ISSN-0972-2548
Volume - 26 No. 2 | July 2020

Innovation | Technology | Business

FITT FORUM

Newsletter of Foundation for Innovation and Technology Transfer,
Indian Institute of Technology Delhi, New Delhi

MESSAGE

Devastation

In the last about 100 years, the nightmarish year 2020 may rank amongst the worst catastrophic periods for the entire humanity. Millions have been infected and a few hundred thousand have succumbed. It almost happened from around the first day of the year. What began in Wuhan soon engulfed the world. Even after six months, the understanding about the way the new coronavirus behaves is still incomplete making the entire world edgy and struggling with strategies to cope with this villainous microbe - to test its presence, control its spread and also find a credible cure. Even the peer reviewed publications and other posts coming out with feverish regularity reflect the complexity of the situation. This undoubtedly puts a huge pressure and responsibility on the authorities to contain the contagion. What's no brainer is that a populated country like India is slated to face huge challenges on many counts. We are managing it so far. But, what is heartening is that besides the Govt., there has been an all-around effort by various organisations, start-ups and individuals to rise to the challenge and support the development of or proffer some mitigating solutions. In particular, one has to bow to the herculean task and selfless service being provided by the frontline health professionals who have no luxury of work-(or no-work)-from-home. From the world of academia, we wait with bated breath for the successful launch of vaccines and other solutions. In India, the IIT Delhi has been in the news for all the right reasons in enabling the Corona fight. It started with the development and technology transfer of non-probe method of RT-PCR based assay and Cover-all PPE by the Institute faculty. The Institute mentored start-ups were not to be left behind as they too got into various solutions – Ventilators, Masks, PPE sanitizer etc. A few of these start-ups have made a mark with interesting solutions – all made while working during the lockdown ! Ironically, Covid19 has rightly brought forth the importance of not just health, hygiene and respectful distancing but reinforced the thinking of investing much more in the R&D of basic sciences. Such research efforts are absolutely necessary to further enhance our knowledge base and strengthen our technology platforms to address the grave challenges to humanity. We pray to come out of the pandemic and get back to our happy days.

Anil Wali

INSIDE

Low-Cost Synthetic Tissues for Multifunctional Application

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Introduction

Soft tissues form the building blocks of the human body. They include the most widely distributed skin and muscle tissues, and also the connective and supporting tissues for the organs. The skin is composed of three layers namely the epidermis (outermost layer), the dermis (middle layer) and hypodermis (inner most fat layer which connects with the muscles), with an overall thickness of approximately 3 mm (Annaidh et al., 2012). The muscle tissues provide mechanical strength to the body and are categorized as voluntary (i.e. skeletal muscles) and involuntary (i.e. muscles forming walls of organs such as the stomach, esophagus, heart, lungs, and blood vessels). Mechanical properties vary widely across soft tissues; brain tissues have been observed to be the softest tissue followed by the tissues in different layers of the artery (intima, media, and adventitia). Pelvic tissues are typically stiffer than brain and arterial tissues, but softer than skin and muscles. To date, most human tissues have been characterized mechanically using uniaxial, biaxial, multiaxial and indentation tests, under static and dynamic loading conditions. It has been observed that soft tissues exhibit anisotropic mechanical properties due to complex collagen fibre distribution within a soft gelatinous matrix material. Through histology and microscopic studies, these fibre distributions have been found to not only vary across tissues types, but also across tissue layers and locations on the body (Chanda & Callaway, 2018).

studies widely (Chanda et al., 2017; Chanda & Upchurch, 2018). Based on this research, a range of soft tissue surrogates were developed for the skin (Chanda, 2018), muscles, fat, brain (both grey and white matter) (Chanda, Callaway, et al., 2018), artery (Chanda & Curry, 2018), foot pad (Chanda & McClain, 2019), and pelvis (Chanda, Flynn, et al., 2018) (Figure 1).

There is a lack of accurate synthetic tissue models for surgical training in south Asia, specifically in India. Interviews with doctors, surgeons, and medical schools (i.e., AIIMS, Delhi and PGI, Chandigarh) in India has revealed that the existing surgical training models are limited to hard manikins, animal models (i.e., mice) and polymeric materials with mechanical properties and feel widely different from the natural tissue. Also, due to the high cost of synthetic tissues offered by a few US based companies, such products are highly inaccessible in India. These challenges inhibit accurate surgical training practices. It has also been reported that in some cases, needle insertion simulations and suturing have been conducted on orange peels due to non-availability of any cost-effective indigenous skin like material. Commercialization of low-cost synthetic tissues is anticipated to disrupt the surgical training market in India. Compositions with mechanical properties and feel similar to natural tissue from different body locations will allow doctors and medical trainees to practice and plan a wide range of surgeries. Also, the lack of

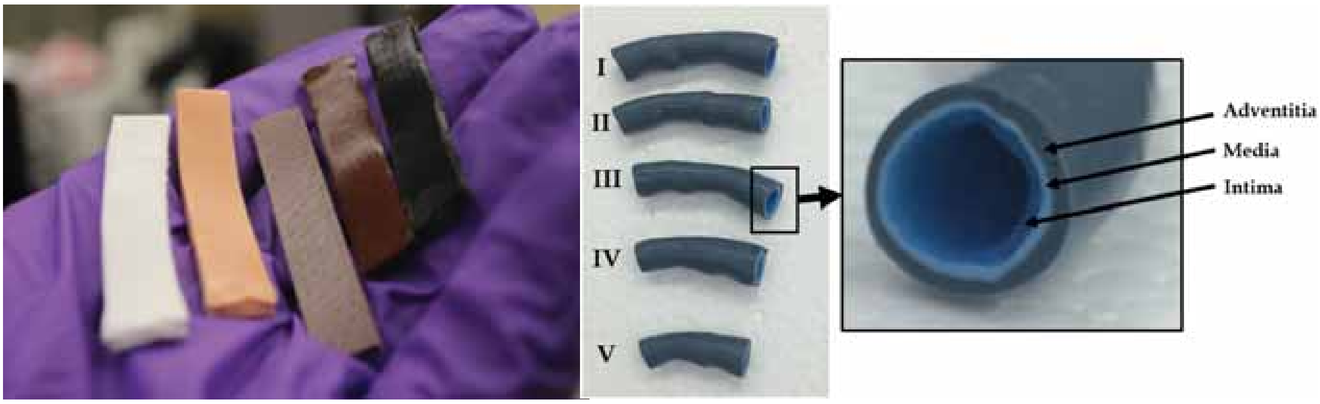

Figure 1: Soft tissue surrogates for skin, muscles, fat, brain, and three-layered arteries

Experimental work with soft tissues has numerous biosafety and ethical issues, due to which, several synthetic surrogates have been developed from time to time. To date, human tissue surrogates have been fabricated with materials such as gels and polymers like silicone, polydimethylsiloxane (PDMS), and polyurethane, which have mechanical properties widely different from natural tissues. In addition, pigskin and cowhides have been used extensively in experiments, which have not only different mechanical properties from most human tissues, but also ethical and biosafety concerns. Recently, the development of elastomeric biofidelic skin simulant (US Patent No. 10,049,601 B2 (Chanda et al., 2018)) and conductive soft tissue surrogates (US Patent No. US20190057624A1 (Chanda et al., 2019)), are the only works on high fidelity tissue mimicking, which have been used for soft tissue mechanical characterization and computational

biosafety or handling issues, and ultra-low-cost of the product (i.e., <500 Rs./Kg) will make the technology accessible widely, with potential for immediate lab-to-market transition and use in multifunctional applications.

Methods

Surrogates mimicking the average linear and nonlinear mechanical properties (i.e., stress-strain, elasticity, Poisson's ratio, and tensile strength), and feel of soft tissues from different body locations, can be developed using patented material compositions invented by Chanda et al. (US Patent No. 10,049,601 B2 (Chanda et al., 2018) and US Patent No. US20190057624A (Chanda et al., 2019)). Tissue property measurements can be either performed in-vivo using an indenter or durometer, in-vitro on a cadaver with ethical clearance, or obtained from literature. A soft two-part elastomer material (Shore hardness 0-10) combined with a stiffer two-part elastomer material (Shore hardness 20-50) based on prior works by (Chanda, 2017) will help generate all tissue surrogate compositions. The mechanical properties of the surrogates need to be tuned to match the realistic soft tissue properties through mechanical testing. Each test specimen is clamped on a universal testing machine (UTM) and tested under tensile and compression loads (Figure 2), at strain rates of 0.1-500 mm/s. Several considerations need to be taken while testing the soft materials. Soft materials slip very easily, thereby special grips coated with a rubber-like material which provides high friction against slipping should be used. Strain rate has been observed to significantly affect the load response of soft materials, and thus a specific strain rate may be used, so that results can be precisely compared between surrogates and human tissues. Also, the surrogates need to be tested for repatibility and reproducibility.

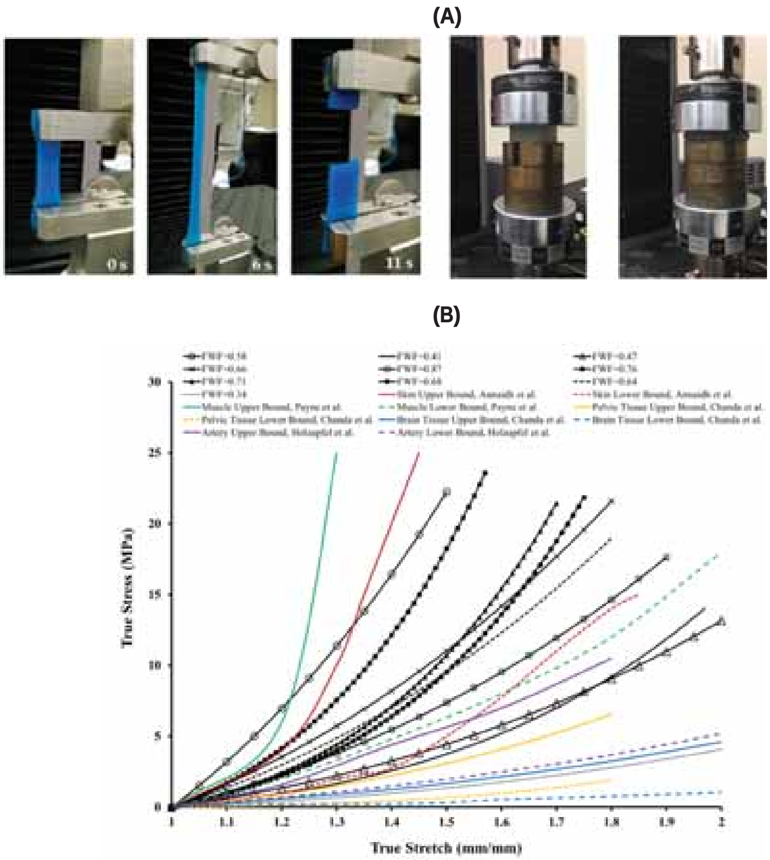

Figure 2: Mechanical testing of soft tissue surrogates: (a) Tensile and compression tests, (b) Comparison of true stress versus true stretch of surrogate compositions (FWFs) with natural tissue properties

Applications

The primary application of soft tissue surrogates is the development of surgical training models with mechanical properties and feel silimar to natural tissues. The surrogates can be used to fabricate any tissue or organ ranging from micro-scale arteries in the brain to the entire human heart. Medical trainees and doctors can extensively use such models for surgical planning. With advancement of 3D printing technologies, such tissue surrogates can also be used to develop artifical organ replacements, prosthetics, and also bionic arms for human-like surgical robots and exoskeletons. Also, tissue surrogates are employed in ballistic testing in the military to study penetration resistance of different human tissues, and predict the extent of traumatic injury. Recently, development of non-leathal ballistics, is a new area of research seeking to fabricate projectiles which could be used for crowd control and do not lead to major tissue damage.

Robotic surgery is an vast and untapped area in which the synthetic tissue surrogates can serve to be extremely useful. An example of a recent work by (Chanda et al., 2017) studied the suturing forces required for closing wounds of varying shapes using a composite skin and muscle tissue phantom. As suturing techniques vary widely across surgeons and with years of experience, estimating wound specific suture forces can allow uniform surgical steps to be applied by a robot during a surgery. Another work by (Chanda, Ruchti, et al., 2018) investigated the interaction of hernial mesh with a pelvic tissue surrogate to understand mesh suture failures (Figure 3). In summary, with the commercialization of low-cost synthetic tissue surrogates, the possibilites are endless in the area of biomedical research.

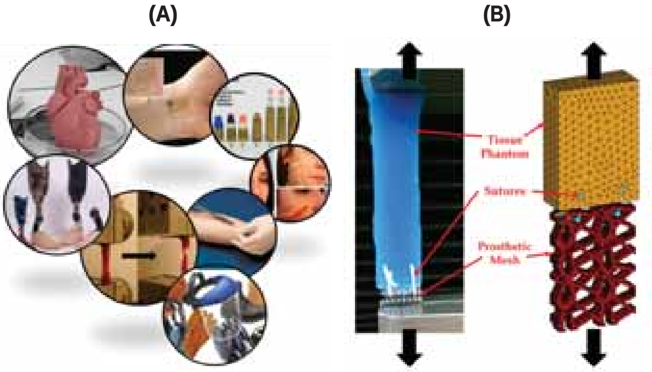

Figure 3: (a) Summary of range of synthetic tissue surrogate applications, (b) Recent study by (Chanda, Ruchti, et al., 2018) on the hearnia mesh and pelvic tissue interaction to understand mesh failures

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NSafe Mask: A revolutionary antimicrobial and washable mask

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The recent COVID-19 pandemic has created a massive scaled worldwide health threat, causing huge loss of lives, fear and detrimental impact to economic foundations of developed and developing countries. Till the time a potent vaccination protocol against the contagious virus is not clinically established, community mitigation control plays a critical factor for deciding containment of the disease in times of public health emergency. Since the community transmission of the virus is very high, implementation of face masks as personal protective equipment (PPE) represent a form of 'source control' in public settings which is to be used in conjunction with social distancing and hand hygiene practices [1].

Masks can be broadly classified into two categories- surgical masks and medical grade N95 respirators. Surgical masks are cheap (Rs. 5-10) and are typically three layered with a melt-blown polypropylene non-woven layer sandwiched between two spun bonded polypropylene non-woven layer [2]. N95 respirators are costlier (Rs 200-500) and serve as a better alternative to surgical masks in terms of fit and protection. N95 masks have to be mandatorily certified by National Institute for Occupational Safety and Health (NIOSH). The filtering material is based in electrostatic (positively charged) non-woven polypropylene fiber outer layer along with melt-blown polypropylene second layer (filter layer), followed by a shape forming polyester layer and an inner spun-bonded polypropylene layer [3].

The SARS-CoV-2 virus causing COVID 19 pandemic is primarily transmitted via contact through droplets generated when an infected person coughs or sneezes, or through droplets of saliva or discharge from the nose [4,5]. The filtration mechanism to trap/eliminate virus or contaminant in both cases is based on principles of mechanical filter. The size of the SARS-CoV-2 is 50-200 nm in diameter [6], which is 0.05 to 0.2 microns whereas N95 has a filtration efficacy of 95% at 0.3 microns. Making a filter which can eliminate viruses of this size is expensive and is difficult for mass production. However, the respiratory droplets hosting the virus is larger and is about 5-10 microns in diameter [7].

Contrary to popular belief, mechanical filters do not work via size exclusion mechanism, but rather by forcing the particles to navigate through a high surface area maze of multiple layers. This causes air to flow through the layers (making the mask breathable) while causing particles to attach to the fibres. Large particles (>0.6 microns) are slowed down due to gravity in a flowing air stream and is attached to the fibres through inertial impaction and interception mechanism. Smaller particles (<0.1 microns) haphazardly move in the air stream and are caught due to diffusion. Particles between these size ranges are captured by a combination of these mechanisms [8]. Additionally, the fibers are electrostatically charged to attract the particles and capture them through interception [9].

With the emerging threat of COVID 19 crisis around the globe, there was a shortage of raw materials of nonwoven polypropylene to make the masks [10]. N95 type masks are based on man-made non-woven polypropylene which is non-biodegradable and non-recyclable. The non-biodegradable nature of the mask furthers affects the environmental sustainability [11]. Additionally, these are rarely discarded in biohazard bins unless used in a hospital setting [12]. Without proper decontamination before disposal, masks create a pathway for pathogen transmission to other wearers and persons handling disposals. It should also be kept in mind that N95 masks are not washable, washing may deteriorate the charge on fibers leading to decreased filtration efficiency [13]. Another challenge of by these masks is that it is not able to absorb moisture (polypropylene has low moisture absorption properties) and therefore dissipate the generated heat due to sweating, which makes the wearer highly uncomfortable, sometimes leading to skin allergic reactions [14].

NSafe mask was designed keeping in mind the shortcomings associated with conventional non-woven and cloth based masks. Important considerations were given to make the mask reusable to reduce environmental load and provide extra protection to wearer by using antimicrobial chemistry to decontaminate trapped virus in the mask.

The mask has been designed with special woven man-made fabrics in middle and outer layer to maximize the durability and dimensional stability, so that the mask can be reused 50 times keeping the bacterial filtration efficiency and other attributes intact.

NSafe mask is a premium mask which is antimicrobial and reusable upto 50 washes and is engineered to protect against virus, bacteria, dust and allergens. It is a triple-layered product consisting of - inner hydrophilic and antimicrobial layer for comfort, -middle filtration layer having antimicrobial activity and -outer most layer having water and oil repellent behaviour. The mask has been designed with special woven man-made fabrics in middle and outer layer to maximize the durability and dimensional stability, so that the mask can be reused 50 times keeping the bacterial filtration efficiency and other attributes intact. It has 99.2% bacterial filtration efficiency and complies with ASTM standards of breathability and splash resistance.

The following are the special features of NSafe mask:

1. Reusability and washability: NSafe mask is reusable upto 50 washes with each usage cycle for 8-9 hours. According to Centers for Disease Control and Prevention (CDC) guidelines, masks should be ideally washed daily as sweat in the masks provides a medium for virus to remain viable for prolonged duration. Also, the masks should be completely dried before next use to remove any moisture. The lifespan of Nsafe mask is approximately 2 months depending on the usage times.

2. Antimicrobial nature: The middle filtration layer is functionalized with antimicrobial finish to decontaminate any trapped virus aerosol inside the mask. The active agent used is based on active copper which has antiviral activity against influenza H1NI and H2N3 virus, respiratory syntactical virus (RSV) and feline coronavirus [15-17]. No strains of SARS-CoV-2 was found on copper surfaces after 4 hours while on cardboard and plastic, it was found to be viable even after 28 h and 72 h respectively [18].

3. No seam design: The outer layer of the fabric is deliberately kept as a continuous fabric as seams in the outer layer facilitates entry of small particles through the needle hole.

4. Adequate breathability: The inner layer of the mask is made from soft knitted cotton which in addition to providing comfort to the wearer, also helps in moisture management by dissipating the sweat to the middle and outer layers.

5. Excellent fit: Every face counter is different. Therefore, with conjunction with the nose wire, an elastic band in the chin region is introduced to ensure tight fit in the chin.

NSafe mask is trademark and design protected. NSafe mask is also registered with ISO and CE. Since its launch, NSafe mask has created tremendous impact and received positive reviews from thousands of happy customers. NSafe is currently being used by numerous citizens and healthcare workers in India. The product is listed at nanosafesolutions.com from where it can be ordered online with integrated delivery across India.

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Prof. Kamal Kishore Pant, (Ph.D., FRSC, FIIE, FIIChE, FBRSI) is presently Head and Petrotech Chair Professor in the Department of Chemical Engineering at IIT Delhi. He is also Adjunct Professor in Centre for Rural Development at IIT Delhi and University of Saskatchewan as well as Honorary Faculty at the University of Queensland, Australia. Prof. Pant's research contribution involves a wide range of innovative studies covering both theoretical and experimental aspects of heterogeneous green catalysis for hydrocarbon conversion, CO2 capture and conversion, coal to chemicals, bioenergy, and greener approach for conversion of soild waste to value-added products. He has over 30 years of research and teaching experience during which he has published more than 150 Journal articles having more than 7600 citations, several book chapters, granted large number of national and international patents jointly with Industrial partners.

In recognition of his work, he has been conferred several national and international awards such as Fellowship of Royal Society of Chemistry (2017), Herdilia Award for Excellence in Basic Research in Chemical Engineering by Indian Institute of Chemical Engineers in 2017, GYTI award by the honorable vice president of India, CHEMCON distinguished speaker (CDS) award in 2019 (IIChE award of the year 2019), three times Dr A V Rama Rao award for best PhD supervised (IIChE award of the year 2009, 2015, 2019) and Dr SS Deshpande Award for highest citations (2013). Prof. Pant has also received a grant from DAAD Germany and the American Chemical Society in the year 2017. Prof. Pant has been elected as a fellow Biotech Research Society of India (2019), Fellow of Indian Institute of Chemical Engineers (2017), and Member of Institution of Engineers Limited (2016). Prof. has also been conferred life membership of the National Academy of Sciences of India (2019), Indian Carbon Society (2005), and Catalytic Society of India (2005).

Moreover, Prof. Pant had been invited as a visiting faculty at Auburn University, USA, University of Tuskegee, USA, UTAH, University of Saskatchewan, Canada, Fraunhofer UMSICHT, Germany, and Aston Univ. U. K. He is also among the most sought-after chairman/ expert members in several boards and councils' private industries, academia as well as Government of India Organizations such as IIP Dehradun, ONGC, PCRA, GAIL, IOCL R&D, BPCL, and many other national and international universities. He has guest-edited various journals of international repute - American Chemical Society Journal "Industrial & Engineering Chemistry Research", Springer's "Biomass Conversion and Biorefinery," two books in Springer nature specifically dedicated to bio-renewable energy and chemicals production and authored one book under Wiley publication on 'Metal extraction from the E-waste'.

Most of Prof. Pant's research work is aligned with the National Mission Mode projects that include the development of coal to methanol process, CO2 capture, and conversion, green approach for disposal of e-waste and precious metals recovery, waste plastic to liquid fuel /char technology, as well as biofuels and biochar production from residual agro biomass to thwart stubble burning. Most of his work is funded and received funding more than INR ~450 million by the Industries and government organizations such as SERB/DST, Ministry of Fertilizers, GAIL, HPCL, BPCL, IOCL, ONGC, DRDO, Tata steel and many more.

Prof. Pant's research group is also working for the development of an indigenous self-sustainable greener technology for e-waste and plastic waste management. As a result, a zero-waste discharge process for recovery of metals and energy production from e-waste has been developed. Also, a 10 kg/hr highly sophisticated pilot plant is designed and demonstrated at IIT Delhi premises. Indeed, he is amongst the leading academician in India who is working on solving the problems of accumulating biomass, plastic waste and electronic waste. Moreover, a thermo-catalytic process has been developed for the plastic waste conversion which has been recognized and appreciated by the honorable Vice-President of India in the form of the GYTI award. Eventually, several news channels have broadcasted the news, thereby attracting a considerable number of potential investors interested in the commercial-scale implementation of the project. These research works are under progress for commercialization.

Another mission mode project currently ongoing in Prof. Pant's lab is the development of Coal to Methanol technology funded by DST, Government of India to a consortium consisting of Prof. Pant and 6 other professors of IITD and industrial partner Thermax). Furthermore, his group has received a research grant from the DST under mission mode innovation (MI) project for the development of CO2 capturing from flue gas and conversion technologies. Overall, most of his research is catering to requirements of the development of technologies of national importance and the Government of India policies such as Swatch and Aatmnirbhar Bharat, Make in India, and Unnat Bharat Abhiyan. Besides these, Prof. Pant has extensively working for the development of novel catalysts and Industrial process for the direct conversion of natural gas to pure hydrogen and carbon nanotubes for hydrocarbon sectors. Prof. Pant has a remarkable contribution for the development of catalysts and process for the dry reforming of methane and steam/ oxidative reforming of bioethanol and bio-oil compounds. Moreover, his research contribution to the development of a biomass pyrolysis unit and value-added chemicals production and hydrothermal conversion of biomass to green chemicals is appreciable in the area of utilization of renewable sources and development of bio refinery concept in the country. Prof. Pant's research has lot of Industrial relevance and recently his group initiated research on conversion of crude oil and heavier feedstock to chemicals, which is the need of the future oil refinery and petrochemicals.

Furthermore, Prof. Pant is a well known researcher and highly sought after PhD supervisor in India and has guided 25 PhD theses and more that 65 MTech theses. Some of these PhD theses have been supervised jointly in collaboration with Professors from international universities including the University of Saskatchewan, Virginia Commonwealth University, University of Alabama, University of Birmingham, Fraunhofer UMSICT. Presently, Prof. Pant group has more than 30 PhD students, 4 post-docs, and several master's degree students. Some of these students are also recipient of prestigious Prime Minister Fellowship and under joint India–Queensland (UQIDAR) scheme. Because of Prof. Pant's thorough supervision and excellent guidance, many of his former students have become successful academicians and scientists at different universities or Industries. Some of these are: Alabama state university, USA, University of Virginia, IIT Ropar, IIT Dhanbad, NITs, AMU, and several multinational companies. Furthermore, the NPTEL based web/video courses developed on Chemical reaction engineering, reactor design, and Heterogeneous Catalysis, by Prof. Pant are referred worldwide and highly popular among the chemical engineering students and academicians.

The further details are available at http://web.iitd.ac.in/~kkpant/

Prof. Vasant Matsagar
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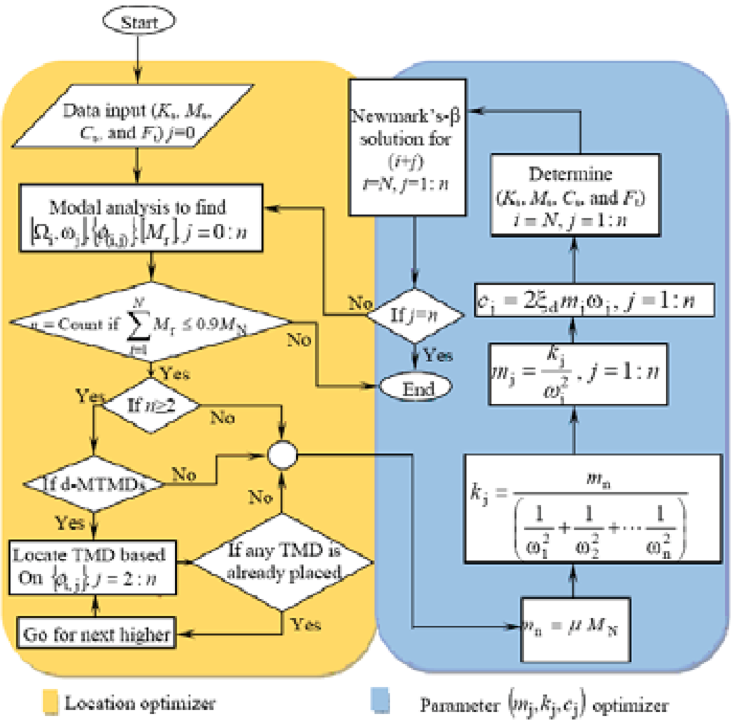
IIT Delhi

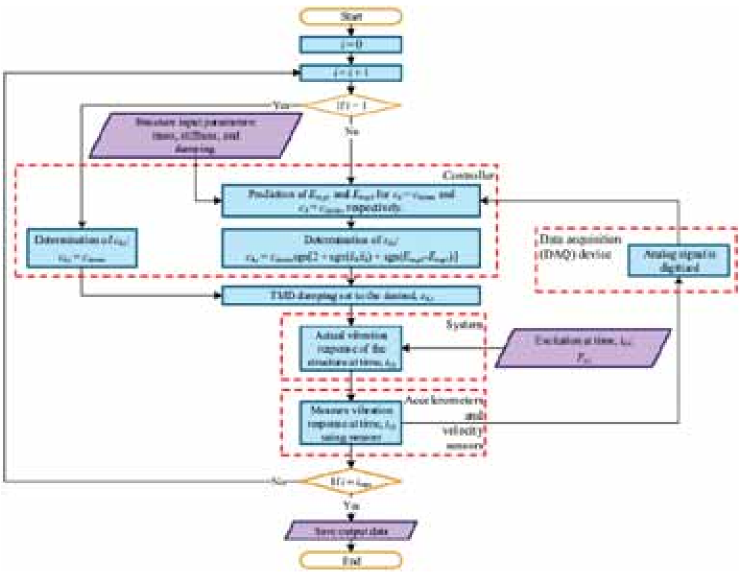
Prof. Vasant Matsagar is currently serving as Professor and incumbent Dogra Chair in the Department of Civil Engineering at IIT Delhi. He obtained his doctorate degree from IIT Bombay in the area of seismic base isolation of structures, and performed post-doctoral research at the Lawrence Technological University (LTU), USA for about four years in the area of application of carbon fiber reinforced polymer (CFRP) composites in prestressed concrete bridge structures. He joined IIT Delhi in 2009 and since then been making research contributions in developing innovative computational frameworks for life-cycle structural safety assessment under accidental, manmade, and natural hazards such as blast, fire, wind, and earthquake, thereby evolving new design methods for resilient infrastructure employing advanced engineered materials.

Prof. Matsagar's decade-long career in IIT Delhi focuses primarily introducing and establishing a novel research field in Structural Engineering: "Multi-Hazard Protection of Structures". He included therein two natural hazards (earthquake and wind) and two accidental/manmade hazards (blast and fire) for investigation. Civil infrastructures in design service-life experience more than one natural and/or manmade hazard with varying intensity. Therefore, while designing the structures, consequences of all such possible hazards, along with their anticipated return periods and varying intensities are required to be taken into consideration in structural designs, appropriately based upon site-specific and scenario-specific prevalent conditions. His research emphasizes the requisiteness to modify the traditional structural design codes, merely estimating peak design parameters at design stage only, by incorporating multiple hazards that a structure is likely exposed to in its entire service-life. A new research laboratory named, Multi-Hazard Protective Structures (MHPS) was conceptualized by Prof. Matsagar in 2009 and established in the Department of Civil Engineering at IIT Delhi. The MHPS Laboratory now houses unique world-class facilities for conducting experimental and computational research in the disciplines of earthquake, wind, blast, and fire engineering. The mammoth tasks of designing, developing, purchasing, installing unique laboratory equipment, and commissioning state-of-the-art testing facilities have been accomplished with the unconditional support of several students and researchers working in the MHPS Laboratory, faculty colleagues, and IIT Delhi administration. These facilities have been generously sponsored by various funding agencies, such as (a) Defense Research and Development Organization (DRDO), Ministry of Defense (MoD), Government of India; (b) Department of Science and Technology (DST), Ministry of Science and Technology, Government of India; (c) Board of Research in Nuclear Sciences (BRNS) at Bhabha Atomic Research Centre (BARC), Department of Atomic Energy (DAE), Government of India, to name a few. Numerous high-valued sponsored research projects to the tune of about Rs 27.8 Crores have helped the MHPS Laboratory housing some of the major testing facilities such as high strain-rate testing of concrete and reinforcing materials; elevated temperature (1300°C) thermo-mechanical testing of construction materials as well as scaled-down structures; oxy-hydrogen gas generation - pressure welding apparatus for rebars; high-performance computing (HPC) workstation clusters for conducting computational research etc.

Prof. Matsagar has formulated several conceptual structural analysis frameworks for multi-hazard life-cycle vulnerability/risk assessments of critical civil-infrastructures, employing advanced engineered materials, under multiple cascading/uncorrelated scenario-specific earthquake, wind, blast, and fire hazards. He is an internationally recognized scholar for his contributions made in "Multi-Hazard Analysis and Design of Civil Infrastructure" and making fundamental research contributions in the development of "Multi-Hazard Protective Structures", thereby he has been invited on the editorial boards of several reputed international journals. Some of the most notable research contributions made by Prof. Matsagar in structural response control include, (a) the novel "multi-mode dynamic response control theory" for installing spatially distributed passive, semi-active, and hybrid control systems in structures to abate vibrations bourne from different sources, and (b) a hybrid system employing an innovative "energy-based predictive (EBP) semi-active control algorithm" improving effectiveness in dynamic response control of structures by real-time adjustment of parameters in adaptive/tunable systems using feedback sensors, for which copyright claim and patents have been filed with cooperation from the Foundation for Innovation and Technology Transfer (FITT), IIT Delhi.



(a) Multi-Mode Dynamic Response Control using Spatially Distributed Multiple Tuned Mass Dampers.



(b) Energy Based Predictive (EBP) Semi-Active Control Algorithm for Tuned Mass Dampers.

Furthermore, his research on deploying lightweight aluminum-syntactic metallic/polymeric foams and high-strength fiber-reinforced polymer (FRP) composite materials enhanced the blast resistance of strategically important structures with fire retarding attributes. His contributions in rate-dependent constitutive laws for advanced engineered construction materials and thermo-mechanical response evaluation, through computationally challenging non-linear analyses, gave new insights into the structural behavior under dynamic, impulsive, and thermal loading scenarios. His recent research on the blast-resistant design of structures dealt with the inelastic response considering uncertain system parameters under random impulse loading and improved blast-resistance achieved through advanced engineered materials, such as the FRP composites. Notably, Indian armed forces are benefitting significantly from his innovating structural designs employed for strategically important infrastructures of national importance. Myriad of technological solutions, including structural design approaches resulting from his research, published in over hundred journal papers, are being incorporated into various construction codes/design standards, and being implemented on lifeline structures such as vital hospital buildings, bridges, tanks containing sensitive liquids and strategically important structures, for minimizing the destructive impacts of multi-hazards emanating from earthquakes, windstorms, blast, and fire. Thus, Prof. Matsagar's research focuses on holistically developing new technologies for civil-infrastructures, with advanced engineered materials having sustainability attributes for improved protection from multi-hazard scenarios.

(a) Aluminum Syntactic Metallic Foam and Polymeric Foam Materials.

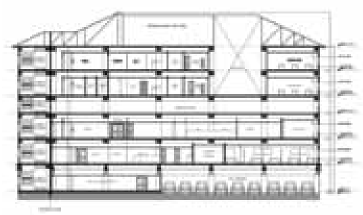
(b) Fiber-Reinforced Polymer (FRP) Composite Materials.

The societal impact of the applied research work delivered by Prof. Matsagar can be appreciated from the real-life seismically base-isolated buildings constructed with his close technical involvement through translational research. He has given fundamental understanding in the dynamic response of the base-isolated structures and patented innovative seismic base isolation systems. IIT Delhi had extended its specialized technical expertise in the structural design of the seismically base-isolated (a) Sardar Patel Bhawan / New Bihar Police Headquarters Building in Patna, which was inaugurated by the Chief Minister of Bihar, Honorable Shri Nitish Kumar on Friday, 12th October 2018. It is notable that the first building with double-curvature sliding base isolation system in India is nearing its construction at the (b) Resistoflex Base-Isolated Showcase Building in NOIDA, wherein Prof Matsagar had contributed to its structural design. Similarly, the other two major base-isolated building projects towards completion include, (c) Indira Gandhi Hospital Building in Dwarka, and (d) Lal Ded (LD) Hospital Building in Srinagar, wherein he has been able to contribute in designing and production testing. Furthermore, (e) Bihar Animal Sciences University (BASU) Buildings with seismic base isolation technology are currently under design stage with him. These are some examples of technology transfer to the construction industry in India as outcomes from the research work conducted at IIT Delhi in the MHPS Laboratory.

During the 2010 Commonwealth Games in Delhi, in recognition of the specialized structural analysis and design of 45.5 m tall lighting tower erected at the Chhatrasal Stadium, the Indian Buildings Congress (IBC) has conferred Prof Matsagar with the "IBC Award for Excellence in Built-Environment". Subsequently, he has been serving as a representative on the technical committees

(a) Base-Isolated Sardar Patel Bhawan / New Bihar Police Headquarters Building in Patna, Bihar.

(b) Resistoflex Base-Isolated Showcase Building in NOIDA, Delhi.



(c) Base-Isolated Indira Gandhi Hospital in Dwarka, Delhi.

(d) Base-Isolated LD Hospital Building in Srinagar.

in (a) Disaster Management Committee, Government of Delhi, and (b) National Disaster Management Authority (NDMA) as well as in the (c) National Building Code (NBC) of India to contribute in developing standards on multiple loading scenarios emanating from earthquakes, windstorms, blast, and fire; structural behavior requirements; and design recommendations to achieve desired structural performance.

Prof. Matsagar is a serving member of the committees developing specifications for earthquake-resistant design of structures in the Bureau of Indian Standards (BIS), technical committee member in the Indian Roads Congress (IRC), and working group member in the International Standards Organization (ISO). His focused development of site-specific, scenario-based, and performance-based design computational frameworks is contributing towards the next-generation building codes and standards. He is an elected executive committee member of the Indian Society of Earthquake Technology (ISET); Secretary of the ISET Structural Dynamics Forum; Secretary General of the Indian Association for Structural Engineering (IASE) and Indian Association for Computational Mechanics (IndACM); founding expert member of the Seismic Academy established by the Hilti. Moreover, he is serving on Program Advisory Committee (PAC) of the Department of Science and Technology (DST) in different programs and capacities, as well as member of the expert panel in the European Research Council (ERC) for evaluation of scientific proposals submitted to the ERC Starting Grant, and that in the National Commission for Scientific and Technological Research (CONICYT-Chile) for evaluation of the scientific proposals submitted to the National Fund for Scientific and Technological Development (FONDECYT).

Prof. Matsagar has reinforced the structural engineering discipline by innovating new patented technologies, developing products for field applications through translational research, and disseminating advanced protective technologies extensively in academia and construction industry. Thereby, he received invited memberships in the editorial boards of reputed journals apart from that in the code committees. Currently, he is serving as Editor-in-Chief of the Indian Society of Earthquake Technology (ISET) Journal and an editorial board member of the Bulletin of the New Zealand Society for Earthquake Engineering (BNZSEE), Proceedings of the Institution of Civil Engineers (ICE) - Structures and Buildings, Advances in Civil Engineering, and Indian Concrete Journal (ICJ); Guest Editor of Institution of Engineers India (Series A), Shock and Vibration, Frontiers in Built Environment, Journal of Low Frequency Noise, Vibration, and Active Control; and served as Responsible Editor of the Earthquake Spectra journal.

Prof. Matsagar's research contributions have received remarkable attention by peers in the research fraternity. On the topic, "Stochastic Dynamic Assessment Framework for Long-Span Pre-stressed Concrete Bridges with Carbon Fiber-Reinforced Polymer Tendons under Multi-Hazard Scenarios", the Alexander von Humboldt Fellowship for Experienced Researcher was awarded to him. Besides, Prof Matsagar is the recipient of numerous national and international awards including "Carl Friedrich von Siemens Research Award"; "IEI Young Engineer Award" by the Institution of Engineers (India) as well as he is elected as Fellow of the IEI and other such accolades. In recognition of his doctoral research contributions published through highly cited publications, he has been awarded with the "IIT Bombay Research Paper Award". The Department of Atomic Energy (DAE) and the Department of Science and Technology (DST) have sponsored his research in the MHPS Laboratory through "DAE Young Scientist Award" and "DST Young Scientist Award".

Prof. Matsagar is making contributions to teaching and research supervision in the IIT system by playing crucial role in new curriculum development at undergraduate (UG) and postgraduate (PG) levels. Having passion for teaching, he considers that the genuine comments given by the students in the feedback helps him finetuning teaching and learning experience. He believes in enthusing students to contribute to the society in delivering the much-needed technological solutions. IIT Delhi has adopted anonymous course evaluation policy, wherein, the students give their feedback on the courses they have studied in a semester. Based on such evaluation, Prof Matsagar has been awarded with the "IIT Delhi Teaching Excellence Award". He is also recipient of the ASEM-DUO-India Professor Fellowship Award for conducting research at the University of Dundee, UK; and the Erasmus+ Fellowship for teaching at the Technische Universität München (TUM) in Germany.

Prof. Matsagar is continuing his professional and outreach services by conducting several quality improvement programs (QIP), short- and long-term courses, technical workshops, training programs for different stakeholders in the academia and construction industry. He was Indian representative and invited speaker in number of international workshops/symposia organized in different countries, such as New Zealand, United Arab Emirates (UAE), China, Germany, etc. He had organized some notable conferences at IIT Delhi such as "Natural Hazards & Risk", a national curtain raiser event for the "Asian Ministerial Conference on Disaster Risk Reduction" (AMCDRR); and "Structural Engineering Convention (SEC) 2014", 9th Biennial Event of the Indian Association for Structural Engineering (IASE).

Prof Matsagar is serving on Academic Councils, Board of Studies, and faculty selection committees at some National Institutes of Technology (NITs) and engineering institutes in the country. He has served in different capacities in the Public Service Commissions of Rajasthan, Haryana, and Madhya Pradesh. He has contributed to the development of a course on "Introduction to Earthquake Engineering", under the National Program on Technology Enhanced Learning (NPTEL). He is currently serving as National Coordinator for Civil Engineering and allied subjects in the Swayam Prabha DTH Channel, a Ministry of Human Resource Development (MHRD) Project, National Mission on Education through Information and Communication Technology (NME-ICT).

Prof. Matsagar is instrumental in establishing several academic collaborations with research laboratories internationally. IIT Delhi has signed new memorandum of understanding (MoU) with the Michigan State University, USA and Toyohashi University of Technology, Japan as an outcome of the initiatives taken by him. Through these MoUs now, exchange of researchers is taking place and joint research projects are being executed. The Indo-U.S. Science and Technology Forum (IUSSTF) and Suzuki Foundation have funded their collaboration respectively in the U.S. and Japan. Furthermore, through the "Partnership 2020" programme between U.S. and India, this cooperation has recently been funded for executing a key project on "Fire-Resistance Guidelines for Hybrid FRP Structural Components made of Cellulosic Fibers derived from Agricultural Waste". His collaboration with the University of British Columbia in Canada was sponsored by the Shastri Indo-Canadian Institute. Prof Matsagar received "Erasmus Mundus Award" to conduct research at the Ecole Centrale de Nantes (ECN) in France. Through this collaboration, high strain-rate characterization of fiber-reinforced polymer (FRP) materials has been carried out. Later, through "Research Excellence Programme USC - India" he conducted research on numerical analysis of concrete structures in fire at the University of Santiago de Compostela in Spain.

Prof. Matsagar works in close association with the German Academic Exchange Programme, i.e. Deutscher Akademischer Austausch Dienst (DAAD) in various capacities. With the extensive research collaborations established by him with different Technical Universities (TUs) in the TU9 alliance apart from the exchange of students, he has been appointed as the "DAAD Research Ambassador". An Indo-German research project, "Sensor Based Security and Emergency Management System for Underground Metro Systems during Disaster Events (SenSE4Metro)" under the Indo-German (DST-BMBF) Cooperation in Civil Security Research, International Division, Department of Science and Technology (DST), Government of India and the Federal Ministry of Education and Research (BMBF - Bundesministerium for Bildung und Forschung) was completed with his involvement. Subsequently, he has been the Indian lead in yet another BMBF-sponsored research project, "Sensor Systems for Localization of Trapped Victims in Collapsed Infrastructure (SORTIE)", under the theme of International Disaster and Risk Management (Internationales Katastrophen - und Risikomanagement - IKARIM). This partnership has also been funded under the Scheme for Promotion of Academic and Research Collaboration (SPARC) of the Ministry of Human Resource Development (MHRD). Similarly, research collaborations are established with fire engineering research group at the University of Queensland in Australia, earthquake engineering research group at the University of Canterbury in New Zealand, and other partners, initiated respectively through the SPARC and Global Initiative on Academic Network (GIAN) Schemes of the MHRD. Also, the UK-India Education & Research Initiative (UKIERI) has facilitated his partnership with consortia of institutes in UK, led by the University of Wolverhampton, UK on "Urbanization and Resilience Against Natural and Manmade Disasters - Developing a Roadmap to Build Resilient Cities in India".

Prof. Matsagar considers himself blessed to be part of the IIT Delhi family, the excellent support and encouragement of which has helped him in delivering the academic and research obligations diligently. He expresses his profound gratefulness towards the students, researchers, faculty and staff colleagues for associating with him in delivering thus far the unassuming outcomes enumerated erstwhile. He strongly believes that we owe to the society and ought to give back in the best of our capabilities. In the same pursuit, he is looking forward for making such contributions that are most relevant to the mankind at large.

Technology Transfers at FITT during Jan- June 2020

Sl. No.	Technology	PI/ Dept
1	UV-Disinfection System for microbes including bacteria and virus	Prof. Harpal Singh, CBME
2	Design and development of PPE coverall	Prof. Harpal Singh, CBME
3	Process and composition imparting multifunctional properties to fabrics	Prof. S Mukhopadhyay, TFE
4	RIPSTOP weave for enhanced tearing strength and breathability	Prof. Deepti Gupta, TFE
5	COVID-19 Molecular diagnostic kit	Prof. V Perumal, KSBS
6	Microfludic Analyser	Prof. R Elangovan, DBEB

Innovations

List of IPR applications filed during January-June 2020

S No	Title	PI	Dept/ Center/ School
1	Shear thickening behavior of hybrid mesoporous silica	Prof. L Nebhani	DMSE
2	Hydrophilic polymeric composition, method of preparation and its coating on fabric	Prof. AK Agarwal	TFE
3	A process for producing trimellitic acid from biomass	Prof. MA Haider	CHEME
4	Ejector-diffuser for gas turbine engine	Prof. SN Singh	AM
5	Compressed binary search tree for K-NN searches in hamming space	Prof. Jayadeva	EE
6	Silicone based novel finish for multifunctional finishing of textile	Prof. J N Sheikh	TFE
7	Mama Pod- Assistive Garment	Prof. D Gupta	TFE
8	Power factor correction converter based charger	Prof. B Singh	EE
9	Agro residue derived biodegradable bio-composites and their application in cultivation of transplantable horticultural crops	Prof. K Hariprasad	CHEME
10	Nano encapsulated phase change materials for thermal regulation and energy storage	Prof. BP Tripathy	DMSE
11	Electrically conductive aerated concrete (ECAC) blocks	Prof. AN Bhaskarwar	CHEME
12	Nano-size abrasive and method of preparing the same	Prof. SW Ali	TFE
13	An electrode and a process for preparation thereof	Prof. PP Ingole	CHY
14	Biomarkers, kit and applications thereof	Prof. B Kundu	KSBS
15	MOF functional textiles and process of fabrication thereof	Prof. AK Agarwal	TFE
16	Aerodynamic journal bearing	Prof. RK Pandey	ME
17	Process and system for using unused optical power in photonic on-chip networks	Prof. SR Sarangi	CSE
18	Near infrared spectroscopy for protein formulation and uses thereof	Prof. AS Rathore	CHEME
19	Jewellery	Prof. S Singh	DOD
20	High performance induction machine drive	Prof. AK Jain	EE
21	Method for mode switching and power allocation in device to device communication	Prof. S Prakriya	EE
22	Fluid flow measuring apparatus	Prof. SN Singh	AM
23	Hypersensitive load cell	Prof. S Mukherjee	ME
24	A novel green micro-emulsion for controlling fungal wilt diseases	Prof. S Sharma	CRDT
25	Method, system and apparatus for multilingual and multimodal keyword search in a mixlingual speech corpus	Prof. A Kumar	CARE

26	Monitoring system for a flow battery	Prof. A Verma	CHEME
27	A system for monitoring and control of chromatography	Prof. AS Rathore	CHEME
28	Precision nano-imprinting machine	Prof. JP Khatait	ME
29	Single-site metal-organic framework-catalysts for conversion of Natural Gas Liquids (NGL) to value-added products	Prof. K Mannna	CHY
30	Battery operated touchless automated assembly for dispensing any liquid or semi-liquid substance	Prof. M Aggarwal	CARE
31	A powered air purifier respirator for health workers	Prof. M Aggarwal	CARE
32	Multifunctional microcapsules for textile finishing and preparation method there	Prof. J N Sheikh	TFE
33	Exoskeleton device for upper limb rehabilitation	Prof. A Mehndiratta	CBME
34	Synchronous reluctance generator based wind energy conversion system	Prof. B Singh	EE
35	An improved arrangement of a cascaded u-cell based multilevel converter device by using a modified fundamental switching technique	Prof. B Singh	EE
36	Monitoring system for a flow battery	Prof. A Verma	CHEME
37	Tunable substrate integrated waveguide filters	Prof. SK Koul	CARE
38	Wound healing dressing and method of preparation thereof	Prof. J Bhattacharyya & Prof V Koul	CBME
39	Core-shell nanoparticles for in-situ removal of total dissolved solids in textile effluents and a process of removal thereof	Prof. K Manna	CHY
40	Single phase induction motor for ceiling fan	Prof. B Singh	EE
41	System and method for integrating power from renewable energy sources to high-voltage direct-current transmission line	Prof. A Das	EE
42	Electrochemical preparation method for vanadium electrolyte and its application thereof	Prof. A Verma	CHEME
43	System and method for improving efficiency of EV chargers with different open circuit voltages	Prof. B Singh	EE
44	Solar PV generation for improved utilization of DG set	Prof. B Singh	EE
45	System and methods for hybrid local caching in radio access networks	Prof. M Suri	EE
46	Method in blockchain systems for fast stabilization and increased responsiveness using links	Prof. V Ribero	CSE
47	Compiler-operation in a computing system and method thereof	Prof. S Bansal	CSE
48	A shadow-less cascaded solar panel based photovoltaic power generation system and method of its operation thereof	Prof. DS Mehta	PHY
49	Fabrication of coating free structured superhydrophobic polydimethylsiloxane (PDMS) surface and its use thereof	Prof. S Aravindam	ME
50	Integrated purification system for air and water	Prof. D Dasgupta	ME
51	Solar PV integrated sensor less PMSM drive for e-rickshaws with regenerative braking capability	Prof. B Singh	EE
52	Indoor air purification device	Prof. D Das	TFE

Integrated Purification System for Air and Water

Prof. Debabrata Dasgupta
Department of Mechanical Engineering
IIT Delhi

Lately, mortality rates due to exposure to two major forms of environmental pollution viz., air pollution and water pollution have touched alarming highs. Public health problems caused by lack of access to potable water and clean air provide motivation for our current efforts. While significant advancements have been made in terms of techniques to achieve air and water purification till date, our objective is to address the factors of affordability and practicality with an innovative approach in employing such technologies in a host of settings, spanning from indoor to outdoor environments. We introduce the concept of integrating and combining the two processes of air and water purification within a single device having a compact footprint, presenting a host of process, cost, and pragmatic benefits [1].

Figure 1: Isometric view of the device

Both, polluted air and contaminated water are made to pass through multi-staged filtration processes [2] which involve techniques such as, but not limited to, particulate pre-filtration for eliminating large impurities and increasing the life of subsequent layers, activated carbon filtration for removing volatile organic compounds (VOCs) and other harmful gaseous pollutants, polymer, synthetic, or HEPA-based filtration for tackling PM2.5 pollutants and photochemical oxidation for immobilizing Sulphur Dioxide and oxides of Nitrogen present in the air, and sediment filtration, reverse osmosis and activated filtration for purifying particulates, dissolved impurities and VOC impurities present in water. In addition, we make use of UV light with a suitable transmitting arrangement for eliminating biological contaminants from both air and water at the same time without allowing for any form of contact between the two. A protective film fitted on to the front face of water storage tank prevents UV radiation from coming out into the environment.

Our invention features a novel air-handling and delivery system that is responsible for guiding the transport of air from suction to outlet. In addition to suitable flow regulating design bits within the path of air passage, multi-staged fans with a combination of different airfoil profiles facilitate efficient suction through the filter media and impart superior flow rates. Our proposed invention not only poses the potential to serve the best health interest of lower-middle class to middle class households, but also establishes new grounds for dispensing great boon in the outdoor space as a meaningful public facility.

References:

1. D. Dasgupta, A. Roy and C. Mishra, “Integrated purification system for air and water”, Patent application filed by IIT Delhi (Ref. Number: 202011026877)

2. R.P. Knuth and W.F. Carrey, “Air purification system”, US Patent US5997619A

Exoskeleton Device for Rehabilitation of Upper-Limb

Prof. Amit Mehndiratta and Dr. Neha Singh
Centre for Biomedical Engineering
IIT Delhi

Stroke is a neurovascular insult to the brain, that disrupt sensory and motor functions of patient. It is a highly morbid disease having severe impact on activities of daily-living for the patient. Conventional rehabilitation therapy for stroke involves physiotherapy which is a time taking, labor-intensive and highly subjective procedure. With a high clinical-load in a country like India, it is difficult for the present healthcare system to provide effective rehabilitation services to the community [1]. Robotic devices offer an innovative rehabilitation training environment, by applying motor learning principles to facilitate recovery and can substantially reduce the clinical-load [2]. However, these devices are either inherently large requiring enough space, are mostly installed in a facility, require trained staff to operate, are highly expensive and compel patients to visit the hospital every day. Also, they provide isolated joint movements instead of facilitating physiologically relevant inter-joint coordination for activities of daily-living with patient-specific impairment [3].

We have developed a human-computer interface hand-exoskeleton for upper-limb rehabilitation of patients with stroke. A Computer-Aided Design model of exoskeleton was designed and Finite Element Analysis was performed to analyze stress distribution and Factor of Safety (FOS) with the loads simulating conditions of hand spasticity post-stroke. The device was then 3D printed using ABS and was coupled with mechanical assembly. This electromechanical device focuses on synchronizing the

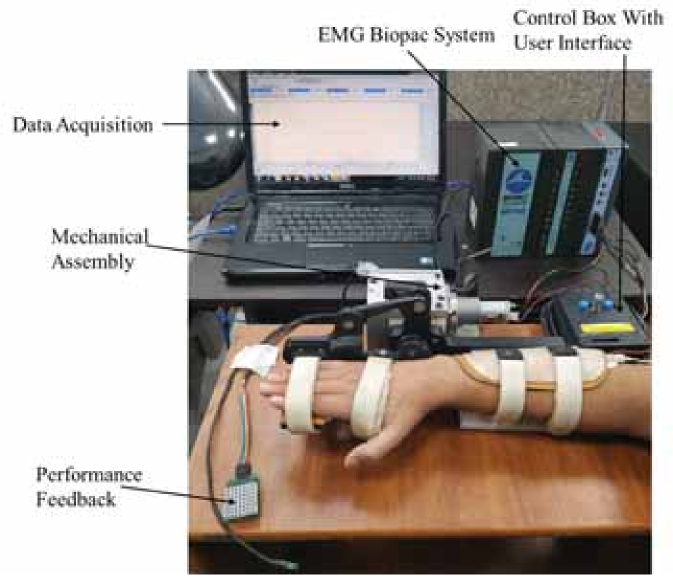


Figure: Set-up of the exoskeleton device for right hand with a patient.

movement of wrist extension with finger flexion and wrist flexion with finger extension to improve activities of daily-living and reduce spasticity in hand. It is a voluntarily triggered mechanism using residual muscle activity through Electromyogram (EMG) and is tailored to be patient-specific. Device provides real-time adaptive visual performance biofeedback based on quantitative measures of the patient's voluntary trial effort, which has a significant role in further motivation of the patient. The device can cater to the requirements of a large cohort of patient population with a variety of symptoms. Device has been already evaluated for therapeutic benefits on twenty-five patients in the Department of Neurology, AIIMS. It is low-cost, lightweight, portable and user friendly. Device was designed for the ease of manufacturing and maintenance, with specific considerations for countries with limited resources.

The device is now patented in India and USA. The technical details on device are published in IEEE Transection of Neural Systems and Rehabilitation Engineering [4].

References:

1 Q. Qian, X. Hu, Q. Lai, S. C. Ng, Y. Zheng, and W. Poon, "Early stroke rehabilitation of the upper limb assisted with an electromyography-driven neuromuscular electrical stimulation-robotic arm," Front. Neurol., vol. 8, no. SEP, pp. 1–13, 2017.

2 R. Colombo et al., "Design strategies to improve patient motivation during robot-aided rehabilitation," J. Neuroeng. Rehabil., vol. 4, no. 1, p. 3, 2007.

3 S. W. Lee, K. A. Landers, and H. S. Park, "Development of a biomimetic hand exotendon device (BiomHED) for restoration of functional hand movement post-stroke," IEEE Trans. Neural Syst. Rehabil. Eng., vol. 22, no. 4, pp. 886–898, 2014.

4 Singh, N.; Saini, M.; Anand, S.; Kumar, N.; Padma Srivastava, M.V.; Mehndiratta, A. (2019) Robotic Exoskeleton for Wrist and Fingers Joint in Post-Stroke Neuro-Rehabilitation for Low-Resource Settings. IEEE Transactions on Neural Systems and Rehabilitation Engineering. 27(12):2369-2377. DOI: 10.1109/TNSRE.2019.2943005.

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
CART:	Centre for Automotive Research and Tribology
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
DOD:	Department of Design
EE:	Department of Electrical Engineering
HUSS:	Department of Humanities and Social Sciences
KSBS:	Kusuma School of Biological Sciences
MATHS:	Department of Mathematics
ME:	Department of Mechanical Engineering
PHY:	Department of Physics
TFE:	Department of Textile and Fiber Engineering

and many more...

Call for Proposals - BIG Scheme

FITT calls for proposals under the 17th Biotechnology Ignition Grant (BIG) Scheme of BIRAC from

August 1, 2020

Details: www.fitt-iitd.in / www.fitt-iitd.org | Phone:+ 91 11 - 26597289/ 26597153/ 26597167

SNIPPETS

POSOCO Power System Awards (PPSA)-2020 concluded on March 13, 2020

Awardees of PPSA-2020 were felicitated by Mr Sanjay Malhotra, Additional Secretary, Ministry of Power, GoI and Prof TC Kanpal, Deputy Director(Operations), IIT Delhi at the Senate Rooom IIT D

Technology Transfer at FITT

IIT Delhi Technology "Design and Development of PPE Coverall" by Prof H Singh, CBME, transferred to Uflex Ltd on May 29, 2020

Some examples of Investigative/ Development Projects at FITT from Jan- July 2020

Sl No	Title	PI	Dept/Centre
1	Surge tank management for continuous processing	Prof. AS Rathore	CHEME
2	Managing charge variant profile in continuous processing	Prof. AS Rathore	CHEME
3	Development of numerical model for leakage rate modeling under dynamic conditions of barriers/configurations	Prof. BP Patel & Prof. P Mahajan	AM
4	Deep learning methodologies to develop novel pre-or early cancer detection technology for patients diagnosed with pancreatic cancer	Prof. AS Rathore	CHEME
5	Development of compressor oil suspension using non-particles	Prof. D Kumar	CART
6	Identifying scope for technological intervention to India's air quality problem	Prof. S Dey	CAS
7	Phase analysis of API 5L X80M PSL2 grade line pipe steel	Prof. J Jain	DMSE
8	Design and development of high dynamic range CMOS image sensor for low light applications	Prof. M Sarkar	EE
9	Development & support for motor solutions by Mathworks	Prof. V Kumar	CRDT
10	Endurance/Fatigue testing & analysis in track pin	Prof. P Mahajan	AM
11	Curriculum development and implementation for B.Tech programme	Prof. SR Kale	ME
12	Concept design for home appliances for LG, considering users aspirations and need	Prof. S Singh	DOD
13	Fatigue Test and Analysis of Pin for Munish Forge	Prof. P Mahajan	AM
14	Application of Machine Learning & Artificial Intelligence in Cancer genomics	Prof. AP Prathosh	EE
15	Electro-oxidation of CH4 Gas to liquid products	Prof. A Verma	CHEME

LEADERSHIP AT FITT

Prof. V Ramgopal Rao, Director IIT Delhi & Chairman FITT

Dr Anil Wali, MD FITT

We value your feedback

FITT seeks to explore various avenues to enhance the quantum of interaction between industrial units/end-users and IIT Delhi. Therefore, we keenly look forward to your feedback and suggestions on various issues that can help meet our objectives.
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