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[54] **RECOVERY OF SUGAR FROM CLARIFIER SCUM BY COUNTERCURRENT EXTRACTION**

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[58] **Field of Search** ..... 127/43, 46 R, 48, 50, 57, 127/45

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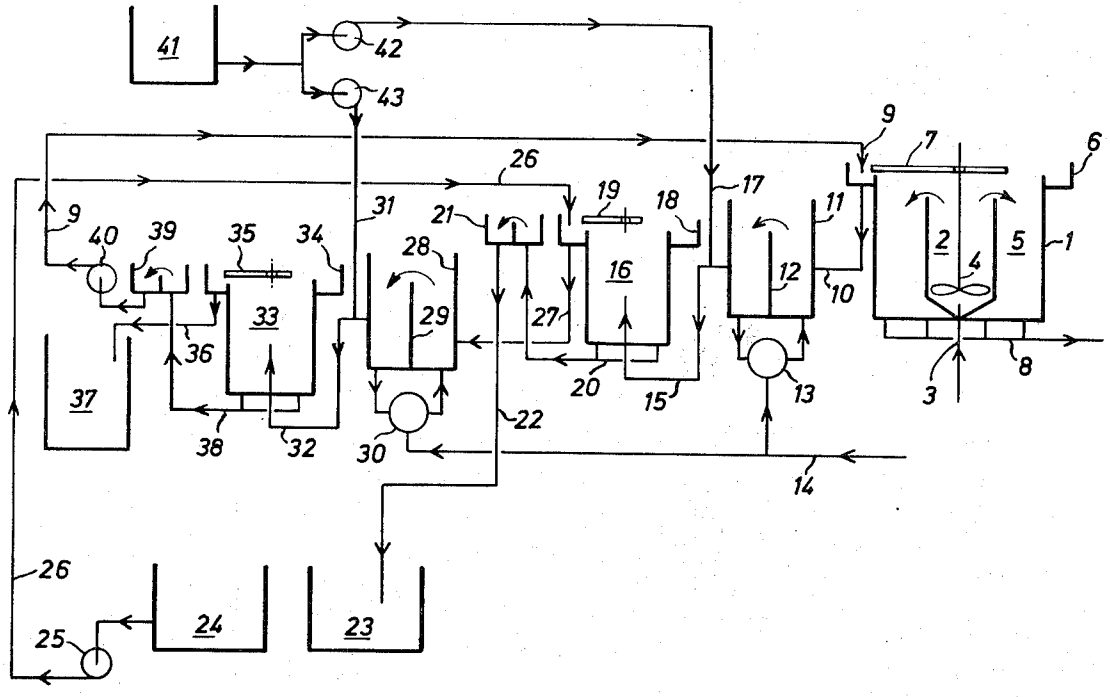
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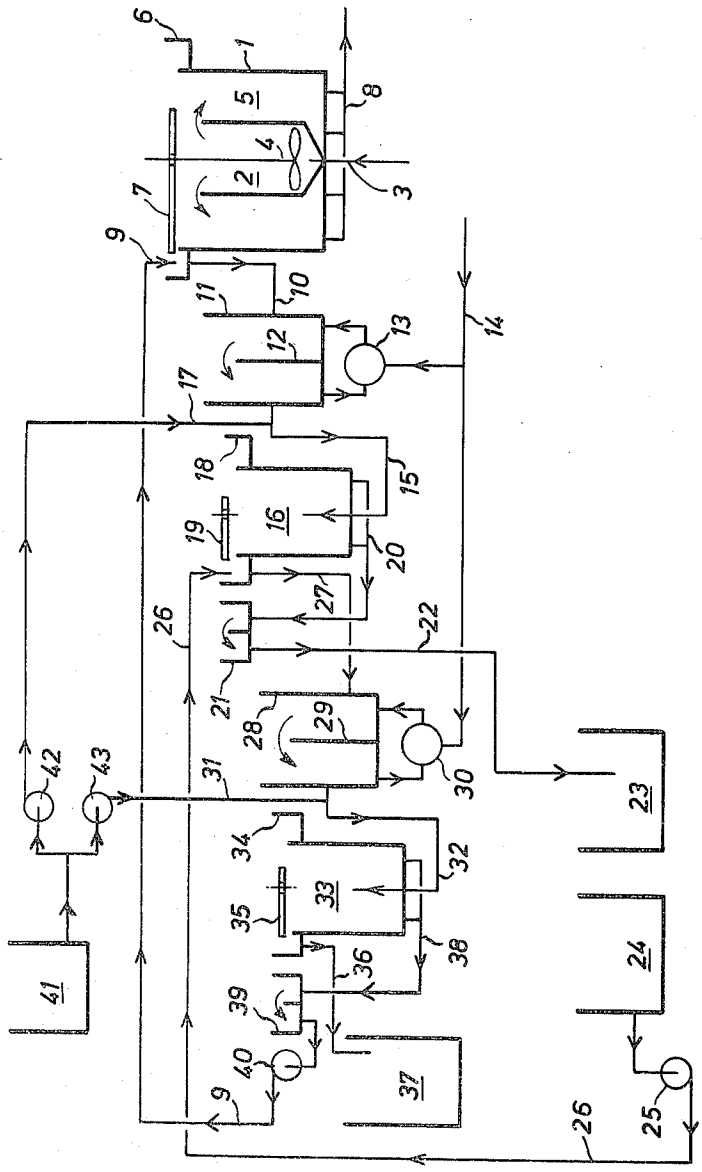
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[57] **ABSTRACT**

In the phosphatation-flotation process of sugar refining, sugar is recovered from the clarifier scum by a multi-stage reflotation process involving at least two consecutive stages of counter-current aqueous extraction, using an organic polymeric flocculating agent. The residual sugar loss can typically be reduced to about 0.05% or less of the total sugar input to the refinery, without the need for filtration or centrifugation of the scum.

11 Claims, 1 Drawing Figure




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RECOVERY OF SUGAR FROM CLARIFIER SCUM BY COUNTERCURRENT EXTRACTION

This invention relates to a process for the recovery of sucrose from clarifier scum obtained by the phosphatation process in sugar refining.

The production of sugar for human consumption generally comprises two distinct operations, namely the production of raw sugar and the production of refined sugar, which are often carried out in geographically separate locations. Raw sugar is manufactured from "raw juice", obtained from sugar cane or sugar beet, by "clarification" (i.e. removal of suspended solids), evaporation to a thick syrup, and crystallization. If special processing is introduced into these stages, the crystallized product can reach a standard suitable for direct consumption, and is then known as "Mill White" or "Plantation White" sugar; but, generally, raw sugar must be refined before it reaches an acceptable standard of purity. In the conventional sugar refining process, raw sugar is first washed and centrifuged to remove adherent syrup, and the "affined sugar" so produced is dissolved in water as "melter liquor". The melter liquor is then purified in two successive steps, the first of which is termed "defecation" and prepares the liquor for the second step, which is termed "decolorization". The liquor produced by these successive steps is termed "fine liquor"; and refined sugar is obtained from fine liquor by crystallization. When a relatively low quality refined sugar product is required, the decolorization step may be omitted altogether.

The defecation step may comprise simple filtration through a bed of diatomaceous earth or another suitable filter aid; but, more generally, defecation involves an inorganic precipitation reaction, whereby insoluble and colloidal impurities are removed along with the inorganic precipitate. In the "carbonatation" process, the inorganic precipitate is calcium carbonate, formed in situ by dissolving lime in the melter liquor and introducing carbon dioxide, for example in flue gas: the precipitate, which contains various impurities, is removed by filtration, the calcium carbonate acting as its own filter aid. In the "sulphitation" process, the inorganic precipitate is calcium sulphite, formed by the introduction of sulphur dioxide into limed melter liquor: the calcium sulphite is then removed by filtration, as in the carbonatation process. Sulphitation is often used in conjunction with carbonatation; and, because of the special effect of sulphur dioxide in preventing colour formation during the subsequent processing of the sugar liquor, a separate decolorization process is seldom necessary with this particular combination of defecation treatments. Alternatively, the inorganic precipitate may be calcium phosphate, for example formed by the addition of lime and phosphoric acid to the melter liquor, in which case the process is termed " phosphatation". This precipitate can also be removed by filtration, but large quantities of filter aid are required: consequently, it is more common to remove the calcium phosphate precipitate by flotation, in association with air bubbles.

In the phosphatation-flotation process, the flocculent calcium phosphate precipitate is aerated and rises to the top of the liquor in a clarifier vessel, carrying with it various suspended impurities. The calcium phosphate is removed as a scum from the top of the clarifier, and the clarified defecated liquor is removed from the bottom. Many chemical additives have been recommended to aid the flotation separation of the phosphatation precipitate, including high molecular weight anionic polymers of the poly-acrylamide type, which increase the size of the floc and the retention of air bubbles within it. However, the mere addition of such flocculants will not necessarily give rise to the efficient flocculation which is needed in order to achieve subsequent rapid and complete clarification of the liquor. In particular, as described in our copending application Ser. No. 263,784, now U.S. Pat. No. 3,853,616, it has been discovered that optimum flocculation of the suspended solids and efficient clarification of the liquor can be achieved by a process which comprises: forming a primary floc in the liquor containing suspended solids; aerating the primary floc, with agitation; distributing an organic polymeric flocculant uniformly through the liquid phase of the aerated liquor, to initiate the formation of a secondary floc therein; retaining the resulting mixture in a flocculator vessel with non-turbulent agitation preventing the segregation of the secondary floc from the liquor and allowing the secondary floc to grow; transferring the liquor, with minimal agitation, from the flocculator vessel to a separator vessel; allowing the secondary floc to segregate by flotation from the liquor in the separator vessel; and separately removing clarified liquor and flocculated solids from the separator vessel. In our copending application Ser. No. 263,785, now U.S. Pat. No. 3,834,541, we also describe an apparatus, known as the "TALO clarifier", which allows this improved flotation process to be carried out in a particularly advantageous way. Moreover, as described in our U.S. Pat. No. 3,698,951, dissolved anionic high molecular weight impurities, including the colorant impurities, can be precipitated from melter liquor by adding a cationic surfactant, which forms an insoluble complex with the impurities, the precipitated complex then being removed by a defecation treatment, such as phosphatation-flotation, along with the inorganic precipitate.

A problem which arises in all phosphatation-flotation processes is that an appreciable proportion of the sugar is retained in the clarifier scum. In the conventional processes, typically about 4% by weight of the input sugar is present in the calcium phosphate scum removed from the clarifier, and even in the improved processes described in our U.S. Pat. No. 3,698,951 and application Ser. No. 263,784 (now U.S. Pat. No. 3,853,616) about 2% by weight of the input sugar is present in the scum. For efficient and economical refinery operation, at least some of this sugar must be recovered, by "desweetening" the clarifier scum.

In the past, three methods have been used for desweetening clarifier scum, by extracting the sugar in it with "desweetening water". Desweetening water is plain water, for example steam condensate, or a dilute sugar solution from another sugar refining operation, characterized by an impurity content low enough for returning to the process stream.

1. Filtration of the scum and washing with desweetening water. This suffers from the disadvantage that the rate of filtration is poor if the floc system is broken, while the recovery of the sugar is inefficient if the floc is not broken.
2. Dilution of the scum with desweetening water and settling. This is a cumbersome and inefficient

method, in which large volumes of liquid and "mud" have to be handled.

3. Dispersion of the scum in desweetening water and reflotation. It has been found difficult to reform the floc fast enough to trap sufficient air for proper flotation, and the system produced has usually been unstable, with a proportion of the scum sinking instead of floating.

In any case, methods 2 and 3 normally have to be followed by filtration, or the sugar loss is too high. Centrifugation has been used as an alternative to filtration, but the equipment is expensive in initial cost and maintenance, and the separation of solid from liquid phases can be incomplete.

When method 3 has been used in the past, it has involved just one reflotation stage and the use of expensive ancillary plant such as filter-presses or centrifuges. In the low-viscosity dilute sugar solutions involved, air bubbles rise much more rapidly than in melter liquor, and aeration of the floc is difficult. Consequently, flotation has been unreliable, and the method is not well liked in the sugar refining industry.

Surprisingly, we have now found that the sugar can be quickly and efficiently recovered from clarifier scum by using a multi-stage reflotation process, without subsequent filtration or centrifugation, and that the problems of flocculation, aeration and flotation in dilute sugar solution can be overcome, by following a particular sequence of specific steps.

The invention provides a continuous process for recovering sugar from the clarifier scum produced by phosphatation-flotation in sugar refining, which process comprises: subjecting the scum to at least two consecutive stages of counter-current aqueous extraction, wherein each extraction stage comprises the successive steps of

a. dispersing the scum in desweetening water, to give a homogeneous mixture, and aerating the mixture,
b. distributing an anionic organic polymeric flocculant uniformly throughout the aerated mixture, to flocculate the scum therein,
c. passing the mixture, without further agitation, to a clarifier,
d. allowing flocculated scum to segregate from the mixture by flotation in the clarifier, and
e. separately removing a clarified dilute sugar solution and flocculated scum from the clarifier;

passing the flocculated scum from step (e) of each except the last extraction stage to step (a) of the next extraction stage; passing the dilute sugar solution from step (e) of each except the first extraction stage to step (a) of the immediately preceding extraction stage, for use as desweetening water therein; discharging the flocculated scum from step (e) of the last extraction stage, as desweetened scum; and recovering the dilute sugar solution from step (e) of the first extraction stage.

Because the process of the invention is a multi-stage counter-current extraction, it achieves effective desweetening of the clarifier scum without producing inconveniently large volumes of dilute sugar solution. The dilute sugar solution recovered from step (e) of the first extraction stage typically has a concentration of from 10° to 20° Brix. This solution, known as "sweetwater", can be recycled to the melter, where it is used to dissolve raw sugar and produce more melter liquor. The sugar concentration in the dilute sugar solution removed from step (e) of the last extraction stage is typically from 0.2° to 2° Brix. The residual sugar content in the desweetened scum removed from step (e) of the last extraction stage typically represents a loss of 0.05% by weight or less on the total sugar input to the refinery; and the desweetened scum can, therefore, be discarded without filtration or any other treatment.

Most frequently, the desweetening water used for step (a) of the last extraction stage is plain water, normally in the form of steam condensate provided from elsewhere in the refinery.

In each extraction stage, the scum is first thoroughly mixed with and dispersed in desweetening water. This is important, to ensure that the sugar is equilibrated throughout the system and not left trapped in the flocs. The homogeneous mixture thus obtained must be thoroughly aerated. The dispersion and aeration can be performed independently of each other, by conventional means. However, in accordance with a particularly preferred embodiment of the invention, homogeneous dispersion of the scum and aeration of the mixture are simultaneously performed in a mixing tank provided with an external recirculation loop which includes a power-driven high-speed high-shear aerator, with the injection of compressed air. The mean residence time of the mixture in the mixing tank is preferably from 2 to 10 minutes. Desirably, the amount of air introduced is from 1% to 5% by volume, on the basis of the mixture volume; and the recirculation rate in the loop should be from 1 to 10 times the throughput in the mixing tank. The aerator should operate with a rotor speed of not less than 2,500 r.p.m., and preferably at about 3,500 r.p.m. A suitable aerator is available from the TALO Products and Processes Division of Tate & Lyle Enterprises Limited, London, England.

After completion of the dispersion and aeration step, an organic polymeric flocculant is added to the aerated mixture. Such polymeric flocculants are well known per se. Particularly suitable are the high molecular weight anionic polyacrylamide flocculating agents (i.e. having a molecular weight of at least 1 million), especially those containing up to 20 mole percent of acrylic acid or sodium acrylate units, such as that available under the Trade Mark "TALOFLOTE". For each extraction stage, it is preferred to use from 0.1 to 5.0, most preferably 0.5 to 2.0, parts by weight of flocculant per million parts by weight of melt sugar solids throughput in the refinery.

The manner in which the polymeric flocculant is added to the aerated mixture can significantly affect the success of the subsequent steps. Thus, the flocculant should desirably be used in the form of a dilute aqueous solution, generally having a concentration of from 0.25 to 5.0, preferably 0.5 to 2.0, grams per litre, since a high dilution of the polymer molecules allows better utilization of the full activity of the flocculant. The flocculant solution should not be subjected to vigorous mechanical treatment which can rupture the polymer molecules: instead, a stream of air bubbles or a paddle rotating at not more than 200 r.p.m. can be used to dissolve the polymer. The flocculant solution should be "aged" for a few hours before use, to aid dissolution, but should not be kept longer than about 3 days, otherwise hydrolysis and fragmentation of the polymer molecules can occur; generally, ageing for 2 to 3 hours is satisfactory.

The satisfactory distribution of the polymeric flocculant in the aerated mixture is also important. On the

one hand, good distribution of the flocculant cannot be achieved by merely dosing it into a volume of the mixture; whilst, on the other hand, violent blending, such as produced in some in-line mixers or by passing the mixture through a centrifugal pump, is also unsatisfactory. Thus, although good distribution is desirable, it has been found that completely homogeneous blending is undesirable; it is theorized that, with too thorough mixing, the flocculant molecules are lost within the growing flocs and can no longer gather together suspended solid particles, to form larger flocs. The degree of disbribution of the flocculant molecules in the mixture will depend on the intensity and duration of mixing. For instance, the right degree of distribution is achieved by a degree of turbulence corresponding to Reynolds numbers ranging from 7,000 to 70,000 at a sugar concentration of 20° Brix, and from 14,000 to 140,000 at sugar concentrations below 5° Brix. In practice, this satisfactory distribution can be achieved by dosing the flocculant through a metering pump into the aerated mixture flowing with a linear velocity of from 30 to 300 cm. per second, preferably about 150 cm. per second, in a pipe of appropriate bore; but the right degree of distribution can also be obtained in other ways, such as by causing the liquor to flow through a pipe containing one or two right-angle bends in it.

Without further agitation, the mixture then enters a clarifier, in which the flocculated scum is allowed to segregate by flotation. Normally, the mixture should enter the clarifier at a velocity not greater than 20 cm. per second, preferably not greater than 10 cm. per second. In the clarifier, the flocculated scum floats to the top, and the clarified "sweetwater" is removed from the bottom. The residence time in the clarifier is generally 5–10 minutes. The size of clarifier needed will obviously depend upon the volume of scum to be treated, which in turn depends on the throughput of the refinery, usually expressed in terms of the sugar melt rate. For example, in a refinery having a sugar melt rate of 40 tons per hour, the scum clarifiers will typically be cylindrical, with a height and diameter of about 150 cm. each. The scum clarifiers can all be of the same size, irrespective of the number of extraction stages.

The temperature of the extraction process is not critical, but it is generally convenient to operate the process at a temperature of from 50° to 90°C, and preferably at about 70°C. The temperature used is largely dictated by the requirements of the main refining process, in that the steam condensate fed to the last extraction stage will already be hot, and the sweetwater recovered from the first extraction stage should be hot for recycling to the melter.

The invention will be further described with reference to the accompanying drawing, which shows a flow diagram for a process in accordance with the invention comprising two counter-current extraction stages.

In the drawing, **1** is a liquor clarifier of the "TALO" type. It comprises a central flocculator chamber **2**, into which the aerated phosphated melter liquor is fed at **3**. As the liquor rises in the flocculator chamber **2**, it is kept gently stirred by the stirrer **4**, allowing the flocs in it to grow. The liquor then flows into the separator chamber **5** which surrounds the flocculator chamber **2**. In the separator chamber, the flocs rise to the top of the liquid as a scum, which is pushed into the annular trough **6** surrounding the top of the chamber by means of the slowly rotating scum rake **7**. The clarified sugar liquor is removed from the bottom of the separator chamber via the liquid outlet **8**.

In accordance with the invention, the clarifier scum in the trough **6** is diluted with sweetwater from the pipe **9**, and led via the pipe **10** into the first scum mixing tank **11** which is fitted with a baffle **12**, dividing it into two compartments. In the mixing tank, the flocs in the scum are broken up, the scum is uniformly dispersed in the desweetening water, and the mixture is simultaneously aerated by recirculation through the external loop containing the aerator **13**, fed with compressed air from the main compressed air line **14**.

Typically after a residence time of 2–10 minutes, the aerated mixture flows out of the mixing tank **11** via pipe **15** into the first scum clarifier **16**. As the mixture flows out of the mixing tank, it is dosed via pipe **17** with a solution of an organic polymeric flocculant. This solution is supplied from holding tank **41** via metering pump **42**. The feed line **15** to the clarifier **16** contains right-angle bends in it, so as to provide the correct degree of turbulence in the mixture for uniform distribution of the flocculant solution.

In the first scum clarifier **16**, the scum rises to the top and is pushed into the annular trough **18** by means of the slowly rotating scum rake **19**. The clarified sweetwater is removed from the bottom of the first scum clarifier via outlet **20**, and flows via level control box **21** and pipe **22** to the sweetwater tank **23**, from where it is removed to process as required.

The scum in the trough **18** of the first scum clarifier is diluted with water from the condensate tank **24**, via the pump **25** and pipe **26**. The diluted scum then flows via pipe **27** into the second scum mixing tank **28** fitted with a baffle **29**. The scum is there treated in exactly the same manner as in the first scum mixing tank, being simultaneously dispersed and aerated by means of the aerator **30** fed with compressed air from the line **14**.

On leaving the second scum mixing tank, again typically after a residence time of 2–10 minutes, the aerated mixture is dosed with a solution of organic polymeric flocculant via pipe **31** (fed from flocculant holding tank **41** via metering pump **43**), and flows through the pipe **32** having right-angle bends in it, into the second scum clarifier **33**.

In the second scum clarifier, the scum rises to the top and is pushed into the annular trough **34** by means of the slowly rotating scum rake **35**. From the trough **34**, the now desweetened scum is discharged via pipe **36** into the scum tank **37**, for eventual disposal.

The clarified sweetwater flows from the bottom of the second scum clarifier via outlet **38** and level control box **39** to pump **40**, from which it is recycled via the pipe **9** to the annular trough **6** on the main clarifier **1**, to dilute the scum fed to the first scum mixing tank.

In practice, the number of extraction stages and degree of scum dilution in each stage will depend upon the specific conditions and requirements of the particular refinery, especially the level of sugar loss which is acceptable, the quantity and quality of desweetening water available, and the quantity and quality of sweetwater which can be accommodated back in the process, for example for recycling to the melter. Typically, two stages of extraction with a relatively high degree of dilution will be adequate, but three stages of extraction with a lower degree of dilution will sometimes be necessary. The following typical performance data are given to illustrate how operating conditions may be

chosen to suit different refinery conditions and requirements.

Table 1 shows how the sugar loss, expressed as a percentage of the refinery melt solids throughput, varies with the sugar concentration in the water present in the desweetened scum discarded from the last extraction stage of the process. Of course, this is precisely the same as the sugar concentration in the clarified sweetwater removed from that stage, which is recycled for use as desweetening water to the previous extraction stage. These data are based on operating results obtained from a refinery having a sugar melt solids throughput of 10 tons per hour (corresponding to 220 tons per day refined sugar production), operating at a P_2O_5 level of 0.03% on melt solids, producing a mean volume of 385 liters per hour of final discard scum with a water content of 75%. The loss values shown are independent of the sugar content of the input scum, obtained from the main clarifier, and the volume of desweetening water used.

Table 1

Sugar concentration of water in discard scum (° Brix)	Sugar loss (% by weight of refinery melt solids)
0.1	0.003
0.3	0.009
0.5	0.014
1.0	0.029
1.5	0.043
2.0	0.058
3.0	0.087
5.0	0.144
7.0	0.202
10.0	0.289

The relationship between the scum dilution ratio and the sugar concentration of the sweetwater obtained from each extraction stage is shown in Tables 2 and 3, respectively for a two-stage and a three-stage process. The "scum dilution ratio" is the weight ratio of input desweetening water (normally steam condensate, and therefore assumed to have zero sugar concentration) to input scum (obtained from the liquor clarifier). It is assumed that the liquor present in the input scum has a sugar concentration of 65° Brix, which is a typical value. Tables 2 and 3 give data for input scums containing 2% and 4% by weight of refinery melt sugar solids, representing scum obtained from liquor clarifiers operating with good and poor flotation-separation, respectively.

Table 2

Scum Dilution Ratio	Two-stage desweetening process: Input scum containing 2% refinery melt sugar solids — Sweetwater ° Brix at Extraction Stage: - I	II	Input scum containing 4% refinery melt sugar solids — Sweetwater ° Brix at Extraction Stage: - I	II
3:1	20.3	4.6	18.2	2.3
4:1	15.5	3.0	14.1	1.4
5:1	12.6	2.2	11.7	1.1
6:1	10.7	1.8	9.9	0.9
7:1	9.2	1.4	8.2	0.7
8:1	7.9	1.0	7.4	0.5
9:1	6.6	0.8	6.5	0.4
10:1	5.9	0.53	5.5	0.31
12:1	4.1	0.20	3.7	0.12

Table 3

Scum Dilution Ratio	Three-stage desweetening process: Input scum containing 2% refinery melt sugar solids — Sweetwater ° Brix at Extraction Stage:- I	II	III	Input scum containing 4% refinery melt sugar solids — Sweetwater ° Brix at Extraction Stage:- I	II	III
3:1	22.0	7.3	2.7	20.0	3.7	1.4
4:1	17.0	4.0	1.0	15.1	2.0	0.6
5:1	14.0	2.7	0.5	13.0	1.4	0.3
6:1	11.6	2.1	0.3	10.6	1.1	0.2
7:1	10.0	1.6	0.2	9.1	0.8	0.1
8:1	8.6	1.1	0.13	7.8	0.6	0.07
9:1	7.3	0.9	0.09	6.6	0.45	0.05
10:1	6.0	0.6	0.07	5.5	0.35	0.04
12:1	4.1	0.25	0.05	3.7	0.15	0.03

As an example of how these data can be used in practice, it will be assumed that the maximum acceptable sugar loss in a particular refinery is set at 0.04% by weight of total melt solids. Reference to Table 1 shows that the sugar concentration of the water in the discard scum, and hence of the sweetwater from the final extraction stage, should not exceed 1.5° Brix. If the input scum contains 4% by weight of refinery melt sugar solids, Table 2 shows that the sugar loss target can be achieved with a two-stage desweetening process operating at a scum dilution ratio of about 4:1, while Table 3 shows that the same target can be achieved with a three-stage desweetening process operating at a scum dilution ratio of about 3:1. On the other hand, if the input scum contains only 2% by weight of refinery melt sugar solids, as when operating the improved phosphatation-flotation processes mentioned hereinbefore, Table 2 shows that the sugar loss target can be achieved with a two-stage desweetening process operating at a scum dilution ratio of 7:1, while Table 3 shows that the same target can also be achieved with a three-stage desweetening process operating at a scum dilution ratio of about 3.5:1.

Tables 2 and 3 also show the sugar concentration of the sweetwater recycled to the melter, in the columns for "Extraction Stage I", and the volume of this sweetwater can be calculated. Thus, the optimum operating conditions can be selected for any particular refinery.

For comparison, Table 4 shows the relationship between the scum dilution ratio and sweetwater sugar concentration in a desweetening process comprising a single extraction stage (and consequently outside the

scope of the present invention), but otherwise operated under the same conditions as the processes of Tables 2 and 3. It will be noted that the sugar concentration in the sweetwater corresponds to unacceptably large sugar losses. In order to achieve the sugar loss target of 0.04% by weight exemplified above, Table 4 would have to be extended to cover scum dilution ratios up to 15:1 or even 20:1, which are impractically large.

Table 4

Scum Dilution Ratio	Single-stage desweetening process: Input scum containing 2% refinery melt sugar solids	Input scum containing 4% refinery melt sugar solids
	Sweetwater ° Brix	Sweetwater ° Brix
3:1	15.7	15.9
4:1	12.5	12.7
5:1	10.4	10.6
6:1	8.9	9.0
7:1	7.8	7.9
8:1	6.9	7.0
9:1	6.2	6.3
10:1	5.3	5.4
12:1	3.6	3.7

The invention is illustrated by the following Examples, all of which make use of the two-stage desweetening process shown in the drawing. In all of the Examples, the "TALOFLOTE" flocculating agent was used in the form of an aqueous solution having a concentration of 1 gram per liter.

EXAMPLE 1

A phosphatation refinery having a melt solids throughput of 10 tons per hour operated at a P_2O_5 level of 0.03% by weight on melt solids, using a single "TALO" liquor clarifier, with a clarified liquor sugar concentration of 65° Brix and a scum pH of 7.0–7.5.

The two-stage desweetening process of the invention was installed in this refinery, using 4,000 liters per hour of desweetening water. The amount of air introduced at each extraction stage was 3% by volume; and the aerated mixture in each stage was dosed with 1.2 parts by weight of "TALOFLOTE" flocculating agent per million parts by weight of melt solids throughput. The last stage produced 400 liters per hour of discard scum, the water in which had a sugar concentration not exceeding 0.2° Brix, representing a sugar loss not greater than 0.006% by weight of refinery melt solids throughput. The first stage produced 3,800 liters per hour of sweetwater having a sugar concentration of 8°–12° Brix, for return to the melter.

EXAMPLE 2

A phosphatation refinery having a melt solids throughput of 13 tons per hour operated at a P_2O_5 level of 0.02% by weight on melt solids, using two Williamson liquor clarifiers, with a clarified liquor sugar concentration of 65° Brix and a scum pH of 6.9–7.1.

The two-stage desweetening process of the invention was installed in this refinery, using 3,200 liters per hour of desweetening water. The amount of air introduced at each stage was 2% by volume; and the aerated mixture in each stage was dosed with 1.3 parts by weight of "TALOFLOTE" flocculating agent per million parts by weight of melt solids throughput. The first extraction stage gave 3,000 liters per hour of sweetwater having a sugar concentration of 10°–15° Brix, for return to the melter; and the second stage produced 389 liters per hour of discard scum, the water in which had a sugar concentration not greater than 0.2° Brix, representing a sugar loss of not more than 0.006% by weight of refinery melt solids.

EXAMPLE 3

A phosphatation refinery had a melt solids throughput of 36 tons per hour, operating at a P_2O_5 level of 0.02% by weight on melt solids, using two Bulkley-Dunton liquor clarifiers, with a clarified liquor sugar concentration of 65° Brix and a scum pH of 6.8–7.2.

The two-stage desweetening process of the invention was installed in this refinery, with 8,000 liters per hour of desweetening water supplied to the first stage. The amount of air introduced at each stage was 3% by volume, and in each stage the aerated mixture was dosed with 1.5 parts by weight of "TALOFLOTE" flocculating agent per million parts by weight of melt solids throughput. The first stage produced 7,200 liters per hour of sweetwater having a sugar concentration of 9°–14° Brix, for return to the melter; and the second stage produced 1,300 liters per hour of discard scum, the water in which had a sugar concentration not higher than 0.3° Brix, representing a sugar loss not greater than 0.009% by weight of refinery melt solids throughput.

EXAMPLE 4

A phosphatation refinery had a melt solids throughput of 75 tons per hour, operating at a P_2O_5 level of 0.02% by weight on melt solids, using two "TALO" clarifiers, with a clarified liquor sugar concentration of 65° Brix and a scum pH of 6.8–7.1.

The two-stage desweetening process of the invention was installed in this refinery, with 16,000 liters per hour of desweetening water supplied to the first stage. The amount of air introduced at each stage was 2% by volume, and in each stage the aerated mixture was dosed with 0.7 part by weight of "TALOFLOTE" flocculating agent per million parts by weight of melt solids throughput. The first stage produced 15,000 liters per hour of sweetwater having a sugar concentration of 8°–14° Brix, for return to the melter; and the second stage produced 2,400 liters per hour of discard scum, the water in which had a sugar concentration not higher than 0.2° Brix, representing a sugar loss of not more than 0.006% by weight of refinery melt solids.

We claim:

1. A continuous process for recovering sugar from the clarifier scum produced by phosphatation-flotation in sugar refining, which process comprises: subjecting the scum to at least two consecutive stages of countercurrent aqueous extraction, wherein each extraction stage comprises the successive steps of

a. dispersing the scum in desweetening water, to give a homogeneous mixture, and aerating the mixture,

b. distributing an anionic organic polymeric flocculant uniformly throughout the aerated mixture, to flocculate the scum therein,

c. passing the mixture, without further agitation, to a clarifier,

d. allowing the flocculated scum to segregate from the mixture by flotation in the clarifier, and

e. separately removing a clarified dilute sugar solution and flocculated scum from the clarifier;

passing the flocculated scum from step (e) of each except the last extraction stage to step (a) of the next extraction stage; passing the dilute sugar solution from step (e) of each except the first extraction stage to step (a) of the immediately preceding extraction stage, for use as desweetening water therein; discharging the flocculated scum from step (e) of the last extraction stage, as desweetened scum; and recovering the dilute sugar solution from step (e) of the first extraction stage.

2. The process according to claim **1,** wherein there are two of the said consecutive stages of counter-current extraction.

3. The process according to claim **1,** wherein there are three of the said consecutive stages of counter-current extraction.

4. The process according to claim **1,** wherein, in step (a) of at least one of the said stages of counter-current extraction, the homogeneous dispersion of the scum and aeration of the mixture are simultaneously performed in a mixing tank provided with an external recirculation loop which includes a power-driven aerator, with injection of compressed air.

5. The process according to claim **4,** wherein the mean residence time of the mixture in the mixing tank is in the range of from 2 to 10 minutes.

6. The process according to claim **4,** wherein from 1% to 5% by volume of air is introduced into said mixture, on the basis of the mixture volume, and the recirculation rate in said loop is from 1 to 10 times the throughput in said mixing tank.

7. The process according to claim **1,** wherein, in step (b) of each of the said stages of counter-current extraction, there are distributed from 0.1 to 5.0 parts by weight of said flocculant per million parts by weight of melt sugar solids throughput in the refinery.

8. The process according to claim **1,** wherein, in step (b) of each of the said stages of counter-current extraction, there are distributed from 0.5 to 2.0 parts by weight of said flocculant per million parts by weight of melt sugar solids throughput in the refinery.

9. The process according to claim **1,** wherein said flocculant is added to said aerated mixture in the form of an aqueous solution having a concentration in the range of from 0.25 to 5.0 grams per liter.

10. The process according to claim **1,** wherein said flocculant is added to said aerated mixture in the form of an aqueous solution having a concentration of from 0.5 to 2.0 grams per liter.

11. The process according to claim **1,** wherein said flocculant is an anionic polyacrylamide flocculating agent having a molecular weight of at least one million and containing up to 20 mole percent of anionic units selected from the group consisting of acrylic acid and sodium acrylate units.

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