TPRI 西安热工研究院有限公司
XI'AN THERMAL POWER RESEARCH INSTITUTE CO.,LTD

应用于直接空冷系统的板式蒸发式凝汽器的设计及工程示范

System Design and Demonstration Project of Plate Evaporative Condenser in Direct Air-cooling Unit

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引言

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Introduction

直接空冷机组夏季运行背压高

High operating back pressure and low efficiency

01 **空冷技术节水，快速发展，装机容量全球第一**

Air-cooling technology is widely used in the northern regions for its outstanding performance in water-saving.

02 **空气与乏汽一次换热，ACC性能受环境因素影响较大**

Heat transfer occurs directly between air and exhaust, ACC performance is greatly affected by environmental factors such as wind velocity, air temperature.

03 **夏季运行背压高，限负荷运行，经济性差。**

The efficiency of ACC reduces and operating back pressure increases, inducing a lower output power and economic efficiency of the air-cooling unit.

解决方案 Solving plans

01 **喷淋除盐水**

Atomization spraying system

02 **结构改进：挡风墙，导流装置**

Extending the windbreak wall, installing diversion device

03 **排汽管道喷除盐水**

Spraying desalted water into the steam inlet pipe of ACC

04 **加装湿冷凝汽器及附属系统，分流乏汽**

Adding surface condenser and taking circulating water as cooling medium to distribute part of steam turbine exhaust and the ACC heat load reduces.

本文目的 Main Purpose

采用板式蒸发式冷却技术分流部分汽轮机排汽，降低空冷岛热负荷，从而降低机组背压，提高机组出力。

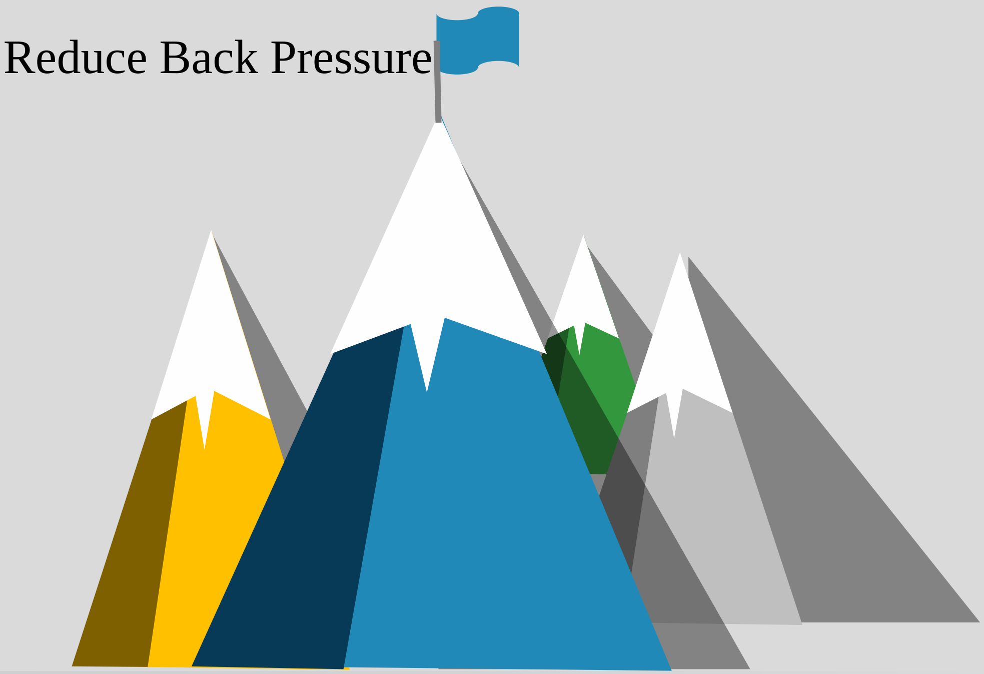


Plate evaporative cooling technology is proposed in this paper. A portion of turbine exhaust steam is bypassed to reduce heat load of air-cooled island, thereby reducing turbine back pressure and improving output.

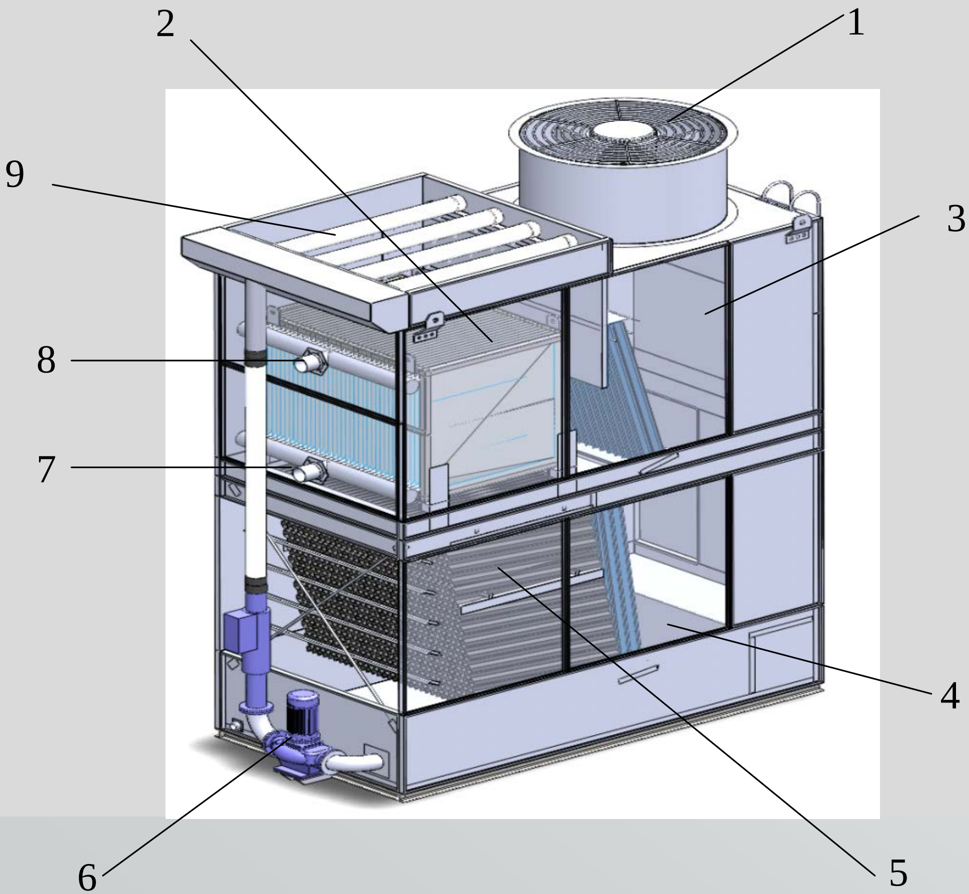
工作原理及工程设计

2

Working Principle & Engineering Design

板式蒸发式凝汽器工作原理

Working Principle of Plate Evaporative Condenser



1. 风机 2. 板式换热器 3. 风腔 4 循环水池 5.填料 6.循环水泵7.冷凝水出口管8.蒸汽进口管9喷淋分配装置

1 fan, 2 plate heat exchanger, 3 wind cavities, 4 circulating basin, 5 filler, 6 pump, 7 condensate outlet pipe, 8 steam inlet pipe, 9 spray distribution device

工程设计 Engineering Design

以热平衡为基础，采用试算法进行板式蒸发式凝汽器的工程设计。

Based on heat balance, test algorithm is used for the design of plate evaporative condenser, which meets the requirements of engineering design

工程依托、试验结果和分析

3

Results and Discussions of Engineering Support Unit

3.1 工程依托机组 Engineering Support Unit

01

机组概况 Unit Operation Condition

亚临界300MW直接空冷，设计性能：29℃背压30 kPa；实际运行：30℃背压42kPa。

300MW subcritical direct air cooling steam generator, design performance : 30kPa at 29℃, while 40kPa at 29℃ during actual operation.

02

板式蒸发式凝汽器的设计 Design of Plate Type Evaporative Condenser

设计目标函数：TRL夏季工况，环境温度30℃，降低运行背压3kPa。根据第三章的试算法，板片换热面积为1272m^2。

the design heat transfer area is 1272m2 following the design methods introduced in Chapter 3. Equipment processing and manufacturing is accomplished by the relevant manufacturers.

$$t_1=\frac{\Delta t_a}{1-e^{-NTU}}+t_a+\delta t=\frac{D_0(h_k-h_c)}{3600A_w u_w \bar{\rho}_a c_a}\times\frac{1}{1-e^{-NTU}}+t_a+\delta t$$

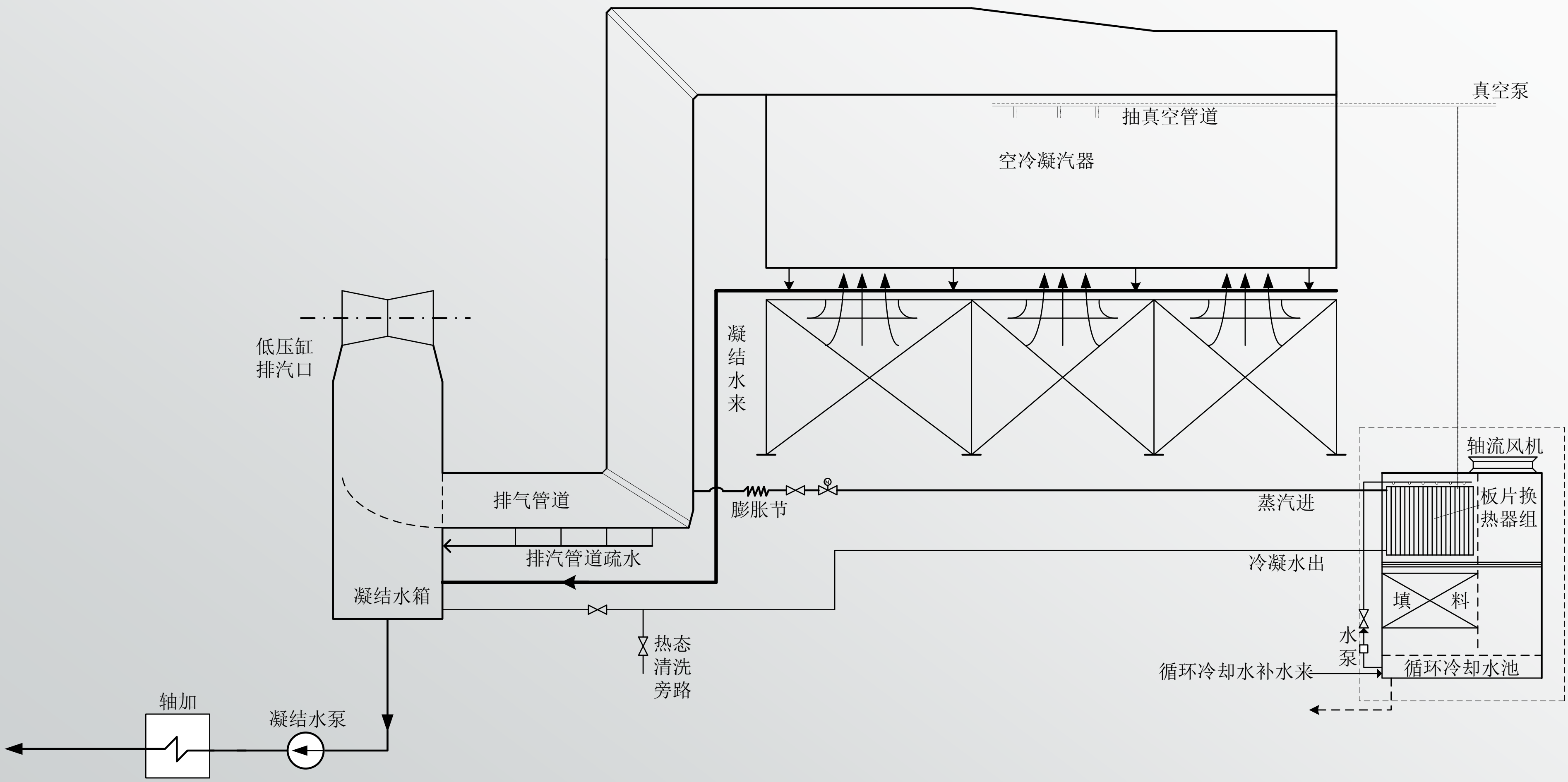
03 附属系统 Auxiliary System

01 蒸汽分配及凝结水系统 Steam distribution and condensate system

02 抽真空系统 Vacuum pumping system

03 循环水及补充水系统 Circulating and supplementary water system

04 电气及控制系统 Electrical and control system


真空泵
抽真空管道
空冷凝汽器
凝
结
水
来
低压缸
排汽口
排气管道
膨胀节
蒸汽进
轴流风机
板片换
热器组
排汽管道疏水
冷凝水出
凝结水箱
填
料
水
泵
热态
清洗
旁路
循环冷却水补水来
循环冷却水池
轴加
凝结水泵

3.2 结果和分析 Results and Discussions

A 投运效果 Operation Effect

1）空冷系统未投运喷淋系统时，TRL工况环境温度30℃下背压下降4.1kPa；

On the condition of not-using spraying system, back pressure decreases by 4.1 kPa at 30°C for TRL.

2）空冷凝汽器投运喷淋系统时，TRL工况环境温度30℃下背压下降3.7kPa；

On the condition of using spraying system, back pressure decreases by 3.7 kPa at 30°C for TRL.

3）定义水耗率为循环冷却水补水量与蒸汽冷凝量的比率，运行表明板式蒸发式凝汽器的水耗率在0.7~0.8之间。

Water consumption rate representing the ratio of circulating cooling supplement water to steam condensation is among 0.7~0.8.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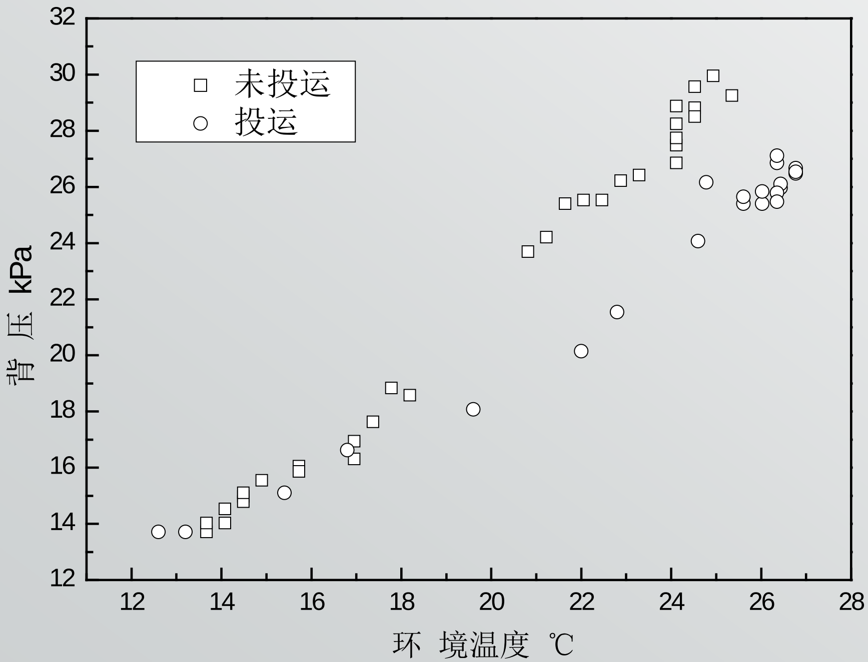
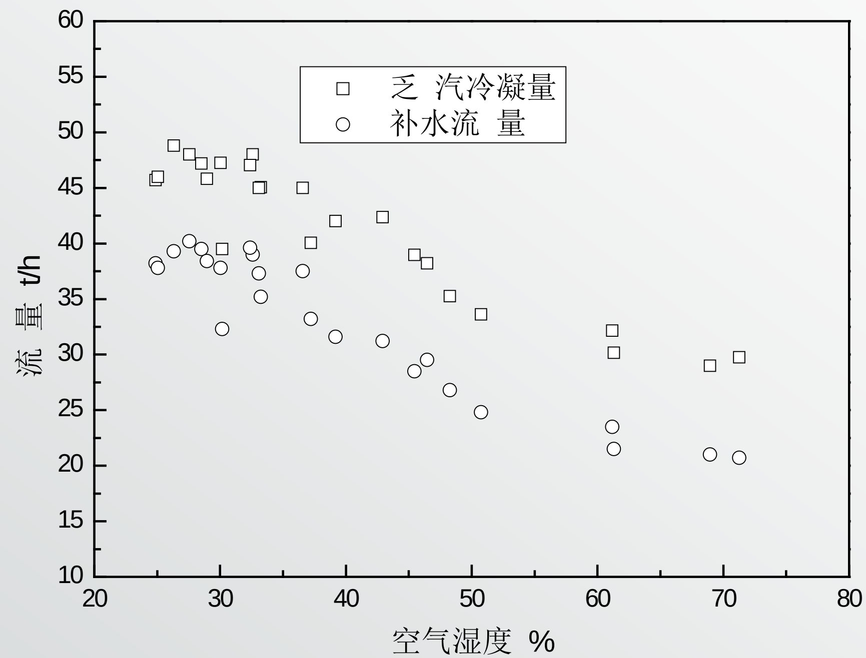
3.2 结果和分析 Results and Discussions

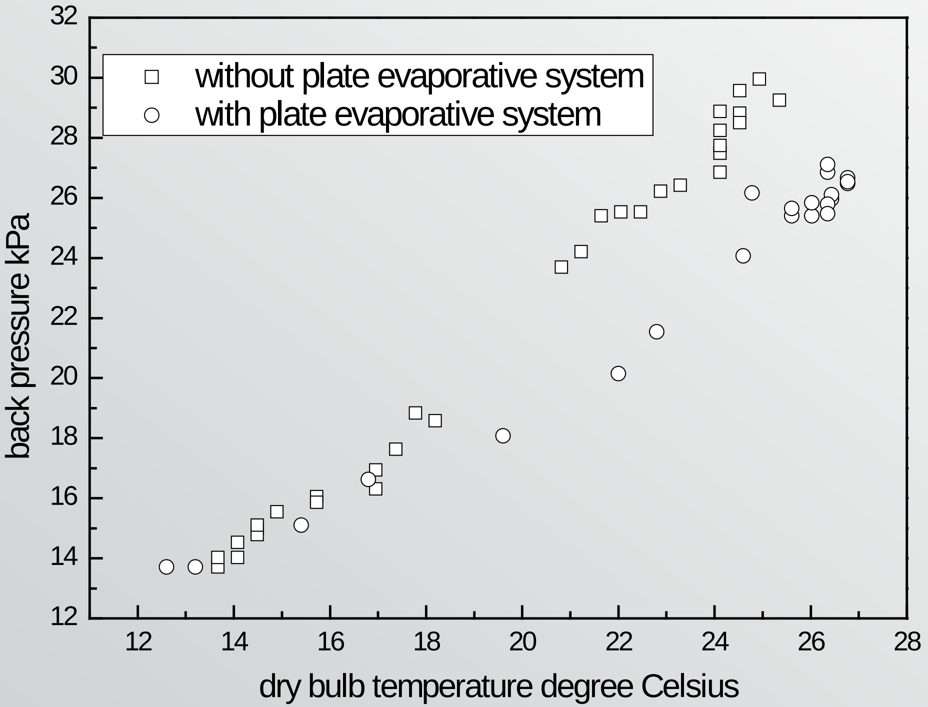
B 性能分析 Performance Analysis

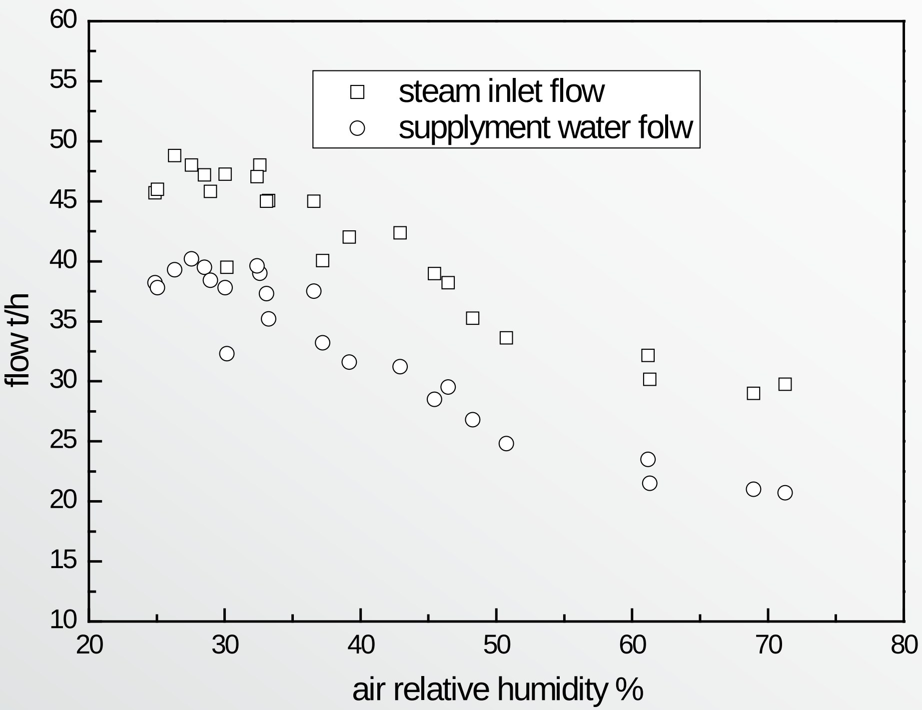




1）板式蒸发式凝汽器系统的冷却效果随着环境温度的升高而提高；

2）随着外部空气湿度增大，板式蒸发式凝汽器的冷凝量和补水流量逐渐减小，且趋势相同；空气湿度增大到一定程度后，其冷凝量和补水流量趋于定值。





1) Back pressure increases with the increase of temperature for full outload, leading to the increase of the temperature difference between steam and water as well as condensation ability.

2) When the dry dulb temperature is specified, the temperature difference between steam and water decreases with the increase of wet dulb temperature inducing the final decrease of condensation ability, steam inlet flow, and supplement water flow.

结论

4

Conclusion

01 依托某300 MW直接空冷机组的板式蒸发式凝汽器系统性能完全达到设计要求，性能稳定。

Test algorithm was adopted to meet the requirements of engineering design based on heat balance. For an engineering demonstration unit with rated load 300MW, the performance of the designed system fully fulfils the design requirements and stable performance has been achieved.

02 板式蒸发式凝汽器系统的投运效果随着环境温度增加而增加；随着环境空气湿度增大，板式蒸发式凝汽器系统的冷凝量和补水流量随之减小，且呈同一趋势，空气湿度增大到一定程度后，其冷凝量和补水流量趋于定值。

Operation effect of plate evaporative condenser system increases with environment temperature. With the increase of air relative humidity, steam inlet flow and supplement water flow decrease accordingly and same trend has been obtained.

03 板式蒸发式凝汽器的水耗率为0.7~0.8。

Test shows that water consumption rate is among 0.7~0.8.

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谢谢大家

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