FIVE YEARS' EXPERIENCE WITH WEAK CATION SOFTENING ON THIN JUICE

Tom Henscheid, Research Manager
Larry Velasquez, Research Technician
Dave Meacham, Research Engineer

THE AMALGAMATED SUGAR COMPANY
RESEARCH LABORATORY
TWIN FALLS, IDAHO

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Section D

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For the past five years Amalgamated Sugar has been softening thin juice at their Twin Falls plant. This past year another installation was commissioned at our Mini-Cassia facility. These softeners were not installed to merely produce soft thin juice even though there are some real advantages to be gained by doing so. The ultimate goal was to produce a soft molasses which could be processed in our chromato-separator. This softening process has been a real success both from the thin juice and molasses standpoint. The first softener was placed in service several years before the separator was built so that the system was perfected and operating well when the separator came on line.

There are various methods available for softening thin juice. Some of the most common are:

1. Conventional strong catex

2. Gryllus process

3. N.R.S. (New Recovery System)

4. Weak catex system

Some of the advantages and disadvantages of each system are listed below.

1. Conventional strong catex

    a. Low operating capacity
    b. Excess regenerant required
    c. Large installation
    d. Waste regenerant

2. Gryllus process

    a. No regenerant chemicals
    b. No dilution
    c. Low resin capacity
    d. Molasses not soft

3. N.R.S. process

    a. Strong catex in sodium form
    b. Thin juice plus sodium hydroxide for regeneration
    c. No dilution
    d. Low resin capacity
    e. Must cool to 40°C for regeneration

4. Weak catex

   a. High resin capacity
   b. Small installation
   c. Minimal dilution
   d. Waste used as pressing aid
   e. Excellent softening
   f. Requires special operating conditions

A good summary appeared in Sugar Technology Reviews in 1988[1].

The Amalgamated Sugar Company uses the weak catex system[2] which was developed in house to soften thin juice. It was first installed in the Twin Falls factory for the 1984-85 beet campaign. Prior to this time a pilot unit was installed which processed about one-third the juice flow. Installation was originally on an upflow basis using two cells. It was later changed to three cells and switched to downflow.

The softener uses a weak catex resin in the hydrogen form. Because of this, special operating conditions have to be imposed on the system in order to prevent inversion of the sucrose. Flow rates through the resin bed are kept very high (40-100 bed volumes/hr) at temperatures slightly above 80°C. With this high flow rate it is imperative that the juice be free of suspended solids. Double filtration of second carbonation juice is practiced at our plants and the filtered juice checked for suspended solids. In the six years of operation suspended solids plugging the resin bed have never shut down the softener. Temperatures are also very critical to the operation because below 80°C bacterial infections became a real problem.

The system incorporates a three-cell design with two cells being exhausted on thin juice simultaneously. These are staggered with respect to exhaustion so that both do not require regeneration at the same time. The third cell is being regenerated or in standby (Figure 1).

The high resin capacity and the fast flow rates make it possible to process the entire factory stream (6200 ton/day slice) with a very small installation compared to other processes using strong catex resins.

When a new cell is placed on line the processed juice exits the cell at a low pH (Figure 2). This is due to the fact that not only calcium and magnesium are exchanged for hydrogen ion but also the sodium and potassium are picked up by the resin. As the cell continues to exhaust, these sodium and potassium ions are displaced from the resin by calcium and magnesium. About 80% of the total resin capacity is occupied by divalent ions at the time the cell is removed from service. The remaining 20% is occupied by sodium, potassium and hydrogen ions.

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[1] Xavier Lancrenon and Daniel Heove, *Sugar Techn. Reviews,* 14 (1988), 207-274.

[2] K. Schoenrock, P. Richey, and H. Rounds, U.S. Patent 3,982,956 (1975).

This low pH juice must be neutralized as soon as possible after exiting the softener in order to reduce invert formation. This can be done by adding either MgO or soda ash. The amount of the invert formed across the softener is then very small. However, as limesalts increase and the system is cycled more often, the amount of invert would also increase. Invert is formed during the first 60 minutes of the cycle (Figure 3) when the pH is low. Toward the end of the cycle the pH approaches the pH of the feed and further neutralization is not needed and no invert is formed.

A characteristic of weak cation resins is that in going form the hydrogen form to the monovalent form the resin swells significantly. If the flow rate is too high so as not to allow this resin to expand it compresses together causing high pressure drop across the resin bed. This swelling lasts for the first 30-60 minutes then starts to decrease again as the monovalent ions are displaced by divalent ions. Cell construction must be such that it allows for this expansion.

Exhaustion cycle length varies with limesalts concentration. Minimum cycle lengths of four hours are necessary to properly turn around a cell and preserve the resin integrity. Cycle length becomes very long as limesalts decrease in concentration and may last 30-40 hours. Figure 4 shows the cycle length versus limesalts concentration for the Twin Falls softener during the 1989-90 campaign. This graph reflects the average of all three cells and over 594 cycles. With high limesalt concentrations the cycle length becomes so short that the softener cells cannot be turned around fast enough. Either some calcium must be allowed to leak through the softener or soda ash must be added to second carbonation in order to get the level down within the ability of the softener to process the juice.

When a cell first comes on line there is a very small amount of divalent ions in the processed juice. This is due to a small amount of divalent ions being left in the resin following regeneration. They may be either attached to the resin or present as residual calcium sulfate. Counter-current regeneration would eliminate this leakage. This quantity is so small that it does not effect juice quality. Divalent ions are totally eliminated from the juice until the resin is nearly totally exhausted. When leakage starts to occur the cell is removed from service and the next cell placed on line (Figure 5).

During sweet-on the water in the cell is pushed foward and goes to the diffuser supply tank. During sweet-off the juice is pushed across the resin and returned to the softener supply. These cutoff points are determined by conductivity with a timed backup. As a result very little water is being pushed forward to the evaporators.

Regeneration is carried out co-current to the juice flow. Sulfuric acid is the regenerant of choice so it can be recycled to the diffuser. Hydrochloric acid presents less of a problem but adds chlorides to the system which is detrimental to stainless steel and is more melassigenic than the sulfate. Since the calcium sulfate formed during regeneration is only sparingly soluble care must be taken to insure that the solubility of this product is not exceeded. To prevent this from happening the acid concentration must be below 0.5%. The disadvantage here is that a large volume of spent regenerant is produced. It can all be used back in the process but must be metered into the diffuser supply at a rate which gives the desired quantity of pressing aid or pH to the diffuser supply water. Early in the regeneration cycle the effluent is primarily calcium sulfate. Toward the end of regeneration the pH drops and the acid concentration is the major constituent. A typical regeneration pH profile is shown in Figure 6.

The weak catex system can be regenerated very efficiently with only 110% regenerant on capacity to give complete conversion to the hydrogen form (Figure 7). If run counter-currently the same regeneration could be achieved with 100% regenerant on capacity. In our process sulfuric acid is used to adjust the pH of the diffuser supply water. Therefore any excess regenerant reduces this requirement and is not wasted.

A typical regeneration profile is shown in Figures 8. Following regeneration a rinse step is very critical to insure that any precipitated calcium sulfate is rinsed from the resin. This also keeps pipes and tanks free from scale. All the water is returned to the diffuser supply water so no waste streams are produced.

The system works very well and produces a thin juice with an average of less than 0.006 gm CaO/100 RDS when the cells are exhausted to the point of leakage. If desired this can be reduced to zero by switching cells at a earlier point.

The benefits gained by softening thin juice are substantial. Our factories have been able to slice more beets because of the clean evaporators. Energy usage per ton of beets sliced has dropped significantly. Evaporator boil-outs are history and scaling of thick juice filters no longer occur. Pan vapors have improved increasing sugar end capacity and allowing the use of lower vapors. The resulting benefits to our process we feel would pay for the installation in about four years. The real pay-out is in producing a molasses that is of sufficient quality to process in the separator without any further softening.

With soft juice there can be some increased corrosion to pipes and evaporators down stream. As a precaution the evaporator bodies were coated above the wetted surfaces. After five years of operation, the corrosion rates have not been excessive. If the evaporators are not coated, there is a slight increase in corrosion rate.

FIGURE 1

THREE-CELL SOFTENER ARRANGEMENT

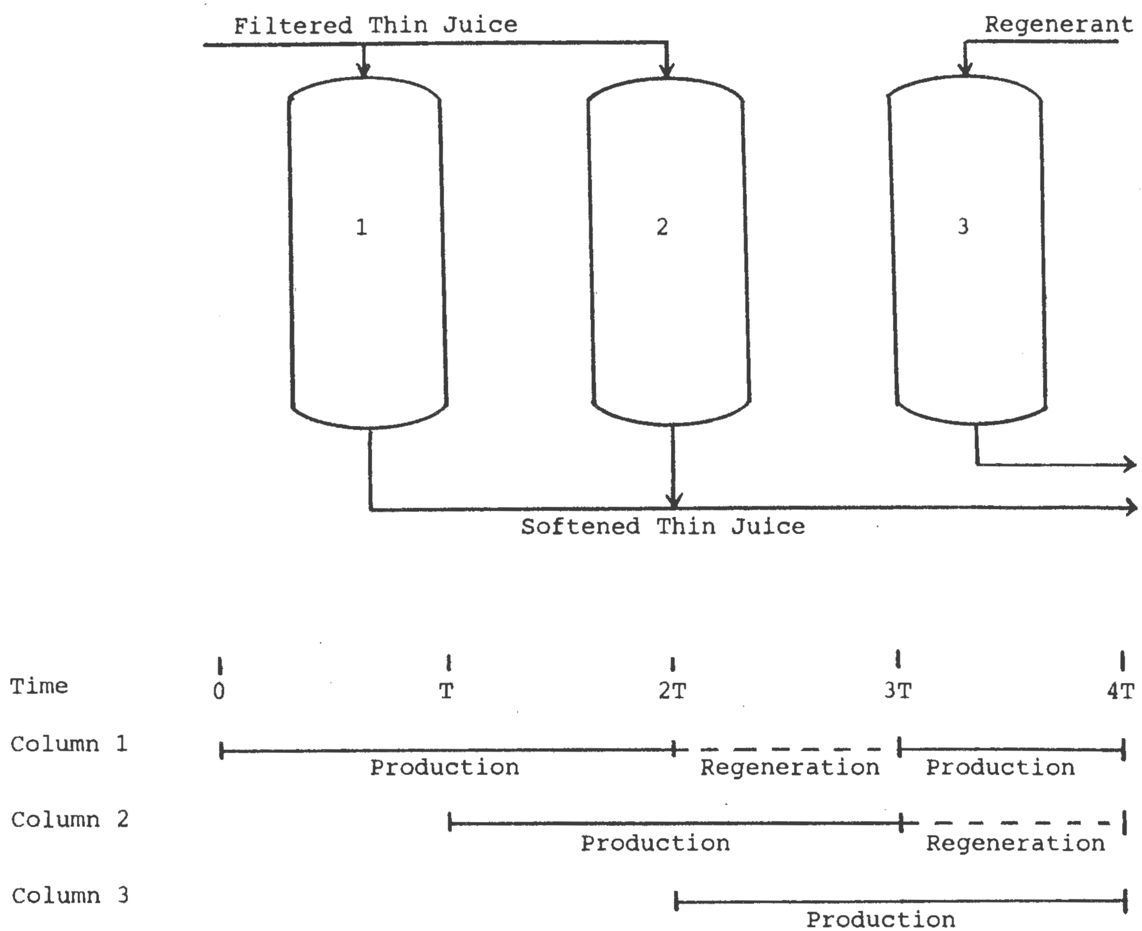

FIGURE 2

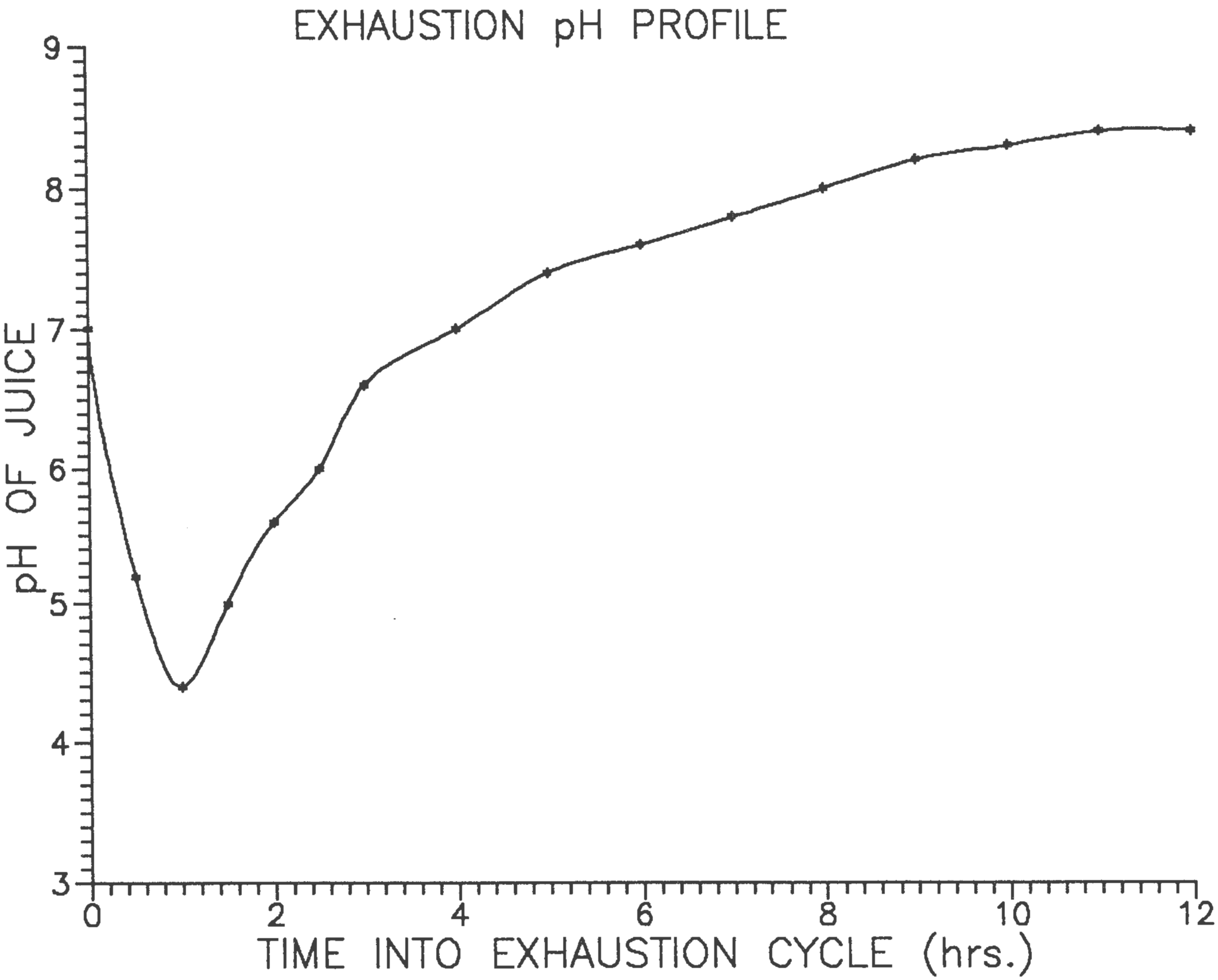
EXHAUSTION pH PROFILE
pH OF JUICE
9
8
7
6
5
4
3
0
2
4
6
8
10
12
TIME INTO EXHAUSTION CYCLE (hrs.)

FIGURE 3

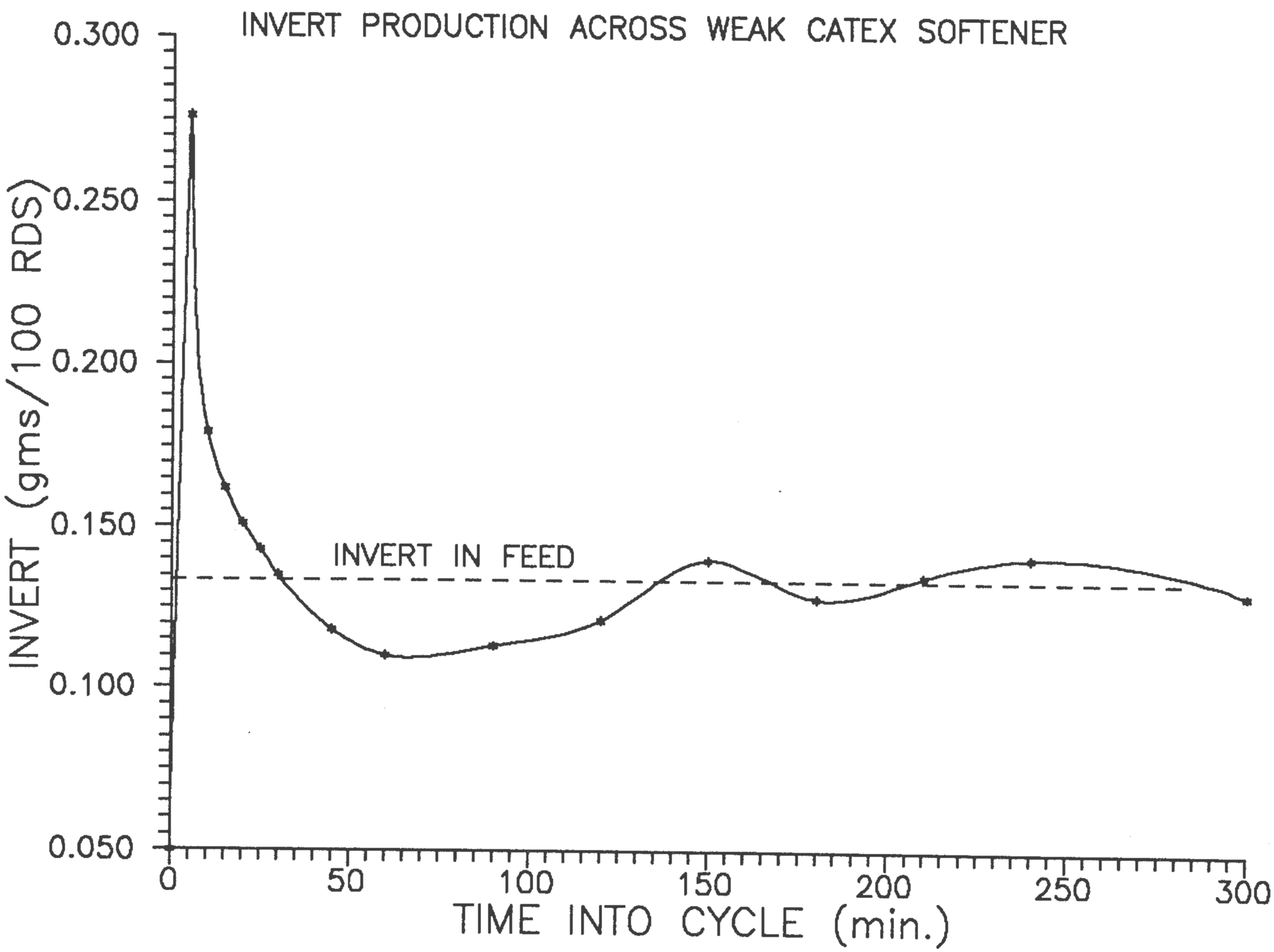
INVERT PRODUCTION ACROSS WEAK CATEX SOFTENER
INVERT (gms/100 RDS)
0.300
0.250
0.200
0.150
0.100
0.050
INVERT IN FEED
0
50
100
150
200
250
300
TIME INTO CYCLE (min.)

FIGURE 4

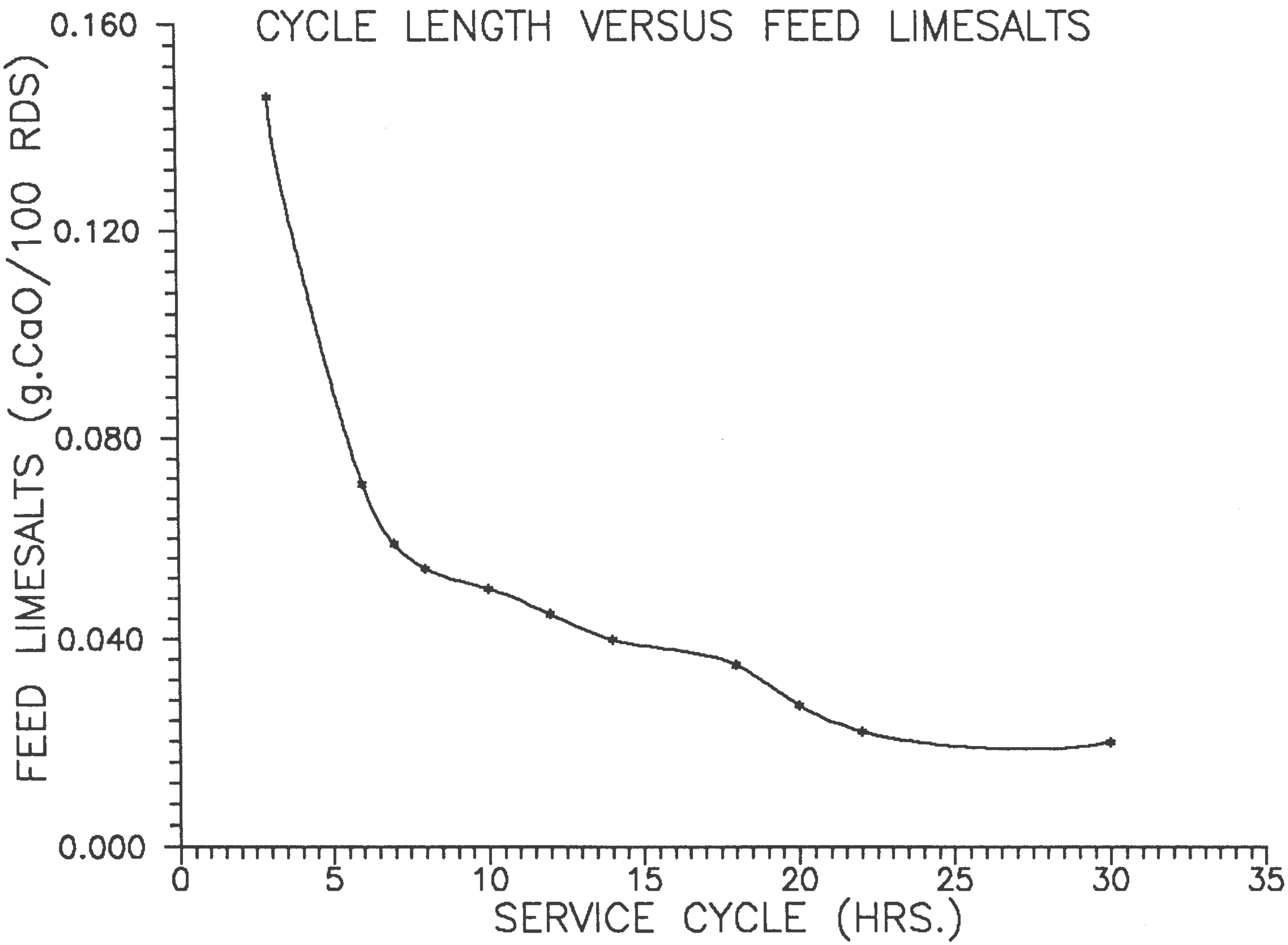
CYCLE LENGTH VERSUS FEED LIMESALTS
FEED LIMESALTS (g.CaO/100 RDS)
0.160
0.120
0.080
0.040
0.000
0
5
10
15
20
25
30
35
SERVICE CYCLE (HRS.)

FIGURE 5

SOFTENER EXHAUSTION PROFILE

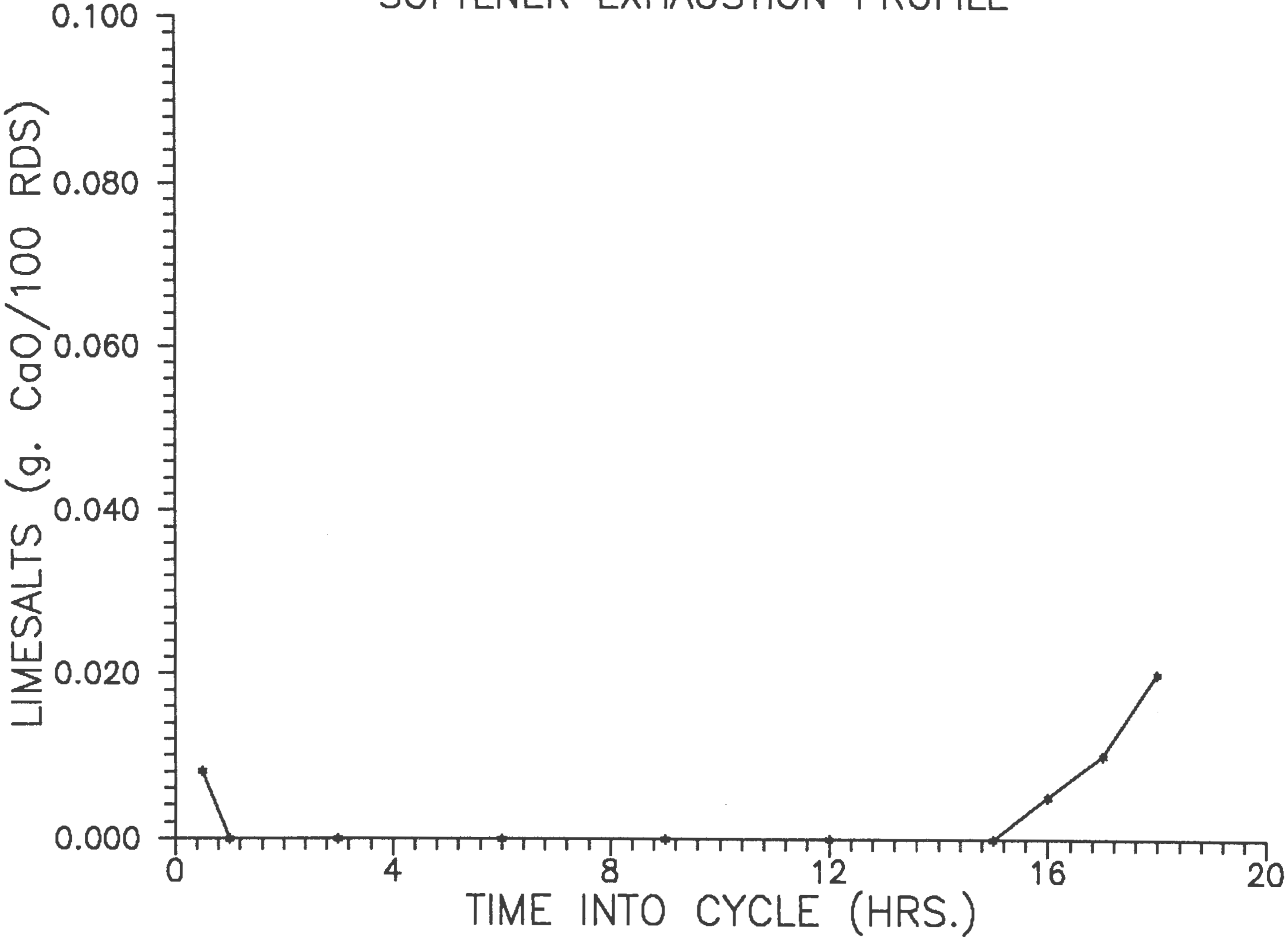

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FIGURE 6

SOFTENER SPENT REGENERANT pH PROFILE

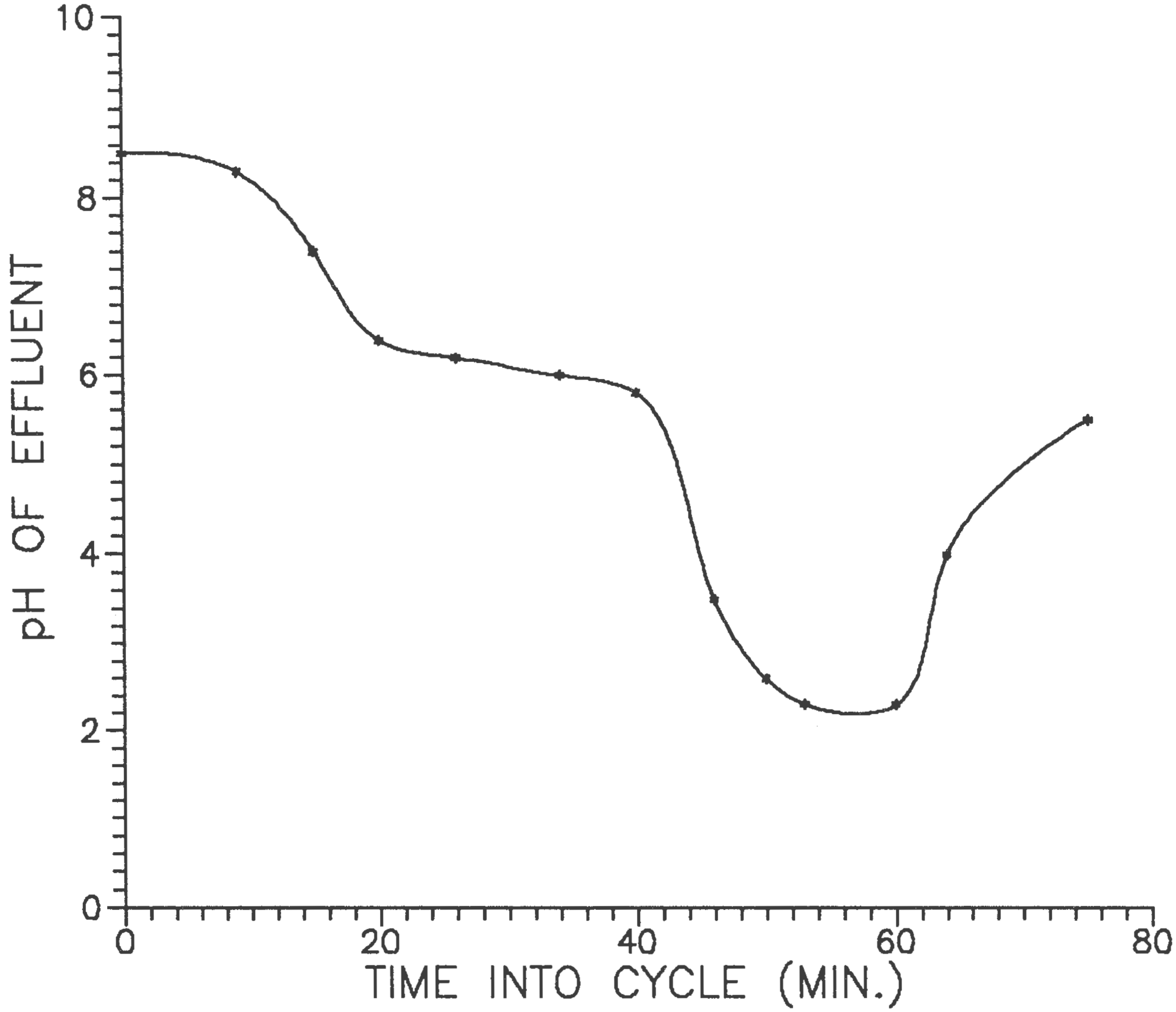


FIGURE 7

REGENERATION CURVE FOR SOFTENER

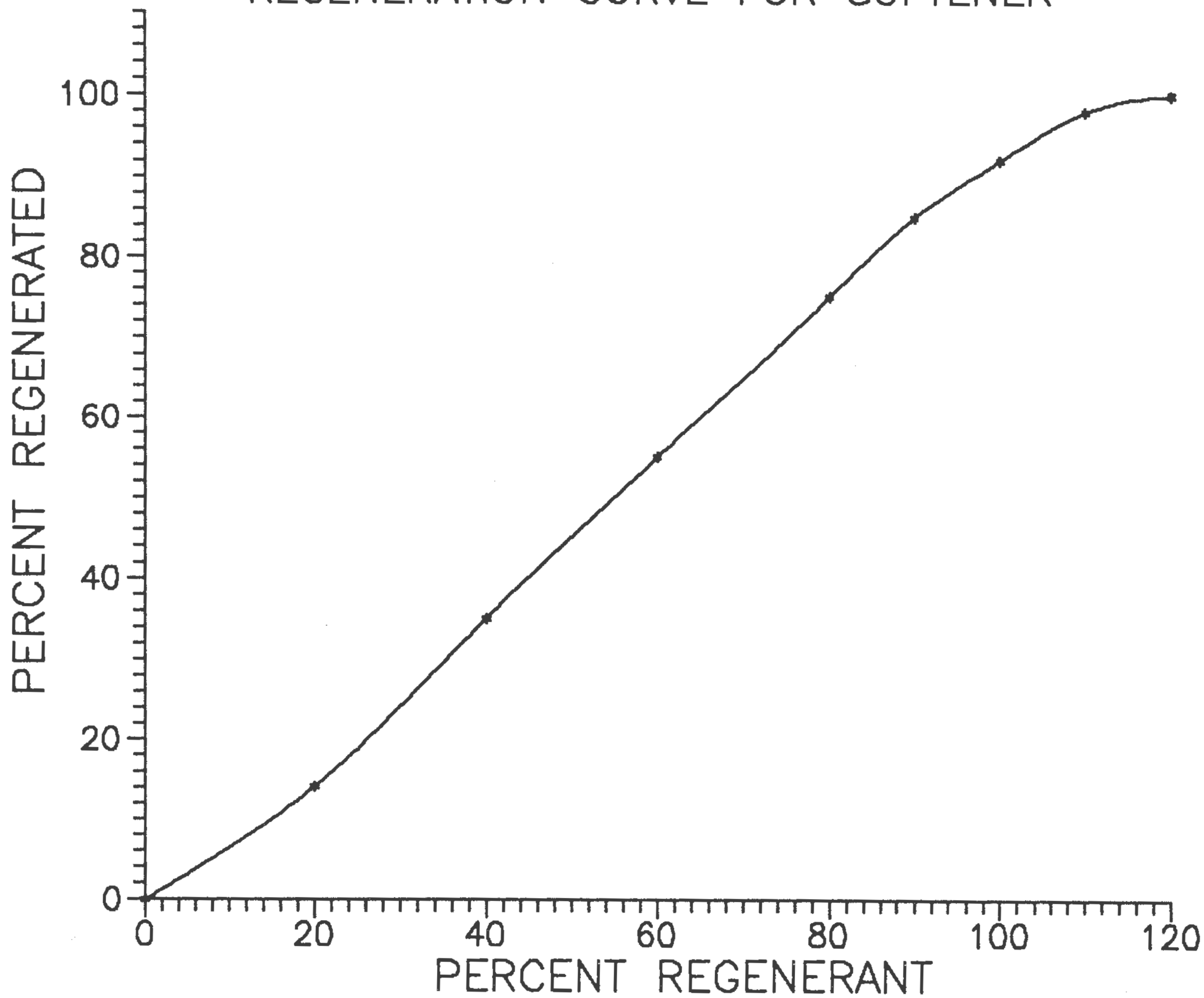
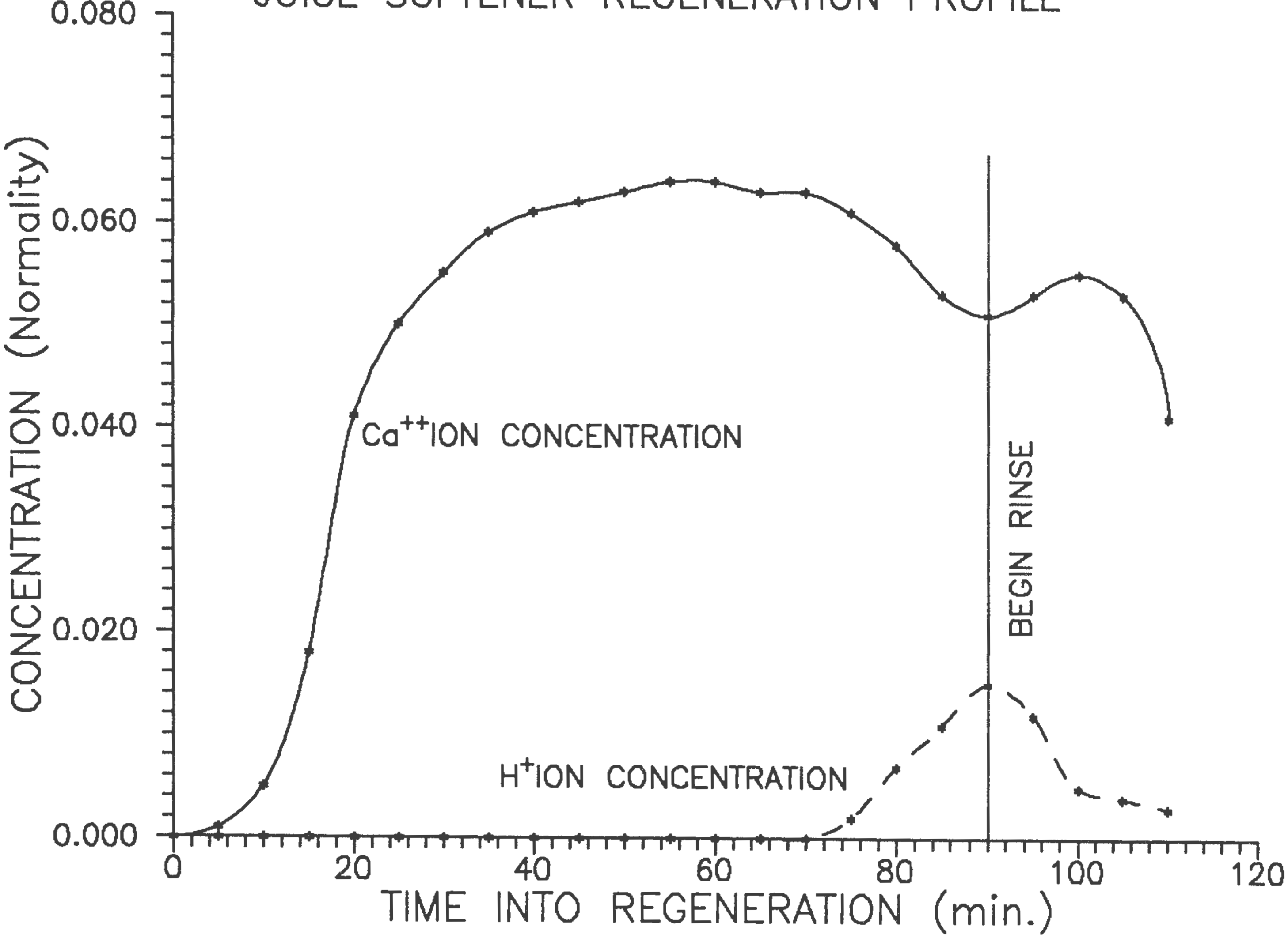


FIGURE 8

JUICE SOFTENER REGENERATION PROFILE



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