Institution: University of Salford

Unit of Assessment: B13: Electrical and Electronic Engineering, Metallurgy and Materials

Title of case study: Salford "Eco-valve": The next generation of consumer aerosols

1. Summary of the impact

Research at the University of Salford directed at the development of a new consumer aerosol without liquefied gas propellant; the Salford Eco-valve, demonstrates the following impact:

- Developing new, commercially viable, environmentally friendly spray and aerosol products in the healthcare, personal care, air-freshener, insecticide, cleaning, polish, cooking and painting fields, with acceptable product spraying properties but eliminating the Volatile Organic Compounds (VOCs) and Greenhouse Gas propellants currently used in the vast majority of aerosols;
- Successfully submitting a range of five inter-related international patent applications, all granted in the UK in 2011/12 under the Green Channel fast-track scheme for environmental innovations;
- Introducing the technology to consumer aerosol companies and influencing their change in focus towards aerosol technology which meets the requirements of potential EU directives on the reduction of VOCs in aerosols;
- Pursuing exploitation and licensing agreements with multinational companies to use the new technology, resulting in advanced stage negotiation with a preferred partner to acquire the global exclusive manufacturing and distribution rights for commercialisation.

2. Underpinning research

The key researchers and positions they held at the institution at the time of the research are as follows: Prof Ghasem Nasr, Professor of Mechanical Engineering and Innovation, (from 2001), School of Computing, Science and Engineering (Head of Research Centre: Engineering 2050 Research Centre from 2009-2011). Prof Nasr joined the University of Salford in 2001 bringing with him his research group and many years of experience in industrial and domestic sprays and atomisation. Research in the area of new generation aerosols has been conducted at the University of Salford since 2004 and focuses on four principal projects directed at new types of eco-valve and actuator for use in the consumer, healthcare and industrial aerosol sectors, with the commonly used liquefied gas propellant replaced by safe gases, whilst maintaining acceptable spraying performance. Research in the area of eco-valves and atomizers (inserts and actuators) for portable spraying devices, is underpinned by the following research:

- **2004-2006:** Via an STI/DTI award Nasr demonstrated the efficacy of linking spraying quality to atomizer designs in conditions where inert compressed gas acted as the propellant in the container of the spraying (aerosol) device, leading to novel insert designs (1st Patent).
- **2007-2012:** Demonstrating that acceptable spray quality for most applications could be produced only if a percentage of the gas in the container was bled into the atomizing nozzle, led to the patenting (2nd Patent) of new types of "bi-valve", bleeding gas into the valve to give the required bubbly flow in order that good spray quality could be achieved with a wide range of liquid products.
- **2008-2012:** Market research indicated that there was a special interest in new "metering valves" that used inert gases rather than liquefied gas propellants, such valves never having been successfully developed in the past. "Continuous spray" research has developed a novel compressed (inert) gas propellant metering valve suitable for both consumer and health applications (4th and 5th Patent).
- **2009-2012:** Demonstrating that a different approach was required in order to spray "difficult liquids" that tended to be viscous and/or emulsions or suspensions a third strand of research developed new "low loss" valve designs that permit spraying such liquids

successfully using compressed gas propellants (3rd Patent).

The primary technology is aerosol valve designs and design principles that generate a novel type of 'two-fluid atomisation':

- Two-fluid atomisation, also known as 'bubbly flow', is generated by injecting a small proportion of propellant directly into the passing flow of product within the aerosol valve assembly. The propellant is directly tapped off from the head space within the aerosol can.
- The bubbly flow passes un-impinged on to a conventional valve 'insert'. The interaction of the bubbly flow with the valve insert causes a flow attachment and reattachment phenomenon, generating a highly energised and turbulent state.
- The technique acts to reduce the subsequent droplet size of the product when dispensed from the valve, generating superior spray characteristics.
- In addition, by controlling the ratio of liquid to gas injected (via selecting the correct orifice sizes in the correct ratio), enables maintenance of consistent spray performance throughout the life of the can.

3. References to the research

Key outputs

1. Nasr G.G., Yule A.J., and Hughes T., April 2011, *A New Fine Spray, Low Flowrate, Spill-Return Swirl Atomizer* Journal of Mechanical Engineering Science, Proceedings of Institution of Mechanical Engineers, Part C, 225 (part-c), pp 897-908. DOI
2. Nasr, G & Enyi, C, 2013, *'Fine Spray Generation for Single-Wall Carbon Nanotubes (SWCNT) Production'*, Journal of Environmental Science and Engineering. DOI
3. G.C.Enyi, G.G.Nasr, 2012, *Effluent Treatment of Waste Water*, SPE Journal of Petroleum Technology, Vol. 64, No 4, pp 112 - 115. URL
4. Akanji, L T & Nasr, G and Bageri, M 2013, *'Core-scale Characterisation of Flow in Tight Arabian Formations'*, Journal of Petroleum Exploration and Production Technology, pp.1-9, Springer Link, 10.1007/s13202-013-0062-1. DOI
5. Enyi, C & Nasr, G & Burby, M, 2013, *'Economics of Waste Water Treatment in GTL Plant Using Spray Technique*', International Journal of Energy and Environment, vol. 4, issue 4, pp 561-572. URL
6. G. G. Nasr, A. Whitehead, A. J. Yule, 2012, '*Fine Sprays for Disinfection within Healthcare'*, Journal of Multiphyscis, June 2012, 6(2), pp.148-165. DOI **(REF 2)**
7. Nasr G.G. and Yule A.J, EPSRC Newsline, Nov 2006, The Power of Spray, pp 16-17.

Key grants

8. **2004-2005:** STI/DTI (STI/DTI (GR/S25821/02) Envirospray, EPSRC, £86,830.00.
9. **2004:** Spray Measurements for Actuator Design, CPF Research Ltd, £22,500.00.
10. **2013 :** New Product Development, KTP, £127,000

4. Details of the impact

- Both consumer opinion and legislation increasingly propose reduction in the use of hydro-carbons and other low boiling point propellants for consumer aerosols. The annual production of more than 12 billion consumer aerosol cans powered by VOCs may have replaced CFCs, but may still present a significant and growing source of greenhouse gas emissions. A revolutionary new eco-valve has been developed by University of Salford researchers; the Salford Eco-valve, working together with the UK, European and US aerosol industry, which demonstrates:
  - Replacing butane or other liquefied hydrocarbon gas with air, nitrogen or other non-flammable gas propellant;
  - Customer acceptable spray quality and consistency during can lifetime;
  - Using conventional cans and filling technology.
- Low-carbon flashing propellants replacements which reduce VOCs and greenhouse gases have been developed but have not achieved widespread adoption. A more

practical approach for the total replacement of VOCs and greenhouse gases has been found to be compressed gas (e.g. air or nitrogen) propellants.

- However, aerosols using compressed gas propellant with an outlet valve derived from conventional designs typically have poor spray characteristics (large droplet size) and a noticeable deterioration in performance during the life of the can as the product is used.
- Nasr demonstrates that atomisation can be improved by gas bubbles and turbulence inside the atomiser insert of the actuator, ensuring that compressed gas aerosols fitted with the eco-valve provided consistent pressure through life of the can and delivered the fine droplet spray qualities required by consumers.
- The main beneficiaries of the new development are global consumer goods companies who manufacture products such deodorants (the biggest single annual user of aerosol technology); hairsprays; air fresheners; polish; insecticide; disinfectant; shaving foam; food products (such as whipped cream, olive oil and cooking oil) and pharmaceutical application such as medical inhalers, and their customers.
- Nasr worked in partnership with multi-national manufacturers involved in the production and use of aerosols to collaborate on and take up the development. Key to this collaboration is working in partnership with advisors from the aerosol industry's manufacturing association who gave insights and guidance on the product to encourage take up.
- A portfolio of five patents protect the technological solutions that were developed to overcome long-standing problems of gradual loss of power and poor spray consistency that have hindered the previous adoption of the compressed air aerosol. The Salford Eco-valve works by inducing a 'bubbly' flow within the stem of the aerosol valve by injecting compressed gas into the passing flow, generating turbulence, thus creating an effect equal in look, feel and spray with current VOC (Volatile Organic Compound) powered systems.
  - Nasr, G. G., Yule, A. J. and Burby, M. L., 2009, Spray Discharge Assembly, Patent No. WO2011/061531, April 2011.
  - Nasr, G. G., Yule, A. J. and Burby, M. L., 2009, Aerosol Spray Device, Patent No. WO2011/128607, April 2011.
  - Nasr, G. G., Yule, A. J. and Burby, M. L., 2009, Low Loss Valve, Patent No. WO2011/061481, April 2011.
  - Nasr, G. G., Yule, A. J. and Burby, M. L., 2009, Liquid Dispensing Apparatus, Patent No. WO2011/042751, April 2011.
  - Nasr, G. G., Yule, A. J. and Burby, M. L., 2009, Liquid Dispensing Apparatus, Patent No. WO2011/042752, April 2011.
- Pilot production of 100,000 consumer aerosols is currently being arranged in collaboration with a UK consultancy and a European aerosol packaging company. See confidential information for details.
- An assignment of the eco-valve technology is being negotiated with a preferred partner for exclusive global manufacture, sales and distribution of the valves. See confidential information for details.
- The technology is already being evaluated for take up by a major commercial aerosol filling partner which is looking to invest in the next phase development of the valve.
- Numerous other major companies have also expressed interest in Salford eco-valve technology and constructive dialogue has progressed. Many of these companies have entered into formal evaluation and/or testing under appropriate non-disclosure agreements and material transfer agreements. See confidential information for details.
- The eco-valve technology will be presented to multinational aerosol companies during the FEA Exhibition in Sept 2013.

5. Sources to corroborate the impact (Provided in confidence owing to commercial sensitivity).