Pakistan J. Sci. Ind. Res., Vol. 24, No. 2, April 1981

A PRELIMINARY STUDY OF JUTE-PULP PAPER AS A DIELECTRIC MEDIUM IN CAPACITORS

S. M. A. Tirmizi, M. Ashraf Chaudhry

Department of Physics, University of Karachi, Karachi-32, Pakistan

(Received December 14, 1978; revised March 19, 1981)

A perliminary study is made for checking the suitability of indigenous paper as a dielectric medium. For this, both the dielectric constant and the loss tangent have been measured for six types of papers. It is concluded that two types of jute-pulp paper may be useful as a dielectric medium in paper capacitors.

INTRODUCTION

There is hardly any electronic system these days which is not using the capacitor as its integral part. Different materials are being used as dielectrics to make the capacitors which are classified on the basis of the type of dielectric used therein, e.g. mica capacitors, film (of polystyrene, teflon, polyethylene etc). capacitors, glass-ribbon and enamel capacitors, electrolytic capacitors, ceramic capacitors, and so on. At the present time most of the capacitors are being made of kraft paper, ranging in thickness from 0.008 cm to 0.046 cm, obtained from wood pulp.

The desired values of capacitance, power factor, and insulation resistance of a capacitor and variations of these characteristics are determined by its applications. For D.C. capacitors the power factor as such is of no importance, but it serves as a check on materials and processing methods. The correlation between capacitor life and insulation resistance or power factor is extremely poor, unless these values are extremely low or very high [1]. A more reliable evaluation can be based on the variations of capacitance, power factor and insulation resistance as a function of temperature, frequency voltage, and time.

MATERIALS AND METHODS

The disc shaped samples were cut from the locally prepared jute-pulp paper sheets. Similar samples were obtained from three other varieties of paper namely ordinary cyclostyling paper (rough paper) was obtained from PCSIR Laboratories Karachi. While the other three varieties were abundantly available in the local market. All the samples were 5.08 cm in dia. They were kept in a dessicator for two days to make them dry, and then silver painted for good electrical contact and for avoiding moisture absorption during measurements.

A G.R. capacitance measuring assembly, type 1610-A, with 716-C capacitance bridge of General Radio Co. and 1690-A dielectric sample holder was used to measure the capacitance and the loss tangent of the sample by using substitution method [2]. The sample holder [3] used is straightforward, and has been described before [4,5]. The bridge had an accuracy of ± 0.2% or ± 2 PF, which ever is larger, for capacitance and ± 0.00005 or ± 2% of the change in loss tangent, when the change was less than 0.06.

RESULTS AND DISCUSSIONS

The results are shown in Figs. 1-4. Both the dielectric constant and the loss tangent change with frequency. The dielectric constant of aeroflex decreases form 4.650 at 0.5 kHz to 3.144 at 100 kHz, whereas the loss tangent increases from 399.47 x 10^{-3} at 0.5 kHz to 442.19 x 10^{-3} at 1.5 kHz and then decreases with increasing frequency such that its value becomes 164.29 x 10^{-3} at 100 kHz.

The dielectric constant and the loss tangent of art paper decreases with increasing frequency. The dielectric constant of art paper changes from 3.289 to 2.975 and its loss tangent decreases from 267.55 x 10^{-3} to 63.18 x 10^{-3} as the frequency shifts from 0.5 kHz to 100 kHz. For ordinary cyclostyling paper we can see that both parameters i.e. the dielectric constant and the loss tangent are frequency sensitive. The change in dielectric constant of ordinary cyclostyling paper (rough paper) is very small, but its loss tangent shows a large change. The value of dielectric constant of ordinary cyclostyling paper changes from 2.281 to 1.898 and its loss tangent decreases from 569.64 x 10^{-3} to 92.5 x 10^{-3}.

Now we consider three varieties of the jute-pulp paper. The dielectric constant and the loss tangent of first

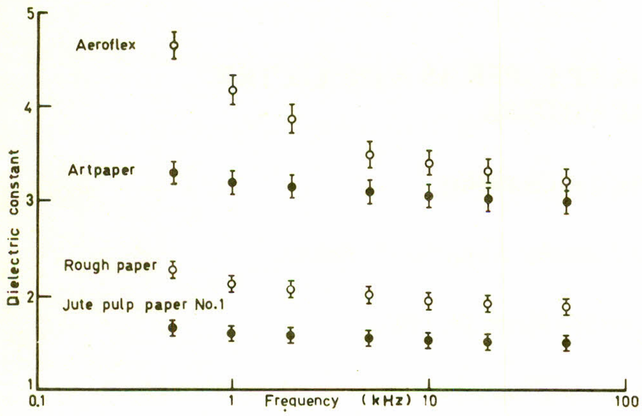

Fig. 1. Plot of dielectric constant *vs* frequency for different samples.

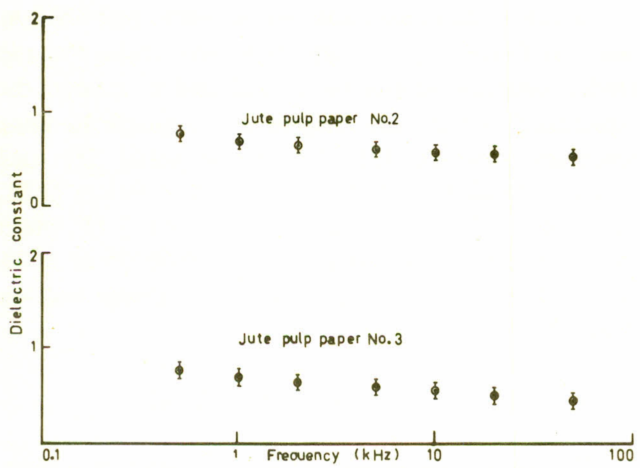

Fig. 2 Plot of dielectric constant *vs* frequency for different samples.

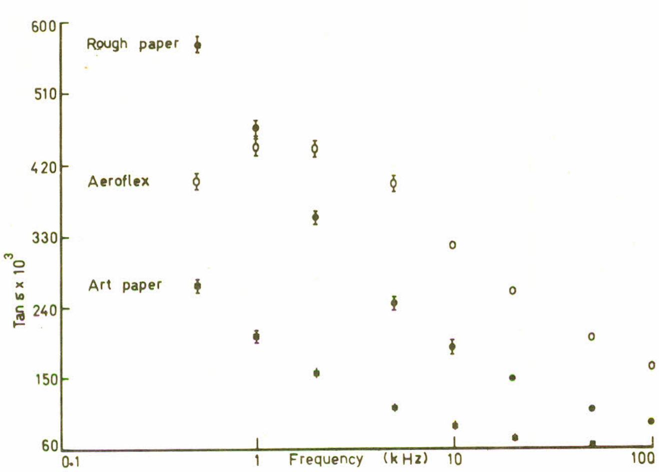

Fig. 3. Plot of loss tangent *vs* frequency for different samples.

variety of the jute-pulp paper decreases with increasing frequency. The value of dielectric constant changes from 1.678 to 1.501 and that of loss tangent changes from

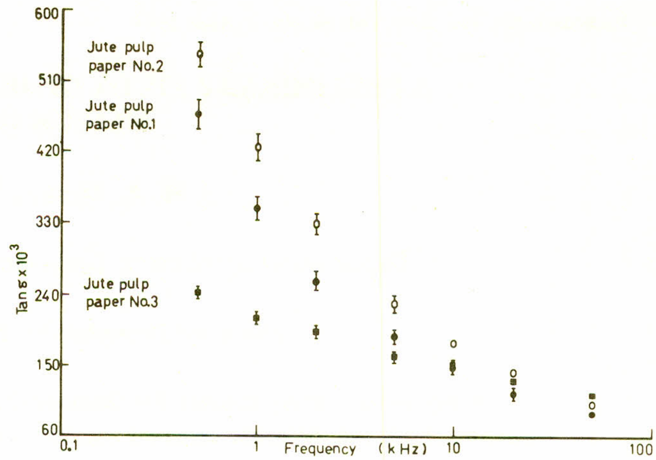

Fig. 4. Plot of loss tangent *vs* frequency for different samples.

467.94 x 10^{-3} to 75.69 x 10^{-3} as the frequency changes from 0.5 kHz to 100 kHz. The over all difference in dielectric constant values and loss tangent values at 0.5 kHz and 100 kHz is 0.177 and 393.25 x 10^{-3} respectively. The dielectric constant and the loss tangent of second variety of the jute-pulp paper at 0.5 kHz is 1.775 and 573.05 x 10^{-3} and at 100 kHz these values change to 1.529 and 93.66 x 10^{-3} respectively. Thus the difference in low frequency and high frequency values of the dielectric constant and the loss tangent of second variety of paper is 0.246 and 479.39 x 10^{-3} respectively. The dielectric constant at 0.5 kHz is 1.766 and that at 100 kHz is 1.474, where as the values of loss tangent at the two extremes of frequency range are 243.84 x 10^{-3} and 99.95 x 10^{-3} respectively. Thus the difference in extreme values of the dielectric constant and the loss tangent is 0.292 and 143.89 x 10^{-3}.

We can thus conclude from the jute-pulp paper results that the dielectric constant of first variety of paper is least frequency sensitive. In other words it is more stable as compared to the other two varieties. However, the loss tangent of third sample of jute-pulp paper is smaller than that of first and second specimen of the jute-pulp paper.

Campbell [6] used Maxwell's method to measure the dielectric constant of paper. The values reported by him varies between 1.7 and 2.6. The dielectric constant of paper reported by Ahmed [7] varies from 1.7 to 2.1 depending upon the variety of the paper. Jabeen [8] quotes the values as 1.8 to 2.5. Ahmed [7] and Jabeen [8] have neither mentioned the frequency of measurement nor they have described the type of the material, hence no useful comparison can be made for the dielectric constant which changes with the frequency and with the type of material.

We, thus, conclude that first variety can be used for the construction of stable capacitors and the third one for the capacitors which should' have smaller loss of energy, provided other conditions like resistance to deterioration ect. are fulfilled.

Acknowledgement. One of the authors (M.A.C.) is thankful to Mr. Tanzeel Haider of PCSIR for providing the jute-pulp paper samples. Financial assistance from U.G.C. is also acknowledged thankfully.

REFERENCES

1. A.R. Von Hippel, *Dielectric Materials and Applications* (M.I.T. Press, Cambridge, Massachusetts, U.S.A.,1961), third edition, p.222.
2. R. F. Field, General Radio Experimenter, **xiv**, p.3 (May, 1940).
3. I.G. Easton, General Radio Experimenter, **xxvi**, p. 1 (Aug., 1951).
4. S.M.A. Tirmizi, M.A.Chaudhry, M.A. Shah, Pakistan J. Sci. Ind. Res., **21**, 164 (1978).
5. S.M.A. Tirmizi and M.A. Chaudhry, Pakistan J.Sci. Ind. Res., **21**, 168 (1978).
6. A. Campbell, Proc. Roy. Soc.,Ser. A, 78, 196 (1960).
7. M. Ahmed, M.Sc. Thesis, Punjab University, Lahore (1953).
8. N. Jabeen, M.Sc. Thesis, Punjab University, Lahore (1964).