Notes Visit to Surface Transforms

Friday 4 April

<u>To see a demonstration of the inductive system developed by XXX to measure the wear in silicon carbide disc breaks.</u>

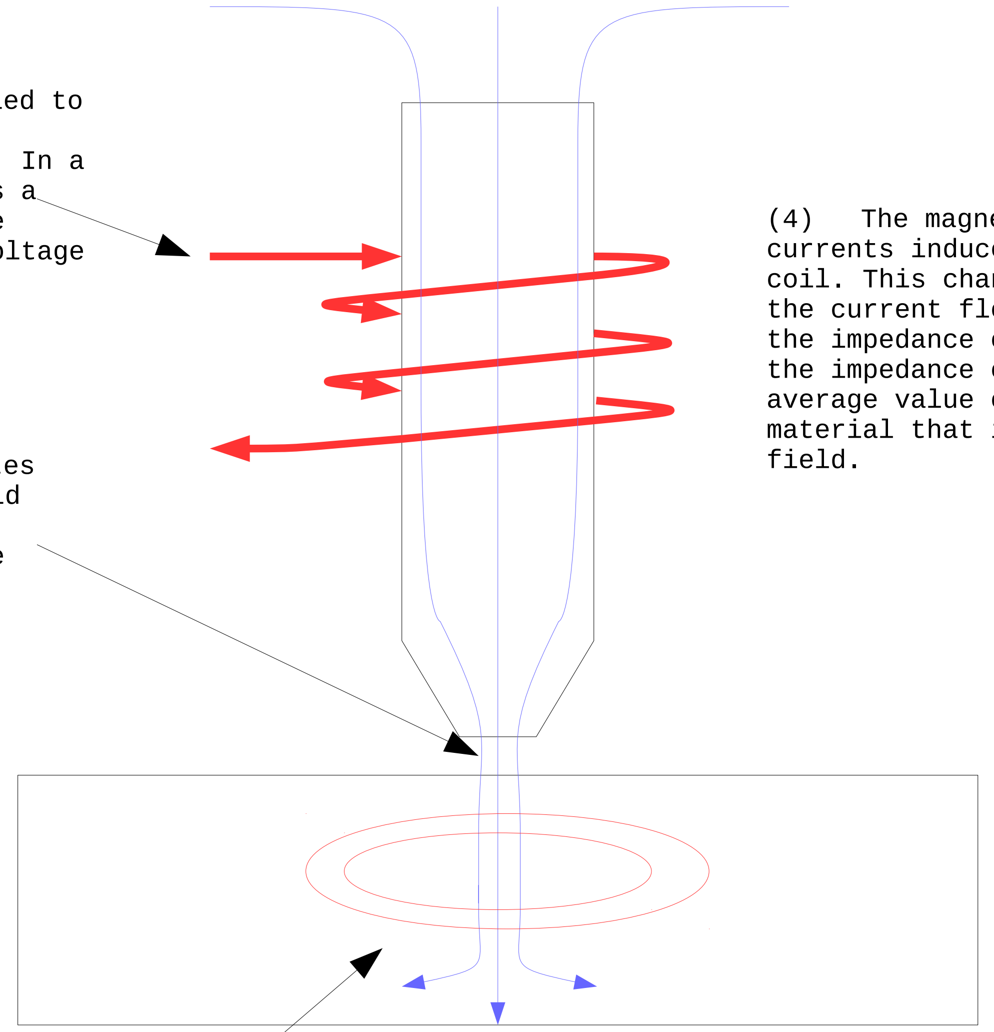
The system is inductive and works by inducing eddy currents into the disc. These are monitored by measuring the impedance of the induction coil. Currently a reading of 100 indicates a disc with maximum conductivity. This is an arbitry scale set by current commercial disc supplier. As the conductivity falls due to oxidation (of the silicon?) so the reading falls indicating wear. ST discs have much better conductivity(electrical and thermal) and so the reading was saturated at 100. Changing the algorithm with in the device to deal with the higher conductivity ST discs should be trivial. It is claimed that the device probes the whole thickness of the disc over an area of many square centimetres. Note ST discs have an additional durable surface layer, for ST this layer needs to be characterised. Therefore the surface sensitivity of any characterisation technique needs to be optimised.

It would not appear difficult to build a laboratory demonstrator using standard commercial components. The inductive system is shown below.

(1) An AC voltage is applied to the coil which causes an AC current to flow in the coil. In a pure inductor(coil) there is a well defined 90 degree phase shift between the applied voltage and the current.

(2) The AC current generates a time varying magnetic field that is concentrated by the magnetic material within the core of the coil.

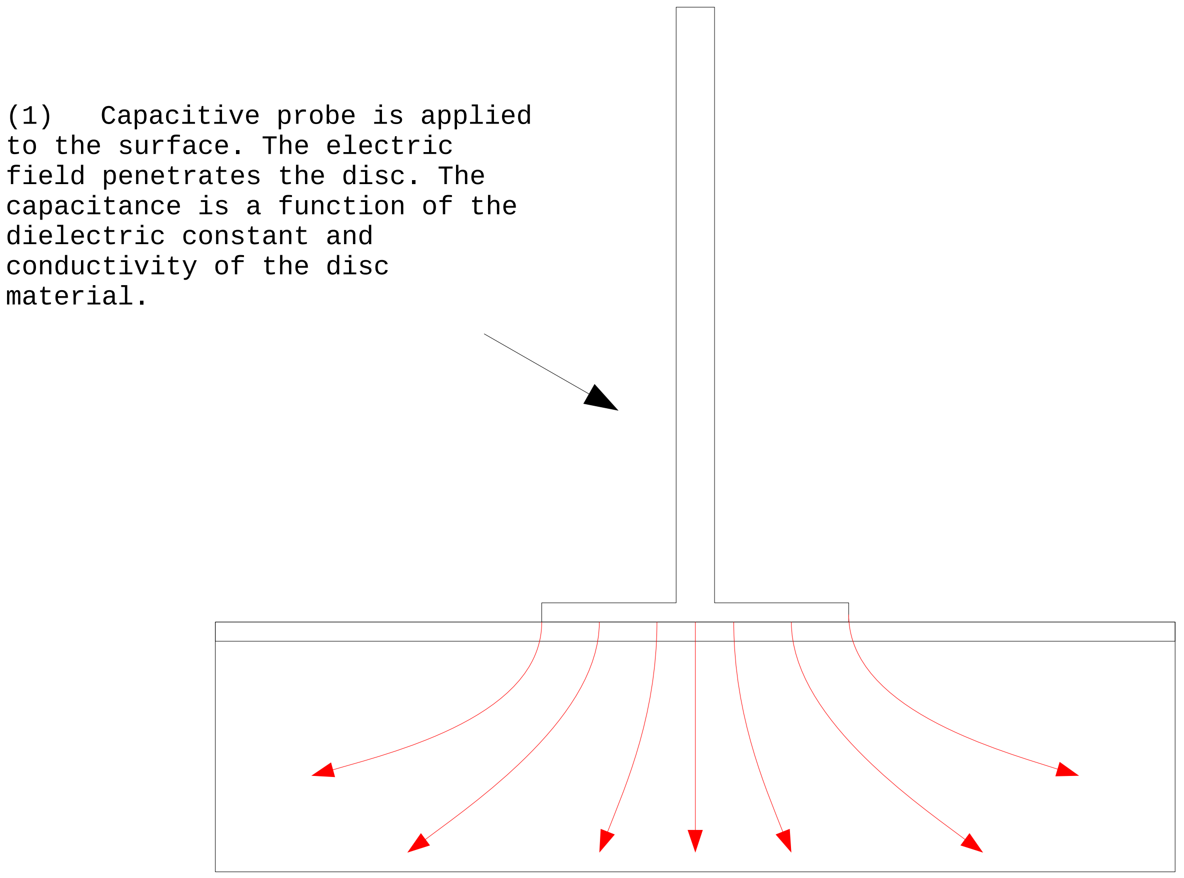
(4) The magnetic field generated by the Eddy currents induces a voltage back on to the main coil. This changes the magnitude and phase of the current flowing in the coil. This changes the impedance of the coil. Thus by measuring the impedance of the coil we can determine an average value of the conductivity of the disc material that is penetrated by the magnetic field.



(3) The time varying magnetic field penetrates the disc brake and induces circulating eddy currents within the disc. The size and distribution of the Eddy currents is a function of the electrical conductivity of the disc. The Eddy currents generate their own magnetic field.

<u>Inductive monitoring system</u>

A capacitance measurement could also be be made to determine the electrical properties of the disc. Being an electrical technique this is a short range probe and so should be more sensitive to the surface layer.



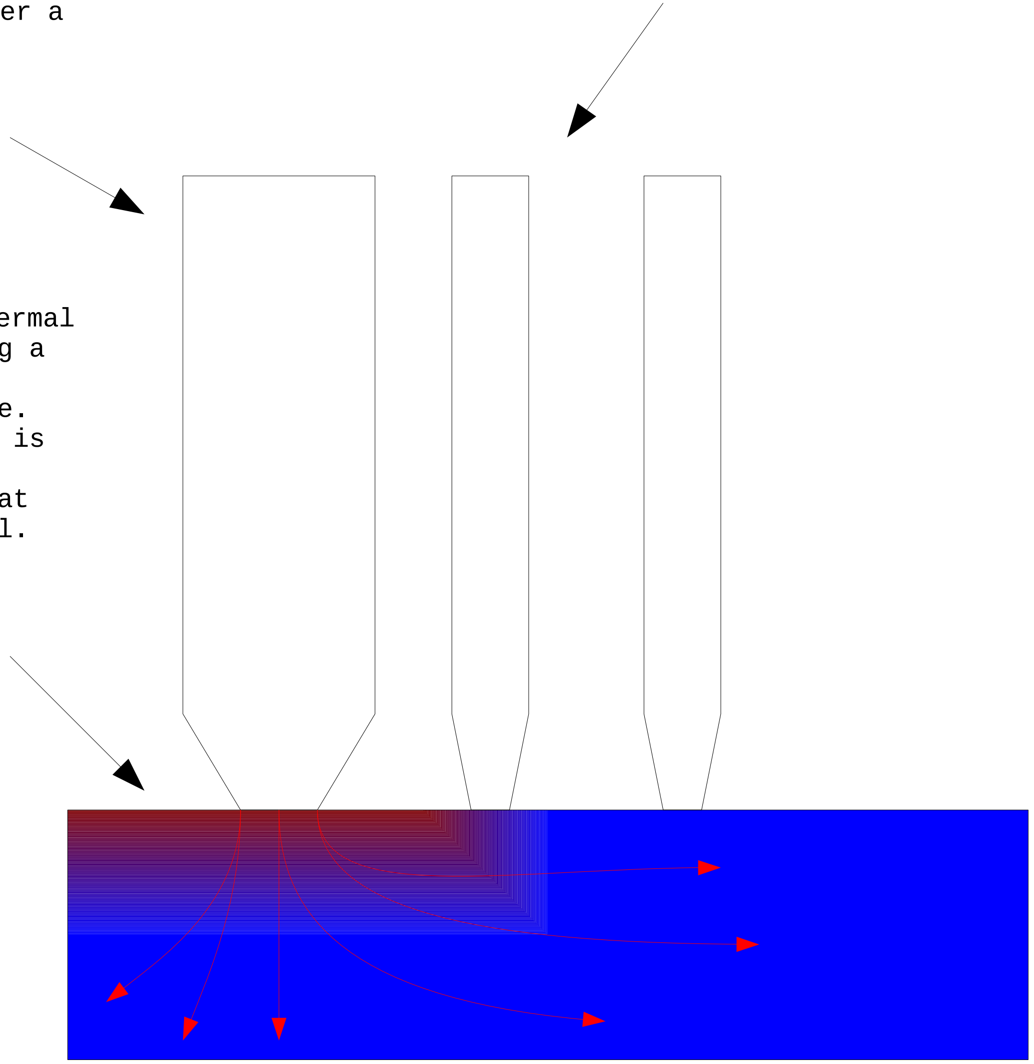
Capacitance monitoring system

Additionally a thermal probe could be employed to directly measure the thermal conductivity of the disc. Note the thermal conductivity is more important parameter in determining the disc performance and so is prefered over the electrical conductivity whichis assumed to correlate with the thermal conductivity.

(1) A thermal source, rather like a soldering iron, is placed onto the surface if the disc. Important that it is applied with a reproducible force and over a known surface area.

(3) Two temperature probes monitor the temperature transient at known positions. From the form of the transient the thermal conductivity and specific heat capacity of the disc material can be determined.

(2) Heat flows from the thermal source into the disc, causing a temperature transient to propagate out from the source. The propagation of the pulse is determined by the thermal conductivity and specific heat capacity of the disc material.



<u>Thermal monitoring system</u>

Actions

- Use existing inductive system to characterise know discs.
- Under take design calculations for capacitive system.
- Under take design calculations for thermal system.
- Try and optimise designs for surface layer sensitivity.
- Undertake laboratory trials of capacitive and thermal system.
- Consider potential benefits of combined inductive, capacitive and thermal monitoring.
- Cost Arduino system solution.

M Ward
April 2014