Institution: Brunel University London		
Unit of Assessment: 12 Engineering		
Title of case study: Sustaining a UK Business through the Development of Polymer-based Water Meters		
Period when the underpinning research was undertaken: 2005-2013		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s): Karnik Tarverdi	**Role(s) (e.g. job title):** Professor	**Period(s) employed by submitting HEI:** 12/1980-present
Period when the claimed impact occurred: August 2013 – December 2020		
Is this case study continued from a case study submitted in 2014? Y		

1. Summary of the impact (indicative maximum 100 words)

Prof Tarverdi's research in polymer processing has led Elster, a global water meter manufacturer, to shift their business strategy and completely stop brass-based water meter production since 2013 and replace it with the production of polymer-based water meters. The new compounds based on Prof Tarverdi's research in the water meters have not only enhanced their performance but made their production quicker, cheaper and more environmentally sustainable.

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Elster assert that the research done with Brunel has enabled them to maintain both a production facility and a research and development centre in the UK (in Luton), helping to secure UK jobs, employment and exports. Elster have continued to invest in their UK Research and Development Centre, where they work with Prof Tarverdi and the production facility continues to produce all polymer-based water meters, selling to over 130 countries. Building on their continued success, in 2017 for instance, Elster successfully agreed with Vitens, the largest water supplier in the Netherlands to supply 600,000 V200P volumetric water meters.

2. Underpinning research (indicative maximum 500 words)

Prof Tarverdi, the Director of Extrusion Technology at Brunel, specialises in polymer processing and mechanical, thermodynamical, microscopic and elemental analyses of extrusion and injection moulding technologies. Due to his expertise, Prof Tarverdi was approached by Elster Metering Ltd in 2003 to help identify the factors influencing the wear and fatigue in the moving parts of their water meters and develop new materials to improve installation life-time and reduce maintenance costs.

Elster at that time was an international company specialising in advanced metering infrastructure, installing intelligent metering to the gas, electricity and water industries worldwide. It was subsequently acquired by Honeywell and became part of the Honeywell Group in 2015.

This initial relationship with Elster has developed into a long-term collaborative partnership, and this has continued to date, resulting in the enhancement of the material properties for manufacturing and moulding their water meters [Ref 1]. During this time, over 20 projects were commissioned and completed by the Brunel research team led by Prof Tarverdi.

In 2005, Prof Tarverdi examined the effects of using polycarbonate with 'nano-clay' in replacement of the metal and glass components in Elster meters [Ref 2] and concluded that nano-clay could be more beneficial as it could prevent moisture ingression, thereby maximising

the transparency of the polycarbonate moulding. This has opened up the possibility of using a new composite for Elster [Ref 3 and 4].

Subsequently, in 2008 and 2009, Prof Tarverdi explored potential compounds which could be used in water meters that could last much longer without corrosion. This research involved exposing a range of polymers to the chemicals in the water and the intensive rays of the sun (ultra-violet oxidation) to determine their susceptibility. He identified a specific set of acetal polymers which demonstrated minimal chemical degradation. In addition, he provided guidelines for connecting the meters into the water network in the presence of copper and bronze pipes. His research proved that some chemicals, which are supposed to enhance the properties of polymers [Ref 5], were not performing to the required standard to prevent polymer deterioration and degradation. The compounds used to manufacture the Elster meters did not seem to have had the optimum masterbatch (concentrated compounds) to prevent UV oxidation and degradation of the meters.

The project 'Ultrasonically Assisted Compounding for Masterbatch Production' [Ref 6] funded by the Technology Strategy Board 'Boosting Innovation in Manufacturing Competencies' in 2013, established that using nano-fillers such as nano-carbon black, pigments and antioxidants through ultrasonication could enhance the masterbatch productions. The industrial partners of the grant –Colloids Ltd., Telsonic, Omya, Johnson Matthey and Elster – were keen to achieve the maximum dispersion of nano-fillers and the research findings were fully incorporated into the production line by Elster to manufacture their components and assess its effectiveness.

3. References to the research (indicative maximum of six references)

Ref 1) K. Tarverdi, "Establishing the failure characteristics of small pistons", Elster Metering Technical Report 2005. Commercially sensitive. Available on request.

Ref 2) K. Tarverdi and S. Sontikaew, "Experimental study of extrusion and surface treatment of organo clay with PET nano-composites", Annual Technical Conference, Society of Plastic Engineers, ANTEC 2008 Milwaukee May 4-10, pp1387-1391. http://bura.brunel.ac.uk/handle/2438/7665

Ref 3) S. Sontikaew, "PET/Organoclay nano-composites", PhD Thesis, Brunel University 2008, http://bura.brunel.ac.uk/handle/2438/3280.

Ref 4) K. Tarverdi, "Experimental study of extrusion and surface treatment of organo clay with PET nano-composites", Polymer Process Engineering 2009, Enhanced Polymer Processing, IRC polymer engineering - University of Bradford, pp160-172 ISBN: 13-978-1-85143-262-2.

Ref 5) K. Tarverdi, "Chemical Attack – Acetal/Zinc Chloride and Creep Test Programme", Elster Metering Technical Report 2008. Commercially sensitive. Available on request.

Ref 6) Grant: Technology Strategy Board grant number 101272, Ultrasonically Assisted Compounding for Masterbatch Production, August 2013, GBP981,000.

4. Details of the impact (indicative maximum 750 words)

Prof Tarverdi's research on polymer compounds to enhance the properties of Elster's water meters has contributed significantly to their business success since 2013, providing more sustainable and innovative solutions for their water meter productions.

Manufacturing low carbon-footprint water meters in the UK

Having seen the initial success and potential of the polymer-based water meter, Prof Tarverdi's research led Elster to completely shift their production line from glass-based and brass-based water meters to polymer ones, shifting their business strategy. As a result, due to the flexibility of polymer-based design of the water meters, all metal machining was removed from the

production assembly lines. This change made production of the water meters quicker, cheaper and more environmentally sustainable. (E1)

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Establishing a sustainable business in the UK

After being acquired by Melrose Plc for GBP1,500,000,000 in 2012 – a 49% premium on its share price at the time – Elster was subsequently obtained by Honeywell at a premium of USD5,100,000,000 (approximately GBP3,800,000,000 [12-2020]) in December 2015. (E5) Elster employs over 7,000 staff across 39 countries and sells its products in over 130 countries.

Elster has 2 core manufacturing sites and 6 regional manufacturing sites in the world and one of its core manufacturing sites is located in the UK along with the Water Division Headquarters in Luton. All of the water meters manufactured in the UK now utilise the polymer-based on Prof Tarverdi's research. Elster emphasises the importance of working with Prof Tarverdi and setting up their Research and Development Centre in the UK:

> *'Working with Brunel has resulted in a change of materials strategy so that all new products are polymer based. Driven by the all-polymer meter, Elster has continued to maintain the work forces and establish the UK as the Research and Development Centre for water meters [sic] as well as maintaining the production facility and selling its products in over 130 countries.' (E1)*

The compounds based on Prof Tarverdi's research had been proved to enhance its performance and they provide 'optimum accuracy and performance regardless of whether they are installed in horizontal, vertical or inclined pipelines.' (E2)

This has led to a noticeable success in their business: for example, in 2017 Honeywell celebrated that Vitens, the largest water supplier in the Netherlands, selected their V200P volumetric water meters. Vitens serves approximately 5,600,000 people and companies, delivering 350,000,000m3 of water annually and Honeywell Elster has agreed to supply up to 600,000 water meters over the next few years. (E6)

5. Sources to corroborate the impact (indicative maximum of 10 references)

E1) Corroborating Letter from Honeywell

E2) Honeywell brochure V200 and V210

E3) Commercially sensitive information – [text removed for publication]

E4) Commercially sensitive information – [text removed for publication]

E5) "Honeywell Pays Premium to Acquire Metering Giant Elster in $5 Billion Deal" (28 July 2015) https://www.greentechmedia.com/articles/read/honeywell-pays-premium-to-acquire-metering-giant-elster-in-5-billion-deal#gs.mt552f

E6) Honeywell V200P Vitens case study