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Application of Electronics in Yarn Testing Instruments in Textile

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Abstract - The electronics techniques have entered through many fields. In textile industry many electronic components are used and many instruments and machines are fitted with electronic measurement techniques. In this paper yarn testing instruments fitted with electronic components are discussed. How those instruments are working could be found from electronics literature. They are presented in this paper. Yarn count, yarn twist, evenness of yarns, imperfections of yarns, hairiness of yarns, single yarn strength tester, Lea strength of yarn, computerised lea strength tester, dynamic shrinkage, crimp, draw force of yarn are determined using electronic techniques.

***Key Words*:** PLC, Light sensors, displacement sensors, intrinsic sensors, bridge circuits, intelligent devices.

1. INTRODUCTION

In this paper i.e Textile industry is one of the ancient industries which came into existence along with the mankind. As we all know that during the beginning of Middle Ages humans used to spin and weave cotton using needle and thread. This industry took a giant leap during the industrial revolution during last century and changed the way of spinning and weaving cloths. But these changes remain steady for more than a century until it became a subject for scientific study or need for designing the machines that can complete the complicated tasks of cloth spinning, fabric designing, production etc. automatically and more efficiently. The latest developments in the field of Electronics made it possible to achieve greater efficiency through the electronics machines. Today's textile industry is focusing on implementing these latest technologies in all the sectors of textile industry to increase the efficient production at lesser prices. This is given in reference (1).

2. Programmable Logic Controller (PLC)

A Programmable Logic Controller, or PLC, is a ruggedized computer used for industrial automation. These controllers can automate a specific process, machine function, or even an entire production line.

How does a PLC work?

The PLC receives information from connected sensors or input devices, processes the data, and triggers outputs based on pre-programmed parameters. Depending on the inputs and outputs, a PLC can monitor and record run-time data such as machine productivity or operating temperature, automatically start and stop processes, generate alarms if a machine malfunctions, and more. Programmable Logic Controllers are a flexible and robust control solution, adaptable to almost any application.

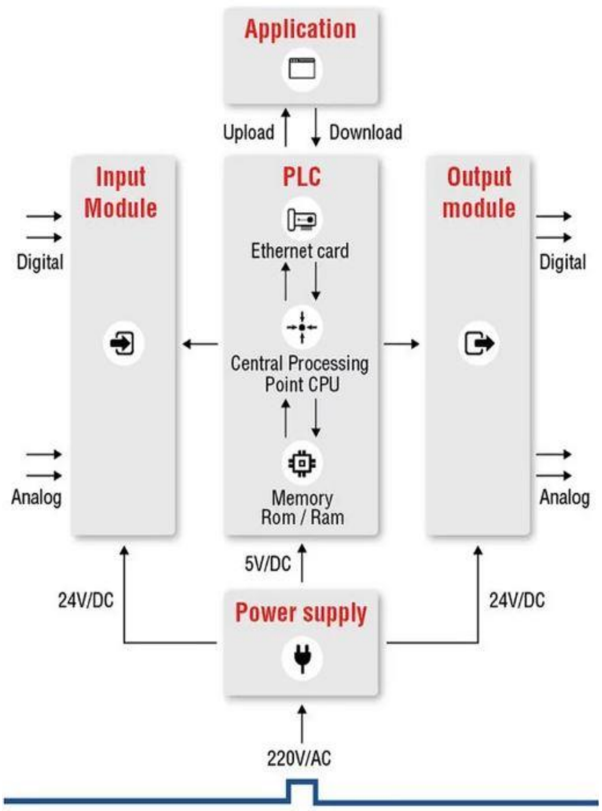

Fig-1:

What is a PLC? – Programmable Logic Controller

A Programmable Logic Controller, also called a PLC or programmable controller, is a computer-type device used to control equipment in an industrial facility.

The kinds of equipment that PLCs can control are as varied as industrial facilities themselves. Utility Plants, Batch Control Application, Chemical Processing, Conveyor systems, food processing machinery, auto assembly lines etc…you name it and there's probably a PLC out there controlling it.

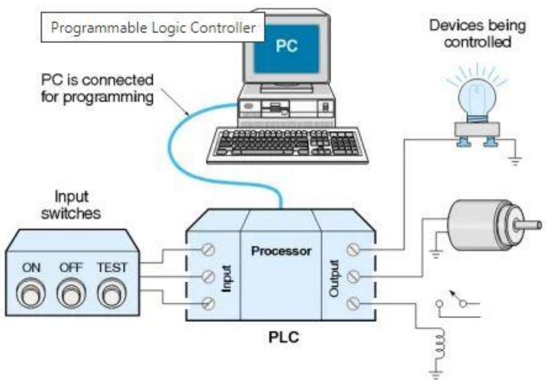

Fig-2: Programmable Logic Controller (PLC)

In a traditional industrial control system, all control devices are wired directly to each other according to how the system is supposed to operate. In a PLC system, however, the PLC replaces the wiring between the devices.

Thus, instead of being wired directly to each other, all equipment is wired to the PLC. Then, the control program inside the PLC provides the "wiring" connection between the devices.

The control program is the computer program stored in the PLC's memory that tells the PLC what's supposed to be going on in the system. The use of a PLC to provide the wiring connections between system devices is called soft wiring.

EXAMPLE

Let's say that a push button is supposed to control the operation of a motor.

In a traditional control system, the push button would be wired directly to the motor. In a PLC system, however, both the push button and the motor would be wired to the PLC instead.

Then, the PLC's control program would complete the electrical circuit between the two, allowing the button to control the motor.

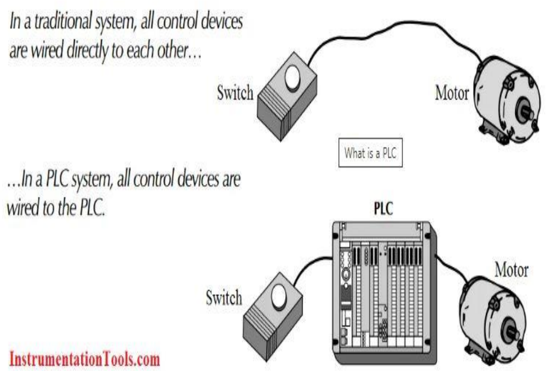

Fig-3:

The soft-wiring advantage provided by programmable controllers is tremendous.

In fact, it is one of the most important features of PLCs. Soft-wiring makes changes in the control system easy and cheap.

If you want a device in a PLC system to behave differently or to control a different process element, all you have to do is change the control program.

In a traditional system, making this type of change would involve physically changing the wiring between the devices, a costly and time-consuming endeavor. This is given in reference (3).

In textile instruments many PLC are employed and the working of the instruments is made easy with digital output. In this paper testing of yarns are done using the modern electronic equipments. These are analysed and given here.

3. Testing of yarns

The various types of instruments used in textile industry for yarns are given in reference (2). The modern developments are given in reference (4). How they are working is not taught in the syllabus of textile persons. The working and circuit of some instruments are analysed and presented in the following paper.

4. Count of yarn

The traditional method requires preparation of samples and calculation of data. But in Uster tester 6, sensor FA determines yarn count automatically. Together with yarn count other measurements such as evenness, imperfections and hairiness are given with greater precision. So other tests can be done immediately with less time.

Old methods of determining count of yarn are analytical balance, Knowles balance, quadrant balance, beegley balance, stub yarn balance.

The determination of count by modern instruments are with sensors. when yarn passes between the light source and light detector the obstruction of yarn to light source reduces the intensity of light falling on light detector. Measuring light detector intensity gives the count of yarn. The working of optical sensors (air path) is explained below.

Optical Sensors (Air Path)

Optical sensors are based on the modulation of light travelling between a light source and a light detector, as shown in Fig-4. The transmitted light can travel along either an air path or a fibre-optic cable. Either form of transmission gives immunity to electromagnetically induced noise, and also provides greater safety than electrical sensors when used in hazardous environments.

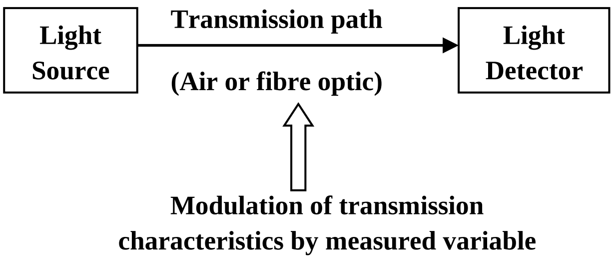

Fig-4: Operating principles of optical sensors

Light sources suitable for transmission across an air path include tungsten-filament lamps, laser diodes and light-emitting diodes (LEDs). However, as the light from tungsten lamps is usually in the visible part of the light frequency spectrum, it is prone to interference from the sun and other sources. Hence, infrared LEDs or infrared laser diodes are usually preferred. These emit light in a narrow frequency band in the infrared region and are not affected by sunlight.

The main forms of light detector used with optical systems are photocells (cadmium sulphide or cadmium selenide being the most common type of photocell), phototransistors and photodiodes. These are all photoconductive devices, whose resistance is reduced according to the intensity of light to which they are exposed. Photocells and phototransistors are particularly sensitive in the infrared region, and so are ideal partners for infrared LED and laser diode sources.

Air-path optical sensors are commonly used to measure proximity, translational motion, rotational motion and gas concentration.

In Uster 6 these principles are used and detection of count of yarn is done automatically.

5. Twist in Yarns

In old method twist in yarn is determined by straightened fibre method, Rock band twist tester, continuous twist tester, twist to break method, optical method, twist contraction method, twist in doubled yarns, take up twist tester.

But now in modern instruments twist is done automatically. In modern methods the twist is given in digital format and it is also made motorized and digital. This requires less time and quick testing of samples.

The twist is determined using displacement sensors. Magnetic sensors are used to measure translational and rotational displacements. Its working is given below.

Magnetic Sensors

Magnetic sensors utilize the magnetic phenomena of inductance, reluctance and eddy currents to indicate the value of the measured quantity, which is usually some form of displacement.

Inductive sensors translate movement into a change in the mutual inductance between magnetically coupled parts. One example of this is the inductive displacement transducer shown in Fig-5. In this, the single winding on the central limb of an ‘E’ shaped ferromagnetic body is excited with an alternating voltage. The displacement to be measured is applied to a ferromagnetic plate in close proximity to the ‘E’ piece. Movements of the plate alter the flux paths and hence cause a change in the current flowing in the winding. By Ohm’s law, the current flowing in the winding is given by

$$I = V/\ \omega L$$

For fixed values of ω and V, this equation becomes

$$I = 1/KL$$

Where K is a constant.

The relationship between L and the displacement, d, applied to the plate is a non-linear one, and hence the output-current/displacement characteristic has to be calibrated.

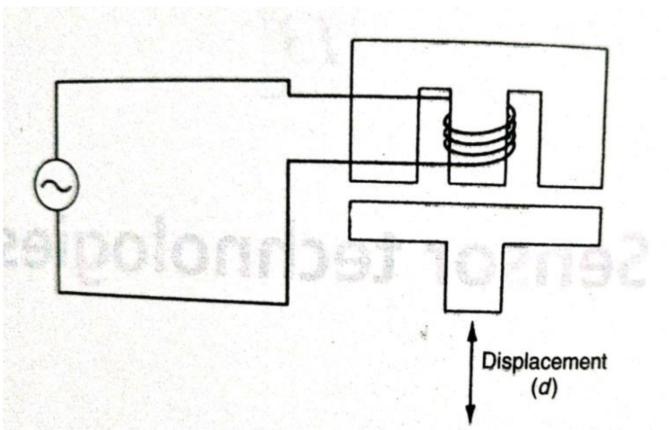

Fig-5: Inductive displacement sensor

The inductance principles also used in differential transformers to measure translational and rotational displacements.

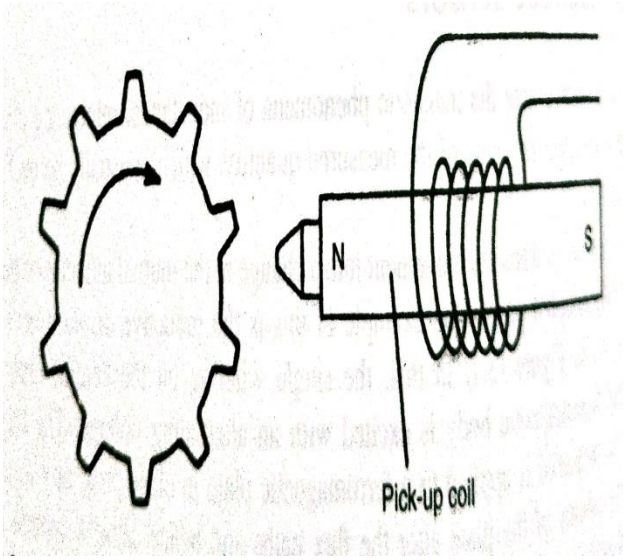

Fig-6: Variable Reluctance Sensor

In Variable reluctance sensors, a coil is wound on a permanent magnet rather than on an iron core as in variable inductance sensors. Such devices are commonly used to measure rotational velocities. Fig-6: shows a typical instrument in which a ferromagnetic gearwheel is placed next to the sensor. As the tip of each tooth on the gearwheel moves towards and away from the pick-up unit, the changing magnetic flux in the pick-up coil causes a voltage to be induced in the coil whose magnitude is proportional to the rate of change of flux. Thus, the output is a sequence of positive and negative pulses whose frequency is proportional to the rotational velocity of the gearwheel.

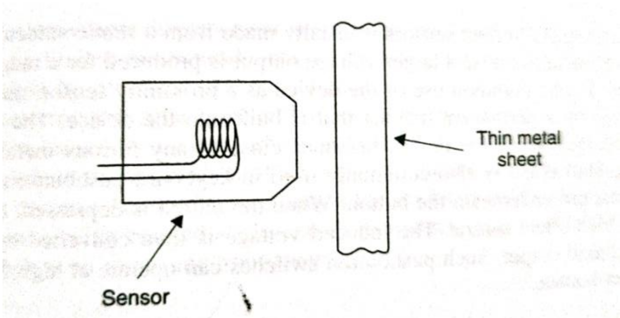

Fig-7: Eddy Current Sensor

Eddy current sensors consist of a probe containing a coil, as shown in Fig-7:, that is excited at a high frequency, which is typically 1 MHz. This is used to measure the displacement of the probe relative to a moving metal target. Because of the high frequency of excitation, eddy currents are induced only in the surface of the target, and the current magnitude reduces to almost zero short distance inside the target. This allows the sensor to work with very thin targets, such as the steel diaphragm of a pressure sensor. The eddy currents alter the inductance of the probe coil, and this change can be translated into a d.c. voltage output that is proportional to the distance between the probe and the target. Measurement resolution as high as 0.1µm can be achieved. The sensor can also work with a non-conductive target if a piece of aluminum tape is fastened to it.

With the use of magnetic sensors twist of yarn is measured and using PLC the measured values are converted to digital output. This is shown in display in modern instrument. Motor rotates the yarn & extension & contraction points are seen and correct twist on the yarn is displayed.

6. Evenness of Yarns

Evenness of yarns is previously done with capacitive method (Uster evenness tester). Other old methods are visual examination method, cutting & weighing method, electronic capacitance testers, fielden walker evenness tester. Uster evenness tester, spectrogram analysis, Uster classimat, tests for textured yarns, dynafil tester.

Now optical method of evenness determination has come (Zweigle G580). Optical method measures the variations in diameter of yarn. Infrared transmitter and two identical receivers are available in machine. The previous values are compared with measured value and correct evenness is obtained.

The optical method of determining the diameter of yarn is already discussed is count of yarn topic. The same method is used for determining the evenness of yarns.

Also the intrinsic sensors are used to determine the intensity of light. It is used in modern evenness light sensors. It is explained in below.

Intrinsic Sensors

Intrinsic sensors can modulate either the intensity, phase, polarization, wavelength or transit time of light. Sensors that modulate light intensity tend to use mainly multimode fibres, but only monomode cables are used to modulate other light parameters. A particularly useful feature of intrinsic fibre-optic sensors is that they can, if required, provide distributed sensing over distances of up to 1 metre.

Light intensity is the simplest parameter to manipulate in intrinsic sensors because only a simple source and detector are required. The various forms of switches shown in Fig-8: are perhaps the simplest form of these, as the light path is simply blocked and unblocked as the switch

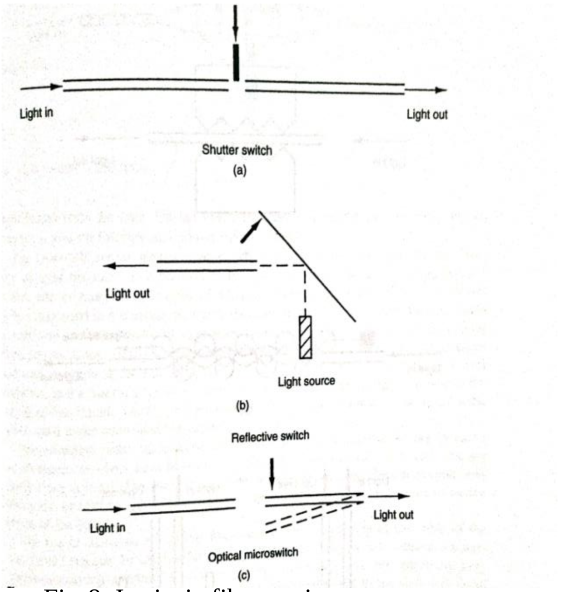

Fig-8: Intrinsic fibre-optic sensors

Modulation of the intensity of transmitted light takes place in various simple forms of proximity, displacement, pressure, pH and smoke sensors. Some of these are sketched in Fig-9:.

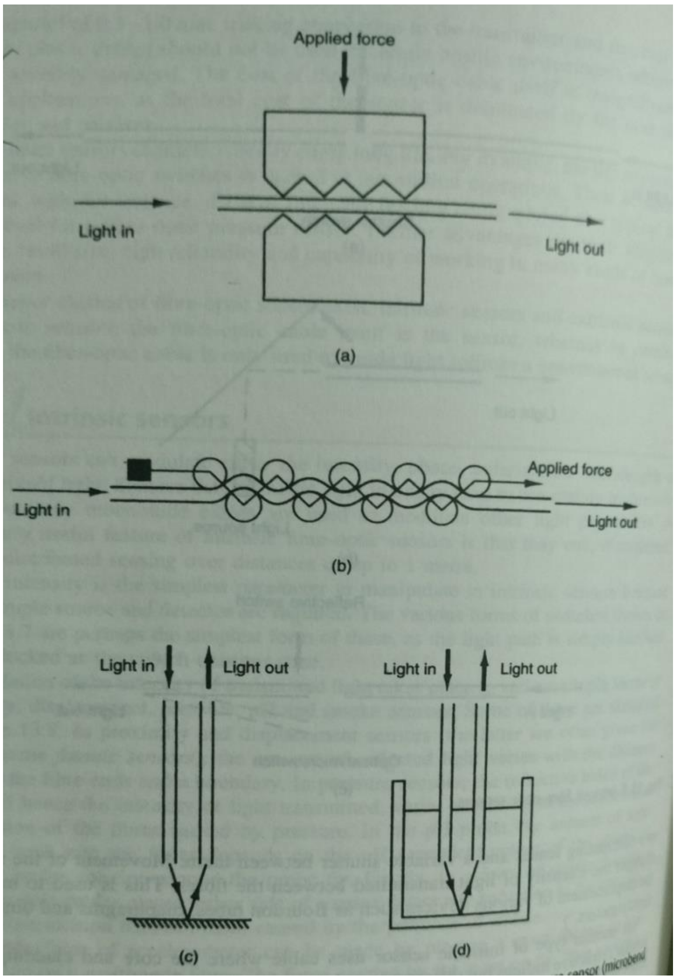

Fig-9: Intensity Modulating Sensor:

changes state.

(a) Simple Pressure Sensor (b) Roller-Chain Pressure Sensor (Microbend Sensor) (c) Proximity Sensor (d) pH Sensor

In proximity and displacement sensors (the latter are often given the special name fotonic sensors), the amount of reflected light varies with the distance between the fibre ends and a boundary. In pressure sensors, the refractive index of the fibre and hence the intensity of light transmitted, varies according to the mechanical deformation of the fibres caused by pressure. In the pH probe , the amount of light reflected back into the fibres depends on the pH-dependent colour of the chemical indicator in the solution around the probe tip. Finally, in a form of smoke detector, two fibre-optic cables placed either side of a space detect any reduction in the intensity of light transmission between them caused by the presence of smoke.

A simple form of accelerometer can be made by placing a mass subject to the acceleration on a multimode fibre. The force exerted by the mass on the fibre causes a change in the intensity of light transmitted, hence allowing the acceleration to be determined. The typical inaccuracy quoted for this device is ±0.02g in the measurement range ±5 g and ±2% in the measurement range up to 100 g.

A similar principle is used in probes that measure the internal diameter of tubes. The probe consists of eight strain-gauged cantilever beams that track changes in a diameter, giving a measurement resolution of 2 µm.

A slightly more complicated method of effecting light intensity modulation is the variable shutter sensor shown in Fig-10:

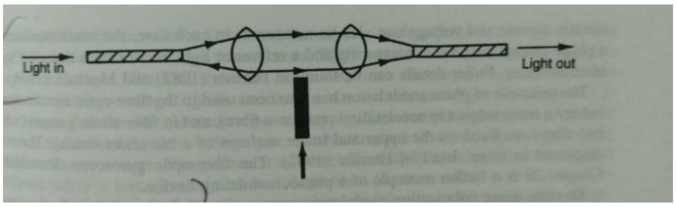

Fig-10: Variable – Shutter Sensor

This consists of two fixed fibres with two collimating lenses and a variable shutter between them. Movement of the shutter changes the intensity of light transmitted between the fibres. This is used to measure the displacement of various devices such as Bourdon tubes, diaphragms and bimetallic thermometers.

These intrinsic sensors are used for measurement of evenness of yarns.

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7. Imperfections of yarns

The various imperfections of yarns such as thin, thick, slubs, neps and classimat faults can be measured with suitable program in the PLC and sensing with light. They are given as digital output.

8. Hairiness

The number of hairiness in yarn is determined using Shirley hairiness meter. But in modern instruments all are automatically done with the use of light sources.

9. Single yarn strength tester

Old method determination is by the use of single thread strength tester, single thread strength tester based on inclined plane principle, Uster single thread strength tester, Instrom tester. Single yarn strength tester is used for testing strength of single yarn. The traditional method requires labour and heavy calculation is required to find it. But in modern instrument digitally all values are determined. 20 cops at the same time can be tested.

Tensorapid, Instron were developed and it was used from old days. They employ electronics to it. But many other methods are invented and used in modern yarn strength testing equipments. In instrom wheatstone bridge is employed and the resistors finds the strength of yarn.

Bridge Circuits

Bridge circuits are used very commonly as a variable conversion element in measurement systems and produce an output in the form of a voltage level that changes as the measured physical quantity changes. They provide an accurate method of measuring resistance, inductance and capacitance values and enable the detection of very small in measurement system technology because so many transducers measuring physical quantities have an output that is expressed as a change in resistance, inductance or capacitance. The displacement-measuring strain gauge, which has a varying resistance output, is but one example of this class of transducers. Normally, excitation of the bridge is by a d.c voltage for resistance measurement and by an a.c. voltage for inductance or capacitance measurement. Both null and deflection types of bridge exist, and, in a like manner to instruments in general, null types are mainly employed for calibration purposes and deflection types are used within closed-loop automatic control schemes.

Deflection Type D.C. Bridge

A deflection-type bridge with d.c. excitation is shown in Fig-11:. This differs from the Wheatstone bridge mainly that the variable resistance R_v is replaced by a fixed resistance R_1 of the same value as the nominal value of the unknown resistance R_u. As the resistance R_u changes, so the output voltage V_0 varies, and this relationship between v_0 and R_u must be calculated.

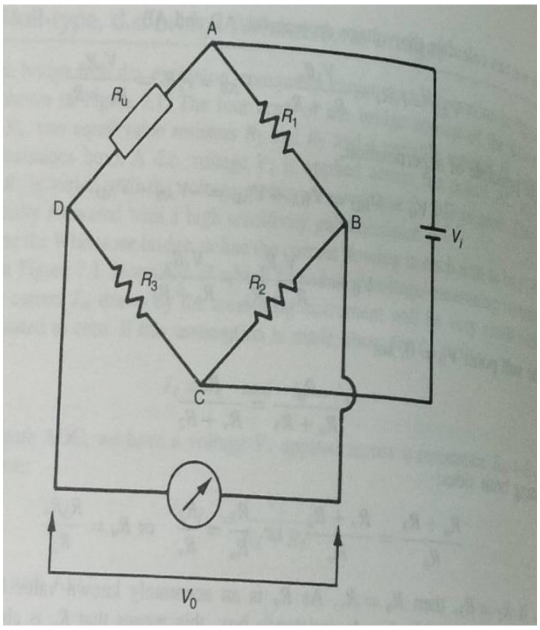

Fig-11: Deflection Type D.C. Bridge

Wheatstone and deflection types are employed for measuring yarn strength test.

Null-type Impedance Bridge

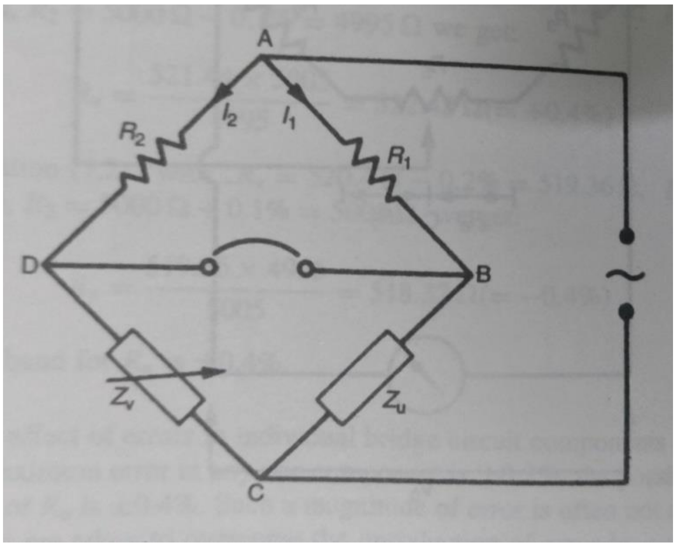

Fig-12: Null-type Impedance Bridge

A typical null-type impedance bridge is shown in Fig-12. The null point can be conveniently detected by monitoring the output with a pair of headphones connected via an operational amplifier across the points BD. This is a much cheaper method of null detection than the application of an expensive galvanometer that is required for a d.c. Wheatstone bridge.

Maxwell Bridge

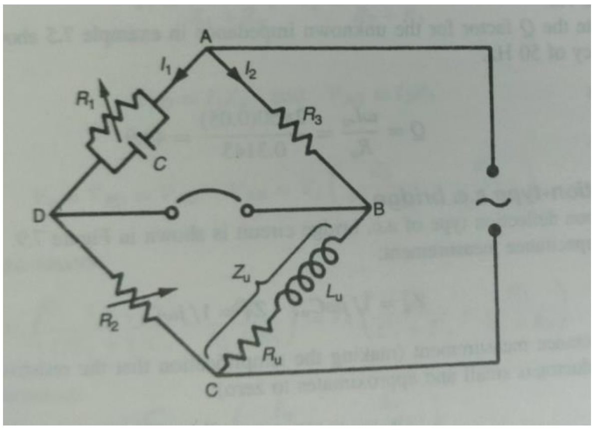

Fig-13: Maxwell Bridge

A Maxwell bridge is shown in Fig-13. The requirement for a variable inductance box is avoided by introducing instead a second variable resistance. The circuit requires one standard fixed-value capacitor, two variable-resistance boxes and one standard fixed-value resistor, all of which are components that are readily available and inexpensive.

Deflection-Type A.C. Bridge

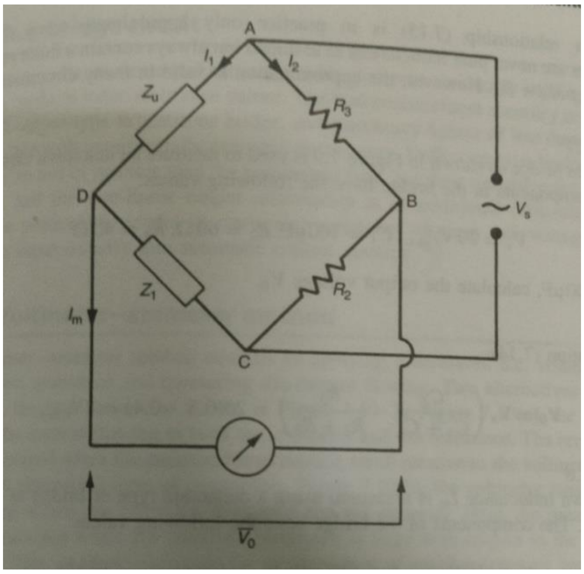

Fig-14: Deflection Type A.C Bridge

A common deflection type of a.c bridge circuit is shown in Fig-14:

For capacitive measurement

$$Z_u = 1/j\,\omega\,C_u$$

$$Z_1 = 1/j\,\omega\,C_1$$

For inductance measurement (making the simplification that the resistive component of the induction is small and approximates to zero.

$$Z_u = j\,\omega\,L_u$$

$$Z_1 = j\,\omega\,L_1$$

These bridge circuits are employed for measuring yarn strength test.

10. Lea Strength of Yarn

Old method employs lea strength tester and ballistic tester. The lea strength testing of yarn is determined mechanically in old method. But in modern developments the load cell is employed and quick determination of lea strength is done. Digitally the values are available. Computerized lea strength tester is also available.

Previous methods of d.c. bridge circuits and a.c. bridge circuits can be employed for lea strength of yarn determination.

D.C. Bridge Circuit

D.C. bridge circuits, as discussed earlier, provide the most commonly used method of measuring medium value resistance values. The best measurement accuracy is provided by the null-output-type Wheatstone bridge, and inaccuracy figures of less than ±0.02% are achievable with commercially available instruments. Deflection-type bridge circuits are simpler to use in practice than the null-output type, but their measurement accuracy is inferior and the non-linear output relationship is an additional difficulty. Bridge circuits are particularly useful in converting resistance changes into voltage signals that can be input directly into automatic control systems.

11. Computerized Lea Strength Tester

The measurement is done with D.C or A.C bridge circuits. After that the information is given to computer and output is obtained.

In early applications of digital signal processing, the computer remained as a distinctly separate component within the measurement system. However, the past few years have seen the development of measurement systems in the form of intelligent devices in which the computational element (usually called a microcomputer or microprocessor) is much more closely integrated into the measurement system. These devices are known by various names such as intelligent instruments, smart sensors and smart transmitters.

Programming and Program Execution

In most modes of usage, including use as part of intelligent devices, computers are involved in manipulating data. This requires data values to be input, processed and output according to a sequence of operations defined by the computer program. However, in practice, programming the microprocessor within an intelligent device is not normally the province of the instrument user, indeed, there is rarely any provision for the user to create or modify operating programs even if he/she wished to do so.

In many computer applications, including their use within intelligent devices, the external peripheral requires signals to be in analogue form. Therefore the input-output interface must provide for conversion between these analogue signals and the digital signals required by a digital computer. This is satisfied by analogue-to-digital and digital-to-analogue conversion elements within the input-output interface.

A standard form of interface used to connect a computer to its peripheral devices is the UART (Universal Asynchronous Receiver/Transmitter). This has been used for around 30 years. A newer interface protocol that is particularly suitable for connecting a large number of devices and providing for communication between different computers is the PCI (Peripheral Component Interconnect) interface. Very recently, an alternativeprotocol called the Universal Serial Bus (USB) has been developed that is rapidly gaining in popularity.

12. Dynamic Shrinkage, Crimp, Draw Force

The yarn shrinks when treated with chemicals or heat. This can be measured with new testers. The crimp in yarn inside fabric is also determined using the tester. Draw force is the force required to extend the yarn. These are also determined using the various electronic equipments.

Intelligent Instruments

The first intelligent instrument appeared over 20 years ago, although high prices when such devices first became available meant that their use within measurement systems grew very slowly initially. The processor within an intelligent instrument allows it to apply pre-programmed signal processing and data manipulation algorithms to measurements. One of the main functions performed by the first intelligent instruments to become available was compensation for environmental disturbances to measurements that cause systematic errors. Thus, apart from a primary sensor to measure the variable of interest, intelligent instruments usually have one or more secondary sensors to monitor the value of environmental disturbances.

Smart Sensors

A smart sensor is a sensor with local processing power that enables it to react to local conditions without having to refer back to a central controller. Smart sensors are usually at least twice as accurate as non-smart devices, have reduced maintenance costs and require less wiring to the site where they are used. In addition, long-term stability is improved, reducing the required calibration frequency.

The functions possessed by smart sensors vary widely, but consist of at least some of the following

These are given in reference (5).

- Remote calibration capability
- Self-diagnosis of faults
- Automatic calculation of measurement accuracy and compensation for random errors
- Adjustment for measurement of non-linearities to produce a linear output
- Compensation for the loading effect of the measuring process on the measured system.

The capabilities of smart transmitters are perhaps best emphasized by comparing the attributes of the alternative forms of transmitter available. There are three types of transmitter, analogue, programmable and smart.

a. Analogue transmitters
    - Require one transmitter for every sensor type and every sensor range
    - Require additional transmitters to correct for environmental changes
    - Require frequent calibration
b. Programmable transmitters
    - Include a microprocessor but do not have bi-directional communication (hence are not truly intelligent)
    - Require field calibration
c. Smart transmitters
    - Include a microprocessor and have bi-directional communication
    - Include secondary sensors that can measure, and so compensate for, environmental disturbances
    - Usually incorporate signal conditioning and a-d conversion
    - Often incorporate multiple sensors covering different measurement ranges and allow automatic selection of the required range. The range can be readily altered if initially estimated incorrectly
    - Have a self-calibration capability that allows removal of zero drift and sensitivity drift errors
    - Have a self-diagnostic capability that allows them to report problems or requirements for maintenance
    - Can adjust for non-linearities to produce a linear output

The use of intelligent instruments measures the various yarn shrinkage, crimp and draw force.

Using these instruments various yarn parameters are determined.

13. RESULTS AND DISCUSSIONS

Using electronics for instruments makes the testing accurate and large calculations are automatically done using PLC designs. The role of electronics to textiles is presented. The discussion on PLC is given & its understanding is done clearly. The working of modern instruments for determining various yarn parameters are presented. They are not present in syllabus of current curriculum of textile students. But industries uses only these modern instruments. So necessary steps to introduce these techniques to curriculum of textile students should be taken to cater the need of textile industry.

14. CONCLUSIONS

Various new modern instruments uses electronic techniques & computers which gives accurate results with less time and less labour work. To have good quality of product modern techniques should be employed. Students should be taught with modern techniques in polytechnics and colleges.

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