MODULAR UNDERGROUND

AIR COOLING UNIT

(ACU)

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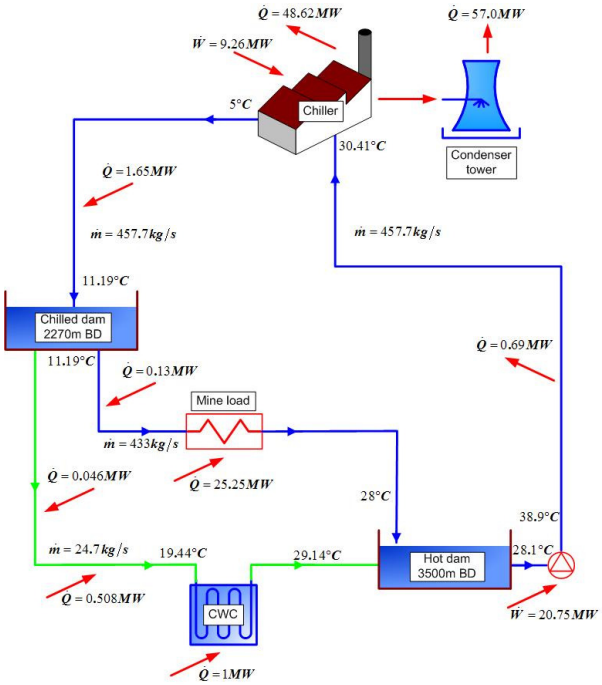
Existing mine cooling concept

Chilled Water Cars (CWC) are widely used in underground mine cooling. These units mainly utilize chilled water supplied from large-scale surface chillers as the heat sink to cool local ventilation air via conventional finned-tube cooling coils.

The effective cooling capacity attained per CWC is highly dependent on the supply temperature of the chilled water. Unfortunately, the water temperature is adversely affected by the depth underground as well as heat gains over long distances. This implies that the system performance degrades rapidly with depth and distance from the main water supply shaft.

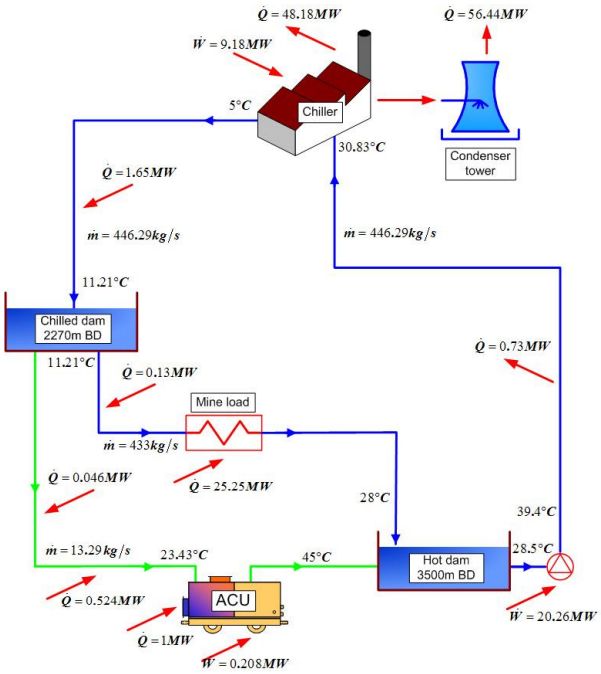
In addition to this, a relatively small temperature rise must be maintained through the cooling coil. This requires large quantities of water to be pumped back to the surface once it has absorbed the heat extracted from the ventilation air.



Due to this, the required number of cooling cars and the quantity of chilled water that must be supplied can increase exponentially with depth and distance. This implies high capital expenditure and excessive energy costs associated with the underground pumping power.

What is the ACU concept?

The ACU is a modular underground Air Cooling Unit that can utilize water at temperatures of up to 40°C as the heat sink, as opposed to chilled water only. It is a robust, low maintenance vapour compression heat pump cycle with efficiency comparable to that of surface chillers.



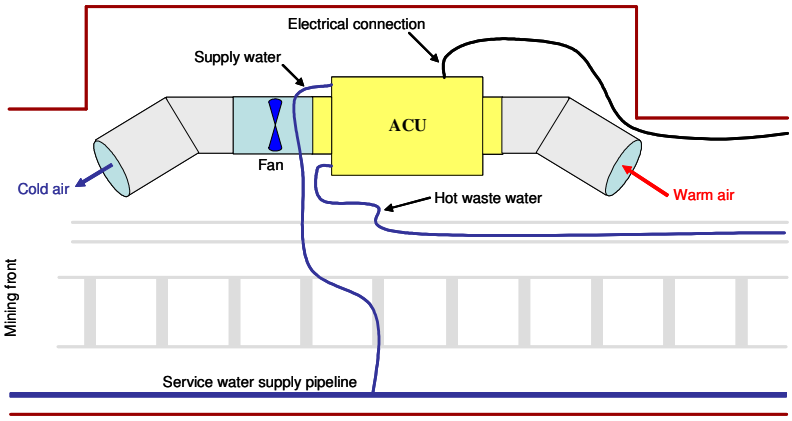
Heat is extracted locally from the ventilation air via a finned-tube evaporator coil. The heat is transferred to the water in a special condenser unit that can operate efficiently with a wide range of inlet water temperatures and with a large water temperature rise through it.

The fact that relatively warm water can now be supplied to the ACU means that the heat gains from the surroundings can be reduced. Furthermore, the fact that the water temperature rise through the ACU can be much larger than for the CWC, means that the required water quantities are significantly reduced.

Since the performance of the ACU does not degrade much with higher inlet water temperatures, the number of units and therefore the capital expenditure, is not really affected by depth and distance. Furthermore, the decreased water quantities significantly reduces the underground pumping power requirements, and therefore also the energy consumption.

ACU versus CWC

The ACU is also mobile and comes standard fitted on rolling stock to suite any mine infrastructure. It is available in two models namely an 80 kW unit utilising R134a as refrigerant and a 100 kW unit utilising R407c. Multiple units can be connected in parallel to obtain larger cooling capacities.



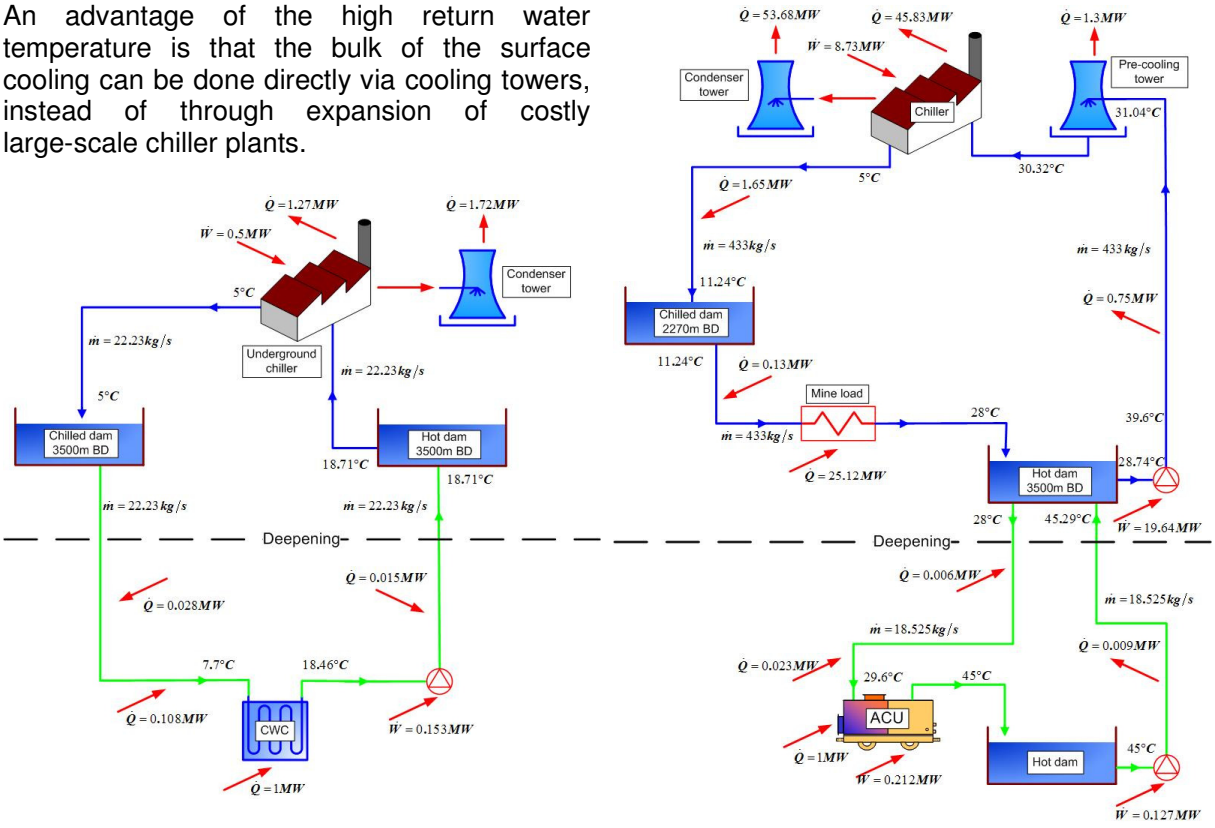
The positional efficiency of the ACU is extremely high in the sense that primary cooling can be provided exactly where and when required.

For a typical mine layout where cooling is required at a depth of 3500 m and at an equal distance away from the main shaft, the capital cost of the ACU system per MW cooling is comparable to that of a CWC system. The energy consumption of an ACU system is typically 20% to 50% less than an equivalent CWC system, mainly due to the reduced pumping power requirement.

Deep mine ACU application

The ACU offers an especially cost effective and energy efficient solution for application in deep mine cooling below 4000 m. The required capital expenditure of an ACU system is 25% to 35% less than that of an equivalent underground refrigeration plant with CWC network. Energy consumption of the ACU system is typically 25% to 45% less than that of the underground refrigeration plant system, due to reduced pumping power as well as cooling better efficiency.

An advantage of the high return water temperature is that the bulk of the surface cooling can be done directly via cooling towers, instead of through expansion of costly large-scale chiller plants.



Technical Specifications for a Nominal 100kW Mobile Air Cooling Unit

1. Scope

This document gives technical specifications on a mobile air cooling unit, designed for use in underground mining operations.

2. Technical Specifications

Operating conditions

– Nominal Cooling Capacity	
○ @ 32.5℃$_{air,wb}$, 50℃$_{ref,cond}$, 12.5℃$_{ref,evap}$	100 kW
– Air volume flow rate	
○ ± 7.5℃ $\Delta T_{air,wb}$	4.9 m^3/s
– Water inlet temperature (maximum)	40 ℃
– Water outlet temperature	
○ @ 50℃$_{ref,cond}$	45 ℃
– Water mass flow rate (15℃ water inlet)	
○ @ 50℃$_{ref,cond}$	0.8 l/s
– Maximum water mass flow rate (40℃ water inlet)	
○ @ 50℃$_{ref,cond}$	4.8 l/s
– Water inlet pressure	
○ Maximum	10 Bar
○ Minimum	2 Bar
– Nominal power input (compressor)	
○ @ 50℃$_{ref,cond}$, 12.5℃$_{ref,evap}$	22.7 kW

Compressor specifications

– Type	Scroll
– Configuration	Tandem
– Nominal voltage	500 V
– Voltage range	450 – 550 V
– Frequency	50 Hz
– Phases	3
– Working pressure range high side	670 – 2200 kPa
– Working pressure range low side	60 – 390 kPa
– Maximum high pressure safety switch setting	2600 kPa
– Minimum low pressure safety switch setting	20 kPa
– Protection rating of terminal box	IP54
– Overheating protection	Internal
– Over current/locked rotor/single phasing protection	External overload

Refrigerant specifications

– Type	R-407c
– Lubricant	Poly ester oil

Air coil specifications

- Type of tube: Copper
- Diameter of tubes: 12.7 mm
- Tube wall thickness: 1.2 mm
- Fin thickness: 0.25 mm
- Fin spacing: 4.25 mm
- Fin material: Aluminium
- Fin coating: Epoxy
- Flange: Stainless steel
- Flange wall thickness: 2 mm

Water coil specifications

- Configuration: Tube-in-tube
  - Inner fluid: Water
  - Annulus fluid: R-407c
- Tube material
  - Inner tube: Copper
  - Outer tube: Carbon Steel
- Maximum pressure
  - Inner tube: 3100 kPa
  - Outer tube: 3100 kPa
- Number of coils: 4

Electrical specifications

- Nominal voltage: 500 V +/-10%
- Phases: 3
- Frequency: 50 Hz
- Control circuit voltage: 110 V
- Step-down transformer: 500VA (525V – 110V)
- Over/under voltage comparator incorporating phase failure and reversal
- Compressor protection: Manual reset overload relay
- Fan protection: Manual reset overload relay
- Isolator: 80 A
- Enclosure protection rating: IP65

Car specifications

- Type 1

  Maximum size

  - Length: 2280 mm
  - Width: 1250 mm
  - Height: 1800 mm
- Type 2

  Maximum size

  - Length: 2600 mm

○ Width	1450 mm
○ Height	1570 mm
– Total weight	1850 kg
– Buffers	Steel buffer at each end
– Rail gauge size	610 mm / 762 mm / 918 mm

Connections

– Water Inlet	50mm flange connection
– Water Outlet	50mm flange connection
– Air	Flange connection for 7.5kW mine ventilation fan
– Electrical supply cable (minimum Amps)	525 V 60A/phase

M-Tech Industrial company profile

M-Tech Industrial (Pty.) Ltd. is an ISO9001 accredited engineering company based in Potchefstroom with a full-time technical staff of forty graduate engineers. A number of lecturers from North-West University (Previously Potchefstroom University) also work on a part time basis in the company.

M-Tech was founded in 2000 by Dr. Gideon Greyvenstein and Dr. Pieter Rousseau, at the time both professors in mechanical engineering at Potchefstroom University. M-Tech Industrial grew out of an engineering consultancy known as M-Tech Mechanical that has existed since 1987.

M-Tech initially focussed on consulting work in the fields of fluid mechanics and thermodynamics as well as the design of thermal-fluid systems. M-Tech also developed commercial thermal-fluid systems simulation software that is licensed internationally.

In 2005 M-Tech Industrial acquired Enerflow Technologies cc, a heat pump systems design and manufacturing company that was established in 1992. M-Tech therefore attained the technology and manufacturing expertise associated with a wide range of refrigeration and heat pump products, including the ACU.

M-Tech has close ties with the Engineering Faculty of North-West University which acts as its research partner. The special relationship with North-West University contributes to the high-tech entrepreneurial culture of the company.

www.mtechindustrial.com

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