Recycled Salt Precipitation Rules of Yabulai Salt Lake Brine

Salt Production

Key words: Yabulai salt lake, precipitation rules, recycled salt, phase diagram

Abstract

After decades of mining, the richment of Glauber's salt and magnesium salt resulted a decline in the quality and yield of recycled salt in Yabrai Saline Lake brine. In this work, the rule of recycled salt precipitation was studied for Yabrai Saline Lake. According to the local climate conditions and the original production process, the NaCl precipitation rules was investigated at 20ºC, 25ºC and 30ºC.The rules of recycled salt precipitation under different temperature of brine salting was studied with the aid of equilibrium phase diagram of the quaternary system (Na^+, Mg^{2+}//Cl^-, SO_4^{2-}-H_2O), It was found that the main reason affecting the quality of regenerated salt was glauber's salt enrichment. At 20ºC, NaCl and $Na_2SO_4 \cdot MgSO_4 \cdot 4H_2O$(Ast) was saturated in brine when the brine density reach 1.2635 g/cm^3 , and glauber's salt began to precipitate. Then, the precipitation ratio of NaCl was 68.53%. At 25 ºC, NaCl and Ast was saturated in brine when the brine density reach 1.2619 g/cm^3 , then the precipitation ratio of NaCl was 69.54%. At 25 ºC, NaCl and Ast was saturated in brine when the brine density reach 1.2611g/cm^3 , then the precipitation ratio of NaCl was 64.39%.

Introduction

The summer season is short at Yabulai Salt Lake, but the temperature is high and the amount of evaporation is very large. The brine precipitation of salt through evaporation in the salt lake mainly concentrates from April to September. In this article, the raw brine is used as that in salt area of reproduction in Yabulai Salt Lake in April and the precipitation rules of sodium chloride from brine in salt lake are studied in the process of evaporation under different temperatures to provide reference data for production of regenerated salt in salt lake. Yabulai Salt Lake is located in the west of Inner Mongolia with the lower temperature from November to February and the average temperature below -5°C. There is a large amount of Glauber's salt and ice in brine of salt lake brine. There is a slow increase for temperature from March and ice and glauber gradually dissolve. In April, the average temperature rose to about 10°C and the solid salt in brine of salt lake basically dissolves completely, and that the salt lake evaporation mainly concentrates from April to December is taken into account. Therefore, the raw brine in evaporation from regenerated salt area of Yabulai Salt Lake in April 2013 is used as the focus of this research.

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The raw brine in evaporation from regenerated salt area of Yabulai Salt Lake in April 2013 is used as the research object. According to the composition of brine in Table 1, the brine is configured in lab. Take 2L brine from the laboratory configuration and it is concentrated at 80°C -100 °C. The rate of distilled water (the amount of distilled water takes up that of brine before evaporation) can be roughly estimated by the theoretical phase diagram. The evaporated brine is kept at 20°C or 25°C in incubator for 60 hours and the composition basically reaches stable state.. Finally, the brine solid-liquid phase is separated and the chemical composition, brine density of the brine and solid phase composition are measured.

Table 1 The brine composition in regenerated salt production areas in April

Concetration（g/L）						Physical Property	
Cl^-	SO_4^{2-}	Mg^{2+}	Ca^{2+}	Na^+	H_2O	Temperature（℃）	density（kg/L）
185.16	35.74	12.71	trace	112.70	878.69	12	1.225

Result and discussion

Salt Precipitation through evaporation at 20 ℃ Constant Temperature

The brine is stable at 20℃ constant temperature, and liquid ion concentration changes are shown in Figure 1 with water consumption trends. When there is no solid phase precipitation in the brine, the brine is a simple concentration process, in which various ion concentration increases in the liquid. In this experiment, after there is solid phase precipitation in the brine, taking samples occurs. When the water loss rate is less than 51.49%, the concentrations of Cl^- and Na^+ in the liquid phase decrease slowly, and the concentrations of SO_4^{2-} and Mg^{2+} increase, which is due to the solid phase precipitation in the initial phase. Enough sodium chloride exists in the liquid, while the concentrations of magnesium ions and sulfate ions are rich, resulting in decreasing sodium chloride solubility. When the water loss rate is more than 51.49%, the SO_4^{2-} concentration tends to be gentle and the Na^+ concentration decreases quickly. This is due to the saturation of the second solid phase and SO_4^{2-} precipitation.

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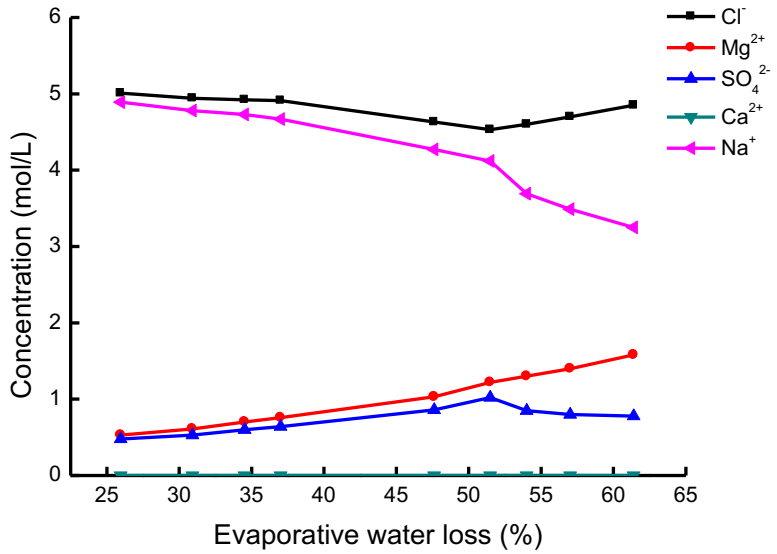

Figure 1 Change trend of Ion concentration in liquid phase of Yabulai salt-lake brine in evaporation process

In order to find out the turning point of the solution saturation to the second solid phase, the composition change of the liquid phase during the evaporation is drawn at 20 °C for Na^+, Mg^{2+}//Cl^-, SO_4^{2-}-H_2O system. (Figure 2), in which the point 1 is the raw brine, 2-10 points respectively correspond to compositions of liquid phase in different water loss rate of brine evaporation. The position of the raw brine in the phase diagram is in the saturated phase of the NaCl single solid phase. Before the brine is not saturated during the evaporation, the liquid phase composition is always at the point 1. With the water evaporation, the brine is first saturated to NaCl and the composition of liquid phase moves toward double solidus. When the liquid phase composition reaches 6 points (steam loss rate of 51.49%), brine is saturated to sodium alum (Ast) with NaCl and Ast precipitation, the liquid phase will move along the double solid saturation line. Salt Lake aims to produce salt products, in order to ensure the production of NaCl while ensuring the quality of NaCl, through setting 20 °C control point near 51.49%, the loss rate of water.

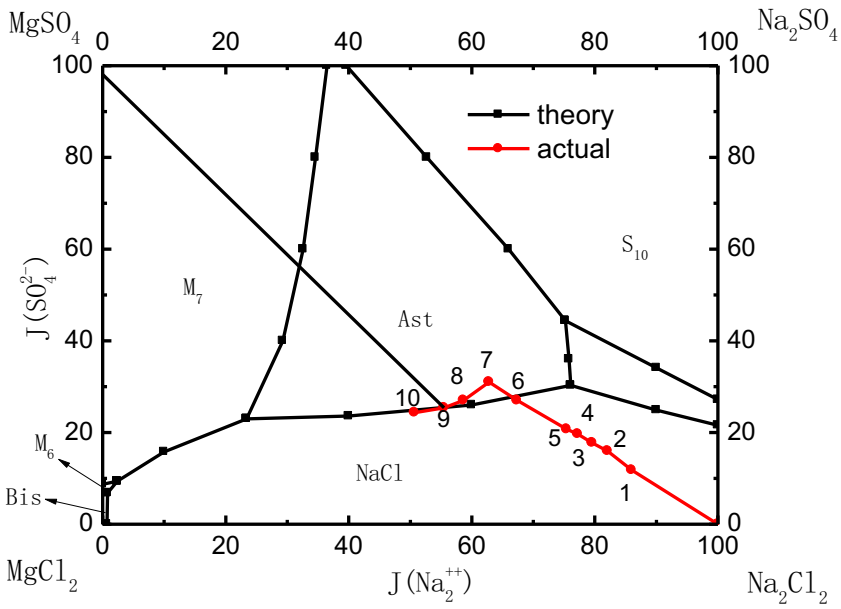

Figure 2 Laws of crystallization of Yabulai salt-lake brine in evaporation process at 20℃

In general, the brine density is used as control indicator in actual production for salt lake. The density changes of liquid phase in brine are shown in Figure 3 during the evaporation.

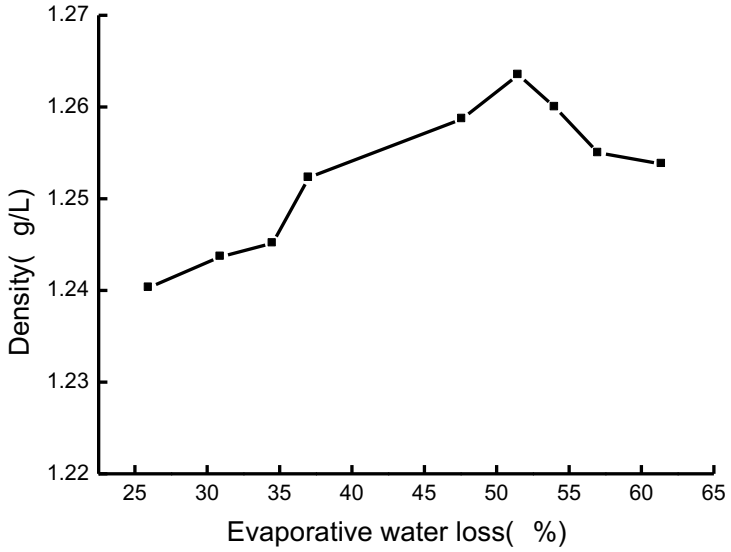

Figure 3 Evaporative water loss vs. liquid density of Yabulai salt-lake brine

In the process of evaporation, the density of brine slowly increases at first, when the brine is

saturated with the double solid phase, the brine density will slightly reduce. Therefore, in the actual production process we should always pay attention to changes in brine density, controlling the brine density at 1.2635g / L or less.

Salt Precipitation through evaporation at 25℃ Constant Temperature

The brine is stable at 25°C constant temperature, liquid ion concentration changes are shown in Figure 4 under different water loss rates. There are three stages of changes for ion concentration during evaporation. In the first stage, before the brine is not saturated, all ion concentrations increase with water loss; in the second stage, the brine is saturated with first solid phase and it precipitates in the solution, at that time the concentrations of SO_4^{2-} and Mg^{2+} in the liquid phase continue to increase with the concentration of water. At the same time, the concentrations of Cl^- and Na^+ decrease with the salt precipitation; in the third stage, the brine is saturated with the double solid phase, NaCl and the other solid phase are precipitated at the same time. The Cl^-concentration increases slightly and the decreasing trend of Na + concentration turns larger. The change of SO_4^{2-} concentration tends to be gentle, but the change trend of Mg^{2+} concentration is weak. The water loss rate of the solution to the second solid phase is 51.38%.

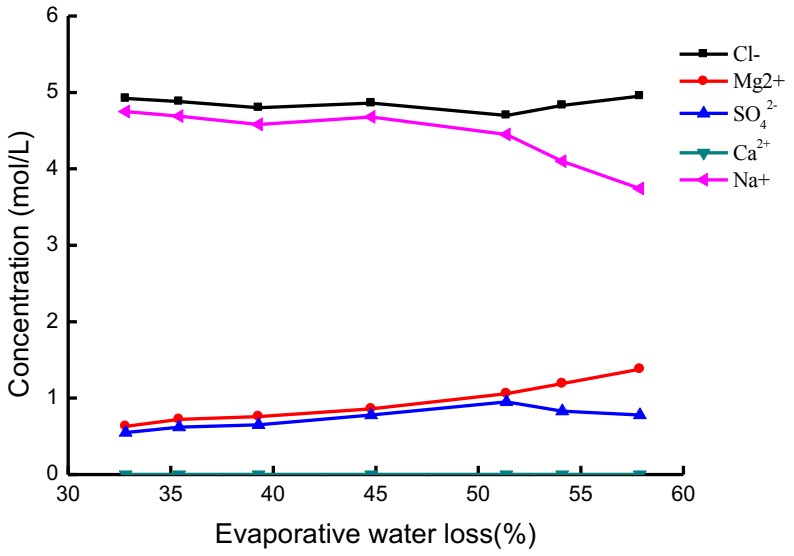

Figure 4 Change trend of Ion concentration in liquid phase of Yabulai salt-lake brine in evaporation process

The liquid phase composition is plotted at 25 °C for Na^+, Mg^{2+} // Cl^-, SO_4^{2-} system (Figure. 5) according to the Yeneck index (J value) of the brine liquid phase composition.

Point 1 in dry point map is the raw brine, points 2 to 8 respectively correspond to the liquid composition with steam loss from 32.81% to 57.88%. It can be seen from the phase diagram that the raw brine is also in the NaCl zone, and during the evaporation, the brine is first saturated with

NaCl. Brine continues to concentrate, when the brine water loss rate reaches 51.38%, the brine in is saturated with the second solid phase Ast and NaCl and Ast simultaneously precipitate, if brine continues to concentrate, the quality of NaCl can not be guaranteed, so this point is selected as concentration limit point at 25 ℃.

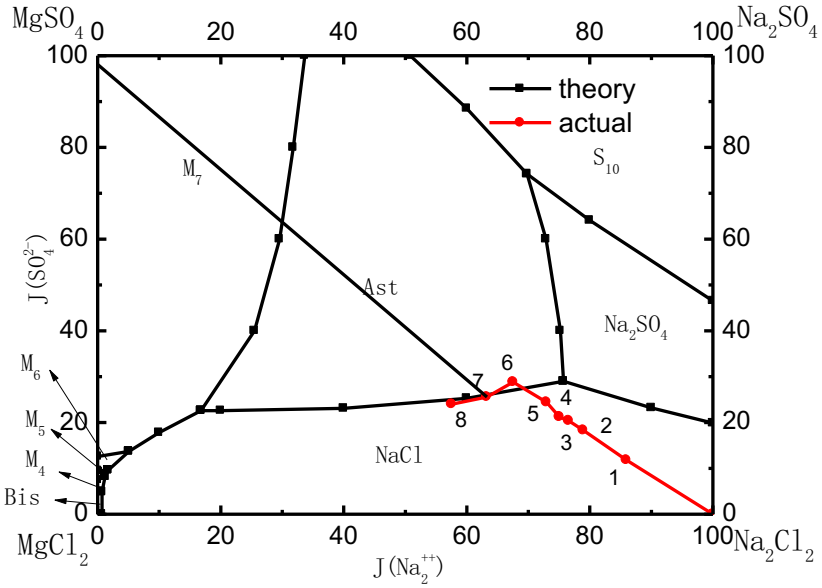

Figure 5 Laws of crystallization of Yabulai salt-lake brine in evaporation process at 25℃

In this process, liquid phase density changes in the brine are shown in Figure 6, and brine density firstly increases and then decreases. The brine concentration of 1.2619g/ml is used as a craft control point, at any time brine density is detected, the brine density is always controlled at less than 1.2619g/ml to ensure the quality of the regenerated salt.

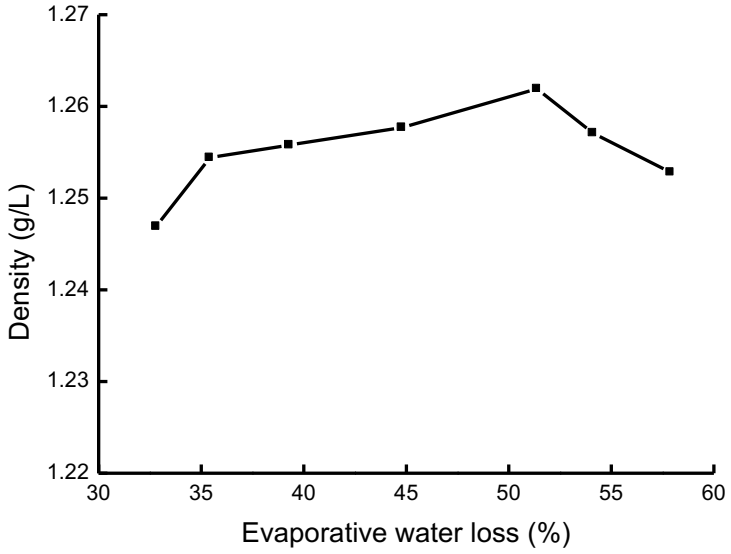

Figure 6 Steaming water-losing ratio vs. liquid density of Yabulai salt-lake brine

Conclusions

The main reason for the salt quality is the enrichment of Mg^{2+} and SO_4^{2-} in salt lake. When the water loss rate reaches or exceeds the boundary point of second solid saturation, there will be precipitation of Ast. In this chapter, through the study on rules of brine regeneration in the Yabulai Salt Lake, the water loss rate and brine density to common saturation of NaCl and Ast are determined to guide the salt production in salt lake. At 20°C constant temperature, it can evaporate. The steam loss rate is 51.49% and the brine density is 1.2635g / cm^3 when the brine is saturated with NaCl and Ast, meanwhile, the precipitation rate of NaCl is 68.53%. At 25 °C constant temperature, it can evaporate. The steam loss rate of brine is 51.38% and the brine density is 1.2619g / cm^3 when the brine is saturated with double solid NaCl and Ast with the precipitation rate 69.54% of NaCl.

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