FIVE EXPERIMENTS IN MATERIALS SCIENCE FOR LESS THAN $10.00

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KEY WORDS

Diffusion, Twinning, Fatigue, Acoustic Emission, Ageing.

ABSTRACT

Diffusion, Twinning, Fatigue, Acoustic Emission and Ageing can be studied using readily available materials and the household oven. Each experiment can be expanded to a more extensive investigation of the properties of the material investigated, as well as other materials, and offers an opportunity for the student to learn about the relationship between engineering, science, society and politics.

INTRODUCTION

Simple experiments with everyday items can be used to familiarize students with the importance of materials and some of the properties which they possess. The following experiments have been performed by the author for over eight years with enthusiastic response by audiences of all ages.

EQUIPMENT AND SUPPLIES

1) Aluminum nails,
2) United States Pennies,
3) Metal Paper Clips.

THE ALUMINUM NAIL

Aluminum nails are age hardened to disperse the silicon and harden the aluminum. If an aluminum nail is re-heated to 600 F for one hour it will soften and can be bent by hand. This brief experiment demonstrates the movement of atoms in a material. This migration of atoms in a material is diffusion. In the age-hardened state the silicon atoms are finely dispersed, whereas in the re-heated or over-aged material the silicon atoms coalesce into larger particles and no longer strengthen the aluminum to a useful hardened state.[1]

THE UNITED STATES PENNY

The U.S. penny has an interesting history; the pennies minted since 1982 are electroplated zinc. The present composition is 97.6%

zinc and 2.4% copper. The copper can easily be scratched from the surface of the coin to reveal the zinc. Before 1982 the penny was 95% copper and 5% zinc or 95% copper, 2.5% zinc and 2.5% tin, except for 1943 when the penny was zinc coated on steel.[2, 3, 4, 5]

An interesting experiment can be performed on all of the pennies except the 1943 version by placing them in an oven at 350-400 F for about an hour or so. The surface of the penny will acquire a heat tint that makes the coin appear golden. This heat tint can easily be removed by normal wear or by polishing.

The pennies minted since 1982 exhibit another interesting property when heat treated. If this penny is heated at 700 F for one hour the zinc grains will become large and can easily be twinned by biting on the penny or by bending it. An acoustic emission will be heard when the penny is deformed. This experiment clearly demonstrates diffusion and grain growth, as the "as found" penny will not twin because the grains are so small. Diffusion is causing the grain growth of the zinc and the deformation is causing the twinning. The twinning is causing the crackling noise heard when the penny is deformed. This crackling is called acoustic emission and is being extensively researched for NDE purposes.[1,3,4,5]

THE PAPER CLIP

An ordinary metal paper clip can readily be used to demonstrate fatigue. A fatigue failure arises from the cyclic loading of a material at relatively small loads.[1] If a paper clip is opened so that it appears as an elongated "S" and is repeatedly bent back and forth it will break, clearly demonstrating the phenomenon of fatigue. If the broken paper clip is quickly moved to the lower portion of the upper lip the paper clip appears warm, a result of internal friction. If the color of the region around the fracture is examined a discoloration will be observed, and if the texture is observed the area around the fracture will be noticeably roughened.

CONCLUSIONS

As previously mentioned, these demonstrations have met with much success and the author's experience has been that many in the audiences have demonstrated them to others and frequently called the author for more information or other experiments. Each of these experiments can be expanded to be quantitative, and include other materials, variation of heat treatments, different loading techniques and perhaps observations of different properties. It is the author's opinion that the equipment need not be complex and in fact should not be complex to interest students in the study of materials.

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