MEASUREMENT OF FABRIC GSM USING NON DESTRUCTIVE METHOD

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ABSTRACT

GSM stands for grams per square meter. Fabric GSM means weight of one square meter fabric in grams. Grams per Square Meter are the important product quality in the field of textile fabrics. The conventional method of GSM measurement involves physical destruction of the fabric. This leads to wastage of fabric and makes the remaining fabric unusable. The main objective of this project is to replace time-consuming and destructive method that are being used for calculating the weight in grams per square meter of the fabrics and develop a method for non-destructive fabric GSM measurement. This study uses the capacitance principle to obtain the fabric GSM. The relative permittivity of the sample fabrics changes the capacitance value. A relationship between capacitance and GSM is obtained. The relation shows that the GSM and capacitance are directly proportional to each other. Also, the developed system is applicable for all kinds of fabrics both knitted and woven fabrics. The comparison study was carried out with existing test method. Fabric weight measurement by non-destructive method is essential to control the fabric utilization and cost of manufacture.

Keywords: *Fabric GSM, Non-destructive measurement, Capacitance principle.*

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1. INTRODUCTION

India has been experiencing massive improvement in the textile industry, across different segments of the value chain, from raw materials to garments. Domestic production in India is growing at a constant rate. The export rate has also improved drastically. Total fabric production in India is nearly 50,000 millions of square meter per year, out of which at least one percentage of fabric is utilized for testing their shade and weight. Testing of fabric weight is destructive and the loss of fabric is substantial. So, fabric weight measurement by non-destructive method is essential to control the fabric utilization and cost of manufacture. The conventional method of fabric grams per square meter (GSM) measurement using electronic balance involves physical destruction of the fabric (destructive testing). This leads to wastage of fabric and makes the remaining fabric unusable i.e. nearly 3-5 per cent of the total fabric will be discarded for its destructive testing. Over the past few years several attempts have been made to measure the Fabric GSM online. Online quality control in the textile industry is still a field of research.

Radiometric absorption is one of the approaches used for monitoring fabric weight during weaving. Such an X-ray sensor uses absorption of the X-ray beam depending on the mass and density of the material [1]Yves-Simon GLOY, et al. This absorption can be related to the fabric weight. X-ray shows nearly the same linear behavior. However, the x-ray sensor monitors the right fabric weight per area around 210 seconds later. This result in the desired fabric weight per area was reached with an accuracy of 0.4 g/m^2.

Image analysis has also been proved to be an efficient method of analyzing the density of woven fabric [2]*Ruru Pan, et al*. Fourier transform analysis was proposed to realize the automatic inspection of the thread density of woven fabric. The 2D fast Fourier transform was adopted to process a woven fabric image and the amplitude spectrum was then obtained. This is followed by threshold segmentation followed by Fourier filtering and fabric image reconstruction. Comparing the automatic detection results to those of manual detection, its results are almost the same, with a maximum error of 0.98%. The error mainly results from the different measurement region selected for density detection.

Carvalho.V IECON 2006 [3] presents an automatic yarn characterization system, based on capacitive sensors for evenness measurement and on optical sensors for hairiness analysis. This approach enables direct yarn mass determination in 1 mm range for evenness, an increase by a factor of eight over the most common commercial solutions (8 mm), and will also enable hairiness measurement up to 1 mm with high accuracy. A digital image processing approach was developed to evaluate fabric structure characteristics and parameters [4] *M. Senthilkumar, et al.IJFTR (Vol 40 Sept 2015)*. The developed approach, decomposed the fabric image into two images, each of which included either warp or weft yarns. Yarn boundaries were outlined to evaluate the fabric surface characteristics and further used to identify the areas of interlaces to detect the fabric structure. The fabric GSM was calculated using the parameters obtained from the image processing approach. This method however needs improvement to analyze the sample of satin and twill weave, because of its internal structural complexities.

The main aim of the proposed method is to eliminate the limitations of the conventional method and measure the Fabric GSM online. Thus a Non-destructive method is designed and developed to measure the densities of woven fabrics correctly and it can be used to replace the current manual analysis.

2. METHODOLOGY

The objective of this paper is to obtain the change in capacitance using capacitive transducer in order to determine the relative permittivity of the sample fabrics. This value is used to estimate the relationship between Capacitance and GSM and hence the Fabric GSM is measured online. The system consists of Capacitive transducer (Parallel plate capacitor) where the fabric is inserted, ATmega 328 microcontroller and an LCD display.

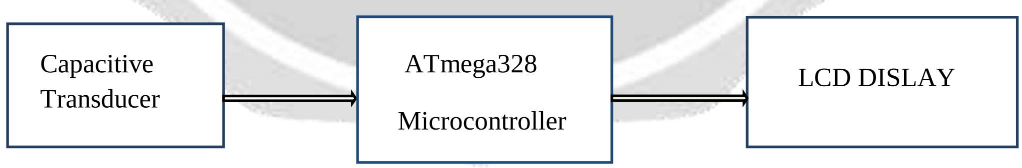

Fig 1: Block diagram of non-destructive fabric GSM measurement

Working of Capacitance test circuit

A simple Capacitance test circuit is designed and sample fabric is inserted between the parallel plate capacitor. The resulting capacitance value is fed to the ATmega328 microcontroller.
The capacitance value is determined using in the following equation:

$$V_{A0} = \frac{V_{A2} \times C_T}{C_1 + C_T}$$

We can rearrange this to get:

$$C_1 = \frac{C_T \times (V_{A2} - V_{A0})}{V_{A0}}$$

And

$$C_T = \frac{V_{A0} \times C_1}{V_{A2} - V_{A0}}$$

Where C_T is the testing capacitance and C_1 value is 37.45nF.

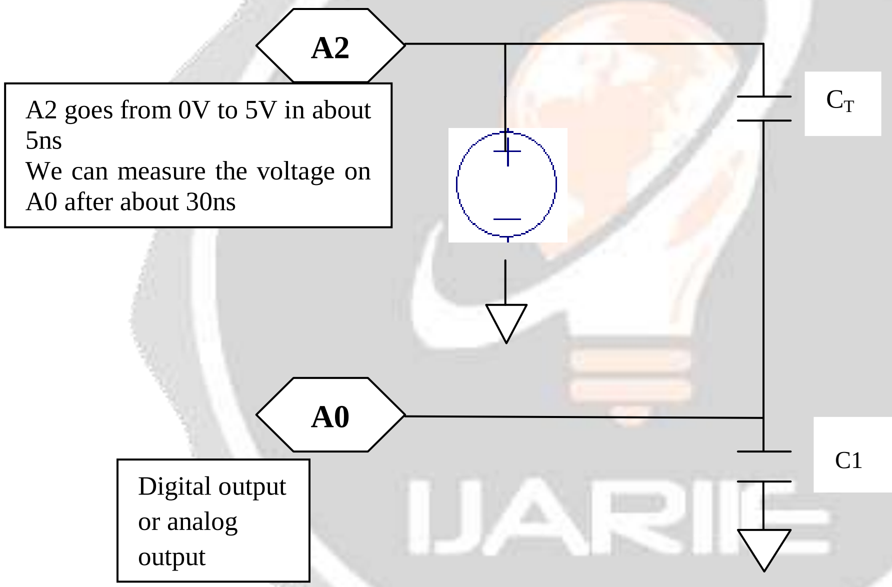

Fig 2: Working of Capacitance test circuit

System implementation
Ten samples of different GSM of both woven and knitted fabrics were chosen and inserted between the two parallel plates. This resulted in change in the capacitance value based on the dielectric constant of the sample fabric. This change in capacitance is given to the capacitance test circuit.

Top view

Front view

Fig 3: Parallel plate capacitor

Specifications of the Parallel plate capacitor

- Length = 100 mm
- Width = 150 mm
- Thickness = 5 mm
- Area = 15000 mm^2
- Distance between the plates = 5 mm

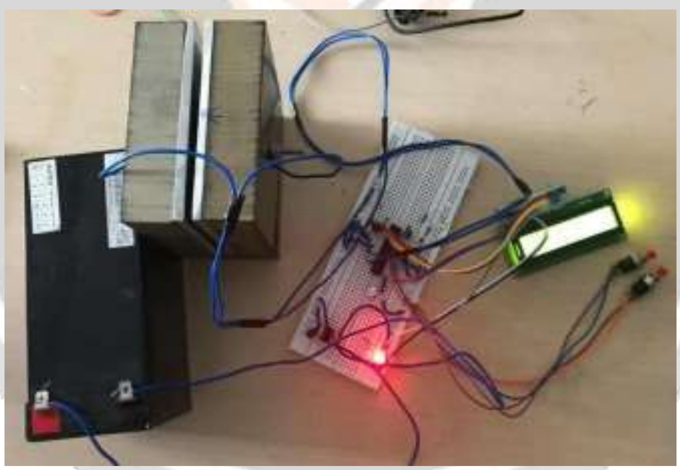

Fig 4: System implementation.

Working of the Instrument

The fabric samples with different GSM are taken and the capacitance values of each fabric sample are calculated by inserting the fabric in between two parallel plate capacitor at standard atmospheric condition (25^0C-29^0C & 63-67% R.H). The capacitance value changes based on the dielectric constant of the fabric. The obtained capacitance values of the samples are tabulated.GSM of the corresponding samples is found using the conventional method. The GSM values and the capacitance values are tabulated and the relation between them is found

The graph is plotted in MATLAB using these values and the best fitting curve is taken among the linear, cubic, quadratic curves. Analysis of these curves shows that the best fitting curve equation is the cubic. The cubic fitting curve equation obtained is shown in the figure below.

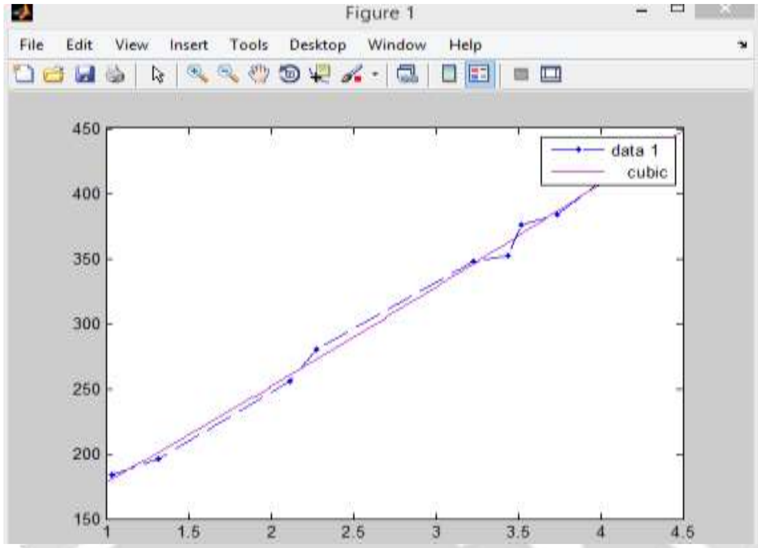

Fig 5: Capacitance Vs GSM plot

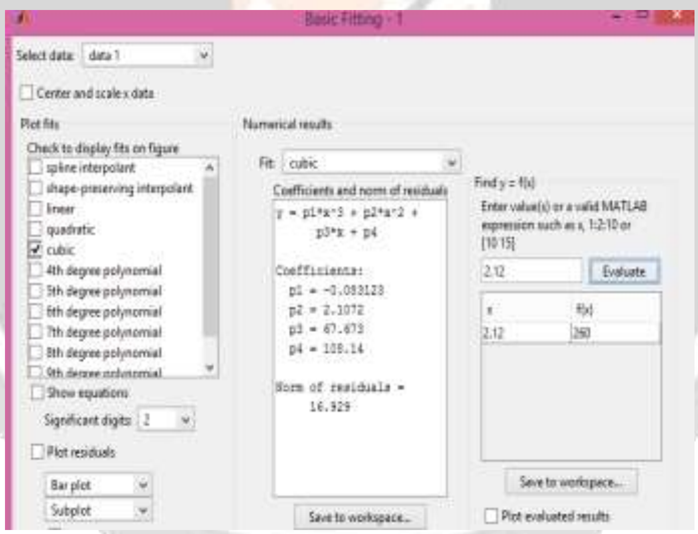

Fig 6: Basic Fitting Equation

Figure 6 shows the equation for best fitting curve i.e. Cubic. .Thus, the relation between capacitance and GSM is represented by the cubic equation shown in the following equation:

$$GSM = w\,(capacitance^{3}) + x\,(capacitance^{2}) + y\,(capacitance) + z$$

Thus the developed system establishes a relation between capacitance and the fabric GSM. The capacitance value depends upon the relative permittivity of the sample fabric. Also, it is observed that the changes are relatively low when operated in high frequency. The effect of moisture content (relative humidity) is also less when operated in high frequency.The developed system is applicable for all kind of fabrics both knitted and woven fabrics. The change in capacitance due to relative permittivity of the sample fabric is in nF range (10−12).

3. RESULTS AND DISCUSSIONS

The developed method was tested with 10 different sample fabrics and compared with GSM values measured by destructive method. The comaprison table is given below. It was further analysed using statistical correlation test and the test result was 0.99. The system can be further improved in terms of accuracy. The method can be further improved for generation of GSM value as a report for record purpose.The first 5 samples are knitted material and from 6 to 10 are woven samples.

Table 1: Comparison between Fabric GSM measurments by Destuctive and Non-Destructive methods

SAMPLES	GSM (Destructive Method) gms/m2	Capacitance (nF)	GSM (Non-Destructive Method) gms/m2	Error %
1	184	1.04	186	1.087
2	196	1.32	202	3.061
3	256	2.12	260	1.563
4	280	2.28	282	0.714
5	284	3.00	286	0.704
6	348	3.23	350	0.575
7	352	3.44	356	1.136
8	376	3.52	380	1.064
9	384	3.74	383	0.260
10	410	4.01	412	0.488

4. CONCLUSION

Based on the results of this study, it is inferred that textile materials are mostly dielectric and the relative permittivity of the dielectric fabric depends upon the yarn composition and yarn diameter. The system is then calibrated based on the relationship between GSM and capacitance and the GSM of the sample fabric is displayed. Thus, the proposed non-destructive method of fabric GSM measurement using capacitance principle is designed, developed and tested.

5. REFERENCES

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