DEVELOPMENT OF AN ABSORPTION CHILLER SYSTEM WITH OPTIMISED HEAT EXCHANGER NETWORK FOR HIGH UTILISATION OF LOW GRADE WASTE HEAT

PROJECT SUMMARY

A large amount of waste heat from industrial plants and processes is released into the environment, particularly in the form of steam condensates of about 100°C or less. Waste heat utilisation is crucial to improve the primary energy efficiency and also reduce CO_2 emission.

Funded under the Sembcorp-EMA Energy Technology Partnership, the project aims to develop a novel absorption chiller system with seawater cooling to achieve high utilisation of low-grade waste heat for a multi-utilities facility. This includes designing an optimal heat exchange network system that is able to fully utilise the waste heat of steam condensates using an absorption chiller to produce chilled water and achieve preheating for certain process requirements.

The absorption chiller is developed for high energy efficiency and good adaptability to variable heat source conditions, whereby the project outcomes achieved through the absorption chiller's implementation can be applied to power plants as well as manufacturing, petrochemical and pharmaceutical related fields where waste heat is produced.

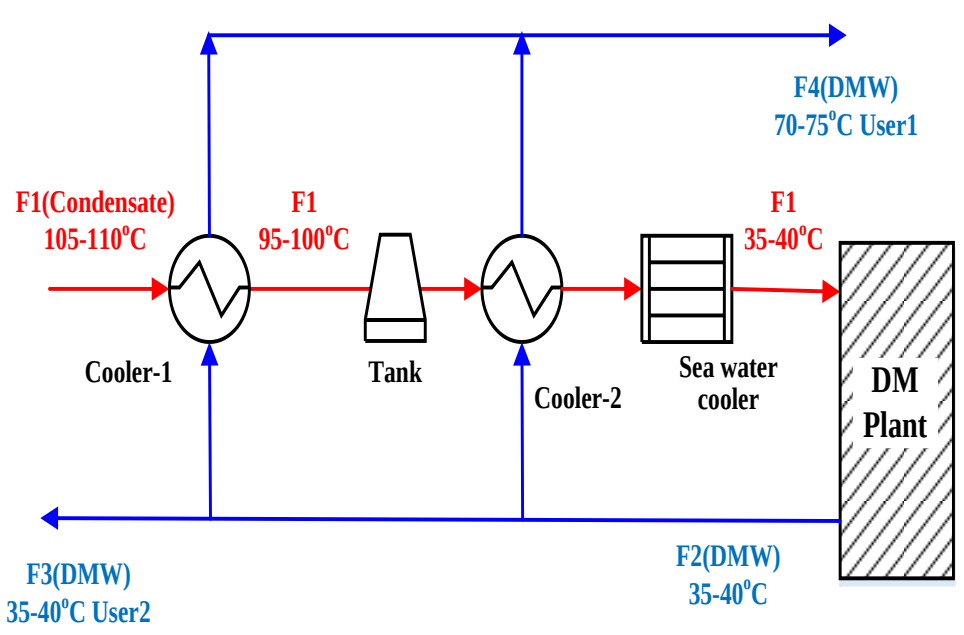

Figure 1: Heat exchanger network before optimisation

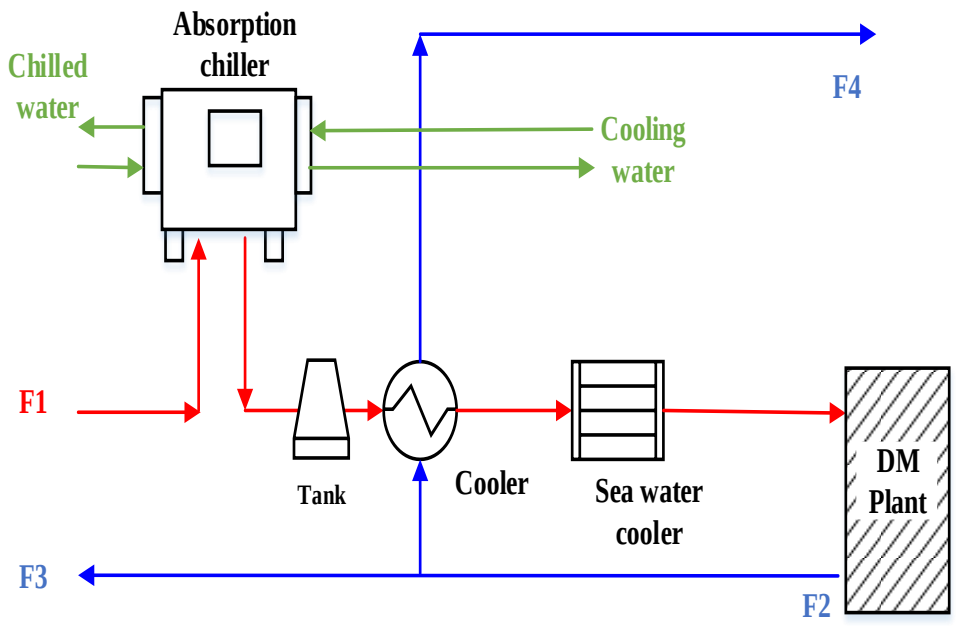

Figure 2: Heat exchanger network after optimisation

PROJECT OUTCOMES

Project Methodology

1. The existing heat exchanger network deployed at Sembcorp Industries was first analysed to determine the requirements for efficient utilisation of the condensate heat through the first and second laws of thermodynamics. Considering the cooling demand, it was proposed for an absorption chiller to be integrated into the optimised heat exchanger network to obtain the heat of the condensate ranged from 105°C to 85°C as the driving heat source of the chiller.

2. Several seawater cooling strategies were analysed to identify the direct seawater cooling as the most optimal design. Absorption chillers with variable effect, double section and multi-compartment were investigated on achieving higher efficiency and better adaptability to variable heat source conditions.

Project Achievements

1. A **direct seawater cooling absorption chiller integrated with an anti-fouling strategy was developed and demonstrated good performance during site testing** at Sembcorp Industries' industrial plant.

2. The **energy efficiency and exergy efficiency** of the heat exchanger network before and after optimisation **improved respectively by 45% and 65.5%** under site testing conditions. The developed optimised heat exchanger network was also found to potentially achieve **savings in electricity consumption, with an equivalent quantity of natural gas savings and CO2 emission reduction are 1.68 million Nm3 and 3639 tons**, respectively. The expected **annual net savings is ~$1 million SGD.**

3. Our optimisation method and proposed direct seawater cooled absorption chiller can be pivoted for deployment in other petrochemical industrial parks located in coastal cities **to enhance overall energy efficiency by enabling recovery of low-grade waste heat to produce chilled water.** There are also plans to further develop an advanced absorption chiller for exploration for applications within and beyond Singapore.

Figure 3: Seawater cooled absorption chiller

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