EFFECT OF THE SCALE FORMATION ON THE PERFORMANCE OF RECIRCULATION MSF PLANT

ALA'A ABDULRAZAQ JASSIM

Chemical Engineering Department - University of Basrah - Iraq

Abstract:

The effect of fouling due to scale formation of pre-heater tubes on the thermal performance of Reticulating multi stage flash Distillation plant performance ratio and the increase of the ratio of Makeup water to the product Quantity for a 5MGPD recirculating System has been prediction .The results appeared That eth Effect of scale formation is more Effected as the Maximum brine temperature decrease.

تأثير تكون القشور على أداء محطات التبخير الفجائي متعدد المراحل

علاء عبد الرزاق جاسم , قسم الهندسة الكيميائية , جامعه البصرة , العراق

الخلاصة:

سيتم في هذا البحث دراسة تأثير تكون القشور ولأوساخ فوق أنابيب المبادل الحراري على الأداء الحراري لمحطات إنتاج الماء المقطر بطريقه التبخير الفجائي متعدد المراحل .تم وضع نموذج رياضي لهذا النوع من المحطات وثم دراسة أمكانيه زيادة نسبه أداء المحطات والزيادة في نسبه الماء المغذى الى الماء المنتج لغرض أنتاج 5mgpd بنظام التبخير الفجائي متعدد المراحل بوجود مجرى أعاده الدوران.

أظهرت النتائج ان تكون القشور على أداء المحطة مؤثر جدا ويزداد تأثير بزيادة درجه حرارة دخول الماء المالح الى المرحلة الأولى.

Introduction

Thermal energy input have the common disadvantage of require large amount of cooling water. The Required seawater feeds range from 7 to 14 multiplies of the water Production rates. The equation of system which represent the mass and heat balances are challenging problems. This is due to the face that the equations describing the process are numerous non linear and complex .the previous work is based mainly on the solution of these equations by stage calculations (2, 3,4). Now, most of research is depended on solving these equations by iterative method (5,6).in order to retain the quality and quantity of water production and to increase the plant life, the heat transfer surfaces in the MSF plant most be clean. The effect of scale formation on the heat transfer surface on the MSF plants is to increase the thermal resistance to heat flow between the vapor formed by flashing and the feed water flowing inside the tubes of the brine heater. The net result of this is a decrease in the plant thermal performance ratio. The purpose of this work is to discuss the effect of scale formation on the thermal performance of the recirculation MSF plants.

Plant Description

To understand the derivation of the general working equations, a brief description of the MSF desalination process is given and the process flow sheet is showing in figure(1). The feed to the plant ,WT,IS allowed to pass through the heat rejection section .On leaving the first rejection stage the feed stream is split into two parts, reject seawater Cw which passes back to the sea and a makeup streams f which is then combined with the recycle stream R. The combined stream W now passes through a series of heat exchangers, its temperature rising as it proceeds towards the heat input section of the plant. Passing through the brine heater, the brine temperature is raised from T_{f1} at the inlet of the brine heater to a maximum T_{BO}, approximately equal to the saturation temperature at the system pressure. The brine then enters the first heat recovery stage through an orifice thus reducing the pressure. As the brine was already at its saturation temperature for a higher pressure, it will become superheated and flashed to give off water vapor. The vapor is condensed and collected in the distillated tries. The process is the repeated all the way down the plant as both brine and distillate enter the next stage which is at a lower pressure. The concentrated brine is divided into two parts as it leaves the plant, the blowdown BD which is pumped back to the sea and a recycle stream R which returns to mix with the makeup stream F.

Input Data for the Al-Khobarh MSF Desalination Plant (Saudi Arabia)

The design data which is used for this purpose depend on Al-Khobar II (Saudi Arabia) MSF desalination plant [4] are list in table (1).

Effect of Scale Formation on the plant performance

For the recirculating MSF plant which is shown in figure(1), assuming an equal temperature drop in all stages, that is:

$$\Delta T_S=(T_{BO} - T_{BD})/N= \text{constant} \quad …..(1)$$

T_{BD} and T_{BO} are the brine temperature in the first and the last stage respectively. The amount of vapor M_n formed by flashing in the height temperature stage (stage number n) is given by:-

$$M_n=M_f *K \quad …..(2)$$

WHERE

$$K=Cp*\Delta T_S/L \quad …..(3)$$

The amount of heat transferred to the feed water M_f due to the condensation of vapor formed by flashing of the brine m_{I-1} and distillate m_{Di-1} coming from previous stage (I-1) is given by the following relationship:

$Q=(m_{I-1}+m_{DI-1})*k*L$ …..(4)

$=M_f *Cp * (T_{I-1}-T_I)$ …..(5)

The overall heat transferred to the system is:

$Q= U_I * A_I * \Theta$ …..(6)

Where Θ is the logarithmic mean temperature which is defined as :

$\Theta= t_I - t_{I+1} /Ln\{(T_{ci} - t_{I+1})/(T_{ci} - t_1)\}$ …..(7)

These details can be represented by figure(2). The pant thermal performance ratio PR is usually defined as the ratios between the mass of fresh water produced Md to the mass of steam used in the brine heaters Ms.

$PR=Mi * Li/(Ms*Ls)$ …..(8)

$=M_f *Cp *(t_n -T_f)/(M_f* Cp*(T_{BO}-t_n)$ …..(9)

$=(t_n -T_f)/ (T_{BO}-t_n)$ …..(10)

Results and Discussion

The aim of the present work is to study the effect of fouling, due to the scale formation, on the thermal performance of recycle brine MSF plant. Figure 3 and 4 shows the dependence of the plant thermal performance PR and the ratio of feed water to the product water M_f/M_d on the thermal resistance Rd due to scale formation. These figures were drawn using the following assumptions:-

Maximum brine temperature $T_{BD}=120^OC$ and 90^oC, temperature drop $=1^oC$ and plant capacity =5MGPD.

As shown in figure (3) the plant thermal performance PR decreases by the increase of the resistance of heat transfer due to scale formation (R_d). since the effect of scale formation on the pre-heater heat transfer is to increase the thermal resistance for heat flow between the vapor formed by flashing and feed water flowing through the pre-heater tubes. The net results of this is the decreases of the outlet temperature from the height stage temperature t_n. Consequently, the steam input to the brine heater must be increased for the same output at the maximum operating temperature which means that the thermal performance decreases.

Figure (4) indicates that the ratio of the feed water to the product fresh water (M_f/m_d) increase by the increasing of the heat transfer resistance. This can be attributed to the increase of the brine rejection temperature or the decrease of the flashing range. It is worth noting that the effect of scale formation is more effected as the maximum brine temperature decreases. The reason of this that as the T_{BO} decrease, the temperature drop per stage will decrease.

References

[1] Genther, K. and El-allawy, M. " Assessment of MSF evaporator design with reduce cooling requirements", Desalination, Vol.31, P. 57, 1979

[2] Hayakawa, K., " process simulation on multi-stage distillation plant", 4th international symposium on fresh water from the sea, Vol. 1, P.303, 1973.

[3] Omar, A. M. " simulation of MSF desalination plants", Desalination, Vol.45, P.64, 1983.

[4] Hamadi, N. K. " Simulation and optimization of a water distillation system"", M. Sc. Thesis, University of Basrah, Iraq, 1993.

[5] Flower, J. R. "Tridiagonal matrix model for multi-stage flash desalination plant", computer and chemical engineering Journal, V.10, P.327, 1986.

[6] Ala'a A. R. "Design and location of multi stage flash evaporation plant for the city of Basrah", M.Sc. Thesis, University of Basrah, Iraq, 1996.

Nomenclatures

A: heat transfer area per stage m^2

Cp: specific heat at a constant pressure KJ/Kmol.°C

Q: amount of heat flow KW

m: steam formed by flashing Kg

M: brine flow rate Kg/s

N: number of stages

T: brine temperature during its flow in the stage °C

ΔT_S: temperature drop per stage

T_B: brine temperature during flow in the pre heater °C

U: overall heat transfer coefficient KJ/m^2. S

Θ: logarithmic mean temperature difference

Subscripts

F: feed

I: stage number

s: stream

BD: blow down stream

B_o: brine feed stream

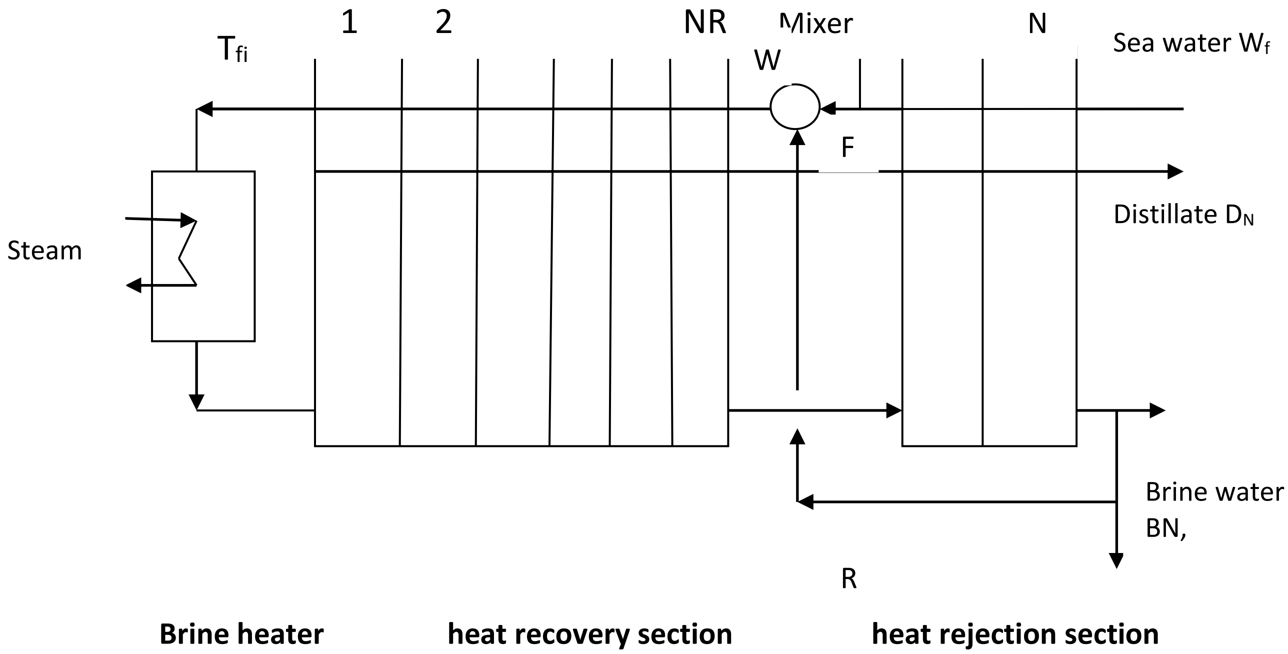
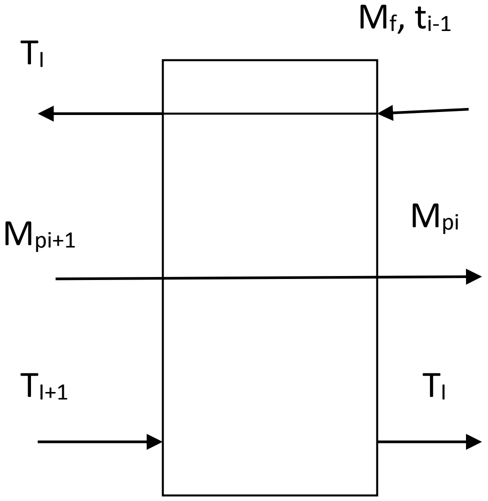


Fig.(1) flowchart for (MSF) desalination plant

Table(1) Operation conditions for Al-KhobarII plant

Type of plant: brine recycle cross tube
Number of recovery stages: 13
Number of rejection stages:3
Total number of stages:16
Capacity:5MGPD
Height of brine level in each stage: 18 inch
Make up flow rate:0.125*10^8(Ib/hr)
Recycle stream flow rate:0.140*10^8(Ib/hr)
Reject cooling sea water:0.124*10^8(Ib/hr)
Steam temperature to brine heater 206^{o}F
Feed sea water temperature: 95^{O}F
Feed sea water concentration:56000PPM

Fig.(2) Temperature distribution in stage number I



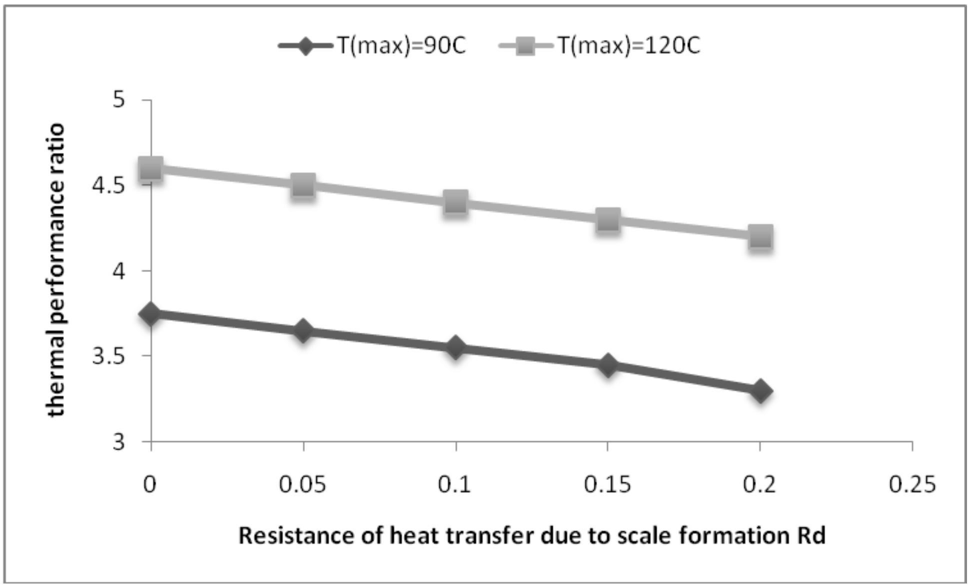


Fig.(3) Effect of fouling on the thermal performance ratio

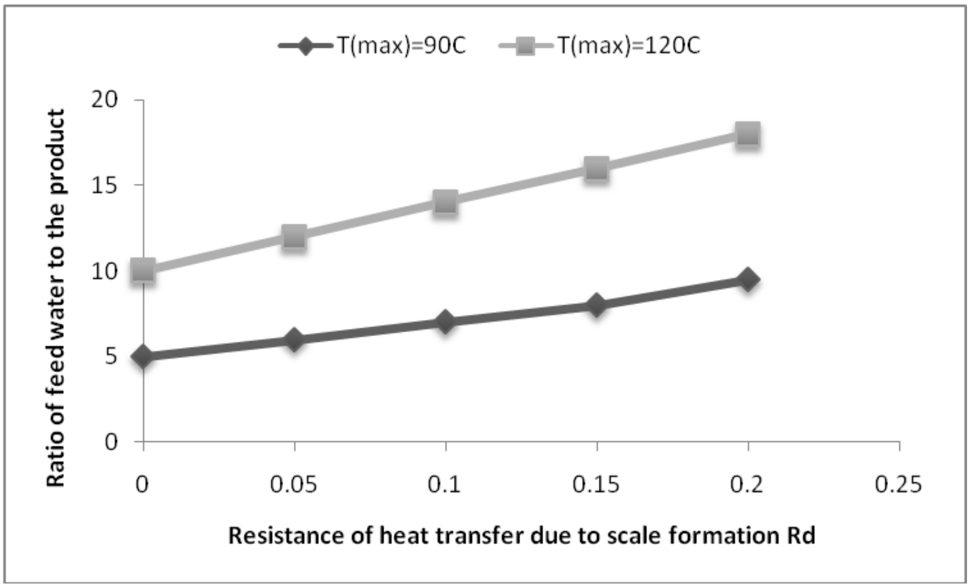


Fig.(4) Effect of fouling on the ratio of feed water to the product