Institution:	University of Northumbria at Newcastle
Unit of Assessment:	15 - General Engineering
Title of case study:	Improving performance of metal cutting tools for SNA Europe

1. Summary of the impact

SNA Europe is an international company employing 2,500 people in 20 countries. The Unit's research on the mechanics of metal removal and coating techniques had an impact on the company's product design, product performance and the manufacturing process. The benefits to SNA Europe since 2008 include:

- 140 per cent per annum return on the research investment;
- New sales of £2 million on 800,000 units/annum generated by the new products;
- Reduced manufacturing costs and improved life time (hacksaw blades by 12 per cent and eight per cent, respectively; bandsaw blades by 11 per cent and nine per cent, respectively);
- Reduced manufacturing time for the bandsaw and hacksaw blades by 10%.

2. Underpinning research

The research on the improvement of the performance of metal cutting tools with SNA Europe, was led by the Unit's staff, Professor Sarwar (retired as Chair in Manufacturing, July 1994 – July 2011) and Dr Daadbin (Senior Lecturer, 1990 – present) during the 1998-2012 period. Cutting tool industries face enormous challenge in terms of economical machining of titanium alloys such as Ti-17. The generation of high thermal and mechanical stresses in cutting tools during machining of titanium alloys accelerates tool wear and therefore significantly affects tool life, productivity and product quality. The application of advanced coatings on cutting tools has become the current trend in improving tool performance when machining titanium alloys. More recently, nano-structured TiAlSiN coating has attracted increasing attention over traditional TiN coating, mainly due to its superior oxidation resistance at elevated temperature and improved mechanical properties, which are ideal for machining titanium alloys.

The collaboration with SNA Europe started in 1998, when the company approached the Unit to provide leverage on its cutting tools and surface engineering expertise. Subsequently, the research focused on understanding the fundamental mechanisms of material removal using existing tools, evaluating their optimum performance, efficiency and lifespan (1). Later in 2000, the research moved on to evaluate scientifically metal removing by measuring the forces, specific cutting energy and metal removing rate (2, 3), as well as monitoring and characterising the wear modes and mechanisms (4). The research areas of special interest were the cutting performance for wear-resistant and difficult-to-cut materials such as ball bearing steel, stainless steel, Ni–Cr–Mo steel and titanium alloy (Ti-17, which is widely used in aerospace industry). The research findings in 2003 were a set of optimised geometry and shape of the cutting teeth in terms of the kerf width, pitch, rake and clearance angles for hacksaw and bandsaw blades.

In 2008, the research focused on the depositing of special coatings on the surface of cemented tungsten carbide cutting tools, in order to increase their toughness and wear resistance (5). A wide range of materials with different coatings was tested and the finished tooth surfaces were investigated using electron microscopy. We used the arc evaporation Physical Vapour Deposition technique for the two selected coatings (AlTiN and TiAlSiN), which were chosen due to their properties of wear resistance and structure (6): TiAlSiN is nano-structured, while AlTiN is conventional in terms of its grain size. The finished structures were characterised using electron microscopy and nano-indentation, showing considerable improvement in their performance.

3. References to the research

1. *****Haider, J., Sarwar, M., Rahman, M. and Hashmi, M.S.J. (2008) 'Investigating the wear characteristics of engineered surfaces: low-temperature plasma nitriding and TiN + MoSx hard-solid coating lubricant coating', *Journal of Materials Science*, **43** (10), 3368–3376, DOI: 10.1007/s10853-008-2471-y
2. *****Haider, J., Sarwar, M., Persson, M. and Hellbergh, H. (2009) 'Measurement of specific cutting energy for evaluating the efficiency of bandsawing different workpiece materials', *International Journal of Machine Tools and Manufacture*, **49** (12), 958–965, DOI: 10.1016/j.ijmachtools.2009.06.008
3. *****Haider, J. and Sarwar, M. (2010) 'Aspects of burr formation in bandsaw teeth manufactured by milling operation', *Robotics and Computer-Integrated Manufacturing*, **26** (6), 596–601. DOI: 10.1016/j.rcim.2010.06.025
4. Haider, J., Sarwar, M., Persson, M. and Hellbergh, H. (2010) 'Forces, wear modes, and mechanisms in bandsawing steel workpieces', *Procs. of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, **224** (11): 1655-1662, DOI: 10.1243/09544054JEM1872
5. Haider, J., Sarwar, M. and Dinsdale, M. (2012) 'Development of advanced broaching tool for machining titanium alloy', *Advanced Materials Research*, **445**, 161-166, DOI: 10.4028/www.scientific.net/AMR.445.161
6. Fahd, K., Daadbin, A., Haider, J., Persson, M. and Hellbergh, H. (2012) 'Assessing the performance of TiAlSiN coating on bandsaw tooth when cutting Ti-17 alloy', *Procs. IMechE Part B: J Engineering Manufacture*, **226** (5), 870-877, DOI: 10.1177/0954405411431194

***** denotes the references that best indicate the quality of the underpinning research.

Related Funding

- SNA Europe grant support: £400,000 (1998-2009); £200,000 (2006-2012); £180,000 (2008-2012).

4. Details of the impact

SNA Europe is an international company and one of the world's oldest continuous producers of hand tools. It employs approximately 2,500 people in over 20 countries across the world. The company produces a wide range of metal cutting and hand tools for its numerous clients in the machine-building industry, buildings construction, automotive industry, green sectors and agriculture. Its market presence spans from Santiago (Chile) to Auckland (New Zealand).

The research undertaken by the Unit (1998-2012), in close collaboration with SNA Europe, has resulted in the development of new tooth design for metal cutting tools (2003), new coating techniques (2008) and new production technologies (2009). The products underpinned by the Unit's research are marketed and sold internationally and include well-known retailers such as B&Q, Homebase, Catalogue, Screwfix, RS, Farnell, as well as specialised shops.

Testimony from SNA Europe states:

> "*The design and performance of a range of metal cutting tools alongside with the technology of their manufacturing have been significantly improved as the outcome of the Unit's research. Investigations carried out at Northumbria University on improving the design, coatings and manufacture process of metal cutting tools was profoundly beneficial for the commercial activity of the company, increasing selling revenue across Europe and especially in South America and Far East and resulting in further strengthening company's position in the metal cutting tools market.*"

The products impacted by the underpinning research from the Unit are the bimetal bandsaw and carbide bandsaw blades. These include the KT- and KS-series (made in China) and the PQ-, the new PF-, TSS- and TSQ-series (made in Bramley, UK). These products cater for the "difficult-to-cut" materials and shapes. The TSS-series, for example, is a unique and patented tooth design: a triple chip tooth with rake angle of 10°, ideal for cutting large difficult and abrasive materials.

SNA Europe has confirmed the following, benefits as a result of the research. Since 2008, the impacts include:

1. 140% per annum return on the research investment

This impact was calculated from sales of products for which the Unit's research has influenced the design, performance and manufacture process. Other non-tangible benefits include product sales safeguarded, market position improvement, enhanced company profile, jobs safeguarded and increased employment**.**

2. New sales revenue of £2 million on 800,000 units/annum

This was achieved through the development of new products as a result of the Unit's research, which led to the introduction of closer process control of tooth manufacturing and hardening for the critical 1mm cutting edge (2009). This maintains tooth geometry and cutting edge, providing a lower specific cutting energy and a vastly improved tool life.

The research on the single tooth testing of metal saws led to an industrial version of the method being developed for SNA Europe (2003). The research showed that it is possible to simulate the function and wear of a metal saw by testing a single tooth instead of the full saws. This has greatly simplified the manufacturing of prototypes as well as the testing of saws and has led to a much shorter time to market for new products. The newly-developed method has been implemented (2009). The advantage offered by this new method is the ability to conduct experiments while eliminating the secondary factors influencing test results. As a result, the accuracy of the data is improved.

3. Reduced manufacturing costs and improved life time (hacksaw blades: by 12% and 8% respectively; bandsaw blades: by 11% and 9%, respectively)

This impact has been achieved through process optimisation and an improved manufacturing process, which were underpinned by the Unit's research. An example of this is the development and implementation of a company standard for grinding discs used in the manufacturing of hacksaw blades (2010). The reduction in grinding wheel dressing has resulted in an improved cutting edge surface finish and reduced grinding wheel usage. Minimising manufacturing consumables has resulted in reduced cost and process time, i.e. reduced dressing and wheel replacement times, and improved productivity. These improvements resulted in reduction of manufacturing costs by 12% and 11% for hacksaw and bandsaw respectively, and improved the life time of these blades by 11% (hacksaw) and 9% (bandsaw). Several fundamental processes, such as milling, grinding, and setting, have been thoroughly investigated and resulted in much improved products and yield.

4. Reduced manufacturing time for bandsaw and hacksaw blades by 10%

This impact is due to the research findings from the Unit on the manufacturing process optimisation techniques which were implemented by SNA Europe. The research work focused on the standard of grinding discs as mentioned in section 4.3 above, has led to reduced manufacturing time of carbide tipped bandsaws. Similar work on the grinding and milling process of bimetal bandsaws has strongly contributed to the reduced manufacturing time of those products. The research work methods have been implemented within the production of hacksaw blades with similar achievements in manufacturing time reduction.

5. Sources to corroborate the impact

The Director of Bimetal Projects (retired December 2012, now working for SNA Europe as a part time consultant) has provided a statement corroborating all of the impacts claimed.

A Research Engineer at SNA Europe has provided a statement corroborating all of the impacts claimed.

Both of these contacts were the industrial supervisors for the project.