Trends in Temperature Control Equipment

Components, wiring, operator interfaces, configuration, operation, support

Walk round a few process plants and you will see some 20 years of evolution.
Starting from the **tried and true** using **Discrete Instruments** all the way up to **SCADA** (Supervisory Control and Data Acquisition) systems with color monitors and operator interfaces, rich in control, protection and data analysis capability

The **discrete instrument** arrangement ranges from a single controller, thermocouple and power switch on an oven for example; up to a multi-zone process using rows of discrete controllers, indicators, recorders, switches and control knobs, generally assembled in control enclosures.
Around the plant you will see a lot of wiring of all sizes and colors; carrying power, signals, serving PLCs, power control devices, temperature and other sensors, signal converters, transducers, control valves and more. You may see controllers and indicators away from the main control panel, serving local plant items that sometimes need operator attention.

Many end users can build a discrete instrument system themselves, start it up, maintain it and understand thoroughly how it relates to the process. It is hard to talk such a user into a move up to a bought-in SCADA system and to abandon the comfort level that he created.
In 2002 **the discrete option outnumbered SCADA type systems by some 5 to 1** - measured in US dollars spent. The comparative figures for cumulative installed base would show a bigger ratio by taking in all installation history. Expect this ratio to decrease as products mature and SCADA costs come down.
Let's see what's in use today and how the quest for productivity, plant efficiency and lower equipment, labor and energy costs is driving trends and improvements.
Temperature sensors have not changed greatly in recent years. The reliable and accurate thermocouple and platinum RTD still dominate and remain cost effective. There is a good case for reduction of the number of thermocouple alloys in use. Types E, J, K, T and S could be dropped (unncessary duplication) and four of these five show unacceptable drift for some applications. You would save money and cut down hazards due to mis-identification and and color code confusion; but don't hold your breath; this industry with its large installed base will be slow to change.
Contamination of thermocouple wires from thermocouple sheath material has been studied and improved sheath materials are being introduced.
M.I. (mineral insulated) thermocouples are coming with improved chemical compatability packed insulation and with much reduced resistance to moisture ingress; a major cause of degradation.

Optical thermometers in non-contact applications will always find a place even though their cost can be some 20 times that of a thermocouple. They generally sit away from the heat source so unlike thermocouples are not prone to burnout. There seems to be room for keener prices.

One very **cost effective** development from Exergen uses special vacuum or gas filled sensors. These optical thermometers are priced in the same range as thermocouples. The absolute accuracy may not equal that of traditional optical sensors but they can be used with recently available controllers and indicators. These instruments are specially linearised and can be calibrated and emissivity-compensated on the job against a thermocouple reference. The sensors delivers acceptable stability and performance in situations where non-contact is essential.

One system reported recently by Davidson Instruments packs 37 fiber optic channels into a ¼ inch OD sheath. The fibers transmit 32 infrared temperature signals from points spaced 1 inch apart out of a catalyst tube. At the receiving end these are multiplexed into what is called a "signal conditioner" which is presumably an IR (infrared) thermometer.

Sensor Checks
You will see a lot of learned looking material written about **self-validation** of temperature sensors in situ**.** Don't be tempted away from the tried and true method of applying a precisely known temperatures, observing all the standard precautions and traceability, and measuring the output signals.

Controllers and indicators are becoming ever smaller, cheaper and richer in features.
In 1980 you would buy a controller for some 14 hrs of tradesman's pay. In 2003/4 it would be 3 hrs pay and weigh about 4 oz against 3 lb in 1980. Expect this trend to continue as Far East production and technology gain momentum.
There have been major improvements in **configurability, displays, choice of sensor inputs, elimination of time lags in cold junction compensation, and choice of control signal outputs**. Virtually all known varieties of these parameters can be supplied in one field-configurable controller.
New **control techniques** have appeared. Here are just a few, old and new:
Self and adaptive tuning
Process identification to match controller and process
Overshoot inhibition.
Protection against wiring, sensor and load malfunction.
High, low and rate-of-change alarms
Logic inputs and outputs that can be used to modify control strategy
Power limit and control of rate-of-change of power.
Automatic changeover and range-change (if needed) to a standby or higher temperature sensor
Cascade, ratio and feedforward control.
Set-point programming.
Safety options on power interruption
Timer functions.
Storage and call-up of recipes relating to different processes or batches.
Digital communications with choice of protocol

Many of these options are built in to the controller's memory and lie waiting to be put to use as the process dictates.
When you wake up the features that you want to use (this is called **configuring** the instrument) you can adapt the same controller to many different and versatile applications. This has led to a great reduction in inventory lying on your spares shelf - and your supplier's shelf. It has also brought faster replacement of suspect instruments – and control components - often avoiding shutdowns.
Your distributor.can configure your intruments before delivery – or supply PC programs so you can do it yourself. This is a great benefit to distributors and OEMs in matching the instrument's configuration to the application.
Expect more features and ingenuity ahead. But there is **one serious problem** and it gets worse as technology gets better and I don't see any reversal of the trend. It pertains too in supervisory and advanced integrated systems.
That is: **the delay and mental fatigue** you can suffer when reading manuals, configuring instruments and putting them to work. Human errors here are common and threaten safety. When you encounter convoluted manuals and key-pushing procedures close your wallet and get to the supplier before the coroner does.
Supervisory Systems. When your process is becoming large or complex there is an intermediate stage if you are not ready for the full SCADA level. That is to add a **supervisory PC** that connects to the communication ports on your instruments, control components and field-mounted devices. This includes PLCs, transmitters, actuators, valves, SCRs and signal converters.

All your process signal values, settings, adjustments and plant graphics can now appear on the PC display. Information can be tables, bargraphs, line graphs and trends, graphical mimics of plant items, archived data, alarm data.

Unless you need local access on the plant, you can do away with the displays and adjustments on controllers and rely on your PC-based Human Machine Interface (HMI).
The now **blind instruments** can lie inside the enclosure, plugged in on a DIN rail and you avoid the tedious and costly job of cutting a lot of holes in a few square yards of metal, mounting instruments and running cables.
There are many well-established **control-software** suppliers who can interface with just about any manufacturer's communicating products. Specview, Labview and Wonderware are just a few that come to mind. At least one supplier offers **automatic detection and configuration** of connected devices. This does away with the job of defining long tag lists for every device and its specific parameters.

Next Level

You can move upmarket to the high profile process control equipment manufacturers who offer mainly their own equipment, along with their proprietary SCADA systems or Distributed Control Systems (DCS) systems. (these titles are often used interchangeably). Such systems are found typically on large acreage plants in the pulp and paper, petrochemical and pharmaceutical industries. It is common at this level to have a control-and-monitor station in a main control room and satellite stations around the site, having different authorised levels of access and control.
Plant Wiring. This has traditionally been extensive and diverse. E.g. **Power cable**; different sizes and power ratings. **Thermocouple extension cable;** a mix of alloy materials, coverings and shielding. **RTD cable;** resistance matching. **Analog signal cable** and **DC power cable** for remote transmitters; different sizes and shielding. **General;** color coding (there are safety issues here).
This mixture makes for non-interchangeability of cables and great expense on both initial wiring, then later when modifying the process and running extra cables.
With a SCADA type system, wiring can be greatly reduced, say by using your **Ethernet** cable to transmit data to and from communicating control components around the plant. By using signal converters, low millivolt signals need not be sent long distances and exposed to electromagnetic interference.
Communication capability and speed is being added to more and more control devices. Not only to send and receive control data but to configure and test the devices, check their health and aid maintenance.

Control valve example. You will be lucky if your newly installed control valve comes with **zero** and **full-stroke** at the two positions you want, and with the degree of linearity that suits your control loop. This operation is often done by cams, linkages and wrench. With a so-called **smart** valve and actuator you can now do it from the control room or from a satellite operator station. Add to this the ability to measure force, speed, hysteresis (fancy name for dead zone), number of cycles and you have an aid to maintenance and validation.

Work is proceeding on **wireless transmission** so at some time you could see fewer, or even no data cables. In this case, apart from power-hungry control devices, you would only need a dc instrument-power line calling at each control component.
Internal wiring by software is already replacing the wired analog and logic signals that commonly pass around inside controllers and from one control component to another.
These techniques are costly - but you can expect savings on wiring, construction and personnel; add efficiency and product quality and reduce your TCO (total cost of ownership).

Record Keeping. The man with the clipboard and wristwatch was not cheap or dependable. Nor synchronised because he moved around. In the SCADA world you replace him by scheduled archiving and time stamping of data. Demands on the vigilance of plant operators are reduced and the watch on

quality and processing conditions improved. Access to process adjustments will be password-protected and audit trails of changes will be logged.
Regulatory and otherwise mandatory record-keeping requirements are readily met, for example in food and pharmceutical processing, aerospace industry heat-treating and emission monitoring.

Start-up sequences, alarm analysis with preplanned automatic responses, proactive fault diagnosis and scheduled maintenance can be programmed and will limit the incidence of unplanned shutdowns.
Controllers may or may not be distributed around the plant. It is feasible for all the controller functions and monitoring to be time shared and integrated in the master control station or done by a PLC.
Issues here are:
CPU or PLC down, everything goes down. Not so with one controller per loop.
Ensuring an adequate update rate and control response for time-shared fast control loops.
Configuring PLC cards into control loops has not yet matched the well-matured and proven control techniques built in to stand-alone controllers

System design, configuration and start up.
Among the penalties of moving up the technology scale are cost and complexity. You expect to recover cost over time but the issues arising from complexity have to be addressed.
Plant engineers and managers have many other jobs related to process and product technology. There is little time to study the construction, manipulation, features and maintenance of advanced instrumentation systems.
It often happens that only the bare essentials are used and the high tech features **abandoned** and unexploited – as in your own home-electronic technology. You have to work with suppliers to build in simple and intuitive operation that **you will use** or stay with the **tried and true** discrete systems.

Design and installation calls for a **systems integrator.** This could be the manufacturer or his distributor who does it for a living or it could be a selection of your own staff.
At the design and integration stage your operations and maintenance staff must be on the team so use their experience. They can tell you all about not being consulted then being called on to pick up the pieces.
Designers and manual writers don't see complexity like the rest of us do because of their own ingrained familiarity in building systems.

System down? Your maintenance wiz left. Supplier is no longer in business or his programmer who did your job left? No problem, you looked ahead.
You specified the documentation, drawings, configuration, training, recording of after-installation changes and descriptions of how the system works before you signed the order. You insisted that this comes with the system, not later.

Influence of academic research in the high volume control market.
You will see large numbers of extremely erudite looking papers on automatic control in the academic press and technical conferences. I do not question the great contributions made by researchers and analysts into the really tough control challenges in the aerospace and defence industries.

Now look at the mainstream process heating industry where some 2 – 3 million single loop controllers per year are sold. Their ingenious designs cover just about every conceivable application. They are installed, tuned, put to work and continue to serve the industry well. This is a remarkable success story but with little evidence of vigorous technology transfer from academia. You might say more pressure from researchers and more suction from users. True but there is a need for an intermediate stage of translation. This will package the technology and its relation to the process in a language that can be readily assimilated by users in this big base of mainstream processing.