OPEN ACCESS

International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-6, March 2020

An Innovative Device to Monitor Material Quality using Magnetic Permeability

Kadripathi K N, K S Kiran, L Yethinder Ragav, Manu Kiran B

Abstract: *the proposed concept in this paper aims to design an instrument that measures and compares the magnetic permeability of the given substance, hence to determine the purity of the sample in a non-destructive manner. This works based on the stimulation method, where the magnetic field acts as a stimulator. A certified pure sample of milk is analyzed using this device to get the standard permeability of the milk. Then this sample is diluted with a known amount of water and the deviation of permeability is studied. The attained results are used to calibrate the device. The equation, which is modeled from the results, is used to interpret the purity of the given sample. The sample that has undergone the test procedure is safe to be reused. This is an effective Non-Destructive Test (NDT) to know the adulterant. Not only milk but other fluids such as hydraulic oil, fuels, and solids can also be tested for their impurity content. This device can also be used as a complementary for Electronic Tongue. It is a more efficient method where the comparative study of materials is used. Further, this method can be used to approximate the boiling and freezing point of the same when the exact composition of the material is known*

Keywords: *magnetic permeability, purity, stimulation, non-destructive, Electronic Tongue, comparative study.*

I. INTRODUCTION

One of the methods to know the nature of the material is the stimulation method, where the material is stimulated by a stimulator and the response of the material is studied to know the nature of the substance like permeability, density, temperature, purity of the material. This response is always unique for a particular material. The commonly used stimulators are light in Photometry, Electric field in Potentiometry, these stimulators are unpreferable in the situation, where the material is opaque and Electric field has an adverse effect on the viscosity of the liquid material [6]. Hence The magnetic field as a stimulator is ideal to study the nature of the material [9]. The response from the material where the Magnetic field is used as a stimulator is the resistance to the flow of magnetic field lines through them. This is the measure of Magnetic permeability, which is unique for a particular material in ideal condition. The proposed concept in this paper aims to design one single

piece of equipment to measure and compare the magnetic permeability of a wide range of materials that reveals the nature of the material. The main aim of this equipment is to compare the quality of the produced material to the certified standard sample; hence this is useful to determine the purity of the material and substance when all the physical parameters remain constant. Furthermore, this method can be used to approximate the boiling and freezing point of the same when the exact composition of the material is known. This is the novelty of this work.

Manuscript received on February 10, 2020.
Revised Manuscript received on February 20, 2020.
Manuscript published on March 30, 2020.

* Correspondence Author

Kadripathi K N*, department of Aerospace Engineering, Jain University, Bengaluru, India. Email: kadripathi.knk@gmail.com

Dr K S Kiran, department of Physics, Jain University, Bengaluru, India. Email: kiranxrd@gmail.com

L Yethinder Ragav, department of Aerospace Engineering, Jain University, Bengaluru, India. Email: yethinder@gmail.com

Manu Kiran B, department of Aerospace Engineering, Jain University, Bengaluru, India. Email: manukiran.b@gmail.com

II. EARLIER METHODES TO CHECK THE PURITY

A. Chemical analysis

One of the most accurate methods to determine the nature of the material like purity is the chemical analysis method [7]. This method is used in chemical laboratories to identify the presence and amount of impurities in the sample of the material using chemical analysis. This method is more complex, costly, time-consuming, needs expertise in the field, moreover the test sample is non-recoverable.

B. Physical method

One of the simplest ways to check the purity of the materials is to compare with the certified pure sample. This is completely based on the visual comparison, which reveals the presence of any large impurities, such as dirt or other differently colored impurities. However, this method is unreliable, since there is no uniformity in the segregation process, which varies from person to person.

III. EXISTING INSTRUMENTATION METHOD

In the present trend, the Electronic Tongue is the most promising device that measures and compares the tastes of the sample. It contains seven biosensors to detect dissolved organic and inorganic compounds. Like human taste receptors, each biosensor has a spectrum of functions different from the other. The information given by each biosensor is complementary and the combination of all biosensors' results generates a unique fingerprint.

Both qualitative and quantitative measures of the sample can be obtained.

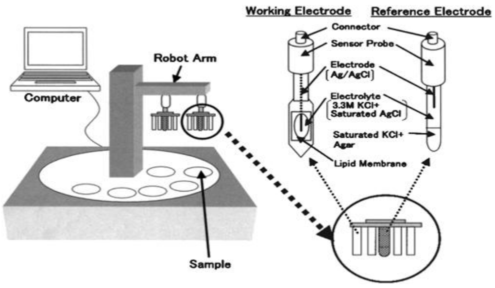

Fig. 1. Schematic Diagram of Electronic Tongue

Liquid samples are directly analyzed without any preliminary preparation, whereas solids require a preliminary dissolution before measurement. Reference electrode and sensors (working electrode) are dipped in a beaker containing a test solution. A voltage is applied between each sensor and a reference electrode, and a measurable current is the response. This current response is a result of oxidizing reactions that take place in the solution due to the voltage difference, and can be amplified through catalytic surface treatments. The response is measured and recorded by the e-tongue's software. These data represent the input for mathematical treatment that will deliver results. It is possible to check and compare the purity through this instrument. This is more advantages than the earlier discussed methods. However, the major drawback of this technique is the test sample gets denatured, it is unfit to reuse in most of the cases. When the sensors are dipped into the test sample, it under go Redox reaction and there might be the possibility of contamination of sample, hence the sample is discarded after the test [1][2][5][9].

IV. PROPOSED METHOD

A. Working Principle

- Whenever a material is placed in a uniform magnetic field of intensity H0, dipoles in the material tends to align in the direction of the applied magnetic field. Hence there will be a significant change in the intensity of the received magnetic field H. This depends on the ability of the material to conduct a magnetic field, which is termed as permeability (μ).
- In this case, the relation $B=\mu \cdot H$ is applicable, where B is the Magnetic flux density.
- Permeability varies with the geometry of the material, the frequency of the field applied, humidity, temperature, and nature of the material. The graph of the curve B v/s H gives the hysteresis loop, which is complicated to analyze the result. Hence for better approximation, the graph of change in magnetic field intensity v/s known amount of impurity in the sample is preferable. When all the parameters are constant then the graph is linear in nature, this is easy for analyzing and interpretation of the result.

B. Methodology

Before finding the purity of the unknown sample, some standardization has to be done. Later this standard reference value is compared to the testing sample of unknown purity, when all the other physical parameters are constant.

- Standardizing the Parameters

a) As an initial approach of the proposed method, only liquid samples are used, in order to maintain the uniform geometry. The testing chamber of 10ml is used, so that the geometry is constant.

b) A uniform magnetic field producing instrument is used such that the frequency of the AC used is constant.

c) The whole process is carried under adiabatic system; hence the temperature and humidity are constant.

d) When all these parameters kept constant, the sole governing parameter that affects the change in applied magnetic field is content (nature) of the material. The graph of which is linear, hence easy for approximation

C. Case study of inspecting milk sample

Milk as a sample is chosen and demonstrated the procedure of standardizing the parameter and calibrating the device using a microcontroller.

- Standardizing the parameter

10ml of certified pure milk is taken in a container and then it is introduced with a toroid that could generate the magnetic field of 0.4 T, using oscillator circuit. The permeability of this sample is calculated and stored in the computer by the assistance of ATmega328P microcontroller (Arduino Uno). Flux intensity of the pure sample Ho is obtained [4].

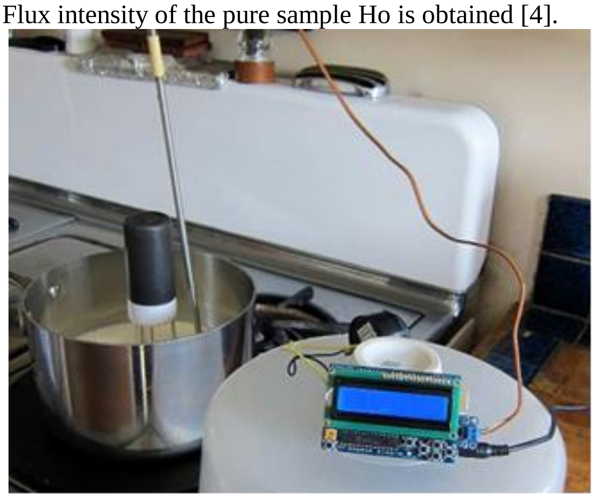

Fig. 2. Arduino set-up to test milk sample.

- Calibrating the device

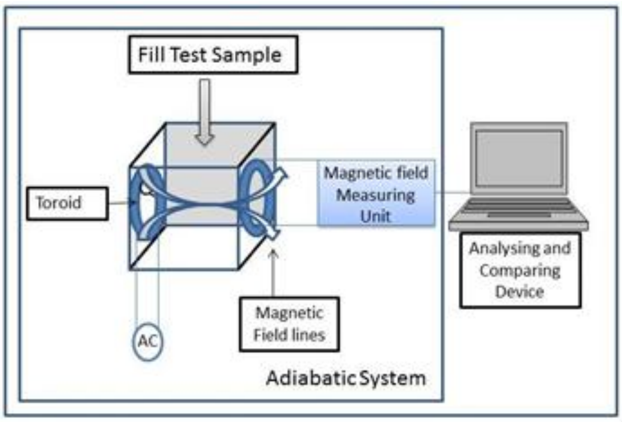

Fig.3. Schematic representation of proposed methodology.

Retrieval Number: F8747038620/2020©BEIESP
DOI:10.35940/ijrte.F8747.038620
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Known certified pure sample of 10 ml milk is taken in a test chamber. Then a uniform magnetic field is produced by the toroid. Then it is purposefully adulterated with a known quantity of water. The water content has hydrogen, which acts as a dipole and tends to align in the direction and creates the magnetic field throughout the sample. But fat content of the milk tends to reduce the propagation of the field. However, when the Magnetic field measuring unit detect and measures the received magnetic field intensity, it is always unique under specified condition (discussed under standardizing the parameters) for a sample of 10ml milk. The deviation in the permeability is recorded. This can be used as a standard reference value to measure the purity of the unknown milk sample. A graph of amount of adulterant in the sample versus change in flux intensity is drawn to the obtained values.
The equation of the line obtained

$$y = 2.4667x + 2.5$$

here y denotes the deviation in the flux from the standard reference value, and x denotes the amount of adulterant.

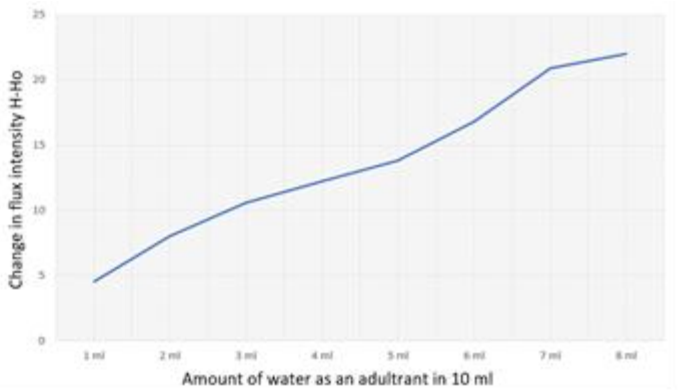

Fig.3. Graph obtained.

The graph obtained above represents the quantity of water added and the change in flux intensity. If a milk sample of unknown purity is taken for a test, the above-mentioned procedures are carried out to measure the change in flux intensity and the value of y is found. From the standard reference value table and the equation, the corresponding amount of water in the sample can be estimated.

D. Advantages of the proposed method

- Less time consuming: if the standard reference value table is saved in the software, then this method takes just few seconds to deliver the purity results.
- Sample is not denatured: it is recoverable for further use.
- Less cost, as the method is simple the cost for implementation is less
- Easy to use: it does not require skilled personnel to operate.
- It is Hygienic: almost zero contamination probability can be assured.

E. Applications of the proposed method

Fig.4. Wide range of applications

The proposed method has a wide range of applications on the diary and milk processing industries,

- This method can be implemented in the milk collection centers from farmers. A standardized price can be fixed based on the quality of the supplied milk.
- This method can also be used in bioscience and pharmacy to monitor the quality of the produced drug.
- This method can also be used to estimate the percentage composition of the metal in alloys, if the combined elements are known.
- Further by studying the change in other parameters, the nature of the material like freezing and boiling point can be estimated.

This method can be affectively used in almost all fields where the comparison method is applicable

F. Limitations

- Unlike Electronic Tongue this method cannot be used to detect the organic and inorganic elements in the sample, but this method can be effectively used to check the composition of the known elements in the sample.
- Standard reference value table has to be prepared for each material
- As of now only liquid samples can be taken for analysis

V. RESULTS

The proposed technique in this paper yields an effective outcome with a sample 10ml of milk. Interaction of external magnetic field with hydrogen molecule in water and lactic acid combination is interpreted in the graph. By diluting milk with water, the concentration on lactic acid decreases and the number of hydrogen molecule increases.

Thus, the number of hydrogen magnetic dipoles available in the large quantity, results in increased magnetic permeability of the sample. The equation $y = 2.4667x + 2.5$ thus obtained is used to calibrate the device and further testing can be done.

VI. CONCLUSION

The proposed method can be effectively used to compare the given sample to a certified pure sample; hence purity of the sample can be estimated, and this can be used as a complimentary with Electronic Tongue.

Applications of this device extend into various fields. Diluted milk, impurities in hydraulic oil, contaminants in fuel and pollutants in other materials can be detected using this device with the same procedure and thus, it can identify counterfeit copies of the original material which is very useful and one of the main objectives of this device. The limitations of this method can be overcome by further study; hence there is a huge scope for improvement.

REFERENCES

1. Marta Podraz˙ka, Ewa Ba˛czyn´ ska, Magdalena Kundys, Paulina S. Jelen´, "Electronic Tongue—A Tool for All Tastes?", http://www.mdpi.com/journal/biosensors.
2. Florian Oberhauser, Master's Thesis "Measurement Device for Magnetic Permeability of Steel in Production Processes" Graz, November 17, 2014.
3. J P. Gourber "A Portable Device to Measure Low Magnetic Permeability in Situ", CERN.
4. http://avilpage.com/2017/12/automatic-magnetometer-calibration-with-arduino.html.
5. Rahman Othman, Muhammad Suzuri Hitam, "Monitoring of Milk Quality with Disposable Taste Sensor", Sensors 2003, 3, 340-349.
6. E. N. da C. Andrade, F. R. S., C. Dodd, (Ph.D.). "The effect of an electric field on the viscosity of liquids", http://rspa.royalsocietypublishing.org/content/187/1010/296.
7. Analytical method, https://sciencing.com/can-check-purity-substance-5950683.html.
8. http://www.encyclopedia-magnetica.com/doku.php/confusion_between_b_and_h.
9. https://en.wikipedia.org/wiki/Electronic_tongue.
10. Xiaojie Xu ,Ming Liu ,Zhanbin Zhang "A Novel High Sensitivity Sensor for Remote Field Eddy Current Non-Destructive Testing Based on Orthogonal Magnetic Field.
11. M.L. Rodriguez-Méndez, C. Medina-Plaza, C. García-Hernández, J.A. de Saja, J.A. Fernández-Escudero, E. Barajas-Tola, G. Medrano, "Analysis of grapes and wines using a voltammetric bioelectronic tongue: Correlation with the phenolic and sugar content", SENSORS 2014 IEEE, pp. 2139-2142, 2014.
12. Hiroyuki Nakamoto, Ninomae Souda, Daisuke Nishikubo, Futoshi Kobayashi, "Food texture evaluation using tooth-shaped sensor and statistic model", Informatics Electronics and Vision & 2017 7th International Symposium in Computational Medical and Health Technology (ICIEV-ISCMHT) 2017 6th International Conference on, pp. 1-4, 2017.
13. Abhishruti Bhuyan, Bipan Tudu, Rajib Bandyopadhyay, Arunangshu Ghosh, Sanjeev Kumar, "ARMAX Modeling and Impedance Analysis of Voltammetric E-Tongue for Evaluation of Infused Tea", Sensors Journal IEEE, vol. 19, no. 11, pp. 4098-4105, 2019.
14. H. Troy Nagle, Susan S. Schiffman, "Electronic Taste and Smell: The Case for Performance Standards [Point of View]", Proceedings of the IEEE, vol. 106, no. 9, pp. 1471-1478, 2018.

AUTHORS PROFILE

Kadripathi K N, undergraduate student in Aerospace engineering at International Institute for Aerospace Engineering and Management (IIAEM), Jain University, Bengaluru. He has over 3 years of experience in working with avionic circuits. He has presented papers at international and national conferences and published papers in international publications. His research is focused on Unmanned aerial vehicle, flight controllers, super inductors, material science. He also authored many science columns in a print media.

Dr. K.S. Kiran is working as a professor, Department of physics, Jain Deemed to be University. He completed his M.Sc. and PhD degrees in Physics from Bangalore University, Bangalore, India. Awarded gold medal in M.sc 6th rank from Bangalore University. He has published 20 papers in reputed national and International Journals and presented around 30 papers. He has 23 years of experience in teaching the Engineering Physics and 7 years in the field of research. His area of research includes material science, crystal growth, x-ray crystallography and Molecular docking studies. He is a life member of many Indian and International Research associations like Life member, Indian society for Technical education, (ISTE), Indian Physics Association, (IPA), Indian Association for Physics Teachers, (IAPT), Luminescence society of India (LSIKC). Serving as an associate editor in Archives of Organic and Inorganic Chemical Sciences and as an editor in open chemistry journal.

L Yethinder Ragav, studying B. Tech Aerospace engineering in IIAEM, Jain University, Bangalore. He has over 9 years of experience in working with electrical and electronic circuits, over 3 years of experience in designing and 3D printing. He has presented papers at international and national conferences and published a paper in international publications. His research interest is focused on Super Capacitors, 3D printing and Renewable energy.

Manu Kiran B, studying B. Tech Aerospace engineering in IIAEM, Jain University, Bangalore. He has presented a paper in international conference. His research interest is focused on Unmanned Aerial vehicles, Super Capacitors, 3D printing and Renewable energy. He is known for teaching skills, he has authored many science blogs about space science and Indian culture.