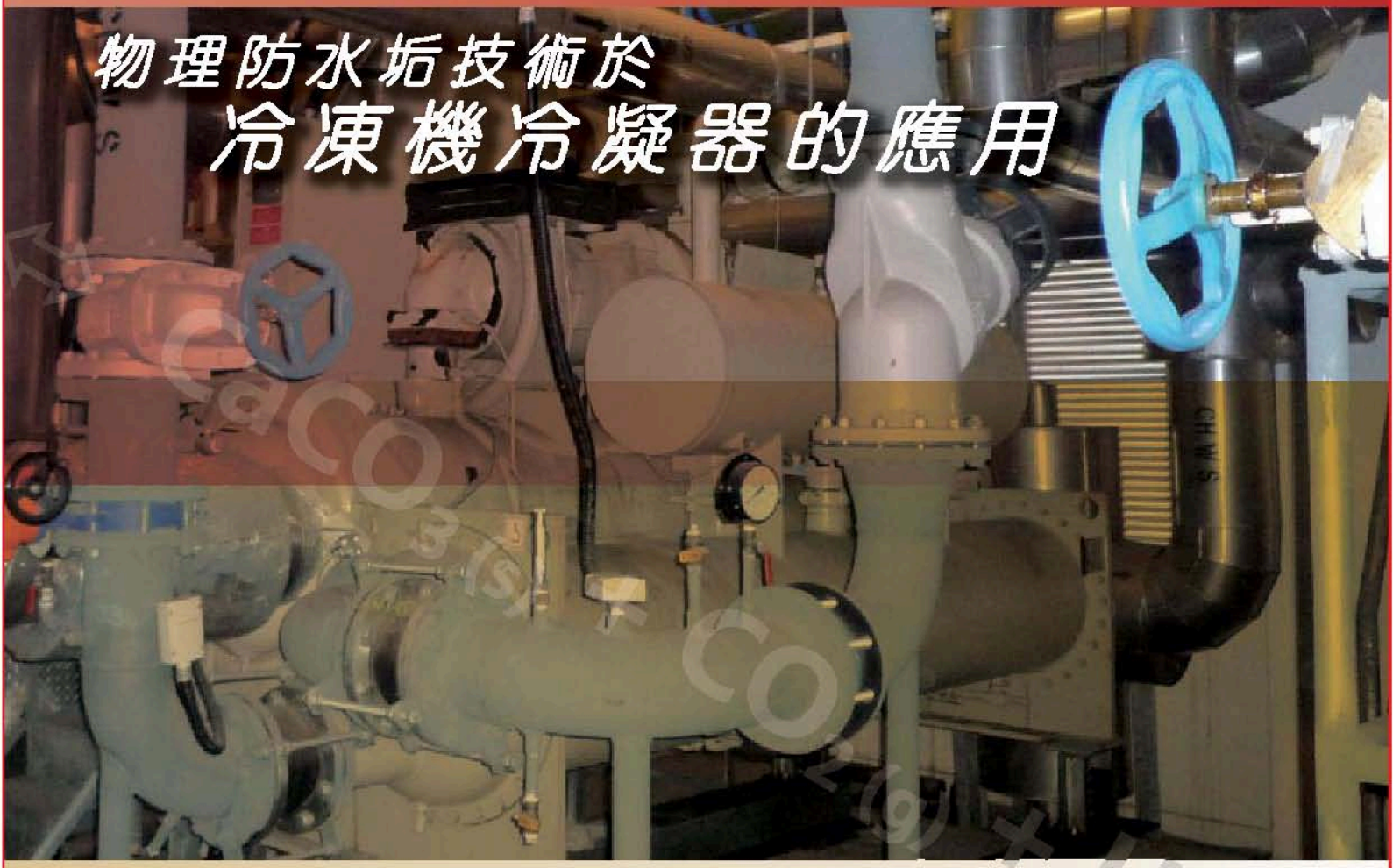
Application of Physical Scale Prevention Technologies for Chiller Condenser

物理防水垢技術於冷凍機冷凝器的應用



機電工程署
EMSD

Introduction

A typical condensing water system for water-cooled central air conditioning system consists of pumps, condenser, condensing water pipework and a heat rejection unit such as cooling tower or heat exchanger etc.

Some physical scale prevention technologies such as automatic tube cleansing system, magnetic and electromagnetic devices have emerged on the market in recent years. This pamphlet aims to introduce these scale prevention technologies for chiller condenser in HVAC system as well as their application limitations. For further information, please contact the Energy Efficiency Office of the Electrical and Mechanical Services Department.

引言

水冷式中央空調系統的冷凝水系統通常包括水泵、冷凝器、冷凝水管道和散熱裝置(如冷卻塔或熱交換器)。

近年來，一些物理防水垢技術相繼於市場上出現，如冷凝器管道自動清洗系統、磁力場和電磁場防積垢裝置。本小冊子旨在介紹這些物理防積垢技術於空調系統冷凍機冷凝器的應用和相關的限制。有關進一步資料，請與機電工程署能源效益事務處聯絡。

Scale - Where and Why?

In fresh water cooled air-conditioning system, fresh water contains traces of mineral ions, in which calcium carbonate is a dominant component because natural water is rich in Ca^{2+} and carbonic species (CO_2, HCO_3^-, CO_3^{2-}). Calcium carbonate ($CaCO_3$) is only slightly soluble in pure water but more soluble when carbon dioxide is present in water. This could be represented by the following equilibrium equation:

水垢 — 在那裡及原因？

一般而言，在淡水冷卻空調系統內所用的淡水會含有微量礦物離子，其中碳酸鈣是主要成份，因為天然水含有豐富的鈣（Ca^{2+}）和碳物種（CO_2, HCO_3^-, CO_3^{2-}）。碳酸鈣（$CaCO_3$）只能微微溶於純淨水，但若水中含有二氧化碳，它的可溶性會提高，這可以下列化學方程來代表：

$$Ca(HCO_3)_{2\,(aq)} \Leftrightarrow CaCO_{3\,(s)} + CO_{2\,(g)} + H_2O$$

When condensing water approaches the heat exchanger (condenser), the temperature rises and solubility of CO_2 gas decreases. The solution will tend to restore the equilibrium by shifting towards $CaCO_{3(s)}$ precipitation and therefore the formation of $CaCO_{3(s)}$ occurs (in the form of calcite) on heat exchanger surface. This is why hard scale is usually found on the heat exchanger of condensers. As scale is a good insulator of heat, the heat transfer efficiency of the chiller condenser is reduced affecting the energy performance of the chiller.

Scale Prevention and Energy Efficiency

The primary aim of scale prevention is to upkeep the condition of inner surface of condenser tube of chiller so that the heat exchange at condenser tube of chiller could be maintained in good condition. As such, chiller could operate more efficiently.

It should however be noted that the achievable energy saving is site specific which depends on the mineral content of condensing water, the conditions of the plant equipment, the operation pattern and the maintenance of the chiller plant, etc.

當冷凝水接近熱交換器（冷凝器）時，二氧化碳在水中的溶解度會隨著溫度上升而減低，為了恢復上述的化學方程之平衡，溶液會傾向於轉化為碳酸鈣沉澱物（$CaCO_{3(s)}$）。因此，$CaCO_{3(s)}$（方解石的型態）就會在熱交換器表面形成了，這也解釋了為什麼堅硬的水垢通常於熱交換器內表面出現。由於水垢是良好的熱絕緣體，冷凍機組傳熱效率因而降低，影響了其能效表現。

防水垢與能源效益

防水垢的主要目的是保持冷凍機冷凝器管道內表面的狀況，以維持冷凝器管道內的熱交換於良好狀態，使冷凍機運作得更有效率。

然而，需留意節能效果於不同冷凝水系統是不同的，這取決於冷凝水內礦物含量、冷凍機組的狀況、運作模式和維修保養情況等等。