ANNAMALAI UNIVERSITY

DEPARTMENT OF MECHANICAL ENGINEERING

INSTRUMENTATION & CONTROL LAB

MECP509 – MECHANICAL LABORATORY – III

(V SEMESTER) - 2020 -2021

List of Experiments

1. Determination of co-efficient discharge of Orificemeter
2. Determination of co-efficient discharge of Venturimeter
3. Experimentation on **DC SERVO** motor controller
4. Experimentation on pressure Process station by On /off method
5. Measurement of displacement using **LVDT**
6. Measurement of Strain using Strain gauge
7. Measurement of temperature using resistance temperature detector **(RTD)**
8. Temperature measurement by bimetallic thermometer **(TIME CONSTANT)**

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

The Mechanical Engineering Department endeavors to be recognized globally for outstanding education and research leading to well qualified engineers, who are innovative, entrepreneurial and successful in advanced fields of mechanical engineering to cater the ever changing industrial demands and social needs.

MISSION

The Mechanical Engineering program makes available a high quality, relevant engineering education. The Program dedicates itself to providing students with a set of skills, knowledge and attitudes that will permit its graduates to succeed and thrive as engineers and leaders. The Program strives to:

- Prepare the graduates to pursue life-long learning, serve the profession and meet intellectual, ethical and career challenges.
- Extend a vital, state-of-the-art infrastructure to the students and faculty with opportunities to create, interpret, apply and disseminate knowledge.
- Develop the student community with wider knowledge in the emerging fields of Mechanical Engineering.
- Provide set of skills, knowledge and attitude that will permit the graduates to succeed and thrive as engineers and leaders.
- Create a conducive and supportive environment for all round growth of the students, faculty & staff

PROGRAM EDUCATIONAL OBJECTIVES

1.	Prepare the graduates with a solid foundation in Engineering, Science and Technology for a successful career in Mechanical Engineering.
2.	Train the students to solve problems in Mechanical Engineering and related areas by engineering analysis, computation and experimentation, including understanding basic mathematical and scientific principles.
3.	Inculcate students with professional and ethical attitude, effective communication skills, team work skills and multidisciplinary approach
4.	Provide opportunity to the students to expand their horizon beyond mechanical engineering
5.	Develop the students to adapt to the rapidly changing environment in the areas of mechanical engineering and scale new heights in their profession through lifelong learning

Experiment No :

Date :

DETERMINATION OF COEFFICIENT OF DISCHARGE OF ORIFICE METER

Aim:

To determine experimentally the coefficient of discharge of Orificemeter.

Apparatus:

Blower, manometer, orificemeter and anemometer

Description

Orifice is a small opening of any cross-section (such as circular, triangular, rectangular,. etc.,) in a vessel or in a plate inserted in a pipe line, through which a fluid is flowing. They are used for measuring the rate of fluid flow (Discharge) based on the simple idea that when contriction is introduced in a pipe, the flow accelerates with a corresponding drop in pressure. This pressure drop is easily measurable and can be related to the discharge.

Procedure:

1) An auto transformer is used to vary the blower speed. The air flow velocity is measured by means of an anemometer.
2) Initially, the auto transformer is adjusted to have an air flow rate of about 2 cu.m/sec.
3) Manometer readings are noted down for the above flow rate.
4) The experiment is repeated for various flow rates.
5) Actual discharge and theoretical discharge for the above readings are calculated and tabulated.

S.No.	Velocity of air in m/sec	Manometer reading			h_a m of air	Q_A m^3/sec	Q_T m^3/sec	C_d
		h_{w1} cm of water	h_{w2} cm of water	h_w $h_{w1} \sim h_{w2}$ cm of water				

Specifications:

Dia. meter of the pipe = 0.039 m

Dia. meter of the orifice = 0.20 m

ρ_w - density of water (1000 kg/m^3)

R – Gas constant (0.287 KJ/kg ^oK)

T_a – Atm. Temp. in ^oK (273+Room Temp)

Calculations:

Theoretical discharge QT = a_o $\sqrt{2gh_a}$

where a_o - Orifice area in m^2 ⇒ $\pi/4d^2$

h_a - Pressure difference across Orifice meter in terms of m of air column.

h_a can be calculated as follows

where ρ_w - density of water (1000 kg/m^3)

ρ_a - density of air

$\rho_a = P_a/RT_a$

where P_a = Atm. pr. in KN/m^2

R – Gas constant (0.287 KJ/kg ^oK)

T_a – Atm. Temp. in ^oK (273+Room Temp)

Actual discharge QA = a.V

where a-Pipe area in m^2 $\pi/4d^2$

V - Velocity of air in m/sec

Coefficient of discharge = Actual discharge / Theo. discharge = Q_A/ Q_T

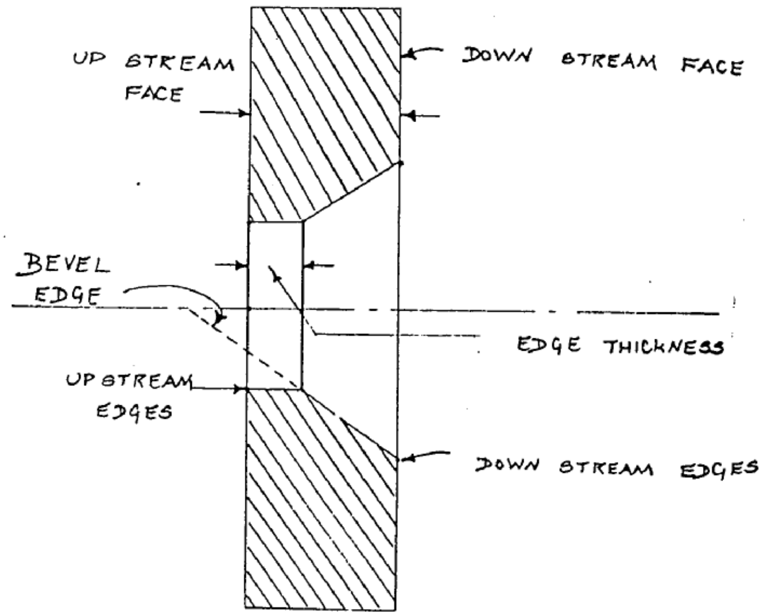
Result:

The following graphs are drawn

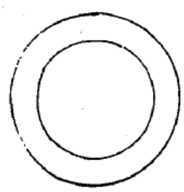
Air Velocity Vs Q_A

Vs Q_T

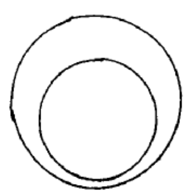
Vs C_d



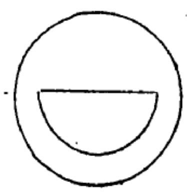
SHARP SQUARE EDGE ORIFICE PLATE



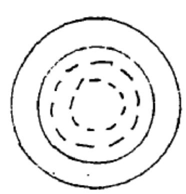
a) CONCENTRIC



b) ECCENTRIC



c) SEGMENTAL



d) QUADRANT EDGE

ORIFICEMETER

Experiment No :

Date :

DETERMINATION OF COEFFICIENT OF DISCHARGE OF VENTURIMETER

Aim : To determine experimentally the coefficient of discharge of Venturimeter

Apparatus : Blower, manometer, Venturimeter and anemometer.

Description : Venturimeter is a device designed to measure the rate of flow of fluid through pipe lives. It is based on the principle of Berrnoulli's equation.

A Venturimeter in its simplest form consists of the following three parts

1. Convergent cone
2. Throat
3. Divergent cone

Convergent cone is a short pipe, which converges from the diameter of the pipe to a smaller diameter usually half as that of the pipe. Throat is the constant diameter portion, which is in between the convergent and divergent cones.

Divergent cone is a pipe, when diverges from throat diameter to the pipe diameter. The length of the divergent portion is usually three to four limes as that of the convergent portion.

Procedure

1) An autotransformer is used to vary the blower speed. The airflow velocity is measured by means of an anemometer.
2) Initially the autotransformer is adjusted to have an air flow of about 2m3/sec.
3) Manometer readings are noted down for the above flow rate.
4) The experiment is repeated for various flow rates.
5) Actual discharge and theoretical discharge for the above readings are calculated and tabulated.

Observation Table:

S.No	Velocity of air in m/sec	Manometer Reading			h_a 'm' of air	Q_A m^3/sec	Q_r m_3/sec	C_d
		h_w cm of water	h_{w2} cm of water	$h_w = h_{w1} - h_{w2}$ cm of water				

Calculation:

Diameter of the pipe = 0.039 m

Diameter of the throat = 0.020 m

Theoretical discharge, $Q_T = K\sqrt{2gh}$

Where

$$k = \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}}$$

a_1 – area of pipe in m^2

a_2 – area of throat in m^2

h_a – Pressure difference across venture meter in terms of meters of air column.

h_a can be calculated as follows

where ρ_w density of water (1000 kg/m^3)

ρ_a = density of air

$\rho_u = \rho_u/R\ Tu$

Where p_a - ATM. pr.in.kN/m

R – Gas constant (0.287 kJ/kg oK)

Actual discharge Q_A =av

Where a – Pipe are in m^2

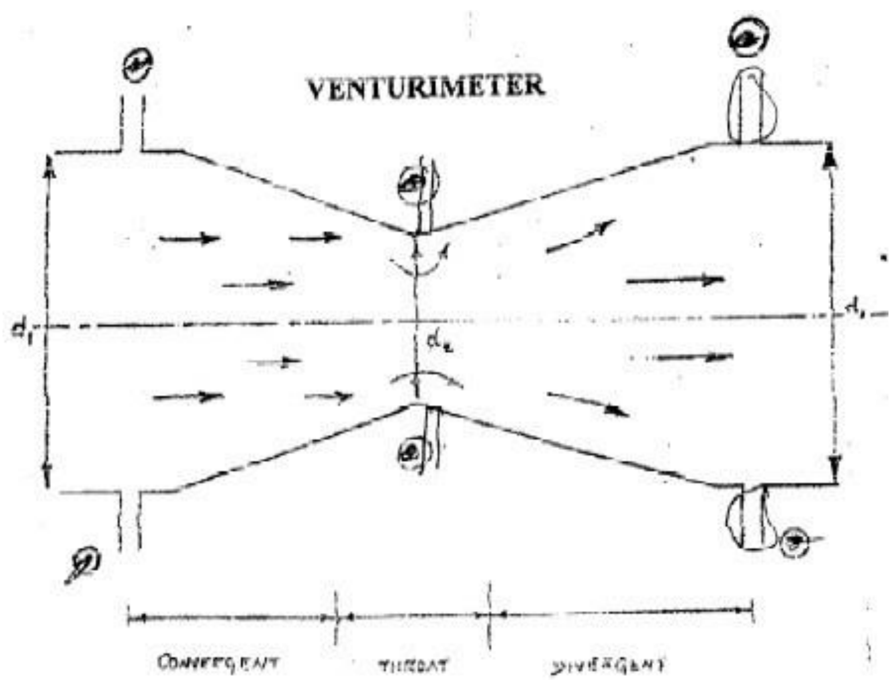
v- velocity of air in m/sec

$$Cd = \frac{\text{Actual discharge}}{\text{Theoretical discharge}} = \frac{Q_A}{Q_T}$$

Result: -

The following graphs are drawn

Air velocity	Vs	Q_A
	Vs	Q_T
	Vs	Q_d



Experiment No :

Date :

EXPERIMENTATION ON DC SERVOMOTOR CONTROLLER

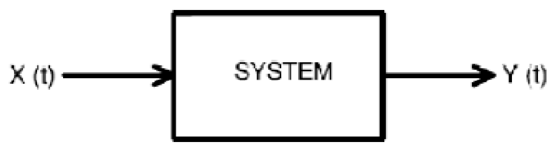
AIM: To obtain the Speed Vs voltage characteristics of the DC motor by using the servo motor controller.

APPARATUS REQUIRED: DC Servo Motor, Controller (ITB - PEC00S), Digital Multi meter

DESCRIPTION:

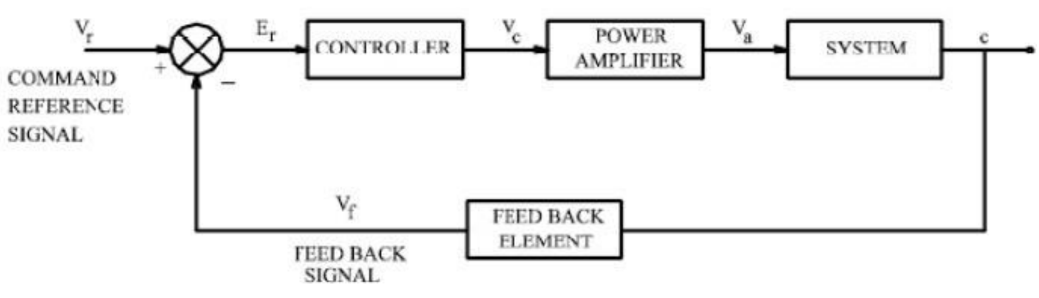
OPEN LOOP SYSTEM

An open-loop system is represented by the block diagram of figure. The system is controlled or activated by a single signal at the input for a single input - single output system. There are no provisions within the system for supervision of the output and no mechanism is provided to correct the system behaviour for any lack of proper performance of the system due to change in environment or loading conditions.



CLOSED LOOP SYSTEM

A closed loop system (feedback system) is represented by the block diagram of figure below. It is driven by two signals (more signals can also used), one the input signal and the other or feedback signal derived from the output of the system. The feedback signal gives the system the capability to act as the self-correcting mechanism through the controller.



COMPONENTS OF A CLOSED LOOP SYSTEM

The Closed Loop system consists of the following components,

i) Error Amplifier

ii) Controller

iii) Power Amplifier
iv) The feedback Element

i) ERROR AMPLIFIER

This compares the reference signal Vr with the feedback signal Vf. The output is a voltage proportional to the difference between the two signals.

ii) CONTROLLER

The controller processes the error signal and gives an output voltage signal VC known as the control voltage. This suggests the necessary corrective measures required in the actuating signal Va to be applied to the system.

iii) POWER AMPLIFIER

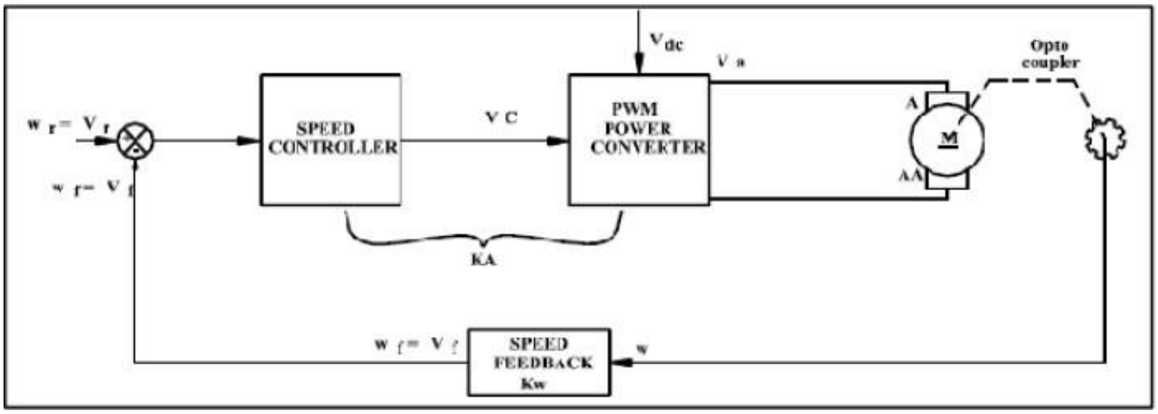
Which takes the input as the control voltage signal VC from the controller and produces the necessary actuating input signal to be applied to the system to achieve the desired output.

iv) FEEDBACK

This constitutes the output sensor and the associated amplifier. The feedback signal Vf is a voltage proportional to the output variable of the system.

DC SERVO CONTROLLER (as a Simple Closed Loop Control System)

For the study of the closed loop control system, a DC motor is used as the system to be controlled. The DC motor can be modelled as a linear system, if the magnetic saturation is neglected and the field flux is assumed to be constant. For this purpose, a permanent magnet DC motor is used. Here the flux is produced by the permanent magnets which are constant. The closed loop transfer function of the system is derived systematically here. The system / plant to be controlled by the DC motor. The objective is to vary the speed through a reference setting. The simplest control system is represented as shown in figure.



The reference speed is compared with the actual speed of the motor sensed through a optical speed sensor. The error is processed through the speed controller. The speed controller sets the required voltage to be applied to the motor. Although the system would achieve the desired speed, it has a drawback. The armature of the motor presents very low impedance to the applied voltage. Under steady state condition most of the applied voltage is balanced by the back emf and only the remainder drives the armature circuit. However, during the transient, there is a mismatch between the applied voltage and the back emf as the speed changes slowly. Therefore, excessive current may be drawn from the converter.

The various components of this system are:

i) An Error Amplifier - which compares the reference speed (set speed /speed command), with the actual speed. The output is a voltage proportional to the differences between the set speed and the actual speed.

ii) A Controller - known as the speed controller. The controller processes the error signal and gives an output, which sets the required voltage to be applied to the motor through the "PWM power controller", to achieve the set speed. The output of the controller is called the control voltage signal. The controller can be of a simple proportional controller or a proportional plus integral controller.

iii) A PWM Power - which takes the input as the control voltage signal Vc from

Controller-the controller and produce the required voltage to be applied to the motor. The power amplifier is a chopper whose average output voltage depends on the duty cycle ratio. The duty cycle ratio is adjusted by the control voltage set by the controller.

iv) Speed Feedback - This constitutes the speed sensor and the associated **Circuit** amplifier. The speed sensor can be a tachogenerator or any other kind of speed measurement which can produce a voltage proportional to the speed of the motor. The speed signal is processed through a feedback circuit and applied to the error amplifier. In this DC motor servo control system, speed is sensed through an optical sensor consisting of a slotted disc, infra-red LED and photo-transistor. The output of the photo transistor is a series of pulses (800 pulses per 100 revolution), which is converted into analog voltage signal using frequency to voltage converter. The output of the F/V converter is 0 to 5 Volts which corresponds to 0 to 1500 rpm.

v) DC Servo Motor - A DC Servomotor of 1500 rpm of 0.25 HP rating is used in this experiment. A slotted disk is provided with a optical sensor to sense the speed.

CLOSED LOOP SYSTEM WITH PI CONTROLLER

The proportional controller can work only with a certain steady state error. The error can be reduced by increasing the gain of the proportional controller. However, the gain is increased the performance of closed loop system becomes more oscillatory and takes longer time to reach the steady state. The steady state error can be reduced by using a PI controller. The equation describing the PI controller is

$$U(t) = K_p \left[e(t) + \frac{1}{T_I} \int_0^t e(t)dt \right]$$

$$U(s) = K_p \left[1 + \frac{1}{T_I s} \right] E(s) = k_p \left[\frac{1 + sT_I}{sT_I} \right] E(s)$$

Where

Kp - Proportional gain of the PI controller

TI - Integral time or reset time and e(t) - Error signal.

From the above equation it is seen that the PI controller has two adjustable or tuning parameters kp and TI. The integral or reset action of the PI controller removes the steady state error. However, the integral mode of control has a considerable destabilising effect which in most of the situations can be compensated by adjusting the
gain kp.

PROCEDURE

Before switching ON the unit

EXT / INT switch should be in INT mode.

Integral open / close switch in open (OL) mode.

Signal conditioner switch in open (OL) mode.

Interface the motor supply sensor with module.

1) Initially, pulse ON/OFF switch should be in OFF mode.
2) Switch ON the unit, and keep the pulse ON/OFF to ON mode.
3) Set the proportional gain kp at minimum.
4) Set Vref = 1 Volt. Slowly increase the gain kp voltage by means of the proportional gain adjustment pot, and find the voltage at which the motor just starts running.
5) Vary the reference voltage in steps, and for each step, note down the motor speed and armature voltage. Tabulate the readings.
6) Plot the ωVs Va characteristics.

OBSERVATION TABLE

Sl No	V_{ref} (V)	V_a (V)	N (rpm)	ω(rad/sec)

Where , $\omega = 2\Pi n / 60$

RESULT

Thus the speed Vs Voltage characteristics of the DC Motor was verified.The following graph is drawn: Speed (N) Vs Voltage (Va)

Experiment No :

Date :

EXPERIMENTATION ON PRESSURE CONTROL PROCESS BY ON /OFF METHOD

AIM

To study the characteristics and control action of ON/OFF on the Pressure Process Station.

APPARATUS REQUIRED

i. VPPS-041 unit

ii. PC

iii. Data Acquisition Card (VAD-104) with software

iv. Patch Chords

v. Loop cable

INTRODUCTION

The pressure process station can be invariably classified under three heads i.e.,

i) Pressure Process Station Mainframe

ii) Data Acquisition Card

iii) Process Control Software

PRESSURE PROCESS STATION MAINFRAME

The mainframe is a metallic structure mounted on open platform. It consists of a bottom plate houses the process tanks. A frame contains pressure transmitter, I/P convertor, control valve, process tank and a cabinet. The cabinet accommodates the multi-output DC power supply and inlet socket for AC mains.

DATA ACQUISITION CARD

VAD 104 is a high performance ADD-ON Data Acquisition Card. This is interfaced with PC through parallel port. The board incorporates with 8 single ended analog inputs through 12-bit ADC, two channels I to V converter and single of V to I converter.

PROCESS CONTROL SOFTWARE

Process control software is in the pressure process station. The software package for pressure control application is very powerful, general purpose package which measures the process variable, displays it on the screen and issues control action to the controller (pneumatic control valve). The software is organised to explain all the control actions available viz. ON/OFF control, proportional control (P), proportional plus integral control (PI), proportional plus derivative control (PD) and proportional plus integral plus derivative control (PID).

Some of the key features of the software are,

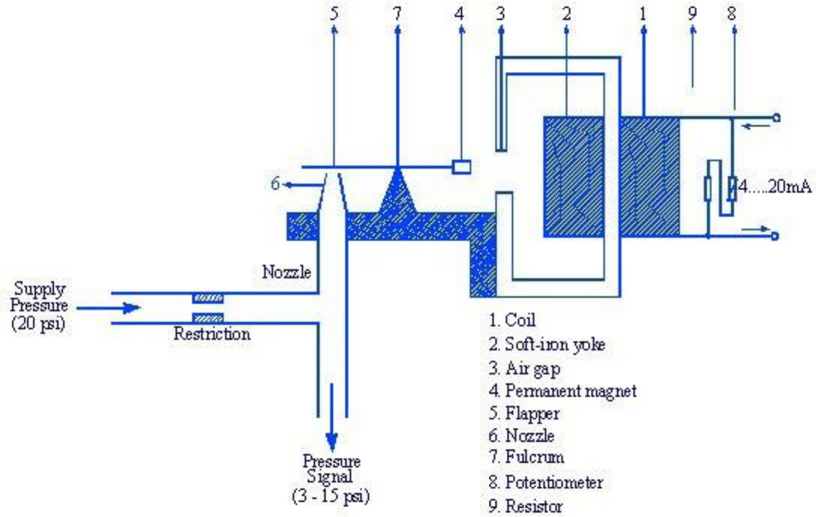
- User feedable process parameters.
- Facility to store the data being processed as a separate file on the disk which can be used for future analysis.
- A complete display of the process pressure chart with animation.
- Display all the process parameters both numerically and graphically.
- Simultaneous graphical display of both process variable and controller output.
- Magnify (zoom) and display the process variable in the proportional band or Dead band.
- Support to take up print outs of the processed data on a centronic printer.
- Convert the stored data to "Wordpad" supported format to study the behaviour of the process.
- Analyse the stored data.
- Dynamically shift set point and there by disturb the process.
- Tune control parameters for PID.
- To perform a historical trend of the process.
- Off-line simulation of process variable.
- Real time simulation using waveform generator.

THEORY - CURRENT TO PRESSURE CONVERTER

Principle of operation

The input current pressures through the coil (1), thereby magnetizing the soft-iron yoke (2). The flux lines of this system being exposed at the gap (3) apply a force proportional to the input signal on the permanent magnet (4) which is made from a highly coercive metal. The small magnet (4) together with the flapper (5) forms the moving parts, controlling the air pressure at the nozzle (6), which is proportional to the magnetic force.

The air pressuring from the nozzle forms a restoring force balanced by the force applied to the magnet. The nozzle (6) is supplied with air through a throttle and back pressure through power amplifier gives proportional output. The described units are properly matched. Hence, a linear correspondence of electric input and pneumatic output signals is achieved. The direction of action of the converter is determined by the coil polarization. Zero adjustment is performed using the potentiometer connected with a resistor in parallel to the coil (1).

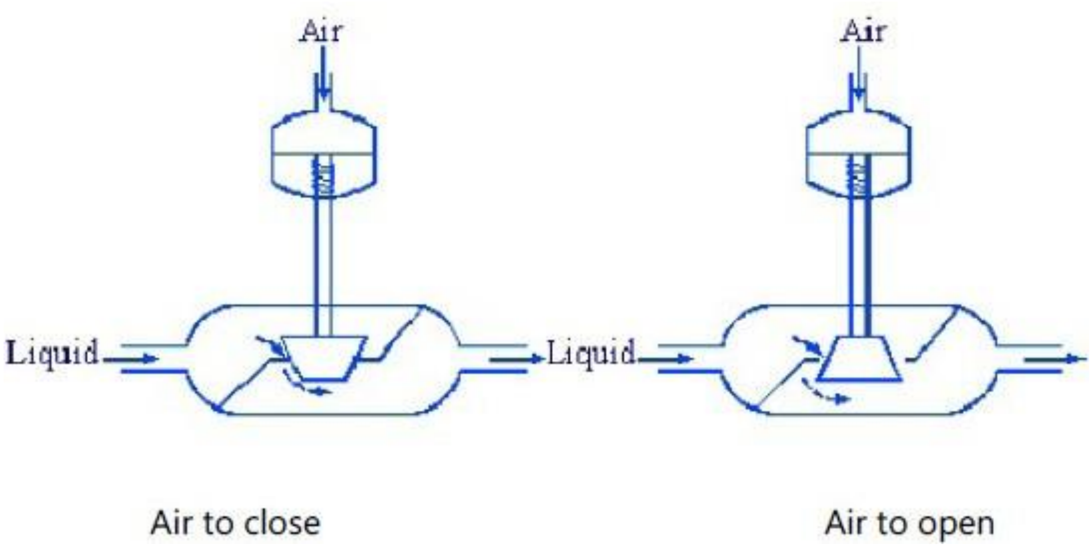


Application

The electro pneumatic (I/P) signal converter is used as a linking component between electric or electronic and pneumatic systems. It converts standard electric signals (4-20)mA, respectively into the standard pneumatic signal (3 - 15) psi. Due to its innovative construction principle based on a fixed coil and a low-mass (100 mg) moving permanent magnet, the I/P signal converter is highly resistant to shocks and vibration.

PNEUMATIC CONTROL VALVE

Air



TYPES OF CONTROL

ON/OFF Control

One of the most widely used type of control is the ON/OFF control. ON/OFF control is also referred as “TWO POSITION” control or “OPEN AND CLOSE” control. Two position control is a position type of controller action in which the manipulated variable is quickly changed to either a maximum or minimum value depending upon the controlled variable is greater or less than the set point. If the process variable is below the set point, the controller output is 100% (i.e. control valve is fully open). If the controlled variable is above the set point, the controller output is 0%(i.e control valve is fully closed), when the differential gap is zero. The tuning parameters for ON/OFF control are differential gap and time delay.

Differential Gap

Differential gap is the region in which the control causes the manipulated variable to maintain its previous until the controlled variable has moved slightly beyond the set point. Small differential gap is not preferred. Because, it introduces oscillations and reduces the life of the final control element.

Proportional Control

Two position control applied to a process results in a continuous oscillation in the quantity to be controlled. This draw back was overcome by a continuous control action which could maintain a continuous balance of the input and output. A mode of control which will accomplish this is known as “PROPORTIONAL CONTROL”.

Proportional control is defined as follows “It is a controller action is which there is a continuous linear relationship between value of the controlled variable and position of the final control element within the proportional band’.

Proportional + Integral (P+I)

The proportional control mode provides a stabilizing influence while the integral mode will help to overcome OFFSET. Integral controller will provide corrective action as long as there is a deviation in the controlled variable from the set point value. Integral control has a phase lag of 90° over proportional control. This lagging feature of reset will result in a slow response and oscillation will come into picture. This is suitable for pressure control and pressure control where the process has little lag. But require a wide proportional band for stability. The small process lag permits the use of a large amount of integral action.

Proportional + Derivative (P+D)

Derivative control action combined with proportional gives a controller which is good on process containing appreciable lag. Because the process lag can be compensated by the anticipatory nature of derivative action (i.e.) derivative action provides the boost necessary to counter act the time delay associated with such control by 90<. Since this controller combination is most effective where the system lags are high, it could be used on most multi capacity process applications. Where the process lag is short, this combination could not be used. This controller combination does not eliminate OFFSET after a sustained load disturbance. It does reduce the magnitude of OFFSET. Because of narrow proportional band. A proportional plus derivative controller properly fitted and adjusted to a process acts to prevent the controlled variable from deviating excessively and reduces the time required to stabilize.

Proportional + Integral + Derivative (P+I+D)

This controller offers the benefit of each control action and moreover the effect duplicates the action of a good human operator on the process. A three mode controller contains the "stability" of proportional control and the ability to eliminate offset. Because of reset control and the ability to provide an immediate correction for the magnitude of a disturbance because of rate control.

PRELIMINARY CHECK

* Air regulator pneumatic input should be more than (G1) 25 psi. And output should be maintained 20 psi (G2).

* Switch ON the VAD-104 and toggle switch should be in "VAD - 104" mode.

* Patch chord and interfacing procedure should be following as per fig shown. DPM displays "00.0" mA. This is also due to disconnected (or) wrong connection.

* For each control action appropriate Software is to be selected (i.e. PID, etc.)

PROCEDURE For ON/OFF Control

1. Electrical and Pneumatic connections should be given as per fig 2 shown.
2. Interfacing connection should be given as per a fig.1 shown.
3. Air Pressure regulator (1) input should be more than 25 psi and maintain the air regulator (1) output pressure (G2) to 20 psi by varying the air regulator knob.

4. Air pressure regulator (2) input should be more than 100psi and maintain the air regulator (2) output pressure 100psi by vary the air regulator knob.
5. Switch ON the VPPS-041 and Data Acquisition Card (VAD-104).
6. Position the Hand valve (HV1, HV5) fully open, (HV3) in the mid position.
7. Invoke “ process control” software in PC and select ‘Process station >> Pressure”.
8. Select “Control >> ON-OFF”.
9. Select “settings >> parameters” and enter values for each parameters (i.e SP-35 Dead Band-20, Delay).
10. Select “File >> Start”
11. Check the control valve opening. Check whether the controller output is 100%,
12. For getting a desired response, tune the process parameter to optimum values.
13. Now, study the response of ON-OFF control action for various values of set point, Dead band.
14. Stop the process(Click “File>>stop”).
15. Save the file in desired file name(Click “File>>Save”).
16. Open the existing file(Click “File >>Load”). Observe the response of the process in graphical format.
17. Take a printout of the report and graphical response.“File>>Load>>option>>report”.

RESULT

Thus the characteristics and control action of ON/OFF on the Pressure Process Station was verified.

Experiment No :

Date :

MEASUREMENT OF DISPLACEMENT USING LVDT

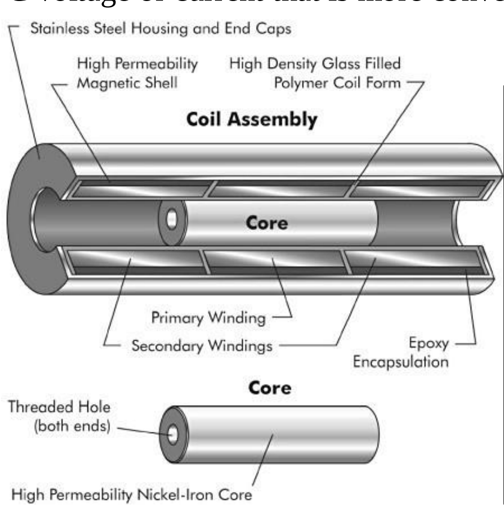
AIM: To measure the linear displacement with the help of L.V.D.T and to calibrate the LVDT with the micrometer.

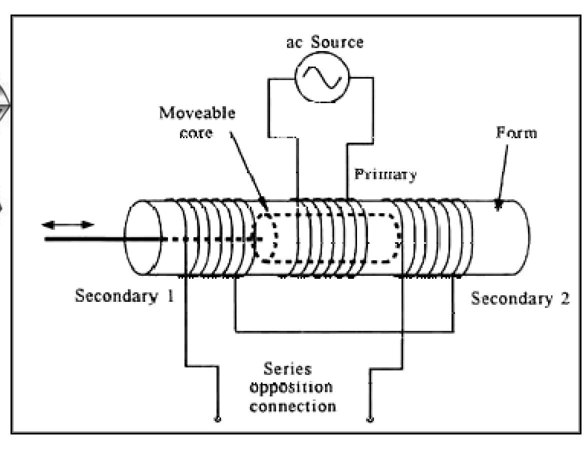
APPARATUS REQUIRED: Instrumentation tutor and L.V.D.T.

DESCRIPTION:

A linear variable differential transformer (LVDT) is an electromechanical sensor that converts the rectilinear motion of an object—to which it is mechanically coupled—into a corresponding electrical signal. Available in a variety of measurement ranges, an LVDT linear position sensor can measure movements as small as a few millionths of an inch to up to ±20 in.

In operation, the LVDT's internal structure consists of a primary winding centered between a pair of identically wound secondary windings, symmetrically spaced about the primary. The coils are wound on a one-piece hollow form of thermally stable glass reinforced polymer, encapsulated against moisture, wrapped in a high permeability magnetic shield, and then secured in cylindrical stainless steel housing. This coil assembly is usually the stationary element of the position sensor. It is driven from an AC signal, known as the primary excitation, and normally between 3–6 kHz. The secondary coils will pick up the signal, through magnetic induction, as the core moves (Shown in figure). The LVDT's electrical output signal is the differential AC voltage between two secondary windings, which varies with the axial position of the core within the LVDT coil. Usually this AC output voltage is converted by suitable electronic circuitry to a high-level DC voltage or current that is more convenient to use.





General LVDT Assembly

Application of LVDT:

1. Hydraulic Applications

LVDTs provide position feedback in hydraulic applications by monitoring the performance accuracy of actuators and cylinders to improve operational efficiencies. The role of the cylinder in most hydraulic applications is to move something, e.g., a valve, airplane tail rudder, or a boom or shovel on an off-road vehicle. In these applications, the control system needs a feedback device that tells it how far the cylinder or actuator moved. For example, if a pilot wants to turn the plane, he moves the joystick. The plane's control system senses that he has moved the joystick and sends a signal to the tail rudder actuator to move the tail rudder. If the system has no way of knowing how far the actuator has moved, the plane could turn too much or not enough. Another example would be a robotic arm picking up a piece of glass. If the control system does not know when to stop the arm, based on position feedback from an LVDT, the hydraulic cylinder could drive the arm right through the piece of glass.

2. Position measurement of steam control valves:

Because of their extraordinary reliability and their ability to withstand high ambient temperatures, LVDT linear position sensors are being used in the rehab of power generation plants to better monitor the position of steam control valves for increased efficiency and reduced operating costs.

3. Petroleum extraction:

Serving the petroleum industry, LVDTs are used for position feedback control of down hole drilling equipment such as bore scopes that measure the inner diameter of the drilled hole. LVDTs are used on the drilling cutters to ensure a near-perfect hole as it is being cut, a quality called bore hole ovality. The LVDT provides continuous position information of the cutter jaw at temperatures up to 200°C and pressures up to 20,000 psi.

4. Ever-Expanding Utility of LVDT

- In everyday life, LVDTs can be found in ATM machines, ensuring money is correctly dispensed;
- In flight-control systems for military and commercial aircraft; as well as in metrology labs; steel, aluminum, and paper mills to control thickness;
- Industrial production lines to ensure properly dimensioned products;
- In outer space on satellite actuator lenses; and under the sea on oil well choke valves.

PROCEDURE:

1. Connect the power supply chord at the rear panel to the 230V, 50HZ supply. Switch on the instrument by pressing down the toggle switch. The display glow to indicate the instrument is ON.
2. Allow the instrument in ON position for 10 minutes for initial warm-up.

3. Rotate the micrometer till it reads “20.0” Adjust the CAL potentiometer at the front panel so that the display reads “10.0”
4. Rotate the core of micrometer till the micrometer reads “10.0” and adjust the ZERO potentiometer till the display reads “00.0”
5. Rotate back the micrometer core up to 20.0 and adjust once again CAL potentiometer till the display read 10.0. Now the instrument is calibrated for +/- 10.0mm range. As the core of LVTD moves, the display reads the displacement in mm.
6. Rotate the core of the micrometer in steps of 1 or 2mm and tabulate the readings. The micrometer will show the exact displacement given to the LVDT core and the display will read displacement sensed by the LVDT. Tabulate the reading and plot the graph between Actual reading and indicator reading.

Observation table

S.No	Actual Micrometer Reading (mm) –A	Indicator Reading LVDT (mm)-B	Error A-B	Error %

RESULT:

Hence, the linear displacements were determined using the LVDT and the error was determined. The following graph was drawn:

Actual reading Vs Indicator reading

Experiment No :

Date :

MEASUREMENT OF STRAIN IN CANTILEVER BEAM USING STRAIN GAUGE

AIM: To measure strain in a wire by resistance wire strain gauge.

APPARATUS REQUIRED: Instrumentation tutor, strain gauge, weighing pan, weights, etc.

DESCRIPTION:

When a material is subjected to any external load, there will be small change in the mechanical properties of the material. The mechanical property may be, change in the thickness of the material or change in the length depending on the nature of load applied to the material. This change in mechanical properties will remain till the load is released. The change in the property is called strain in the material or the material get strained. So the material is mechanically strained, this strain is defined as 'The ratio between change in the mechanical property to the original property'. Suppose a beam of length L is subjected to a tensile load of P Kg the material gets elongated by a length of l. So according to the definition strain S is given by

$$S = l/L \qquad (1)$$

Since the change in the length of the material is very small it is difficult to measure 1. So the strain is always read in terms of microstrain. Since it is difficult to measure the length Resistance strain gauges are used to measure strain in the material directly. Strain gauges are bonded directly on the material using special adhesives. As the material get strained due to load applied, the resistance of the strain gauge changes proportional to the load applied. This change in resistance is used to convert mechanical property in to electrical signal which can be easily measured and stored for analysis.

The change in the resistance of the strain gauge depends on the sensitivity of the strain gauge. The sensitivity of strain gauge is usually expressed in terms of a gauge factor S_g where S_g is given as

$$\Delta R/R = Sg \qquad (2)$$

Where Sg is strain in the direction of the gauge length.

The output $\Delta R / R$ of a strain gauge is usually converter in to voltage signal with a Whetstones bridge, If a single gauge is used in one arm of whetstones bridge and equal but fixed resistors is used in the other arms, the output voltage is

$$E_O = E_i / 4\ (\Delta Rg/Rg) \qquad (3)$$

Substitute Eq 2 into Eq 3 gives

$$E_O = 1/\ 4\ (Ei\ Sg) \qquad (4)$$

The input voltage is controlled by the gauge size (the power it can dissipate) and the initial resistance of the gauge. As a result, the output voltage Eo usually ranges between 1 to 10 V microunits of strain.

Specimen calculation for cantilever beam

$$S = \frac{6 \times p \times x}{E \times b \times t^2}$$

p = Load applied in Kg. (1 Kg) = 0.143 m

l = Effective length of the beam in Cms. (22 Cms)

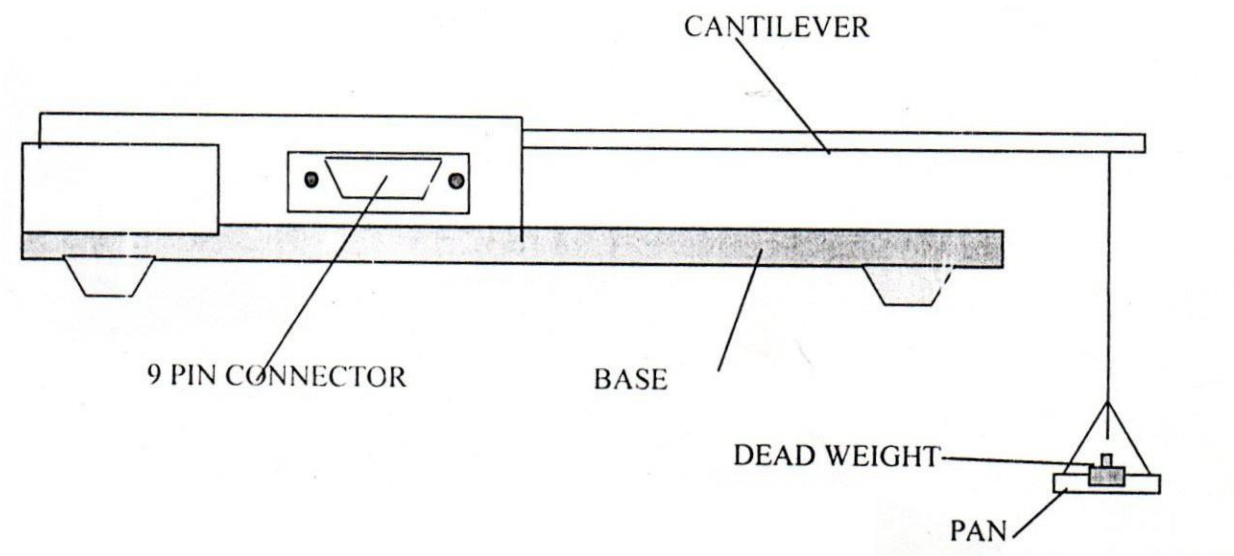
b = Width of the beam (0.0325 m)

t = Thickness of the beam (0.003 m)

e = Youngs modulus (97×10^9 N/m^2)

s = Microstrain

<u>CANTILEVER BEAM SETUP</u>



EXPERIMENTAL PROCEDURE:

1) Calibration of the equipment.
2) After applying the load, the equipment is to be calibrated.
3) Given weight is added in terms of 200 gms upto 1000 gms
4) Actual strain is measured in the instrument.
5) Theoretical strain is to be calculated by using the dimension of the cantilever beam.
6) The percentage error is to be calculated by using actual and theoretical strain.
7) Graph to be plotted for (Weight added Vs % error) weight added Vs (actual strain and Theoretical strain).

OBSERVATION TABLE

S.No.	**Weight added (gms)**	**Actual strain**	**Theoretical strain**	**% error**
1	200			

2	400			
3	600			
4	800			
5	1000			

RESULT

Hence, the pressure was determined by using the strain gauge and the error of the instrument was found. The following graph was drawn: Actual pressure Vs Indicator pressure.

Experiment No :

Date :

TEMPERATURE MEASUREMENT USING RESISTANCE TEMPERATURE DETECTOR (RTD)

AIM: To conduct an experiment on the R.T.D. using Instrumentation Tutor and to measure the temperature.

APPARATUS REQUIRED: Instrumentation tutor, R.T.D. element and beaker

DESCRIPTION:

The change in the resistance of metals with temperature provides the basis for a family of temperature measuring sensors known as resistance temperature detectors. The sensor in simply a conductor fabricated either as a wire wound coil as a film or foil grid. The change in resistance of the conductor with temperature is given by the expression.

$$\Delta R/Ro = \lambda_1(T-To) + \lambda_2(T-To)^2 + \ldots\ldots\ldots\ldots\ldots\ldots \lambda_n (T-To)^n$$

Where To is a reference temperature.

Ro is the resistance at temperature To

λ_1, λ_2, …………….. λ_n are temperature Co-efficient of resistance. Platinum is widely used for sensor fabrication since it is the most stable of all the metals, is the least sensitive to contamination and is capable of operating over very wide range of temperatures. They are slowly replacing the use of thermocouples in many industrial applications below 600 °C, due to higher accuracy and repeatability. The dynamic response of on RTD depends almost entirely on construction details.

CIRCUIT EXPLANATION

The circuit comprises of three parts

1. Power Supply
2. Signal condition and amplifying

3. Analog to digital converter

1. POWER SUPPLY

Inbuilt power supply is used to power all electronic devices inside the circuit. High stable regulated power supply is used for better performance. There are three different power supplies inside the unit. +5 0 - 5 V, 500 mA for analog and digital circuits and also for sensor excitation.

2. SIGNAL CONDITIONING AND AMPLIFYING

The circuitry comprises of signal conditioner and amplifier. The output of the sensor is amplified to required level. The thermocouple gives out directly which is amplified. Thermistor and RTD are connected to the ground through a resister, and the voltage is applied to the other end of the sensor. The resistance change in the sensor will give the mV out put which is amplified and controlled. Analog out put is fed to the ADC.

3. ANALOG TO DIGITAL CONVERTER

The output from the amplifier is a linearised analog DC voltage. This analog output is converted into digital output with the help of IC 7107, 3.5 digit 200mA A to D converter. Then it is displayed through seven segmented LEDs (Light emitting Diode)

OPERATING PROCEDURE

- Check connection made and switch ON the instrument by rocker switch at the front panel.
- The display glows to indicate the instrument is ON.
- Allow the instrument in' ON' Position for 10 minutes for initial warm up.
- Pour around 3/4th full of water in the beaker. Then insert a thermometer.
- Select the sensor on which the experiment is to be conducted through selection switch on the front panel.
- Adjust the Initial set potentiometer in the front panel till the display reads initial water temperature.
- Switch on and wait till the water boils. Note down the reading in the thermometer and set final set potentiometer till the display reads boiling water temperature.
- Remove the sensor from the boiling water and immerse it in the cold water. set the cold water temperature using initial set potentiometer.

- Repeat the process till the display reads exact boiling water and cold water temperature, change the water in the kettle with and reheat the water. Now the display starts showing exact temperature rise in the kettle.
- Experiment can be repeated for all the three sensors. Temperature in the thermometer and the indicator readings in steps of 10°C can be tabulated.

Observation:

Sl.No.	Room temperature / Thermometer Reading °C (Actual temperature)	RTD °C	RTD ohms

RESULT:

Hence, the experiment on the R.T.D. was conducted using Instrumentation Tutor to measure the temperature.

The following graph was drawn:

Actual reading Vs Indicated reading

Experiment No :
Date :

DETERMINATION OF TIME CONSTANT OF A BI METALLIC THERMOMETER.

Aim:

To determine the heating and cooling time constants of a bimetallic thermometer.

Apparatus:

Bimetallic thermometer, heater, stop watch and beaker.

Description

The bimetallic thermometer is mathematically modeled as a linear first order ODE with constant coefficients. The solution of this subjected to the conditions.

$T=T_o$ at $t = 0$
$T=Tf$ at $t = \propto$ is
$T=Tf + (To-Tf)e-t/ \tau$

Where

T_o = initial value indicated by instrument
T = Value indicated by instrument
Tf final steady value
t = time
τ= time constant

The time constant is the time required to indicate 63.2 percent of complete change. In many cases the measuring lag is specified by the time required to attain 90 percent or 99 percent of the full change. The measuring lag for first order type instruments is given by the time constant ‘t.

Procedure

1) Water is taken in a beaker and placed over the heater.
2) The ambient temperature is noted and the Bimetallic thermometer is introduced into the water.
3) The heater is switched on and the rise in temperature is noted at regular intervals of time (say for every 5 seconds) till the temperature reaches 100°c
4) The heater is switched off and fall in temperature is noted for every five seconds till the reading shows ambient temperature.

5) Enter the readings in the tabular column.

Tabulation

Time from Starting in sec	**Temperature from biometallic in oC**	
	During Heating	**During Cooling**

Calculation:

$T_{63.2\%}$ = [Tmin +(Tmax - Tmin) 0.632

$T_{63.2\%}$ = [Tmax - (Tmax - Tmin) 0.632

$T_{63.2\%}$ temperature where t = μ

Result:

The following graphs of drawn

Time Vs Temperature (During Heating)

Time Vs Temperature (During Cooling)