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INSTRUMENTATION

AN AUTOMATIC FLAW DETECTOR FOR ALUMINUM CANS

by

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ABSTRACT

A tester, utilizing eddy currents, was developed to detect inclusions and voids in aluminum cans. The sensing element is a small probe that does not touch the can under inspection. An experimental feeder, developed along with the tester, permits the automatic inspection of one can per .-minute.

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AN AUTOMATIC FLAW DETECTOR FOR ALUMINUM CANS

INTRODUCTION

Aluminum cans for uranium slugs are visually inspected for defects before the canning operation. The method has the disadvantage that subsurface defects are not detected. Due to operator fatigue, some surface defects are missed also. A more reliable testing method is desirable.

Eddy current techniques offered a promise in overcoming the shortcomings of visual inspection. This report covers the development of an eddy current instrument for surface and subsurface inspection of such cans.

SUMMARY

An eddy current instrument was developed which automatically inspects cans at the rate of one a minute. A laboratory study of 10,000 cans showed that the instrument will detect iron inclusions five mils in diameter and voids ten mils in diameter in the can surface. Slightly larger subsurface defects are also detected. The sensing element is a small probe that does not come into contact with the sample under inspection. The electronic circuit was designed to make the instrument insensitive to small variations in the probe-to-sample spacing. A mechanical system was developed that maintains a close probe-to-sample spacing in order to secure maximum sensitivity to small defects. The instrument is sufficiently sensitive and stable for automatic operation.

DISCUSSION

In eddy current inspection, a coil carrying an alternating current is placed on or near the object under inspection. Eddy currents induced in the object produce a magnetic field that opposes the field of the coil. As a result, the inductive component of the coil impedance is lowered and the resistive component is increased. The resultant coil impedance depends upon the resistivity of the object and the probe-to-object distance. A defect in the material under inspection has the effect of changing the resistivity of the material and, therefore, produces a change in the impedance of the coil. This change gives an indication of a defect. Unfortunately, small changes in probe-to-sample spacing produce a change in coil impedance comparable to that produced by a defect.

The distance effect in the present tester was minimized by the design of the electronic circuit. The sensitivity of the detector to small defects was also increased by the use of a probe coil of special design.

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DESCRIPTION OF THE TESTER

The circuit of the detector shown in Figure 1 is similar to one designed by Dr. Fritz Forster of the Dr. Forster Institute, Reutlingen, Germany and described by Stanford⁽¹⁾ and McMillen⁽²⁾. The probe coil is the grid coil of a tuned-plate, tuned-grid oscillator. The oscillator is adjusted so that the output amplitude depends primarily upon the resistivity of the sample under inspection. The output is detected and the level of this signal is a measure of the resistivity of the sample. When this level changes due to a defect passing under the probe, a derivative signal is amplified to fire a thyatron. The derivative circuit eliminates the effect of oscillator drift and further reduces the background signal caused by the distance effect. The aluminum can is rotated and the probe is translated so as to scan the entire surface.

All parts are standard electronic components. The 175-kc I.F. transformer used for the plate tank of the oscillator was retuned to give an operating frequency of approximately 120 kc/sec. This frequency was chosen so that the detector would have maximum sensitivity for defects that occur within ten mils of the outer surface of the can.

The probe, which is shown in Figure 2, consists of 250 turns of No. 32 copper wire wound on a "Micarta" bobbin which is embraced by two halves of a ferrite pickup head. The ferrite core was supplied by the Ferroxcube Corporation of America and is their 1-90-1 Material, Part No. 222F250. The gap width was increased to approximately $3/64$ inch and the pole faces were sloped back so as to concentrate the magnetic field on the outside edge of the gap.

The detector circuit is adjusted by placing a sample can on the feeder and tuning the grid tank for maximum signal as observed on an oscilloscope connected to Test Point No. 1 shown in Figure 1. A standard can containing a defect is then placed on the feeder and rotated so that the defect passes repeatedly under the probe. The grid tank is retuned until the signal-to-noise ratio is a maximum as observed at Test Point No. 2. The bias on the thyatron is then set so that a signal approximately twice that of the average background will actuate the reject mechanism.

The complete tester is shown in Figure 3 and the automatic feeder in Figures 4 and 5. Cans to be tested are placed on the upper ramp and are held in place by retaining pawls. When the circuit is energized, the probe carriage moves to one end of its travel and depresses a microswitch which initiates the unload-load cycle. The unload pawls are forced up between the rollers and eject the tested can onto the unload ramp. As the tested can is discharged, the elevator pawls rise and receive a can from the upper ramp. The new can is then lowered to the drive rollers as the unload pawls return to their lower position. The can is rotated at 60 rpm and the probe translates along the can at a speed of 12 inches per minute. When the probe reaches the far end of its travel the unload-load cycle is again initiated. Defective cans are automatically rejected through a trap door in the unload ramp.

PERFORMANCE

In an initial evaluation by L. E. Goodwin, 10,000 cans were tested with the instrument, and a Brush oscillogram was made of the signals from each can. The cans giving the largest signals were re-tested six times. Of this group, 46 cans were consistently rejected and 97 were rejected fewer than six times. Examination of these cans proved that the instrument consistently rejected cans with scratches and cracks five mils deep along the length of the can, or surface voids ten mils in diameter and ten mils deep. Surface iron inclusions five mils in diameter and slightly larger subsurface iron inclusions were detected. Figure 6 is a photomicrograph of a subsurface iron inclusion consistently rejected by the instrument. Tests made on cans containing manufactured defects also indicate that surface voids ten mils in diameter and ten mils deep are consistently rejected.

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FIGURE 1

CIRCUIT DIAGRAM

FIGURE 2

PROBE

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FIGURE 3

COMPLETE TESTER

FIGURE 4

FEEDER DURING UNLOAD-LOAD CYCLE

FIGURE 5

CAN UNDER INSPECTION

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FIGURE 6

SUBSURFACE IRON INCLUSION

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