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METAL DEPTH DETECTOR

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Metal detectors based on eddy current principles find varied applications. They find use in detection of metals underground, security purposes, measurement of cover thickness in RCC structures, etc. This paper describes the design and performance details of such a metal detector which may find immense use in the measurement of cover thickness of reinforcements in RCC structures.

Key words: Eddy current, cover thickness measurement, RCC structures, metal detector

INTRODUCTION

Use of eddy current based metal detectors [1,2] for measurement of the cover thickness i.e. the distance between the surface and the actual position of the rebar is well known. An attempt in development of such an instrument was made during 1964-65. Though the importance of such an equipment was not realised at that time, later it has been established that such measurements of cover thickness and plotting of cover thickness contours are of immense use. These measurements help to establish the condition of rebars, prestressed cables, etc. in concrete structures from the corrosion point of veiw.

PRINCIPLE

In principle most of the metal detectors are based on the damping of a tuned coil due to the proximity of the metallic object.The sensitivity and accuracy of the instruments depend only on the probe coil, its shape and the applications for which they are meant. Of cover thickness and plotting of cover contours are In some applications, the presence of metallic objects only is to be detected. In that case, only an audible alarm is to be generated. In the case of metal detectors meant for detection of metallic particles in biscuits, paper and textiles, in the respective industries, the inspection head should be able to detect the smallest particle of any metal embedded in them. The equipment should be able to give an audible alarm and stop the processing until the metal particles are located and removed. Hence the design of the inspection head is the crucial part in the development of metal detectors for specific applications. In the present case, the probe coil has been shaped in such a way that it has the required sensitivity and is capable of not only detecting the presence of the metal embedded in various media like reinforced concrete, soil etc. but also gives quantitative information with regard to the position of the metal. The sensitivity to the presence of the test object is due to the interaction of the magnetic field due to the probe and that due to the induced eddy currents in the test object. This results in a change in the reluctance of the coil and a detuning of the Tank circuit. The field modification of the probe coil due to the presence of the object depends on the following parameters:

1. Electrical conductivity of the metal
2. Dimensions (i.e. the diameter of the rod)
3. Magnetic permeability
4. Presence of discontinuities such as cracks or cavities
5. Frequency of the A-6 field of the test coil
6. Size and shape of the test coil
7. Distance of the test coil from the test object.

In view of the above, it is possible to measure the dimension of the rod and cover thickness by keeping all the other parameters constant.

INSTRUMENT

Fig. 1 shows the portable, battery operated instrument developed and Fig. 2 shows the block diagram of the instrument.

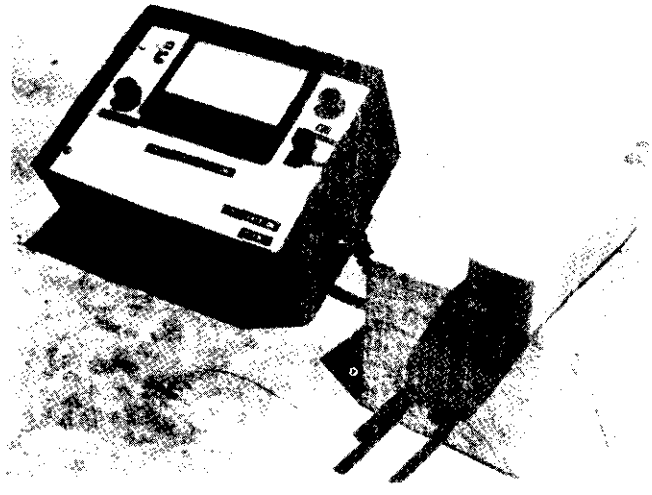

Fig. 1: Metal depth detector

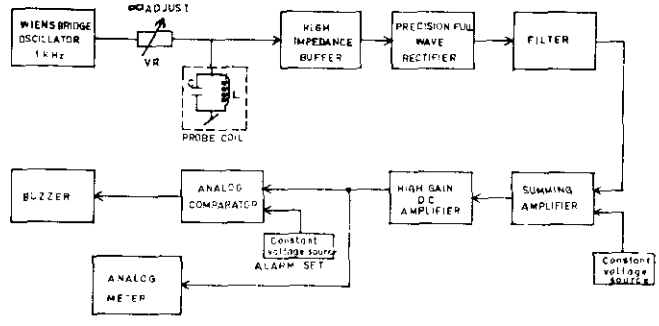

Fig. 2: Block diagram of the metal detector

Oscillator block generates a stabilised sine wave of 1 KHZ. The output of this (in the range of 6V) is applied to the probe coil through a variable resistance(VR). Probe coil (L) along with condenser (C) forms a parallel resonant circuit. The output from the probe is connected to voltage follower which acts as a high impedance buffer. The active rectifier formed by two operational amplifiers with the associated circuitry converts the output of the buffer stage into a DC voltage. This DC voltage is annulled to increase the sensitivity. When there is no Test object in the vicinity of the probe, the meter should indicate infinity. Normally any object beyond a distance of, (say, 15cm) is indicted as ∞. This changes from object to object. When iron rods are to be detected for their distance from the probe, the diameter of the rod should be known. Hence provision has to be made to adjust this according to the requirements so that quantitative measurements with regard to the diameter and distance of the rod from the probe are possible. When the probe is placed over a test concrete cube contining a rebar, the voltage across the probe gets reduced. This depends on the distance of the coil for a given diameter. The meter is calibrated to give the cover thickness in cm. In addition, a comparator circuit energises a piezo electric alarm to give a buzzing sound to indicate the presence of metal. The distance within which this alarm is produced can be set. This provision will help considerably in checking the cable profiles in prestressed concrete structures.

RESULTS

The instrument was calibrated with 1 cm diameter carbon steel rod placed at known distances. The probe was placed on the surface of a test cube containing the iron rod and the cover thickness was noted. Spacers of known thickness were used for calibrating the instruments. Table I shows that there is a good agreement between the actual distance and distance shown by the meter.

Table I: Metal depth measurement

Sl. No.	Actual distance (cm)	Distance measured with the instrument (cm)	
1	1	0.9	with spacer
2	2	1.8	
3	3	3.0	
4	4	3.9	
5	5	4.8	
6	6	6.0	
7	7	7.0	
8	8	8.0	

Fig. 3 gives the relationship between the output of the high gain DC amplifer and the cover thickness.

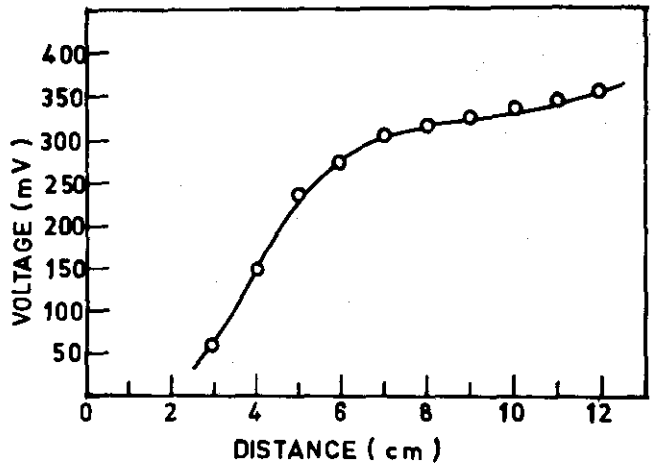

Fig. 3: The relationship between the output of the high-gain DC amplifier stage and the cover thickness

The relationship is a non-linear one as expected. It is also seen from the graph that the sensitivity decreases as the cover thickness increases. To overcome this difficulty, work is in progress to linearise this relation so as to have the digital output with improved signal processing techniques such as phase sensitive detection instead of simple rectification.

CONCLUSION

A metal depth detector based on eddy current principle has been developed and fabricated. The experimental results showed good agreement between the actual cover thickness and the cover thickness measured with the fabricated instrument. The instrument will find wide application in condition survey of RCC structures such as bridges, detection of submerged pipe lines, etc.

REFERENCES

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