USES Conf. Proc. 01 (2014); doi: 10.15445/01022014.12

Bringing Engineering Quality to the Surface

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Abstract

It is well known that it is the surface of almost every engineering product or component that will define its lifetime and performance. The surface is where corrosion and wear occur, where friction is generated and where cracks and defects can have their most profound effect on the component's strength and fatigue life. Also, since the surface is the part we see, it brings aesthetic attributes which should be maintained over the service life. The critical nature of the surface doesn't, however, end with the lifetime-defining properties. The surface is also key to the achievement of vital physical functionalities – such as biocompatibility, thermal conductivity and optical properties such as the reflectivity. Electronic and magnetic characteristics are also often controlled by the surface.

It would be no exaggeration to claim that none of the great technological achievements in new products over recent years could have occurred without major developments in processes and techniques to impart previously unachievable surface properties. This is true whether we speak about the screen of an iPad (with wear- and crack-resisting touch screen capabilities), modern high economy diesel engines with injectors which have a thin low friction wear-resisting surface, or the surface of a hard disc drive which is designed to protect against damage and data-loss during a read-write head crash. These are just a few of the products which we now take for granted but which could not have been created even a few decades ago, were it not for the development of exciting new coating and treatment processes. Many of these processes utilise a plasma or gas discharge to assist in the deposition process (1). Usually this is created in a vacuum, but it may also be created at atmospheric pressure and even in a liquid (2).

This talk will speak about the development of these plasma assisted processes, providing a brief chronology of their development (demonstrating 4 "waves" of innovation (1)) and explain how researchers in the Research Centre in Surface Engineering have had a significant role in these developments, over a period of almost 30 years. Part of this research success has arisen through the group's ability to span technologies; i.e not only the coating and treatment processes but also the application-related technologies (such as the materials processing and manufacturing fields in which the coatings are used (for example on tooling) and the diverse sectors in which the coated products are used (such as automotive, aerospace and energy).

It is probably not widely realised that the surface coating industry is one of the most important manufacturing sectors in the UK. This has been demonstrated in studies over the past 20 years (3, 4, 5). The most recent findings are that the UK surface coatings industry has a turnover of about £11 billion, the products critically affected by coatings have a value of over £140 billion, and these are used in industrial sectors which together have a turnover value in excess of £383 billion to the UK economy each year (6).

The Sheffield surface engineering research has been particularly driven towards applications-related developments, often with funding directly from industry and sometimes through joint support from industry and government (such as the EPSRC and/or TSB). The talk will mention some of these success stories, such as the replacement of a steel-bronze bearing on the Airbus A380 landing gear with one made from titanium (7). The design thinking behind the development of this innovation will be mentioned, which includes the production of a load-supporting plasma diffusion treatment in combination with an advanced coating with enhanced mechanical properties having an optimized ratio between the hardness and the elastic modulus (8, 9, 10, 11, 12).

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Keywords Surface Engineering; Coating; Plasma; Tribology

By taking an estimated 400 kg of weight out of each Airbus plane, the anticipated fuel cost savings over the life of each aircraft is £7.6 million and the reduction in CO_2 emissions is 36,000 tonnes per aircraft. Undercarriage bearing for Airbus A350/A80 developed with industrial partners Airbus, Minebea and Tecvac/Wallwork. (Research at Sheffield supported by TSB and EPSRC.)