the high oxygenated bubbles release oxygen and take THMs and dissolved gases as they move up through the water column. Finally the bubble bursts when reaches the water surface and releases the THMs. In the case of iron and manganese, the bubble causes these minerals to move from their dissolved state to a solid state and precipitate out of solution. The water can then move through a filter to trap the iron and manganese particles.

Bubbles have some intriguing properties including gaseous exchange with surrounding fluids, turbulence generation to mix the fluids, and an ability to affect a fluid's properties. Rising bubbles will draw bottom water less rich in oxygen (measured as Biological Oxygen Demand) up through the water column and will find itself in contact with the ambient air where further gas exchange is achieved. The size of bubbles will determine how much oxygen gets into the water. Smaller bubbles are more effective at doing this because cumulatively they have a larger surface area than the same amount of oxygen in bigger bubbles. That means more oxygen comes into contact with the water and more gets dissolved. On other side, in a very small bubble, the oxygen would diffuse into the water, and the bubble would disappear before an appreciable amount of carbon dioxide could diffuse into the bubble. Also for small bubble the buoyancy is less and so some bubbles cannot reach the surface to release the harmful chemicals. Thus it is a topic of interest as to what should be the optimum bubble size for better efficiency. Apart from this, the process of bubble aeration consumes lot of energy in contrast to surface aeration techniques.

Spray aeration (schematic shown in Fig. 2(b)) is the process of pumping water from the floor of the tank to the ceiling, and spraying it down through a set of spray nozzles. As each droplet flies out of spray nozzle, THMs evaporate out of the droplet and into the air. It is said to be the most energy efficient for THMs removal. The advantages of both drop and bubble aeration can be taken into account by changing the fluid and flow parameters in spray aeration. Drops or jets that impact a free water surface with velocities above about 2 ms^{-1} entrain air and carry bubbles below the liquid surface. Entrainment of air due to drop or jet impact, is an interesting field of research which focuses on the fundamentals of cavity dynamics formed by drop impact.

The literature reveals that the bubble entrainment owing to the impact of a liquid drop onto a liquid pool may take place mainly in two ways: firstly, owing to the closure of the mouth of the crater formed on the liquid pool caused by the impacting of the drop, and secondly, due to the rupture of the air film trapped near the bottom surface of the drop. For the impact of a single drop of millimeter size, different categories of bubble entrapment were identified[1,2] such as *regular entrainment, irregular entrainment, large bubble entrainment, and Messler entrainment.* At sufficiently low velocities, typically no bubble is produced. For a given drop size and impact velocity, the bubble formation is highly reproducible, and so this behavior is referred to as small regular bubble formation. There is a second critical velocity above which bubbles are no longer regularly produced. During regular bubble entrapment, the bubble pinches off at the bottom of the crater during crater collapse.

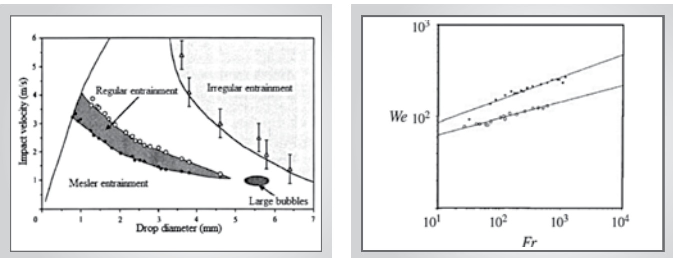


Figure 3. Bubble entrapment regimes on the traditional classification map[1] in the (a) Drop diameter (*D*)-Impact velocity (*V*) plane and (b) Weber number (*We*)-Froude number (*Fr*) plane.

Messler entrainment[1] is characterized by the entrapment of many bubbles by one drop impact; these bubbles are very small (50 micrometer is typical). This type of entrapment seems to occur most often for very small impact velocities, below the small regular entrapment region, but may occasionally occur in conjunction with Franz irregular entrapment, at the collapse of the water column. It is very unpredictable; the number of bubbles entrained varies greatly from one drop to the next, even if the drops are of the same size and impact velocity.

During the ***regular bubble entrainment,*** the bubble pinches off at the bottom of the crater during the crater collapse. Pumphery and Elmore[1-3] identified different regimes of bubble entrapment in the drop diameter (*D*)-impact velocity of this region were determined by Oguz and Prosperetti[4] as $We_u = 48.3Fr^{0.247}$ and $We_l = 41.3Fr^{0.179}$, respectively. The process of regular bubble entrapment can be best understood from the vertical and horizontal flows during the free surface deformation. The process consists of three stages: expansion, retraction, and necking. After the drop impacts a wave-swell is created at the liquid surface (radial deformation) and a crater is formed (axial deformation). During the expansion stage, wave-swell height and crater-depth increase. The crater shape changes from spherical to U-shape. At retraction stage the wave-swell height and crater-depth decrease and the crater transforms to flat V-shape. The liquid from wave-swell converges toward the side walls of the crater leading to neck formation. Finally, the crater side wall collides and causes pinch-off. There is a strong pressure drop below the crater base after pinch-off and a high speed jet is ejected upward and downward. Ray *et al.*[5,6] showed that similar to above phenomena, small regular bubble entrapment can also occur if the Weber number is increased as shown in *We-Fr* plot in Fig. 5(a). Apart from bubble size, the jet characteristic also changes. For low Weber number, a short, thin, high-speed jet appears which again pinches out numerous small secondary drops. Later the velocity of the jet decreases and the jet thickens, rises to a certain height, and finally collapses into the water surface. Whereas for higher We, a similar thin jet is formed which produces many secondary droplets and instead of collapsing quickly, it elongates to form a long, thick jet. The jet speed decreases and owing to capillary instability, it breaks up to yield one or two large secondary droplets.

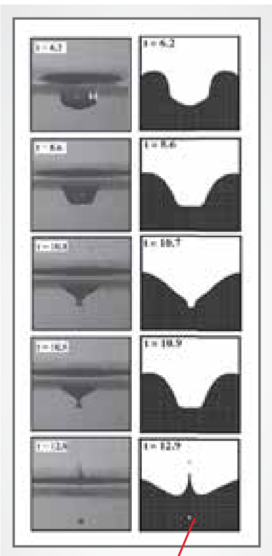
The single *large bubble entrapment*[7-9] is reproducibly pinched off at about halfway along the distorted cavity, which is induced by the impacting drop [Fig. 5(B1, B2)]. Such entrapment occur only for drops that are prolate at impact. On the traditional classification map, the large bubble entrapment occurs over a small region as shown in Fig. 3(a). In this process, the crater produced by the drop impact expands radially and closes at the top to entrap a large bubble. The volume of the entrapped bubble can be much larger than the drop itself. Wang *et al.*[7] experimentally observed a large bubble entrapment outside the reported small region of the traditional *V-D* map [Fig. 3(a)]. Thoraval *et al.*[8] reported that the entrapment of a large bubble is a vortex-driven phenomenon. The vortex ring produced during the drop impact controls the crater deformation and the pinch-off. For a flatter oblate drop, on impact to the pool surface, the neck shape forms a sharper cusp than for a spherical or prolate drop. Sharper curvature produces stronger vorticity. The strong vortex starts to pull on the interface before it fully enters the pool. This results in a thin and more vertical liquid protrusion, which is rapidly pulled back by surface tension. Whereas for a prolate drop, vortex pulls on the interface below the pool surface, on the side of the cavity created by the impacting drop. This makes the thicker and more horizontal liquid protrusion, which then collapses on the central axis to entrap the large bubble. Large bubble entrapment is observed in a wide region on the *V-D* map. Deka *et al.*[9] have identified the regime of a large bubble entrapment on the *We-Fr* map shown in Fig. 5(b).

Spray aeration can be more related to consecutive multiple drop impact rather than single drop impact. The effect of time separation, ratio of drop size and drop impact velocity on consecutive drop impact has been investigated by Bick *et al.*[10]

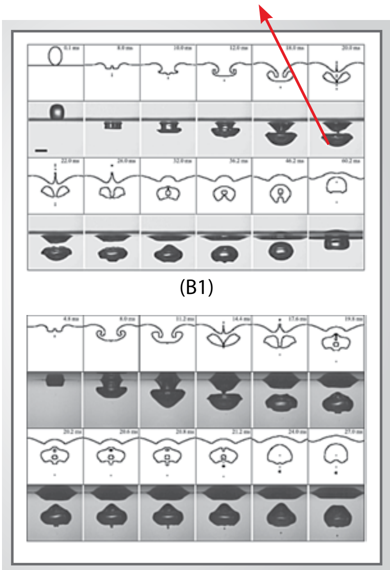
and Ray *et al.*[11]. For the impact of single droplets, a critical impact velocity must be exceeded for air to be entrained in the form of bubbles. Studies showed that bubbles can be generated at much lower velocities provided that two or more drops impact the liquid-air interface within a sufficiently short time interval. Drop pair impact exhibits partial coalescence phenomena when the drops fall one after another within very small time gap and very low impact velocity. The difference in time gap determines whether the drops coalesce before impact or second drop impacts after the first drop. Within this time period the capillary waves formed during first drop impact moves towards the second drop and due to capillary instability leads to secondary drop pinch-off. For slightly higher impact velocity, the cavity formation by first drop impact and subsequent impact of second drop leads to bubble generation as shown in Fig. 4(C). In *We-Fr* map [Fig. 5(c)], this kind of bubble entrapment regime is seen to be much lower the regular bubble entrapment regime.

Bouwhuis *et al.*[12] investigated the impact of a high-speed train of micro-droplets on a deep liquid pool, both experimentally and numerically. They observed that the impact of a train of high-speed micro droplets can create a very deep and narrow cavity as showed in Fig. 4(D), whose behavior is mainly determined by the inertial effects. This cavity further closes near the surface to entrain a large bubble.

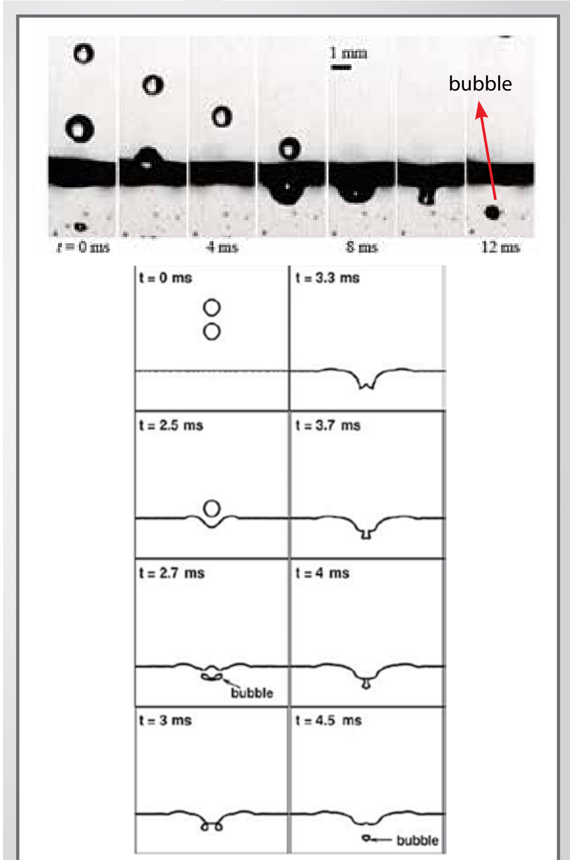
When a droplet impacts on a liquid pool, its momentum gets transferred into the pool, which makes the liquid in the pool to move outward in all directions from the point of impact. This results in formation of a crater in the pool. The crater initially expands until the momentum transferred by the impacting droplet dissipates, and then it starts to retract. During the impact of multiple droplets, the second droplet hits the base of the crater formed by impact of the first droplet and forms another crater at the base of the first crater. Likewise, for a train of droplets, the droplets hit the crater base continuously, and due to continuous transfer of momentum its penetration increases continuously, which results in formation of a deep cavity. When the frequency of drop train is more, it behaves similar to water jet and again entrains large bubble.



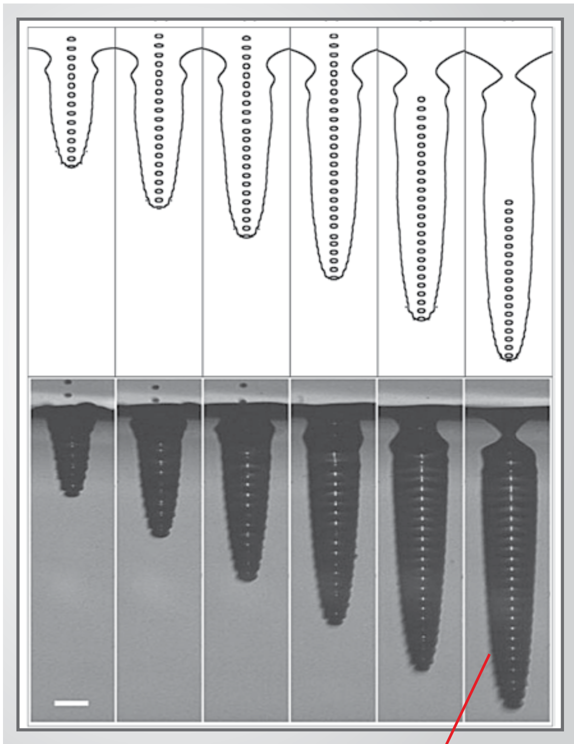
bubble
(A)



bubble
(B1)
(B2)



(C)



(D)
bubble

Figure 4. Bubble entrainment regimes: (A) Regular bubble entrainment due to single drop impact, (B1) Large bubble entrainment due to single drop impact, (B2) Large bubble along with small bubble entrainment due to single drop impact, (C) Regular bubble entrainment due to multiple drop impact, (D) Large bubble entrainment due to multiple drop impact. In each subfigures both experimental and numerical results are shown. The line diagrams are numerical result.

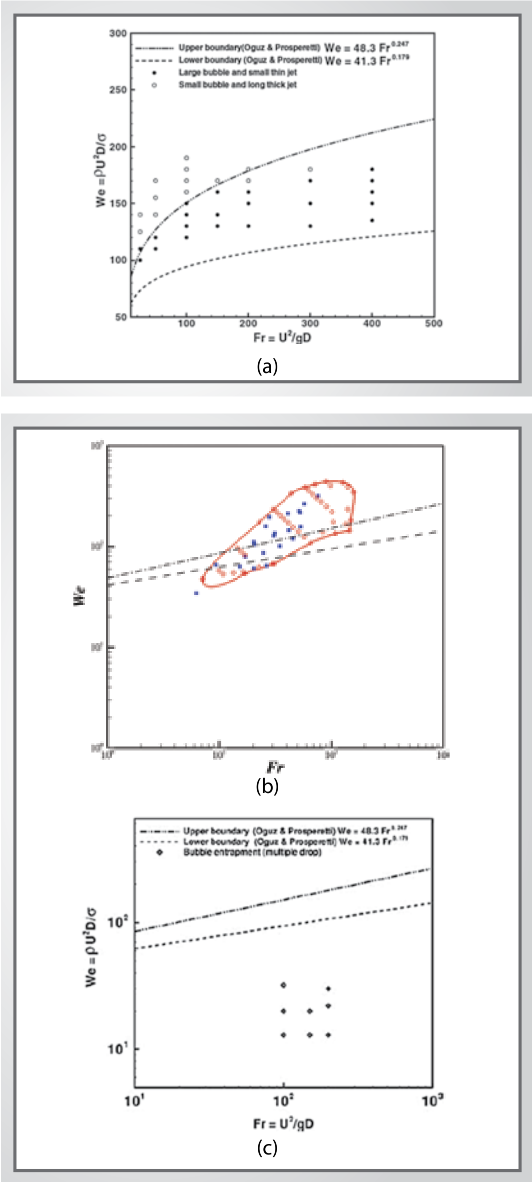


Figure 5. Bubble entrapment regimes: (a) Regular bubble entrapment due to single drop impact, (b) Large bubble entrapment due to single drop impact: the red circles represent the points of the large bubble entrapment. The filled blue squares are the points where a large bubble entrapment was observed experimentally by Wang *et al.*[7], (c) Regular bubble entrapment due to multiple drop impact

Large bubble, as seen from Fig. 4 (B1) , (B2) and (D) can transfer more oxygen to the water, whereas small bubble in Fig. 4(A) and (C) can move to a greater depth of water and can supply oxygen to that depth. Sometimes the large bubble may break to multiple small bubbles, which again can help in transferring oxygen to greater depth. The aeration due to bubbles during spray impact thus vary over a vast range of parameters. By proper control of these parameters the process of aeration could be made more efficient. Proper experimental and numerical techniques help in understanding the underlying physics. Further improvement can be made to the spray aeration technique by adding circulation in the water, which will allow the more polluted water at the bottom to move up and thus remove the THMs and dissolved gases either by evaporation or by bubbles.

Acknowledgement

I acknowledge my collaborators and PhD students with whom the research has been done.

References:

1. H. C. Pumphrey and P. A. Elmore, "The entrainment of bubbles by drop impacts," J. Fluid Mech. 220, 539–567 (1990).
2. P. A. Elmore, H.C. Pumphrey and L. A. Crum, "Further studies of the underwater noise produced by rainfall". PhD thesis, University of Mississippi (1989).
3. H. .C. Pumphrey, L. A. Crum and L. Bjorno, "Underwater sound produced by individual drop impacts and rainfall". J. Acoust. Soc. Am. 85, 1518–1526 (1989).
4. H. N. Oguz and A. Prosperetti, "Bubble entrainment by the impact of drops on liquid surfaces," J. Fluid Mech. 219, 143–179 (1990).
5. B. Ray, G. Biswas, and A. Sharma, "Regimes during liquid drop impact on a liquid pool," J. Fluid Mech. 768, 492–523 (2015).
6. B. Ray, G. Biswas, and A. Sharma, "Bubble pinch-off and scaling during liquid drop impact on liquid pool," Phys. Fluids 24, 082108 (2012).
7. A. B. Wang, C. C. Kuan, and P. H. Tsai, "Do we understand the bubble formation by a single drop impacting upon liquid surface?" Phys. Fluids 25 (2013)
8. M. J. Thoraval, Y. Li, and S. T. Thoroddsen, "Vortex-ring-induced large bubble entrainment during drop impact," Phys. Rev. E 93, 033128 (2016)
9. H. Deka, B. Ray, G. Biswas, A. Dalal, P. Tsai, and A. B. Wang, "The regime of large bubble entrapment during a single drop impact on a liquid pool," Phys. Fluids 29, 092101 (2017)
10. A. G. Bick, W. D. Ristenpart, E. A. van Nierop, and H. A. Stone, "Bubble formation via multidrop impacts," Phys. Fluids 22, 042105 (2010)
11. B. Ray, G. Biswas, A. Sharma and S. M. J. Welch, "CLSVOF method to study consecutive drop impact on liquid pool," Int. J. Num. Methods for Heat and Fluid Flow. 23 (1), 143-158 (2013).
12. W. Bouwhuis, X. Huang, C. U. Chan, P. E. Frommhold, C.-D. Ohl, D. Lohse, J. H. Snoeijer, and D. van der Meer, "Impact of a high-speed train of microdrops on a liquid pool," J. Fluid Mech. 792, 850868 (2016)

Soft Body Armour using Shear Thickening Fluid

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Body amours are being used to protect human lives since Stone Age. Body armours are available in two forms, namely hard and soft. Hard body armours, consisting of ceramic or steel plates inserted in fabric jackets, are used for protection against high speed bullets. In contrast, soft body armour is used as routine protective gear of police officers and security personnel. Soft armours are generally made from multi-layered woven or laminated fabric structures which allows them to be more flexible and lighter than hard armours. Generally 30-40 layers of 2D woven aramid fabrics (Kevlar, Technora etc.) or ultrahigh molecular weight polyethylene (Spectra, Dyneema) sheets are assembled together to make soft armour panels, rendering them heavy and inflexible.

In recent years, application of shear thickening fluids (STF) to improve the ballistic performance of body armour materials has gained the attention of materials scientists as this approach has shown promising results in improving impact energy absorption [1-2]. STFs are non-Newtonian fluids made up of stabilized dispersions of rigid sub-micrometer hard particles (generally silica) in a carrier fluid (generally poly-ethylene glycol). STFs exhibit sudden increase in viscosity above a critical shear rate, which transforms a liquid dispersion into a material with solid-like properties. Fabrics made from high performance fibres are impregnated with STF to prepare flexible composites. During the impact, the fabric gets deformed at a very high strain rate. This causes relative movement of the yarns and fibres within the fabric structure. As a result, the STF which is occupying the inter-yarn and inter-fibre space is also sheared, resulting in shear thickening as shown in Figure 1. Thus the solidified fluid now acts as a bridging material, facilitating the stress transfer between fibres and yarns. The entire fabric structure behaves as a coherent body and absorbs greater amount of impact energy.

Although a lot of interest has been shown by the researchers in the area of application of STFs on body armour materials, there are still many grey areas. A research group in the Department of Textile Technology of IIT Delhi is working in this area since 2008 and has filed three patents. The group has active collaboration with Terminal Ballistic Research Laboratory (TBRL), Chandigarh. This initiative for development of soft body armour reinforced with STF has received funding under the Joint Advanced Technology Centre (JATC), a collaborative platform between IIT Delhi and Defense Research and Development Organizations (DRDO).

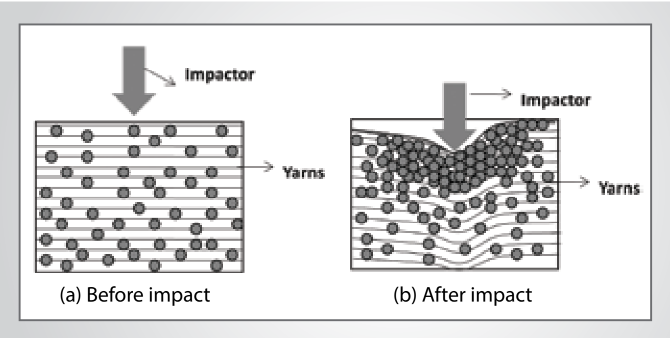

Figure 1: Schematic representation of shear thickening during impact

In the current research, two approaches have been amalgamated to reduce the weight of soft body armour and to improve their effectiveness against bullets fired from pistols and revolvers (velocity up to 450 m/s). The traditional 2D fabrics have been replaced with 3D fabrics in which yarns are arranged in three perpendicular directions, namely X, Y and Z. 3D fabrics have reinforcing yarns in three directions making the structure coherent and more effective in impact energy dissipation [3]. Figure 2 presents the schematic view of a 3D orthogonal fabric where three horizontal green lines represent three layers of stuffer yarns (S_1, S_2 and S_3). Violet and sky blue lines represent binder yarns (B_1 and B_2) and brick red ovals, numbered from 1 to 16, represent weft yarns. STF treated 3D fabric prototypes have been developed in this research by treating 3D fabrics with STF. The prototypes have been tested against projectiles fired from 0.38 inch calibre revolver (165 m/s) and 9 × 19 mm bullets (450 m/s). The results were optimistic as two layers of STF treated 3D fabric structures were able to stop bullets of 165 m/s speed. Also, soft armour panels having STF treated 3D fabrics were able to stop bullets fired at 450 m/s. This was the first attempt to explore the STF treated 3D fabrics as body armour materials.

The ballistic evaluation test set-up which uses two chronographs to measure the pre and post impact velocities of the bullet is shown in Figure 3. For high velocity ballistic evaluation (450 m/s), eight layers of Kevlar XPS fabric were used as the sacrificial layers and 3D woven fabrics were used at the back side of the panel. Fabric panels consisting of STF treated 3D fabrics were able to stop all the bullets (six out of six). Moreover, the depth of back face signature (BFS) for these fabrics varied from 31 to 39 mm which is well within the acceptable limit (44 mm).

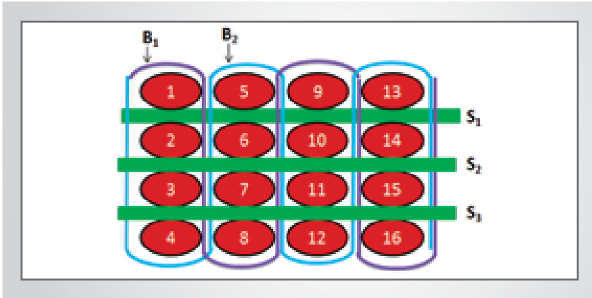

Figure 2: 3D woven fabric [3]

Figure 3: Ballistic evaluation of armour panel at TBRL, Chandigarh [3]

Figure 4 shows 9×19 mm bullet, having a hemispherical tip, used for BFS measurement. After the high velocity (450 m s-1) ballistic evaluation, the shape and size of this bullet changed completely. The resistance generated by the multilayer fabric panel blunts the tip of bullet and it acquires a mushroom like shape. Hence, as the bullet travels through the structure, it gets blunted and comes in contact with more and more yarns, resulting in more effective dissipation of energy.

(a) (b)

Figure 4: 9×19 mm bullet (a) before test (b) stopped by fabric panel [3]

Indian defense forces require indigenous technology for the body armour. Application of 3D woven fabric and STF opens up new possibilities of research in this domain. At very high speed (> 800 m/s) impacts, the response time available to the fabric structure is very small. Moreover, the stability of STF over long duration poses another challenge. Therefore, it is important to tune the rheological behavior of STF by adding nano-fillers or by surface modification of silica particles [4-6]. Research efforts are on to address these issues of STF reinforced soft body armour.

References:

1. Lee, Y. S., Wetzel, E. D., Wagner, N. J., (2003), The ballistic impact characteristics of Kevlar woven fabrics impregnated with a colloidal shear thickening fluid, Journal of Materials Science, 38, 2825-2833.
2. Majumdar, A., Butola B, S., Srivastava. A., (2014) Development of soft composite materials with improved impact resistance using Kevlar fabric and nano-silica based shear thickening fluid, Materials and Design, 54, 195-200
3. Majumdar, A., Laha, A., Bhattacharjee, D., Biswas, I., (2017) Tuning the Structure of 3D Woven Aramid Fabrics Reinforced with Shear Thickening Fluid for Developing Soft Body Armour, Composites Structures, 178, 415-425.
4. Laha, A., Majumdar, A., Interactive effects of p-aramid fabric structure and shear thickening fluid on impact resistance performance of soft armour materials, Materials and Design 89 (2016) 286-293.
5. Laha, A., Majumdar, A., (2016) Shear thickening fluids using silica-halloysite nanotubes to improve the impact resistance of p-aramid fabrics, Applied Clay Science 132–133, 468-474.
6. Talreja K., Chauhan I, Ghosh A, Majumdar A, Butola B. S., (2017) Functionalization of silica particles to tune the impact resistance of shear thickening fluid treated aramid fabrics, RSC Advances, 7, 49787–49794.

Information Management in Construction Projects

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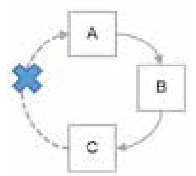
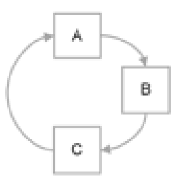
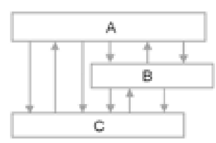
The ambitious project managers of today are eager to win unique attention on their projects apart from the predefined benchmarks/standards. As a result, there is a hunt for innovative solutions to face the newer challenges. One such challenge elaborated in this article is the adhoc information flows. Projects are typically planned for logic flows and/or resource flows. Interdependent relationships and cycles/loops are unavoidable when the projects are planned for information flows. This interdependency relationship demands adequate assumptions either to start or to proceed. The history of interdependent relationships is pictorially shown in Table 1.

Table 1 Planning Interdependency Relationship – Past and Future

20th century	Early 21st century	Future
Interdependency was ignored as no solution was available	Matrix-based techniques to manage simple cycles became popular	Solutions are available for multiple Information exchanges in any direction
		

According to PMI (Project Management Institute), project stakeholders are groups of people who take part either active or silent in a project and whose participation governs the project execution and completion. The snapshot shown in Figure 1 is the planned stakeholder participation for a Metro construction project (truncated for 3 years). It can be observed from this figure that the stakeholders have to collocate and collaborate for the project progress. During this interaction, the stakeholders exchange data/information in diverse media.

Information can be considered as the lifeblood to any construction project progress and execution. This information has to steadily flow throughout the project progress. Understanding the timely information exchange is tricky and challenging at the early project stage as each design group is isolated and works in silos. The snapshot in Figure 2 is to show the differing viewpoints of the eight design teams that interact for the same offshore facility project. Figure 3 actually is a zoom-in view to present the adhoc and unstructured information that are exchanged in a highway design project.

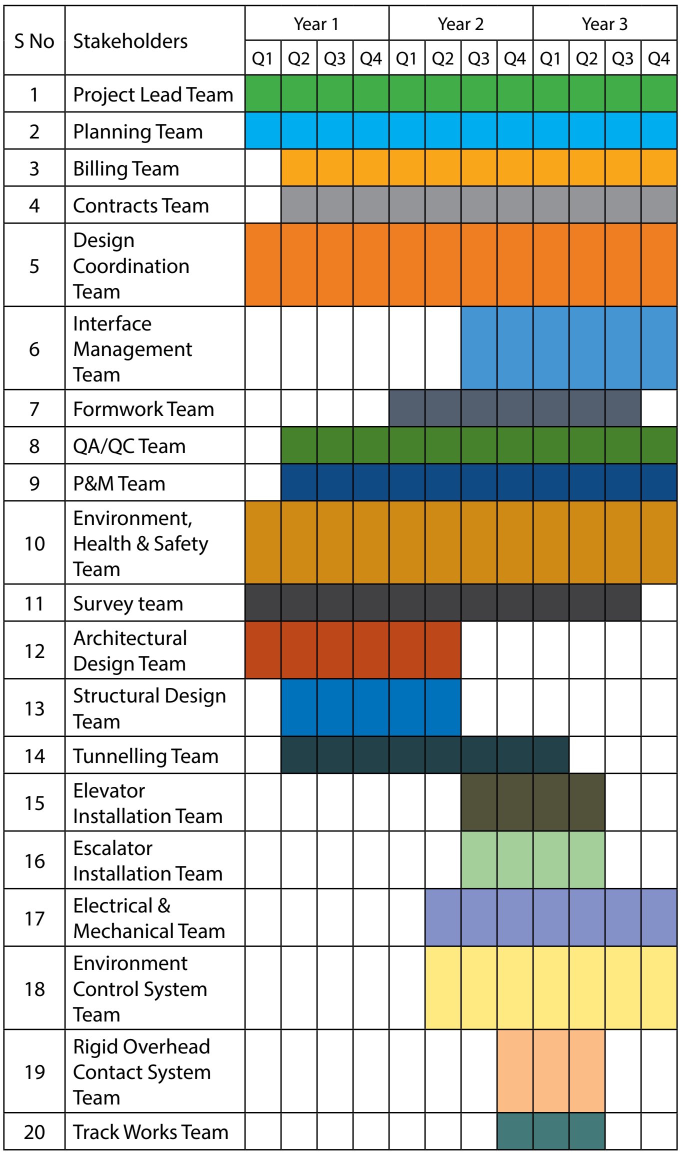


Figure 1: Planned Stakeholder's Interface Timeline in Metro Construction Project (Gwaskoti, 2017)

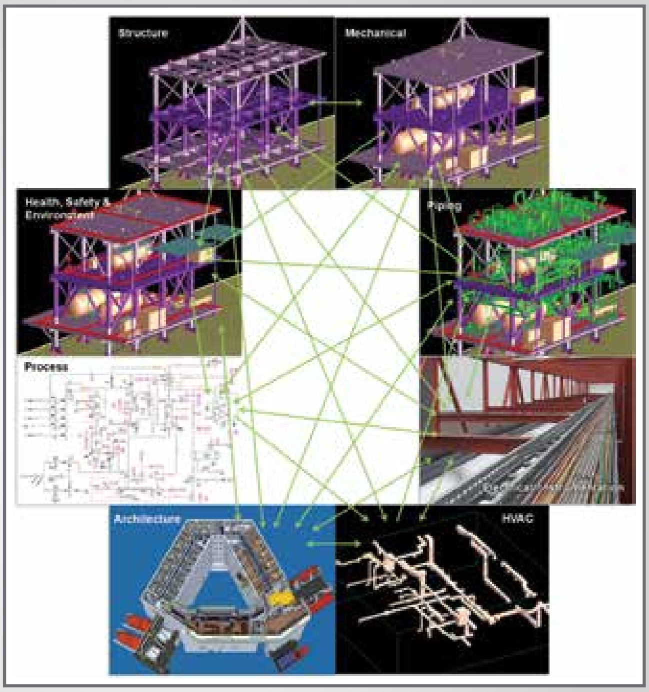


Figure 2: Differing viewpoints of Engineering Teams in an Offshore Facility Project (Mujumdar et al. 2015)

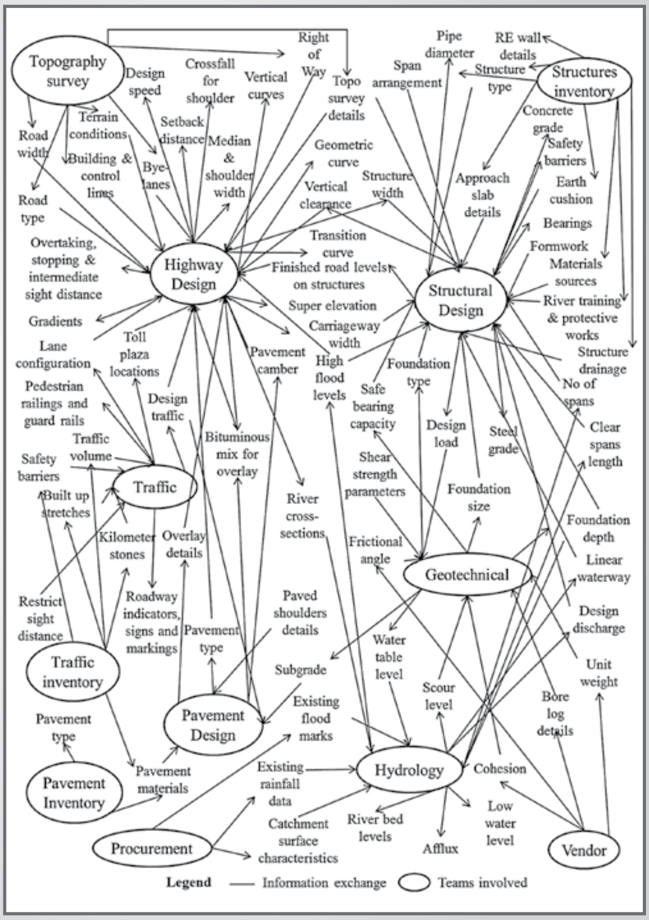


Figure 3: Adhoc Information Exchanges in Highway Design (Mujumdar & Maheswari, 2018)

At IIT Delhi our research group has investigated matrix-based design methods, which are colloquially referred as "DSM (Design Structure Matrix) family" for planning and evaluating these information flows for construction projects. For instance, let us consider metro construction projects. Figure 4 shows the truncated information captured in MDM (Multiple Domain Matrix) for the entities listed in Table 2. This concept was also applied to several projects with proven benefits to industry. In a nutshell, these matrix-based methods have the potential to structure the information flows and they are also expected to replace the available project scheduling techniques.

Table 2 List of entities for Metro design and construction project

ID	Entity	Description
SD	Team	Structural Design Team
EM	Team	Electrical and Mechanical Team
CO	Team	Contractor
SD1	Deliverable	Preliminary Design and Design Reports
SD2	Deliverable	Definitive Design and Design Reports
SD3	Deliverable	Construction Reference Drawings
EM1	Deliverable	Foundation sizes, layout, cutout sizes and location

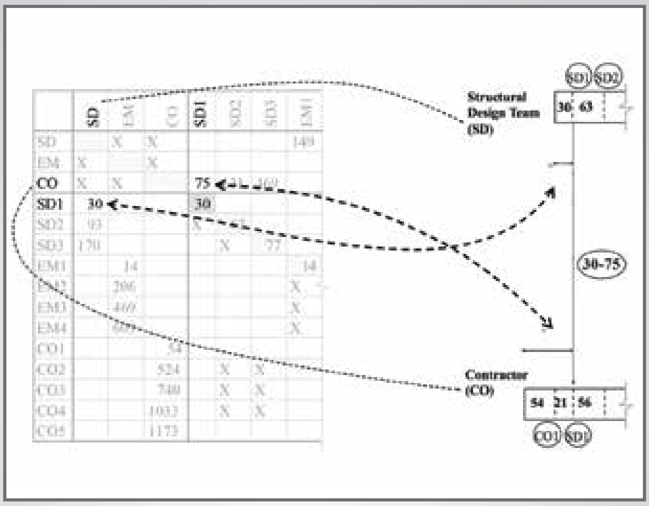


Figure 4: Information Flow representation in MDM (Multiple Domain Metrix) for Metro Design and Construction project (Mujumdar & Maheswari, 2018)

References:

1. Gwaskoti, A. (2017) Practical Approach to Modeling and Estimating Interdepedency-Iteration, MTech Thesis, IIT Delhi.
2. Mujumdar, P. & Maheswari, J. U., Alternate Network Analysis of BDM (Beeline Diagramming Method) on Interdependent Design Entities, ECAM (Engineering Construction and Architectural Management), accepted.
3. Mujumdar, P. & Maheswari, J. U. (2017) Design Iteration in Construction Projects – Review and Directions, Alexandria Engineering, available online.
4. Mujumdar, P., Bhattacharya, S. & Maheswari, J. U., (2015) A Study on DSM Partitioning through Case Study Approach, ICORD (5th International Conference on Research into Design, 7th – 9th Jan, IISc Bangalore, India.
5. Mujumdar, P., Muraleedharan, P. & Maheswari, J. U., (2014) Structured Methodology for Applying MDM (Multiple Domain Matrix) to Construction Projects, 16th International DSM (Design Structure Matrix) Conference, 2nd – 4th Jul, Paris, France.

Faculty Profiles

Prof Ramanan Arunachalam
Department of Chemistry
IIT Delhi

Ramanan Arunachalam is a Professor at the Indian Institute of Technology Delhi. His research interests include Solid state chemistry, Materials chemistry and Crystal engineering.

Ramanan's interest in solids started when he studied the thermomagnetization of holmium ferrite as part of his MSc dissertation at IIT Madras. His PhD work at IISc, Bangalore was on the structural chemistry of ternary bismuth oxides using conventional X-ray and electron diffraction techniques. Thanks to his PhD mentors, he realised very early that understanding a solid is more challenging but can be more stimulating once we have the patience and passion to comprehend the crystals beyond the molecular world. High resolution TEM images of tiny crystals, in collaboration with University of Cambridge below the size of 100nm taught him a completely different perspective of the crystal structures where order, disorder, intergrowth and defects coexist; deviation from stoichiometry is the most exciting part of solids in contrast to molecules that chemists passionately pursue! What appears to be perfect order in the micron range, could be entirely different at the submicron level. Any change at the molecular dimension can change its properties drastically; innocently appearing bulk powders routinely synthesized by materials scientists concealed treasures of complexity when viewed closer to molecular dimensions. A postdoctoral fellowship at University of Exeter, UK (1986-89), enabled him to probe the structure and dynamics of lighter atoms like hydrogen and lithium in complex metal oxides through neutron scattering facilities at Institut Langevin Laue, Grenoble and Rutherford Appleton Laboratory, Oxford. A second post doc at Binghamton University, US (1989-90) opened a new window to explore solid state reactions under mild conditions; this has remained almost an obsession for him till this day. The training at these labs laid the platform for him to take up an independent academic career at IIT Delhi in 1990.

He has been fascinated by the subject of self-assembly since the beginning of his career at IIT Delhi. How does one assemble a wide range of structures exhibiting myriads of frameworks from molecules for the deployment of a plethora of physical and chemical properties? His initial journey began with the structural chemistry of polyoxometalates (POMs) - simple polynuclear molecules, reminiscent of oxide clusters could create complex patterns under mild reaction condition. He found this an ideal materials chemistry problem to develop. The system was also amenable to his interest to pursue materials synthesis with water as solvent and explore solid state reactions under soft condition that let the molecules to communicate through weak intermolecular interactions and organise into periodic structures. His group synthesized a variety of crystalline solids (organic, inorganic or metal organic) in a systematic way and recognised patterns of crystal formation. Powder and single crystal X-ray diffractometers available at the department combined with the crystal structure database made it possible to conceive a structure-synthesis correlation and evolve a 'crystal engineering' approach towards designing new materials. The group also succeeded to grow new crystals built of simple molecular species or POM clusters with inherently useful properties on themselves, a line which has produced fundamental studies of their optical and magnetic properties; some of these can serve as models for nano-sized oxides. The encapsulation or integration of these POMs or molecules into organic, polymeric or inorganic matrices has opened up a whole new field within the area of hybrid materials for coupling the multifunctional properties of these versatile solids in a wide variety of applications. Citations of his works (https://scholar.google.co.in/citations?user=_OzmD8wAAAAJ&hl=en) by leading research groups is a major recognition for him and his students over the years. The major objective of the group still remains the same to establish a reliable connection between the molecules interacting in a medium (with or without solvent) and the aggregation observed in a crystal nucleus during the first order phase transition.

Teaching and mentoring of bright and enthusiastic UG, PG and PhD students is another enjoyable part of his twenty seven years of academic journey at IITD. He is also co-author of the first textbook on crystal engineering.

Ramanan is currently chairing the School of Interdisciplinary Research at IIT Delhi. Earlier he was the Head of Chemistry Department (2012-15) and was also Vice-chairman and Chairman of GATE (2006-9). At present, he is the Chairman of Early Career Research Award and National Postdoctoral Fellowship (Chemical Sciences), SERB and a member of DST-FIST (Chemical Sciences) and RC member of NIIST. He is a Fellow of the Royal Society of Chemistry.

Ramanan grew up on the banks of Cauvery in the interior parts of Tamil Nadu. Crystals fascinated him almost from the beginning of his research career. Minerals, the naturally occurring crystals are the time capsules of the Earth. They have been a witness to several changes occurring in our life cycle. They offer molecular insights into ancient landscapes and early life to the changes in modern times – diamonds to mobile phones. As a chemist, he still wonders how the molecules weave such a colorful world around us in a process called crystallization. Crystal is a holy-grail. It is still a puzzle why is that all molecules don't seem to crystallize equally well or equally quickly. His gazing will continue.

The beautiful lines by Lewis Carroll in 'Alice in Wonderland' summarizes his academic journey.

> *Alice: Would you tell me, please, which way I ought to go from here?*
> *The Cheshire Cat: That depends a good deal on where you want to get to.*
> *Alice: I don't much care where.*
> *The Cheshire Cat: Then it doesn't much matter which way you go.*
> *Alice: …So long as I get somewhere.*
> *The Cheshire Cat: Oh, you're sure to do that, if only you walk long enough.*

Prof Subrat Kar
Department of Electrical Engineering
IIT Delhi

Prof Subrat Kar graduated with Honours in Electrical & Electronics Engineering from the Birla Institute of Technology & Science, Pilani in 1987. He holds a Doctoral Degree in Electrical Communication Engineering from the Indian Institute of Science, Bangalore (1991). After his PhD, he was with the IQE, ETH-Zurich and the International Center for Theoretical Physics, Trieste (1991-1994) as a Post-Doctoral Scientist. He also topped his University twice, first at the Pre-Univ and then at the Intermediate Science exams.

He joined IIT Delhi in 1994. Presently he is serving as Professor, Department of Electrical Engineering, IIT Delhi. Here, he also holds the position of The Ram and Sita Sabnani Chair Professor. He was instrumental in establishing the Bharti School of Telecommunication Technology & Management in 1999 and was the head from 2006-2010. This was IIT Delhi's first ever School to run MTech, MS, MBA and PhD (Engg) and PhD(Management) programs.

He also established and headed (2006-2010) the Airtel IITD Centre of Excellence in Telecom (AICET) in IIT Delhi which conducts programs in contract research, distance education, pre-incubation and super-internship programs.

Prof Kar is a Professional Chartered Engineer and a Fellow of the Institution of Electronics & Telecommunication Engineers (FIETE), Fellow of The Institution of Engineers India (FIE) and a Fellow of the Optical Society of India (FOSI). He is a Member of the IEEE and SPIE USA and a Life Member of the Indian Science Congress Association, the Indian Society for Technical Education, the Computer Society of India and of the Instrument Society of India. He is IIT Delhi's nominee / representative on ECMA, Bureau of Indian Standards (BIS) and, till its dissolution, was IITD's sole representative on the GreenTouch Consortium. He is a wildlife conservation enthusiast and a member of IENE Europe.

He has received several International and national awards, including IETE Prof SVC Aiya Award (2017) for academic guidance and research in telecommunications, O P Bhasin Foundation Award in Science and Technology (2014), Indian National Academy of Engineering (INAE) Young Engineer Award (2001). He has guided award- winning work such as the 1995- 1996 Rajiv Bambawale Award, 1995- 96 ICIM Stay Ahead Award, 1999 INAE National Award for most innovative project at the Bachelors' Level, 1999 INAE National Award for most innovative project at the Masters' Level and an honourable – mention citation from IEEE Computer Society International Design Competition(CSIDC)-2003 in Washington DC, USA.

He is a Fellow of the Institution of Electronics and Telecommunication Engineers, Institution of Engineers (India) and Optical Society of India. There have been several awards and recognitions for his papers:

(a The 2001 KS Krishnan Award for the Best Systems-oriented paper (co-authored with M.S.Rao and S.V.B.Reddy).
(b) The 1999 IETE Students' Journal Award.
(c) The 1992 Sir J.C.Bose Memorial Award for the Best Research Paper in the Engineering Sciences.

His project ideas have garnered awards for his students:

(a) BOSS Award to BTech/Dual degree students for experimental/design based hardware project to SuyashAgarwal –Interdisciplinary Work co-supervised with Prof AK Darpe of Mechanical Engineering, IIT Delhi.
(b) BOSS Award BTech/Dual degree students for experimental/ design based hardware project to Sahitesh Kumar Reddypelly and Matta Joshua Shushan Roy.
(c) The 2016 Dr Shankar Dayal Sharma Gold Medal for MTech - Kandlagunta Sridhar Reddy, MTech(JOP)
(d) Finalist Team (to Sridhar Reddy Kandlagunta with Subrat Kar as Mentor) in 2015 Edmund Optics Educational Award USA – Edmund Optics Educational Award 2015 (this was one of the two finalist teams from India, one of 15 finalists from Asia and of the 45 finalist teams worldwide).
(e) The 1999 INAE National Award for Most Innovative Project at the Bachelors Level [BTech thesis work].
(f) The 1995-1996 Rajiv Bambawale Award.
(g) The 1995-96 ICIM Stay-Ahead Award for the BTech Level Thesis Work on "Design of a low- cost fax modem" by Augustine Renny Thomas and Abhay Gupta.

Prof Kar is the PI / Co-PI of several projects in IIT Delhi - over 35 successfully completed projects, and 8 ongoing projects. His forte is to work in inter-disciplinary areas and with technology solutions drawn from diverse disciplines.

He is an ardent champion of outreach education and is the founder (in 2007) of the highly popular GIPEDI (Global Internship Program in Engineering Design and Innovation, see bit.ly/gipedi) of Dept of Electrical Engineering and FITT which runs throughout the year as one of IITD's most subscribed outreach and internship programs for students of IIT Delhi and non-IITD students across India. He is also serving as the nodal coordinator for several other prestigious programs such as the IASc Summer Fellowship Program. He is the founder member of the DeiTY National Photonics Fellowship Program too and was instrumental in getting IIT Delhi, TIFR and IIT Madras to collaborate on this one-of-its-kind prestigious program for promoting Photonics at the pan-India level.

Prof Kar has served on several National / International Committees. He was a member of the Parliamentary Security Committee which was constituted to secure the Parliament premises after the terrorist attacks on the Indian Parliament. He has served as Member, Sub-Committee on Higher Education (MIT), Tenth Planning Commission, July 2001. He has also served as Member, Steering Group, National Panel on Photonics (erstwhile DOE, now MeITY). He is currently a Member of the Telecom Advisory Board of the PowerGrid Corporation of India. He also serves on several editorial Committees, Technical Committees and Boards of Studies.

Within IIT Delhi, he has held several administrative positions at the Departmental levels (Chairman, Computer Technology Group and Overall MTech Coordinator, EE Dept) and at the Institute level (Head / Coordinator, Bharti School of Telecom Technology and Head, Airtel IIT Delhi Telecom Centre of Excellence). Since 1st August 2017, he is serving as the Associate Dean (Faculty) IIT Delhi.

His research areas are in optical communication, switching, access technologies, telecom protocols, embedded systems and high speed networks. He is the author / co-author of two technical books, over 74 papers in International (59) / National (15, including 3 awarded Papers) Journals, 75 International Conference papers (including 6 Awarded Papers) and 33 national Conference papers. He is a prolific lecturer -- having delivered over 50 lectures on technical and related topics such as technical education. He believes profoundly in incubating young talent and lectures extensively to schools and other neighbouring engineering Institutions. He has guided / co-guided 12 PhD students (with another 10 ongoing PhD students), 197 MTech projects, 22 MSR students, 30 BTech projects and over 80 other projects such as TDP/SURA/Summer Internship Projects/Minor Project/Design Projects etc.

Prof Kar has several eclectic interests. He is a book-lover with a personal collection of over 5000 books most of which he inherited from his father. He is also a self-trained speed-reader (800+ words per minute). He has taught fine arts and continues to paint (specially madhubani and patachitra paintings) and sketch. He is an avid cartoonist – he was the founder Creative Editor of the BITS Pilani Students Newletters "Sandpaper" and "Camel Post" and is the creator of the character Gothilla who featured extensively in the Indian Institute of Science Student Union Newletter between 1987 - 1990) and a book illustrator – having illustrated the translated versions of Kenneth Grahames "The Wind in the Willows" and most of Jim Corbett's books. He is a passionate wildlife conservationist and has several ongoing research projects which are based on animals and wildlife. He has an abiding interest in firearms, jungle-craft and survival techniques, and in hand weapons, especially long-range professional air rifles, throwing knives, archery (crossbow and longbow) and in the design of professional weapon-grade catapults.

As a member of the Optoelectronics and Optical Communication research group, he works in the area of non-linear optical CDMA networks, free-space optical communication (ground-satellite and inter-satellite) and in ultra-fast optical LSI and fault-tolerant integrated optical switching architectures. His interests also involve formalisms in embedded system design, hardware-software co-design, telecom protocol design and verification tools for telecommunication protocols. He has designed and holds patents in the field of large-scale sensor networks, routing algorithms, macro languages, large scale repository design for sensor data and localization issues in sensor networks.

FITT Footprint

Examples of Development/ Investigative Projects at FITT

S No	Title	PI/Dept/Centre
1	Closed loop green technologies for rural communities	Prof VK Vijay, CRDT
2	Integrated Health, Education and Environmental (HEE) intervention to optimize infant feeding through schools and anganwadi network in India	Prof VK Vijay, CRDT
3	A bio pesticide formulation for termite control	Prof S Sharma, CRDT
4	Composition for enhancement of pathogenicity of paecilomyces lilacinus and uses thereof	Prof S Sharma, CRDT
5	Face recognition tool	Prof B Lall, EE
6	Portable device and disposable chip for immunogenetic enrichment of target biomarkers	Prof V Perumal, KSBS
7	Development of aluminum based nano-composites and their characterization studies	Prof S Aravindan, ME
8	Towards robust audio zooming system for smartphone	Prof L Kumar, EE
9	Feasibility/PoC study using neuromorphic hardware	Prof M Suri, EE
10	Swarm intelligence based attack detection in IoT environment	Prof R Bose, EE
11	Application of ALD coating of APIs and lyophilized biotherapeutic	Prof RS Rathore, CHEME
12	Neuromorphic PoC Study	Prof M Suri, EE
13	Illumination of bank's hertage building located at Chandani Chowk , Delhi	Prof M Sarkar, EE
14	Hydrogen storage using colloidal gas aphrons (CGAs) & CGAs-loaded with metal hydrides	Prof AN Bhaskarwar, CHEME
15	Development of a numerical model for the determination of mold thermal stresses and distortion	Prof P Talukdar

Opportunities for IP Licensing

S No	Title	PI/Dept/Centre
1	A process for producing super clean coal	Prof DK Sharma, CES
2	Fire retardant nanocomposite composition	Prof M Joshi, TT
3	Liquid distributors for three-phase applications of monolith catalysts and substrates	Prof S Roy, CHEME
4	A self-configurable surgical armrest	Prof S Mukherjee, ME
5	A three phase grid synchronized micro-grid system	Prof B Singh, EE
6	A system and method for ultrasonic assisted magnetic abrasive finishing with pulsating current	Prof PM Pandey, ME
7	A process of preparation of ordered cell metal foam	Prof PM Pandey, ME
8	A process of manufacturing of a thermally bonded core-sheath structured hybrid yarn	Prof R Alagirusamy, TT
9	Physical layer security in a wireless communication channel	Prof R Bose, EE
10	A power distribution system for supply of uninterrupted power	Prof S Mishra, EE
11	An air purifier	Prof SK Sinha, ME
12	ePrasav Graph: Smart phone based labor monitoring	Prof K Paul, CSE
13	Agrobacterium derived cell penetrating peptides as nanocarriers	Prof A Chugh, KSBS
14	A combination lock with a limited trial and resetting mechanism	Prof S Aravindan, ME
15	Device for oil spill control	Prof AN Bhaskarwar, CHEME
16	A novel device for measuring pressure pulses based on applanation tonometry	Prof S Roy, AM
17	Robotic apparatus/ manipulator with two degrees of freedom (RCM point) for carrying out invasive surgery, actuated using capstan drivers	Prof JP Khatait, ME
18	Cantilever sensor device based on suspended metal oxide and silicon nanostructures and fabrication method thereof	Prof S Dhanikar, CARE
19	A method of file compression and decompression using polar codes	Prof M R Bhatnagar, EE
20	Flexible and stretchable conductors and their fabrication	Prof A Agrawal, TT
21	Magnetic enrichment of magnetically marked analytes	Prof R Singh, DBEB
22	3D neuron model	Prof M Suri, DEE
23	Alveolar distraction device	Prof D Kalyanasundaram, CBME
24	Polypeptide sequence and composition thereof	Prof G Goel, CHEME
25	A recombinant vector comprising a fusion DNA for cell surface display, and uses thereof	Prof P Srivastav, DBEB
26	A novel green micro- emulsion for controlling fungal wilt diseases	Prof S Sharma, CRDT
27	A process for preparing three dimensional porous scaffold and the three dimensional porous scaffold formed thereof	Prof R srivastav, TT

28	Bipolar impact ionization mosfet (I-MOS)	Prof MJ Kumar, EE
29	Method, system and apparatus for multilingual and multimodal keyword search in a mixlingual CH Corpus	Prof A Kumar, CARE
30	Co-operative Movement for Photovoltaic Irrigation (CMPVI) based Irrigation System	Prof S Mishra, EE
31	Thin Capacitively-Coupled Thyristor (TCCT) for ultra-high sensitivity bio sensing	Prof MJ Kumar, EE
32	Process for shikimic acid production	Prof A Srivastava, DBEB
33	A biocompatible triblock copolymer and methods thereof	Prof V Koul, CBME
34	Diagnosis of subclinical mastitis in dairy animals	Prof S Kar, EE
35	A system for obtaining multi-directional view images	Prof S M Ishtiaque, TT
36	A system for acquiring bi-directional view images	Prof S M Ishtiaque, TT
37	Methods for enhanced expression of human serum albumin	Prof S Mishra, DBEB
38	Manta ray interface for neonates	Prof PVM Rao, ME
39	Synergistic combinations of natural antimicrobials encapsulated in the porous PLGA particles and their application in food preservation	Prof S Saha, CPSE
40	Magnetic enrichment of magnetically marked analytes	Prof R Elangovan, DBEB
41	A photo-voltaic fed single input dual output DC/DC converter system for driving load	Prof B Singh, EE
42	Capillary electrophoresis microchip for beer and wine quality testing	Prof SK Jha, CBME
43	Exoskeleton device for upper limb rehabilitation	Prof A Mehndiratta, CBME
44	Tactile feedback in laparoscopes	Prof S Mukherjee, ME
45	Fifth-order generalized integrator based reduced sensor topology for three-phase two-stage grid integrated solar photovoltaic system	Prof B Singh, EE
46	Process for producing δ-decalactone (DDL)	Prof MA Haider, CHEME
47	Bending of orthopaedic plates	Prof S Jha, ME
48	Process and system for nano-finishing a surface	Prof S Jha, DME
49	A single sensor based maximum power point tracking (MPPT) technique for battery charging	Prof B Singh, DEE
50	Neural network classifier	Prof Jayadeva, EE
51	Molecularly modified schottky barrier diode	Prof R Singh, PHY
52	A loop power flow controller for dc distribution networks	Prof S Mishra, EE
53	Bio sensing devices	Prof MJ Kumar, EE
54	Polypropylene composites and method for preparation thereof	Prof AK Ghosh, CPSE
55	3D bio-printed scar tissue model	Prof S Ghosh, TT
56	Multi-purpose charging station for e-rickshaws in rural areas	Prof B Singh, EE
57	A flame retardant composition and applications thereof	Prof W Ali, TT
58	Single stage solar PV array fed water pumping system	Prof B Singh, EE

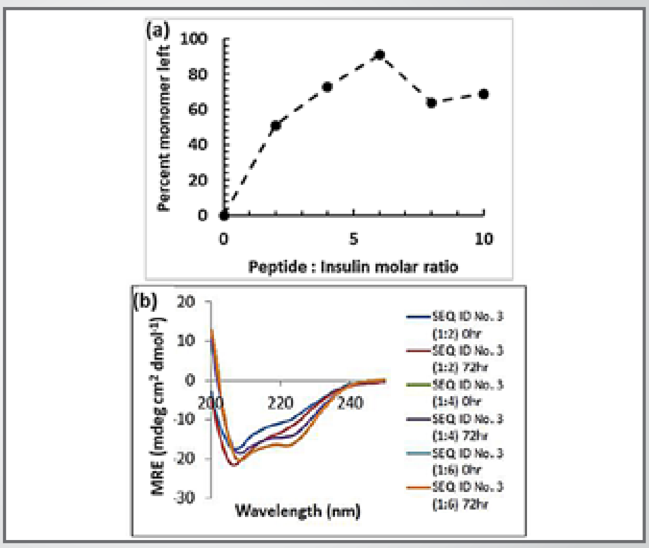
Designed Peptides to Inhibit Insulin Aggregation

Avinash Mishra, Rohit Bansal, Richa Singh, Srishti Joshi,
Prof AS Rathore, Prof G Goel
Department of Chemical Engineering
IIT Delhi

Therapeutic proteins can aggregate during drug manufacture, shipping, and storage. An understanding of aggregation pathways will be an essential aspect concerning the design of mitigation strategies and alignment of manufacturing processes. E.g., recent studies have highlighted the important role of protein unfolding thermodynamics and reconfiguration kinetics for protein aggregation. However, these earliest events in the aggregation process are difficult to characterize in experiments. To this end, significant strides in processor speed and development of new algorithms has made possible the use of compute in making meaningful interventions in biotherapeutical product development.

In the present work, we have used bias-exchange metadynamics (BEMD) simulations to probe millisecond-scale rare events associated with insulin unfolding. These simulations revealed partially folded intermediate (PFI) states of insulin that had a higher hydrophobic surface area than the native state. Based on this information, we developed three 15-mer peptide sequences, each consisting of a 9 residue recognition domain for aggregation prone surface of the PFI and a 6 residue hydrophilic domain for disrupting insulin self-association.

Data on stability of insulin formulations containing one of the designed peptides is plotted in figure 1. Figure 1(a) shows that a maximum of 91% insulin stays in the monomeric form at end of incubation at amyloidgenic conditions (60ºC, pH 3) for formulations containing an optimal peptide concentration in contrast with only 0.07% monomeric form left for formulations without the peptide. Figure 1(b) shows that the native structure of the insulin stays intact at end of incubation for formulations containing the designed peptide. Surface plasmon resonance analysis of binding interactions confirms that insulin in formulations containing the designed peptide binds to its receptor with similar kinetics as those for formulations without the peptide (figure 2).



The present work is particularly relevant for fast-acting monomeric insulin formulations, such as insulin Aspart®, insulin Lispro®. The peptides designed are also expected to increase refolding yield of insulin as excipients that improve protein stability have also been shown to increase the yield of correctly folded protein obtained in refolding from inclusion bodies.

Figure 1: Insulin stability enhancement with peptide addition. 0.52 mM Insulin formulations were incubated at amyloidgenic conditions (60ºC, 1M acetate buffer, pH 3) for 72 hours with varying concentration of peptide SEQ ID no. 3. (a) Percentage monomer left after 72 hour incubation as function of peptide concentration in formulation. (b) CD (circular dichroism) spectra of insulin formulations with varying peptide concentrations at beginning and end of 72 hour incubation.

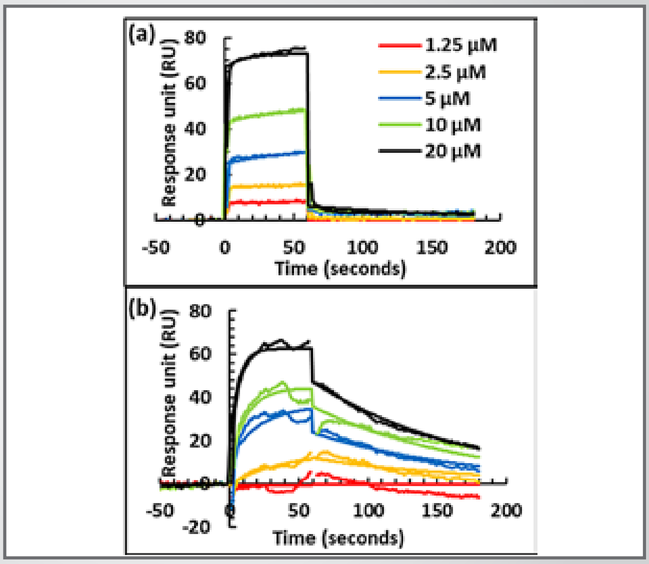


Figure 2: In-vitro assay for binding of insulin to its receptor. Purified recombinant insulin receptor was immobilized onto a CM5 biosensor chip (Biacore, GE Healthcare) using a His coupling kit (Biacore). A HBS-EP running buffer was allowed to flow at 30 ml/min. Insulin formulations of varying insulin concentration (1.25 µM to 20 µM), each either (a) without peptide SEQ ID no. 3 or (b) with peptide in 6:1 molar ratio were injected using a contact time of 90s and dissociation time of 90s. Kinetic constants for binding were calculated from the sensorgrams using the 1:1 fit model of Biacore X100 Evaluation Software 2.0.1.

Low Cost and Easy Maintenance Air Purifier

Prof SK Sinha, ME
Shreshth Tuli, CSE
Shikhar Tuli, EE
IIT Delhi

Air pollution is one of the major factors leading to degradation of our environment and causing harmful effects to humans and all other life forms. Although, many air purification devices exist today in the market, their maintenance requires periodic replacement of expensive filters and cleaning. Moreover, these purifiers are expensive and they are not affordable for the general public and hence renders them out of reach for common man. It thus becomes necessary to develop a new design of an air purification system that is more user friendly in terms of maintenance, efficiency, reliability and also has low cost.

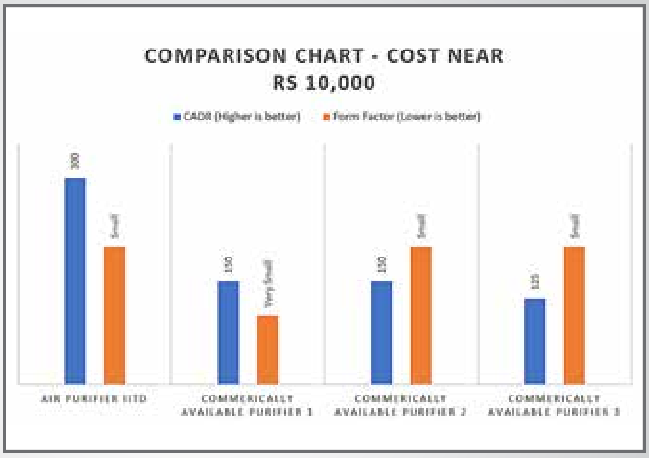
The present invention has a new design that uses easily available air mask/respirator for filtration of air. This makes it low cost and consumer friendly. Unlike present day air purifiers which use bulky and expensive air filters leading to high maintenance cost, our product uses easily replaceable and available, low cost, and efficient air filters. It is also to be noted that the HEPA filter that available air purifiers use is not easily available for replacement and hence the performance of the current air-purifier reduces with the extent of use. It may even become harmful if we continue to use a dirty HEPA filter. This makes the maintenance of our product much easier as compared to all other air purifiers.

The whole design has been developed on Solidworks and optimized using ANSYS Fluent and ANSYS CFX. As per ANSI/AHAM AC-2002 standard tests the CADR (Clean Air Delivery Rate) of our product is 303 Cubic feet per minute, much higher than others available at similar cost. In real environments like the most polluted areas of Delhi where AQI (Air Quality Index) goes as high as 1000, this purifier can bring down particulate levels to satisfactory values in less than an hour for a large room/hall.

Salient Features include:

1. Ability to use both flatbed and round air masks
2. Easy Air mask replacement without clamps and seals
3. Improved Design for High circulation
4. High air throughput
5. Filters Pollen, pet dander, dust mites, UFP, PM10, PM2.5 and other pollutants.
6. 4 Modes of operation – Sleep, low medium, high with LED indicator.
7. Real time sensor based performance
8. Low Energy Consumption (3 – 20 W)

This project was developed as part of DISA (Design Internship Summer Award) project and was an extension of the Engineering Visualization and Communication course.



Abbreviations

- AM : Department of Applied Mechanics
- BSTTM : Bharti School of Telecommunication Technology and Management
- CARE : Centre for Applied Research in Electronics
- CAS : Centre for Atmospheric Sciences
- CBME : Centre for Biomedical Engineering
- CE : Department of Civil Engineering
- CES : Centre for Energy Studies
- CHEME : Department of Chemical Engineering
- CHY : Department of Chemistry
- CRDT : Centre for Rural Development and Technology
- CSE : Department of Computer Science and Engineering
- DBEB : Department of Biochemical Engineering and Biotechnology
- DMS : Department of Management Studies
- DMSE : Department of Material Science & Engineering
- EE : Department of Electrical Engineering
- HUSS : Department of Humanities and Social Sciences
- IDDC : Instrument Design Development Centre
- ITMMEC : Industrial Tribology
- KSBS : Kusuma School of Biological Sciences
- MATHS : Department of Mathematics
- ME : Department of Mechanical Engineering
- PHY : Department of Physics
- TT : Department of Textile Technology

Lecture on IP Awareness by Mr Amit Shukla, Consultant SIDBI-IIT Kanpur organised by FITT at the Senate Room, IIT Delhi on November 27, 2017

Workshop on Engineering Healthcare through Venture Development & Commercialization, organised by FITT & SAM CIRCLE on November 6, 2017

FITT calls for Proposals under the Biotechnology Ignition Grant (BIG) scheme of BIRAC from January 1 to February 15, 2018.

Details: http://www.birac.nic.in/news_description.php?id=350

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