Materials Day 2007: Sticking and Sliding, Wearing and Tearing

Tribology and Adhesion Issues in Materials Science

«Manufacturing by subtractive and additive processes: wear and inkjet printing»

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This lecture will focus on two uncommon groups of manufacturing processes, one involving the removal of material from a surface, and the other the addition of material.

Wear, the loss of material, is usually assumed to be undesirable, yet exactly the same mechanisms which are responsible for wear can also be employed usefully in a wide range of manufacturing processes. The least rapid wear of sliding surfaces is associated with the mixed chemical and mechanical processes of 'mild' wear, for both metals and ceramics. 'Severe' wear is predominantly mechanical, while the presence of hard particles leads to either abrasive or erosive wear. All can be exploited for useful purposes. Abrasion is very widely used in the processes of grinding and honing, not only to remove material in a controlled manner and achieve desired levels of roughness, but also to produce well-defined patterns of surface grooves to enhance lubrication. Smaller abrasive particles are used in polishing, to produce surfaces with well-controlled topography and form. In some applications such as the planarization of semiconductor chips, mechanical and chemical processes are combined. The impact of hard particles, leading to erosive wear, has been used for more than a century for cutting and shaping brittle materials; modern implementations include accurate machining by fine-scale abrasive water jets, as well as by streams of airborne abrasive particles. Soft abrasive or erosive particles can be used to clean coatings and other deposits from a harder surface while causing minimal damage, and applications of this approach include the design of toothpastes and the removal of scale deposits from oil-wells.

The technology of ink-jet printing has led since its inception in the 1970s to the growth of a massive industry. From early uses to print bar-codes and sell-by dates on consumer products, ink-jet printing has become a widely-used process for home and office printing, and is now also finding increasing industrial application, not only for conventional printing but also for manufacturing. For example the unique features of ink-jet printing allow the deposition of biological and electronically-active materials, to make bio-active arrays and flat-panel displays based on light-emitting polymers. The two basic techniques of continuous and drop-on-demand ink-jet printing will be described, and the challenges involved in developing them further, and in handling complex fluids, will be discussed. New experimental techniques involving high-speed photography and digital image analysis are being used at the Inkjet Research Centre in Cambridge to study the development of small-scale liquid jets and drops, and recent results from this work will be reviewed.