Advanced Process Control for Engineers and Technicians

THIS BOOK WAS DEVELOPED BY IDC TECHNOLOGIES

WHO ARE WE?

IDC Technologies is internationally acknowledged as the premier provider of practical, technical training for engineers and technicians.

We specialize in the fields of electrical systems, industrial data communications, telecommunications, automation and control, mechanical engineering, chemical and civil engineering, and are continually adding to our portfolio of over 60 different workshops. Our instructors are highly respected in their fields of expertise and in the last ten years have trained over 200,000 engineers, scientists and technicians.

With offices conveniently located worldwide, IDC Technologies has an enthusiastic team of professional engineers, technicians and support staff who are committed to providing the highest level of training and consultancy.

TECHNICAL WORKSHOPS

TRAINING THAT WORKS

We deliver engineering and technology training that will maximize your business goals. In today's competitive environment, you require training that will help you and your organization to achieve its goals and produce a large return on investment. With our 'training that works' objective you and your organization will:

- Get job-related skills that you need to achieve your business goals
- Improve the operation and design of your equipment and plant
- Improve your troubleshooting abilities
- Sharpen your competitive edge
- Boost morale and retain valuable staff
- Save time and money

EXPERT INSTRUCTORS

We search the world for good quality instructors who have three outstanding attributes:

1. Expert knowledge and experience – of the course topic
2. Superb training abilities – to ensure the know-how is transferred effectively and quickly to you in a practical, hands-on way
3. Listening skills – they listen carefully to the needs of the participants and want to ensure that you benefit from the experience.

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All IDC Technologies workshops include practical, hands-on sessions where the delegates are given the opportunity to apply in practice the theory they have learnt.

REFERENCE MATERIALS

A fully illustrated workshop book with hundreds of pages of tables, charts, figures and handy hints, plus considerable reference material is provided FREE of charge to each delegate.

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Satisfactory completion of all IDC workshops satisfies the requirements of the International Association for Continuing Education and Training for the award of 1.4 Continuing Education Units.

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CERTIFICATE OF ATTENDANCE
Each delegate receives a Certificate of Attendance documenting their experience.

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For more information or a FREE detailed proposal contact Kevin Baker by e-mailing:
training@idc-online.com

IDC TECHNOLOGIES
Worldwide Offices

AUSTRALIA
Telephone: 1300 138 522 • Facsimile: 1300 138 533

West Coast Office
1031 Wellington Street, West Perth, WA 6005
PO Box 1093, West Perth, WA 6872

East Coast Office
PO Box 1750, North Sydney, NSW 2059

CANADA
Toll Free Telephone: 1800 324 4244 • Toll Free Facsimile: 1800 434 4045
Suite 402, 814 Richards Street, Vancouver, NC V6B 3A7

INDIA
Telephone : +91 444 208 9353
35 4th Street, Kumaran Colony, Vadapalani, Chennai 600026

IRELAND
Telephone : +353 1 473 3190 • Facsimile: +353 1 473 3191
Caoran, Baile na hAbhann, Co. Galway

MALAYSIA
Telephone: +60 3 5192 3800 • Facsimile: +60 3 5192 3801
26 Jalan Kota Raja E27/E, Hicom Town Center
Seksyen 27, 40400 Shah Alam, Selangor

NEW ZEALAND
Telephone: +64 9 263 4759 • Facsimile: +64 9 262 2304
Parkview Towers, 28 Davies Avenue, Manukau City
PO Box 76-142, Manukau City

POLAND
Telephone: +48 12 6304 746 • Facsimile: +48 12 6304 750
ul. Krakowska 50, 30-083 Balice, Krakow

SINGAPORE
Telephone: +65 6224 6298 • Facsimile: + 65 6224 7922
100 Eu Tong Sen Street, #04-11 Pearl's Centre, Singapore 059812

SOUTH AFRICA
Telephone: +27 87 751 4294 or +27 79 629 5706 • Facsimile: +27 11 312 2150
68 Pretorius Street, President Park, Midrand
PO Box 389, Halfway House 1685

UNITED KINGDOM
Telephone: +44 20 8335 4014 • Facsimile: +44 20 8335 4120
Suite 18, Fitzroy House, Lynwood Drive, Worcester Park, Surrey KT4 7AT

UNITED STATES
Toll Free Telephone: 1800 324 4244 • Toll Free Facsimile: 1800 434 4045
5715 Will Clayton #6175, Humble, TX 77338, USA

Website: www.idc-online.com
Email: idc@idc-online.com

Technology Training that Works

Presents

Advanced Process Control

for Engineers and Technicians

Revision 3

Website: www.idc-online.com
E-mail: idc@idc-online.com

IDC Technologies Pty Ltd
PO Box 1093, West Perth, Western Australia 6872
Offices in Australia, New Zealand, Singapore, United Kingdom, Ireland, Malaysia, Poland, United States of America, Canada, South Africa and India

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Trademarks

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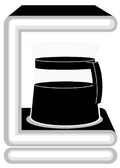
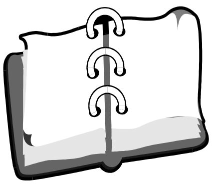
Advanced Process Control

Welcome!

- Please take a seat where you feel comfortable



Help yourself to coffee or tea



Please fill in the questionnaire in the front of your manual

Workshop will start at 8:30

IDC Profile

- International Training & Consulting Company in Industrial Engineering.
- Emphasis on Industrial Areas.
- Approx. 45 Employees & Associates Worldwide.

IDC Profile

- Operations in:
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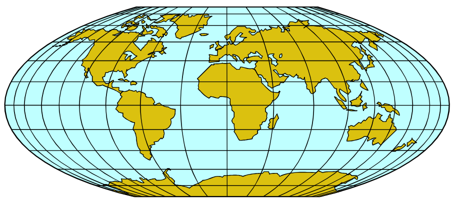

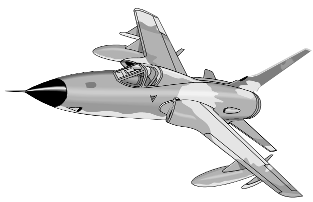

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- Instrumentation, Automation and Process Control
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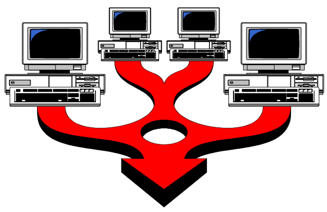


Technology Training that works

The Lecturer

- Who am I?
- What is my background?
- Am I contactable after this workshop?

Technology Training that works

The Workshop

- Timetable
- Format of Workshop
- The Manual
- Practical Exercises and Demonstration
- Computers & Software
- Lunch
- Amenities

The Workshop

- This workshop is for you!
- Interaction with you is important.
- Ask any question - don't be intimidated by your peers.

Technology Training that works

Objectives

- Understand the essentials of advanced process control (APC)
- Grasp the key differences between the various technologies
- Perform simple APC design strategies and implementations
- Be able to perform simple PID control
- Troubleshoot simple APC problems
- Identify processes suited to APC

Program

- Justification
- Fundamentals of Process Control
- Fundamentals of tuning PID loops
- Internal Model control (IMC)
- Model Predictive control (MPC)
  - Introduction
  - Representations
  - Identification
  - Observers
  - Control
- Reference Models
- Control formulation problem
- MPC Steady State optimisation
- Application of theory

Module 1

Advanced Control : Economic Justification

Advanced Process Control (APC)

Advanced control is one of the most important ways in which the production situation can be improved, and model-based control offers a very direct and feasible solution for an appropriate operation.

Advanced Process Control (APC)

Advance Process Control system consist of three components :

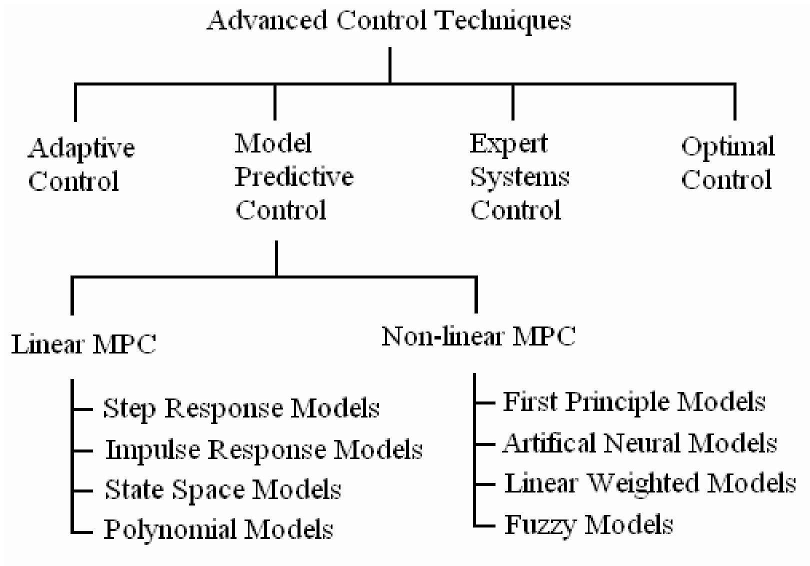
- a computer-simulation model that integrates process knowledge and historical data,
- control and optimization algorithms, and
- current, real-time process information.

APC relates manipulated variables and control variables, provides multivariate control, and also provides adaptive tuning and predictive/ process diagnostics.

Advanced Process Control (APC)

APC is often used for solving multivariable control problems or discrete control problem. APC is composed of different process control tools like :

- Model Predictive Control (MPC)
- Statistical Process Control (SPC) techniques
- Fault detection and classification
- Sensor control
- Feedback Systems



Advanced Process Control (APC)

Normally an APC system is connected to a DCS. The APC application calculates moves that are send to regulatory controllers.

Historically the interfaces between DCS and APC systems were dedicated software interfaces.

Nowadays the communication protocol between these system is managed via the industry standard OPC protocol.

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APC v/s Classical Control

APC is an intelligent and active software layer that sits above the classical regulatory control layer or the DCS in a traditional automation hierarchy.

Regulatory control primarily maintains desired unit measurements such as mass and heat balances. It does not continuously improve the process, but rather ensures that the hardware components within the system are not exceeding known process, equipment and safety limits.

APC v/s Classical Control

In contrast, APC is designed to reducechangeability of key variables and continuously adjust the process to guarantee the desired end result.

APC software solutions are developed by building a mathematical model of the process. Since many variables can affect a single process, a key part of developing an APC model is identifying and understanding the multiple critical variables that affect the desired end result.

APC v/s Classical Control

The model is built using all available knowledge of the process including human operators' knowledge, operating data, and any known scientific principles, such as First Principle equations.

The same process also identifies and explains the critical sources of variability. As described, the basic procedure of creating an APC solution delivers fundamental Process understanding.

The process model itself can be used in an off-line supervisory mode or an on-line measurement and control mode.

APC v/s Classical Control

In an off-line mode, a model-based APC solution can identify the best operating parameters to achieve desired outcomes.

It can also be used on-line as a software-based analyzer to help provide and predict online quality or performance measurements.

Software process analyzers provide more frequent, robust and often more cost effective measurements than are available from traditional laboratory Information systems.

APC v/s Classical Control

This software analyzer allows an operator to monitor the real-time feedback and predictions of future process performance, and make manual adjustments to ensure desired end quality.

The same model-based solution can be deployed online to provide real-time control and optimization.

The APC solution continuously monitors key process variables, predicts outcomes based on the established model of the process, feeds the real-time and predicted data back into the model, simulates the impact on the plant's objectives and then issues commands back to the DCS to make changes to key variables that are driving results.

APC v/s Classical Control

APC improves management and the optimization of a plant operation in four main areas:

(1) Enhanced ability to determine product quality in real-time, on-site without waiting for a lab sample or an end-of-the-run analysis.

(2) Improved operations stability and consistency.

(3) Ability to push process constraints.

(4) Increased operational efficiency.

APC's value and effectiveness have been demonstrated in petroleum, refinining food, paper and other sectors.

APCs : Benefits

APCs are recognized as best practices and proven investment opportunity typically offering 3 to 9 month payback and operational benefits :

- Increased capacity and increased production of preferred/profitable products by 3% to 5%.
- Tighter control of important product quality or operational variables (>50% reduction in variance).
- Increased recovery or operational efficiency, process optimization by 2% to 4% or more.
- Reduced energy per unit feed or product (>3%).
- Improved stability and increased operating reliability in response to process upsets.

Justification of Advanced Process Controls (APCs)

- Justification for implementing APCs comes from improved performance, because they stabilize operations.
- APCs remember different operating scenarios, resulting in no operator errors.
- With adaptive control, existing control model can be updated. E.g., if you're are using PID tuner, then you could develop new tuning parameters.
- With predictive control, time delays can be handled more effectively to optimize throughput and reduce waste.

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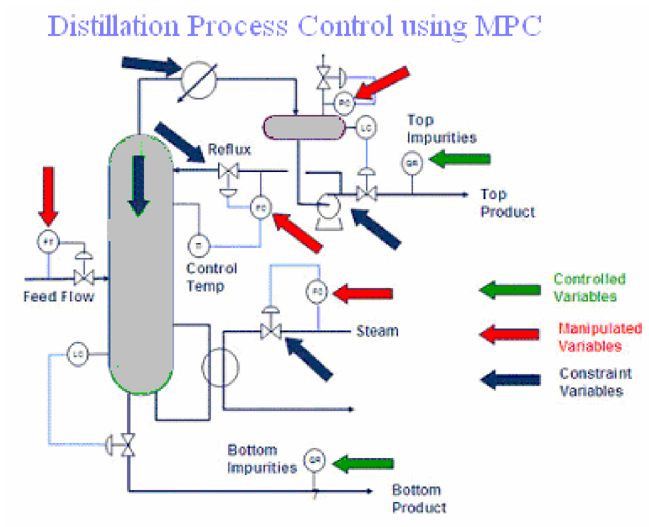
Justification of Advanced Process Controls (APCs)

➢APC is a software layer in a plant automation system above the primary controls that is responsible for maintaining operations within the desired limits or at desired targets, stable operations after process upsets, coordination of operating changes, and with a continuous drive for improved basic economics.

Example-1 : Application of APC in Distillation Process



Example-1 : Application of APC in Distillation Process

- The distillation process is a classic multivariable problem with control variables, manipulated variables and constraint variables.
- Using model predictive control, the column can be controlled and operated as a unit instead of a collection of loops.
- In addition to reduced operator load, the process engineer identified 400 lb/hour savings in steam on one of the columns and 900 lb/hr on the column where Distillation Optimizer application was implemented.
- With a cost for 135 psi steam of $5 per klb, this translates into energy savings of more than $50,000 USD for these particular columns.
- This savings adds up as all of the distillation columns on site are converted over from multi-loop control to MPC-based control.
- Steam reductions are a result of lower reflux flows that have been reduced by about 20%. While this change increases the average overhead impurities as is expected, it is well within specifications.
- Beyond better performance and increased efficiency, the best measure of the success to date has been operators leaving the MPC control on more than 90% of the time.

Example-2 : APC Application in Food industry

- Fonterra Co-op. Dairy ingredients Group, implemented APC at its facilities in 1995, to improve processing efficiency for milk proteins, powders, cheese and casein.
- The company realized an ROI of over 60%.
- Production rates improve by 5 to 15%.
- Its product quality by 50%, energy efficiency by 5 to 12%, while product yields increased and variability fell, for all key control variables.
- As a result of the performance gains, the company has installed APC at many of its 23 New Zealand-based operations and Fonterra's majority-controlled overseas joint ventures.

- Let us consider one specific implementation, a milk powder plant making nutritional, whole milk and skim milk powders. The plant has two evaporators and one spray dryer with the two falling-film evaporators feeding a Niro atomizing spray dryer processing 6.5 to 9 tons per hour.

Example-2 : APC Application in Food industry

- The evaporators concentrate the milk to approximately 50% total solids (TS), with each evaporator using two effects.
- There is Mechanical Vapor Recompression (MVR) on the first effect and Thermal Vapor Recompression (TVR) on the second effect.
- After passing through the evaporators, the concentrate is dried in the dryer chamber and then in the static fluid bed (SFB) and the two vibrating fluid beds (VFB's).
- The final moisture specification limit is typically set between 2.5-3.5%.

- The APC project was implemented in two phases.
- In the first phase, Fonterra's on-line grading analysis system was installed to allow In-Process Testing (IPT) results to be measured and reported statistically. This allows operators to view product composition results relative to product specifications and budget goals. The on-line grading analysis system also provides a means to interface IPT results to control applications.

Example-2 : APC Application in Food industry

- In the second phase, an APC application was developed to minimize process variability by compensating for disturbances, with the intention of creating a performance-driven, "obedient" plant. Multivariable predictive control software was used to implement the evaporator and dryer application.

- In addition, as part of the implementation, a software-based analyzer was deployed to predict moisture for continuous feedback to the control application. A wealth of historical data for dryer's wide product mix allowed a model to be created that reflected moisture ranges for a variety of products with a high degree of accuracy. The analyzer was enhanced by installing an application that biased the prediction hourly with IPT data from the online grading analysis system.

Example-2 : APC Application in Food industry

- Control applications were developed for each evaporator feeding the dryer with the goal of reducing total solids (TS) variability by 50%. An audit conducted that demonstrated that the APC solution had exceeded this objective, reducing the variation by approximately 73% for Evaporator 1 and 68% for Evaporator 2.

- The reduction in standard deviation of evaporator total solids will allow operations to increase total solids targets in the evaporators without violating viscosity limits. This allows increased water removal in the more thermally efficient evaporators. A higher concentrate total solids additionally allows increased dryer throughput. A 0.5% increase in total solids from the evaporators could lead to a 2% increase in dryer throughput.

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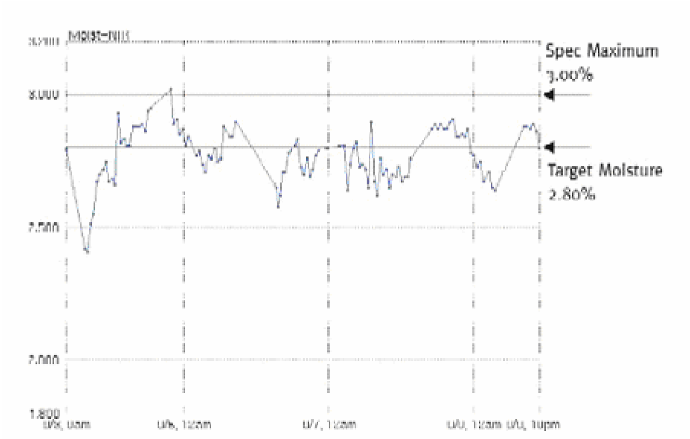
Example-2 : APC Application in Food industry – reduction in Moisture Variability



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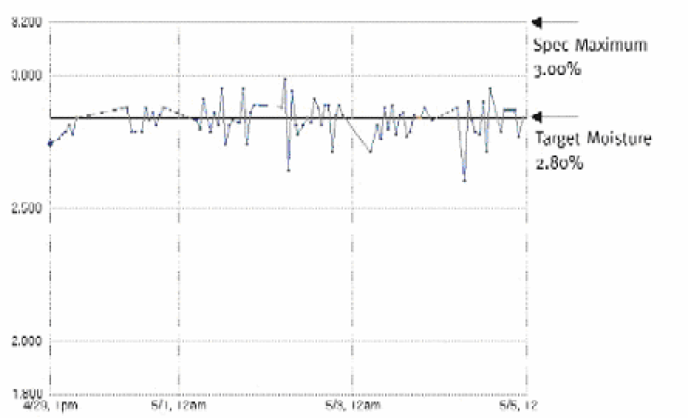
Example-2 : APC Application in Food industry – reduction in Moisture Variability



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