Institution: University of Aberdeen

Unit of Assessment: 15 (General Engineering)

Title of case study: Leak sealing technologies for the oil and gas industry

1. Summary of the impact

Research into computational fluid dynamics carried out at the University of Aberdeen has resulted in the development of the innovative platelet(R) technology for sealing leaks in pipelines and wells. This led to the creation of a spin-out company, Brinker Technology. Both in the UK and internationally, as far afield as Alaska and Oman, the technology has benefitted the oil and gas sector, leading to six-figure savings for client companies by minimising lost production time and postponing the expense of a permanent repair. The technology has also led to positive environmental impacts through the early sealing of leaks from oil wells and pipelines.

2. Underpinning research

Leaks in oil wells and pipelines can cost operators hundreds of thousands of pounds, both in direct repair costs and in terms of revenue lost when a well or pipeline sits idle. It is estimated that some 15% of the world's oil wells may be shut in awaiting repair at any one time. Major leaks can also cause serious environmental damage. Finding quicker and more cost-effective ways of sealing leaks has therefore been a priority for the oil industry.

It was on this issue that Ian McEwan, Professor of Environmental Fluid Mechanics at the University of Aberdeen, focused part of his work. Having joined the University of Aberdeen in 1991 as a Lecturer, his research in the 1990s had given him a strong track record in Environmental Hydraulics with particular emphasis on the movement of solid particles (e.g. sediment) in turbulent fluid flows, as well as wind-blown sand transport, fluvial sediment transport and discrete particle modelling. [1, 2]. This research context underpins the development of platelet(R) technology.

The development of the technology itself involved an incidence of scientific serendipity. McEwan cut his finger on a piece of paper, which happened to be a note from the EPSRC appealing for researchers to engage with the acute leakage problems of Britain's water supply industry. This made McEwan realize that the human body had its own effective mechanism for 'leak sealing', which in principle should be applicable to engineering systems.

By this time promoted to Reader, he then set about providing laboratory confirmation of the concept's potential. In 1999 a laboratory flow loop was constructed which was 8m long and 250 mm in diameter, with a working section into which transparent pipe containing known leaks could be inserted. The facility was capable of generating pressures of up to 5 bar and of producing conditions comparable to those commonly found in water supply systems. A programme of systematic testing was undertaken, leading McEwan and his team to make rapid progress in understanding the fluid mechanics of pipe leakage and refining the design of platelet technology(R). Clear 'proof of concept' was obtained during this project.

The platelet(R) technology works by injecting discrete sealing elements, known as 'platelets(R)', into a fluid flow upstream of a known or suspected leak. These are then conveyed to the leak vicinity, where a combination of pressure and flow causes one or more of the platelets(R) to be entrained, so stemming the leak. From the original mimetic insight, design strategies and expertise were developed for fabricating and deploying platelets(R) (generally polymers) suitable for diverse applications in a wide variety of pressurised flow systems.

However, there remained a substantial 'credibility gap' between demonstrations in laboratory conditions and first use of the technology in the field. In 1999, McEwan and his team secured a £150k 'Proof of Concept' Award from Scottish Enterprise to undertake a further 18-month development study. This project culminated in successful large-scale high pressure demonstrations of leak sealing before oil industry observers at the Industry Technology Facilitator (ITF) in Bridge of Don. The strength of positive industry response led directly to the spin-out of Brinker Technology.

3. References to the research

1. **McEwan**, I. K. & Willetts, B. B. (1993) *"Adaptation of the near surface wind to the development of sand transport*." Journal of Fluid Mechanics, 252, 99-115.

2. Sørensen, M. & **McEwan**, I. K. (1996) *"On mid-trajectory collisions during sand transport by wind."* Sedimentology, 43, 65-76.

3. Nikora, V. I., Goring, D. G., **McEwan**, I. K. & Griffiths, G. (2001) *"Spatially-averaged open channel flow over a rough bed"*, Journal of Hydraulic Engineering, ASCE, 127(2), 123-133.

4. McEwan, I. K. & Heald, J. G. C. (2001) *"Discrete particle modelling of uniformly-sized sediment* ***beds****: Entrainment."* Journal of Hydraulic Engineering, ASCE, 127(7), 588-597.

5. **McEwan**, I.K., Sørensen, M. Heald, J. G. C, Tait, S. J., Cunningham, G. J., Goring, D. G. & Willetts, B. B. (2003) *"Probabilistic Modeling of Bed-load Composition."* Journal of Hydraulic Engineering, ASCE, 130(2), 129-139.

6. Heald, J., **McEwan**, I. K. and Tait, S. (2004) *"Sediment transport over a flat bed in a unidirectional flow: simulations and validation."* Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 362 (1822). 1973-1986.

4. Details of the impact

Impacts of the research have been both commercial – through the successful spin-out company, Brinker Technology – and environmental. They have been significant both in the UK and a number of other countries across the globe. The principal benefit to Brinker's clients has been in the cost savings achieved through minimising lost production time.

Brinker Technology Ltd was spun out of the School of Engineering in 2002 (with McEwan taking on the role of Technical Director). It grew rapidly to become a world leader in leak sealing applications both for oil and for gas. The company's staff grew from 6 in 2004 to 30 by 2008, reaching a peak of 34 in 2011. Sales turnover increased from £900K in 2006-7, peaking at £4,479K in 2009/10 [1]. These figures demonstrate that the company achieved maximum commercial performance after 2008.

Since 2008 the platelet(R) technology has been used in various projects for the international oil and gas sector. One example was a project for ConocoPhillips [2], where the technology was used to address five highly problematic annuli leaks (the annulus being a void between piping and the casing surrounding it) in down-hole oil wells in the Kuparuk oil field in Alaska in 2009. Wells with annuli leaks usually require costly and time-consuming work to excavate and remove the conductor casing in order to patch the leaking casing.

For one particular operation in Kuparuk, the Brinker Technology team identified a leak with an equivalent diameter of 3mm and an approximately round geometry. A single type of Platelet® was selected for the seal, and a small number displaced to the leak via the annular wing valve. It is estimated the leak volume was approximately 1.0-1.25 litres/second (0.5 barrels/minute) [b]. Annular pressure rose as soon as the Platelets® reached the target depth. The operation stopped the casing to formation communication, and the well passed a Mechanical Integrity Test (MIT) at 1,800 psi to reinstate full service qualification. It is understood that production was regained far more quickly than conventional methods would have allowed. The temporary repair postponed the need for an expensive rig workover. In addition, the local environment benefitted due to the reduction in waste water leakage. The leak was confirmed as still holding 11 months after deployment [2].

In a further example, the technology was applied to remedy leaks in seven wells in Oman in 2011. The wells were suffering from various well integrity issues. The oil producing wells had been shut in for between 6 months and 5 years whereas the water injection wells were flowing, but with restrictions placed upon them in terms of operational use. To eliminate the requirement for a rig workover of these wells, Brinker engineers rebuilt the integrity of the wellhead via a dynamic, flexible, and robust seal while ensuring that full functionality was retained. As a result, the wells were brought back into production sooner than previously planned, with significant well intervention time savings, significant workover cost reductions, and significantly reduced health and safety risk compared to alternative means of remedial work. For just one well, the Petroleum Development Company of Oman [3] estimates that a conventional workover would have incurred at least US$200,000 in deferment costs over 8 days, while deferment for the chosen Brinker method was just a few hours. All seven wellheads were repaired within 45 man hours.

Brinker Technology has undertaken around 60 similar projects since 2008 [4], all based on the original technology. 67% of the company's total sales revenue was earned in or after 2008. Other companies that have benefitted from the technology include BP; Aker Kvaerner; and Shell.

Brinker Technology Ltd won Scottish Offshore Achievement Awards in 2008 and 2010 (Innovator Award) [6]; Best Well Invention Technology at the World Oil Awards in 2010 [7], and the Harts E&P Magazine Meritorious Award for Engineering Excellence in 2011; each on the basis of the novel technology developed. These and other awards were reported in a range of media, raising awareness of the technology and its significance among the general public, including BBC News online (March 2008 and April 2012) [8]. Coverage in technical and trade publications, such as in Scandinavian Oil-Gas Magazine (May 2011) [9], has raised understanding of the technology among international oil and gas industry practitioners.

5. Sources to corroborate the impact

1. *The Deputy Director Research & Innovation, University of Aberdeen can provide access to annual reports to corroborate the commercial performance of the spin-out company.*

2. M.J. Loveland, P. Klein, N. J. Ryan, C. Bowie, Sealing casing leaks through the remote deployment of discrete particles, SPE technical paper 130428, 2010.
   This document corroborates the benefits derived for the Kuparuk project.

3. A member of staff at Well Integrity Focal Point, Petroleum Development Company of Oman will corroborate the commercial and other benefits of the technology as applied on behalf of PDO.

4. A Well Integrity Project Supervisor, ConocoPhillips Alaska, Inc. can corroborate the commercial and other benefits of the technology as applied on behalf of ConocoPhillips.

5. A former Director of Brinker Technology Ltd, now at Steer Energy can corroborate the level of activity and breadth of projects undertaken by the spin-out company.

6. Scottish Offshore Achievement Awards 2010. http://www.scottish-enterprise.presscentre.com/content/Detail.aspx?ReleaseID=515&NewsAreaID=2

7. World Oil Awards 2010. http://www.worldoil.com/press-detail.aspx?PressContentID=74130

8. BBC News online coverage, April 2012. http://www.bbc.co.uk/news/uk-scotland-scotland-business-17793825

9. Scandinavian Oil-Gas Magazine coverage, May. 2011. http://www.scandoil.com/bm.tags/brinker-technology/

10. http://www.technologyreview.com/news/407023/self-healing-pipelines/
This source corroborates the individual cost savings to individual oil companies on a given project on which the technology was applied.