

Thin layer activation for measurement of wear and corrosion

Harwell has developed a highly sensitive method of measuring the amount of material loss due to wear, corrosion, erosion, sputtering, etc., which can be applied to a wide range of materials.



A valve seating being positioned in the irradiation jig

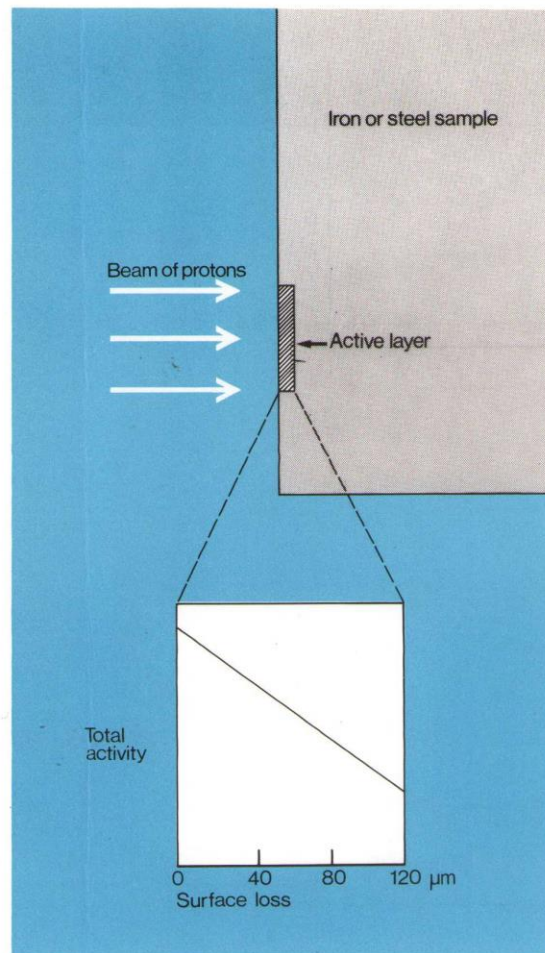
The thin layer activation technique

A thin radioactive layer is produced within a small surface area of the material subject to wear. The difference in radioactivity caused by wear of the thin surface layer is measured and the amount of wear can be calculated. The extent of the layer is usually between $50\ \mu\text{m}$ and $300\ \mu\text{m}$; layers less than $10\ \mu\text{m}$ and greater than $1000\ \mu\text{m}$ can be produced as required.

The technique is suitable for a number of materials, including most of the common engineering materials such as iron, copper, aluminium and carbon (diamonds). It is also suitable for composites containing these materials e.g. steels, brass, carbides, plastics, ceramics and abrasives.

The principle features are:

- It is possible to measure small surface loss; for a $50\ \mu\text{m}$ layer, the sensitivity is $0.5\ \mu\text{m}$ (generally 1% of the active layer).
- It is possible to measure wear or corrosion inside equipment without dismantling.
- It can be applied in open situations where the debris cannot be collected.
- The total activity is very low, often little more than that on the luminous dial of an ordinary wristwatch. For most applications this should allow exemption from "Radioactive Substance" regulations.
- The activated area is usually of the order of $3\ \text{mm}^2$ but areas up to $5\ \text{cm}^2$ can be irradiated as required. For larger areas it is often possible to arrange to move the sample during irradiation.



Thin layer activation of iron or steel by a proton beam

Typical applications

The method is being applied to study wear in a variety of engine components (viz. cam followers, cylinder liners, fuel injectors, valve inserts, etc.) It is also being developed to study corrosion rates in aqueous and hostile environments.

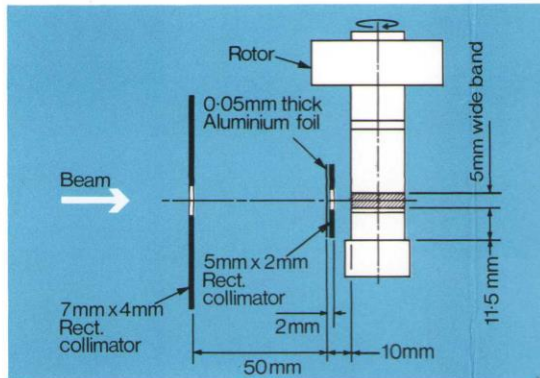
A recent measurement of erosion due to an electrical plasma yielded a rate of $35.4 \pm 7\ \text{\AA}$ per plasma pulse.

The effectiveness of surface treatment in reducing wear and corrosion can also be evaluated by this technique.

Some users' comments

C.A.V. Ltd.

"The wear rate of diesel fuel injection equipment can vary depending on the duty and the fuel used. Thin layer activation is being used as a method of on-line wear measurement to investigate the behaviour of critical components of fuel injection equipment under a variety of operating conditions."



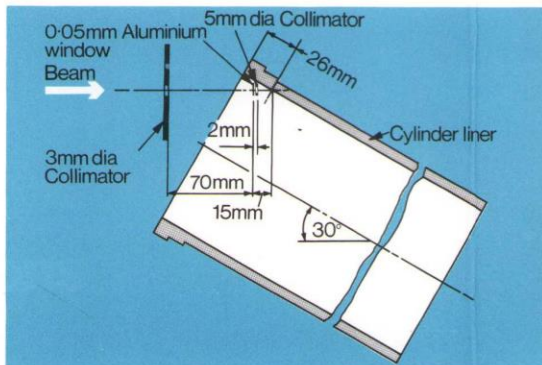
Schematic arrangement for the irradiation of a fuel injection rotor



An injection rotor being positioned in the irradiation jig

British Petroleum Company

"In engine testing of lubricants, one of the variables most often investigated is the wear rate of the components. At the BP Research Centre, cylinder liners have been activated to a known depth for the assessment of anti-wear properties of lubricating oils, giving a means of considerably reducing test time."



Schematic arrangement for the irradiation of a cylinder liner



A cylinder liner being positioned in the irradiation jig

CEGB (Berkeley)

"Graphite is a widely used bearing material in gas cooled reactor technology. The Tribology Section at Berkeley Nuclear Laboratories of the CEGB has investigated the use of the technique with the graphite for extrapolation of lifetime behaviour from short endurance tests on components. For such extrapolations to have validity, very accurate measurements of small wear volumes must be made."

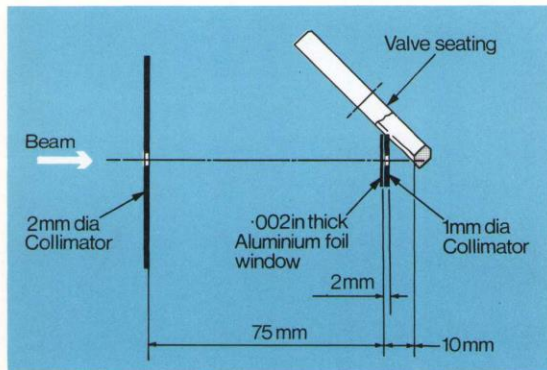
CEGB (Leatherhead)*

"Study of long term corrosion/erosion behaviour of steel surfaces in high temperature, high velocity water requires the extrapolation of data from short term tests, and an intimate knowledge of the processes involved. Thin layer activation may provide a means of accurately monitoring the small corrosion/erosion losses expected with time, and give information on the mechanisms involved."

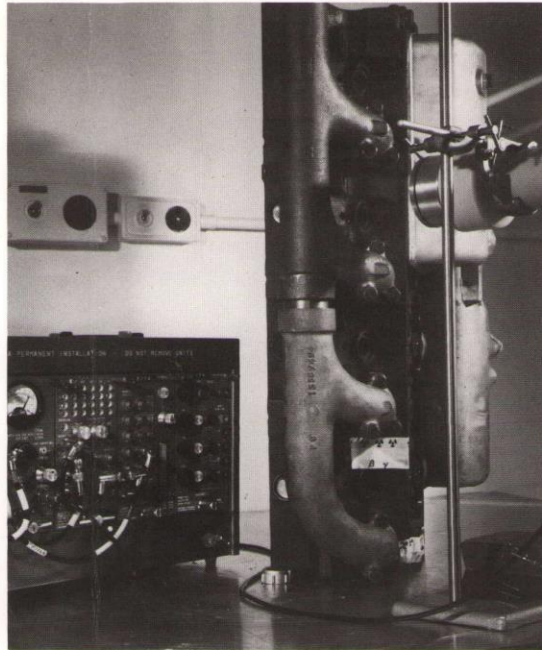
Perkins Engine Co.Ltd.

"The wear of cast iron and alloy irons in diesel engine valve seats is being examined by Perkins Engine Research Engineering Department. Accurate measurement of small amounts of wear occurring during short accelerated tests was required.

One of the techniques of wear detection and measurement investigated was the thin layer activation technique."



Schematic arrangement for the irradiation of a valve seating



Calibration tests on an activated valve seating

Ricardo & Co.Ltd.*

"The wear of gears in the drives of prototype engines has two components. Initial short term attrition occurs due to minor imperfections, debris such as fine casting sand from new casting and, possibly, very fine metallic particles from the initial running of other components. As the period of operation under load continues this attrition ceases and is replaced by one of two further wear regimes. In the "good" case the fine scratches produced during the initial phase are polished out, the rubbing surfaces of the gear teeth take on a highly polished appearance and the wear rate is very low. In the "bad" case with incompatible materials, excessive peak loading or inadequate lubrication the scratches initiate scuffing and rapid wear. With the normal procedure it is necessary to visually examine the gears after short periods of running which introduces uncertainties due to the stripping and rebuilding.

Using a "spot" irradiation at three points around the gears, in conjunction with a fixed location monitoring point on the gear case, the "wear" can be monitored without stripping the engines and the extent of the initial phase and time to the transition can be readily determined."

*Subject to contract

British Rail

"The technique shows great promise for examining in detail the surface loss of rails and railway wheels due to wear and corrosion which, till now, could only be assessed crudely using profilometry."

Business arrangements

Initial discussions are free and without obligation. A written proposal is made before a client incurs any cost. Our experience in protecting information ensures that the interests of clients can be dealt with in strict confidence.

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