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Design of Data Acquisition System (DAS) for Electro-Mechanical Tension Creep Testing Machine

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Abstract: ***This research paper is based on the design and working of data acquisition system of electro-mechanical tensile creep testing machine. Microcontroller Arduino Nano, ADXL-345, DS-1302, SD card module, display unit is used in DAS. To improve the accuracy and precision of machine it is important to monitor several parameters like temperature, load and strain with respect to time. For this a low energy consuming and large storage capacity DAS is designed. The system can monitor creep behavior of different polymers and soft metals like lead. This system can store all the required data, which is needed to analyze creep behavior of materials automatically in a nonvolatile memory which will subsequently transmitted to computer system. Also system can make timed samples of the process of creep deformation. This data can be compared with the simulated data which will use for further research work.***

Keywords: Microcontroller, Creep, ADXL-345, DS-1302, Display unit

1. Introduction

High temperature progressive deformation of a material at constant stress is called creep. Normally, creep appears when vacancy in the material migrates towards grain boundaries that are oriented normal to the direction of applied stress. It is both a time and temperature dependent phenomenon. It results from the viscoelastic flow of polymer with time. Creep rate of thermoplastics is classically associated with time dependent plasticity at an elevated temperature, often in limits with 0.4 - 0.5 of its melting temperature. Creep is generally divided into three stages; i.e. primary creep, secondary creep, tertiary creep.

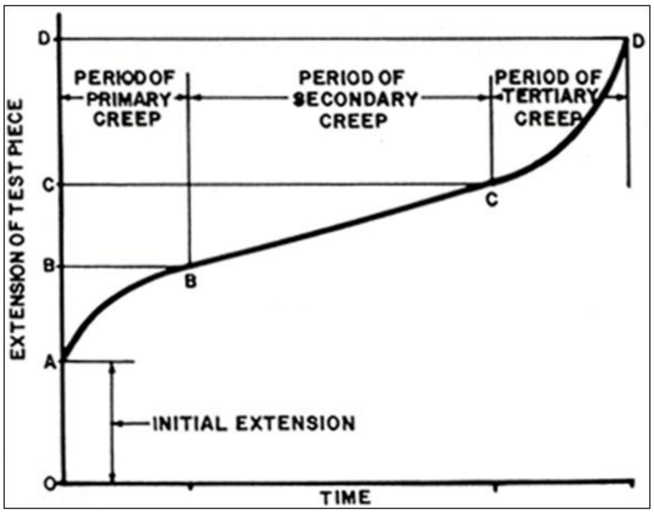

Figure 1: Typical creep graph showing strain verses time function

An electromechanical creep testing machine is designed to experiment various materials to determine its creep behavior. In old creep testing machine lever arm mechanism is used to apply load. The lever arm should be kept horizontal always which is difficult for longer period of time. So, in this creep testing machine it is replaced with wire and turnbuckle arrangement to apply load. It improves the accuracy of machine but it is still a time consuming process where observer should have to record all the deflections manually and there will be possibility of human error.

Data acquisition system must be required for monitoring several parameters like temperature, load and strain with respect to time. It gives precise reading and improves the accuracy of creep testing machine. The system is able to monitor creep behavior of thermoplastic polymers like polypropylene (PP) and soft metals like lead. Microcontroller arduino Nano (ATmega 328P-8 bit), ADXL-345, DS-1302, SD card module, display unit 16*4 is used for designing DAS.

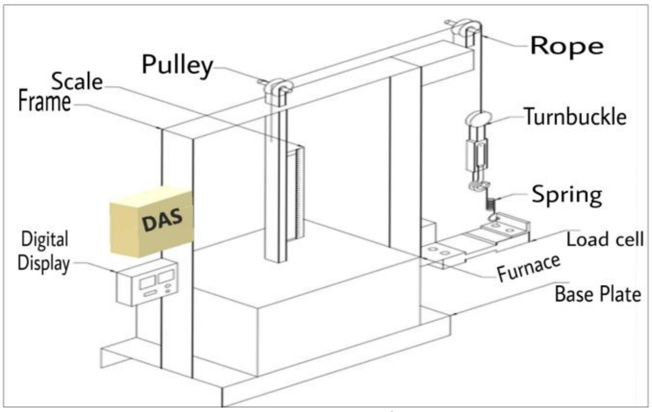

Figure 2: Schematic Diagram of Creep Testing Machine with DAS

2. Design of Data Aquasition System (DAS)

Data acquisition system consists of following components;

a) **Arduino Nano:-** It is ATmega328 10 bit microcontroller. The ATmega328 has 32 KB Memory; (also with 2 KB used for the boot loader) The ATmega328 has 2 KB of SRAM and 1 KB of EEPROM. Each of the 14 digital pins on the Arduino Nano can be used as an input or output, using pin Mode, digital Write, and digital Read functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. The Arduino Nano can be powered via the Mini-B USB connection, 6-20V unregulated external power supply (pin Vin), or 5V regulated external power supply (pin 27). The power source is automatically selected to the highest voltage source. Maximum frequency of this microcontroller is limited to 16 MHz and voltage limit is 5V.

b) **ADXL-345:-** The ADXL345 is a small, thin, ultralow power, 3-axis accelerometer with high resolution (13-bit) measurement at up to ±2g to ±16 g. It measures the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion or shock. Its high resolution (3.9 mg/LSB) enables measurement of inclination changes up to 0.1°. Several special sensing functions are provided. Activity and inactivity sensing detect the presence or lack of motion by comparing the acceleration on any axis with user-set thresholds. An integrated memory management system with a 32-level first in, first out (FIFO) buffer can be used to store data to minimize host processor activity and lower overall system power consumption. The ADXL345 is supplied in a small, thin, 3 mm × 5 mm × 1 mm, 14-lead, plastic package. Supply voltage is 2.0-3.6V. The main feature of ADXL-345 is its ultralow power which is as low as 23 µA in measurement mode and 0.1 µA in standby mode at VS = 2.5 V. It has wide range of working temperature i.e. from -40^0 C to 85^0 C.

c) **DS1302:-** The DS1302 Trickle Charge Timekeeping Chip contains a real time clock/calendar and 31 bytes of static RAM. It communicates with a microprocessor via a simple serial interface. The real time clock/calendar provides seconds, minutes, hours, day, date, month, and year information. The end of the month date is automatically adjusted for months with less than 31 days, including corrections for leap year. The clock operates in either the 24–hour or 12–hour format with an AM/PM indicator. Interfacing the DS1302 with a microprocessor is simplified by using synchronous serial communication. Only three wires are required to communicate with the clock/RAM: (1) RST (Reset), (2) I/O (Data line), and (3) SCLK (Serial clock). Data can be transferred to and from the clock/RAM 1 byte at a time or in a burst of up to 31 bytes. The DS1302 is designed to operate on very low power and retain data and clock information on less than 1 microwatt. The DS1302 is the successor to the DS1202. In addition to the basic timekeeping functions of the DS1202, the DS1302 has the additional features of dual power pins for primary and back–up power supplies, programmable trickle charger for VCC1, and seven additional bytes of scratchpad memory.

d) **Potential Divider:-**Potential divider is a passive linear circuit that produces an output voltage that is a fraction of its input voltage (Vin). Microcontroller ATmega 324 has voltage limit of 5V. To prevent microcontroller from high voltage damage potential divider is implemented in DAS. Voltage division is the result of distributing the input voltage among the components of the divider. A simple example of a voltage divider is two resistors connected in series, with the input voltage applied across the resistor pair and the output voltage emerging from the connection between them.

Resistor voltage dividers are commonly used to create reference voltages, or to reduce the magnitude of a voltage so it can be measured, and may also be used as signal attenuators at low frequencies. For direct current and relatively low frequencies, a voltage divider may be sufficiently accurate if made only of resistors; where frequency response over a wide range is required (such as in an oscilloscope probe), a voltage divider may have capacitive elements added to compensate load capacitance. In electric power transmission, a capacitive voltage divider is used for measurement of high voltage.

e) **LCD Display**:**-** LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x4 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. A 16x4 LCD means it can display 16 characters per line and there are 4 such lines. In this LCD each character is displayed in 8x5 black and white LED. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

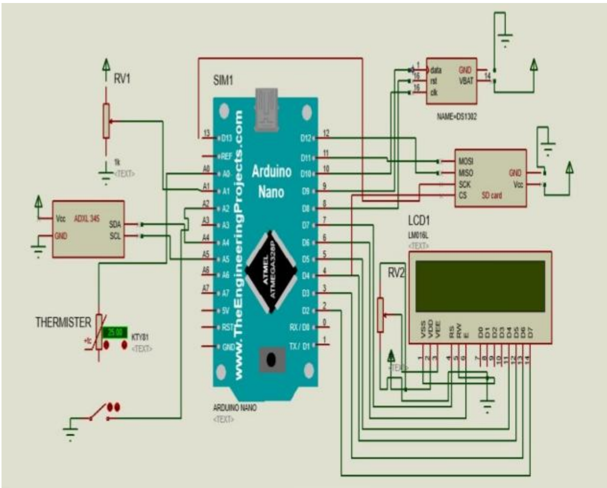

Figure 3: Circuit Diagram of Data acquisition system

3. Working of Data Acquisition System (DAS)

This electromechanical creep testing machine is used to determine creep behavior of different materials. The main purpose of the data acquisition system is to automatically record time to time data of creep deformation during the experimentation. This data can be saved in SD card Module in the form of Excel sheet which includes parameters like "load, temperature, deflection and strain with respect to time".

Circuit diagram of DAS system (Fig-2) shows all the main components that is Arduino Nano, ADXL 345, DS1302, SD card Module, Potential Divider and 16*4 (Black and White) LCD display. All these components are integrated on the PCB. Direct power supply is given to the DAS system which initiates Boot Loader in the Arduino Nano. Also LCD display, ADXL345, DS1302 starts their functioning. If SD card is detected by the DAS system then message will display on the screen "DATA LOGGING IS ON" and if not detected then message will be display as "DATA NOT LOGGING".

Deflection in the specimen is detected and recorded by ADXL 345 which is a small, thin, ultralow power, 3-axis accelerometer. It records change in angle (θ) in the form of coordinates (XYZ). Then this data is send to the accumulator which converts it into the ASCII value which is understood to the Arduino Nano. During the operation real experimentation time and date is given by the proper functioning of DS1302 which is a Trickle Charge Timekeeping Chip. A potentiometer is integrated with the DAS system to regulate the load. Also a temperature regulator is implemented to record the temperature with respect to deflection. A potential divider is also connected to the Arduino Nano which is passive linear circuit that produces 5V voltage as an input to the Arduino Nano. Finally this all the experimental data is stored and recorded in SD card Module. An excel sheet is generated which can be subsequently displayed and analyzed on the computer system. This experimental data is compared with the simulated data to determine the exact creep deformation by plotting graph of strain vs. time.

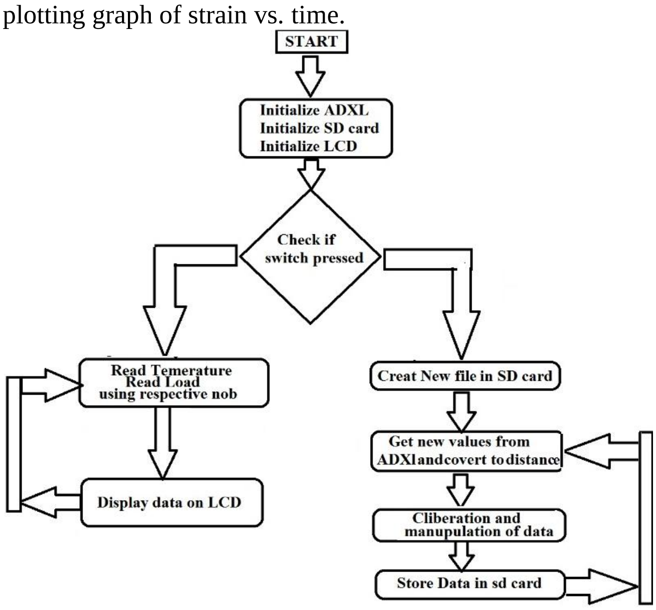

Figure 4: DAS program execution flowchart

4. User Interface

	A	B	C	D	E	F	G
1	Original Length	Date	Time	Change in Length	Strain	Temperature	load
2	30	14-03-2019	22:23:10	0	0	70	30
3	30	14-03-2019	22:23:51	0.16	0.01	70	30
4	30	14-03-2019	22:24:26	0.31	0.01	70	30
5	30	14-03-2019	22:25:21	0.5	0.02	70	30
6	30	14-03-2019	22:25:36	0.67	0.02	70	30
7	30	14-03-2019	22:26:12	0.83	0.03	70	30
8	30	14-03-2019	22:26:17	0.95	0.03	70	30
9	30	14-03-2019	22:26:57	1.15	0.04	70	30
10	30	14-03-2019	22:27:02	1.25	0.04	70	30
11	30	14-03-2019	22:27:05	1.61	0.05	70	30
12	30	14-03-2019	22:27:07	1.74	0.06	70	30

Figure 5: Main Window of User Interface

The data acquisition system (DAS) records all the data and it is stored in the form of Excel Sheet. This excel sheet contains the original length, date, time, change in length, strain, temperature and load. The original length, date, load and temperature are the constant parameters whereas other parameters are varying with respect to time.

5. Technical Specifications

Technical specification of DAS system is summarized in table 1. The noticeable characteristics of DAS system is its low energy consumption and high storage capacity. Another important feature of DAS system is it has expandable memory about 32 GB.

Table 1: Technical Specifications

Power supply to Arduino Nano	6 - 20 V
Maximum memory of Arduino Nano	30720 bytes
Frequency	16 MHz
Maximum resolution of ADXL-345	±16 g
Supply voltage of ADXL-345	2 - 3.6 V
Temperature Range	-40 – 85 °C
Static ram of DS1302	31 bytes
LCD	16*4 display
SD card module	Max up to 32 GB

6. Conclusion

The design and working of data acquisition system constituted microcontroller and software user interface has been explained in this paper. DAS is successfully recording accurate readings of various parameters like load, temperature and strain. This experimental data automatically stored in the non-volatile memory which can be displayed on the computer system in the form of excel sheet through user interface.

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