Computing and Systems Technology Division Communications

Volume 10, Number 1, April 1987

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About This Issue

Peter R. Rony and Joseph D. Wright

This issue inaugurates an important experiment in communications with CAST Division members: the publication of all of the Call for Papers for a national AIChE meeting in one place. This is one consequence of revised procedures for national meetings that are discussed in greater detail in Chairman Jeff Siirola's column, "Changes, Changes, Changes." It is our suspicion that in the past these more detailed announcements tended to be sent only to academics.

Other important changes should also be noted. The By-Laws amendment for the creation of a Computing Practice Award passed. To quote from Jeff Siirola's letter to members, "The new award would be called the *Computing Practice Award* and is intended to honor an outstanding effort that resulted in a specific embodiment or possibly an industrial or commercial application of computing and systems technology. The new award would consist of $1000 and a plaque. Although not restricted in any way, it is expected that many of the nominees would be from the industrial community."

The proposed addition of a fourth area committee, Area 10d–Applied Mathematics and Numerical Analysis, was presented by the Programming Board to the CAST Executive Committee in October 1986. The proposal stated: "The CAST Division has, since its inception, limited itself to three programming committees (10A, 10B, and 10C) with the themes Systems and Process Design, Systems and Process Control, and Management and Information Processing, respectively. The Design area has included within its purview not only computer-aided design, process modeling, and process simulation, but also applied mathematics and numerical analysis. Since the latter subjects are represented by a strong and independent research community, it is proposed that a fourth area committee be created. It would be labelled 10D and entitled 'Applied Mathematics and Numerical Analysis.' Furthermore, to reflect the growing concern with computer-aided process operations, it is proposed that the title of area 10C be changed to Operations and Information Processing."

The proposal continued: "A review of both the AIChE and the CAST Division By-Laws indicates that creation of a new area committee is at the discretion of the Division. Coordination with the EBPC is required to ensure that duplication in areas between different groups is avoided. This has been confirmed in consultation with the current Chairman of the EBPC. The CAST By-Laws do not explicitly name the three area committees, hence a new area can be created without a By-Laws change. Finally, in the absence of specific rules defined for programming areas, and assuming that creation of an area committee should follow the same rules as apply to the formation of a new section within the Division, it appears that approval of the creation of a new area requires a 2/3 vote of the Executive Committee of the Division (Article IV, Section 8)." At the Executive Committee Meeting on November 3, 1986, in Miami Beach, Florida, it was moved, seconded, and passed that a new area 10D be formed as proposed by Rex Reklaitis and the Programming Board.

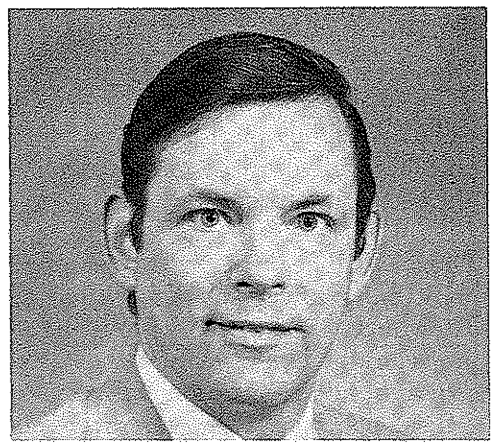
The editors wish to present members of the CAST Division some data concerning the publication cost of this newsletter. As calculated by CAST Division Treasurer Herb Britt, the total cost of the newsletter (printing, mailing labels, and postage) divided by the total number of pages printed was as follows for the last three issues:

Fall 1985	$ 0.0461 per page	(28-page issue)
Spring 1986	$ 0.0451 per page	(32-page issue)
Fall 1986	$ 0.0411 per page	(40-page issue)

The total costs for these three newsletters was $2709.07, $3133.94, and $3620.91. The cost increases were due entirely to the number of pages in the newsletter, not escalating charges.

Chairman's Message: Changes, Changes, Changes

Jeffrey J. Siirola, Eastman Kodak Co.



As many of you have probably read or heard, AIChE Council in Miami last November adopted a number of experimental changes related to meeting programs, schedules, abstracts, microfiche, and other matters. The immediately most obvious of these will be, starting with the Minneapolis meeting, the elimination of the 50-word abstracts from the meeting program booklet, which will now contain for each session only authors, affiliations and paper titles. However, as a new feature, the extended (about one page) abstracts usually prepared by authors for preliminary consideration by session chairmen will be collected, bound, and distributed to all registrants at the meeting. This change was motivated in part by a desire to control production and postage costs, and although it will result in less advance information with which to justify meeting attendance, members may be inundated once they arrive.

In another change, authors will no longer be required to submit manuscripts months in advance to New York to enable the preparation of microfiche, or failing that deadline to bring hundreds of copies for distribution at the meeting. Instead, each author will bring or send one copy to the meeting site before the beginning of the meeting from which hardcopies will be prepared for attendees on demand. Only after the meeting will microfiche be prepared and available by mail from New York (and hopefully will be more complete and better organized).

There will be other changes that principally affect speakers, such as allowance of the use of overhead projectors and rescission of the AIChE copyright and publication right of first refusal policies. However, probably the most significant effect of the abstract and manuscript changes will be a dramatic shortening of the schedule for meeting program development. Elimination of the abstract galley proofreading cycle and the pre-meeting preparation of microfiche now means that session chairmen need not finalize their programs until five months before the meeting, half the time presently required.

This schedule compression would seem to be generally beneficial. The results presented in papers are likely to be more timely, and the more widely disseminated extended abstract ought to reflect closely the actual presentation. With the elimination of galley proofreading and manuscript collection, the session chairmen's job also ought to be a little easier. And CAST Communications is going to try to help even more.

For some time, CAST Communications has been listing future session titles and chairmen. Because of the new schedule, it is now feasible to publish the calls for papers containing more specific information for sessions upcoming in twelve months. Some of you may have received such calls in mailings from the individual chairmen in the past. The hope now is that all of the calls will reach all of the membership. So, elsewhere in this issue you will find solicitations for sessions at the 1988 Spring Meeting in New Orleans. Look them over, and if you are working on something that might fit in, give the session chairman a call.

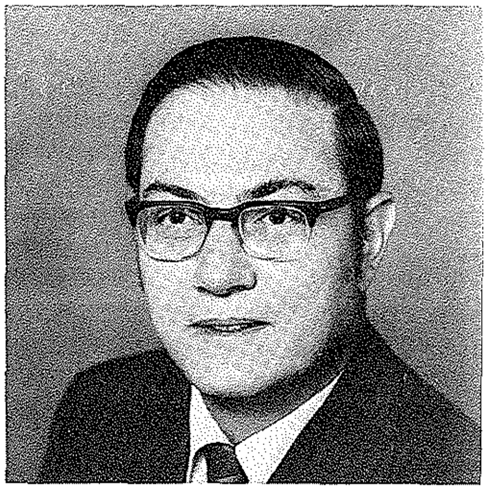
And if you think of a way that CAST or CAST Communications might serve you better, give us a call too.

Introduction to "A Personal Perspective on Computing"

by Peter R. Rony

David M. Himmelblau, the Recipient of the 1986 CAST Computing in Chemical Engineering Award, gave a delightful and witty award address at the CAST Division Awards Dinner on Tuesday, November 4, 1986, in Miami Beach. Those in attendance will likely remember the talk for years. We tried to provide a flavor of the visual quality of his address by obtaining copyright permission to publish some of the cartoons used, but were not successful in tracking down more than two of them. Your editor, who took notes during the address, feels that the subtitle, "The Wisdom of David Himmelblau," is appropriate, as you will observe. The text of the address is published in CAST Communications as a series of quotes, laws, myths, and observations.

A description of Professor Himmelblau's educational background and accomplishments appeared in the September 1986 (**9**, No. 2) issue of CAST Communications.



A Personal Perspective on Computing

by David M. Himmelblau, University o[f] Texas

"The Surgeon General has determine[d] that listening to this talk could disrup[t] your sober business sense and lead t[o] long-term career damage."
. . . David M. Himmelblau

"A foot in the door is worth two on th[e] desk."
. . . anonymous

Hebditch's Second Law: Th[e] number of problems encountere[d] during and after implementation i[s] directly proportional to n square[d] where n is the number of supplier[s] involved in the system.

Term	Definition
Analyst	Opposite of catalyst; i.e., a person not taking part in a process who impedes it.
Bug	An elusive creature living in a computer program that causes the program to yield incorrect results.
Debugging	Removing bugs from a program.
Design	What you regret not doing, in retrospect.
Hardware	The parts of a computer that can be hit.
Machine-independent program	A computer program that will not run on any machine.
Software	The elements of a computer that cannot be hit.

Table 1: Glossary of Terms
Courtesy D. Himmelblau

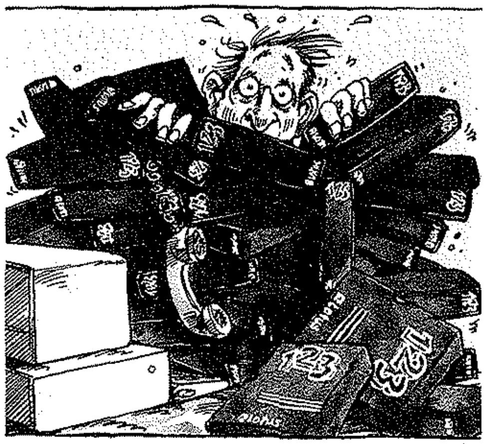
Hebditch's Third Law: The ideal terminal for your system is the one that has just been announced but is not available for delivery.

Corollary: Any working terminal is obsolete.

1.	Use of computers always makes your work easier.
2.	Computers will result in a "paperless" office.
3.	"100% compatibility"
4.	"User friendly"

Table 3. Computing Myths.
Courtesy D. Himmelblau

Reciprocal Law of Computing: 1. Old software never runs on a new



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system. 2. Old software never runs on an old system.

"The curse of the low serial number: People who do great leaps forward tend to land at the bottom of great pits."
. . . David M. Himmelblau

Murphy's Eighth Corollary: It is impossible to make anything foolproof because fools are so ingenious.

Third Law of Computer Programming: If a program is useful, it will have to be changed.

1.	Osborne 1
2.	Commodore PET
3.	TRS-80 Model 1
4.	DEC Rainbow
5.	Apple III
6.	IBM Portable
7.	IBM PCjr.
8.	Apple Lisa
9.	TI 99-4A
10.	KAYPRO II

Table 4: Ten Personal Computers You Can No Longer Buy. Courtesy D. Himmelblau

1.	Artificial intelligence-based applications
2.	Parallel processing
3.	Transparent use
4.	Access to thousands of megabytes of data

Table 5. The Future.
Courtesy of D. Himmelblau.

Fourth Law of Computer Programming: If a program is useless, it will have to be documented.

Fifth Law of Computer Programming: Any given program will expand to fill all available memory.

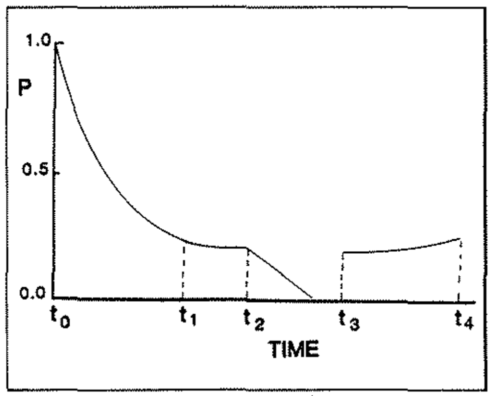


Figure 1. Probability of existence of bugs in a given piece of software versus time. Software desperation (t_0 to t_2). Software consultants employed (t_2 to t_3). Software placed into use (t_3). Software abandoned (t_4).

Troutman's Fifth Programming Postulate: If the input editor has been designed to reject all bad input, an ingenious idiot will discover a method to get bad data past it.

Troutman's Sixth Programming Postulate: Profanity is the one language all programmer's know best.

Finagle's Third Law: In any collection of data, the figure most

Computer	Avg. monthly Rental (1960 $)	Max. core storage cap. (1000 bits)	Addition time (microsec)	Read time, (cards per minute)
IBM-CPC (195x)	700	0.260	Executed one	card at time as fed
IBM 650	9000	4 (drum)	700	250
IBM 7090	55000	160	0.004	250
CDC-1604	34000	32	0.005	1300
DED PDP1	2200	4	0.010	tape input

Table 2. Computers I have known (in 1960 dollars).
Courtesy D. Himmelblau

obviously correct, beyond all need of checking, is the mistake.

Corollaries: 1. No one whom you ask for help will see it. 2. Everyone who stops by with unsought advice will see it immediately.

Lubarsky's Law of Cybernetic Entomology: There's always one more bug.

Troutman's Second Programming Postulate: Not until a program has been in production for at least six months will the most harmful error be discovered.

"With artificial intelligence, the danger is that men will be thinking like computers."
... David M. Himmelblau

"If artificial intelligence (AI) exists, there must also be artificial stupidity (AS)."
... D. M. Himmelblau

"Artificial stupidity (AS): getting people to do what computers do better."
... D. M. Himmelblau

"With parallel processing, we can get confused three times faster!"
... (cartoon caption)

"You want to try it . . . Before you buy it."
... (cartoon in advertisement)

"Already my computer is outmoded, but I try to tell myself that my computer isn't me."
... New Yorker cartoon

Introduction to "Effective Utilization of Parallel Vector Processors"

by Mark Stadtherr, University of Illinois at Urbana-Champaign

At the recent AIChE Annual Meeting in Miami Beach (November 1986) a two-part symposium on the "Impact of Advanced Computer Architectures in Chemical Engineering Computing" was held. At this symposium, two "overview" papers were presented. The first of these, by Vegeais et al., concentrated primarily on computer architectures and was published in the December 1986 issue of Chemical Engineering Progress. The second such paper, by John M. Levesque, concentrated primarily on performance and programming issues, and is presented here.

Effective Utilization of Parallel Vector Processors

John M. Levesque, Vice President of Computer Sciences, Pacific-Sierra Research Corporation

Ten years ago the first CRAY-1 computer was delivered to Los Alamos Scientific Laboratories and with that delivery, a viable general purpose vector processor was introduced to the scientific community. The need for such a machine was obvious: scalar processing was limited by the speed of the circuitry and that speed had only been reduced by a factor of two over the previous eight years. Other attempts at parallel and vector processing had been failures. The ILLIAC IV, a parallel computer where each of its 64 processors had to perform the same operation at the same time was doomed primarily due to its inability to perform scalar operations well. The STAR 100, a vector processor built by Control Data Corporation also had the same problem, its scalar processing speed was only a fourth of the fastest scalar machine, at that time the CDC 7600. The CRAY was successful because its scalar speed was twice as fast as the CDC 7600. Although its vector speed was slower than either the ILLIAC IV or the STAR 100, th balance between vector and scalar speed on the CRAY-1 was the main reason for its tremendous success.

The reason for the failure of the ILLIAC IV and STAR 100 and the success of the CRAY-1, is a lesson that must be learned by computer manufacturers and users. The reason was formulated by Gene Amdahl long before the advent of the CRAY-1 and is known today as AMDAHL's LAW. AMDAHL's LAW is quite trivial if one thinks about the time required to execute a program on a machine that has two different processing speeds. The time required to execute a program on a vector processor is:

$$TIME = FV*TV + (1-FV)*TS \quad (1)$$

where:

FV = The fraction of code which can use vector operations.

TV = The time required to perform operations in vector mode.

TS = The time required to perform operations in scalar mode

If one uses this relationship to analyze the comparison between the machines, the problem which faced the STAR and ILLIAC IV is very clear. The following is a table of the relative speeds of the four machines.

MACHINE	SCALAR SPEED	VECTOR SPEED
CDC 7600	1	1
ILLIAC IV	0.25	16
STAR 100	0.25	20
CRAY-1	2	10

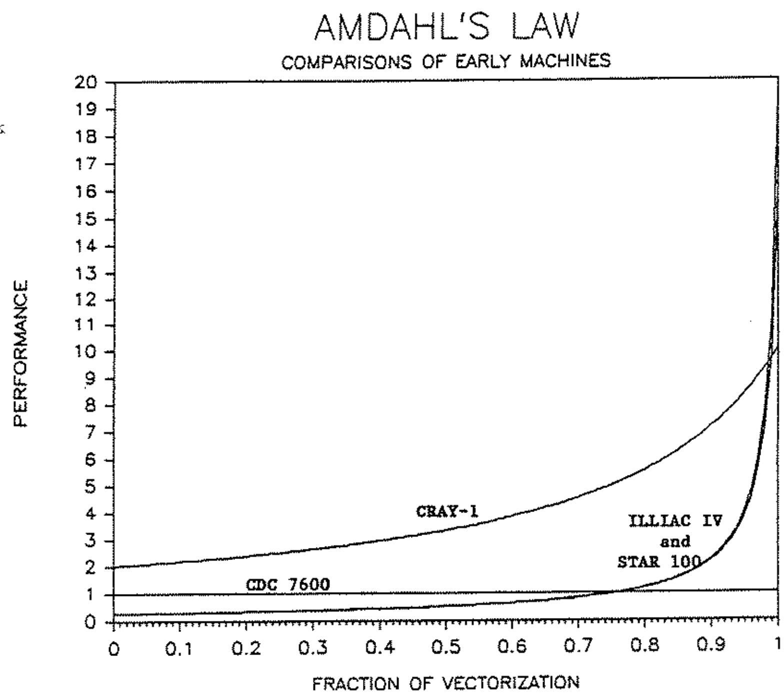
Using equation (1) to calculate the performance gain over the CDC 7600, one obtains Graph 1, which gives the performance gain as a function of the amount of code vectorized or parallelized.

On the ILLIAC IV and the STAR 100, performance gains greater than the CDC 7600 were only attainable if a significant portion of the code (76-78%) could utilize the vector or parallel capabilities of the machine. The CRAY-1 out-performed the CDC 7600 irrespective of the percent of vectorization. For this reason scientific installations all over the world acquired CRAYs and soon were learning how to restructure their Fortran programs in order to achieve additional performance gains on the CRAY-1.

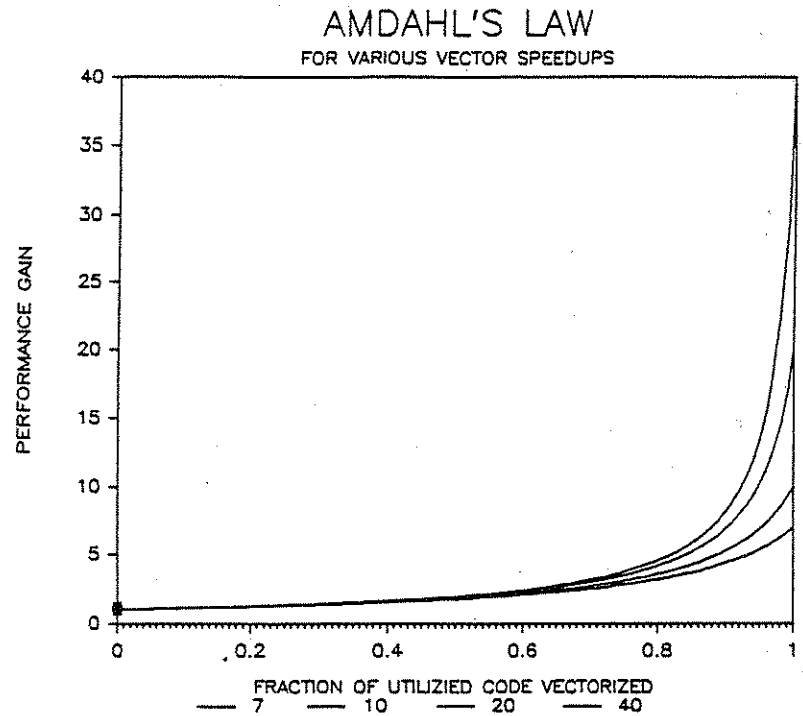
Today we still have limitations on scalar speed and we see definite limitations on vector speed for the same reason high vector speeds on the STAR 100 were ineffective. The Japanese machines from FUJITSU, HITACHI and NEC, as well as the new machines from ETA, have or will have much larger vector speeds than the CRAY X-MP; however, the value of these higher speeds is very questionable. Consider Graph 2, which shows the effect of vector performance as a function of fraction of vectorization. The higher vector speeds are of no advantage unless the code is able to utilize vector operations over 75% of the time. This result is supported by benchmarking the three FUJITSU machines: the VP100, VP200 and VP400. As the model numbers indicate, the VP200's vector speed is twice as fast as the VP100 and the VP400 is another factor of two over the VP200. The scalar performance on all the machines are the same. A large general purpose code, for instance NASTRAN, would show very little gain in going from the VP100 to the VP400 for obvious reasons–most of the code uses scalar operations.

Today we have the advent of parallel processing. The extent of the parallelism varies from two on the CRAY X-MP/24 to 2048 on some of the hypercubes. Table 1 gives important characteristics of some of the significant parallel processors.

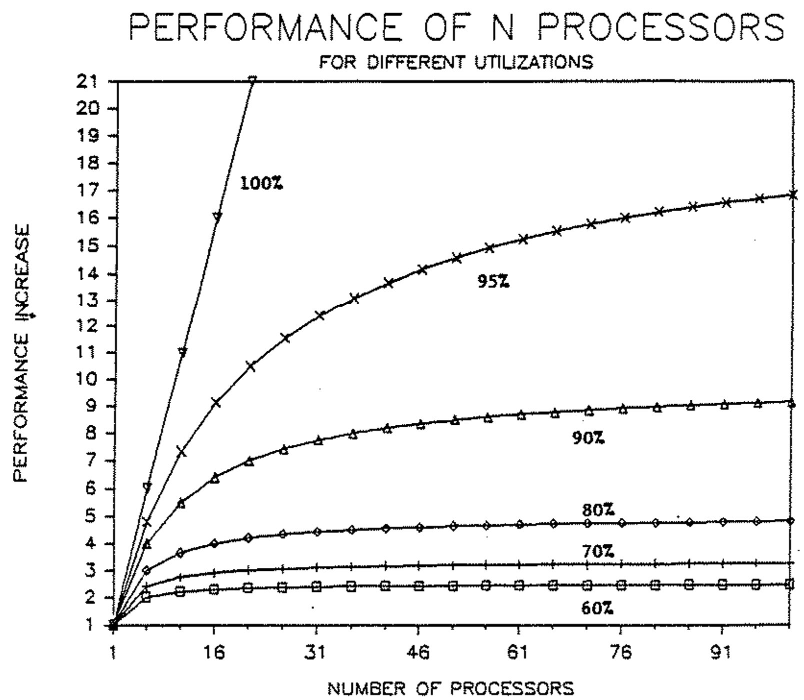
Before we extend AMDAHL's LAW to parallel processing, it is important to understand what parallel processing is and the advantages it offers. Unlike the ILLIAC IV, these parallel processors can perform different calculations (or operations) at the same time. Within the MIMD (Multiple Instruction, Multiple Data) stream group of parallel processors, one has many variations. First, we have MIMD machines that share memory, for example the CRAYs, ETA, IBM, and ALLIANT machines. Then we have the machines that must each have its own local memory and communicate between the processors whenever sharing of data is necessary. The MIMD machines that must communicate for sharing data are more difficult to use for general scientific processing. Without exception all of the machines listed that have large numbers of processors (>16) have no shared memory and therefore the utility of these systems on examples such as the ones in this paper is questionable. Given the ability to perform different operations at the same time, one can obtain performance gains in more instances on a parallel processor than on a vector processor if the overhead for initiating and synchronizing the parallel tasks is small. This overhead can be for task initiation or communicating between processors. Communication can be quite significant on MIMD machines, which don't share a common memory. The amount of overhead affects the granularity (size) of a task which can be efficiently performed in parallel. If this overhead is on the order of microseconds, the size of the task should be much larger. In this way the overall performance is not degraded by the overhead. With this caveat, consider some of the following



(GRAPH 1)



(Graph 2)



(Graph 3)

Processor	Max Speed of Single Processor	Scalar Speed MFLOPS	Max # Proc	Shared Memory Size	Local Memory Size	Overhead for Task Initializing Synchronizing	Overhead for Communication
CRAY X-MP	210 MFLOPS	20	4	8 x 10^6	–	multitasking 10^{-3} sec. microtasking 10^{-3} sec.	–
CRAY 2	240 MFLOPS	20	4	256 x 10^6	0.016 x 10^6	" " "	–
GF 10	800 MFLOPS	20	8	256 x 10^6	4 x 10^6	(similar to CRAY?)	–
IBM 3090	108 MFLOPS	10		8 x 10^6	–	(similar to CRAY?)	–
INTEL Hypercube	<< 1 MFLOPS	<< 1	1024	–	<< 1 x 10^6	?	large
BB&N	<< 1 MFLOPS	<< 1	1024	–	<< 1 x 10^6	?	large
FX/8	12 MFLOPS	4	8	8 x 10^6	–	order of clock cycle	

Table 1: Characteristics of Some Parallel Processors

examples where parallel or concurrent processing can out-perform vector processing.

Whenever a function or subroutine call appears in a Fortran DO loop, all present compilers for vector processors inhibit vectorization of the DO loop. On a parallel processor one should be able to direct the compiler to generate code that calls the function or subroutine concurrently. That is, each processor can independently call the routine. Of course, there are examples where this can't be done. For instance, if local variables in the called subroutine carry values from one iteration of the DO loop to the next, concurrent processing is not possible unless the code is restructured. Consider the following DO loop. It could be called concurrently, thus achieving an increase in speed proportionately to the number of processors or, if N is less than the number of processors, an increase in speed equal to N (assuming zero overhead).

```
     DO 100 I = 1,N
     X(I) = SQRT(ABS(Y(I)**2 + Z(I)**2))
     ZT = PI*X(I) + COS(A(I))
     CALL SSUB(X(I),ZT,TY(I),TZ(I))
     TX(I) = ABS(TZ(I))
100  CONTINUE
     ...

     SUBROUTINE SSUB (Y1,Y2,Y3,Y4)
     Y4 = Y1**2 + ALOG(ABS(Y1 + Y2)*
     EXP(Y1-Y2)
     Y3 = Y1 + Y2
     RETURN
     END
```

Other examples that tend to be very difficult to vectorize are cases where the logical path through the code is quite convoluted and difficult to predict. For example, whenever one has very complex decision processes, like those that are typical of Monte Carlo simulation, vector processors have always had a very difficult time organizing enough similar calculations for a vector operation. Parallel processors with low overhead and shared local memory have a simple time optimizing such an example. Each processor simply takes an independent iteration of the DO loop and whoever is finished first takes the next available iteration of the DO loop. The following are two examples which can be performed in parallel very easily. In the first example each pass through the DO loop may execute a different branch. Some passes may not do any work at all. On a vector processor there are several ways of doing the calculations in vector mode; however, none is as trivial or rewarding as on a parallel processor. Each processor initially takes a pass through the loop; those processors which do not do any work will quickly be available for subsequent passes through the loop.

```
     DO 100 I = 1,N
     IF(A(I).EQ.0) GOTO 100
     IF(ABS(A(I)).LT.EPS) GOTO 50
     B(I) = SQRT(C(I)**2 + D(I)**2)
     GOTO 100
50   B(I) = SQRT(C(I)**2-D(I)**2)
     B(I) = SIN(B(I)-A(I))
100  CONTINUE
```

The next example is a little more difficult for vector processors. This is an example of a randomly-spaced table look-up. On a vector processor one must first perform the look-up for all values of I, then gather up the table entries for the linear interpolation and finally perform the interpolation for all values of I. Once again the parallel processor can simply have each processor take a different pass through the outer DO loop on I. If the processor happens to have a vector facility in each of the processors, the inner loop on LL can be vectorized, thus achieving a larger increase in speed.

```
      DO 100 I = 1,N
      U1 = X2(I)
      DO 120 LL = 1, NTAB
      IF(U1.GT.X1(LL)) GOTO 120
      L = LL
      GOTO 121
120   CONTINUE
      L = NTAB-1
121   Y2(I) = Y1(L-1) + (Y1(L)-Y1(L-1))/1
      (X1(L)-X1(L-1))*(X2(I)-X1(L-1))
100   CONTINUE
```

In order to extend AMDAHL'S LAW to parallel processing, we must define the following quantities:

Ts = the time required to perform an operation on one processor (scalar mode)

Fs = fraction of operations performed in scalar mode

TP = the time required to perform an operation on m processors in scalar mode

OH = the overhead for synchronizing parallel processors

FP = fraction of code able to use m processors

NT = number of disjoint parallel tasks

Then the time to perform N operations is:

$$T = N(Fs\,Ts + \sum_{i=1}^{NT} (TP_i FP_i + OH_i))$$

Normalizing $Ts = 1$ and $TP = 1/m$ processors being used during that task

$$T = N\,(Fs + \sum_{i=1}^{NT} (FP_i/m_i + OH_i))$$

where

$$Fs + \sum_{i=1}^{NT} FP_i = 1$$

and where m_i is the average number of processors used during the i^{th} task.

As we can see, the relationship is much more complex for multiprocessing; however, several important factors can be derived from the equation.

(1) Though difficult to obtain, the upper bound for performance on a parallel processor is the same relationship as for vector processing. (The amount of code that could possibly use parallel processing will be larger than the amount of code to be vectorized.)

(2) If the overhead of initializing a task and/or synchronizing tasks is anywhere close to the size of the task, the performance gain will be lost. Consider using 32 processors on a task of duration 1 second. If the overhead is on the order of 0.1 seconds, the time for the task will be 1/32 + 0.1, or about 0.13, for an overall speedup of about 8.

(3) The most important fact that can be derived from this relationship is that the time spent using 1 processor has a dramatic effect on the overall run time. For example, if we only spend 1 percent of the overall time using one processor, the maximum speedup we can get over the performance of that one processor is 100 even if we have 2048 processors.

Rather than examining the effect of the percent of optimization in the usual way, let's look at the effectiveness of n processors on programs which can utilize those processors to different degrees.

In Graph 3, we plot the performance gain vs. the number of processors for a number of different utilization figures. If one is able to use all the available processors 100% of the time, then the performance curve is linear with the number of processors. The alarming feature of the graph is that for 90% utilization (a very high number for general scientific computing) the maximum number of processors that can be taken advantage of is approximately 20-30. For lower utilization figures, the curve tops out at fewer processors.

This analysis paints a very bleak picture for large arrays of paralle processors as a general computing resource; however, two important fact hold some hope for the future o parallel processing:

(1) Applications such as signa processing, image processing an some finite difference codes, ma be very well suited for paralle processing on a large number c parallel processors–just don' expect dramatic results on th bulk of Fortran in existence toda

(2) In this paper we are onl considering parallelism on the D loop level because today's Fortra is much too difficult for today state-of-the-art compilers optimize (via generation of parall instructions). Acceptance another language, which h parallelism built into it, by tl scientific community, wou definitely increase the utilizati figures by more scientif

programs once they are rewritten with parallelism in mind.

John M. Levesque, Vice President of Computer Science Pacific-Sierra Research Corporation received his Master's Degree in Numerical Analysis from the University of New Mexico, and currently heads a group of 18 computer scientists who specialize in the effective utilization of advanced scientific computers. For the past 15 years, the group has worked on computers ranging from the ILLIAC IV to the latest machines from Cray and Control Data Corporation.

Statistical Process Quality Control in Process Industries

by Victor Zaloom, Ph.D., P.E., Professor & Head of Industrial Engineering, Lamar University

Abstract

Statistical process quality control is defined and a historical overview of its development is presented. Quality and manufacturing productivity for U.S. companies is then compared with that of companies from other nations over the period of time since World War II.

A nine-step model for statistical process quality control training and implementation is then outlined. The model includes a procedure to implement statistical process quality control as a new way to manage. Also included is a course outline for middle management level training.

Historical Perspective

Statistical process quality control is a method of gathering and analyzing data to aid in the control and improvement of a process or system. It involves a meticulous attention to details. Details of interest include but are not limited to: (1) What are the key performance variables for a system, (2) How and when should these variables be measured, (3) What is the accuracy and precision of the measuring system, (4) How should management respond to various levels of the measured variables.

Most of the statistical theory and methods utilizing control were developed in the 1920's by Walter Shewhart. Dr. Shewhart's book: **Economic Control of Quality of Manufactured Product**[1], was first published by D. Van Nostrand in 1931 (see Figure 1).

Other important early contributions to the theory and methods of statistical process quality control were: **Handbook of Quality Control** published by Western Electric Company[2] and the **Quality Control Handbook** edited by Dr. J. Juran[3].

During the 1930's many American companies embraced the methods of statistical process quality control. However, the impact of this management methodology rarely reached the very top levels of an enterprise. Consequently, as production pressures built in the pre-World War II time span, quality control was not widely practiced as a process improvement tool as Shewhart envisioned. The quality effort in many companies was limited to inspection departments or laboratories whose purpose was to simply segregate units not meeting specifications from those which could be shipped. Very elaborate inspection schemes were developed most notably by Dodge and Romig: **Sampling Inspection Tables, Single and Double Sampling**[4]. These statistically based methods were often misinterpreted as being the essence of statistical process quality control.

During the years following World War II, many manufacturing systems in the United States were converted from military hardware production to production of consumer goods. Consumer demand swelled because of the large number of returning military personnel with pay checks to spend. The supply of consumer goods was limited because of the urgency of producing military goods for the war effort. This created a very favorable market position for manufacturers. In this favorable market, quality was not a paramount consideration for most manufacturers. Delivery date, price, or style in many instances were considered more important than quality.

1930's	Dr. Shewhart wrote: "Economic Control of Quality of Manufactured Product."
1940's	Inspection procedures used to "assure" compliance with government requirements.
1950's	Japanese hire Dr. Deming.
1950-present	Quality and productivity in Japan skyrocket.
1980's	N.B.C. White Paper: "If Japan Can Why Can't We."

Figure 1. Historical Perspective on Statistical Process Quality Control

Meanwhile in the 1950's and beyond, Dr. Edwards Deming[7] was working with Japanese manufacturers, effectively developing quality management teams at the highest corporate levels. These teams were busy accomplishing the statistically based management of manufacturing process improvements. Good quality management systems impacting manufacturing and service systems over long periods of time (1950-

present) produced a tremendous cumulative effect.

Quality and Productivity

The results of the productive Japanese efforts in the area of quality and the corresponding lack of productive efforts on the part of manufacturers in the United States is seen in Figure 2.

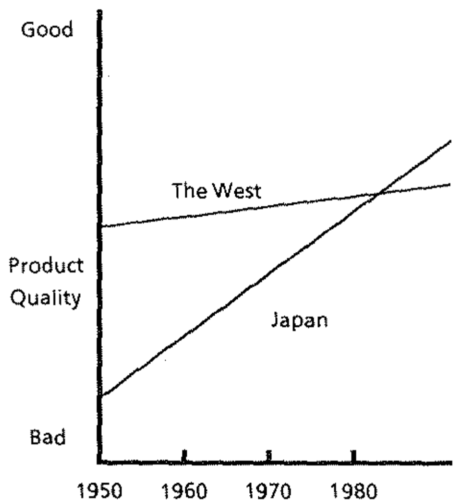


Figure 2. Quality Improvements: A Comparison of Japanese and Western Progress

This figure compares product quality improvements achieved by Japanese and Western manufacturers. According to Juran[5], the quality of products manufactured in Japan surpassed that of Western manufacturers in the 1970's and the gap continues to widen. Figure 3 presents manufacturing productivity data for several industrial nations. The United States is the established world leader. However, manufacturing productivity growth in the United States has lagged that of other Western nations which in turn have lagged Japan. Viewing Figures 2 and 3 together clearly indicates a positive relationship exists between quality improvements and productivity growth.

United States Taken as 100%

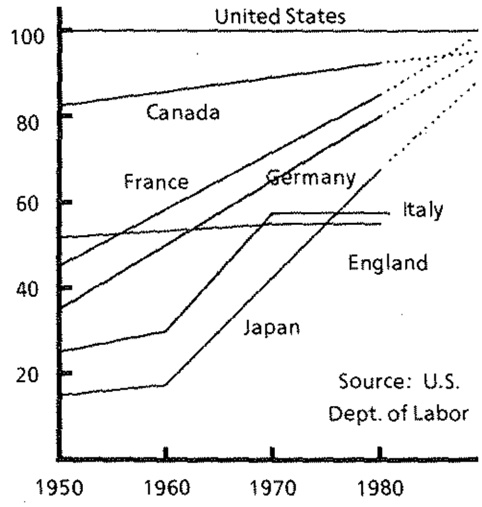


Figure 3. Absolute Manufacturing Productivity

An example of how Japanese productivity growth has followed its quality improvements is their ability to produce high quality compact cars at a significant cost advantage over American manufacturers. Fortune Magazine[6] presents data showing Japanese compact cars with an average manufacturing cost of $3,750 compared to the U.S. manufactured compact car's cost of $5,850. This translates to a 36% cost advantage.

Today thousands of United States companies in both the unit manufacturing and process industries are establishing quality improvement goals and implementing statistical process quality control programs. This renaissance of interest has come about because of tremendous market pressures. In the past ten years, we have made the transition from a national economy, where manufacturing competitors were located in the United States, to a global economy where competition from abroad is the rule rather than the exception. It is estimated that in 1975 United States manufacturers competed with offshore competition in only 20% of their markets. Today we have offshore competitors in approximately 80% of our markets.

The preceding discussion leads to several conclusions:

- Japanese quality and manufacturing productivity have experienced a tremendous growth over the past 30 years.
- The competitive position of United States manufacturers has been severely eroded especially in the past 10 years.
- We must improve both quality and productivity at an explosive rate i we are to maintain competitive i a global economy.
- The way to attain this necessar growth is by focusing on qualit and implementing statistica control of our manufacturin processes.

The next section discusses a nine-st procedure for implementing statistic process quality control as a new way manage an enterprise.

Steps Required to Impleme Statistical Process Quality Contr

The *first step* (see Figure 4.) is recognize a need exists to impro quality and productivity. This c happen because of increasing custom requirements, decreasing share of market, or poor earnings. Forwa looking companies recognize the n before major or permanent damag done to their competitive positi Once the need has been recognized, management must be informed as what to do.

The *second step* required is presentation of training in statist process quality control for management. Top managem training can be general (as oppose industry or company oriented). He specialized course development may not be necessary until training is presented to lower levels of the organization. Initial training should be required for top management before lower levels of the management are trained. Although the need for statistical process quality control may be first recognized by persons at any level of the organization, formal training should begin at the top.

The *third step* required is the commitment of top management. They must be committed to actively participate in implementing statistical process quality control as a means of managing the company. Quality improvement through statistical process quality control cannot be achieved without top management support, commitment and involvement. When top management understands the concepts of statistical process quality control and is committed to its implementation throughout the company, then specialized training for lower levels of management and engineering and technical personnel should be developed.

The *fourth step* is to develop specialized training programs for middle managers, engineers and technical personnel. These programs should be more technical and oriented to the specific industry involved. Industry and/or company data should be utilized in the examples discussed and calculations performed by participants.

The *fifth step* is to train middle managers, engineers and technical personnel. Most training programs at this level of the organization require two to five days to complete. Participants should be presented with numerous "case study" type applications and have the opportunity to gather and utilize data from their own job areas. A typical course outline is presented in Figure 5, which was taken from the continuing education catalog of the American Institute of Chemical Engineers.

The *sixth step* is to provide the tools necessary to permit and encourage implementation of statistical process quality control by those trained in step five. Consulting help, external or internal, should be available when problems arise which go beyond the scope of the training provided. New equipment may be required such as measuring devices, tools, or other data gathering hardware. Software in the form of computer programs or systems and procedures may need to be provided as well.

Step 1.	Recognize the need.
Step 2.	Train top management in Statistical Process Quality Control.
Step 3.	Obtain top management commitment/participation.
Step 4.	Develop specialized training for middle management.
Step 5.	Train middle managers, engineers and technical personnel.
Step 6.	Provide tools necessary and encourage implementation.
Step 7.	Develop "Job Oriented" training for hourly workers.
Step 8.	Train all hourly workers.
Step 9.	Show management commitment by rewarding results.

Figure 4. Steps Required To Implement Statistical Process Quality Control

The *seventh step* is for middle managers, engineers and/or technical personnel to develop "job oriented" training programs for hourly or para-professional employees in their specific work areas. These programs must be hands-on in that participants utilize data with which they normally work with on their job.

Step eight is to train all employees. It is often convenient to utilize company employees to do the training and to train in small segments of time such as two- to four-hour sessions.

Step nine is to show management's commitment to statistical process quality control by publicizing quality and productivity achievements and rewarding those employees actively participating in the new management philosophy.

How The System Works

One of the most common tools of statistical process quality control is the *control chart*. Other tools include but are not limited to: *frequency functions*, *Pareto charts*, *run charts*, *correlation analyses*, *regression analyses*, *experimental design*, and *analysis of variance*. Each of these tools is based on the premise that the value of a measured variable will vary according to a random pattern within a certain range of values. When the measured variables take on values outside their usual range, then we conclude that these variations are not due to the randomness in the production or measuring systems but rather are due to "special" causes.

Statistical methods are used to calculate the limits of the range of values within which the system commonly operates. Therefore when a value or values are obtained which are outside the statistical limits we conclude that the system has been altered. The reason for the altered system state is called a special cause or assignable cause. The special cause might be equipment malfunction, application of new technology, a sudden extreme change in the environment, a change in operating discipline, a new management policy, an employee training program or any other planned or unplanned cause for variation of a measurement or

Statistical Process Quality Control-Management of Quality Improvement in Industry

1. Motivation For Quality
   - A. Management responsibility
   - B. Productivity and competitiveness
   - C. Employee reactions
   - D. Customer reactions
2. Tools Of Statistical Quality Control (SQC)
   - A. A definition of quality
   - B. Charts and diagrams
   - C. An exercise using charts and diagrams
   - D. Some important statistics
   - E. Measures of central tendency
   - F. Measures of variability
   - G. An exercise calculating simple statistics
3. Control Charts For Variables
   - A. The X-bar and R charts
   - B. Calculation of control limits
   - C. Calculation of revised limits
   - D. Process capability analysis
   - E. Working with batch data-reactor control application
   - F. Control charts for individual measurements-continuous operations
   - G. An exercise to develop X-bar and R control charts
   - H. Control charts for batch data
4. Control Charts For Attributes
   - A. The P chart assumptions and calculations
   - B. Example application of P charts–plant maintenance
   - C. An exercise utilizing P charts
   - D. The C chart assumptions and calculations
   - E. An example application of C charts
   - F. An exercise utilizing C charts–molding operation defects
5. Special Process Industry Applications
   - A. Process interference–application to chemical processes
   - B. Measurement system variation–tank car loading
   - C. The control chart as a test of hypothesis
   - D. Type I and type II errors
   - E. The normal distribution
   - F. Test for a normal distribution
   - G. Probability plots
   - H. An example utilizing the normal distribution
6. Management Responsibility for Quality
7. Problems and Pitfalls

Figure 5. Outline of Course Offered Through the American Institute of Chemical Engineers

sequence of measurements outside their prior or natural range of values.

One of the primary reasons for the effectiveness of statistical process quality control methods is their ability to pinpoint exactly when a system change occurred. If operating personnel and engineers are aware of when significant changes in the measurements of a variable occurred, then the cause of such changes is more easily detected and corrected. For example, marked differences in product quality are frequently observed when employee shifts change or when a new raw materials vendor's product goes into use.

Another aid in analyzing system problems and designing improvements is to know where problems occur. The location of a problem could be a specific part of the process such as a reactor or a distillation column. One of the best ways to isolate the location of system changes is by sampling appropriate variables at several strategic points in the system that converts raw materials to finished products.

Consider the data in Table 1. Columns A, B, C, D and E are the individual measurements in a subgroup. Columns $\overline{X}_i$ and R_i are the subgroup $_i$ average and range, respectively. These data will be utilized to prepare a control chart. Every control chart has three parameters: a center line, an upper control limit and a lower control limit. The center line is the average of the variable being plotted on the chart. The upper and lower control limits are at a distance of three standard deviations above and below the average, respectively. If a physical boundary exists that is between a control limit and the center line, then it supersedes the control limit. For example, if the calculated upper control limit exceeded 100% purity a line would be drawn on the chart at the 100% value. The formula for th center line on the X-Bar chart is:

$$Centerline = \overline{\overline{X}} = \frac{\Sigma_{i=1}^{ns} \overline{X}_i}{ns}$$

where ns is the number of subgroups.

The upper and lower control limits the X-Bar chart are respectively at:

$$\overline{\overline{X}} + A_2 \overline{R} \; and \; \overline{\overline{X}} - A_2 \overline{R}$$

where $A_2\overline{R}$ is the estimator of th standard deviations of the subgro averages (i.e., $3\sigma_{\bar{x}}$). The average of subgroup ranges is $\overline{R}$ (i.e., $\overline{R} = \Sigma^n$ $= R_i/ns$), and A_2 is an empirica derived factor whose value for vari subgroup sizes is presented in Tabl (see[8] for details). Note that subgroup size is the number measurements (columns A-E in Ta 1) in each subgroup (row). For data, the upper control limit is,

DATE	SUB-GROUP NUMBER, i	PERCENT PURITY					$\overline{X}_i$	R_i
		A	B	C	D	E		
July 1-5	1	94	96	96	96	95	95.40	2
July 6-10	2	89	96	94	92	91	92.40	7
July 11-15	3	95	97	90	92	94	93.60	7
July 16-20	4	90	93	96	95	96	94.00	6
July 21-25	5	93	94	97	96	92	94.40	5
July 26-30	6	90	93	95	94	95	93.40	5
July 31-Aug.4	7	92	95	94	96	95	94.40	4
Aug. 5-9	8	95	94	96	93	93	94.20	3
Aug. 10-14	9	95	92	93	95	96	94.20	4
Aug. 15-19	10	94	95	87	98	93	93.40	11
Aug. 20-24	11	97	94	93	92	93	93.80	5
Aug. 25-29	12	92	94	93	92	95	93.20	3
Aug. 30-Sept. 3	13	94	95	92	93	92	93.20	3
Sept. 4-8	14	95	94	95	93	94	94.20	2
Sept. 9-13	15	94	97	96	96	93	95.20	4
Sept. 14-18	16	97	96	98	94	94	95.80	4
Sept. 19-23	17	93	95	96	95	95	94.80	3
Sept. 24-28	18	94	95	97	94	94	94.80	3
Sept. 29-Oct. 3	19	94	95	96	93	93	94.20	3
Oct. 4-8	20	97	93	94	93	93	94.00	4
Oct. 9-13	21	93	97	96	95	95	95.20	4
Oct. 14-18	22	94	99	93	95	94	95.00	6
Oct. 19-23	23	94	98	95	94	95	95.20	4
Oct. 24-28	24	96	93	95	91	99	94.80	8

Table 1: Percent Purity Measurements

Upper Control Limit =
$94.28 + (0.58)(4.6) = 96$

and the lower control limit is,

Lower Control Limit =
$94.28 - (0.58)(4.6) = 91.62$

The upper and lower control limits for the range chart are, respectively,

Upper Control Limit $= D_4\overline{R}$
$= (2.11)(4.6) = 9.71$

Lower Control Limit $= D_3\overline{R}$
$= (0)(4.6) = 0.$

In these formulas $D_4\overline{R}$ is the estimator of $\overline{R} + 3\sigma r$ and D_3 is zero because $3\sigma r$ is estimated to be larger than $\overline{R}$ thus yielding a negative lower control limit.

The data from Table 1 were used to create the control charts in Figure 6. In reviewing Figure 6, first observe subgroup 10, which falls above the upper control limit on the R chart. This indicates that corrective action should be taken. Note also that subgroups 12 through 21 have ranges below the average range. The theory of runs says that if eight or more values in a row are on the same side of the center line, then the process is out of control. In this case the values are below the center line, thus indicating a reduction in range has been achieved. Since range is a measure of variability, this is a desirable condition for the process. Studies should be conducted to reveal the cause of this reduced variability, leading to a process improvement.

An engineering process analysis resulted in the following findings:

1. Raw materials utilized in subgroup 10 were not mixed according to prescribed methods. This resulted in abnormally low percent purity for batch 6C and high percent purity for batch 6D. Affected employees were shown the results of not using prescribed methods and then retrained. Also, a change in the mixing process was instituted.

SUB-GROUP NUMBER, i	A_2	D_3	D_4
2	1.88	0	3.27
3	1.02	0	2.57
4	0.73	0	2.28
5	0.58	0	2.11
6	0.48	0	2.11
7	0.42	0.08	1.92
8	0.37	0.14	1.86
9	0.34	0.18	1.82
10	0.31	0.22	1.78
12	0.27	0.28	1.72
14	0.24	0.33	1.67
16	0.21	0.36	1.64
18	0.19	0.39	1.61
20	0.18	0.41	1.59

Table 2:
Factor Values for A_2, D_3, D_4

2. Low ranges for subgroups 12 through 21 were because of special care taken by work crews recently retrained in proper methods and procedures. The conclusion is that the product variability can be reduced by careful attention to prescribed methods and procedures.

A simple example has been used to illustrate the potential measuring the impact of changes on a system whether those changes were instituted by management or occurred without management knowledge and/or approval. Graphical feedback of systems performance in the form of control charts has proven to be both a technical and motivational tool for achieving improved systems performance. In general the variables measured are not easily related to the bottom line. However, the great resurgence of interest in the techniques of statistical process quality control attests to the fact that there is a positive relationship between the measuring procedures and analyses involved and a company's profitability and long-term competitiveness. In fact, the deteriorating competitiveness of U.S. versus Japanese industries has supplied much of the impetus for the use of this technique, which requires cooperative participation and involvement of both labor and management.

Software Packages

An abundance of commercially available software exists to perform the statistical calculations necessary to implement a statistical process quality control system. Most companies subscribe to a major statistics package for their central computer system. Popular mainframe packages are the programs developed at UCLA called the "BMDP Statistical Software" programs[9] or the statistical analysis system developed at North Carolina State University called SAS[10].

Quality Progress, a monthly publication of the American Society for Quality Control, has incorporated a directory of software for quality assurance and quality control in the March issue each year since 1984. The 1986 directory[11] listed over 150 programs ranging in price from $25 to several thousands of dollars. Most software packages for microcomputers are available in the $500 to $1000 price range.

Most process industries have tremendous computer capability for data capture and storage. However, the utilization of the information available to make process decisions seems to be somewhat unorganized. For example, if one were to present several board operators with the same set of process data and ask each to decide on a course of action, there might be as many different actions proposed as their are operators. Each operator has his own implicit algorithm for running the process. What is needed is a more uniform operating procedure based on past performance data. One potential step in this direction is the development of Expert Systems in Chemical engineering (see previous CAST paper[12]). Statistical process quality control is another attempt to utilize data in a more organized manner. Control charts can serve as an effective feedback mechanism for operators and engineers. If those in charge of running the process handle the data to the extent that they can correlate the process measurements to their process decisions, then the feedback necessary for improvement can take place. Hence it is generally recommended that automation of the data collection and processing be delayed until operators have had a chance to work manually with the data. This will provide operators the opportunity to see the correlations and patterns required to make effective decisions. The operator's ability to recognize patterns in the data that are indicative of future process problems is frequently a major benefit of the use of control charts. This could be a precursor to the development of effective expert systems for chemical process control.

Conclusions

The deteriorating competitive position of U.S. manufacturers has been placed in a historical perspective. The primary cause of this situation is the rapid improvement of quality and productivity by offshore competitors. A major tool used to achieve their success was statistical process quality control. Therefore, we must learn to use this tool more effectively throughout our industries. A stepwise procedure to accomplish this end has been presented. This procedure for training and implementation has been utilized by a number of American companies with tremendous results. An example of how statistical process quality control can be used to improve

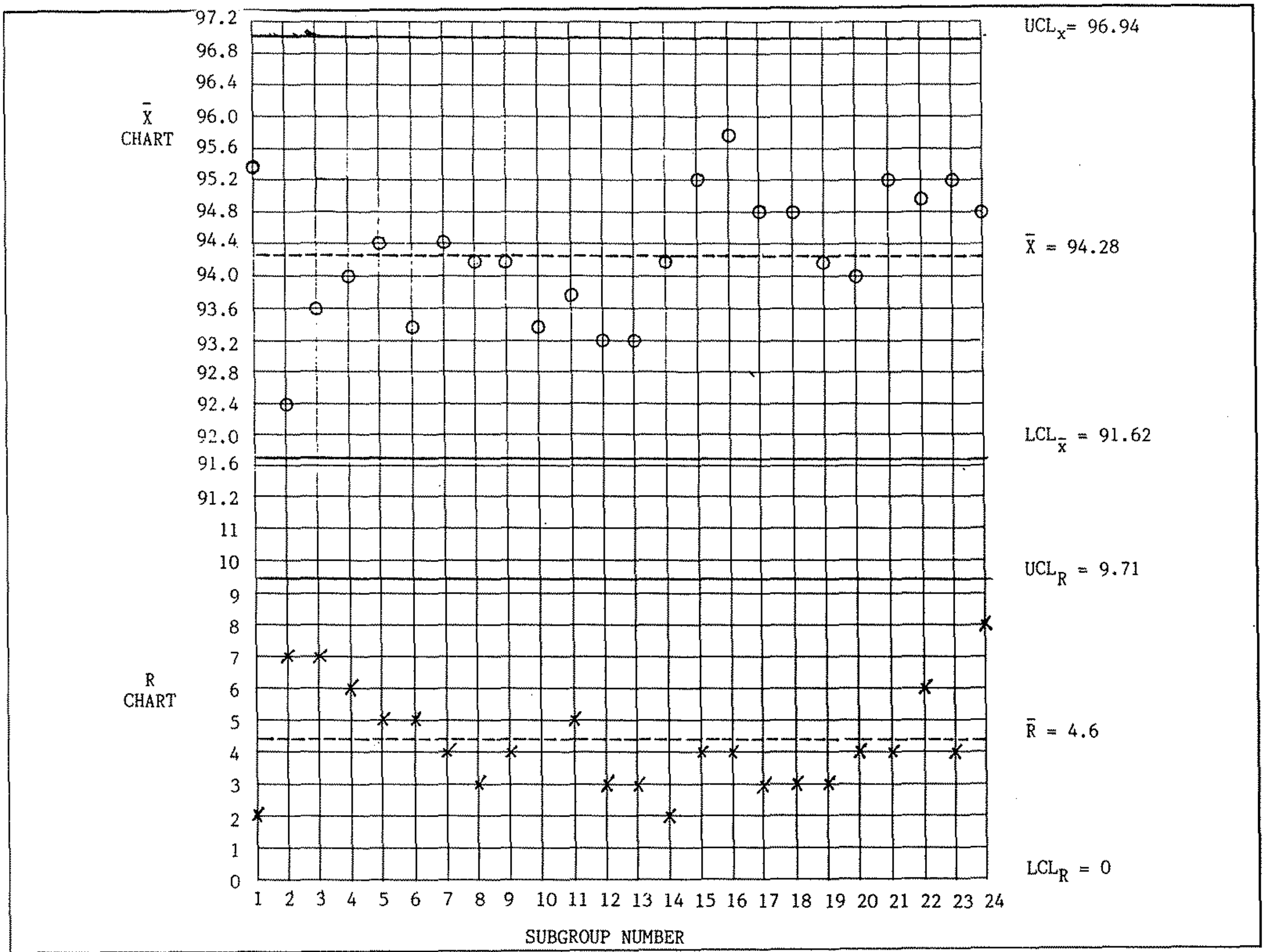


Figure 6: Complete $\bar{X}$ and R Control Charts

a system's performance is presented. Finally, a significant amount of software is available for automating the task of gathering data and preparing control charts. Although the number of successful statistical process quality control projects throughout industry is large and growing, very few process industry projects are reported in the literature because of their proprietary nature.

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The Chemical Process Modeling and Control Research Center at Lehigh University

by Christos Georgakis, Lehigh University

Center Overview

The Process Modeling and Control (PMC) Research Center is an Industry/University Cooperative Research Center performing innovative generic and applied research that addresses the Chemical Processing Industry's needs. Founded in January of 1985, the Center is funded through the membership fees of a consortium of industrial companies. The Center has also been recognized with a $250,000 five-year grant from the Industry/University Cooperative Research Center Program of the National Science Foundation. A $500,000 grant from the Control Data Corporation has equipped the PMC Research Center with a Cyber 810 Computer-Aided Design Facility. Substantial additional funds have been awarded to the Center by the Ben Franklin Partnership Program of the State of Pennsylvania.

Professor Christos Georgakis is the Center's Director and Professor William Luyben serves as the Co-Director of the Center. Thirteen additional faculty members collaborate in the research and teaching responsibilities of the Center. They bring to the Center expertise from academic disciplines such as Chemical, Mechanical, Industrial and Electrical Engineering, and such diverse research areas as Polymer Reaction Engineering and Biotechnology.

The Center's Research Challenge

Prior to the establishment of this Research Center, Lehigh faculty, in collaboration with industrial representatives, assessed the research needs in the area of Process Modeling and Control. This assessment recognized that rapid technological advances were driving engineering toward cross-disciplinary interactions. It identified several important trends that have already affected, and will continue to affect, the chemical, petroleum, petrochemical, and biochemical industries during the next decade. These trends have generated the need for an intensified research effort in chemical process modeling and control and define the research mission of the Center. In particular:

- The trend to improve the production efficiencies of existing chemical plants has increased the need for more effective dynamic models, for improved real-time process measurements, and for more practical techniques for synthesizing multivariable, nonlinear and optimizing control structures. Research activities in this area have already been undertaken, but there still exists the strong need for practical and comprehensive methods that industry can use effectively.
- Efforts to develop new technologies and processes in growth fields, such as biotechnology and polymer engineering, have created the need to construct quickly new process models and develop more reliable control strategies. Modeling and control strategies in these areas have barely scratched the surface of very important problems that exist. Traditional solutions influenced by past experience are clearly not adequate. Novel ideas are needed in postulating the appropriate research problems and in providing fresh approaches to their solution.
- Increased process complexity, together with strict industry and governmental standards for safety and the environment, require more reliable methods for alarm system analysis, system design, and for new dynamic process fault diagnostic methods with productive capabilities. Although industry has pursued this field quite effectively with in-house approaches, there is a need for more systematic methods for the design and safe operation of the tightly integrated processes that will be employed in the future.
- Rapidly evolving technologies for low cost computer-designs and VLSI systems fabrication are creating new opportunities to apply powerful computer hardware and software for process control, including real-time integrated plant transient simulation and optimization.
- Continuing advances in our ability to make more accurate measurements of process variables, especially under complex or harsh conditions, opens

up many possibilities for better understanding of process behavior, leading to improved techniques for process optimization and control. Research opportunities, for example, with respect to measurements in the processing of polymers and in biotechnology are numerous.

- Industry has growing requirements for well-educated engineers who possess a combined understanding of chemical process technology, up-to-date modeling and control approaches, and methods and theory for solving challenging process-related problems. Furthermore, the growing use of computers in industry, coupled with the rapidly increasing power and distributed nature of the computer, is fundamentally altering the process of design, engineering, and process operation as well as the manpower needs of industry.

The Center has initiated ten research projects that address the above research needs.

The Center's Character

Twelve companies are presently members of the Research Center. Their membership fees are used to support generic research that focuses on advanced, practical methods and tools that are pertinent to several processing problems. Example titles of such generic problems of interest to the Center are given below. Member companies are encouraged to propose candidate research problems that are of interest to them. The proposed problems are used to help define the generic research activities of the Center. This process assists the definition of research problems that are aimed at solving a class of significant industrial problems.

This generic research of the PMC Research Center will provide the needed tools to solve present and future industrial problems. Once a generic problem is solved, the application of its solution to a specific process situation is by no means a straight-forward developmental effort. There are many research challenges that remain to be addressed in order to transform a theoretical methodology into a useful engineering tool for specific process applications. The Center strongly believes that generic problems alone are not sufficient to address the challenges that the chemical processing industry has to meet in the '80s and '90s. To properly address these challenges, the Center is offering to a member company the additional option of participating in a process-specific research project. Each member company that utilizes this Company Specific Research Option (CSRO) suggests, on a confidential basis, three different research problems that are targeted toward specific company processing problems and are related to the generic research activities of the Research Center. From these suggestions the Center Director, in consultation with the appropriate faculty, selects one project for active research. This type of project not only addresses the solution to a specific process situation, but concurrently considers the generalization of the immediate problem at hand to a broader class of problems.

There are several advantages to the Company Specific Research Option. The applied research component of the related projects are useful in demonstrating the applicability and economical impact of generic research on actual process operations. This type of research is expected to open new directions for future generic research, something that is presently nonexistent in many Industry/University interactions. The Center feels that this special feature constitutes a necessary component in engineering research and is one that, while absent from the U.S. universities for several decades, has existed quite effectively for many years in Japan and several European countries.

The Center provides a unique research environment for its students. They have the opportunity to work on process-specific problems as well as generic problems. In addition, they closely interact with practicing engineers involved in research and development activities as well as in the operation of plants.

Research Activities

Presently, ten generic research projects have been initiated as the active projects of the Center. These projects, representing major research challenges not fully addressed and resolved in the process control literature, are:

1. Design of Effective Nonlinear Controllers for Chemical Reactors. Professors C. Georgakis and Matthew J. Reilly
2. Design of Practical Multivariable Process Controllers. Professors C. Georgakis and W. L. Luyben
3. Design and Control of Energy-Efficient Distillation Column Systems. Professor W. L. Luyben and C. Georgakis
4. Development of Software for Dynamic Process Simulation and Control System Design. Professors W. E. Schiesser and C. Georgakis
5. Application of Fluorometry to the Monitoring and Control of Biological Reactions. Professors J. A. Phillips, C. Georgakis and A. E. Humphrey
6. Modeling and Control of Semi-Continuous Emulsion Reactors. Professors M. S. El-Aasser, C. Georgakis and A. Klein

7. Plant-Wide Control. Professors C. Georgakis and J. C. Wiginton

8. Utilization of Fourier Transform Infra-red (FTIR) Spectroscopy for the On-Line Analysis of Fermentations. Professors J. A. Phillips, and A. E. Humphrey

9. Expert Multivariable Controllers. Professors C. Georgakis and L. Ungar (Univ. of PA)

10. Batch Reactor Control. Professors C. Georgakis and H. Stenger

Some of the other research and educational activities of the Center include:

- Week-long short courses in a wide range of areas.
- Progress reports of the research activities that are released to the member companies twice a year.
- An exchange program in which industrial researchers come to Lehigh University to participate in the research program.
- The development of specific contractual research arrangements between member or non-member firms and Center faculty.

Educational Opportunities

Because of its special character and mission, the PMC Research Center offers unique educational opportunities to those students who wish to perform graduate work in the area of Process Modeling and Control. In recognition of the growing need for an engineering education that cuts across the engineering sub-disciplines, the Center actively involves faculty and students with varied backgrounds and expertise. Furthermore, with its research and educational activities, the Center aims at lessening one of the primary weaknesses in present-day engineering education. This relates to students' inadequate understanding of engineering practice; that is, the understanding of how engineering knowledge is converted by industry into societal goods and services. This goal is very well served by our generic and applied research activities and by a comprehensive series of graduate and undergraduate courses, invited industrial and academic speakers and group meetings and seminars.

All Lehigh University control courses are coordinated and crosslisted between the Department of the Chemical, Mechanical and Electrical Engineering. Group meetings and seminars are used as a mechanism for the increased transfer of information and ideas among Center graduate students and industrial researchers from the member firms. Several distinguished academic and industrial researchers, in the areas of process modeling and control, are invited to Lehigh University each year for extended series of lectures and in-depth discussions of current research topics with the Center researchers.

To increase their awareness of the challenges and rewards of research, the Center offers undergraduate students the opportunity to participate along with graduate students in the Center research activities. This activity provides our graduate students with a teaching/supervisory experience as well.

For additional information about the Center, please direct inquires to: Professor Christos Georgakis, Director, Process Modeling and Control Research Center, Room 445, Whitaker Laboratory #5, Lehigh University, Bethlehem, PA 18015 or call the Center at (215) 758-4781.

Dynamic Simulation of Complex, Multi-Stage Separation and Reactor Systems by a Modified DSS/2 Simulator

by J. C. Pirkle, Jr., Exxon Research and Engineering Co., and W. E. Schiesser, Department of Chemical Engineering, Lehigh University

1) DSS/2, a method-of-lines dynamic simulation code for the numerical integration of systems of ordinary and partial differential equations (ODE/PDE), is now available as Release 4. Since time integration is a central feature of a method-of-lines code, the library of DSS/2 integrators has been extended to include:

   RKF45
   DASSL
   LSODE, LSODI, LSODES
   DVERK, DREBS, DGEAR

   The following set of software are also available in Release 4, or separately.

2) A set of subroutines and associated test problems for computing second derivatives directly, rather than by stagewise differentiation, in the solution of second-order PDEs. Initial experience has indicated that the new subroutines produce solutions to PDE problems when stagewise differentiation either fails or gives solutions with spurious effects.

3) A set of subroutines and associated test problems for orthogonal collocation on finite element solutions to PDE problems, on one- and two-dimensional spatial domains. Orthogonal collocation is a well established numerical method in engineering research for the solution of PDE problems, but has the reputation of being complicated and difficult to apply to each new problem. The new

subroutines essentially automate orthogonal collocation and therefore make it straightforward to use.

4) 150 applications that run under DSS/2, in separations, chemical kinetics and reactors, heat transfer, fluid flow, and process control.

Each set of software is thoroughly documented internally with comments, and includes a set of test problems to demonstrate the use of the software and to verify that it is working correctly on the user's local computer(s). The software is written as single- and double-precision Fortran 77 source code, and can be provided on nine-track tape (items 1 through 4) or 360 kb diskettes (items 2 and 3).

Inquiries should be directed to: Dr. William E. Schiesser, Department of Chemical Engineering, Whitaker No. 5, Lehigh University, Bethlehem, PA 18015, (212) 758-4264.

A paper on DSS/2, Release 4, co-authored by J. C. Pirkle Jr. and W. E. Schiesser, was presented at the AIChE Annual Meeting, Miami Beach, Florida, November 2-7, 1986.

Forum

Over the past few weeks we have been reading with interest a number of articles in computer magazines on 80386 architecture and the current set of machines which are built around it. In parallel we have read several survey articles on technical, engineering or scientific workstations built around 68000 or 80386 CPUs. The workstation systems differ from those evolving from the PC world in that most of them run multi-tasking operating systems. The software supports window-oriented user interfaces, allows multiple devices to operate concurrently, and usually supports a higher level language for computation. Object-oriented programming languages as well as scientific computing languages are included.

Most of our readers have experience with Fortran running on large minicomputers or mainframe systems. Many now use PCs to do much of the low level computing as well as a host of spreadsheet, database and word processing applications.

We would welcome some brief notes or letters in which our readers tell us what they believe is needed for engineering workstations. What would you like to have on your desk? What features are required? Colour? Large-screen monitors? 32-bit or 16-bit architecture? MS-DOS or UNIX operating systems? Memory size? Languages? etc.? We will publish or abstract the responses in our next newsletter. The most thoughtful note may even win a small reward at the next CAST Division Dinner in New York.

So far our readers have been very unresponsive about issues. Perhaps a chance to specify your dream environment for computing will inspire the creative genius we know you have. Please reply to the Editors (see inside front cover) by August 31, 1987, preferably via Bitnet or on diskettes for other than brief letters.

The Editors

Meetings and Conferences

The following items summarize information in the hands of the Editor by February 15, 1987. Please send CAST Division session information, meeting, and short course announcements to me on Bitnet or diskette by September 1, 1987 for inclusion in the fall 1987 issue of CAST Communications.

Peter R. Rony,
Editor, CAST Communications

Excerpts from Report of the CAST Division Programming Board

(November 3, 1986)

"PACHEC IV (Acapulco, Mexico, October 16-21, 1988): "It is anticipated that CAST will be asked to organize several sessions in its programming areas. Time tables and themes have not yet been set.

"1988 American Control Conference (Atlanta, June, 1988): Area 10b will again contribute a number of sessions under the direction of Yaman Arkun as AIChE coordinator.

"Foundations of Computer Aided Process Design–PSE 89 (Summer 1989): Agreement has been reached with CACHE on the organization of this specialist conference. Jeff Siirola will be Chairman. The meeting will carry the co-title PSE to reflect support of the CAST division for the continuation of the PSE conference series. Jeff has begun plans for the meeting, including selection of an organizing committee and consideration of alternative sites.

"General Comments: With the increase of our Annual Meeting programming beyond 16 sessions, it becomes necessary to schedule three parallel session tracks. The next natural limit for the number of sessions is thus 24. Simimlarly, once more than 12 sessions are scheduled for the Spring meeting, the need arises for three tracks. Three parallel tracks is probably the limit for our Division, since it becomes increasingly difficult to avoid scheduling conflicts in audience interests. Because of the summer ACC meetings as well as the periodic CPC, FOCAPD, and presumably

FOCAPO conferences, it continues to be undesirable to schedule CAST sessions at the summer AIChE meetings. However, with suitable coordination it may be appropriate to periodically (say, every 3-4 years) to schedule a summer specialist conference on the PSE (Process Systems Engineering) theme, under the aegis of AIChE in cooperation with the Japanese Institute, and the Working Party on Computers in Chemical Engineering of the European Federation, and in parallel with a summer AIChE meeting. These possibilities will be discussed with the Executive Board of the National Program Committee."

Workshop on Artificial Intelligence in Process Engineering, Columbia University

(March 9-10, 1987)

In the past few years, considerable work has been done in applying recent advances in Artificial Intelligence to problems in the various disciplines of engineering. Substantial impact is already seen in fields such as electrical, mechanical, and civil engineering. The field of chemical engineering, in particular the domain of Process Engineering, has much to gain from the applications of AI. Interest in the process engineering community (both in academia and in industry) is substantial, but only a handful of researchers are currently engaged in applying AI to problems in process engineering. This workshop is being organized to provide this much needed exposure to researchers in academia and industry. The workshop would serve the following needs: (1) Bring together for an intense program people in academia as well as in industry who are interested in AI in process engineering. (2) Disseminate the ideas and techniques of AI in an appropriate form by relating them to various problems in process engineering. (3) Help resolve the confusion about what AI can do, how to go about applying AI for process engineering problems, etc. (4) Provide a long term research focus, and identify a set of problems that have important basic research issues as well as useful practical components.

Speakers include, from chemical engineering, Jim Davis, Prasad Dhurjati, George Stephanopoulos, V. Venkatasubramanian, and Art Westerberg; from computer science, B. Chandrasekaran, Ken Forbus, Jeff Pan, and John Kunz.

The number of participants, besides the invited speakers, will be limited to fifty. Interested parties were encouraged to contact members of the organizing committee before December 15, 1986. The organizing committee consists of V. Venkatasubramanian (Chairman), Department of Chemical Engineering, Intelligent Process Engineering Laboratory, Columbia University, New York, NY 10027, (212) 280-4453; George Stephanopoulos (Co-Chairman), Laboratory for Intelligent Systems in Process Engineering, Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, MA 02139, (617) 253-3904; and James Davis, Department of Chemical Engineering, Ohio State University, Columbus, OH 43210, (614) 422-0090.

Fourth Annual Short Course On Practical Techniques for Robust Multivariable Process Control, Case-Western Reserve University

(March 9-13, 1987)

Short course topics include Process Dynamics and Control Fundamentals, Internal Model Control, Constrained Control, Multivariable System Dynamics and Control, and Multivariable Internal Model Control. Course fee is $1150, with full payment due by March 2, 1987. Make check payable to Case Western Reserve University; to reserve a place by phone, please call (216) 368-4182. Course lecturers are Coleman Brosilow (Case Western Reserve University) and Manfred Morari (California Institute of Technology). For further details, contact Professor Coleman Brosilow, Case Western Reserve University, 116 Smith Bldg., Cleveland, OH 44106, (216) 368-4182.

Multivariable Control Methods (Short Course), University of Louisville

(March 17-20, 1987)

Because of the continuing rise in the price of raw materials and energy accompanied by international competitive pressures, it has become very important to operate the commercially important multivariable processes efficiently under control strategies that properly account for process interactions, time delays, nonlinearities, and operating constraints. The availability of low cost microprocessors has led to the development of multivariable control systems. This four-day short course covers some of the most promising techniques for multivariable control. The first day of the course is essentially a review of computer process control (sampled-data control) techniques that will be reinforced by computer software. The remaining days of the course are devoted to a discussion of the various multivariable control methodologies.

The course fee is $795, which includes course notes, lunch, and breaks. Lecturers include Pradeep B. Desphande, Charles F. Moore, Darrel L. Chenoweth, Patricia A. S. Ralston, and G. R. Arulan. Contact the course organizer, Dr. Desphande, Laboratory for Applied Control, Chemical Engineering Department, University of Louisville, Louisville, KY 40292.

Houston AIChE Meeting
(March 29-April 2, 1987)

Area 10a Sessions

1. **Process Data Reconciliation and Rectification**. Cameron M. Crowe (Chairman), Department of Chemical Engineering, McMaster University, Hamilton, Ontario, Canada L8S 4L7, (416) 525-9140 x-4947 and William Y. Svrcek (Vice Chairman), Department of Chemical Engineering, University of Calgary, Calgary, Alberta, Canada T2N 1N4, (403) 284-5755. Papers include:

"*Effect of Redundancy on Estimation Accuracy in Process Data Reconciliation*," by Kretsovalis and Mah.

"*Detection and Reconciliation of Measurement Errors in Gas Distribution Systems*," by Heenan, Cardiel and Serth.

"*Interval Analysis as a Tool for Data Rectification*," by Himmelblau.

"*A Hybrid Algorithm for Detection of Gross Errors in Linearly Constrained Data*," by Serth, Johnston and Heenan.

2-4. **Modern Applications of Chemical Engineering Theory I, II, and III**. Richard Pollard (Co-Chairman), Department of Chemical Engineering, University of Houston, Houston, TX 77004, (713) 749-2414 and Mark E. Orazem (Co-Chairman), Department of Chemical Engineering, University of Virginia, Charlottesville, VA 22901, (804) 924-6282. Papers in Session I include:

"*Theoretical Analysis of a Rotating-Disk Chemical Vapor Deposition Reactor*," by Coltrin, Breiland, Evans and Kee.

"*Modeling and Analysis of Plasma Etching Reactors*," by Economou and Alkire.

"*The Structure of DC Negative Glow Discharges*," by Huffstater and Graves.

"*Temporal and Spatial Resolution of Optical Emission in RF Plasmas*," by Jellum and Graves.

"*In-Situ Characterization of Surface States with Application to Photoelectrochemical Semiconductor Processing*," by Bonham and Orazem.

"*Modeling of Thermal Oxidation of Silicon*," by Singh, Schlup and Fan.

Papers in Session II include:

"*Stochastic Modeling and Control of a Semiconductor Etch Process*," by Rhinehart and Wu.

"*The Computer Simulation of Melting, Freezing, and the Glass Transition for Simple Materials*," by Clancy and Chokappa.

"*A Mathematical Model for the Rate and Uniformity of Deposition in a Planar Source Diffusion System*," by Yeckel and Middleman.

"*Fundamentals of Powder Production Using Aerosol Reactors*," by Nguyen, Wu and Flagen.

"*Mathematical Modeling of Coarsening in Phase-Separated Polymer/Solvent Systems*," by Caneba.

"*Polypropylene Powder Compaction at Temperatures Above Tg*," by Wang.

Papers in Session III include:

"*Reaction Sintering of Submicron Silicon to Produce Dense Si_3N_4 Ceramics*," by Gregory and Lee.

"*Gas Phase Synthesis of Silicon Carbide Powders*," by Mehosky.

"*Application of Chemical Engineering to Friction Materials (Composites)*," by Shah.

"*Color Shifts of High-Solids Paints in Circulation Systems*," by Service.

"*The Electronics Industry: Opportunities for Chemical Engineers*," by Goldman.

"*Composite Airframe Structures: Can Thermoplastics Compete with Thermosets?*," by Margolis.

5. **Retrofitting and Optimization**. A. L. (Pete) Parker (Chairman), Shell Oil Co., P. O. Box, Norco, LA 70079, (504) 465-7459 and Ed Gordon (Vice Chairman), Computer Consultant, 24932 Hendon Street, Laguna Hills, CA 92653, (714) 768-7025. Papers include:

"*Advanced Plant Management for the Optimization of Olefin Plant Operation*," by Sigal.

"*Simulation and Optimization of Three-Phase Distillation Processes*," by Kingsle and Lucia.

"*Dynamic Simulation for Plant Retrofit–Redesign of Polymerization Reactor Systems*," by Kaushik and Augustine.

"*Concepts and Pitfalls in Plant Retrofitting*," by Kesler.

"*Synthesis of Flexible Heat Exchanger Networks*," by Floudas and Grossman.

Joint Areas 10a and 11b Sessions

1-2. **Expert Systems and Computational Methods in Process Safety I and II**. V. Venkatasubramanian (Chairman), Department of Chemical Engineering, Columbia University, New York, NY 10027, (212) 280-4453 and Ernest J. Henley (Vice Chairman), Department of Chemical Engineering, University of Houston, Houston, TX 77004, (713) 749-4947. Papers include:

"The Falcon Project: An Application of an Expert System to Fault Diagnosis," by Fickelscherer, Dhurjati, Lamb and Chester.

"Narrowing Diagnostic Focus by Control System Decomposition," by Finch and Kramer.

"Qualitative Modeling and Model-Based Reasoning for Fault Diagnosis," by Venkatasubramanian and Rich.

"Disturbance Analysis Using Digraphs," by Henley and Kohda.

"An Expert System Approach to Diagnosis of Product Quality Deviations," by Davis, Punch, Hess and Chadrasekaran.

"Real-Time Diagnosis of Chemical Processes: A Model-Based Algorithm," by Ulericl and Powers.

"Analyzing Process Alarms When Your Expert System Fails," by Hall.

"PRISIM–An Expert System for Process Risk Management," by Arendt.

For further details concerning Area 10a sessions and scheduling, please contact Jeffrey J. Siirola (Chairman, Area 10a), ECD Research Laboratories, Eastman Kodak Co., Kingsport, TN 37662, (615) 229-3069.

Area 10b Sessions

1. **Recent Advances in Computer Control**. Christos Georgakis (Chairman), Process Model and Control Research Center, 443 Whitaker Bldg., Lehigh University, Bethlehem, PA 18015, (215) 758-4781 and Jorge Mandler (Vice Chairman), Air Products and Chemicals, Inc., Allentown, PA 18105. Articles include:

"Direct Control of Molecular Weight Distribution During Continuous Polymerization," by Tanner, Adebekun and Schork.

"Computer Based Optimal Control of a Complex Distillation Unit," by Horton and Edgar.

"Experimental Application of a Nonlinear Multivariable Control Strategy to Distillation Column," by Wong and Seborg.

"An Intelligent System for the Design of Plant-Wide Control Configurations," by Stephanopoulos, Johnston and Stewart.

"Side Reboiler Optimization," by Waltz.

2. **Distillation Tower Control**. Karlene A. Hoo-Kosanovich (Chairman), Exxon Chemical Company, Linden, NJ 07936 and John Slaby (Vice Chairman), Halcon SD Group, New York, NY 10016. Articles include:

"Performance Comparison of Methods for On-Line Updating of Process Models for High Purity Distillation Control," by McDonald and Kapoor.

"Process Model Based Control and Optimization of Binary Distillation Columns," by Cott, Sullivan and Durham.

"Nonlinear Control of a High Purity Distillation Column by the Use of Partially Linearized Control Variables," by Alsop and Edgar.

"Analysis and Control of an Ethanol-Water Column," by Moore and Canter

"Closed-Loop Identification of Multivariable Models for Distillation Towers," by Clough and Hogenson.

3. **Control of Chemical Reactors**. Herman Bozenhardt (Chairman), Fisher and Porter Company, County Line Road, Warminster, PA 18974, (215) 674-6086 and W. David Smith, Jr. (Vice Chairman), E. I. DuPont and Company, Polymer Products Division, Experimental Station 262/219, Wilmington, DE 19898, (302) 772-1476. Articles include:

"Discrete Time Reactor Models for Process Control," by Rutzler.

"Linear Programming Model for Batch Reactor Kinetics Optimization," by Dybeck.

"Control Structure for Batch Reactor Control," by Craig.

"Control of a Laboratory Water-Gas Shift Reactor," by Edgar and Bell.

"Control of Nonlinear Bioreactor Systems Using a Robust Multivariable Modern Control Design Methodology," by Wang, Moore and Birdwell.

For further details concerning Area 10b sessions and scheduling, please contact Yaman Arkun (Chairman, Area 10b), Department of Chemical Engineering, Georgia Tech, Atlanta, Georgia 30332, (404) 894-2871.

Area 10c Sessions

1. **Networking**. Ed Gordon (Co-Chairman), Computer Consultant, 24932 Hendon Street, Laguna Hills, CA 92653, (714) 768-7025 and William S. Alper (Co-Chairman), M. W. Kellogg Company, Three Greenway Plaza East, Houston, TX 77046, (713) 960-2000. Papers include:

"Specifying a Local Area Network," by Blauth.

"The Use of Broadband as an Industrial Communication Medium," by Skiyipp.

"Network Issues in CAM," by Canfield.

"Strategy, Tactics and Uncertainties," (panel discussion)

3. **Human Factors and Computing Interfaces.** Rajeev Gautam (Chairman), Union Carbide Corporation, P. O. Box 8361, South Charleston, WV 25303, (304) 747-3710 and Larry Biegler (Co-Chairman), Department of Chemical Engineering, Carnegie-Mellon University, Schenley Park, Pittsburgh, PA 15213, (412) 578-2232. Papers include:

"Design Kit: An Intelligent Interface and Database for Process Engineering," by Stephanopoulos, Joback, Johnston, Lakshmanan, Kritkos, Mavrovouniotis, and Siletti.

"User-Interfaces–Practice and Experience," by Angus and Ganguly.

"Economical, Effective and Efficient Interface to a General Purpose Process Simulator," by Vernueil and Colbert.

"Human Computer Interface in Pinch Technology," by Ahmad and Shah.

"User-Interactive Process Simulators," by Kesler, Kesler, Graham, and Weissbrod.

"The Development of an Interactive User Interface for Chemical Flowsheet Synthesis," by Kirkwood, Coury, and Douglas.

For further details concerning Area 10c sessions and scheduling, please contact Ignacio Grossman, School of Chemical Engineering, Cornell University, Ithaca, NY 14853, (607) 255-7204.

Second International Conference on Chemical Engineering Education, Robinson College, Cambridge, England
(April 14-16, 1987)

Sessions include The European Situation, The Situation in Japan and the USA, Recruitment to the Profession, Initiatives in Engineering Education, Computing in Chemical Engineering Education, University/Industry Interaction, Future Trends, and Summary and Action. All correspondence and inquiries in connection with the conference should be addressed to: The Conference Section, The Institution of Chemical Engineering, 165-171 Railway Terrance, Rugby, Warks CV21 3HQ. Telephone: (0788) 78214. Telex: 311780. Attention Mrs. Julie Tayler or Miss Anne Hughes. Conference fees are £201.25 for members of IChemE/EFCE Member Societies, and £241.50 for Non-members.

CEF 87: The Use of Computers in Chemical Engineering, Taormina, Sicily, Italy
(April 26-30, 1987)

The Congress will focus attention on the basic and fundamental features of the use of computers in chemical engineering. Three main topics have been chosen:

(1) Numerical problems, including solution of algebraic systems, solution of ordinary partial differential equations, nonlinear programming/optimization, and nonlinear regression. (2) Physico-chemical properties, including equations of state, transport properties, electrolyte solutions, and crude characterization. (3) CAD/Processes, including unit operation modeling, process synthesis, process dynamics, solution of recycle problems, and equation-oriented approaches.

The technical program for the plenary lectures includes:

G. Byrne: Integration of stiff differential equations. Systems coupled to algebraic equations in chemical engineering.

L. T. Biegler: On the simultaneous solution and optimization of large scale engineering systems.

A. Fredenslund: Transport properties–thermal conductivity, viscosity, surface tension–for gases and liquids.

B. Behar: Crude characterizations.

G. Georgakis: Computer-aided control strategies for the chemical industry. Status and future challenges.

H. Hofmann: Future trends in chemical engineering modeling.

M. A. Stadtherr: Applications of supercomputers in chemical engineering.

M. Dohnal: Fuzzy set theory–basic concepts and applications.

The Congress language will be English. Simultaneous translation will not be available. The international congress will take place at Naxos Beach Hotel of Giardini Naxos (close to Taormina, Messina). The complex provides excellent conference facilities and is situated on the Sicilian coast, which offers exceptional tourist interest and is particularly appreciated from a climatic point of view. Registration fees after January 31, 1987 are 500,000 Lire. Payment should be made by circular check written to MBS-AIDIC in Italian lire and sent to MBS, Foro Bonaparte 63, 20121 Milano, Italy, or by bank remittance on account no. 5289/18 in the name of MBS-AIDIC, Banca del Monte di Milano ag. 5, Via Fabio Filzi 23, 20124 Milano, Italy. Cancellations received before February 28, 1987 will be subject to an administrative charges of 20% of the total remittance. No refunds will be made for cancellations received after this date, or for non-attendance.

Advanced Process Control (Short Course), McMaster University, Hamilton, Ontario, Canada
(May 11-14, 1987)

Short course topics include Review of Process Dynamics and Control, Discrete Time Process Identification, Process Identification Laboratory, Introduction to Discrete Control, Introduction to Univariate Stochastic Control and Self-Tuning Regulators, Controller Design Workshop, Advanced Identification and Control, Adaptive Controllers, Deterministic Optimal Control, Plant-Wide Optimal Control, Controller Performance Workshop, State Estimation and Optimal Stochastic Control, and Review Workshop. Short course lecturers are J. F. MacGregor, P. A. Taylor, and A. Hrymak (all from McMaster University), and J. D. Wright (Xerox Research Centre of Canada). Cost per person is $1100, which includes room and board for 4 days and detailed lecture notes. For additional information, contact Dr. P. A. Taylor, Department of Chemical Engineering, McMaster University, Hamilton, Ontario, Canada L8S 4L7, (416) 525-9140, extension 4952.

4th Biennial Short Course on Applications of Advanced Control in the Chemical Process Industries, University of Maryland
(May 18-22, 1987)

This course is designed to cover the theory and application of advanced control concepts to the chemical process industry. Emphasis will be placed primarily on those techniques which have already solved and/or potentially can help solve real industrial problems. Lecturers have been chosen equally from the leading chemical and petroleum companies, from hardware vendors, and from universities. The course format is such as to encourage a significant amount of interaction and discussion among the participants. This course is intended for engineers who have a good working knowledge and background in dynamics and control. It is not intended for the novice. Engineers with one or more years of practical experience will benefit most from the course. Attendance will be limited to the first 35 qualified applicants. The fee is $1,195, which includes course notes, daily lunch, and picnic on Thursday. Lecturers included A. O. Asbjornsen, K. Astrom, T. F. Edgar, T. J. McAvoy, M. Modarres, R. Moore, M. Morari, M. Morshedi, F. G. Shinskey, and B. Tyreus. Contact Dr. Thomas J. McAvoy, Department of Chemical and Nuclear Engineering, University of Maryland, College Park, Maryland 20742, (301) 454-4593.

1987 American Control Conference
(June 10-12, 1987)

The American Automatic Control Council will hold the 6th American Control Conference at the Hyatt Regency Hotel in Minneapolis, Minnesota. The General Chairman is Thomas F. Edgar, Department of Chemical Engineering, University of Texas, Austin, TX 78712, (512) 471-3080. AIChE Invited Sessions under development include:

Nonlinear Process Control (Developers: J. Kantor, Notre Dame, and C. Kravaris, Michigan)
Expert Systems in Process Control (Developers: T. J. McAvoy, Maryland, and R. Moore, Lisp Machine)

Adaptive Control (Developers: W. K. Lee, Ohio State, and C. Tsiligiannis, City College of CUNY)

Recent Developments in Process Control (Developers: A. Palazoglu, UC Davis, and B. Holt, Seattle)

Applications of Advanced Process Control (Developers: K. Levien, Oregon State, and T. Taylor, 3M)

Robust Control for Processes with Constraints (Developers: E. Zafirou, Maryland, and M. Morari, Caltech)

Modeling and Control of Distributed Parameter Systems (Developers: J. B. Rawlings and B. W. Bequette, University of Texas at Austin)

Foundations of Computer-Aided Process Operations
(July 5-10, 1987)

H. Dennis Spriggs, Linnhoff March, P. O. Box 2306, Leesburg, VA 22075, (703) 777-1118 and Rex Reklaitis, School of Chemical Engineering, Purdue University, West Lafayette, IN 47907, (317) 494-4089. Area 10c is planning this conference. The program consists of a keynote speaker, 20 invited speakers, 11 commentators, and a contributed paper poster session involving 10 papers. See pages 24-26 in the September 1986 issue (Volume **9**, Number 2) of CAST Communications.

Announcement Process Control Education: A Round Table Discussion at the 10th World Congress of the International Federation of Automatic Control in Munich, Germany
(July 26 - 31, 1987)

Objectives:

To review and critique process control education for chemical engineers.

To put forward necessary changes.

To look to the future of the subject and its relation to all of engineering.

Organizers and Moderators:

Alan S. Foss, University of California, Berkeley, CA Odd A. Asbjornsen, University of Maryland, College Park, MD

An International Panel:

David Prett, Shell Development Co., Houston, TX. James S. Anderson, ICI, Cleveland, UK. Jens G. Balchen, Norwegian Inst. Technol., Trondheim, Norway. George Stephanopoulos, MIT, Cambridge, MA. Takeichiero Takamatsu, Kyoto Univ., Kyoto, Japan

Format:

Perceptions of the panel members.

Questions and discussion from the floor.

Minneapolis AIChE Meeting
(August 16-19, 1987)

No CAST sessions are planned.

New York City AIChE Meeting
(November 15-20, 1987)

Area 10a Sessions (Tentative)

1. **Design and Analysis**. Richard S. H. Mah (Chairman), Department of Chemical Engineering, Northwestern University, Evanston, IL 60201, (312) 491-5357 and Iftekhar Karimi (Vice Chairman), Department of Chemical Engineering, Northwestern University, Evanston, IL 60201, (312) 491-3558.

2. **Complex Dynamics**. Michael F. Doherty (Chairman), Department of Chemical Engineering, University of Massachusetts, Amherst, MA 01003, (413), 545-2359 and B. Erkik Ydstie (Vice Chairman), Department of Chemical Engineering, University of Massachusetts, Amherst, MA 01003, (413) 545-2388.

3. **Computer-Aided Design of Batch Processes**. Kris R. Kaushik (Chairman), Shell Oil Company, P. O. Box 2099, Houston, TX 77252-2099, (713) 241-2098 and Malcolm L. Preston (Vice Chairman), Imperial Chemical Industries PLC, P. O. Box 7, Winnington, Northwich, Cheshire CW8 4DJ, England.

4. **Artificial Intelligence in Process Engineering**. H. Dennis Spriggs (Chairman), Linnhoff March, P. O. Box 2306, Leesburg, VA 22075, (703) 777-1118 and V. Venkatasubramanian (Vice Chairman), Department of Chemical Engineering, Columbia University, New York, NY 10027, (212) 280-4453.

Joint Areas 10a and 10b Session

1. **Integration of Process Design and Control**. Bradley R. Holt, Department of Chemical Engineering, BF-10, University of Washington, Seattle, WA 98195, (206) 543-0554 and W. David Smith (Vice Chairman), Polymer Products Division, E. I. DuPont de Nemours and Co., Wilmington, DE 19898, (302) 772-1476.

For further details concerning Area 10a sessions and scheduling, please contact Jeffrey J. Siirola (Chairman, Area 10a), ECD Research Laboratories, Eastman Kodak Co., Kingsport, TN 37662, (615) 229-3069.

Area 10b Sessions

1. **Batch Process Control**. Mark Juba (Chairman), Eastman Kodak Co., Bldg. 337, Kodak Park, Rochester, NY 14650, (716) 558-3637 and Christos Georgakis, Process Model and Control Research Center, 443 Whitaker Bldg., Lehigh University, Bethlehem, PA 18015, (215) 758-4781.

2. **Expert Systems Applied to Process Control**. Richard Weber (Chairman), Exxon Chemicals, P. O. Box 100, Baytown, TX 77520, (713) 428-6385 and George Stephanopoulos, Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, MA 02139, (617) 253-3904.

3. **Adaptive Control**. Won Kyoo Lee (Chairman), Department of Chemical Engineering, Ohio State University, Columbus, Ohio 43210, (614) 292-7907 and Dale Seborg, Department of Chemical and Nuclear Engineering, University of California, Santa Barbara, CA 93106.

4-5. **Recent Developments in Process Control I and II**. Evanghelos Zafiriou (Chairman of Session I), Department of Chemical Engineering, University of Maryland, College Park, MD 20742, (301) 454-2431; Amhet Palazoglu (Chairman of Session II), Department of Chemical Engineering, University of California, Davis, CA 95616, (916) 752-8774; and Thomas F. Edgar (Vice Chairman of both sessions), Department of Chemical Engineering, University of Texas, Austin, TX 78712-1062, (512) 471-3080.

For further details concerning Area 10b sessions and scheduling, please contact Yaman Arkun (Chairman, Area 10b), Department of Chemical Engineering, Georgia Tech, Atlanta, Georgia 30332, (404) 894-2871.

Area 10c Sessions

1-2. **Advances in Optimization I and II.** Ignacio Grossman (Chairman), School of Chemical Engineering, Olin Hall, Cornell University, Ithaca, NY 14853, (607) 255-7204 and Lorenz T. Biegler (Vice Chairman), Department of Chemical Engineering, Carnegie-Mellon University, Pittsburgh, PA 15213, (412) 268-2232.

3-4. **Scheduling and Planning of Operations. I. Continuous Processes, II. Batch Processes.** Moe Sood (Chairman), Mobil R and D Corporation, P. O. Box 1026, Princeton, NJ 08546, (609) 737-4960, and G. V. Reklaitis (Vice Chairman), School of Chemical Engineering, Purdue University, West Lafayette, IN 47907, (317) 494-4089.

5. **On-Line Fault Administration.** Mark Kramer (Chairman), Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, MA 02139, (617) 253-6508.

For further details concerning Area 10c sessions and scheduling, please contact Ignacio Grossman, School of Chemical Engineering, Cornell University, Ithaca, NY 14853, (607) 255-7204.

Area 10d Sessions

1. **What Has Applied Mathematics Done for Chemical Engineers? What Next?.** D. Ramkrishna (Chairman), School of Chemical Engineering, Purdue University, West Lafayette, IN 47907, (317) 494-4066 and Christos G. Takoudis (Vice Chairman), School of Chemical Engineering, Purdue University, (317) 494-2257.

Joint Areas 10d and 1h Sessions

1-2. **Instabilities and Nonlinear Phenomena in Chemical Engineering Systems I and II**, Runga Narayana (Co-Chairman), Department of Chemical Engineering, University of Florida, Gainesville, FL 32611, (904) 392-9103 and Gerasimos Lyberatos (Co-Chairman), Department of Chemical Engineering, University of Florida, (904) 392-0898.

The above three sessions were developed by Area 10a but have now been transferred to the newly formed Area 10d, and are included here for information purposes only. For corrections and further details concerning Area 10d sessions and scheduling, please contact Doraiswami Ramkrishna, Purdue University, School of Chemical Engineering, West Lafayette, IN 47907, (317) 494-4066.

New Orleans AIChE Meeting
(March 6-10, 1988)

Area 10a Sessions

1. Recent Advances in Computer-Aided Process Design

Henry H. Chien (Chairman), Monsanto Company–CS7N, 800 N. Lindbergh Blvd., St. Louis, MO 63167, (314) 694-8274 and Jude T. Sommerfeld (Vice Chairman), School of Chemical Engineering, Georgia Institute of Technology, Atlanta, GA 30332, (404) 894-2873.

2. Simulation and Optimization of Unusual Systems

Edward M. Rosen (Chairman), Monsanto Company–CS7S, 800 N. Lindbergh Blvd., St. Louis, MO 63167, (314) 694-6412 and Heinz A. Preisig (Vice Chairman), Department of Chemical Engineering, Texas A&M University, College Station, TX 77843-3122, (409) 845-0386.

3. Practical Application of Statistical Methods in the Processing Industries

Gary E. Blau (Chairman), Dow Chemical Company, 1776 Building, Midland, MI 48674, (517) 636-5170 and David M. Himmelblau (Vice Chairman), Department of Chemical Engineering, University of Texas, Austin, TX 78712, (512) 471-7445.

4. Applications of Personal Computers

Peter R. Rony (Chairman), Department of Chemical Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, (703) 961-7658 and Babu Joseph (Vice Chairman), Department of Chemical Engineering, Washington University, St. Louis, MO 63130, (314) 889-6076.

Joint Areas 10a and 10b Session

1. Retrofitting for Improved Process Control

Eli Neisenfeld (Chairman), Applied Synaptics, P.O. Box 634, Ridewood, MD 21139, (301) 821-5178 and James M. Douglas (Vice Chairman), Department of Chemical Engineering, University of Massachusetts, Amherst, MA 01003, (413) 545-2252

Joint Areas 10a and 10c Sessions

1-2. Industrial Applications of Expert Systems I and II

Krishna R. Kaushik (Cochairman), Shell Oil Company, P.O. Box 2099, Houston, TX 77252-2099, (713) 241-

2098 and Mohinder K. Sood (Co-chairman), Mobil R and D Corporation, P.O. Box 1026, Princeton, NJ 08540, (609) 737-4960.

For further details concerning Area 10a sessions and scheduling, please contact Michael F. Doherty (Area 10a Chairman-Elect), Department of Chemical Engineering, University of Massachusetts, Amherst, MA 01003, (413) 545-2359.

Area 10b Sessions

For further details concerning Area 10b sessions and scheduling, please contact Yaman Arkun (Chairman, Area 10b), Department of Chemical Engineering, Georgia Tech, Atlanta, Georgia 30332, (404) 894-2871.

Area 10c Sessions

1-2. **The Role of Computers in Safety and Reliability I and II.** Richard S. H. Mah (Chairman), Department of Chemical Engineering, Northwestern University, Evanston, IL 60201, (312) 491-5357 and Ernest Henley (Vice Chairman), Department of Chemical Engineering, University of Houston, Houston, TX 77004, (713) 749-4947.

3-4. **Computer-Aided Engineering.** Rajeev Gautam (Chairman), Union Carbide Corporation, P. O. Box 8361, South Charleston, WV 25303, (304) 747-3710 and Pete Parker (Vice Chairman), Shell Oil Company, P.O. Box 10, Norco, LA, (713) 241-6214.

Joint Areas 10a and 10c Sessions

5-6. **Industrial Applications of Expert Systems I and II.** Kris Kaushik (Chairman), Shell Oil Co., P.O. Box 2099, Houston, TX 77252, (713) 241-2098 and Moe Sood (Vice Chairman), Mobil R and D Corporation, P. O. Box 1026, Princeton, NJ 08546, (609) 737-4960.

For further details concerning Area 10c sessions and scheduling, please contact Ignacio Grossman, School of Chemical Engineering, Cornell University, Ithaca, NY 14853, (607) 255-7204.

Understanding Process Integration II, University of Manchester, England
(March 22-23, 1988)

Call for Papers. Papers relating to topics listed below are invited. A copy of an abstract in English of about 500 words should be submitted to the conference secretary by February 1, 1987. The abstract should contain the title, authors, institutional affiliations, and full mailing addresses. Authors will be notified of preliminary acceptance by April 1, 1987. The full paper should be submitted for refereeing by August 1, 1987. The final camera-ready version will be required by December 1, 1987.

The conference will be concerned with the design of integrated processes, both chemical and biochemical, and will concentrate on the following areas:

Reaction paths: Techniques leading to novel reaction routes for new or existing products.

Separation systems: The synthesis of total separation systems involving distillation or other separation techniques, such as crystallization and membranes.

Heat recovery, heat power, and utility systems: The design of heat recovery and combined heat and power systems

Process operability and uncertainty in design: The design of integrated systems against a background of variable feedstocks and production requirements, etc., or uncertainty in design parameters (technical or economic).

Batch processes: Systematic approaches to the design of integrated batch processes.

Steady-state and dynamic simulation: Recent research or applications experience in using simulators to evaluate integrated systems

Case studies in process integration: Case studies from continuous or batch processing in the oil, chemical, petrochemical, pharmaceutical, food, cement, steel, and paper industries showing the application of integration techniques.

Further information can be obtained from:

Mr. D. V. Greenwood (Conference Secretary), 45 Hadrian Way, Sandiway, Northwich, Cheshire CW8 2JT, United Kingdom. Tel: 0606 888238.

Dr. R. Smith, Chemical Engineering Department, UMIST, P.O. Box 88, Manchester M60 1QD, United Kingdom. Tel: 061 236-2174.

Mr. P. R. Crump, Design Systems Group ICI Engineering Dept., Brunner House, Winnington, P.O. Box 7, Northwich, Cheshire CW8 4DJ, United Kingdom. Tel: 0606 70-4887.

Washington, DC AIChE Meeting
(November 27-December 2, 1988)

Area 10a Sessions

1-2. Process Synthesis I and II

James M. Douglas (Chairman), Department of Chemical Engineering, University of Massachusetts, Amherst, MA 01003, (413) 545-2252.

3-4. Design and Analysis I and II

G. V. Reklaitis (Chairman), School of Chemical Engineering, Purdue University, West Lafayette, IN 47907, (317) 494-4089.

5. Design of Integrated Biotechnology Process Systems

George Stephanopoulos (Chairman), Department of Chemical Engineering 66-562, Massachusetts Institute of Technology, Cambridge, MA 02139, (617) 253-3004.

6. Design of Polymer Process Systems

Michael F. Malone (Chairman), Department of Chemical Engineering, University of Massachusetts, Amherst, MA 01003, (413) 545-0838.

For further details concerning Area 10a sessions and scheduling, please contact Michael F. Doherty (Area 10a Chairman-Elect), Department of Chemical Engineering, University of Massachusetts, Amherst, MA 01003, (413) 545-2359.

Area 10b Sessions

For further details concerning Area 10b sessions and scheduling, please contact Yaman Arkun (Chairman, Area 10b), Department of Chemical Engineering, Georgia Tech, Atlanta, Georgia 30332, (404) 894-2871.

Area 10c Sessions

Tentative Sessions: **Advanced Computer Architectures** (Mark Stadtherr), and **Computer Integrated Manufacturing for the Process Industry** (Norm Rawson and Verle Schrodt). Other topics suggested include Computing in R and D, Computer Support of Plant Operation, New Technology, and Integration Between Operations Analysis and Control.

For further details concerning Area 10c sessions and scheduling, please contact Ignacio Grossman, School of Chemical Engineering, Cornell University, Ithaca, NY 14853, (607) 255-7204.

Houston AIChE Meeting
(Spring 1989)

Area 10c Sessions

Tentative Sessions: **Innovative Uses of Computer Software and Plant Operations and Maintenance**

For further details concerning Area 10c sessions and scheduling, please contact Ignacio Grossman, School of Chemical Engineering, Cornell University, Ithaca, NY 14853, (607) 255-7204.

News and Information

Information

Members of the CAST Division may be interested to know that most of the material in this newsletter was delivered electronically, either on diskettes or through electronic mail. This time we have used *Bitnet* as our electronic link as it appears to be more easily accessible to many of our members than some of the other options. We encountered some difficulties on file transfers which are not yet understood but in general the communications were smooth. We will continue with *Bitnet* for the next issue and encourage potential contributors to explore this option.

The Editors would like to introduce Fern Lackenbauer of the Xerox Research Centre of Canada who took primary responsibility to collect the incoming files from Peter Rony and to massage them from various word processors and standard fonts into what you have received. Her efforts significantly reduced the load on the Editors and are gratefully acknowledged. She has done a superb job, fitting CAST Communications in between her other priorities.

CALL FOR PAPERS

CAST Sessions at New Orleans AIChE Meeting
(April 6-9, 1987)

The CAST Division is sponsoring the following sessions at the Spring AIChE meeting in New Orleans:

Area 10a: Computers in Process Design

- Recent Advances in Computer-Aided Process Design
- Simulation and Optimization of Unusual Systems
- Practical Application of Statistical Methods in the Processing Industries
- Applications of Personal Computers
- Industrial Applications of Expert Systems I and II (joint with 10c)

Area 10b: Computers in Process Control

- Industrial Applications of Multivariable Control
- Experiments with On-Line Optimization
- Retrofitting for Improved Process Control (joint with 10a)

Area 10c: Computers in Operations and Information Processing

- The Role of Computers in Safety and Reliability I and II
- Computer-Aided Engineering I and II

Area 10d: Numerical Analysis and Applied Mathematics

No New Orleans sessions planned.

The names, addresses, and telephone numbers of the session chairpersons are given below, as are brief statements of the topics to receive special emphasis in soliciting manuscripts for these sessions. Prospective session participants are encouraged to observe the following deadlines:

August 1, 1987: Submit an extended Abstract of no less than 500 words in length to each of the session chairs. Since many of the sessions are likely to be in high demand, the chairmen will, in the case of papers of equal interest, select papers by earliest submission date.

September 15, 1987: Authors informed of selection and session content finalized.

March 1, 1988: Two copies of the final manuscript submitted to the session chair.

Prospective participants should note that these deadlines conform with the new timetables set by AIChE. The deadlines are firm and contain no slack or grace period. Papers that do not conform with these deadlines will have to be excluded from the meeting program.

Recent Advances in Computer-Aided Process Design

Topic of Interest Include:

- Implementing New Design Criteria (operability, optimality, etc.)
- New Models and Solution Algorithms (unit operations, processes, etc.)
- New Flowsheet Convergence Methods (simultaneous, sequential, etc.)
- Advances in Simulation (including batch and continuous processes)
- Direct Design Methods (instead of case studies with rating programs)
- Data Integration Methodology (data organization, storage, retrieval, etc.)
- Interactive and/or Al-Based User Interface (graphics, robust systems, etc.)

Chairman

Dr. Henry H. Chien
Monsanto Company
800 N. Lindbergh Blvd.
St. Louis, MO 63167
(314) 694-6412

Co-Chairman

Prof. Jude T. Sommerfeld
School of Chemical Engineering
Georgia Institute of Technology
Atlanta, GA 30332-0100
(404) 894-2873

Simulation and Optimization of Unusual Systems

This session will deal with simulation of difficult/unusual chemical processing systems. The systems may be steady state or dynamic, but have challenged the routine capabilities of currently available simulators. Systems might include:

- Reactive Distillations
- Difficult to Converge Systems
- Electrolyte Systems
- Inorganic Systems such as Sulfuric Acid
- Non-Equilibrium Models
- Optimization

Chairman

Edward M. Rosen
Monsanto Company
800 N. Lindbergh Blvd.
St. Louis, MO 63167
(314) 694-6412

Co-Chairman

Heinz A. Preisig
Department of Chemical Engineering
Texas A&M University
College Station, TX 77843
(409) 845-0386

Practical Applications of Statistical Methods in the Processing Industries

Speciality chemicals have stimulated the process industry to produce low-volume high-quality products in multi-product plants. The purpose of this symposium is to bring together scientists and engineers from academia and industry to discuss the use of statistical methods to meet the requirements of such processes. Topics to be addressed may include:

- Statistical Methods in Model Building
- Quality Control Programs for Specialty Plants
- Sensitivity Analysis

- Plant Design under Uncertainty
- Model Identification from Plant Data

Chairman

Gary E. Blau
The Dow Chemical Company
1776 Building
Midland, MI 48674
(517) 636-5170

Co-Chairman

David M. Himmelblau
Department of Chemical Engineering
University of Texas
Austin, TX 78712
(512) 471-7445

Applications of Personal Computers

Papers, including those that have a tutorial and broad overview nature, are solicited on the application of personal computers in chemical engineering. This session presents an opportunity for discussions of the applications–to industrial process and product development, data analysis, communications, research, the undergraduate laboratory, and instructional activities–of personal computer hardware, software and systems. Potential topics include, but are not limited to:

- Use of personal computers in instrumentation and controls, pilot plants, research labs, undergraduate laboratories, and so forth
- Survey, comparisons of, and uses of available chemical engineering mainframe and minicomputer design packages that have recently been converted to personal computer use
- Overviews and surveys of available software, hardware, or systems
- Special-purpose personal computer software, hardware and systems
- Available personal computer software that make significant changes in chemical engineering courses and curricula
- Ideas and suggestions on personal computer applications that exist in other fields

Chairman

Peter R. Rony
Department of Chemical Engineering
Virginia Tech
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Co-Chairman

Babu Joseph
Department of Chemical Engineering
Washington University at St. Louis
St. Louis, MO 63130
(314) 889-6076

Industrial Applications of Expert Systems I & II

These sessions are intended to cover applications of expert systems and artificial intelligence for planning, optimization, and control of plant operations. Papers are solicited for on-line and off-line applications with emphasis on one or more of the following–functionality, systems, tools, tool-kits, and hardware. Papers describing experience and acceptance by operations personnel are also of interest.

Chairman

Moe Sood
Modil R&D Corporation
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Princeton, NJ 08546
(609) 737-4960

Co-Chairman

Kris Kaushik
Shell Oil Company
P.O. Box 2099
Houston, TX 77252-2099
(713) 241-2098

Industrial Applications of Multivariable Control

Session is intended to yield a snapshot of the state-of-the-art in applications of multivariable control. Preference will be given to applications of advanced algorithms which demonstrate the usefulness of theoretical developments in the past 15 to 20 years on full scale industrial processes.

Chairman

Heinz A. Preisig
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(409) 845-0386

Co-Chairman

Simon Tuffs
Process Control and Computer Technology
Division Alcoa Laboratories
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(412) 337-2946

Experiences with On-Line Optimization

Papers are requested in the area of:

- Methods for On-Line Process Optimization
- Optimizing Control
- Application Studies in On-Line Process Optimization
- Economic Incentives for On-Line Optimization
- Computer Methods for On-Line Optimization
- Case Studies in Implementing On-Line Optimization Methods
- Process Models for On-Line Optimization

In addition, papers on the general area of process design, simulation, and control which address issues in on-line optimization will be considered.

Chairman

Dr. Babu Jospeh
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(314) 889-6076

Co-Chairman

Lynn A. Richard, P.E.
Department Manager
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Retrofitting for Improved Process Control

Both improved product quality and reduction of operating cost are major considerations in today's chemical industry. The most common approach taken to solve both problems is to develop improved control systems. However, in some cases, it might be better to modify the process flowsheet to simplify the control problem. Papers that discuss retrofit procedures for this purpose, or case study applications are of interest.

Chairman

James M. Douglas
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Co-Chairman

Eli Neisenfeld
Applied Synaptics
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Ridewood, MD 21139
(301) 821-5178

Computers in Safety and Reliability

Topics of interest include local and global automated safety systems; computer-failures; surveillance systems; automated shutdown systems; and new computer-implementable algorithms for safety and reliability.

Chairman	*Co-Chairman*
Prof. Richard S.H. Mah	Prof. Ernest J. Henley
Department of Chemical Engineering	Department of Chemical Engineering
Northwestern University	University of Houston
Evanston, IL 60201	Houston, TX 77004
(312) 491-5357	(713) 749-4947

Computer-Aided Engineering

I. Systems and Tools

This session will address the development of innovative applications of hardware (PCs,workstations, mainframes) and software systems and tools for process engineers. Topics can include, but are not limited to, integration of process engineering tools, integrations with down-grade systems, for example, CAD, impact of new hardware on computer-aided design tools, data input, results presentation, and new process design aids.

II. Data Management

Data management systems (DMS) are used in integrated process engineering systems, expert systems for process design project management, research and development for planning and controlling plants. This session will focus on the applications and development of systems for process, project and plant engineering. Papers can include one or more of the following: data models, distributed data management systems, applications experiences and benefits, uses and limitations of data base packages, potential and future prospects for engineering DMS.

Chairman	*Co-Chairman*
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(304) 747-3710	Norco, LA
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