COMPARATIVE STUDY ON CHILLER CONFIGURATIONS IN AN EFFICIENT CHILLED WATER SYSTEM IN A TROPICAL HIGH-RISE BUILDING

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ABSTRACT

Energy-efficiency concerns have changed several design trends, and chilled water systems are now designed for different delta T values. The delta T affects the coil sizes of Air Handling Unit (AHU) and Fan Coil Unit (FCU), pumping power and pipe sizes of the chilled water distribution system and capacity of the chiller. Designing a chilled-water system for a higher delt T (ΔT), reduce the initial costs due to smaller valves, piping, pumps and also reduce the operating cost due to low chilled water flow rates. However, this topic is accompanied by a multitude of arguments and contradictions.

This research was based on the comparative study of parallel flow and series counter flow (SCF) chiller arrangement for different ΔT values and finding the best chiller configuration and ΔT value with higher Coefficient of Performance (COP).

For this comparative study, a high-rise commercial building was selected, and the chilled water system was designed by conducting cooling load calculations and appropriately selecting chillers and pumps.

For two chillers with the same capacity configured in parallel and SCF arrangement, chilled water flow rate, chiller lift, and COP values were calculated for various ΔT values. Additionally, a comparative study was also done for the chilled water pump power and distribution system piping sizes for different flow rates. The CoolPack software was used for the calculation of COP values.

Based on the study, it was observed that there was a decrease in chilled water flow rate as the ΔT increases. The analysis also revealed that compared to parallel flow chillers, SCF chillers have chiller lift reduction and higher COP for both conventional and high ΔT system. It also found that chiller lift does not depend on ΔT value and it only depends on chilled water supply temperature.

The maximum COP was attained at a chilled water supply temperature of 9.0 ^{0}C which was the maximum supply temperature selected with 10^{0}C ΔT (beyond the 8.3^{0}C ΔT recommended by ASHRAE), resulting in a COP value of 6.60. There was an improvement in the COP value of 1.36 for 10 ^{0}C ΔT with a temperature range of 9-19 ^{0}C using the SCF arrangement compared to the conventional 5^{0}C ΔT with temperature range of 7-12 ^{0}C with parallel configuration.

A reduction of about 50% in flow rate and pump power were observed for a 10^0C ΔT compared to conventional 5^0C ΔT. In this building, the percentage reduction in pipe sizes within the chilled water distribution system remains constant at 29.29 of % for a 10^0C ΔT compared to a 5^0C ΔT.

The research concludes that utilizing design strategies such as higher temperature differences, elevated supply chilled water temperatures, and SCF chiller configurations can enhance the chiller efficiency, reduce pumping energy use, and piping installation costs, leading to overall cost savings for chiller system.

Keywords: Conventional ΔT, High ΔT, Series Counter Flow Chillers, Parallel Chillers, COP, Chiller lift

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF NOMENCLATURE

Abbreviation	Description
AC	Air Conditioning
AHRI	Air Conditioning, Heating, & Refrigeration Institute
AHU	Air Handling Unit
ARI	Air-Conditioning & Refrigeration Institute
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers.
CEWT	Condenser Entering Water Temperature
CH	Chiller
CHW	Chilled water
CLWT	Condenser Leaving Water Temperature
CO_2	Carbon Dioxide
COP	Coefficient of Performance
CWRT	Chilled Water Return Temperature
CWST	Chilled Water Supply Temperature
CWT	Chilled Water Temperature
DBT	Dry Bulb Temperature
EEWT	Evaporator Entering Water Temperature
ELWT	Evaporator Leaving Water Temperature
EPA	Environmental Protection Agency
FCU	Fan Coil Unit
GHG	Greenhouse gases
GWP	Global Warming Potentials
HFC	Hydrofluorocarbons
HFO	Hydro-Fluoro-Olefins
HVAC	Heating Ventilation & Air Conditioning
IEA	International Energy Agency
IESNA	Illuminating Engineering Society of North America
ODS	Ozone Depleting Substances
OEM	Original Equipment Manufacture

PF	Parallel Flow
SCF	Series Counter Flow
VPF	Variable Primary Flow
WBT	Wet Bulb Temperature

Notations	**Description**
C_p	Specific heat capacity of water
C_{ref}	Heat Capacity of refrigerant
L_{ref}	Latent heat capacity of refrigerant
m	Mass flow rate of water
m_{ref}	Mass flow rate of refrigerant
Q	Heat capacity
V	Volume flow rate
ΔT	Delta T
ρ	Density