Dr Tilak Dias

Dr Tilak Dias is Senior Lecturer in Knitting Technology at the University of Manchester's School of Materials. Through Engineered Fibre Structures Ltd, he consults to industry on a broad range of textiles based subjects. The following is a synopsis of his curriculum vitae with regard to research and development.

Photo by Ed Swinden (07817 363 585)

Tilak originally studied electrical and electronic engineering at the University of Moratuwa in Sri Lanka, and then went on to study for his five year Dipl.-Ing Textile Engineering degree at the Technische Universitat Dresden in Germany. He then completed a further four years of study for his Dr.–Ing. at the University of Stuttgart, choosing to study automated fault detection and on-line data monitoring in circular knitting machines.

Early Days in Manchester

Tilak joined UMIST in 1992 with the vision of creating a world class knitting research centre equipped with the latest mechatronics knitting machines and staffed with experienced technologists and research associates working at the cutting edge of knitting research.

Funding his vision however, was impossible without external support, due to the high cost of equipment and the need for highly skilled technicians and technologists. Tilak, had some immediate successes with equipment, due to contacts developed during his doctoral research, with knitting equipment manufacturers such as Stoll GmbH, Mayer & Cie GmbH, Memminger GmbH and Multiscan GmbH. However, there is a limit to the generosity of machine manufacturers and Tilak soon realised that he had to develop a strategy that would provide regular funding streams, enabling him to realise his goal.

After twelve years of energetic fundraising, the core infrastructure is now in place with a broad portfolio of funding sources. Tilak has recruited a team of experts in 3D knitting, mathematical modelling, knitted transducers, knitted compression systems, knitted protection systems and software development. His research group has evolved from one Project Officer in 1995 to twenty seven staff in 2006, and is arguably the best in the world today, in its field.

Tilak’s success resulted in his Knitting Research Group being formed into a multidisciplinary research centre, called the William Lee Innovation Centre, by UMIST in 2002. It has become a centre of excellence for research into knitted medical devices and smart knitted products.

Advancement of Knitting Research

Photo by Ed Swinden (07817 363 585)

When Tilak first joined UMIST, his research focus was in the area of quality control and assurance of the knitting process , his PhD research being the impetus for this line of research. One of the key findings of his PhD research at ITV Denkendorf, Germany, was that, the controlled delivery of yarn on circular and flat-bed knitting machines had not been researched in any depth, and Tilak therefore, decided to centre his research on the study of controlled yarn delivery on weft knitting machines.

This research, which was a theme in several PhD studies carried out under his supervision, resulted in the development of intelligent yarn delivery systems. In the precision control of the fibre/yarn movement, the knitted loop and the needle movement and its selection during the stitch formation process is crucial. Modern electronic flat-bed technology has centred on electronic needle selection and precise displacement control using very accurately manufactured cams, and defining the position and the orientation of the knitted loop via servo/stepper motor control systems. These areas were mastered by the leading machine manufacturers at the beginning of 1990s.

Technology Integration

Since the creation of the William Lee Innovation Centre in 2002, Tilak has focused his research activities in the following two areas:

Technical knitted structures

- textile based medical devices
- smart textiles
- mathematical modelling of knitted structures

Integration of knitting technology with other technologies

- Precision yarn delivery systems - integration of electronic needle selection with servo motor control systems

- Customised compression systems such as Scan2Knit technology - integration of body scanning with electronic flat-bed knitting technology
- Electronic yarn manufacture - novel technology for encapsulating CMOS chips within fibres in a yarn
- Electroluminescent yarns - integration of micro-encapsulated phosphor with fibres
- Customised wadding systems - integration of body scanning with 3D printing, 3D knitting and laser engraving
- CAD/CAM software - digital prescription system for compression therapy

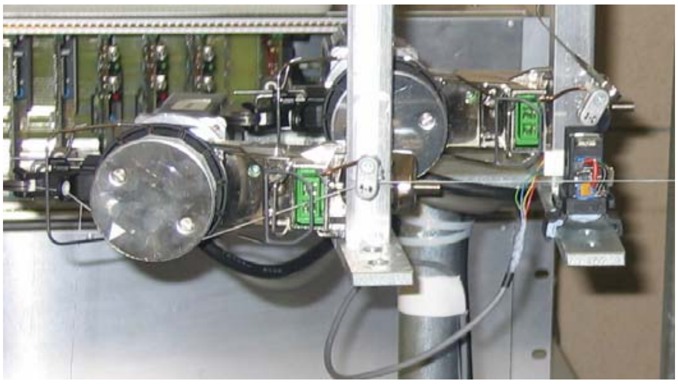
This research focus has resulted in the creation of two novel core technology platforms which are described below.

Intelligent Yarn Delivery

One of the prerequisites for producing a knitted structure for a specific functionality is to form stitches to a predetermined size. This was not attainable in 1992 due to the lack of technology for controlling yarn movement precisely on an electronic flat-bed knitting machine. As such Tilak's initial research activities at UMIST resulted in the creation of microprocessor based intelligent fibre/yarn delivery systems for the precise control of the stitch length on electronic flat-bed knitting machines.

The resultant IP has now been assigned by The University of Manchester for commercial exploitation. In recognition of his research on near-zero tension yarn feeding two state-of-the-art machines were donated to UMIST by one of the leading flat-bed knitting machine manufacturers, Stoll GmbH in Reutlingen, in 1994 and 1996. This equipment was the impetus to further his research activities in other areas, and also enabled him to develop a unique knowledge base on 3D knitting.

True Positive Feed



The research on fibre/yarn delivery also resulted in a novel fibre/yarn delivery system in 1998/99, and its integration with the Stoll knitting machines provided a unique platform for manufacturing three dimensionally shaped knitted structures with much narrower tolerances than is otherwise possible with current standard technology. The IP related to the intelligent yarn delivery technology, the True Positive Feed or TPF has been protected in two patents, both granted in the USA, UK and EC. The commercial version of the TPF is now being developed by an industrial partner under licence.

Knitted Medical Textiles

At the same time, the migration of the UK's knitted garment manufacturing industry overseas, caused Tilak change his research focus to medical textiles. The integration of mechatronics systems with flat-bed knitting machines revolutionised weft knitting technology, where the needles, stitch cam settings, fabric take-down and needle bed racking are very precisely controlled by microprocessors.

This technology was developed by the machine manufacturers for the knitwear industry to improve the patterning and shaping efficiency.

However, Tilak realised as early as 1990 the potential of this technology as a tool for creating complex seamless shaped 3D shell structures and shaped spacer structures for non-fashion applications.

He therefore decided to utilise this technology as the platform for developing the new research area of knitted medical textiles, engineered to a predetermined functionality, e.g. medical products/devices three dimensionally shaped to conform to the patient's medical needs. This change of direction resulted in the award of significant research funding from the Wellcome Trust and the UK's Department of Health.

Engineered Medical Compression Treatment Systems

In 2001, Tilak initiated a unique collaboration between Vascular Surgery and Textile Research by joining with Professor Charles McCollum of The University of Manchester Medical School in order to develop engineered compression garments for medical applications. Professor McCollum directs the Vascular Studies Unit at South Manchester University Hospital.

This collaboration was initially funded by a major grant from the Wellcome Trust to develop engineered compression stockings for the prevention and treatment of venous ulcers, leg swelling and deep vein thrombosis or DVT.

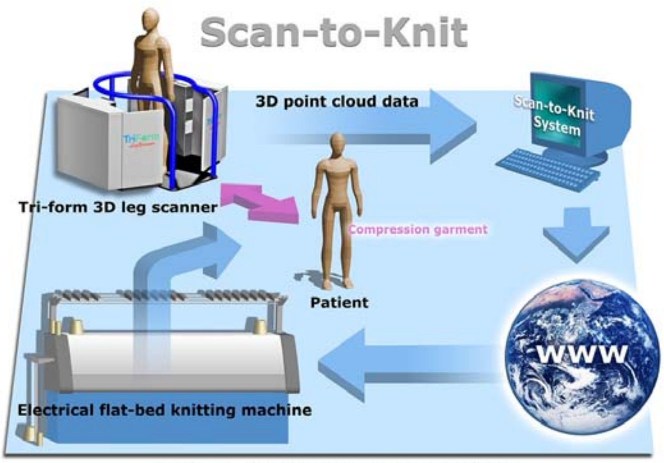
Veins are thin walled blood vessels that return blood from the body to the heart. Deep vein thrombosis and the incompetence or failure of the valves in the perforating veins in the legs frequently causes high vein pressures (venous insufficiency) which results in capillary proliferation and increased permeability leading to leg swelling, aching venous ulcers which are unpleasant, painful and often malodorous sores. There are approximately 450,000 people in the UK prone to leg ulcers and 130,000 elderly patients will have active ulcers at any one time.

The cost to the NHS, UK is over £600 million a year for leg ulcers alone, which affect 1.5% of the elderly population. The costs for treating venous insufficiency which may follow DVT, are much higher as there are 1.5 million sufferers. Sustained graduated compression is the key to healing a venous ulcer. Currently this involves four layer compression bandaging which needs to be re-applied weekly or twice weekly. The substantial cost of dressings and bandages is small compared with the time commitment for highly trained nursing staff.

The real issues of four layer bandaging are that the pressure applied in the bandaging system depends on the precise stretching of the bandage during application. Manual application is very subjective and has very high tolerances associated with it. Additional issues include non-uniform pressure due to the variation in curvature of the limb profile, loosening of the bandage due to movement, application only possible by a trained nurse and discomfort for the patient including difficulty with bathing.

In the early stages of treatment the dressings under the bandages may need to be changed as often as three times a day. The focus of the research was to address these problems by radically changing the culture from the manufacturing and application of graduated pressures via a craft-based approach of trial and error, to that of precision engineering.

The research team used a 3D limb scanner to accurately measure the size and shape of the lower leg and foot and this information was then transmitted as a digital point cloud data set to a computer aided compression stocking engineering system, which allows the doctor to prescribe the desired pressures for differing clinical applications. A precisely fitting seamless engineered compression stockings is then seamlessly knitted and delivered to the clinic for fitting.



Scan-to-Knit technology platform

The compression stocking engineering system's software engine, which was developed under the Wellcome Trust research grant, creates a visual simulation of the 3D pressure profiles which would be generated when the stocking is worn by the patient. Finally, the system creates the machine code data files for the manufacture of the compression stocking on a modern electronic flat-bed knitting machine. In the research programme the data file was transmitted via the internet to a machine at the William Lee Innovation Centre for the manufacture of the engineered compression stockings for the clinical trials.

Further Collaborative Research

The creation of the above technology platform led to a second collaboration with Prof Nigel Bundred, Professor in Surgical Oncology, Department of Surgery, South Manchester University Hospital NHS Trust. The focus of this collaboration is to develop the above technology for the manufacture of compression sleeves for the treatment of lymphoedema. Lymphoedema is a painful swelling of the arm and hand that can develop in women after surgery or radiotherapy for breast cancer.

One method of treating the condition is to apply pressure by way of an elasticated sleeve. Although precise pressure profiles are required, the current production method for compression therapy garments is relatively crude. The aim of the research is to apply the above technology platform to improve efficacy and comfort at reduced cost.

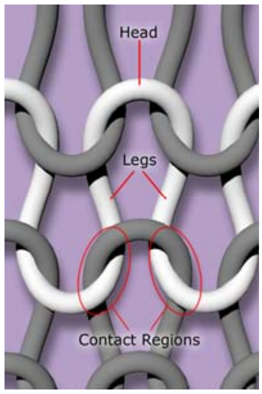
The research will use an optical scanning technique to determine the patient's arm profile, together with the computerised manufacturing process to produce customised garments. The technology will be further advanced by developing methods for the production of compression therapy gloves, using high-resolution scans of the patients hands. In addition to advancing the manufacturing process, the research will also seek ways of using the pre and post operative scanned arm profiles of patients to predict those who will go on to develop lymphoedema. The new collaboration has been awarded two successive NEAT (UK Department of Health) grants to advance the above research.

Collaborative research with Prof McCollum continues on the application of engineered compression stockings for other medical conditions:

- Engineered compression stockings to prevent venous insufficiency following hip and knee replacement
- The further development and clinical evaluation of engineered compression stockings for the prevention of venous diseases and post surgery lymphoedema treatment
- Detailed evaluation of engineered compression stockings and four-layer bandages for the treatment of venous leg ulcers: A North West Multi-centre Trial

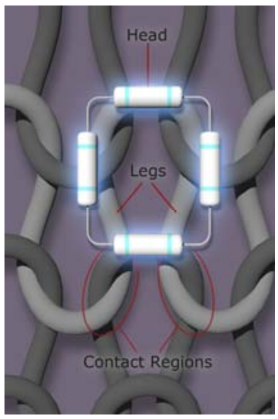
A new leg scanner and funds to advance the research were provided by The Clothworkers' Foundation recently, and the partnership have also been invited by the Wellcome Trust to apply for additional funds to develop a new 3D wadding system to enhance the current engineered compression stockings.

Electrically Active Knitted Textiles



In 2002 Tilak decided to widen his research focus to encompass fibre meshed transducers in order to integrate two areas of his expertise, textile engineering and electronics engineering.

A new generation of transducers was required to create integrated, computerised, sensor-rich smart fabric, applied primarily in the field of wearable computing. This required expertise in accurate fibre assembling in 3D space, microelectronics and software design. The research involves the development and integration of three basic technologies including the novel idea of fabrication of transducers, low power microelectronic and adaptive signal processing techniques.



The aim of this research was to advance the understanding of the behaviour of the electrical properties of knitted structures when they undergo static and dynamic deformations. The scientific knowledge gained by the research was useful in the development of fibre based transducers which can be utilised in the field of wearable computing and in the development of the next generation of SMART clothing.

The demand for this form of transducers arose from the limitations associated with traditional rigid transducers currently used in wearable computing, to measure internal environmental parameters such as body vital signs (breathing rate, breathing patterns, bodily electrical activity, body motion and gesturing). The current generation of fabric transducers are being made by integrating sensors into the fabric of the garment using traditional textile processes such as embroidery and sewing.

The key areas of research are:

- A detailed study of characteristics of electro-conductive fibres/yarns
- The development of dynamic mechanical and geometrical models of fibre structures. The models will be used to study the electro-mechanical behaviour of fibre mesh structures involving electro-conductive fibres of different conductive levels. An area which has not been systematically and scientifically researched. The modelling will be performed by using the finite element approach

- Creation of fibre meshed strain gauges. The objective is to utilise the variations in resistance, inductance and capacitance of the fibre based structures constructed with electro conductive fibres/yarns

- Development of fibre based displacement transducers for the measurement of linear and angular displacement
- Development of dry bio-potential electrodes. The electrodes are constructed by knitting electrodes into the apparel

Tilak's aim was to model the electrical resistance and impedance of a predetermined area of a knitted structure, created from an electro-conductive yarn, the electrically conductive area. The electrical resistance of the electrically conductive area was determined by defining the unit cell of the electrically conductive area, and calculating its equivalent electrical resistance by considering the geometry of the unit cell and the electrical properties of electro-conductive yarn.

The equivalent electrical resistance of the electrically conductive area was modelled by building an electrical mesh circuit from the unit cell.

The model enabled Tilak and his team to design and construct the electrically conductive area for different applications such as electrodes, resistive and inductive strain gauges, resistive and inductive displacement transducers, capacitive proximity sensors and knitted capacitors.

In order to advance these research findings into medical applications, a collaboration was established with the Department of Imaging Science and Biomedical Engineering (ISBE)at The University of Manchester's Medical School, which resulted in the creation of the science and engineering base for constructing knitted electrodes for bio potential measurements and respiratory sensors. These transducers and their conductive pathways are fabricated within multiple layers using electronic flat-bed knitting technology.

Tilak's collaboration with ISBE has resulted in the development of the second core-technology platform for the creation of a vest capable of obtaining information relating to the functional behaviour of internal body organs (e.g. cardiac response, respiratory pattern and temperature distribution of the body), and information relating to body movements and gestures of the wearer.

Electronically Functional Yarns

Everyday clothing consists of textile fibres which are woven and knitted to produce a fabric or garment with both structural and aesthetic properties. Integration of information technology into fabric material can provide added functionality. Tilak's aim is to integrate this new dimension of functionality into fibres, thus turning everyday objects into intelligent artefacts. Moreover, the goal of fibre electronic research is to turn the existing "bricks around the body" products, i.e. textiles with discrete electronic domains/regions, into a comfortable, flexible and wearable textile form.

The research is based on the concept of encapsulating micro-devices, such as RFID chips within the fibres of a yarn with a flexible hermetic seal for mechanical, thermal and electrical protection. The research goals are:

- Development of the encapsulation technique
- Modelling of the encapsulation process
- Evaluation of the fibre encapsulated chip, i.e. for mechanical stresses etc.
- The development of an experimental rig

Electro-Luminescent Yarn (EL Yarn)

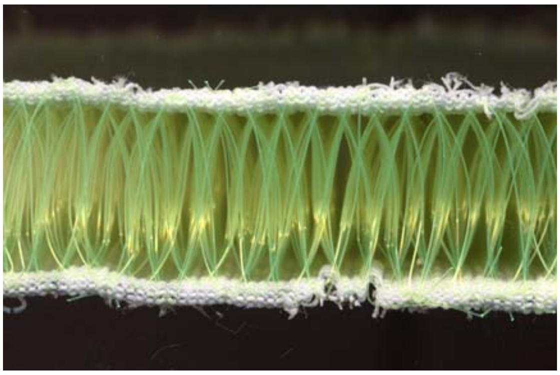
EL polymer sheets are created using micro-encapsulated phosphors and by screen-printing the above on to plastic sheets. The above technology was developed following the commercial manufacture of micro-encapsulated phosphor by Osram and the creation of a suitable electro-conductive polymer binder for Osram micro-encapsulated EL powder by DuPont. Current EL sheets are manufactured by sandwiching the DuPont EL ink between two silver coating layers thus creating the electrical field perpendicular to the surface of the plastic sheet.

However the integration of EL sheets with textile structures has so far had limited success. The aim of the research is to create EL fibres/yarns. The EL yarns can then be processed via existing textile manufacturing methods. The technical advantages are increased durability, improved flexibility and the washability of the end products. The research aims are:

- Material selection and concept development
- Mathematical modelling of the illuminating zone
- Design and development of an experimental rig
- Manufacture of EL yarn and knitting trials

Knitted Structures for the Management of Ambient Noise

The aim of the research is to model 3D structures for their noise absorbent characteristics, and to study the development of anti-noise knitted structures. The models created were the impetus for the development of a technique to produce a new generation of spacer structures with flat-bed knitting technology.



Commercialisation of Research Knowledge Base

Tilak strongly believes that the UK and European economies should benefit by the scientific knowledge created by his research. The University of Manchester has protected a portfolio of intellectual property generated by Tilak and his team and has filed no fewer than eighteen patents, many of which have been granted and subsequently licensed or assigned to industry.

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