CHAPTER

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.

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.

In this research work material selected for the creep test is polypropylene (PP). Polypropylene is widely used in various applications due to its good chemical resistance. Some common uses of polypropylene includes; food packaging, automobile battery cases, disposable syringes. Investigation of creep behavior on polypropylene at different temperature and load is of practical use for improving the safety and reliability in packaging, automotive and medical applications. In this paper the tensile creep testing machine is used to study the creep behavior of PP at varying temperature and loading conditions. In this work we studied the tensile creep behavior of PP to understand the long term stability of its size and load capacity, to predict its service lifetime.

1.1 PROBLEM IDENTIFICATION

- Creep testing machine is not able to detect changes in length below 1 mm manually. Also this process is very time consuming and not precise.
- 2 After many experimentations it is observed that at higher loads above 10 kg turnbuckle arrangement is not able to apply constant load.
- 3 load is gradually decrease with respect to elongation after 20-24 hours of experimentation which leads to failure of experimentation.
- 4 The spring used in the turnbuckle arrangement is not hold good to apply load more than 10 kg.
- 5 mild steel wire of diameter 1mm which is used in the machine not able to sustain load above 23 kg.

1.2 PROJECT OBJECTIVE

- The main objective of our project is to determine the creep behavior of the different materials by experimentation electromechanical creep testing machine and simulation on software.
- One objective is to improve the accuracy and precision of machine. For that DAS system is integrated with the tensile creep testing machine which now gives readings with 0.01 mm accuracy.
- Human errors and time consuming manual process of observation is also eliminated with implementation of DAS system.
- A new wire of mild steel of diameter 1.2 mm or more can be used that will sustain load more than 40 kg also.
- Old turnbuckle arrangement is replaced by the new hanger system with loads. This system is hold good to apply constant load even for longer period of time.
- Old spring is replaced with new spring which is more stiff because of which about 40 kg load can be apply on specimen constantly while experimentation.

1.3 SCOPE

In the course of this work, an attempt has been made to modify and improve the accuracy of tensile creep testing machine. For that a Data Acquisition System is implemented in this creep testing machine. This DAS system gives real time and precise readings of creep behaviour of various materials like lead, aluminium, polypropylene etc. This creep behaviour helps in forecasting the creep failure of material under high temperature and pressure.

By this project we have tried to give an electromechanical creep testing machine for college laboratory to help the student to understand the concept of creep behaviour and the professional creep testing machine has a great scope in future to study the various material used under high temperature and pressure application like boilers, aeroplane, etc.

CHAPTER

REVIEW OF LITERATURE

Dean, G.D.; Broughton, W. A model for non-linear creep in polypropylene [J]. Polym. Test. Volume 26, Issue 8, December 2007, Pages 1068-1081.

Measurements of the creep behaviour of a polypropylene polymer under uniaxial tension have been modelled using a stretched exponential function with four parameters. Non-linear behaviour arises because one of the parameters, related to a mean retardation time for the relaxation process responsible for creep, is dependent on stress. Creep curves measured under a uniaxial tensile stress and a uniaxial compressive stress of the same magnitude are different. The differences can be described by relating the retardation time parameter to an effective stress that is determined by the magnitude of both the shear component of the stress and the hydrostatic component. This analysis has then been generalized to enable expressions to be formulated for creep behaviour under an arbitrary multiaxial stress state. This requires an assumption that either the Poisson's ratio or the bulk modulus is independent of time. The validity of this assumption has been evaluated through comparisons of predictions of creep under a pure shear stress with measurements, which show that a time-independent Poisson's ratio is the better approximation. Although not the main theme of the paper, examples are given illustrating the dependence of model parameters on the structure of the crystalline and amorphous regions of the polymer. This is particularly relevant to the application of the model to the analysis of the creep behaviour of welded polypropylene where properties will, in general, be influenced by the heat treatment.

G.D. Dean, W. Broughton Industry and Innovation Division, Review of accelerated ageing methods and lifetime prediction techniques for polymeric materials, National Physical Laboratory, Teddington, Middlesex TW11 0LW, UK Received 11 May 2007; accepted 17 July 2007.

Manufacturers of polymer-based materials are increasingly being asked for assurance of product lifetime, particularly for components, which cannot be easily inspected or may fail catastrophically in service. Whilst the life expectancy of products in non-demanding applications have traditionally been predicted from previous in-service experience, the use of plastics in long-term or critical applications requires a far better understanding of the failure mechanisms and the use of accelerated ageing conditions to enable reliable lifetime predictions to be made. This report reviews the failure mechanisms that are commonly experienced in service and the techniques that have been developed to predict life expectancy. The report consists of: a summary of the main degradation mechanisms present in polymeric materials; a review of techniques for predicting the life expectancy of polymers; standards for life-prediction; and the results of an industrial survey examining current UK practice.

L. M. Vas*, P. Bakonyi, Estimating the creep strain to failure of PP at different load levels based on short term tests and Weibull characterization Department of Polymer Engineering, Faculty of Mechanical Engineering, Budapest University of Technology

and Economics, H-1111 Budapest, Megyetemrkp. 3., Hungary Received 13 April 2012; accepted in revised form 22 July 2012.

The short and long term creep behaviour is one of the most important properties of polymers used for engineering applications. This paper describes creep measurements were performed and analysed using long term creep behavior estimating method based on short term tensile and creep tests performed at room temperature, viscoelastic behavior, and variable transformations.

Xiaolin Liu,1 Yajiang Huang,1 Cong Deng,2 Xiaojun Wang,2 Wei Tong,1 Yuxin Liu,1 Jianqian Huang,1 Qi Yang,1 Xia Liao,1 Guangxian Li1, Study on the Creep Behavior of Polypropylene, 1 The State Key Laboratory for Polymer Materials Engineering, College of Polymer Science and Engineering, Sichuan University, Chengdu 610065, People's Republic of China. 2 Analysis and Testing Centre, Sichuan University, Chengdu 610065, People's Republic of China.

The creep behaviour and creep failure law of polypropylene (PP) were investigated by using a multifunctional stress-aging testing machine under different aging environmental conditions (temperature, UV, and stress).In this paper the study of Photo induced changes in samples were studied using gel permeation chromatography and X-ray photoelectron spectrometer.

Kenneth KanayoAlaneme 1, 2* , Bethel Jeremiah Bamike 1 , Godwin Omlenyi ,Design and Performance Evaluation of a Sustained Load Dual Grip Creep TestingMachine,1Department of Metallurgical and Materials Engineering, Federal University of Technology, Akure, Nigeria, Department of Mining Metallurgical Engineering, University of Namibia, Ongwediva Engineering Campus, Ongwediva, Namibia, Journal of Minerals and Materials Characterization and Engineering, 2014, 2, 531-538Published Online November 2014.

The design and performance evaluation of a sustained load creep testing machine was undertaken in this research. The design was motivated by the need to make locally available, a cost effective, technically efficient, and easily operated creep testing facility; for creep behaviour studies of materials. Design drawings and purchase of materials and components for the design were undertaken after thorough evaluation of the following design and materials selection criteria: design principle and theory, local availability of raw materials and components required for the design, material properties, cost of materials and design, ease of utilization and maintenance, and basis of testing and data capture. The machine casing and frame, heating chamber (consisting of the furnace and a dual specimen mounting stage), load lever and hanger system, and the electro-technical components; were fabricated and coupled following the produced design specifications. The machine was tested and its performance was assessed using its heating efficiency, repeatability and reproducibility of experimental test results, maintainability and cost-effectiveness as criteria. It was observed from repeat tests that the machine has the capacity of generating reliable data for computing creep strain-time results.

Salah K. Jawad, Investigation of the Dimensions Design Components for the Rectangular Indirect Resistance Electrical Furnaces, Department of Production and Metallurgy Engineering, University of Technology, Baghdad, Iraq, American J. of Engineering and Applied Sciences 3 (2): 350354, 2010 -ISSN 1941-7020.

Problem statement: The objective of this study was to study the Indirect Resistance Electrical Furnaces (IREF) based on analytical and experimental analyses. The analytical analysis focused on a constant set of equations representing the internal and external flow of heat energy in the furnace, which demonstrated, relatively with the surface area of walls, heat transferring inside the furnace chamber to get a creation mathematical model including the joining between the temperature required design components (furnace walls, thickness and electrical power supply).The experimental analysis has divided in to tow parts; first part based on process number of practice experiments with three prototypes have manufactured in certain engineering dimensions that changed in three different volumes of furnace, whichare considered, i.e., chamber volume of furnace is the design dimensions component. The second part of analytical analysis based on use the Simulink program (MATLAB 7.4) compared with experimental results of the manufactured furnaces samples, which showed the direct effect of the design dimensions components on the performance specifications of furnace that involve the required temperature response, temperature stability and the deviation in the setting value of temperature.

Jan Kolarik[a,*], Alessandro Pegoretti[b], Non-linear tensile creep of polypropylene: Time-strain superposition and creep prediction, [a]Department of Materials, Institute of Macromolecular Chemistry, Academy of Sciences of the Czech Republic, 162 06 Prague 6,Czech Republic, [b]Department of Materials Engineering and Industrial Technologies, University of Trento, 38050 Trento, Italy, Received 5 May 2005; received in revised form 1 November 2005; accepted 3 November 2005,Polymer 47 (2006) 346–356.

In most practical applications, isothermal compliance of polymeric materials depends on both time and stress so that their non-linear viscoelastic behaviour is of primary importance. A concept is adopted that the non-linearity of tensile creep is mainly brought about by the strain-induced increment of the free volume (in materials with Poisson ratio smaller than 0.5). Consequently, the traditional stress-strain linearity limit can be viewed as an artificial limit related to limited accuracy of the measurements at low stresses and strains. The internal time—tensile compliance superposition of nonlinear creep data is applied to construct a generalized compliance curve, which corresponds to a pseudo iso-free- volume state.

The superposition of compliance curves obtained at different stresses requires shift factors along the time axis calculated a priori for individual data points. As the generalized curve can be generated by means of short term creeps, the proposed procedure offers essential savings of experimental time. A most practical outcome of the outlined format is that the generalized dependence can be employed for predicting the real time-dependent compliance for any stress in the range of reversible strains. The results indicate that the compliance of PPs decreases with their crystalline, while their creep rates are almost identical. Only rubber-toughened PP does show a slightly higher creep rate, which is attributed to the 'softening' effect of rubber particles in the PP matrix.

E E Granda-Gutiérrez*, S I Pérez-Aguilar, F de J Fuentes-Torres, J C Díaz-Guillén, A Campa-Castilla, A Garza-Gómez, J Candelas-Ramírez, R Méndez-Méndez, SYSTEM FOR DATA ACQUISITION AND STORAGE WITH APPLICATION IN A CREEP TEST MACHIN, Corporación Mexicana de Investigación en Materiales S. A. de C. V. Ciencia y Tecnología 790. Fraccionamiento Saltillo 400. Saltillo, Coahuila, CP 25290 * egranda@comimsa.com

The creep test is an experimental procedure used to evaluate important mechanical properties of a material that are related to its performance when is subjected to stress under high temperature conditions. During the test, several parameters must be monitored to provide sufficient information to evaluate the creep behavior and the use of an acquisition system is mandatory. Commercial stand alone or computer-based data loggers are not well suitable for this application because the long term of the process (up to 5000 hrs.) implies the use of large storage capacity and low energy consumption. With an aim to overcome these restrictive factors, a specially designed system based on a microcontroller is described in this paper. The system has the ability to make timed samples of the process variables and store them in a non-volatile memory for subsequent.

CHAPTER: CREEP

3.1 What is Creep?

Creep can be defined as the slow & progressive (increasingly continuing) deformation of a material with time under a constant stress. It is both a time & temperature dependent phenomenon. Creep is probably the most widely studied long-term property. It results from the viscoelastic flow of the polymer with time. In other words, creep is a time-dependent process where a material under an applied stress exhibits a dimensional change at high temperature. High temperature progressive deformation of a material at constant stress is called creep. The process is also temperature-dependent (i.e. increases with temperature).Normally, Creep occurs when vacancies in the material migrate toward grain boundaries that are oriented normal to the direction of the applied stress. Creep can be occur due to different Mechanism. Different mechanisms are responsible for creep in different materials and under different loading and temperature conditions.

The mechanisms include:-

- Stress-assisted vacancy diffusion
- Grain boundary diffusion (diffusion creep)
- Grain boundary sliding
- Dislocation Glide
- Dislocation creep

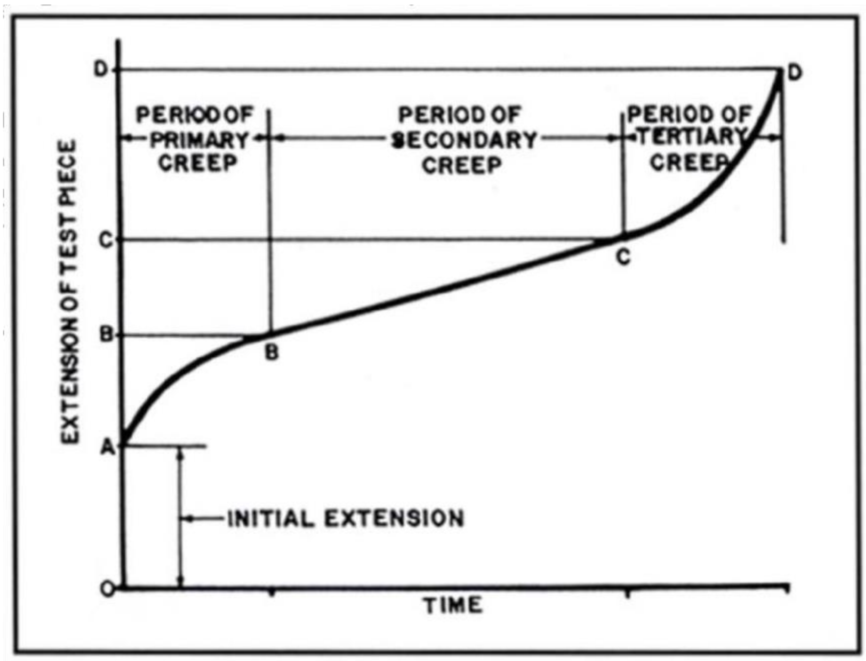
Variation of creep rate with time is due to the changes in the internal structure of material with creep strain and time. The principal deformation processes at elevated temperatures are Slip, Sub grain formation and Grain-boundary sliding

- Deformation by slip: New slip systems become operative when metal are deformed at elevated temperature. Slip under high-temperature creep conditions occurs on many slip planes for small slip distance.
- Sub grain formation: Near lattice boundaries creep deformation leads to lattice bending. This results in formation of excess dislocations of one sign, and in elevated temperatures dislocations arrange themselves into a low-angle grain boundary. This is mostly found in metals with high stacking-fault energy
- Grain-Boundary Sliding: At elevated temperatures the grains in polycrystalline metals are able to move relative to each other. Grain boundary sliding is a shear process which occurs in the direction of the grain boundary. The main importance of grain-boundary sliding is that it initiates grain boundary fracture.

3.2 Stages of Creep

Creep is generally divided into three stages:-

1. Primary creep
2. Secondary creep
3. Tertiary creep



Graph 3.1: - Stages of Creep

At elevated temperatures and stresses, much less than the high-temperature yield stress, metals undergo permanent plastic deformation called creep. Figure 1 shows a schematic creep curve for a constant load; a plot of the change in length verses time. The weight or load on the specimen is held constant for the duration of the test. There are four portions of the curve that are of interest:

- An initial steep rate that is at least partly of elastic origin, from point "0" to point "A" in Figure1.

- This is followed by a region in which the elongation or deformation rate decreases with time, the so-called transient or primary creep, from region "A" to "B" of Figure 1. The portion from point "0"to point "B" occurs fairly quickly.

- The next portion of the creep curve is the area of engineering interest, nearly linear and predictable. Depending on the load or stress, the time can be very long; two years in a test and several decades in service.

- The fourth portion of the creep curve, beyond the constant-creep-rate or linear region, shows a rapidly increasing creep rate which culminates in failure. Even under constant-load test conditions, the effective stress may actually increase due to the damage that forms within the microstructure.

Without going into a detailed discussion of the atom movements involved in creep deformation, suffice it to say that creep deformation occurs by grain-boundary sliding. That is, adjacent grains or crystals move as a unit relative to each other. Thus, one of the micro structural features of a creep failure is little or no obvious deformation to individual grains along the fracture edge.

3.3 Characteristics of Creep

• Creep in service is usually affected by changing conditions of loading and temperature

• The number of possible stress-temperature-time combinations is infinite.

• The creep mechanisms are often different between metals, plastics, rubber and concrete.

3.4 Types of Creep

Creep are classified based on temperature

- Logarithmic creep
- Recovery creep
- Diffusion creep

At low temperature, the creep rate is decreases with time and the logarithmic curve is obtained.

At high temperature, the influence of work hardening is weakened and there is a possibility of mechanical recovery. As a result, the creep rate does not decrease and recovery creep is obtained.

At very high temperature, the creep is primary influences by diffusion and load applied has little effect. This creep is termed as diffusion creep or plastic creep.

CHAPTER

MODIFICATION OF TENSILE CREEP TESTING MACHINE

4.1 What is Data Acquisition System?

Data acquisition (DAQ) is the process of measuring an electrical or physical phenomenon such as voltage, current, temperature, pressure, or sound with a computer. A DAQ system consist of sensors. DAQ measurement hardware and a computer with programmable software. Compared to traditional measurement systems, PC-based DAQ systems exploit the processing power, productivity, display, and connectivity capabilities of industry-standard computers providing a more powerful, flexible, and cost-effective measurement solution.

4.2 DESIGN DATA AQUISATION SYSTEM

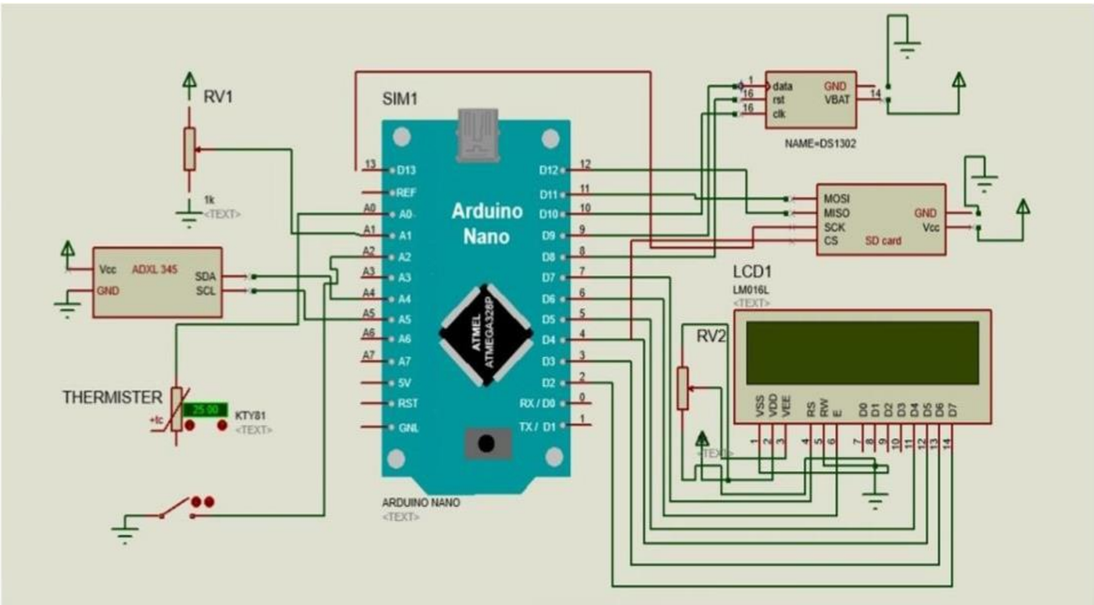


Fig 4.2: Diagram of DAS system.

4.2.1 DATA AQUISATION SYSTEM COMPONENTS

The components of data acquisition system includes sensors, to convert physical parameters to electrical signals.

4.2.2 ARDUINO NANO

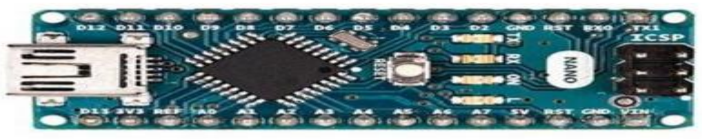


Fig 4.2.2.1: Arduino Nano

Parameters:

Microcontroller	ATmega328
Architecture	AVR
Operating Voltage	5 V
Flash Memory	32 KB of which 2 KB used by boot loader
SRAM	2 KB
Clock Speed	16 MHz
Analog IN Pins	8
EEPROM	1 KB
DC Current per I/O Pins	40 mA (I/O Pins)
Input Voltage	7-12 V
Digital I/O Pins	22 (6 of which are PWM)
PWM Output	6
Power Consumption	19 Ma
PCB Size	18 x 45 mm
Weight	7 g

Table 4.2.2.1: Technical Specification

Power:
Arduino Nano can be powered via the Mini-B USB connection, 6-20V unregulated external power supply (pin 30), or 5V regulated external power supply (pin 27). The power source is automatically selected to the highest voltage source.

Memory:
The ATmega328 has 32 KB, (also with 2 KB used for the bootloader. The ATmega328 has 2 KB of SRAM and 1 KB of EEPROM
.

Input and Output:
Each of the 14 digital pins on the Nano can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() 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 20-50k Ohms. In addition, some pins have specialized functions:

- Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the FTDI USB-to-TTL Serial chip.
- External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach Interrupt () function for details.
- PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analog Write () function.
- SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language.
- LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Nano has 8 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the analog Reference () function. Analog pins 6 and 7 cannot be used as digital pins. Additionally, some pins have specialized functionality:

- I2C: A4 (SDA) and A5 (SCL). Support I2C (TWI) communication using the Wire library (documentation on the Wiring website).

There are a couple of other pins on the board:

- AREF. Reference voltage for the analog inputs. Used with analog Reference ().
- Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

Limitations:

Frequency - 16 MHz

Voltage limit – 5V

Pin Diagram:

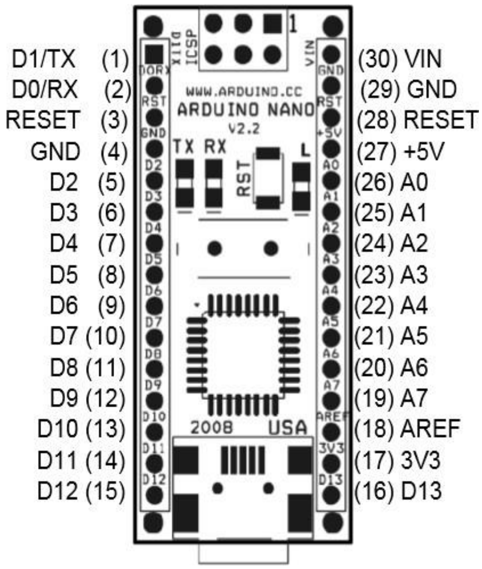


Fig 4.2.2.2: Pin Diagram

4.2.3 ADXL-345:

General Description:

The ADXL345 is a small, thin, ultralow power, 3-axis accelerometer with high resolution (13-bit) measurement at up to ±16 g. Digital output data is formatted as 16-bit twos complement and is accessible through either a SPI (3- or 4-wire) or I2C digital interface.

The ADXL345 is well suited for mobile device applications. 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 less than 1.0°. 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. Tap sensing detects single and double taps in any direction. Free-fall sensing detects if the device is falling. These functions can be mapped individually to either of two interrupt output pins.

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. Low power modes enable intelligent motion-based power management with threshold sensing and active acceleration measurement at extremely low power dissipation.

The ADXL345 is supplied in a small, thin, 3 mm × 5 mm × 1 mm, 14-lead, plastic package.

Features:

- Ultralow power: as low as 23 µA in measurement mode and 0.1 µA in standby mode at VS = 2.5 V (typical)
- Power consumption scales automatically with bandwidth
- User-selectable resolution
- Fixed 10-bit resolution
- Full resolution, where resolution increases with g range, up to 13-bit resolution at ±16 g (maintaining 4 mg/LSB scale factor in all g ranges)
- Embedded memory management system with FIFO technology minimizes host processor load
- Single tap/double tap detection
- Activity/inactivity monitoring
- Free-fall detection
- Supply voltage range: 2.0 V to 3.6 V
- I/O voltage range: 1.7 V to VS SPI (3- and 4-wire) and I2C digital interfaces
- Flexible interrupt modes mappable to either interrupt pin
- Measurement ranges selectable via serial command
- Bandwidth selectable via serial command
- Wide temperature range (−40°C to +85°C)
- 10,000 g shock survival
- Pb free/RoHS compliant
- Small and thin: 3 mm × 5 mm × 1 mm LGA package

Applications:

- Handsets
- Medical instrumentation
- Gaming and pointing devices
- Industrial instrumentation
- Personal navigation devices
- Hard disk drive (HDD) protection

Functional Block Diagram:

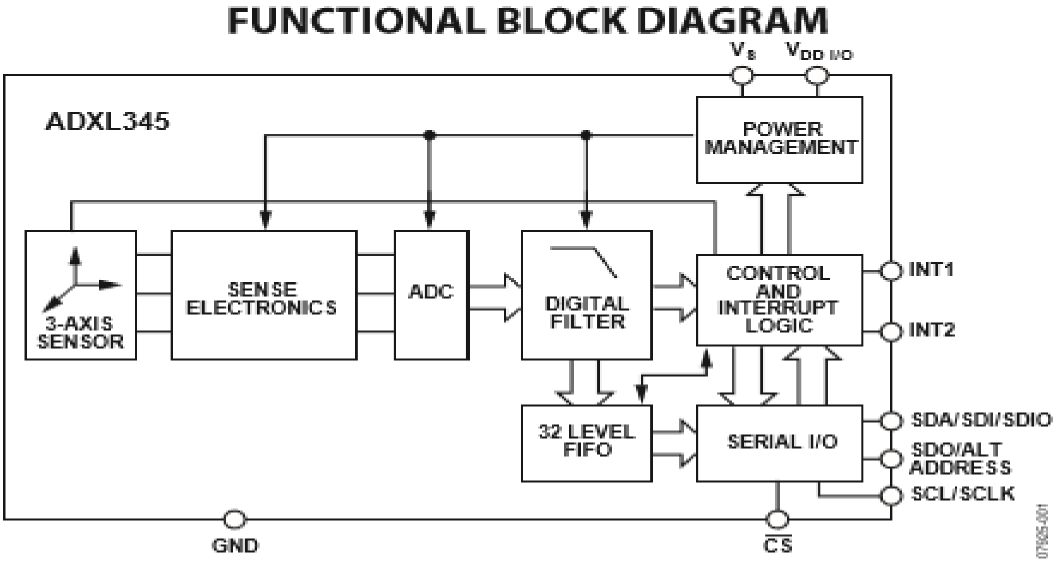


Fig 4.2.3.1: Functional Block Diagram

Pin Diagram:

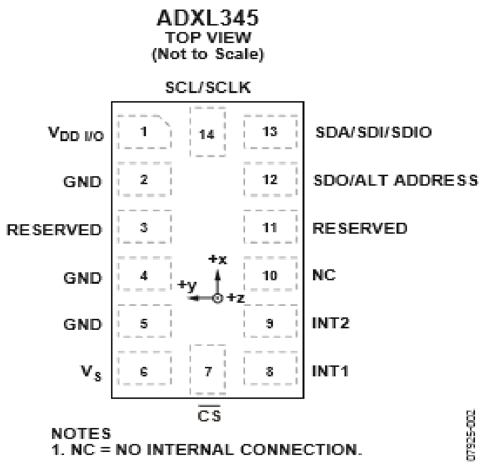


Fig 4.2.3.2: Pin diagram

Pin No.	Mnemonic	Description
1	$V_{DD I/O}$	Digital Interface Supply Voltage.
2	GND	This pin must be connected to ground.
3	RESERVED	Reserved. This pin must be connected to V_S or left open.
4	GND	This pin must be connected to ground.
5	GND	This pin must be connected to ground.
6	V_S	Supply Voltage.
7	$\overline{CS}$	Chip Select.
8	INT1	Interrupt 1 Output.
9	INT2	Interrupt 2 Output.
10	NC	Not Internally Connected.
11	RESERVED	Reserved. This pin must be connected to ground or left open.
12	SDO/ALT ADDRESS	Serial Data Output (SPI 4-Wire)/Alternate I^2C Address Select (I^2C).
13	SDA/SDI/SDIO	Serial Data (I^2C)/Serial Data Input (SPI 4-Wire)/Serial Data Input and Output (SPI 3-Wire).
14	SCL/SCLK	Serial Communications Clock. SCL is the clock for I^2C, and SCLK is the clock for SPI.

Table 4.2.3.1: Pin Configuration

FIFO:

The ADXL345 contains technology for an embedded memory management system with 32-level FIFO that can be used to minimize host processor burden. This buffer has four modes: bypass, FIFO, stream, and trigger (see FIFO Modes). Each mode is selected by the settings of the FIFO_MODE bits (Bits [D7:D6]) in the FIFO_CTL register (Address 0x38).

Bypass Mode:

In bypass mode, FIFO is not operational and, therefore, remains empty.

FIFO Mode:

In FIFO mode, data from measurements of the x-, y-, and z-axes are stored in FIFO. When the number of samples in FIFO equals the level specified in the samples bits of the FIFO_CTL register (Address 0x38), the watermark interrupt is set. FIFO continues accumulating samples until it is full (32 samples from measurements of the x-, y-, and z-axes) and then stops collecting data. After FIFO stops collecting data, the device continues to operate; therefore, features such as tap detection can be used after FIFO is full. The watermark interrupt continues to occur until the number of samples in FIFO is less than the value stored in the samples bits of the FIFO_CTL register.

Trigger Mode:

In trigger mode, FIFO accumulates samples, holding the latest 32 samples from measurements of the x-, y-, and z-axes. After a trigger event occurs and an interrupt is sent to the INT1 or INT2 pin (determined by the trigger bit in the FIFO_CTL register), FIFO keeps the last n samples (where n is the value specified by the samples bits in the FIFO_CTL register) and then operates in FIFO mode, collecting new samples only when FIFO is not full. A delay of at least 5 µs should be present between the trigger event occurring and the start of reading data from the FIFO to allow the FIFO to discard and retain the necessary samples. Additional trigger events cannot be recognized until the trigger mode is reset. To reset the trigger mode, set the device to bypass mode and then set the device back to trigger mode. Note that the FIFO data should be read first because placing the device into bypass mode clears FIFO.

4.2.4 DS1302

Description:

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

Operation:

The main elements of the Serial Timekeeper are shown in Figure 1: shift register, control logic, oscillator, real time clock, and RAM.

Block Diagram:

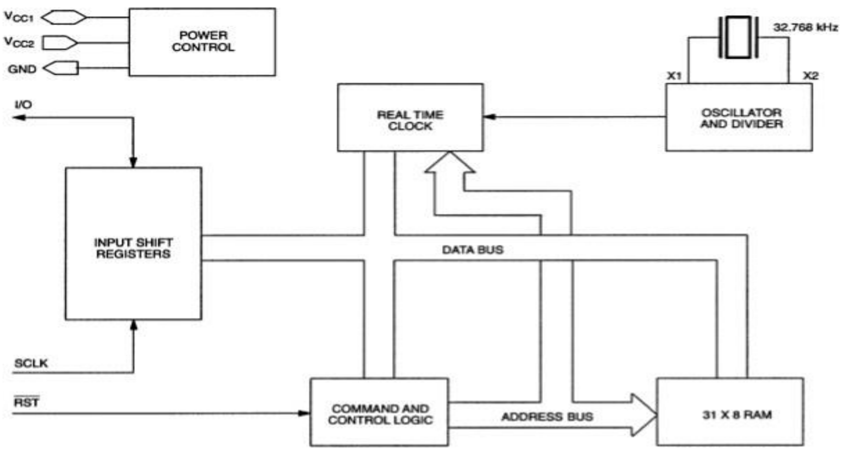


Fig 4.2.4.1: Block Diagram DS1302

Signal Description:

VCC1 – VCC1 provides low power operation in single supply and battery operated systems as well as low power battery backup. In systems using the trickle charger, the rechargeable energy source is connected to this pin.

VCC2 – Vcc2 is the primary power supply pin in a dual supply configuration. VCC1 is connected to a backup source to maintain the time and date in the absence of primary power.

The DS1302 will operate from the larger of VCC1 or VCC2. When VCC2 is greater than VCC1 + 0.2V, VCC2 will power the DS1302. When VCC2 is less than VCC1, VCC1 will power the DS1302.

SCLK (Serial Clock Input) – SCLK is used to synchronize data movement on the serial interface.

I/O (Data Input/Output) – The I/O pin is the bi-directional data pin for the 3-wire interface.

RST (Reset) – The reset signal must be asserted high during a read or a write.

X1, X2 – Connections for a standard 32.768 kHz quartz crystal. The internal oscillator is designed for operation with a crystal having a specified load capacitance of 6 pF. For more information on crystal selection and crystal layout considerations, please consult Application Note 58, "Crystal Considerations with Dallas Real Time Clocks." The DS1302 can also be driven by an external 32.768 kHz oscillator. In this configuration, the X1 pin is connected to the external oscillator signal and the X2 pin is floated.

Features:

- Real time clock counts seconds, minutes hours, date of the month, month, day of the week, and year with leap year compensation valid up to 2100
- 31 x 8 RAM for scratchpad data storage
- Serial I/O for minimum pin count
- 2.0–5.5V full operation
- Uses less than 300 nA at 2.0V
- Single–byte or multiple–byte (burst mode) data transfer for read or write of clock or RAM data
- 8–pin DIP or optional 8–pin SOICs for surface mount
- Simple 3–wire interface
- TTL–compatible (VCC = 5V)
- Optional industrial temperature range –40°C to +85°C
- DS1202 compatible
- Recognized by Underwriters Laboratory

Pin Diagram:

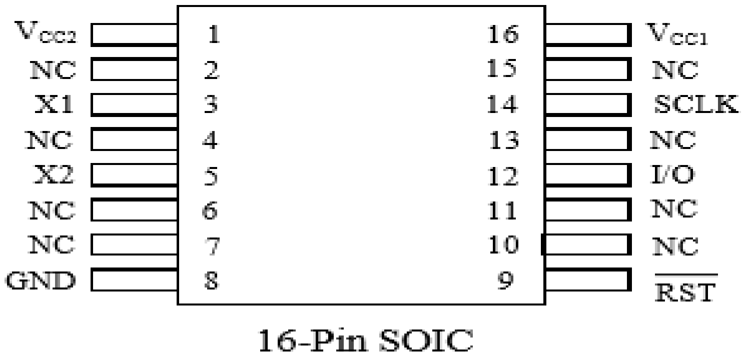


Fig 4.2.4.2: Pin diagram

Pin Description:

- X1, X2 – 32.768 kHz Crystal Pins
- GND – Ground
- RST – Reset
- I/O – Data Input/ Output
- SCLK – Serial Clock
- VCC1, VCC2 – Power Supply Pin

Data Transfer Summary:

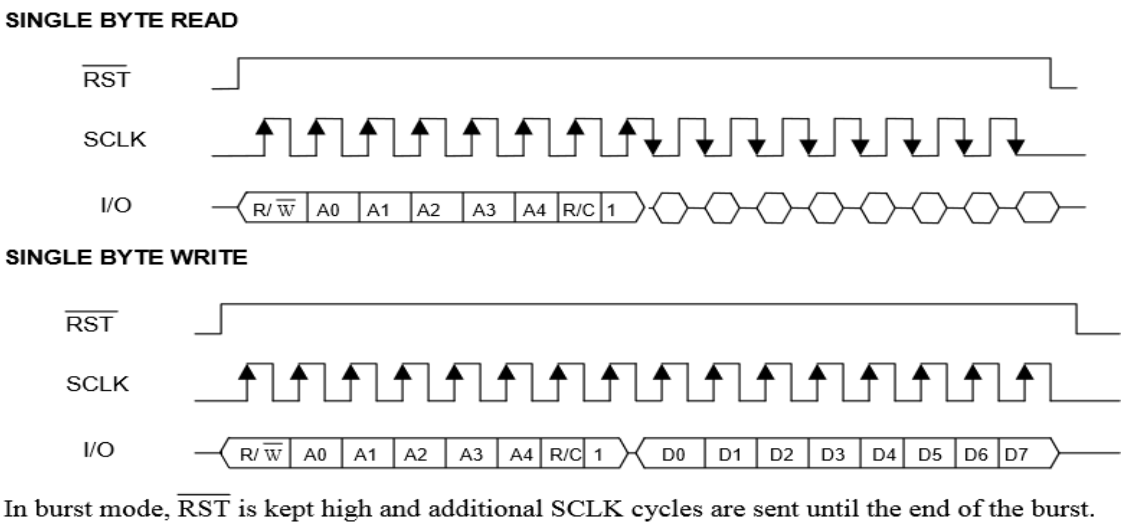


Fig 4.2.4.3: data transfer

4.2.5 Potentiometer:

Fig 4.2.5.1: Potentiometer

A potentiometer is a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider.[1] If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat.

The measuring instrument called a potentiometer is essentially a voltage divider used for measuring electric potential (voltage); the component is an implementation of the same principle, hence its name.

Potentiometers are commonly used to control electrical devices such as volume controls on audio equipment. Potentiometers operated by a mechanism can be used as position transducers, for example, in a joystick. Potentiometers are rarely used to directly control significant power (more than a watt), since the power dissipated in the potentiometer would be comparable to the power in the controlled load. Potentiometers are also very widely used as a part of displacement transducers because of the simplicity of construction and because they can give a large output signal.

4.2.6 LCD:

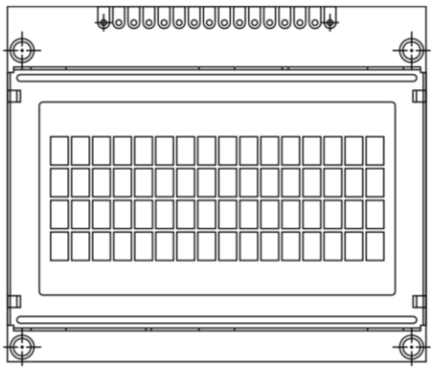


Fig 4.2.6.1: 16 x 4 Character LCD

- Type: Character
- Display format: 16 x 4 characters
- Built-in controller: ST 7066 (or equivalent)

- Duty cycle: 1/16
- 5 x 8 dots includes cursor
- + 5 V power supply (also available for + 3 V)
- B/L to be driven by pin 1, pin 2, pin 15, pin 16 or A and K
- N.V. optional for + 3 V power supply
- N.V. optional for + 3 V power supply.

4.2.7 SD Card Module:

Fig 4.2.7.1: SD Card Module

The module (Micro-SD Card Adapter) is a Micro SD card reader module, and the SPI interface via the file system driver, microcontroller system to complete the Micro-SD card read and write files. Arduino users can directly use the Arduino IDE comes with an SD card to complete the library card initialization and read-write.

Features:

- Supports micro SD card (<=2G), micro SDHC card (<=32G) (high-speed card)
- Level conversion circuit board that can interface level is 5V or 3.3V
- Power supply is 4.5V ~ 5.5V, 3.3V voltage regulator circuit board
- Communication interface is a standard SPI interface
- 4 M2 screw positioning holes for easy installation
- Size: 4.1 x 2.4cm

Control Interface: A total of six pins (GND, VCC, MISO, MOSI, SCK, CS), GND to ground, VCC is the power supply, MISO, MOSI, SCK is the SPI bus, CS is the chip select signal pin.

3.3 V regulator circuit: LDO regulator output 3.3V as level converter chip, Micro SD card supply.

Level conversion circuit: Micro SD card into the direction of signals into 3.3V, Micro SD card toward the direction of the control interface MISO signal is also converted to 3.3V, general AVR microcontroller system can read the signal

Micro SD card connector: Since the bomb deck for easy card insertion and removal.

Positioning holes: 4 M2 screws positioning hole diameter of 2.2mm, the module is easy to install positioning, to achieve inter-module combination

Introduction:

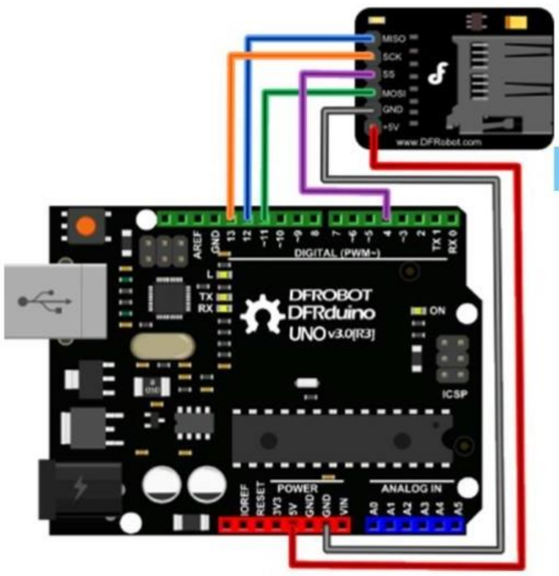
This is a Micro SD (TF) module from DF Robot. It is compatible with TF SD card (commonly used in Mobile Phone) which is the tiniest card in the market. SD module has various applications such as data logger, audio, video, graphics. This module will greatly expand the capability an Arduino can do with their poor limited memory.

This module has SPI interface and 5V power supply which is compatible with Arduino UNO/Mega. The Pin out is fully compatible with DF Robot's IO Expansion Shield V5.

Specification:

- Working Voltage:5V
- Size:20x28mm
- Interface: SPI
- Compatible: Micro SD(TF)

Diagram:



SDmodule	Arduino
MISO	D12
SCK	D13
SS chipSelect	D4
MOSI	D11
GND	GND
VCC	5V

Fig 4.2.7.2: Pin Diagram

4.2.8 LED:

An LED display is a flat panel display, which uses an array of light-emitting diodes as pixels for a video display. Their brightness allows them to be used outdoors where they are visible in the sun for store signs and billboards.

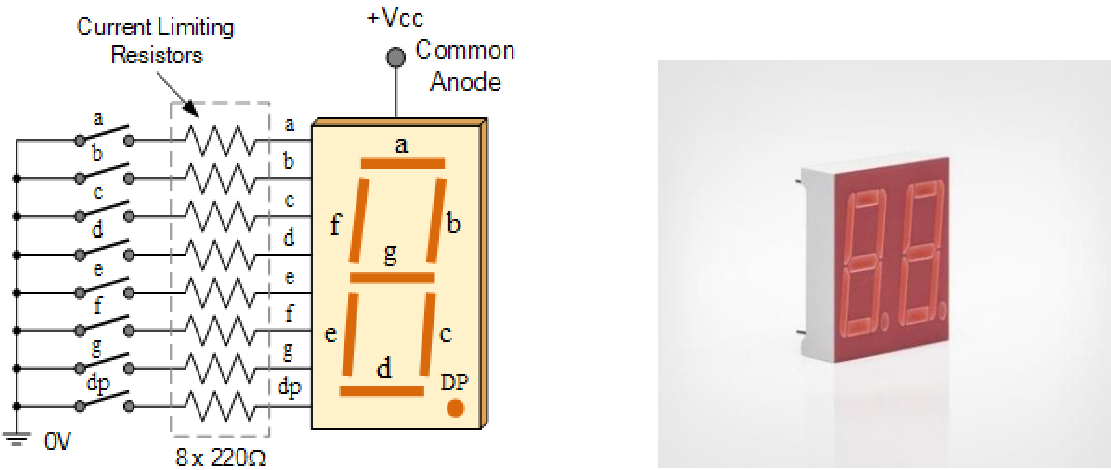


Fig 4.2.8.1: LED PIN Diagram

The emission of these photons occurs when the diode junction is forward biased by an external voltage allowing current to flow across its junction, and in Electronics we call this process electroluminescence.

The actual colour of the visible light emitted by an LED, ranging from blue to red to orange, is decided by the spectral wavelength of the emitted light which itself is dependent upon the mixture of the various impurities added to the semiconductor materials used to produce it.

Light emitting diodes have many advantages over traditional bulbs and lamps, with the main ones being their small size, long life, various colours, cheapness and are readily available, as well as being easy to interface with various other electronic components and digital circuits.

But the main advantage of light emitting diodes is that because of their small die size, several of them can be connected together within one small and compact package producing what is generally called a 7-segment Display.

4.2.9 Voltage divider:

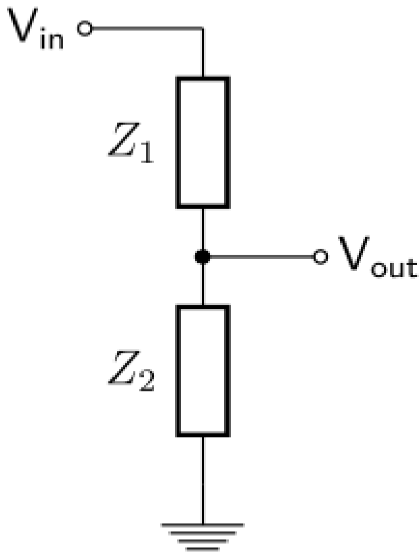


Figure 4.2.9.1: A simple voltage divider

In electronics, a **voltage divider** (also known as a **potential divider**) is a passive linear circuit that produces an output voltage (V_{out}) that is a fraction of its input voltage (V_{in}). **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.

4.3 Working of DAS System:

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.

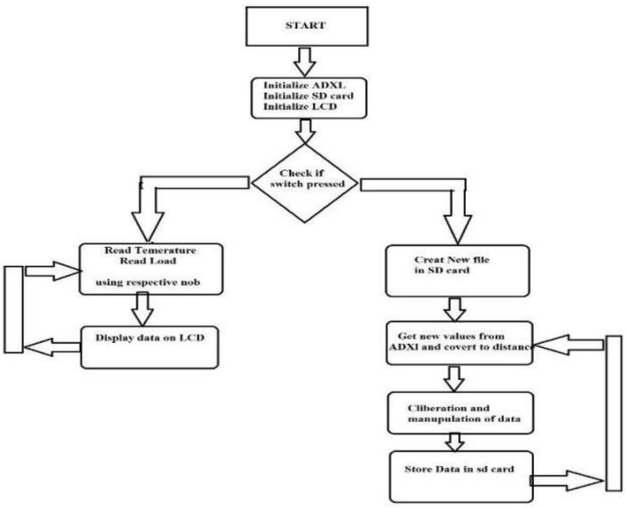


Fig 4.3: DAS program execution flowchart

4.3.1 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

Fig 4.3.1.1: 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.

4.4 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.

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 ^{0}C
Static ram of DS1302	31 bytes
LCD	16*4 display
SD card module	Max up to 32 GB

Table 4.4.1: Technical Specifications

4.5 Investigation of metal wire strength (Mechanical Test)

The metal wire used to apply load on material sample was of 1mm diameter and its braking capacity was around 24kg. So if load has to be increases up to 50kg, the previous was of no use. So as to increase the load capacity of the machine 4 different materials and dimensions were test.

The sample metal wires tested were:-
Mild steel wire Dia. 2.5mm
Mild steel wire Dia. 1.0mm
Mild steel wire Dia.1.2mm
Copper wire Dia. 2.0mm

A tensile test was performed and maximum sustainable load and braking points of metal wires was investigated. the investigation of tensile test of metal wires concludes that, mild steel wire diameter 1.0mm was with a lowest specification i.e. its tensile strength was 324.641 N/mm^2 and maximum sustainable load capacity was 240 N .Mild steel wire diameter 1.2mm was having tensile strength of 371 N/mm^2 along with maximum load capacity of 420 N. mild steel wire diameter 2mm was having highest capacity of 1292.614 N/mm^2 as tensile strength and maximum load capacity of 5850N. A copper wire tensile strength was found to be 317 N/mm^2 but load carrying capacity was 900 N.

CHAPTER V

EXPERIMENTAL STUDY

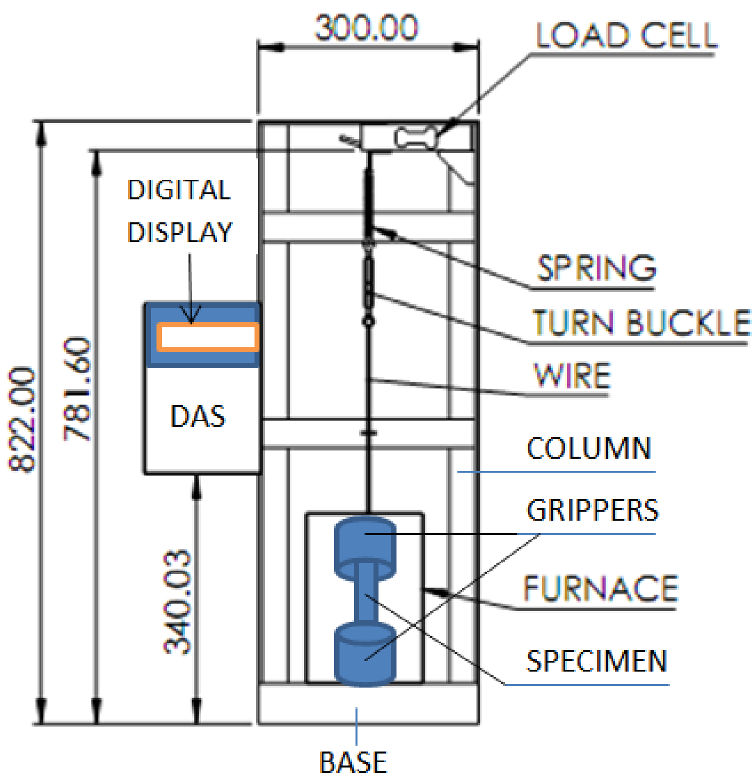
5.1 Experimental system

The experimental system is divided into four parts. These parts include:

1. Specimen is held with the help of grippers inside the furnace.
2. Load is applied with the help of turnbuckle, spring and wire arrangement.
3. Temperature inside the furnace is controlled with the help of temperature controlling system. The specimen should be assembled and kept for 10 minutes inside the furnace in order to uniform the temperature.
4. Data Acquisition System (DAS) is used to record creep rate of (PP) specimen.

5.2 Experimental Method

The material of specimen selected for the tests was polypropylene. Polypropylene is mainly used in food packaging, automobile battery cases and disposable syringes. The dimensions of the specimen were shown in figure 2, with the thickness of 1.3mm. These experiments were mainly performed at a temperature range of 70 ^{0}C and 75 ^{0}C at a static load condition of 30kg.loads are mainly applied by steel wire and turnbuckle arrangement.



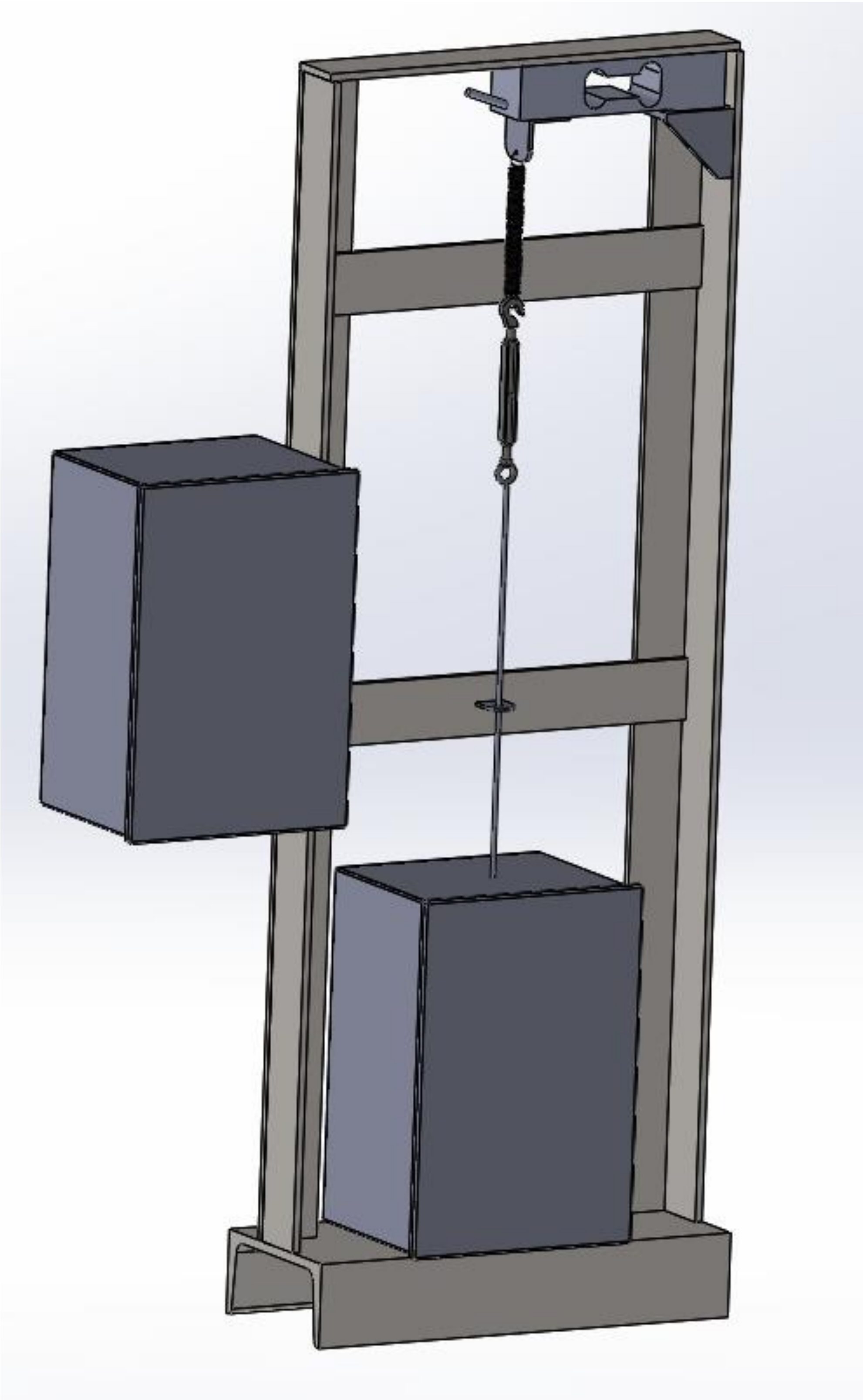


Fig 5.2.1: Schematic of the Test Setup

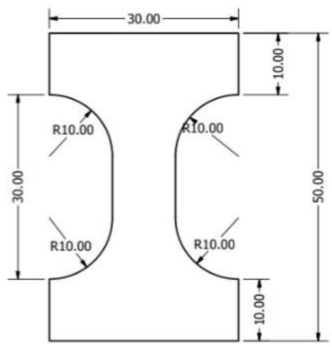


Fig.5.2.2: Dimensions of Sample (unit: mm, thickness: 1.3mm)

Data acquisition system is mainly used to record the deformation in specimen. Variation in creep deformation was saved in SD card to further calculate the creep strain.

Experimental Result

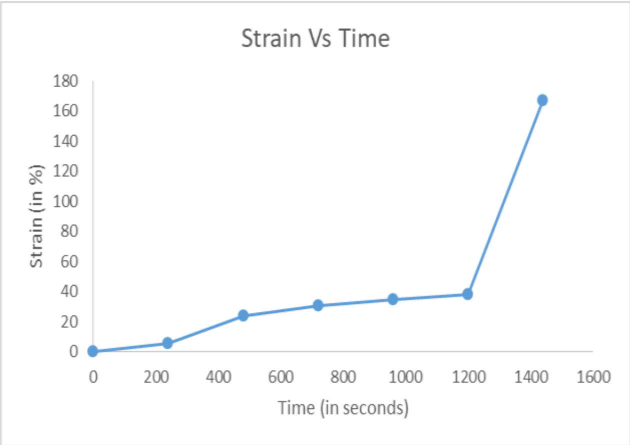
In this experiment at 70 ^{0}C, 30kg load is applied to the specimen. The stress acted across the cross-section of sample is 22.638 Mpa and creep failure time was only about 1464.6 sec. At 75 ^{0}C, 30 kg load is applied to the specimen respectively, and stress induced in the specimen is about 22.638 Mpa and creep failure time is 349.2 sec. The creep fracture time and strain are shown in table 1. The creep curves at different temperatures and loading conditions are described in figure 3-4, respectively.

5.3 EXPERTMENTAL DATA OF POLYPROPYLENE MATERIAL

Temperature (^{0}C)	Strain (%)	Deflection (mm)	Fracture time (sec)
70 ^{0}C	6	1.93	1440
	24	7.34	
	31	9.22	
	35	10.53	
	38	11.42	
	167	50.22	
75 ^{0}C	7	2.13	> 81
	32	9.61	
	33	10.0	
	34	10.14	
	36	10.89	
	38	11.14	

Table 5.3.1 Temperature, loading conditions and results for creep tests of polypropylene

Fig 5.3.1: Result Analysis



Graph 5.3.1: Creep Strain vs. Time at 70 ^{0}C

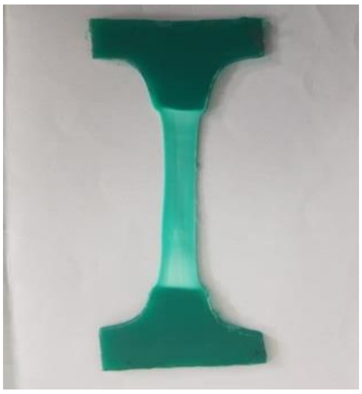
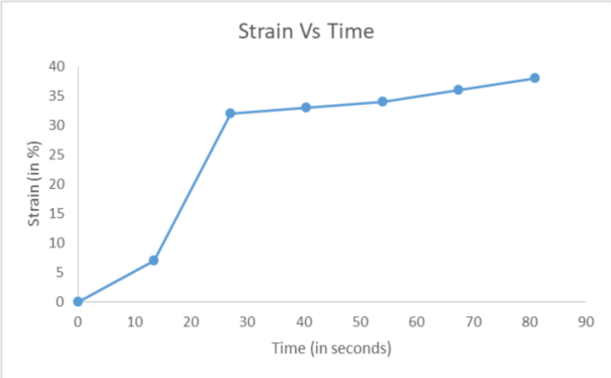


Fig 5.3.2: Result Analysis



Graph 5.3.2: Creep Strain vs. Time at 75 ^{0}C

According to table 1, higher temperature decreases the tensile strength of polypropylene and accelerates creep failure of polypropylene. Figures 3-4 shows that the creep rate increases with respect to increase in temperature.

5.4 EXPERTMENTAL DATA OF LEAD MATERIAL

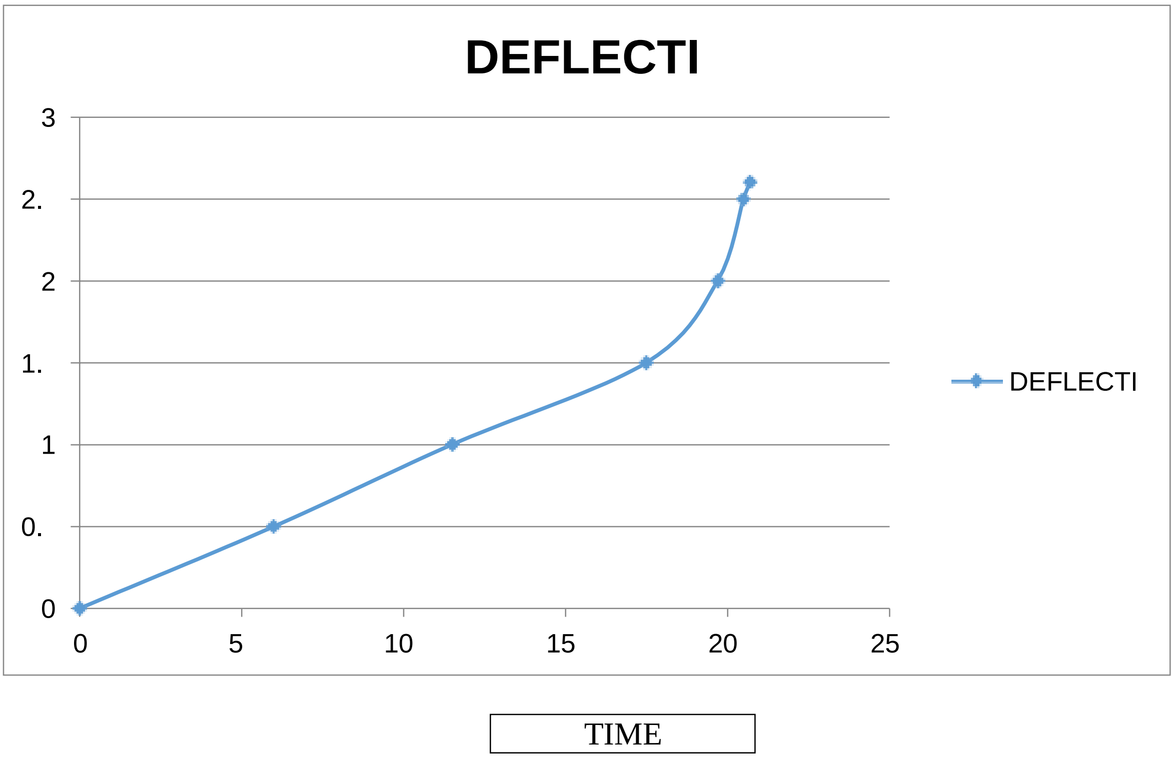
OBSERVATION TABLE: - Deflection of Lead material at constant Load and Temperature

Material	Lead
Constant temperature	70^{o}C
Constant load	3kg

Table 5.4.1: Specification for Experiment

TIME(min)	DEFLECTION(mm)
0.00	-
60	0.5
115	1
17	1.5
197	2
205	2.5
207	2.6

Table 5.4.2:- Deflection of Lead material at constant Load and Temperature



Graph 5.4.1:- Deflection vs. Time Graph

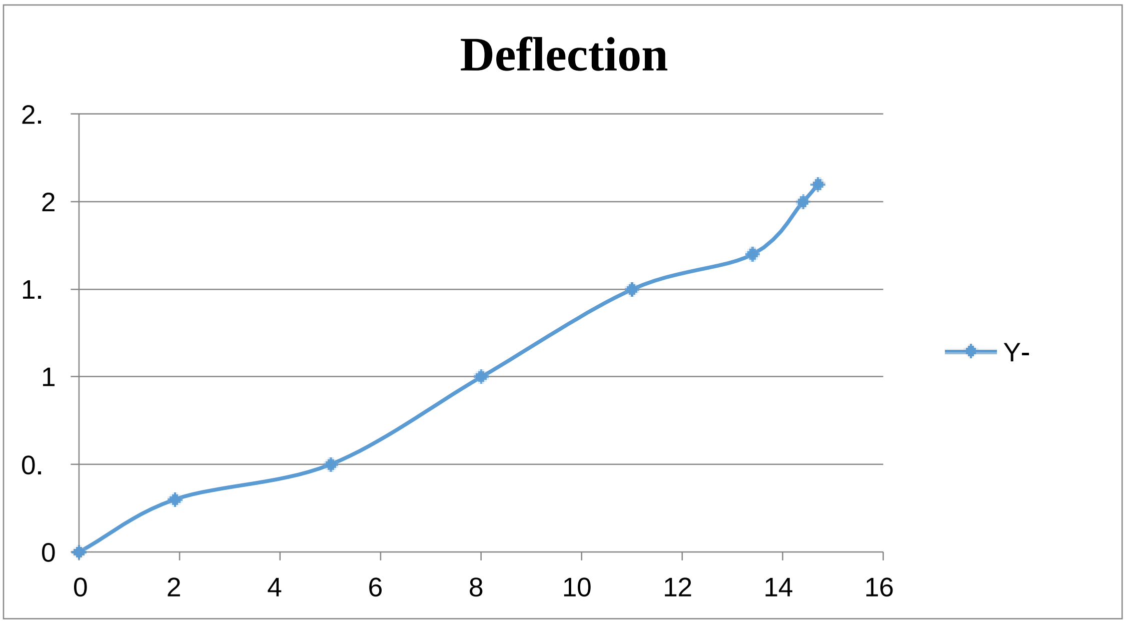
OBSERVATION TABLE: Deflection of Lead material at constant Load and Temperature

Material	Lead
Constant temperature	75^{o}C
Constant load	2.5kg

Table 5.4.3: Specification for Experiment

Time(min)	Deflection(mm)
O	0
19	0.3
50	0.5
80	1
90	1.5
134	1.7
144	2
147	2.1

Table 5.4.4: Deflection of Lead material at constant Load and Temperature



Graph 5.4.2: Deflection vs. Time Graph

5.5 AFTER EXPERIMENT

Fig 5.5.1: Result Analysis

Of Lead

Properties	Values
Material	Lead
Total Deflection	2.2 mm
Temperature	75ºC
Load	2.5kg
Time Analysis	198 Min

Table 5.5.1: Result Analysis

Fig No 8.1.2:- Result Analysis

Of Lead

Properties	Values
Material	lead
Total Deflection	2.5 mm
Temperature	70°C
Load	3 kg
Time analysis	210 min

Table 5.5.2: Result Analysis

CHAPTER VI

SIMULATION STUDY

6.1 FEA SIMULATION

In this experiment finite element analysis is used to study the creep behavior of polypropylene at different temperatures and loading condition. Specimen model is meshed in 1696 elements and 649 nodes. FEA model as shown in figure 5. In this simulation uniaxial load of 30 kg is applied on the FEA model at temperature of 70 ^{0}C and 75 ^{0}C.

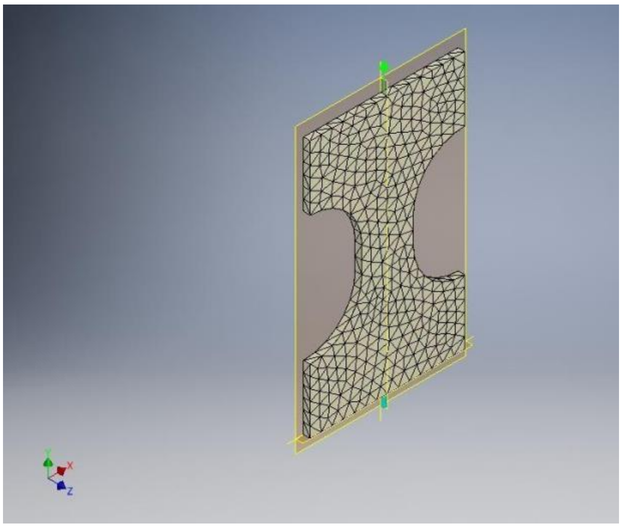


Fig 6.1.1: FEA model

For the analysis of the PP model **ANSYS WORKBENCH -16.2** is used which is a general purpose finite element computer program for engineering analysis and includes preprocessing, solution, post-processing. ANSYS used in a wide range of discipline for solutions to mechanical, thermal and electronic problems. Analysis is carried out by keeping the load constant and varying the temperature. By using this method total deformation and equivalent elastic strain at 70 ^{0}C and 75 ^{0}C is determined at 30 kg (294.3 N).

6.2 ANALYSIS RESULTS OF POLYPROPYLENE AT 70C & 30 Kg

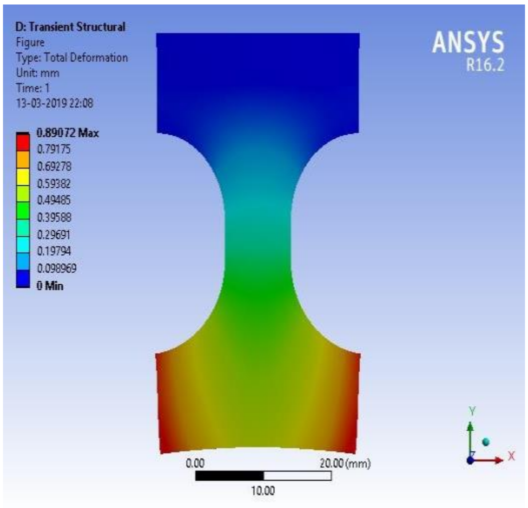


Fig 6.2.1: Total Deformation at 70 ^{0}C

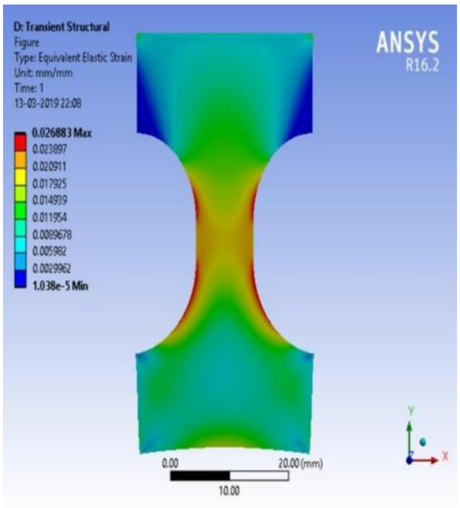


Fig 6.2.2: Elastic Strain at 70 ^{0}C

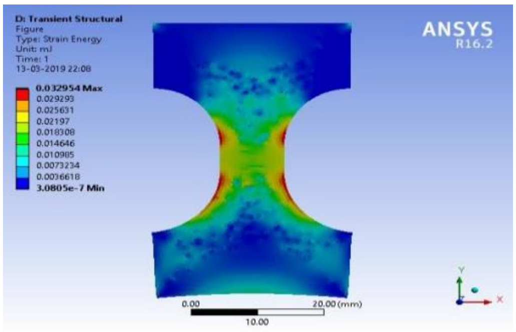


Fig 6.2.3: Equivalent Stress at 70 ^{0}C

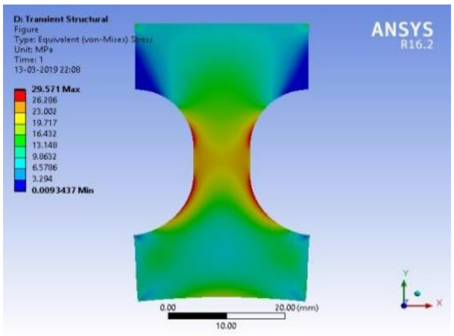


Fig 6.2.4: Strain Energy at 70 ^{0}C

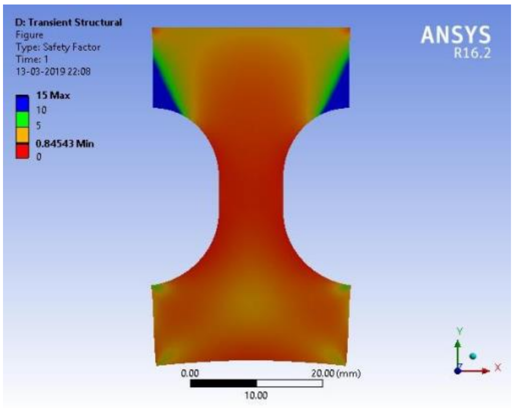


Fig 6.2.5: Safety Factor at 70 ^{0}C

6.3 ANALYSIS RESULTS OF POLYPROPYLENE AT 75C & 30 Kg

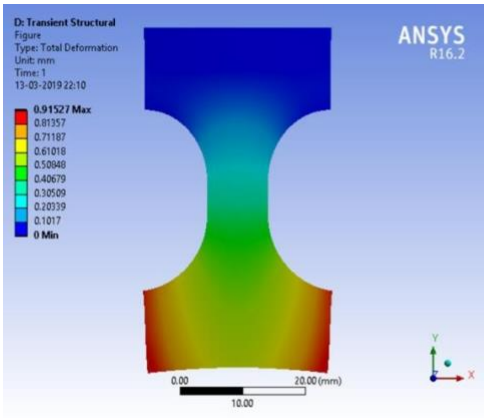


Fig 6.3.1: Total Deformation at 75 ^{0}C

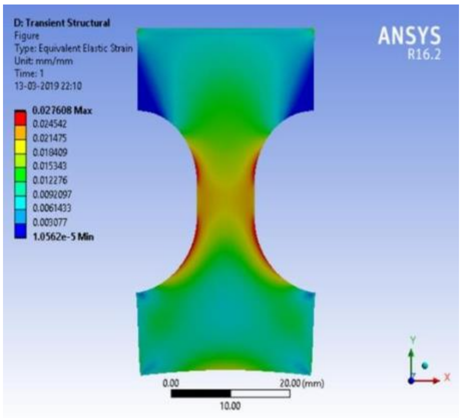


Fig 6.3.2: Equivalent Strain at 75 ^{0}C

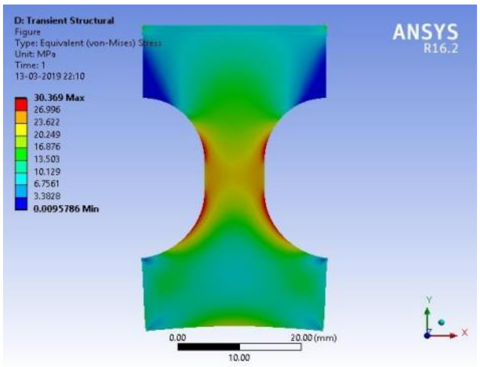


Fig 6.3.3: Equivalent Stress at 75 ^{0}C

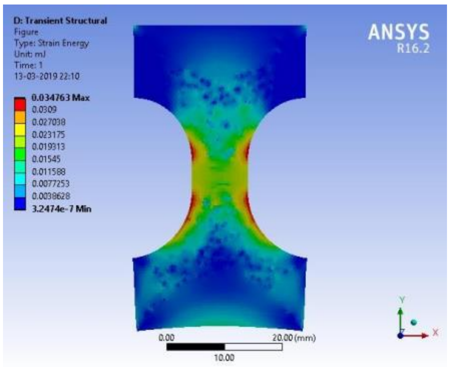


Fig 6.3.4: Strain Energy at 75 ^{0}C

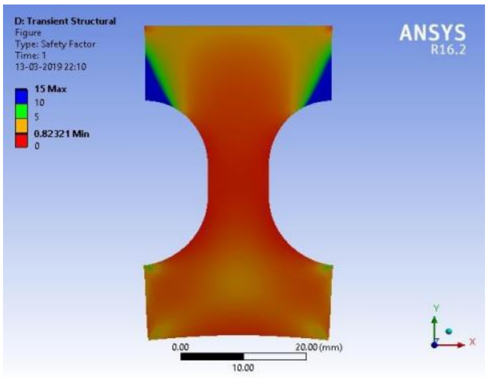


Fig 6.3.5: Safety Factor at 75 ^{0}C

6.4 Analysis results of Polypropylene (PP):

PARAMERTERS	70 C AT 30 KG	75 C AT 30 KG
TOTAL DEFORMATION	0.89072 mm	0.91527 mm
EQUIVALENT ELASTIC STRAIN	0.026883	0.027608
EQUIVALENT (VON MISSES) STRESS	29.571 MPa	30.369 MPa
STRAIN ENERGY	0.032954 MJ	0.034763 MJ
SAFETY FACTOR	15 MAX	15 MAX

Table 6.4.1: Analysis of Results

6.5 ANALYSIS RESULTS LEAD AT 70C & 3 Kg

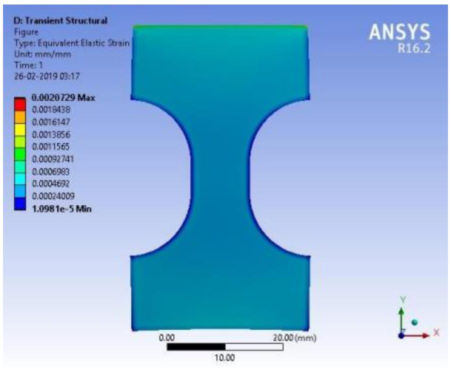


Fig 6.5.1: Total Deformation at 70 ^{0}C

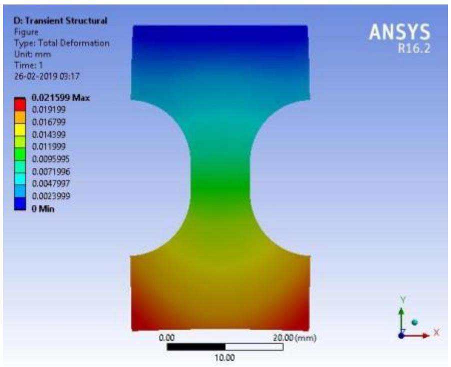


Fig 6.5.2: Equivalent Strain at 70^{0}C

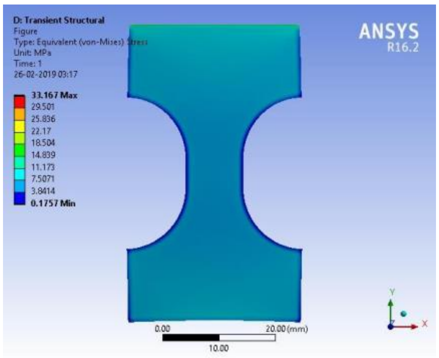


Fig 6.5.3: Equivalent Stress at 70 ^{0}C

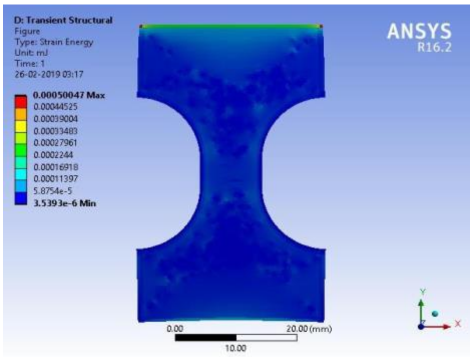


Fig 6.5.4: Strain Energy at 70 ^{0}C

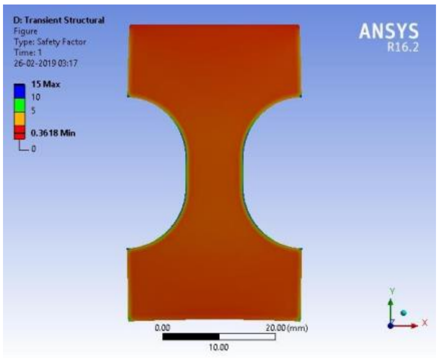


Fig 6.5.5: Safety Factor at 70 ^{0}C

6.6 ANALYSIS RESULTS LEAD AT 75C & 2.5 Kg

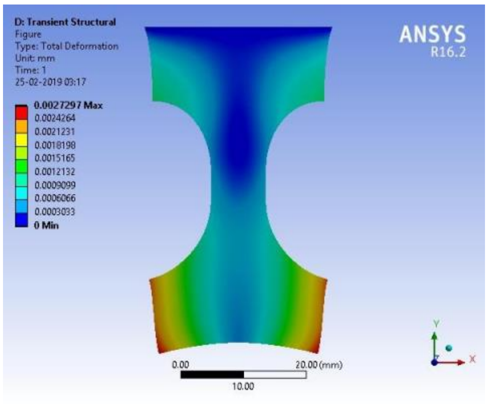


Fig 6.6.1: Total Deformation at 75 ^{0}C

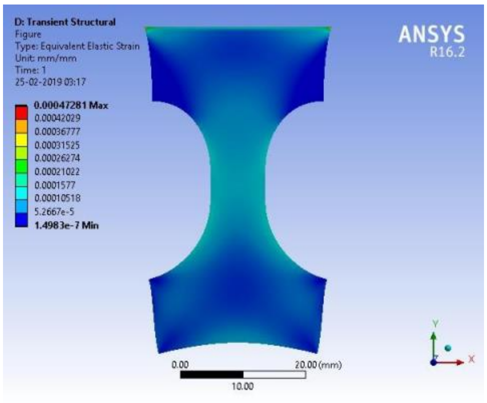


Fig 6.6.2: Equivalent Strain at 75^{0}C

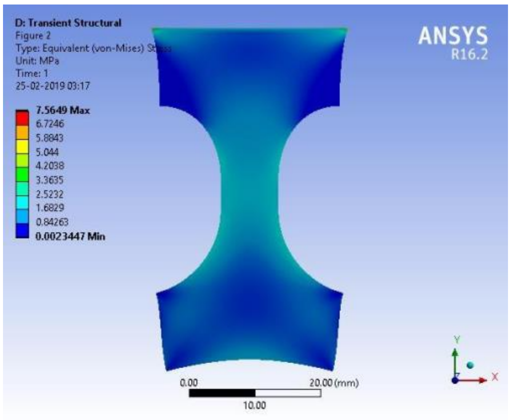


Fig 6.6.3: Equivalent Stress at 75 ^{0}C

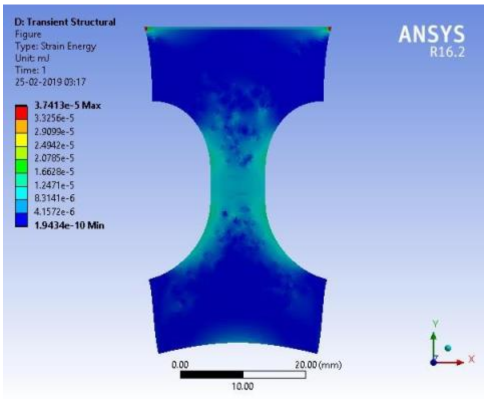


Fig 6.6.4: Strain Energy at 75 ^{0}C

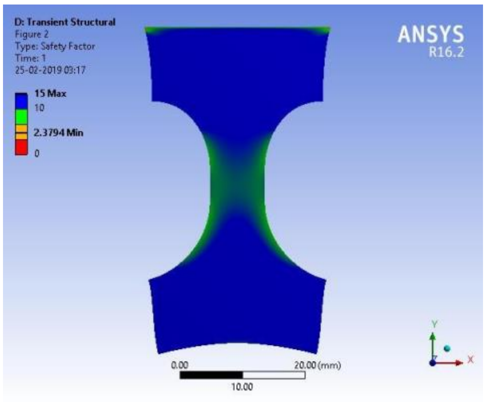


Fig 6.6.5: Safety Factor at 75^{0}C

6.7 Analysis results of Lead:

PARAMERTERS	70 C AT 3 KG	75 C AT 2.5 KG
TOTAL DEFORMATION	0.0027297 mm	0.021509 mm
EQUIVALENT ELASTIC STRAIN	0.00047281	0.0020729
EQUIVALENT (VON MISSES) STRESS	7.5649 MPa	33.167 MPa
STRAIN ENERGY	$3.7413*10^{-5}$ MJ	0.00050047 MJ
SAFETY FACTOR	15 MAX	15 MAX

Table 6.7.1: Analysis of Results

CHAPTER VII

CONCLUSION AND FUTURE SCOPE

7.1 CONCLUSION:

The purpose of this work was to modify the tensile creep testing machine, which was designed and fabricated by previous batch student. Some limitations which were observed in previous machine was eliminated and the capacity of machine was improved.

This work was carried out by applying basic engineering knowledge of mathematics, science, engineering fundamentals and engineering specialization to the solution of complex engineering problem of creep behaviour regarding polymers like polypropylene and soft material like lead.

Study of research literature has to analyse the three phases of creep ie the transient steady state and accelerated creep phases. Long term creep behaviour and short term creep behaviour of polymer was studied to arrive at substantial conclusions.

For obtaining or generating accurate creep data and developing solutions for complex creep behaviour, DAS (Data Acquisition System) was successfully design wi8th consideration for the safety of researcher. DAS records accurate data of various parameters like load, time, temperature, and strain.

Investigation of complex creep nature using research based knowledge was carried out by designing methods of experimentations, analysis and interpretation of data. A valid conclusion was derived lead material deforms less as compared to polypropylene and rupture of lead material occurs earlier. The duration of experimentation of polypropylene material was found to be more than lead.

Modern IT tools like CAD software (AUTODESK INVENTOR) and FEA was done using ANSYS WORK BENCH-16.2

The result derived from experiment gives the safe load and temperature conditions for polypropylene and lead materials. These results can be kept in mind while designi9ng machine element or component by the designer, so as to have a sense of responsibility towards society, health, and safety which is needed for sustainable development.
These work is carried out by ethical principles which comes under professional engineering practices while using one of the parameter of experimentation that is application of 30 kg load to find the short term creep nature. It has been observed that after 20 hours due to helical compression spring constant load was not maintained in the experimentation, which has to be eliminated by using turnbuckle.

Due to this project, a lifelong learning ability can be inculcated which includes an ability to recognize the need, use of contextual knowledge, indulged in research based work and to work independently as an individual or as a team work and effective communication with industry person can be developed.

This project work conclude the application of engineering knowledge, problem, analysis, design and development of a system, conduct of investigation of complex problem, ethics, individual and team work, communication with engineering community, project management and financial skills and last but not least a lifelong learning exposure.

7.2 FUTURE SCOPE:

Regular practical can be conducted on the machine to study the creep behavior of different engineering material in the laboratory for better understanding of the topic in the theory classes.

Research and analysis work can be carried out by using the machine.

In Future by adding more electronic component like extensometer etc. The machine can be made fully automatic and more accurate analysis can be done.

Micro-structural analysis of different materials can also be carried out.

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