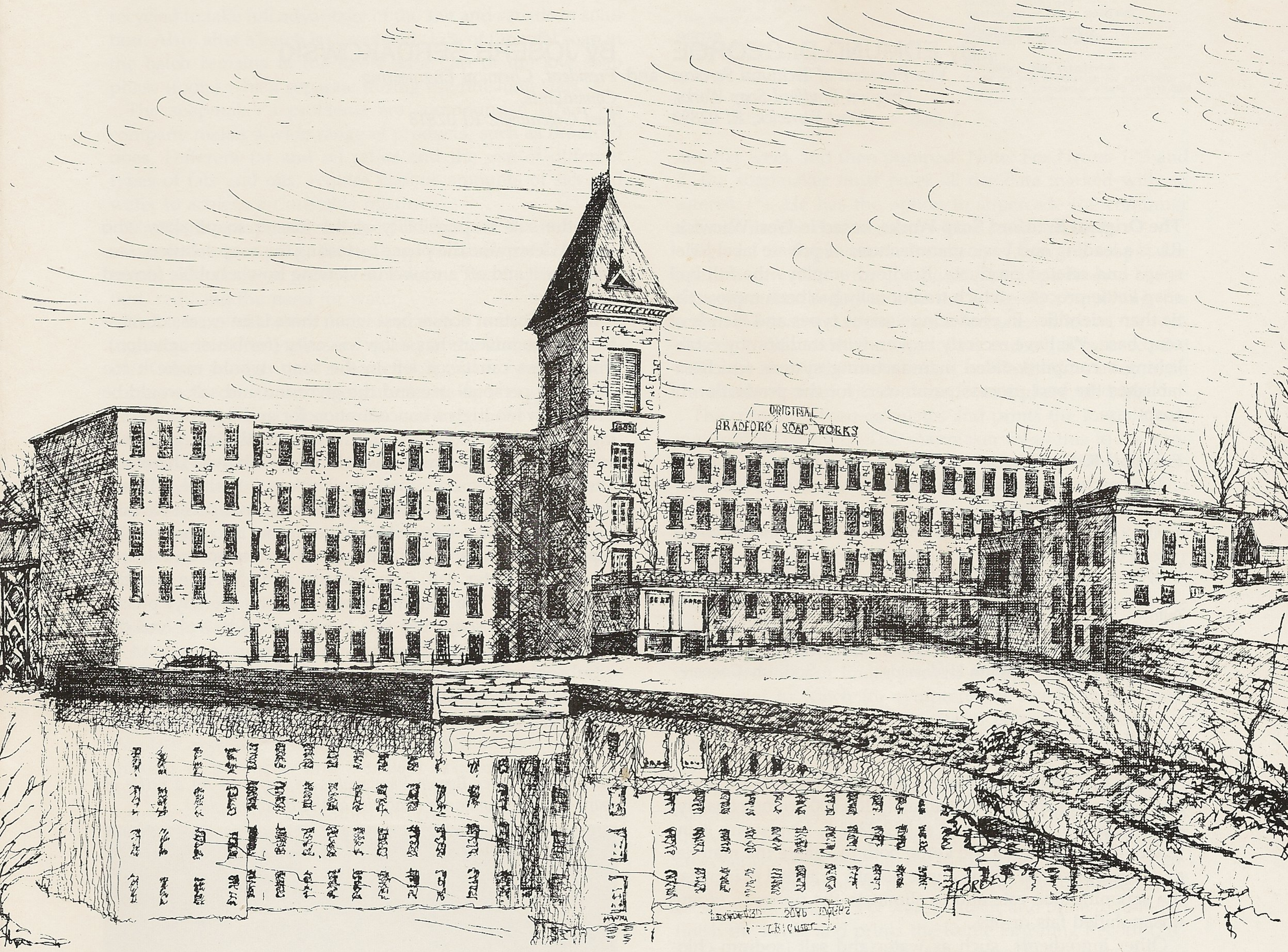
A REPORT FROM BRADFORD SOAP



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COMPUTER MODELING
in the Full Boil Soap Making Process

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The Original Bradford Soap Works, based in West Warwick, RI, is a leading and basic manufacturer of private label toilet soaps and related products. Bradford employs the full boil soap kettle process—which traditionally has been more artistic than scientific—in producing various types and blends of soap base. We have recently broken with tradition by establishing a computer-aided manufacturing system which establishes the best process parameters for the production of soap base.

Full Boil Kettle Process

The reaction to make soap (saponification) is as follows:

FATS	+ CAUSTIC→	SOAP+GLYCERINE
Tallow	Sodium Hydroxide	Sodium Tallowate
Tallow	Potassium Hydroxide	Potassium Tallowate
Coconut Oil	Sodium Hydroxide	Sodium Cocoate

Other combinations are possible.

In the Full Boil Kettle Process the above reaction occurs in large tanks or kettles (approximately 100,000 pound capacity) at atmospheric pressure and at 212-220° F. Live steam is injected at the bottom of the kettle both to agitate the material and to supply heat. Extra caustic usually is added to increase the saponification rate and to eliminate the presence of any unsaponified fats or oils.

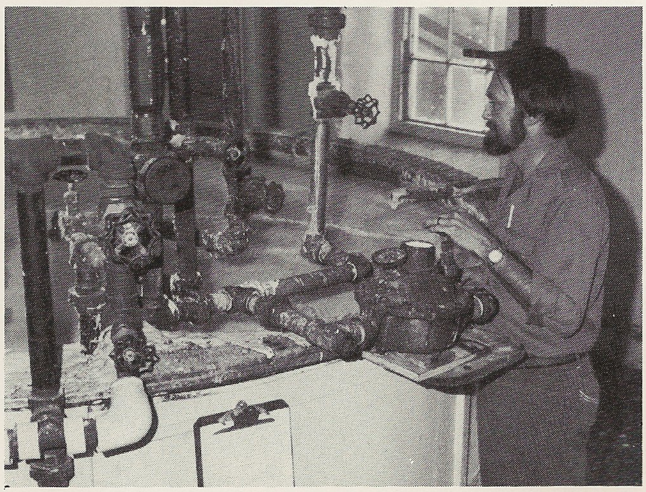
Other ingredients, such as water and salt (sodium chloride), are present to control the physical properties of the total kettle. The five materials (soap, glycerine, excess caustic, water and salt) when mixed and reacted together in different ratios, result in a material that ranges from a water-thin liquid to a sticky, tar-like substance. Not every combination of these ingredients is stable. Some combinations will result (if allowed to settle) in two phases, which results in a top and bottom layer. (For a more detailed discussion of the phase diagram of soap solutions, see Reference [1]).

It is the recognition and control of these phases which is the key to making soap via this method. Traditionally, this was the sole responsibility of the master soapmaker, who would determine the phase by tasting the soap solution, seeing how it slid off a trowel or viewing how a bubble formed and broke.

Saponification occurs best when there is an excess of caustic and the mixture has a low viscosity (for better agitation). This excess caustic, if left in the soap, would make it too harsh for personal use and the glycerine and salt would be present in too high a concentration for subsequent processing into high quality bar soap. In addition, the energy cost to evaporate the excess water would be prohibitive. Therefore, after the batch is saponified, the kettle is "washed." This is done by adding more salt and water to form an unstable mixture which, when allowed to settle, forms two phases. The top phase contains virtually all of the soap and lesser amounts of water, salt, excess caustic and glycerine than the bottom phase. The bottom phase (called the spent lye phase) contains some soap, but this is removed (drawn) and the glycerine is extracted from it.

Subsequent washings are performed until the batch has the proper composition of soap, electrolyte and water. The final washing (or finish) is performed to achieve a solution

Master soapmaker Bernie Pion makes adjustments on a kettle of soap, based on computer analysis, at the Bradford plant.



low in moisture (for drying efficiency), low in excess caustic (for mildness) and with the proper amounts of glycerine and salt to produce a bar with good feel, foaming and workability. We have also developed a post-finishing step to further reduce any batch-to-batch variation in these properties.

Since the soapmaker is relying upon subjective tests, he cannot always identify the exact blend of salt and water required to create a mixture with sufficient instability to settle quickly. A kettle with a proper ratio of ingredients will phase-separate in as little as four hours. A kettle with an improper ratio will not settle at all!

The soapmaker's problem is complicated by the occasional use of recycled materials. Not all of the spent lye produced has sufficient amounts of glycerol for recovery. The lye is recycled to take full advantage of the salt and caustic in solution. Also, after a batch is completed, 15% of the total soap in the batch remains in the kettle as a part of the low soap phase (foots) which separate during the finishing step.

The soapmaker's problems are compounded when his company makes a wide range of products, such as Bradford does. Different fat and oil ratios and the use of different types of fats and oils, require various amounts of salt and water to achieve an unstable mixture.

Finally, the soapmaker is forced to adjust for the amount of steam which is required for heating. Relatively cool raw materials will condense more steam during heating and agitation, reducing the need for water.

Problems result when the soapmaker is forced to achieve high standards for yields and quality and still meet a schedule. Given enough time a master soapmaker could achieve correct salt, caustic and moisture levels in every batch, by repetitive washings. Too much washing, however, lowers the yield, reduces the glycerine content of the soap and produces excess spent lye, low in glycerine content, which must be treated. It also results in extra work and interruption of subsequent production which is dependent upon a constant flow of soap out of the soap room. Finally, the post-finishing operation is slowed if the batch has not been "fitted" properly.

Historical Efforts

Attempts to quantify the soapmaking process are not new. Wigner[2] outlines a quantitative method for making soap. Davidsohn[1] et al provide much technical data on soapmaking; many consider it the soapmaking bible. A new book by Woolatt[3] appears to summarize all published data on soapmaking in a concise and excellent fashion. We have attempted to take the contributions of others plus the over 100 years of experience at Bradford and create a computer model for this traditional manufacturing process.

Kettle Soap Process Simulator (KSPS)

In order to reduce the problem areas mentioned above, the Kettle Soap Process Simulator (KSPS) was designed to provide the soapmaker with parameters for loading and finishing the kettles. These targets were developed from a large data base by incorporating five critical areas in the soapmaking process. *Table I* shows typical examples of the computer-generated KSPS inputs/outputs.

The following figures demonstrate the procedure by which the soapmaker uses the KSPS to assist him in batch making. The product demonstrated is a fictitious low grade industrial soap, "Indust," which is loaded on the foots from another fictitious soap, "Custum." For simplicity, Indust is loaded, allowed to settle for a week, finished, allowed to settle for another week and then pumped. Note: For *Figures 1, 3* and *5*, the soapmaker must enter all the data marked with an asterisk (*). He has the option to supercede the computer defaults for the data marked with a cross hatch (#).

KSPS Inputs/Outputs

Loading Phase

REQUIRED SOAPMAKER INPUTS:
Lot Number
Kettle in use
Type of Soap to be made
Type/Size of seat at the start of the batch
Type of Fats and Oils used
Amount/Source of Lye to be recycled
Water/Brine meter reading

OPTIONAL SOAPMAKER INPUTS:
Composition different from default
-Seat/Caustic/Brine/Lye
Lye temperature different from default

PROCESS ENGINEER INPUTS:
Kettle dimensions/capacities
Frequency of loading rate information
Batch boiling temperature
Loading targets
Formulary
Raw materials physical properties:
- Density
- Molecular weight
- Purity
- Temperature
- Heat Capacity
- Heat of Reaction

Steam energy content

OUTPUTS:
Loading quantities
Loading rate guidelines/Meter readings

Opening/Finishing Phases:

REQUIRED SOAPMAKER INPUTS:
Lye removed
Lye temperature

OPTIONAL SOAPMAKER INPUTS:
Changes in Loading Quantities
Lye composition
Curd composition
Observations on kettle appearance

PROCESS ENGINEER INPUTS:
Opening/Finishing targets
Cooling rate information
Evaporation rate information

OUTPUT:
Opening/Finishing quantities
Warning if kettle is not typical

Data Base Generation

REQUIRED SOAPMAKER INPUTS:
Soap/Lye volume and temperature
Soap pumping rate
Soap composition

OPTIONAL SOAPMAKER INPUTS:
Changes in Opening/Finishing
Lye/Seat composition
Observations on kettle appearance

PROCESS ENGINEER INPUTS:
Performance Index Parameters

OUTPUT:
Performance Index Calculation
Predicted Seat composition for next batch
42 pieces of information stored in Data Base

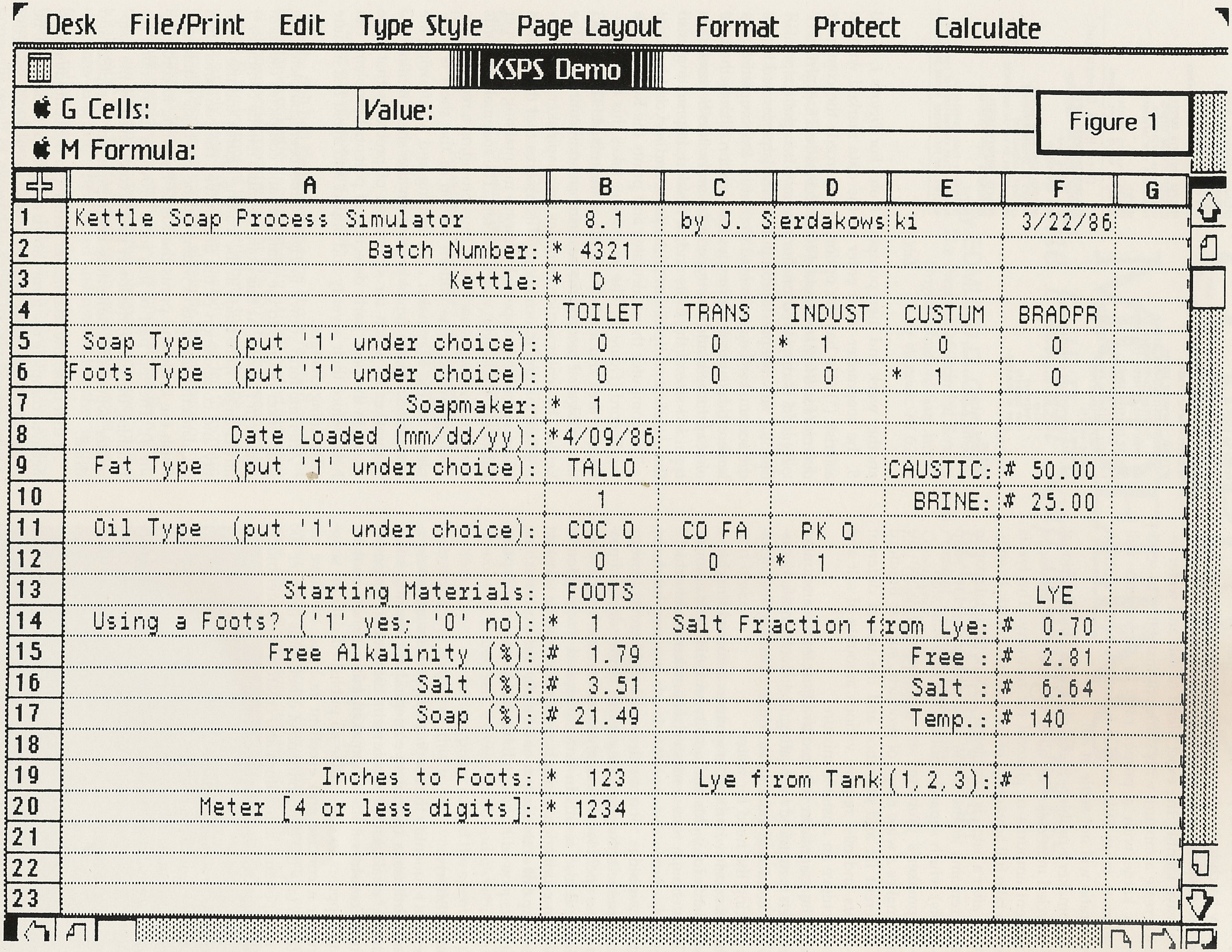
Table I.

Figure 1 is displayed on the screen when the soapmaker opens a new file on the computer. This is performed before the soapmaker begins to load the kettle. By completing this screen the soapmaker provides information such as the type of soap to be made, the type of fat and oil to be used, the type and size of the foots and, if needed, information as to the chemical composition of the foots and recycled lye.

The computer then calculates and prints the Kettle Loading Record (*Figure 2*). The soapmaker takes this to the production area and loads the kettle as instructed. The top section of *Figure 2* records the basic information concerning the kettle. The center section provides the soapmaker with intermediate loading information. This assures that the kettle is being saponified properly by always maintaining the proper balance of electrolyte, water and fats. The soapmaker records the actual values at each step, thus providing a record of the loading process. The bottom section of the sheet is completed by the soapmaker after settling and lye drawing are completed. Alarm limits printed on the sheet remind the soapmaker to watch for symptoms of problems that have arisen in the past. Early detection of potential problems can help reduce their severity and impact and avoid last minute scheduling changes.

After the form shown in *Figure 2* has been completed the soapmaker returns to the computer and completes the form shown in *Figure 3*. At this point he must tell the computer if any changes were made in the loading figures and the quantity and composition of the drawn lye. The computer then caculates the amounts of water, caustic and brine required to finish the kettle and prints the Kettle Finishing Record (*Figure 4*). The top part of this form provides instructions for finishing the batch; the lower part is completed by the soapmaker when the kettle has been pumped, sampled and dried.

At that time, the soapmaker returns to the computer once again to complete the form shown in *Figure 5*. In doing so, he is telling the computer of any changes made in the predicted finishing figures and the remaining foots. This information is used by the computer to calculate the Performance Index for that kettle. In all, 42 pieces of information concerning the kettle are stored in the Kettle Soap Data Base. For the exam-



	A	B	C	D	E	F	G
1	Kettle Soap Process Simulator	8.1	by J. Serdakowski			3/22/86	
2	Batch Number:	* 4321					
3	Kettle:	* D					
4		TOILET	TRANS	INDUST	CUSTUM	BRADPR	
5	Soap Type (put '1' under choice):	0	0	* 1	0	0	
6	Foots Type (put '1' under choice):	0	0	0	* 1	0	
7	Soapmaker:	* 1					
8	Date Loaded (mm/dd/yy):	*4/09/86					
9	Fat Type (put '1' under choice):	TALLO			CAUSTIC:	# 50.00	
10		1			BRINE:	# 25.00	
11	Oil Type (put '1' under choice):	COC O	CO FA	PK O			
12		0	0	* 1			
13	Starting Materials:	FOOTS				LYE	
14	Using a Foots? ('1' yes; '0' no):	* 1	Salt Fraction from Lye:			# 0.70	
15	Free Alkalinity (%):	# 1.79			Free :	# 2.81	
16	Salt (%):	# 3.51			Salt :	# 6.64	
17	Soap (%):	# 21.49			Temp.:	# 140	
18							
19	Inches to Foots:	* 123	Lye from Tank(1,2,3):			# 1	
20	Meter [4 or less digits]:	* 1234					
21							
22							
23							

Figure 1.

Figure 2

```
**** ORIGINAL BRADFORD SOAP WORKS - KETTLE LOADING RECORD ****          VERSION
LOT# K- 1234  KETTLE: D     SOAPMAKER  BP     TYPE: INDUST   DATE: 4/09/86    8.1

         SOAP      FREE      SALT     TOTAL SOAP      TALLO     LAB
OPEN    46.88%     1.31%     1.98%    18,720 LBS       60%      ANALYSIS?
FOOTS   21.49%     1.79%     3.51%       522 LBS       83%      yes         123 IN.DOWN
LYE      1.00%     2.81%     6.64%        26 LBS       60%      no          140 °F

***** L O A D I N G   R A T E   I N F O R M A T I O N *****   TIME LOADING START: ______

 TALLO|PK O | C A U S T I C |   L Y E         | B R I N E      | W A T E R     |
  GALLONS   |   GALLONS     |   GALLONS       | CUBIC FEET     | CUBIC FEET    |
  ACTUAL    |  AIM   ACTUAL |  AIM    ACTUAL  |  AIM   ACTUAL  |  AIM   ACTUAL |
      |     |  50.00 Bé     |                 |  25.0 %        |               |
      |    0|  0      ______|  0-25   ______  |      0______   |  0     ______ |
      |  350| 107-127 ______|                 |                | 23-33  ______ |
      |  700| 223-243 ______| .5 LYE FACTOR   |BRINE SAMPLE    | 50-60  ______ |
      |  956| 309-329 ______|                 |TO LAB: Y  N    | 71-81  ______ |
      |     |               |                 |                |               |
  200 |     | 328-348 ______|  30-50  ______  |  00    ______  | 73-83  ______ |
  400 |     | 348-368 ______|  69-89  ______  |  00    ______  | 75-85  ______ |
  600 |     | 368-388 ______| 109-129 ______  |  00    ______  | 77-87  ______ |
  800 |     | 388-408 ______| 149-169 ______  |  00    ______  | 79-89  ______ |
 1000 |     | 407-427 ______| 188-208 ______  |  0-4   ______  | 81-91  ______ |
 1200 |     | 427-447 ______| 228-248 ______  |  4-8   ______  | 83-91  ______ |
 1400 |     | 447-459 ______| 268-282 ______  |  7-9   ______  | 85-91  ______ |
      |     |         ______|         ______  |        ______  |        ______ |
      |     |         ______|         ______  |        ______  |        ______ |
      |     |         ______|         ______  |        ______  |        ______ |
      |     |         ______|         ______  |        ______  |        ______ |
L O A D I N G   T O T A L S
 1421   956    459  ______     282   ______     9     ______     91    ______

O P E N I N G    BOIL 15 MINUTES AFTER LOADING BEFORE OPENING. TIME OPENING START: ______
ADDITIONS        30  ______                     19    ______     19    ______
 1421   956     489  ______     282   ______    28    ______    110    ______

# A L A R M #:  DRAW KETTLE AFTER 4 HOURS IF FIGURES ARE CHANGED.   TIME OPEN END: ______
=========================================================================================
K E T T L E   D R A W I N G
DATE  TIME   BY    TO TANK  START STOP  TOTAL APPEARANCE   SAMPLE FREE  SALT  TEMPERATURE
____ _____ _____  1  2  3   _____ _____ _____ SYRUP SOAPY   Y  N  _____ _____ _____°F
____ _____ _____  1  2  3   _____ _____ _____ SYRUP SOAPY   Y  N  _____ _____ _____°F
____ _____ _____  1  2  3   _____ _____ _____ SYRUP SOAPY   Y  N  _____ _____ _____°F

A I M S                 # A L A R M S #
INCHES:    15-25        IF INCHES REMOVED ARE DIFFERENT FROM AIM, ANALYZE LYE SAMPLE
FREE:    2.00-3.60      IF SYRUP OR SOAPY APPEARANCE, ANALYZE LYE SAMPLE
SALT:    6.10-7.20      IF ANALYSIS IS DIFFERENT FROM AIM
                        R E P O R T   A L A R M S   T O   B E R N I E
```

Figure 2.

ple illustrated here, the Performance Index is "72" (Cell coordinates Q-15 on *Figure 5*).

Figure 4

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**** ORIGINAL BRADFORD SOAP WORKS - KETTLE FINISHING RECORD ****            VERSION
LOT# K- 1234 KETTLE: D  SOAPMAKER: BP        TYPE: INDUST   DATE: 4/16/86     8.1

                 SOAP       FREE   SALT   SAMPLE?     WEIGHT
CURD:           54.73%     1.06%   .99%   no          33,055 LB     202.572°F
FINISHING:      51.10%      .99%   .92%               18,651 LB SOAP

LYE REMOVED:     1.00%     2.81%  6.64%   no           6,865 LB          15 INCHES

F I N I S H I N G   T O T A L S
                                 C A U S T I C| B R I N E   | W A T E R   |
TIME START:   ______              GALLONS     | CUBIC FEET  | CUBIC FEET  |
TIME END:     ______             AIM  ACTUAL  | AIM  ACTUAL | AIM  ACTUAL |
APPEARANCE BEFORE FINISHING                   |             |             |
Overgrained  Wet  Dry             0    0______| 00   ______ | 28-38 _____ |
                                                         #ALARM IF FIGURES CHANGE#
# A L A R M   S U M M A R Y #   IF ALARMS ARE PRESENT, SAMPLE FROM KETTLE BEFORE PUMPING

LOADING FIGURES CHANGE?   no
DRAWN LYE       FREE:   OKAY
                SALT:   OKAY
              INCHES:   OKAY

P U M P I N G   I N F O R M A T I O N
              TIME       TIME   INCHES      INCHES RATE
DATE  BY    START STOP  TOTAL  START STOP   TOTAL  IN/MIN  PUMP TO:           TEMPERATURE
____ ____  _____ _____  _____  _____ _____  _____  _____   A B MAZ CRUT _____ _____°F
____ ____  _____ _____  _____  _____ _____  _____  _____   A B MAZ CRUT _____ _____°F
____ ____  _____ _____  _____  _____ _____  _____  _____   A B MAZ CRUT _____ _____°F

F O O T S   L Y E   D R A W I N G     #ALARM#  IF FOOTS LYE IS GREATER THAN   5 INCHES
                                               IF SYRUP OR SOAPY APPEARANCE
DATE  TIME  BY     TO TANK  START STOP  TOTAL APPEARANCE  SAMPLE FREE  SALT  TEMPERATURE
____ _____ _____  1  2  3   _____ _____ _____ SYRUP SOAPY  Y  N  _____ _____ _____°F
____ _____ _____  1  2  3   _____ _____ _____ SYRUP SOAPY  Y  N  _____ _____ _____°F

L A B   A N A L Y S I S

NEAT   %H2O   %FREE  %SALT  %GLYC  %SOAP      MISC. ANALYSIS    %SOAP     %FREE  %SALT
BEST:  27-30  <0.1   0.42   2.0    67-70
       _____  _____  _____  _____  _____      FOOTS:            ______    _____  _____
       _____  _____  _____  _____  _____      CURD(After Finish)______    _____  _____

C O M M E N T S:                      GLYCERINE BY: Actual  Composite  Estimate
_______________________________________________________________________________________
```

Figure 4.

The Bradford Laboratory

Bradford's leadership position in the soap and synthetic detergents industry is the result of a detailed understanding of the many manufacturing processes used today. Bradford's modern laboratory facility allows three chemists and 13

Desk File/Print Edit Type Style Page Layout Format Protect Calculate

KSPS Demo

G Cells: Value:

M Formula:

Figure 3

	G	H	I	J	K	L	M	N
1		OPENING FIGURES:		(pounds)		FINISHING DATE:	4/16/86	
2		Fat Actual(gal):	# 1421	10,491				
3		Oil Actual(gal):	# 956	7,053		Water Added to Curd		
4		Caustic Actual(gal):	# 489	6,151		before sample(cu.ft):	* 10	
5		Lye Actual(gal):	# 282	3,682		CURD ANALYSIS:		
6		Brine Actual(cu.ft):	# 28	1,850		Soap (%):	# 54.73	
7		Water Actual(cu.ft):	# 110	6,224		Free (%):	# 1.06	
8		Steam (pounds):		2,085		Salt(%):	# 0.99	
9		Foots (pounds):		2,431		Electrolyle(%):	# 2.19	
10		Total Batch (pounds):		39,967		Batch hot (pounds):	33,055	
11		LYE DRAWING DATES:	#4/16/86					
12		Drawn by:	# 5					
13		To Tank(1,2,3):	# 1					
14		Inches Start:	* 15					
15		Inches Stop:	* 30					
16								
17								
18		LYE ANALYSIS:						
19		Free Alkalinity (%):	# 2.81					
20		Salt (%):	# 6.64					
21		Temperature (°F):	# 162					

Figure 3.

skilled technicians to constantly probe and explore the many nuances of existing and proposed products. The lab routinely formulates customized products to meet the needs of Bradford's customers. The lab is organized into five sections: Quality Assurance, Analytical Instruments, Quality Control, Application Lab and Bulk Soap Testing.

Along with development of new and improved products, Bradford has pioneered improved analytic techniques[4]. In order to support the development of the KSPS, the laboratory was asked to increase its already extensive evaluation of every kettle. Prior to the KSPS system, three critical tests (water, free alkali and salt) were performed on a real time basis on every kettle, with several other routine tests performed after the kettle was finished. Three additional tests were developed in order to accommodate a wider range of values needed to support the KSPS system:

1. A Percent Soap test was developed that was faster and more accurate than existing methods. Typically, solutions ranging from .5% to 88.0% soap can be analyzed within 30 minutes. Samples include neat soap, lyes and foots.

2. A High Performance Liquid Chromatography (HPLC) determination of 1% glycerine[4] was developed to incorporate a wide range of concentrations while cutting down on the analysis time required by conventional methods. Samples include neat soap, spent lyes, foots, glycerine lyes and finished soap.

3. Computer aided analysis was developed utilizing an IBM PC-XT computer. The Nelson Analytical HPLC software system and various in-house programs have been integrated to quantitate and compile data involving fatty acid distribution, acid value, iodine value, glycerine content and antioxidant system.

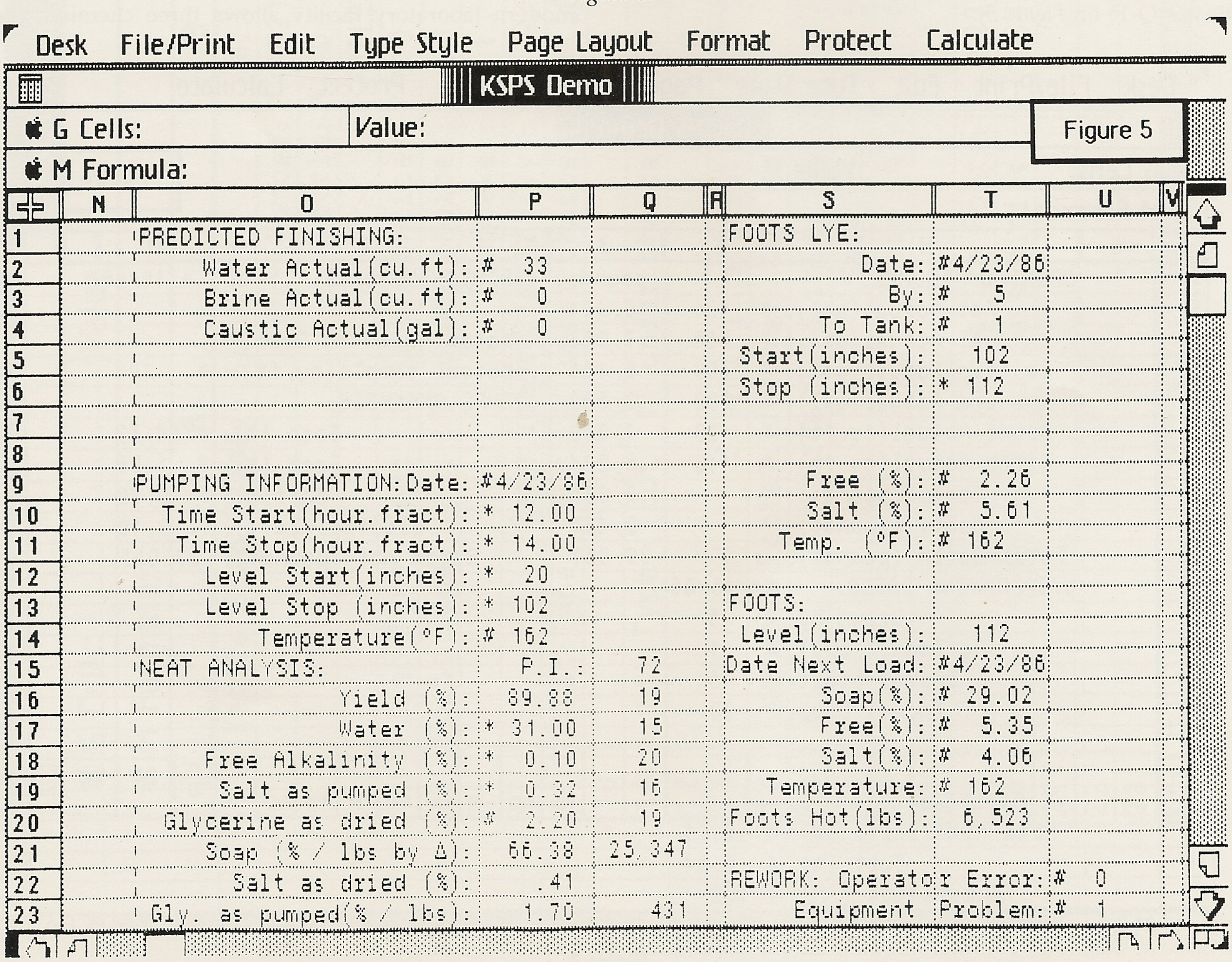
Performance Index Measures Efficiency

We have derived a Performance Index (P.I.) to measure the efficiency of our soap base manufacturing operation. The P.I. is a number from 0-100, as defined in *Table II.*

Table II. Performance Index

VALUE	DEFINITION
80-100	Little or no post-finishing required, excellent yields. No schedule interruptions, extra washings or equipment problems.
70-80	Some post-finishing required, good yields. No schedule interruptions, extra washings or equipment problems.
60-70	Post-finishing required, adequate yields. Minor schedule interruptions, extra washings or equipment problems.
50-60	Post-finishing required, below average yields. Significant schedule interruptions, extra washings or equipment problems.
0-50	Post-finishing required, poor yields. Major schedule interruptions, extra washings or equipment problems.

Figure 5.



	N	O	P	Q	R	S	T	U	V
1		PREDICTED FINISHING:				FOOTS LYE:			
2		Water Actual(cu.ft):	# 33			Date:	#4/23/86		
3		Brine Actual(cu.ft):	# 0			By:	# 5		
4		Caustic Actual(gal):	# 0			To Tank:	# 1		
5						Start(inches):	102		
6						Stop (inches):	* 112		
7									
8									
9		PUMPING INFORMATION:Date:	#4/23/86			Free (%):	# 2.26		
10		Time Start(hour.fract):	* 12.00			Salt (%):	# 5.61		
11		Time Stop(hour.fract):	* 14.00			Temp. (°F):	# 162		
12		Level Start(inches):	* 20						
13		Level Stop (inches):	* 102			FOOTS:			
14		Temperature(°F):	# 162			Level(inches):	112		
15		NEAT ANALYSIS:	P.I.:	72		Date Next Load:	#4/23/86		
16		Yield (%):	89.88	19		Soap(%):	# 29.02		
17		Water (%):	* 31.00	15		Free(%):	# 5.35		
18		Free Alkalinity (%):	* 0.10	20		Salt(%):	# 4.06		
19		Salt as pumped (%):	* 0.32	16		Temperature:	# 162		
20		Glycerine as dried (%):	# 2.20	19		Foots Hot(lbs):	6,523		
21		Soap (% / lbs by Δ):	66.38	25,347					
22		Salt as dried (%):	.41			REWORK: Operato	r Error:	# 0	
23		Gly. as pumped(% / lbs):	1.70	431		Equipment	Problem:	# 1	

A condensed formula for the performance Index is expressed mathematically below:

$$\prod_{m=1}^{M} \left\{ \sum_{n=1}^{N} \{1-[(X_n-A_n)/(C_n-A_n)]^{P_n}\} H(C_n-X_n)\, H(X_n-D_n)\, B_n \right\} E_m^{F_m}$$

Where:
N=The number of power-law parameters,
M=The number of exponential parameters,
Xn=The value of parameter n,
An=The value of parameter n which yields maximum Performance Points,
Bn=The number of Performance Points assigned to parameter n,
Cn=The minimum value of parameter n for which any Performance Points are allowed.
Dn=The maximum value of parameter n for which any Performance Points are allowed. (For this special case, Dn=2An-Cn),
Pn=The power of the power-law fitted parameter n. For this simplified model, p is restricted to a positive even number (2,4,6 . . .)
Em=The penalty for one occurence of parameter m ($0 \leq E \leq 1$),
Fm=The total number occurences of parameter n,
H(y)=The Heavyside Step Function:

for $y>0$, $H(y)=1$; $y \leq 0$, $H(y)=0$.

We require additional features to generate our Performance Index, but the above expression is sufficient to understand the utility of this approach.

Example: Assume we are concerned with two power law parameters: moisture of the kettle soap and yield; and two exponential parameters: the number of unscheduled openings and equipment problems. We then have the results shown below:

N = 2

n	parameter	An	Bn	Cn	Dn	Pn
1	Moisture %	30	60	29	31	2
2	Yield %	85	40	80	90	8

M = 2

m	parameter	Em
1	Unscheduled Openings	0.80
2	Equipment Problems	0.85

Because P_1 where n=1 is a relatively small number (=2), a kettle in the middle of the desired range (≈ 30) will receive maximum moisture Performance Points, but a kettle on the edge of the range (≈ 30.9) will receive few Performance Points. Because P_2 where n=2 is a relatively large number (=8), a kettle on the edge of the range (≈ 81) will still receive close to the maximum number of Performance Points for the parameter (40).

We examine three cases: an excellent, an acceptable and a poor kettle, with the results shown in *Table III.*

Table III. Three Examples

	EXCELLENT	ACCEPTABLE	POOR
(X_1)Moisture %	30.1	29.4	30.9
Moisture Performance Pts.	59.4	38.4	11.4
(X_2)Yield %	84.9	89.0	79.0
Yield Performance Points	40.0	33.29	0.0
(F_1)Unscheduled Openings	0	0	1
E_1^{F1}	1	1	0.8
(F_2) Equipment Problems	0	0.85	0.7225
E_2^{F2}	1	0.85	0.7225
Performance Index	99.4	60.9	6.6

Charts Indicate Improvements

We have produced two pie charts which display a marked improvement in kettle soap manufacturing performance as a result of implementation of the KSPS (*Figures 6* and *7*). Note the dramatic reduction in the number of kettles below 50,

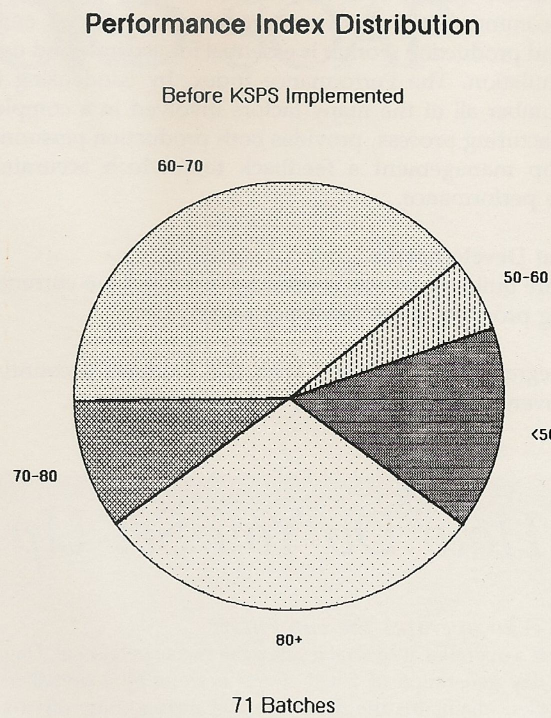
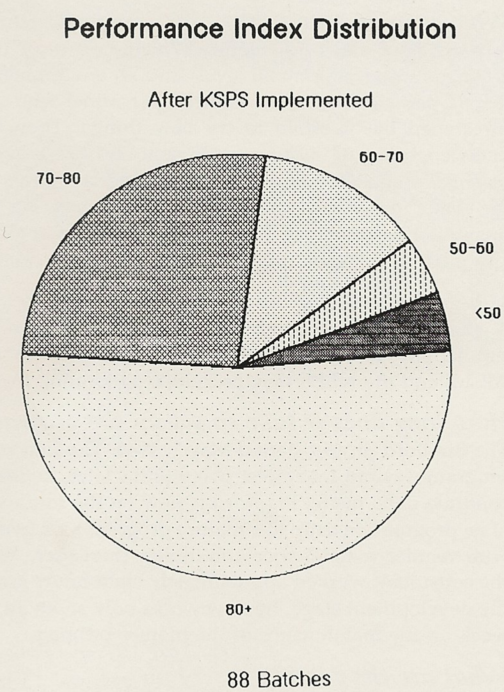


Figure 6.

Figure 7.



and the equally dramatic increase in the kettles exceeding 80. This change has meant dramatically reduced scheduling interruptions, increased overall yields and quality and has allowed management and engineering to devote more time to growth oriented projects.

The KSPS assists experienced soapmakers in their efforts to maximize quality and to conform to tight scheduling. Close communication between programmer, process engineer and production worker is essential for accurate and useful simulation. The Performance Index, by condensing to one number all of the many factors involved in a complex manufacturing process, provides both production personnel and top management a feedback tool which accurately gauges performance.

Current Developments

We are building on our knowledge base and are currently making progress in the following areas:

- Integration of the KSPS with the Bradford accounting and inventory control system,
- Improved tracking of glycerol to aid in glycerol recovery and refining,
- Improved foots composition prediction to decrease lab analysis,
- Improved finishing prediction to further improve the Performance Index,
- Improved KSPS contribution to low volume and specialty products,
- Real time use of incoming fats and oils analysis. ■

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How Do You Set Up a Computer Program?

Who operates the computer?

It's operated at several levels by in house personnel. Day-to-day generation of batch sheets is done by soapmakers; a clerk maintains the data base and does routine reports. A computer programmer checks the work of the clerk and maintains the computer and operating system; a process engineer reviews the data base and Performance Index, generates non-routine reports and makes changes as needed to the program. The consultant outlines the structure of the program, reviews major changes and offers general guidance. Mr. George and the VP-manufacturing oversee the program and approve any changes.

What does it take to set up a computer model?

A number of skills are required, including most notably good communication at all levels and an environment that fosters participation by all affected personnel who are not threatened by or afraid to try new things. Then there's knowledge . . . of existing equipment and processes, laws of physics, mathematical expressions and computer codes; the ability to establish a fair and accurate measuring system to monitor performance. Finally, an outside expert to supply any missing skills and to provide the necessary training.

Where do you find such an expert?

A small but growing number of firms specialize in computer simulation. The Society for Computer Simulation (SCS), the AIChE and the NSPE may be helpful in locating them.

How long does it take to set up the program?

The Bradford project started May 1, 1984. The first working program was put into effect two months later. Refinements continue to be made; Bradford is now on the ninth version of its program. Startup to a mature program took two years, with regular maintenance continuing thereafter. Whereas the consultant worked approximately eight hours a week in the development stage, he now works only about an hour a week on the maintenance of the mature program.

What are the costs?

Labor costs of all the participants (about 27 hours a week during startup; 11 hours a week for the mature program); the cost of additional sampling; and computer hardware and software (about $10,000 initially and $1000 a year for maintenance.)

What are the savings?

It is difficult to separate this project from other ongoing projects, but there has been a significant improvement in the efficiency of the soap base manufacturing operation, which would translate into a substantial cost savings.

What were the major obstacles?

A. Operator acceptance—since soapmaking has traditionally been considered an art, soapmakers were reluctant to believe that a computer could help them. B. One of a kind problems—changing the end product of a kettle after half the ingredients have been added; accommodating weekends and holidays; new product blends. C. Data analysis—spotting subtle trends requires "normalization" techniques to account for seasonal and product differences. D. Transition and training—personnel at all levels must learn to use the computer while at the same time maintaining the existing system. ■

Checking a computer program are consultant Joseph Serdakowski (left) and Edmund George, of Original Bradford.