Executive summary of UGC minor research project [F. 47-756/13(WRO)]

Analysis and Use of Barkhausen Noise for Non-destructive testing of imperfections in Ferromagnetic materials

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Many efforts have been made during last decades to develop the reliable non-destructive evaluation methods and instruments for stress measurements in various materials used in constructions and machine parts. Each of the developed technique has its own advantages and limitations. The Barkhausen technique has been used as one of the techniques in non destructive testing and evaluation of elastic and inelastic deformations. This important phenomenon can be used to find how stress will change the bulk magnetization of a ferromagnetic material in the presence and absence of magnetic field.

In this present study, a simple and economic device was developed to measure the damage and imperfections in the ferromagnetic material due to stresses and other factors, leading to the knowledge of the quality of the material. Design, construction and calibration of all electronic circuits required for experimental study of Magnetic Barkhausen Noise in different samples of ferromagnetic materials of different geometries at different frequencies were done in the laboratory. The Barkhausen noise in samples of magnetic materials of various geometries dimensions and smoothness, subjected magnetic fields at different intensities will be observed with Digital Storage Oscilloscope (DSO) interfaced with a personal computer.

For the study of the phenomenon, Magnetization coils (Electromagnets) and coils for pickup (Electromagnetic stress sensors) were designed and constructed professionally. Power supply for magnetizing coils, construction of all other allied electronic circuits required for experimental study of Magnetic Barkhausen Noise in different samples of ferromagnetic materials of different geometries at different frequencies were designed and constructed in the laboratory.

Ferromagnetic materials of different geometry, dimensions and smoothness were chosen for study of Magnetic Barkhausen noise. The voltage induced in the sensor for steady and for time varying fields were studied and the variation of Barkhausen effect in the presence and absence of stress in the material were found.

The Barkhausen activity was found to be prominent at very low fields. As the field intensity increases, the BN activity was found to increase initially and further increase in the field decreased the BN voltage and the peaks vanished. This was due to the saturation of the magnetised sample and the saturation of core of the electromagnet. The BN activity was higher at the deformed segment compared to other parts of the strip.

A 500 mm long beam of cross section 20mm x 35mm was clamped at one end and loaded at the other end. The stress was calculated using a strain gauge of gauge factor 2 bonded on the surface of the specimen rod to find elongation stress. The BN sensor coil (27 swg, 75 turns in 3 layers of 25 each wound on ferrite core 15 mm in diameter) was mounted on the magnetized specimen rod. Barkhausen peaks were recorded and measured using a DSO interfaced to a PC for steady fields and time varying fields from 10 to 50 Hz.

For calibration, a series of loads was applied to the stress beam. At each loading level, the value of the stress at the beam's surface was determined using the strain gauge bonded to the surface. Stress on the surface of the beam was calculated from change in resistance of strain guage (hence strain), with load. Elastic limit was found to be 2.5 Kg (200 MPa).

Another calibration relating the Peak value of the magnetic Barkhausen noise obtained on DSO and the corresponding values of the stresses in the calibration specimen surface was obtained. The loads used during the calibration stage are selected in order to generate stresses at the beam's surface in the range from zero to a point beyond the elastic limit. The BN noise was found to increase with increasing stress. The BN signal in beam loaded beyond the elastic limit was measured after removal of load. The BN remained same before and after loading with small loads. An increase in BN was observed as the load increased beyond the elastic limit.

BN peaks of different frequencies were got at excitation frequencies 10 to 40 Hz at 1 W and 50 Hz at 6 W powers. BN with rise in temperature was also studied at various steady magnetic fields up to 4 K Gauss using electromagnet. An increase in BN was found with rise in temperature up to 1 K Gauss field and when it was cooled at room temperature, original the BN was not restored. This could be due to the disappearing of pinning sites due to annealing.

With this experimental set-up, the stress levels acting in the test specimen, under the presence of uniaxial stresses were determined. The developed device can be used as a tool in judging quality of the material.