

Research Assessment Exercise 2020
Impact Case Study

University: The Hong Kong Polytechnic University (PolyU)

Unit of Assessment (UoA): 14 - Mechanical engineering, production engineering (incl. manufacturing & industrial engineering), textile technology and aerospace engineering

Title of case study: New International Standards and Instruments Upgrade the Textiles and Clothing Industry

(1) Summary of the impact

PolyU has developed a range of innovative instruments for evaluating textiles and clothing. One, the *Moisture Management Tester*, is the only instrument that can precisely evaluate ‘wicking’ fabrics and provides the basis for international standards. This instrument aids innovation in a US\$ 2.6 billion global market with over 250 units sold in the RAE period. Another instrument, the *Fabric Touch Tester*, sold in 16 countries, provides global clothing companies with the only affordable objective measure of hand-feel, supporting R&D and quality control. A further example, *Walter* the ‘sweating thermal manikin’, has underpinned revised international standards for thermal comfort of buildings and vehicles for those in non-western dress, as well as helping Hong Kong win gold at the 2014 Asian Games.

(2) Underpinning research

Since 2002, PolyU textile research groups have developed innovative evaluation instruments to solve problems in the textiles and apparel industry. Our groups have worked on key industry issues of how to examine and identify the mechanical and physical properties of fabrics and how these translate into characteristics such as how fabric feels against the skin. Three such research areas are outlined below.

1). Moisture Management Tester

A major textiles industry challenge was a lack of machinery to measure the dynamic behaviour of liquid transfer on, and through, textile materials (‘wicking’). In response, Prof. Yi Li’s research team invented the *Moisture Management Tester* (MMT) at PolyU in 2003 [1] which measures and records how liquids move through fabrics in multiple directions. A series of indexes, including *Wetting Time*, *Maximum Absorption Rate*, *Maximum Wetted Radius*, *Spreading Speed*, *Cumulative One-way Transport Capacity* and *Overall Moisture Management Capacity* have been defined and calculated to characterize test specimen’s liquid moisture management performance [1, 2]. The MMT can analyse a fabric’s ‘wicking’ properties in a standardised fashion in a matter of minutes.

2). Fabric Touch Tester

Evaluating a fabric’s tactile properties is crucial in the textiles and apparel industry. In 2006, Prof. Yi Li and his research team announced another innovative instrument, the *Fabric Touch Tester* (FTT), which measures the physical parameters associated with touch using a simple test taking just a few minutes [3]. This research has detailed how the sensory touch experience is determined by factors such as flexibility, compressibility, elasticity, resilience, density, surface contour (roughness, smoothness), surface friction, and thermal characteristics [4]. This project created scales which accurately grade and provide objective measures of the sensations evoked. The FTT can be used to generate a series of defined preferences to communicate requirements through the global supply chain rapidly, consistently and objectively.

3). Walter

A fabric’s thermal comfort is a combination of its thermal insulation and its evaporative resistance. Measuring thermal comfort accurately was impossible before Prof. Jintu Fan’s research team

invented the world's first sweating fabric thermal manikin - "Walter," at PolyU in 2002 [5]. *Walter* (US patent: 6543657) is different to previous manikins because *Walter* mimics humans. *Walter* is filled with water heated to 37°C circulating to simulate human body temperature distribution. His fabric 'skin' is covered in millions of micropores that mimic sweat glands and allow him to perspire enabling simultaneous testing of the total thermal insulation and moisture vapour resistance of fabrics. Prof. Fan's team showed that *Walter* demonstrates high accuracy and reproducibility. This technology can be invaluable in the design and evaluation of clothing for individuals operating in extreme environments as well as in testing everyday clothing's thermal comfort properties.

(3) References to the research

- [1] Hu, J., Li, Y., Yeung, K., Wong, A. and Xu, W. (2005). Moisture management tester: a method to characterize fabric liquid moisture management properties. *Textile Research Journal*, 75(1), 57-62. Citations = 187 (as of Nov 2019, Scopus)
- [2] Yao, B., Li, Y., Hu, Y., Kwok, Y. and Yeung, K. (2006). An improved test method for characterizing the dynamic liquid moisture transfer in porous polymeric materials. *Polymer Testing*, 25(5), 677-689. Citations = 71 (as of Nov 2019, Scopus)
- [3] Hu, J., Hes, L., Li, Y., Yeung, K. and Yao, B. (2006). Fabric Touch Tester: Integrated evaluation of thermal-mechanical sensory properties of polymeric materials. *Polymer Testing*, 25(8), 1081-1090. 10.1016/j.polymertesting.2006.07.008 Citations = 33 (as of Nov 2019, Scopus).
- [4] Liao, X., Li, Y., Hu, J., Wu, X. and Li, Q. (2014). A simultaneous measurement method to characterize touch properties of textile materials. *Fibers and Polymers*, 15(7), 1548-1559. Citations = 23 (as of Nov 2019, Scopus)
- [5] Fan, J. and Chen, Y. (2002). Measurement of clothing thermal insulation and moisture vapour resistance using a novel perspiring fabric thermal manikin. *Measurement Science and Technology*, 13, 1115-1123. Citations = 95 (as of Nov 2019, Scopus). Research funded by RGC grant PolyU5113/98E.

The MMT team received over HK\$2 million in research funding, FTT development was supported by around HK\$9.3 million from government project grants and consultancy (e.g., Winner Medical Co. Ltd. and P&G Technology Beijing Co. Ltd.).

(4) Details of the impact

PolyU has developed instruments which have enhanced product development, quality control, and product evaluation in the industry worldwide. Their commercialisation has economically benefited companies that license the technologies, as well as the global clothing brands that use our tools. Certified as the authorized instruments for international testing standards, they have become key tools in the global textiles market, and have also been used to support standards in the building industry. Prof. Yi Li worked at PolyU until August 2015 and continued to provide assistance on the development of MMT and FTT instruments during that time. Prof. Jintu Fan was at PolyU until 2012 and returned in September 2018. In his absence, PolyU colleagues including Dr Yuhau Au and Dr Ho Chu Po continued to contribute to creating impact with *Walter*.

Moisture Management Tester (MMT) – Textile manufacturers and clothing brands need precise instruments and standards for innovative product development. The MMT is the **only** instrument on the market that can precisely measure a fabric's liquid management properties: one 2-minute test can comprehensively profile a fabric's performance [A]. In 2015, MMT became the authorised tool for a **new national testing standard in China (FZ/T 73051)**. Four existing standards in the US, China and Taiwan based on the MMT had already been **extensively adopted by industries worldwide** during this assessment period [B]. This further illustrates MMT's growing value to industry.

The global market for moisture management fabrics is estimated to be over US\$ 2.6 billion in 2019. Initially concentrated in sportswear brands, such as Nike and Adidas, this market has spread, with global high street retailers such as Uniqlo stocking own brand clothing designed to wick away moisture.

The MMT is *licensed to SDL Atlas, the largest global supplier of testing equipment* to the textile industry. During the assessment period, *over 250 MMT units have been sold to over 42 countries* [B]. 25% of sales are direct to fabric manufacturers, a further 25% to retailers, military and other (e.g. medical). 50% of all sales are to laboratories which provide testing services to the industry at large such as *Centexbel*, a Belgium based textiles lab specialising in professional, military and protective clothing that provides services to a global customer base. *Cotton Inc*, who license two leading moisture management fabric technologies to manufacturers (Wicking Windows and TransDRY) use MMT measurements to illustrate their performance [C].

The SDL Atlas General Manager describes the benefits to their customers: *“MMT is used for R&D of new materials, quality control for production, and product warranty claim study; and its application field has been extended from the original target for sportswear to casual wear, medical textiles, personal hygiene, chemicals, and military... In addition to the country standards, some customers, especially the retailers also have their internal standards based on MMT, which their supply chain vendors also need to comply to”* [B].

The Chief Technology Officer at XXXXXX, *one of the world’s largest XXXXXX materials manufacturers*, supplying leading brands such as XXXXXX, explains the value of MMT to their business: *“Thermal-moisture comfort is an important factor which can significantly influence consumer’s purchase decision making process... Using MMT to objectively characterize fabric material properties is key for our product development... Objective evaluation data hugely benefits our quality control and communication within the whole supply chain. With the MMT data we can easily determine fabric functional performance in a grading system. We use MMT for first layer sportswear fabric development, more than 20 new fabrics will be developed annually with moisture one-way transfer properties.”* [D].

Fabric Touch Tester – ‘Hand-feel’ is vitally important in the textiles industry yet very difficult to describe. Previously, for a company wishing to objectively assess a fabric’s hand-feel qualities, the only option was the ‘Kawabata’ system, a very expensive test that takes an entire day. *The FTT is a 10 minute test enabling buyers and manufacturers to accurately communicate their wants, needs and available products.* The FTT provides a vocabulary and scale for measuring touch analogous to how a spectrophotometer provides colour measurement and description, with far reaching impact for the industry.

SDL Atlas licensed the *FTT* and between 1 October 2013 and December 2018 have *sold 42 FTT to 16 countries* (including semi-autonomous districts such as Hong Kong) [B]. The clients include fabric manufacturers, retailers, commercial labs, as well as universities and research institutes, in the U.S., the U.K., China, and Europe. An example is AITEX, one of Europe’s leading private textile research centres providing characterisation trials for a wide range of sectors including fashion, work wear, and sports and leisure.

“Feedback from customers has been extremely positive as the FTT is an innovative technology developed to resolve a long-lasting traditional issue of hand-feel and touch feel, in a prompt and economic way. This gives us a market-leading position as it is the only affordable single instrument system on the market that can accurately measure and quantify hand and skin touch sensations that correlate with human perception” General Manager, *SDL Atlas* [B].

This new invention is currently in the process of being adopted as an authorized national testing standard and instrument in China. *FTT* received the Grand Award for Equipment and Machinery Design from the Hong Kong Awards for Industries in 2016.

Walter - *Walter* has helped to **set international standards for thermal comfort**, reaching beyond the textiles industry into the building industry. In 2015, *Walter* was used to **expand the database on which 3 international standards are based - ASHRAE Standard 55, ISO 7730, and ISO 9920** - to include non-western clothing. These standards are used by heating, ventilation and air conditioning design engineers to ensure thermal comfort in residential, commercial and industrial buildings as well as vehicles. The database enables users “to make more accurate thermal comfort predictions under realistic conditions for people clothed in non-Western attire as applicable for buildings, aircraft, rail and road vehicles” [E]. The expanded database therefore **improves thermal comfort engineering** where non-western attire is common, resulting in more energy-efficient design.

Walter has also been used in numerous projects related to the **evaluation and improvement of functional uniforms**. In 2013-2015, PolyU used *Walter* in a project to help the Hong Kong Correctional Services Department (CSD) replace their uniforms by creating a data range for thermal comfort acceptable to the CSD for their tender document. The CSD’s Chief Officer stated that “the final recommendation on the technical specification was a proven success in sourcing the required waterproof fabric” [F]. *Walter* was also a key element in a PolyU project to design the Hong Kong Rowing Team’s uniforms for the 2014 Asian Games. *Walter*’s assessment allowed the selection of a lighter weight fabric that did not compromise thermal comfort, contributing to a 200g reduction on previous uniforms: “At the high level of competition, weight and any minor competitive advantage can be the difference between the gold medal and the silver medal. So, it was crucial for us to keep the weight to a minimum” said project sponsor Edwin Keh from the Hong Kong Research Institute of Textiles & Apparel [G]. The team came home with Hong Kong’s first Asia Games gold medal in rowing.

In April 2019, a new licensing agreement was signed between PolyU and *Shanghai Standard Textile Testing Ltd* for the **commercial manufacture and sale** of *Walter*. They have invested HK\$ 3.3M in *Walter*’s commercialisation and have already sold one unit to Sinosteel Wuhan Safety & Environmental Protection Research Institute [H].

(5) Sources to corroborate the impact

[A] SDL Atlas product MMT online product details (archived November 2019)

[B] Letter from General Manager, SDL Atlas about MMT and FTT, September 2019

[C] Cotton Inc TransDRY product brochure (2019)

[D] Letter from Chief Technology Officer, XXXXXX, October 2019

[E] Havenith G, Kuklane K, Fan J, Hodder S, Ouzzahra Y, Lundren K, Au Y, Loveday D. A database of static clothing thermal insulation and vapor permeability values of non-Western ensembles for use in ASHRAE Standard 55, ISO 7730, and ISO 9920, *ASHRAE Transactions*, Vol 121 <http://ira.lib.polyu.edu.hk/handle/10397/11723>

[F] Project Evaluation Report, April 2015, Chief Officer, Hong Kong Correctional Services Department

[G] HK Government news report on rowing uniforms (archived November 2019)

[H] Letter from General Manager, Shanghai General Standard Testing Technical Company, October 2019