



Introduction

The PCT-200 Process Control and Instrumentation rig provides a self-contained process control system which is representative of many industrial process control systems that are used in the chemical, oil, food, water and other process industries. The rig is fitted with state-of-the-art intelligent process instruments and actuators which are networked via PROFIBUS PA and DP to communicate with a Programmable Logic Controller (PLC).

The controlling PLC can be configured to implement a number of different control strategies for flow and level control using cascade, feed-forward and multi-variable strategies. The rig also provides separate level alarms and process and device temperature monitoring. Further, the control system is linked via an Ethernet Local Area Network (LAN) to a modern PC platform and gateway which provides modern Supervisory Control and Data Acquisition (SCADA) monitoring and control of the process. Asset management tools are also available on the PC workstation for calibration, diagnostics, predictive maintenance and other engineering instrumentation and actuation tasks.

Basic Process and Instrumentation

Figure 1 shows the basic rig Process and Instrumentation (PI) diagram. A reservoir holds water which is pumped by a speed-controlled centrifugal pump (SC) to the rest of the process. The three-phase motor that drives the pump is controlled using a networked variable frequency inverter.

The pump outflow passes through a venturi-tube which provides flow measurement via a differential pressure transmitter (DP). The venturi outlet normally passes to tank 1, however the manual ball valves can optionally be set to bypass tank 1 and direct the flow to a modern electromagnetic flow transmitter (FT). This arrangement means that this highly accurate flow meter can be used for calibration and measurement of the orifice characteristics. Optionally, a pressure transmitter (PT) can be fitted to measure the pump discharge pressure and can be used to enable experiments on centrifugal pump characteristics.

The pump speed control can be used in conjunction with the DP transmitter for flow control, or in conjunction with the level transmitter (LT) for level control in tank 1. A cascade control system can also be implemented by feeding the level controller output as a set-point to the flow controller. A temperature transmitter (TT) is provided in tank 1 for monitoring of the water temperature. This cannot be used for control, but is useful for demonstrating various aspects of instrumentation. The differential pressure transmitter (DP) mounted beneath tank 1 which can be used to provide level measurement. The differential pressure transmitter can also be used in conjunction with a venturi for flow measurement in the line from the pump to tank 1.

The outlet of tank 1 passes to tank 2 via a state of the art electromagnetic flow meter (FT) and then to a modulating control valve fitted with a pneumatic positioner (XV). The control valve can be used in conjunction with the flow transmitter for flow control, or in conjunction with the ultrasonic level transmitter (LT) for level control in tank 2. The outflow from tank 2 back to the reservoir is controlled by a calibrated hand-operated ball valve.

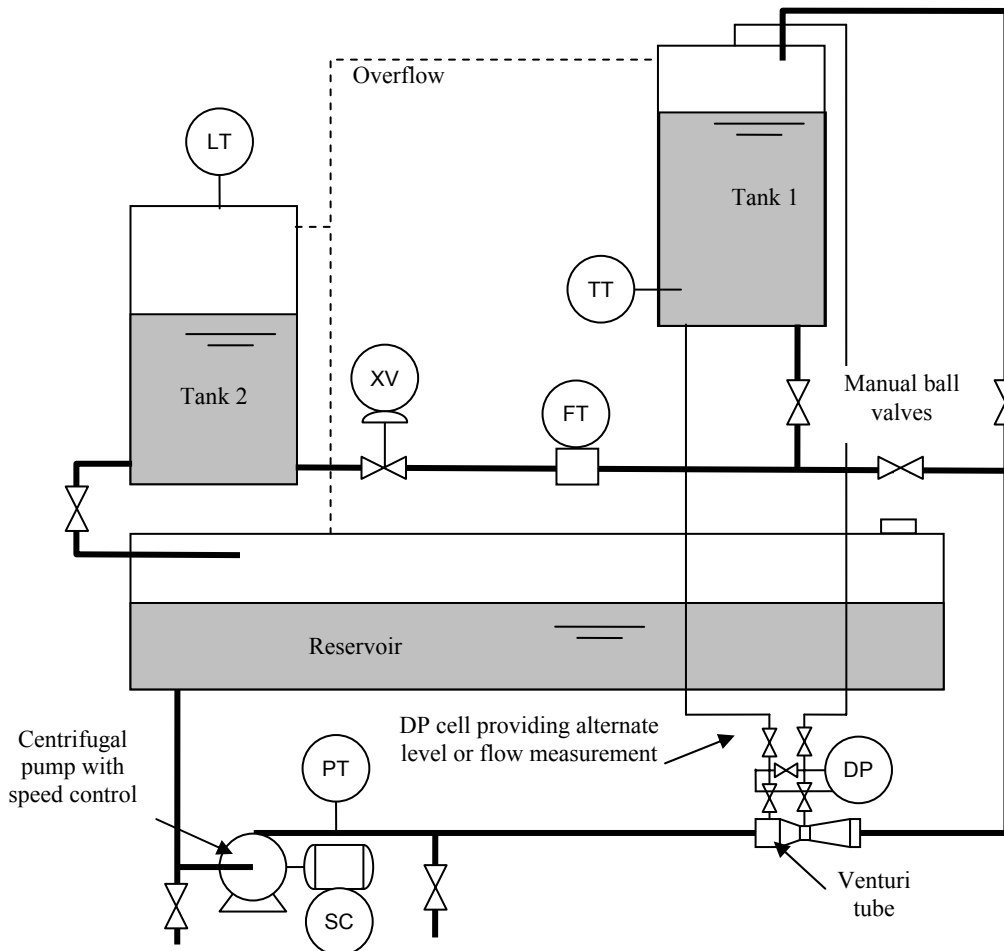


Figure 1 – Basic Process and Instrumentation diagram for the PCI rig

Networking

Figure 2 shows the rig network layout. All instrumentation and actuation is provided with PROFIBUS (PROcess-FIeld-BUS) connectivity. The centrifugal pump speed control is provided by a modern variable frequency inverter with integrated PROFIBUS DP interface. All the process instruments are provided with integrated PROFIBUS PA connectivity. A DP/PA coupler provides a transparent gateway from DP to PA. The PLC incorporates a PROFIBUS DP master which controls cyclic communication with all the field devices. Cyclic data is used for all process data.

The PLC is also provided with an Ethernet interface which enables networking to the PC workstation which runs SCADA software. The gateway provides another route from Ethernet to PROFIBUS for engineering data. This is used with asset management software for reading and writing device parameters within the the field devices. This software has facilities for device configuration, calibration, diagnostics, health checking and predictive maintenance.

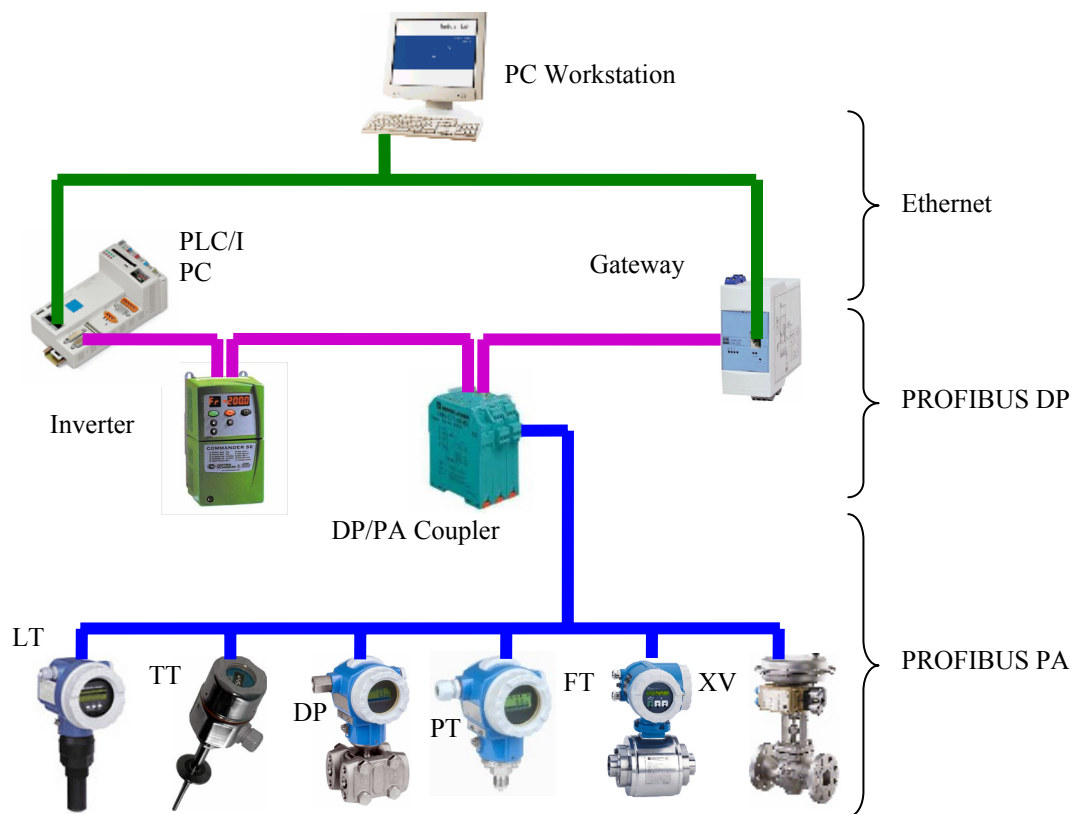


Figure 2 – Rig networking

Laboratory Work

The rig has many possibilities for practical work, exercises and project work. These are concerned with the areas of instrumentation and calibration, process control, instrumentation management and maintenance and networking. The following list outlines some of the many possibilities for laboratory work

- a. Temperature measurement
 - i. Temperature measurement and status indication
 - ii. Scale and alarm limit setting, simulation mode for intelligent sensors.
 - iii. Sensor and transmitter diagnostics.
- b. Level measurement
 - i. Hydrostatic level measurement and calibration, effects of density.
 - ii. Ultrasonic level measurement and calibration.
 - iii. Ultrasonic reflection envelope curve and problem diagnosis.
- c. Flow measurement
 - i. Volume and mass flow measurement using electromagnetic flow meter.
 - ii. Flow meter calibration.
 - iii. Flow rate measurement using a differential pressure transmitter and orifice plate.
 - iv. Square root extraction within an intelligent transmitter.
 - v. Calibration and performance of a head meter.
 - vi. Process noise in flow measurement.

Actuation elements and characteristics

- d. Control valve
 - i. Valve positioner operation and calibration.
 - ii. Valve sizing calculation and verification.
 - iii. Measurement of valve installed characteristic.
 - iv. Fail-safe action in the event of pneumatic or electronic failure.
- e. Inverter, Motor and Centrifugal pump
 - i. Induction motor speed control and characteristics
 - ii. Setting up a drive over PROFIBUS.
 - iii. Centrifugal pump speed/flow/head characteristic measurement.

Feedback control systems

- f. Level control
 - i. Control of level using variable pump speed.
 - ii. Control of level using control valve.
 - iii. P, PI and PID level controller tuning and performance.
- g. Flow control
 - i. Flow control using variable pump speed.
 - ii. Flow control using a control valve.
 - iii. P, PI and PID controller tuning and performance.
- h. Cascade and feed-forward control
 - i. Cascade control of level and flow
 - ii. Feed-forward control using flow measurement
 - iii. Multi-variable control of level and flow.

Fieldbus systems

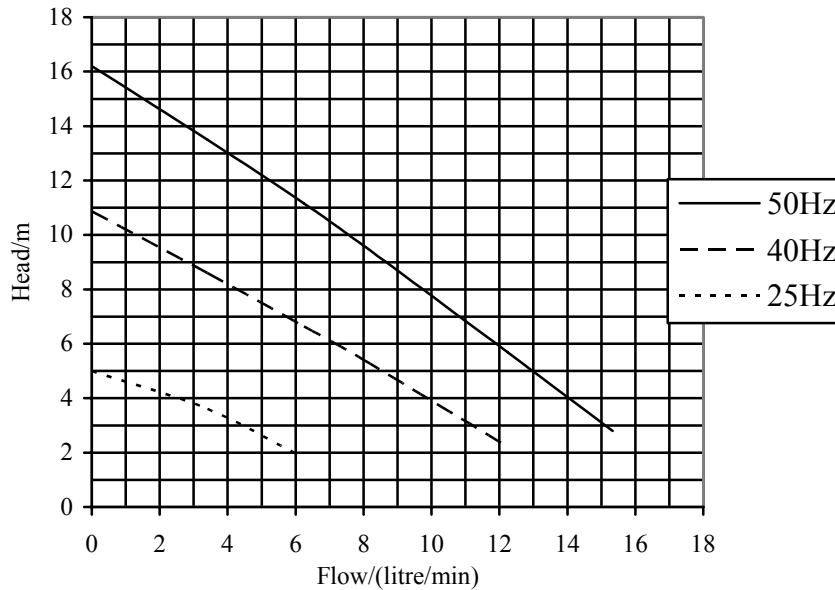
- i. PROFIBUS system configuration for cyclic data
 - i. Basic DP device configuration, GSD files, modules and parameters.
 - ii. Bit-rate selection and cycle time effects.
 - iii. PA system configuration, process value and status byte handling.
 - iv. Diagnostics, watchdog timer setting and fail-safe action.
- j. Acyclic communications
 - i. Use of engineering tools with acyclic communication capability.
 - ii. Device profiles: physical, transducer and function blocks
 - iii. Methods of device calibration using acyclic communications
 - iv. Advanced device diagnostics and status
 - v. Auto, manual and simulation modes of operation for transmitters and actuators.
 - vi. Predictive maintenance features in a modern control valve positioner
 - vii. Predictive maintenance features in a modern inverter.

Ethernet and LAN technology

- k. Network configuration and checking
 - i. MAC and IP addressing, setup and checking
 - ii. PC networking diagnostic facilities.
 - iii. Remote device configuration using http (web) technology.

Pump and pipe sizing

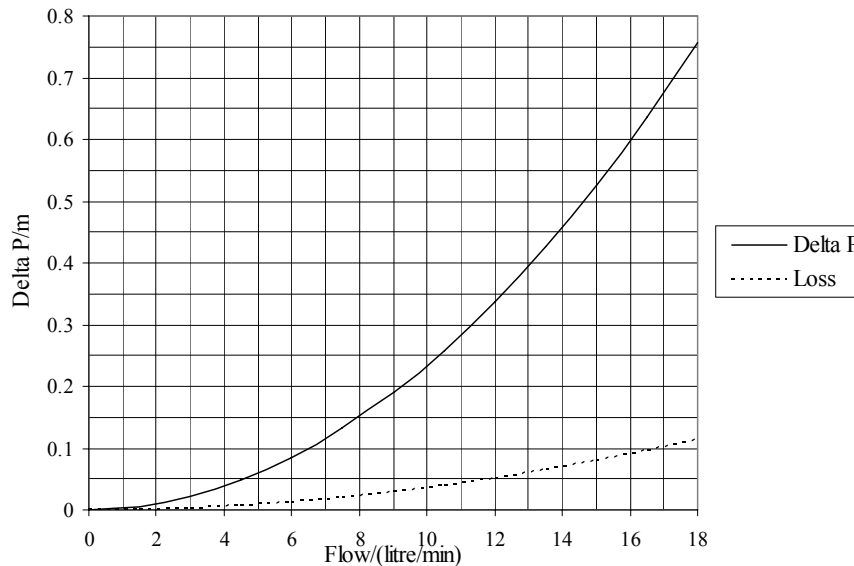
The nominal maximum flow rate around the system is 20 litre/min = 0.3 litre/s. The pump delivers a linear flow/head and flow/speed characteristics. At a speed of 2900 rpm (50 Hz), the pump delivers a maximum head of 16m (~1.6bar) at zero flow dropping to 2m at 16 litre/min. All pipe work and valves are 1" nominal bore schedule 40 clear UPVC piping. The rated working pressure of this piping is 15.2 bar, giving a safety factor of almost 10. The internal diameter of this pipe is 26.14mm.



Pump characteristics at various pump speeds

Venturi and DP cell sizing

A venturi tube (according to EN 5167-4) provides flow measurement for the pump delivery. The maximum differential at a flow rate of 16 litre/min is about 0.6m and the overall loss is about 0.1m. The DP cell incorporates a function block which can calculate the square root of the differential pressure and scale the measurement to give the flow rate.



Venturi tube characteristic

Ordering Information:	
Model Number:	PCT-200
<i>Consists of:</i>	1 x PCT-200 Process Control and Instrumentation Rig
	Control Cabinet
	DP/PA coupler
	Ultrasonic level transmitter (LT)
	Temperature transmitter and thermowell (TT)
	Differential pressure transmitter (DP)
	Electromagnetic flowmeter (FT)
	Pressure Transmitter (PT)
	Global control valve (XV)
	Venturi tube and parts
	3 phase Inverter
	PROFIBUS Master PLC IPC
	Ethernet/PROFIBUS DP gateway (Fieldgate)
	Inverter + PROFIBUS DP interface
	Six-way PROFIBUS PA segment protector
	Asset Management Software (Fieldcare)
	SCADA software
Ethernet switch	
PLC configuration and programming software	
Pipes are 1 inch clear	
Air Supply required	6 Bar continuous supply
Mains supply required	240v AC Single Phase
Shipping Information	
Weight (unpacked) net	150kg
Dimensions (unpacked) cm	176 L x 70 W x 195 H
Weight (packed) gross	320kgs (Tarre weight 170 kgs)
Dimensions (packed) cm	192 L x 88 W x 218 H

Notes.

1. *Specification is subject to change without notice.*
2. *All dimensions are in mm unless specified otherwise.*

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