

纯碱生产及自动控制

〔译文集〕

钱庆元 古涛 刘玉其 译

化学工业出版社

本书是由苏联С. В. 宾科夫斯基等著的《Технология Содопродуктов》1972年版的绪论、第一、二篇和А. В. 谢姆克等著《Автоматизация процессов содового производства》1975年版的第一章和第三章合译而成。

本书主要讲述了氨碱法生产纯碱及其有关产品的工艺学和生产的自动控制。并讲述了天然碱加工、霞石制碱以及热法生产氯化铵、制碱废液制取氯化钙等。

本书译稿第一、二篇分别由陈宝庆、郭如新作了初审、校。第三篇由沈成林审校。

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成,塔圈与塔圈之间用螺栓安紧鼓泡塔板。

盐水从上一圈塔板(或从前一个设备)来到鼓泡塔板上,经溢流槽溢流到下一层塔板。气体由吸氨设备的下一层塔圈上来,穿过塔盘上的盐水层而鼓泡,进入吸氨器或洗涤器的另一层塔圈。气体穿过盐水层(盐水层的高度由菌帽浸没入盐水的高度决定)时,液体被鼓动起泡,构成吸氨的有效表面。

吸氨工段的主要设备——吸氨器和洗涤器的直径都是2.8米,它们的鼓泡塔板数则不一样。过滤机空气洗涤器和吸氨气体洗涤器内各设有四块塔板,塔气第二洗涤器内设有六块塔板,第一吸氨器(按盐水流向)内设有五块塔板。塔气第二洗涤器高度为8.8米,其余设备为7米左右。吸氨设备的上部是空塔圈,用来回收被气体带走的盐水飞沫。各设备之间用塔盘隔开。

塔气第二洗涤器和第一吸氨器的结构如图5-6和图5-7所示。

吸氨塔的第二吸氨器为洗涤塔型(图5-8)。它的填料是用水冷却的小管,小管由铸铁、镍铬合金制成,安装在七层铸铁塔圈的花板上。一层塔圈的冷却面积是170米²,设备的总高度为7米左右。来自蒸氨冷却器的气体,进入设备下部的空圈。上部塔圈内设有使进入的液体均匀分布的塔板。

蒸氨气体冷却器(图5-9),是吸氨塔的一个组成部分,共有五个冷却塔圈,每圈的换热面积为170米²。来自蒸氨气体冷凝器的气体进入设备的上部空圈,冷却后,经下部空圈进入第二吸氨器。

氨盐水喷淋式冷却器示于图5-10,板式冷却器示于图5-11。

板式冷却器由一组组不锈钢波纹板构成,板片的数量由该设备的换热面积决定。板片一对对地与氨盐水和冷却水的进、出口总管相连,并用胶垫密封,胶垫紧贴板片四周和孔的周围,在板片与板片之间构成必要的间隙。一组组板片用活动板紧固在固定板上。

板式冷却器的特点是换热系数高〔达2750千卡/(米²·小时·度)〕、冷却水使用效果好、操作方便、易于拆卸进行检查和

三、碳化工段的设备

碱厂碳化工段的设备包括主要设备和机器（碳化塔、塔气洗涤器、二氧化碳压缩机）以及进行辅助性操作的设备和机器（液体贮槽、塔计量槽、向塔内供氨盐水的离心泵）。

碳化塔 苏联碱厂中使用的碳化塔，其总的尺寸、鼓泡塔圈和冷却塔圈的结构、冷却面积各不相同，因此，塔的生产能力也不同。

碳化塔（图6-6）为一竖式圆筒形设备，由一个个铸铁塔圈用螺栓紧固的法兰连接而成。法兰之间用橡胶垫圈密封。各种型号的塔内径为1.8米至3.0米，高21.7米至27米。

塔装在底圈1上。塔的下部由冷却圈3组成。塔的上部由普通的空吸收圈4——有时亦称塔圈——组成。在相邻的两个塔圈的法兰之间，除上部的三圈外，装有铸铁的鼓泡塔板。

鼓泡塔板（图6-7）是一个正中开有大孔的中间底盘1，大孔的周围，开有八个孔。底盘之上罩有一凸形菌帽2，菌帽的边缘呈锯齿状。菌帽的整个表面开有锥形孔。装在塔下部冷却区的塔板，可以不开这种孔。

塔的冷却圈（图6-8）形状特殊。它的外侧一般都有两个突出的部分，构成两个空室。空室的孔里捻入一排排小管，管子里通入冷却水。空室内装有改变冷却水流向的隔板，可以加快它在小管里的流速，从而提高换热系数。冷却圈的小管用厚3毫米的不锈钢制成，或者用含Ni 0.5%、Mn 0.4%及Cr 0.4%的特种铸铁制成。通常在塔上部第二圈到第五圈之间装有玻璃管液位计（照明器），用以观察液位。

氨盐水和预碳化液从塔上部第四圈或第五圈的管口进塔（见图6-6）。塔下部的圈（底圈）有两个管口2和10，一个用来通入浓二氧化碳气，另一个用来出液。窑气通常从第三冷却圈与第四冷却圈（自下向上数）之间的管口进塔，或者从第七冷却圈与第八冷却圈之间的管口进塔。塔的每一圈都设有检查孔。

或用作生产纯碱的原料。

根据出产的产品种类，蒸氨废液澄清液的浓缩过程要在一定的工艺条件下进行，并遵守这样的温度和压力条件，即一开始先析出固相氯化钠，随后使液相中 CaCl_2 的浓度达到38%，符合对商品液体氯化钙组分的要求。

要生产熔融或片状固体产品时，则将制得的38%的 CaCl_2 溶液进一步浓缩，并对再度析出的食盐沉淀进行分离。

工艺流程 图11-1所示为生产液体氯化钙的工艺流程。

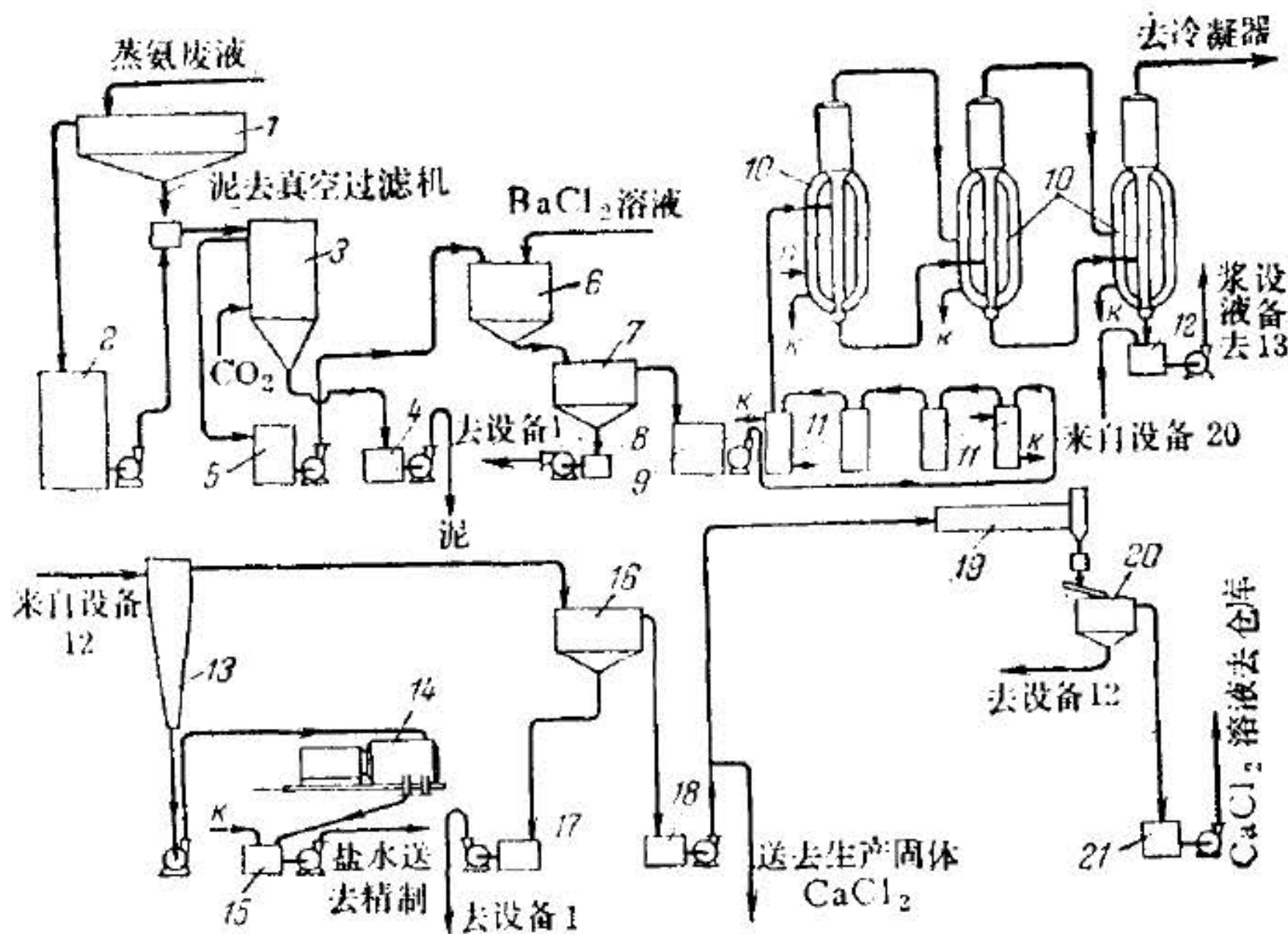


图 11-1 生产液体氯化钙的工艺流程

1, 7, 16, 20—稠厚器；2, 5, 8, 9, 21—收集贮槽；3—碳化器；4—带搅拌机的贮槽；6—反应器；10—蒸发器；11—换热器；12, 17—浆液贮槽；13—澄清桶；14—离心机；15—化盐桶；18— CaCl_2 澄清液贮槽；19—转筒式结晶器； κ —凝液； π —蒸汽

蒸氨废液在进入氯化钙生产的主要设备前要预先进行澄清和化学精制。废液的澄清在稠厚器1内进行。在这里沉淀下来的废泥，为了减少排泥时的液体损失，送入盘式真空过滤机，过滤以后再排入“白海”。澄清液自稠厚器流入收集贮槽2，然后经计量槽用泵

打入碳化器3，碳化器的下部送入二氧化碳气。

碳化器的作用是使氢氧化钙沉淀以防止设备结疤。碳化过程中生成的废泥（碳酸钙），从碳化器的尖底排至带有搅拌机的贮槽4，从这里送至废料堆场。蒸氨废液澄清液流入收集贮槽5，用泵打入反应器6。反应器中加入氯化钡溶液，氯化钡溶液与蒸氨废液中所含的硫酸根起反应，析出硫酸钡沉淀。这样可以防止以后石膏在蒸发设备的加热表面上结疤。

除掉硫酸根离子后的蒸氨废液，在稠厚器7中澄清。稠厚器7底部沉淀下来的硫酸盐废泥打入稠厚器1，从这里与此处分离出的悬浮杂质一起送往盘式真空过滤机。稠厚器7的澄清液，经收集贮槽9用泵送入三效蒸发器10去蒸发。一次蒸汽和二次蒸汽冷凝液的热量在换热器11中用来预热蒸氨废液，然后将冷凝水送往热电站。

在废液的浓缩过程中，在第三效蒸发器中析出NaCl结晶。浆液在澄清桶13中稠厚，然后在离心机14中过滤，从氯化钙溶液中分离出NaCl。食盐用冷凝水溶解后，饱和的盐水自化盐桶15送去精制，然后，供进一步使用。

为了除去NaCl的悬浮结晶，氯化钙溶液从澄清桶13进入稠厚器16，溢流液从这里流入贮槽18，然后用泵打入转筒式结晶器19，从溶液中进一步除去食盐，制得38%的液体氯化钙产品。一部分CaCl₂溶液从贮槽18送往固体氯化钙车间。

含有悬浮食盐颗粒的氯化钙溶液自转筒式结晶器19进入一个小罐，经溜槽流入稠厚器20。食盐的浆液从稠厚器尖底送入贮槽12，再打入澄清桶13，供下一步生产用。冷却和澄清了的38%的CaCl₂溶液自稠厚器20流入收集贮槽21，然后送至成品仓库。

供加工成固体产品的一部分氯化钙溶液（图11-2），送入真空结晶器1，它的上部是汽化器。溶液通过汽化器时沸腾，并由于溶液中水的汽化而使溶液冷却，同时使NaCl结晶和CaCl₂浓度增高。悬浮液自结晶器的底部用泵打入稠厚器4。设备中的真空是由喷射器2提供的。喷射器把二次蒸汽抽出，送入表面冷凝器

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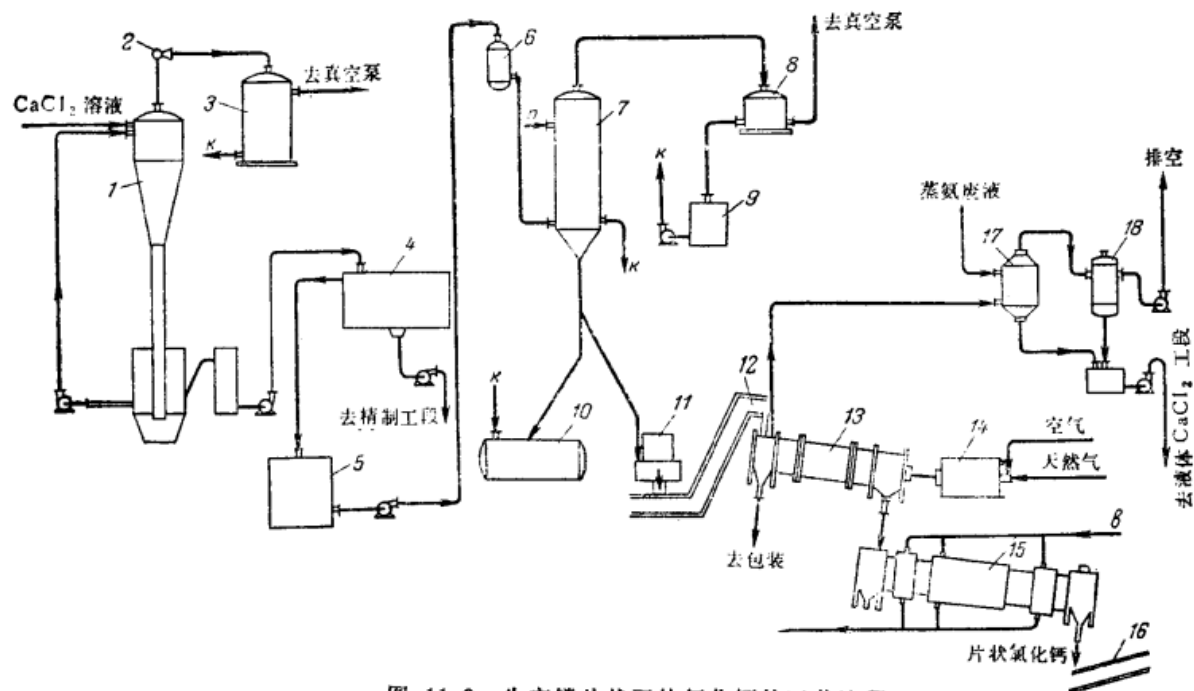


图 11-2 生产鳞片状固体氯化钙的工艺流程

1—真空结晶器；2—喷射器；3、8—冷凝器；4—稠厚器；5—收集贮槽；6—预热器；7—蒸发器；9—冷凝液贮槽；10—熔融液收集贮槽；11—制片机；12、16—皮带运输机；13—转筒式干燥器；14—燃烧室；15—转筒式冷却器；17—洗涤器；18—分离器；B—水；K—冷凝液；D—蒸汽

3。

澄清的40%氯化钙溶液自稠厚器4流入贮槽5,再用泵送入预热器6,然后进管式蒸发器7,在这里蒸至熔融状态。溶液的加热用加热蒸汽的冷凝液进行。

氯化钙熔融液由蒸发器自流至制片机11。制片机是一个转筒,转筒的内部用水冷却,转筒的外部有一部分浸入充至本设备的鼓槽一定液位的熔融液中。在转筒表面生成的产品薄硬壳用刮刀刮下,并破碎成一片片鳞片。片状氯化钙经溜筒落到皮带运输机12上,皮带运输机把片状氯化钙送入转筒式干燥器13去“加工”。进行这一操作的目的是使多余的溶液从片状物的表面蒸发掉,以避免片状氯化钙在储存过程中结块。

片状 CaCl_2 从干燥器进入冷却器15,从这里用皮带运输机16送往成品仓库包装。干燥器出气依次通过洗涤器17和分离器18,除掉产品悬浮颗粒,然后用通风机排空。

主要设备 在氯化钙生产中采用的各稠厚器尺寸如下:澄清蒸氨废液用的稠厚器直径15米、高3.6米;分离38% CaCl_2 溶液和食盐用的稠厚器直径9米、高3.6米。化学法精制蒸氨废液除掉硫酸根离子的反应器直径2.6米、高8.1米。

从38% CaCl_2 溶液的悬浮液中除去食盐是在HIII-2K-800K型连续作用卧式脉冲出料离心机中进行的,离心机的前面设有澄清桶。

蒸发器的各效均为同一类型,有两个外加热室和一根中央循环管(自然循环)。每一效的总加热面积为426米²。换热器为立式列管换热器。

真空结晶器的外径为2.4米,内径2米,总高18.15米,容积32.7米³。在浓缩过程的最后阶段采用有内加热室的蒸发器,其直径是2.2米,高9.62米,加热面积230米²。

转筒式逆流干燥器直径为2米,长12米,容积45.6米³。转筒式冷却器设有水冷却装置。设备的直径为1.6米,长14米,冷却面积41.6米³。制片机的转筒直径为0.8米,长2米。转筒的转速为

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每分钟16转。

为回收产品粉尘，在干燥器和冷却器之后设有：泡沫型洗涤器（直径2米，高3.75米）和分离器（直径1.6米，高3.6米）。

工艺条件 蒸氨废液的澄清与化学精制过程的主要指标如下：

净化率，%	
清除悬浮杂质	99.2
清除硫酸根离子	97.6
和废泥一起去澄清的蒸氨	
废液损失（盘式过滤机后），%	5
按直流方式操作的三效蒸发器的操作指标是：	
CaCl ₂ 溶液浓度，%	
一效进口	10.8
三效出口	38.0
蒸汽的绝对压力，大气压	
一效进口加热蒸汽	7
三效中的二次蒸汽	0.145
蒸汽温度，℃	
一效进口加热蒸汽	164
三效中的二次蒸汽	53
CaCl ₂ 溶液温度，℃	
预热器后	115
一效内	149
二效内	125
三效内	73

在离心机14中分离出的食盐，经澄清桶13后（见图11-1），用冷凝水溶解，制成含NaCl 310克/升的盐水。

38%CaCl₂溶液在真空结晶器中浓缩的条件是：进液中CaCl₂的含量为37~40%，经真空结晶器以后为38~41%，经真空结晶器以后NaCl的含量不大于1.1%。

在蒸发的最后阶段（制取熔融液时），维持下述条件：

蒸汽压力，大气压

	t, °C
加热蒸汽.....	14.5~15
二次蒸汽.....	1~1.1
溶液温度, °C	178
蒸发溶液中CaCl ₂ 的浓度, %	70~72

氯化钙在生产能力为 4 吨/小时的制片机中制片过程的温度条件是:

	t, °C
设备中的熔融液.....	175~179
片状氯化钙	100
排出的冷却水.....	40~50

片状氯化钙在生产能力为 11.7 吨/小时的机组中进行干燥和冷却时, 维持下述温度条件:

产品	t, °C
干燥器进口.....	90
干燥器出口.....	140~150
冷却器出口.....	60~70

烟道气

干燥器进口.....	600~800
干燥器出口.....	140~130

在干燥的产品中, CaCl₂的含量在76~80%范围内。

下面列出制取 1 吨38%CaCl₂的液体氯化钙产品和76% CaCl₂的固体片状氯化钙产品的消耗定额 (以67%CaCl₂计):

消耗项目	液体产品	片状固体产品
蒸氨废液, 米 ³	6.04	—
氯化钡 (ГОСТ742-67, I 级), 公斤.....	13.7	—
CaCl ₂ 溶液 (38%), 吨.....	—	2.17
蒸汽, 吨		
压力 7 大气压	1.241	—
压力15大气压.....	—	0.619
电能, 千瓦小时	72.3	63.4
天然气, 米 ³	—	17.7
工业用水 (循环水), 米 ³		58.5

VERIFICATION

I, Wenli.zhang of 601, Building B-2, Northern Territory, Dongsheng Technology Park, Haidian District, Beijing 100192, China, hereby declare that I am conversant with the Chinese and English languages and am a competent translator thereof. I declare further that to the best of my knowledge and belief the following 纯碱生产及自动控制 *Soda Production and Automatic Control* is a true and correct translation.

All statements made herein of my own knowledge are true and all statements made on information and belief are believed to be true. I further understand that willful false statements and the like are punishable by fine or imprisonment, or both under Section 1001 of Title 18 of the United States Code. I declare under penalty of perjury that the foregoing is true and correct.

Dated this 11 day of Nov. 2022.

Signature:

Wenli Zhang

Name:

Wenli Zhang

Sodium Carbonate Production and Automatic Control

(Translation Collection)

Translated by Qian Qingyuan, Gu Tao and Liu Yuqi

Chemical Industry Press

This book collects the translations of the General Introduction and the first and second titles of 1972 edition "Soda Production Technology" written by C. B. Binkovsky et al., and the translations of the first and third chapters of 1975 edition "Automation of Soda Production Process" written by A.B. Shemke et al. of the Soviet Union.

The book mainly describes the technology and automatic control of production of soda and related products by ammonia-soda process. The processing of trona, the production of soda from nepheline, the production of ammonium chloride by thermal process, and the production of calcium chloride from the waste liquor of soda production are also introduced.

The translations of the first and second titles of this book were first reviewed by Chen Baoqing and Guo Ruxin, respectively. The third title was reviewed by Shen Chenglin.

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Each ammonia absorption equipment is assembled by several cylindrical column rings connected by flanges, and the bubble column tray is fastened by bolts between the column rings.

Brine comes from the previous column tray (or from the previous equipment) to the bubble column tray and overflows to the next column tray through the overflow groove. The gas comes up from the lower column ring of the ammonia absorption equipment, bubbles after passing through the brine layer on the column tray, and enters the other column ring of the ammonia absorber or scrubber. When the gas passes through the brine layer (the height of the brine layer is determined by the height of the cap immersed in the brine), the liquid is agitated and bubbles, forming an effective surface for absorbing ammonia.

The diameters of the ammonia absorber and scrubber, which are the main equipment in the ammonia absorption procedure, are both 2.8 meters, but the numbers of their bubble trays are different. There are four trays in the filter air scrubber and the ammonia absorption gas scrubber, respectively, six trays in the second scrubber of tower gas and five trays in the first ammonia absorber (as per the brine flow direction). The height of the second scrubber of tower gas is 8.8 m, and that of other equipment is about 7 m. The upper part of the ammonia absorption equipment is an empty tower ring, which is used to recover the brine droplets carried away by gas. The pieces of equipment are separated by trays.

The structures of the second scrubber of tower gas and the first ammonia absorber are shown in FIG. 5-6 and FIG. 5-7.

The second ammonia absorber of the ammonia absorption tower is of scrubbing tower type (FIG. 5-8). Its packing is water-cooled tubes made of cast iron and nickel-chromium alloy, which are installed on the carved board of seven-layer cast iron tower rings. The cooling area of each tower ring is 170 m² and the total height of the equipment is about 7 m. The gas from the ammonia distillation cooler enters the empty ring at the lower part of the equipment. The upper tower ring is provided with a tower tray for uniformly distributing the incoming liquid.

The ammonia distillation gas cooler (FIG. 5-9) is part of the ammonia absorption tower. It has five cooling tower rings with a heat exchange area of 170 m² per ring. The gas from the ammonia distillation gas cooler enters the upper empty ring of the equipment, and after cooling, enters the second ammonia absorber via the lower empty ring.

The ammoniated brine spray cooler is shown in FIG 5-10, and the plate cooler is shown in FIG. 5-11.

The plate cooler consists of groups of stainless steel corrugated plates, and the number of plates depends on the heat exchange area of the equipment. The plates are connected in pairs with the inlet and outlet main pipes of ammoniated brine and cooling water, and sealed with rubber pads, which are tightly attached to the periphery of the plates and the periphery of holes to form necessary gaps between the plates. The groups of plates are fastened to the fixing board with movable plates.

The plate cooler is characterized by high heat exchange coefficient (up to 2750 kcal/(m² • hr • °C), good cooling water use effect, easy operation and easy disassembling for inspection and cleaning.

III. Equipment for Carbonation Procedure

The equipment of carbonation procedure of a soda plant includes main equipment and machines (carbonation column, column gas scrubber, and carbon dioxide compressor) and auxiliary equipment and machines (liquid storage tank, column metering tank, centrifugal pump for supplying ammoniated brine to the column).

Carbonation column Carbonation columns used in soda plants in the Soviet Union have different total sizes, structures of bubble column rings and cooling column rings, and cooling areas, so the columns have different production capacities.

The carbonation column (FIG. 6-6) shows a vertical and cylindrical equipment consisting of cast iron column rings connected by bolted flanges. The flanges are sealed with rubber gaskets. Various types of columns have inner diameters of 1.8 meters to 3.0 meters and heights from 21.7 meters to 27 meters.

The column is mounted on a bottom ring 1. The lower part of the column consists of cooling rings 3. The upper part of the column consists of ordinary empty absorption rings 4—sometimes also called column rings. Between the flanges of two adjacent column rings, except for the upper three rings, a cast iron bubble column tray is installed.

The bubble column tray (FIG. 6-7) is a middle base tray 1 with a large hole in the center, and eight small holes are provided around the large hole. A convex cap 2 is covered on the base tray, and the edge of the cap is serrated. The whole surface of the cap is provided with conical holes. The tray installed in the cooling zone at the lower part of the column may not have such holes.

The cooling ring of the column (FIG. 6-8) has a special shape. Its outer side generally has two protruding parts, forming two empty chambers. Rows of small tubes are twisted into the holes of the empty chambers, and cooling water is introduced into the tubes. The empty chamber is equipped with a partition plate to change the flow direction of cooling water, which can speed up its flow rate in the small tubes, thus improving the heat transfer coefficient. The small tubes of the cooling ring are made of stainless steel with a thickness of 3 mm, or a special cast iron containing 0.5% of Ni, 0.4% of Mn and 0.4% of Cr. A glass tube level gauge (illuminator) is usually installed between the second and the fifth rings on the upper part of the column for observing the liquid level.

Ammoniated brine and pre-carbonation liquid enter the column from the tube nozzle of the fourth or the fifth ring on the upper part of the column (see FIG 6-6). The lower ring (bottom ring) of the column has two tube nozzles 2 and 10, one for the introduction of concentrated carbon dioxide gas and the other for the discharge of liquid. Kiln gas usually enters the column through the tube nozzle between the third cooling ring and the fourth cooling ring (counted from bottom to top), or through the tube nozzle between the seventh cooling ring and the eighth cooling ring. Each ring of the column is provided with inspection holes.

In the processing of waste liquor of ammonia distillation, in addition to calcium chloride, edible salt is also prepared, which is sold as a commodity or used as a raw material for producing soda.

According to the types of products produced, the concentration process of clarified waste liquor of ammonia distillation should be carried out under certain technological conditions, and the temperature and pressure conditions should be followed. That is, solid sodium chloride should be precipitated first, and then the concentration of CaCl_2 in the liquid phase should reach 38% so as to meet the requirement for the commercial liquid calcium chloride component.

To produce a molten or flaky solid product, the 38% CaCl_2 solution obtained is further concentrated and the edible salt precipitate once again precipitated is separated.

Process Flow FIG. 11-1 shows the flow of liquid calcium chloride production.

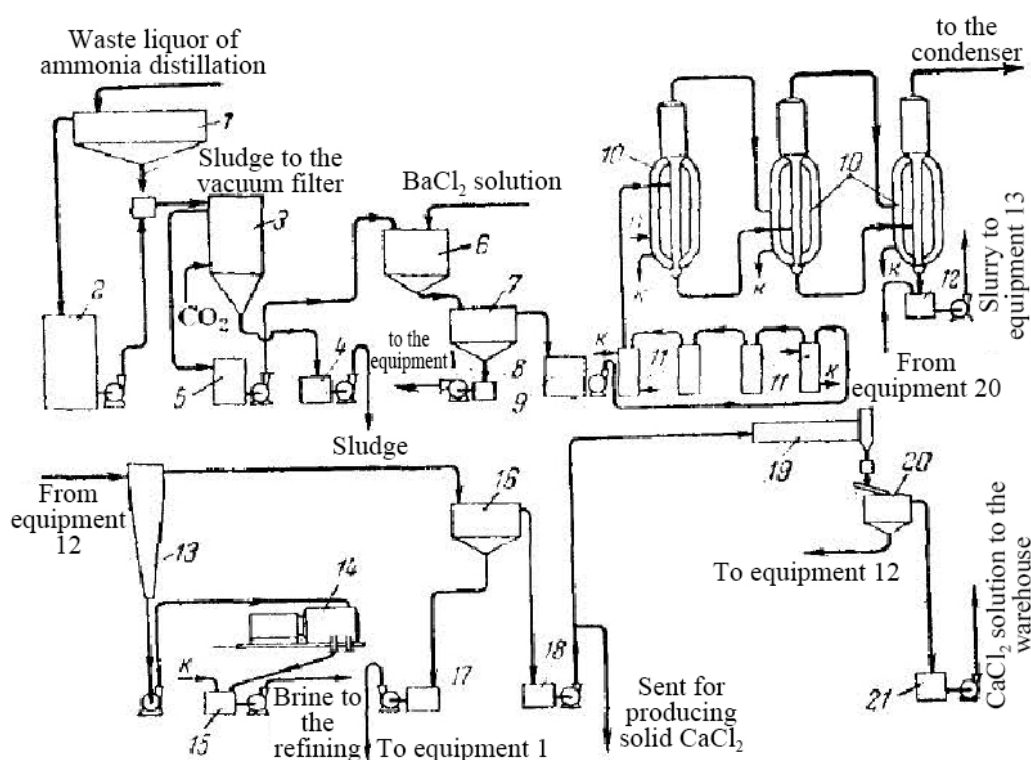


FIG. 11-1 Process Flow of Liquid Calcium Chloride Production

1, 7, 16, 20 - Thickener; 2, 5, 8, 9, 21 - Collection tank; 3 - Carbonizer; 4 - Storage tank with a stirrer; 16 - Reactor; 10 - Evaporator; 11 - Heat exchanger; 12, 17 - Slurry storage tank; 13 - Clarifying barrel; 14 - Centrifuge; 15 - Salt dissolving barrel; 18 - Clarified CaCl_2 liquid storage tank; 19 - Rotary crystallizer; k - Liquor condensate; π - Vapor

The waste liquor of ammonia distillation should be clarified and chemically refined before entering the main equipment for calcium chloride production. Clarification of the waste liquor is carried out in thickener 1. In order to reduce the liquid loss in sludge discharge, the waste sludge settled here is sent to a disc vacuum filter, filtered and then discharged into the "White Sea". The clarified liquid flows from the thickener into the collection tank 2, and then is pumped into the carbonizer 3 through a metering tank, and carbon dioxide gas is fed from the lower part of the carbonizer.

The function of the carbonizer is to make calcium hydroxide precipitate so as to prevent the equipment from scarring. Waste sludge (calcium carbonate) generated in the carbonation process is discharged from the pointed bottom of the carbonizer to the storage tank 4 that has a stirrer and then is further sent to a waste yard. The clarified waste liquor of ammonia distillation flows into the collection tank 5 and is pumped into the reactor 6. Barium chloride solution is added into the reactor, which reacts with sulfate contained in the waste liquor of ammonia distillation to precipitate barium sulfate. This can prevent gypsum from scarring on the heated surface of evaporation equipment later.

The waste liquor of ammonia distillation, after removal of sulfate ions, is clarified in the thickener 7. Sulfate waste sludge precipitated at the bottom of the thickener 7 is pumped into the thickener 1, and is sent, together with suspended impurities separated here, to the disc vacuum filter. The clarified solution from the thickener 7 is pumped into the triple-effect evaporator 10 through the collection tank 9 for evaporation. The heat of the liquor condensate of the primary vapor and secondary vapor is used in the heat exchanger 11 to preheat the waste liquor of ammonia distillation, and then the condensed water is sent to a thermal power station.

In the concentration of waste liquor, NaCl crystals are precipitated in the third effect of the evaporator. The slurry is thickened in the clarifying barrel 13, and then filtered in the centrifuge 14 to separate NaCl from the calcium chloride solution. After the salt is dissolved with condensed water, the saturated brine in the salt dissolving barrel 15 is sent for refining for further use.

In order to remove suspended NaCl crystals, the calcium chloride solution enters the thickener 16 from the clarifying barrel 13, and the overflow flows into the storage tank 18, and then is pumped into the rotary crystallizer 19 to further remove the salt from the solution to obtain a 38% calcium chloride liquid product. A portion of the CaCl_2 solution is sent from the storage tank 18 to the solid calcium chloride workshop.

The calcium chloride solution containing suspended salt particles enters a small tank from the rotary crystallizer 19 and flows into the thickener 20 through a chute. The salt slurry is fed into the storage tank 12 from the pointed bottom of the thickener, and then into the clarifying barrel 13 for use in the next step of production. The cooled and clarified 38% CaCl_2 solution flows from the thickener 20 into the collection tank 21 and is then sent to the finished product warehouse.

A portion of the calcium chloride solution for processing into a solid product (FIG. 11-2) is fed into the vacuum crystallizer 1, the upper part of which is a carburetor. When passing through the vaporizer, the solution boils and is cooled by the vaporization of water in the solution, thereby increasing the NaCl crystallization and CaCl_2 concentration. The suspension is pumped from the bottom of the crystallizer into the thickener 4. Vacuum in the equipment is provided by the ejector 2. The ejector pumps out the secondary vapor and sends it to the surface condenser 3.

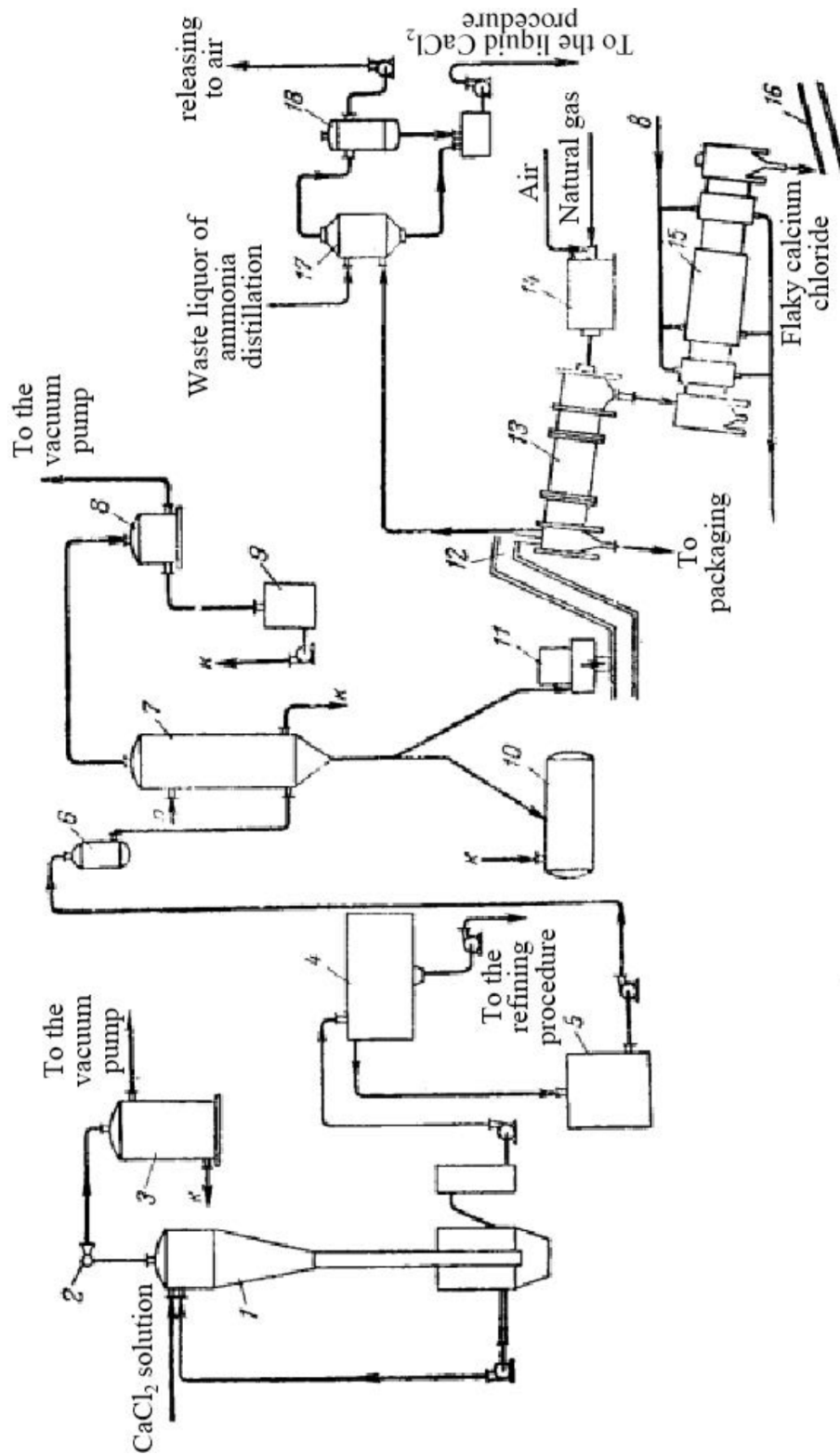


FIG. 11-2 Process Flow of Flaky Solid Calcium Chloride Production

1 - Vacuum crystallizer; 2 - Ejector; 3, 8 - Condenser; 4 - Thickener; 5 - Collection tank; 6 - Preheater; 7 - Evaporator; 9 - Liquor condensate storage tank; 10 - Molten liquid collection tank; 11 - Flaking machine; 12, 16 - Belt conveyor; 13 - Rotary dryer; 14 - Combustion chamber; 15 - Rotary cooler; 17 - Scrubber; 18 - Separator; B - Water; k - Vapor; k - Vapor

The clarified 40% calcium chloride solution flows into the storage tank 5 from the thickener 4, then is pumped into the preheater 6 and further into the tubular evaporator 7, where it is steamed to the molten state. Heating of the solution is carried out with liquor condensate of heating vapor.

The molten liquid of calcium chloride flows from the evaporator to the flaking machine 11. The flaking machine is a rotary drum, the inside of which is cooled by water, and a part of the outside of which is immersed in the molten liquid filled to a certain level of the drum tank of this machine. Thin hard shell formed on the surface of the rotary drum is scraped off by a scraper and broken into pieces of flakes. The calcium chloride flakes fall on the belt conveyor 12 through a chute tube, and the belt conveyor sends the calcium chloride flakes into the rotary dryer 13 for "processing". The purpose of this operation is to evaporate excessive solution from the surface of the flakes so as to prevent the calcium chloride flakes from caking during storage.

CaCl_2 flakes enter the cooler 15 from the dryer, from which they are sent to the finished product warehouse for packaging via the belt conveyor 16. The outgoing gas of the dryer passes sequentially through the scrubber 17 and the separator 18 to remove the suspended particles of the product, and then is vented by a ventilator.

Main equipment The sizes of the thickeners used in calcium chloride production are as follows: the thickeners for clarifying the waste liquor of ammonia distillation are 15 m in diameter and 3.6 m in height; and the thickeners for separating the 38% CaCl_2 solution from salt is 9 m in diameter and 3.6 m in height. The reactor for removing sulfate ions from the waste liquor of ammonia distillation by chemical refining is 2.6 m in diameter and 8.1 m in height.

The removal of salt from the suspension of the 38% CaCl_2 solution is carried out in a HFII-2K-800K continuous-acting horizontal pulse discharge centrifuge, with a clarifying barrel disposed in front of the centrifuge.

All effects of an evaporator are of the same type, and for each effect, there are two external heating chambers and a central circulation pipe (natural circulation). The total heating area per effect is 426 m². The heat exchanger is a vertical tubular heat exchanger.

The vacuum crystallizer has an outer diameter of 2.4 m, an inner diameter of 2 m, a total height of 18.15 m and a volume of 32.7 m³. In the final stage of the concentration process, an evaporator with an internal heating chamber is used, which has a diameter of 2.2 m, a height of 9.62 m and a heating area of 230 m².

The rotary counter-current dryer is 2 m in diameter, 12 m in length and 45.6 m³ in volume. The rotary cooler is equipped with a water cooling device. The equipment has a diameter of 1.6 m, a length of 14 m, and a cooling area of 41.6 m². The rotary drum of the flaking machine is 0.8 m in diameter and 2 m in length. The rotation speed of the rotary drum is 16 rpm.

In order to recover the product dust, after the dryer and cooler, there are: a foam type scrubber (2 m in diameter and 3.75 m in height), and a separator (1.6 m in diameter and 3.6 m in height).

Technological conditions The main indexes of clarification and chemical refining process of waste liquor of ammonia distillation are as follows:

Purification rate, %	
Removal of suspended impurities	99.2
Removal of sulfate ions	97.6
Loss of ammonia distillation waste liquor clarified together with waste sludge (after disc filter), %	5

The operation indexes of the triple-effect evaporator operated in the direct flow mode are as follows:

CaCl ₂ solution concentration, %	
Inlet for the first effect	10.8
Outlet for the third effect	38.0
Absolute pressure of vapor, atm	
Heating vapor at the inlet for the first effect	7
Secondary vapor in the third effect	0.145
Vapor temperature, °C	
Heating vapor at the inlet for the first effect	164
Secondary vapor in the third effect	53
CaCl ₂ solution temperature, °C	
After the preheater	115
Within the first effect	149
Within the second effect	125
With the third effect	73

The salt separated in the centrifuge 14 passes through the clarifying barrel 13 (see FIG. 11-1), and is dissolved with condensed water to make brine containing 310 g/L NaCl.

The concentration conditions of the 38% CaCl₂ solution in the vacuum crystallizer are as follows: the content of CaCl₂ is 37-40% in the feed liquid and 38-41% after passing through the vacuum crystallizer, and the content of NaCl is not more than 1.1% after passing through the vacuum crystallizer.

In the last stage of evaporation (when preparing molten liquid), the following conditions are maintained:

Vapor pressure, atm

	t, °C
Heating vapor.....	14.3-15
Secondary vapor.....	1-1.1
Solution temperature, °C.....	178
Concentration of CaCl ₂ in the evaporated solution, %.....	70-72

The temperature conditions of calcium chloride flaking process in a flaking machine with a 4 t/h production capacity are as follows:

	t, °C
Molten liquid in the equipment	175-179
Flaky calcium chloride.....	100
Discharged cooling water.....	40-50

When flaky calcium chloride is dried and cooled in a unit with a 11.7 t/h production capacity, the following temperature conditions are maintained:

Product	t, °C
Inlet of drier	90
Outlet of drier	140-150
Outlet of cooler	60-70
Flue gas	
Inlet of drier	600-800
Outlet of drier	140-130

The content of CaCl₂ in the dried product is in the range of 76%-80%.

The consumption quotas (calculated as for 67% CaCl₂) for producing 1 ton of 38% CaCl₂ liquid calcium chloride product and 1 ton of 76% CaCl₂ solid flaky calcium chloride product are listed below:

Consumption item	Liquid product	Solid flaky product
Waste liquor of ammonia distillation, m ³	6.04	-
Barium chloride (ГОСТ742-67, Grade I), kg.....	13.7	-
CaCl ₂ solution (38%), ton.....	-	2.17
Vapor, ton		
Pressure 7 atm.....	1.241	-
Pressure 15 atm	-	0.619
Electric energy, kWh.....	72.3	63.4
Natural gas, m ³	-	17.7
Industrial water (circulating water), m ³		58.5