

Deep Mine Air Cooling Units

Industry application:

Mining

Introduction

South Africa's mining industry, largely supported by gold, diamond, coal and platinum group metals production, has made an important contribution to the national economy. As technology improves and the search for natural resources continues most mines are constantly being deepened. In the next few years, the Western Deep mine will reach a depth of 5 km (3.1 miles).

A number of problems arise when expanding operations to greater depths of which heat is the most obvious. For example, at 5 km (3.1 miles) the virgin rock temperature (VRT) reaches 70 °C (158 °F). To create a workable environment the mining industry will need to invest in equipment with a total cooling capacity greater than any system at present.

M-Tech Industrial embarked on a project to design, manufacture and provide the mining industry with an alternative solution to conventional cooling methods. The product is a local underground air-cooling unit (ACU) for the areas where the existing chilled water car (CWC) air-cooling systems are ineffective.

Flownex enabled M-Tech to penetrate the market by convincing clients of the economical benefit associated with the Air cooling Units. A detailed techno-economic evaluation was performed using Flownex. This involved a baseline model of a deep mine system and a retrofitted model with Air Cooling Units (ACU). The results showed that by implementing the ACU instead of conventional cooling methods the mine was not only cooled efficiently at depths in excess of 2km (1.2 miles), but substantial savings (25% to 50%) were made in terms of running cost. Furthermore, the best customised solution could be provided to the client taking each client's existing infrastructure and requirements into account.

Challenges

To prove new concepts to the mining industry normally involves experimental setups and expensive instruments to ensure quality measurements in the inhospitable mining environment. Therefore the first challenge is to prove the new concept using simulation results.

This will involve the simulation of the client's existing CWC installation and proving the ability of Flownex to quickly and accurately simulate the installed CWC by comparison to operational data. Then the advantages of using the ACU concept in favour of the existing CWC technology can be illustrated to prospective clients. For comparison purposes a localised cooling load of 1MW (3.4 MBtu/hour) on level 110 of a deep mine is used. Then after the ACU concept is proven, it is followed by modelling a baseline of a deep mine system and retrofit it with Air Cooling Units (ACU) for a detailed techno-economic evaluation. The purpose of the baseline is to simulate the existing situation (potentially without any cooling) in the mine for verification purposes. Any retrofit proposal can then be benchmarked against the baseline. The ACU retrofit proposal are

then simulated and evaluated in terms of the cost impact and savings potential compared to the existing situation or any cooling alternatives.

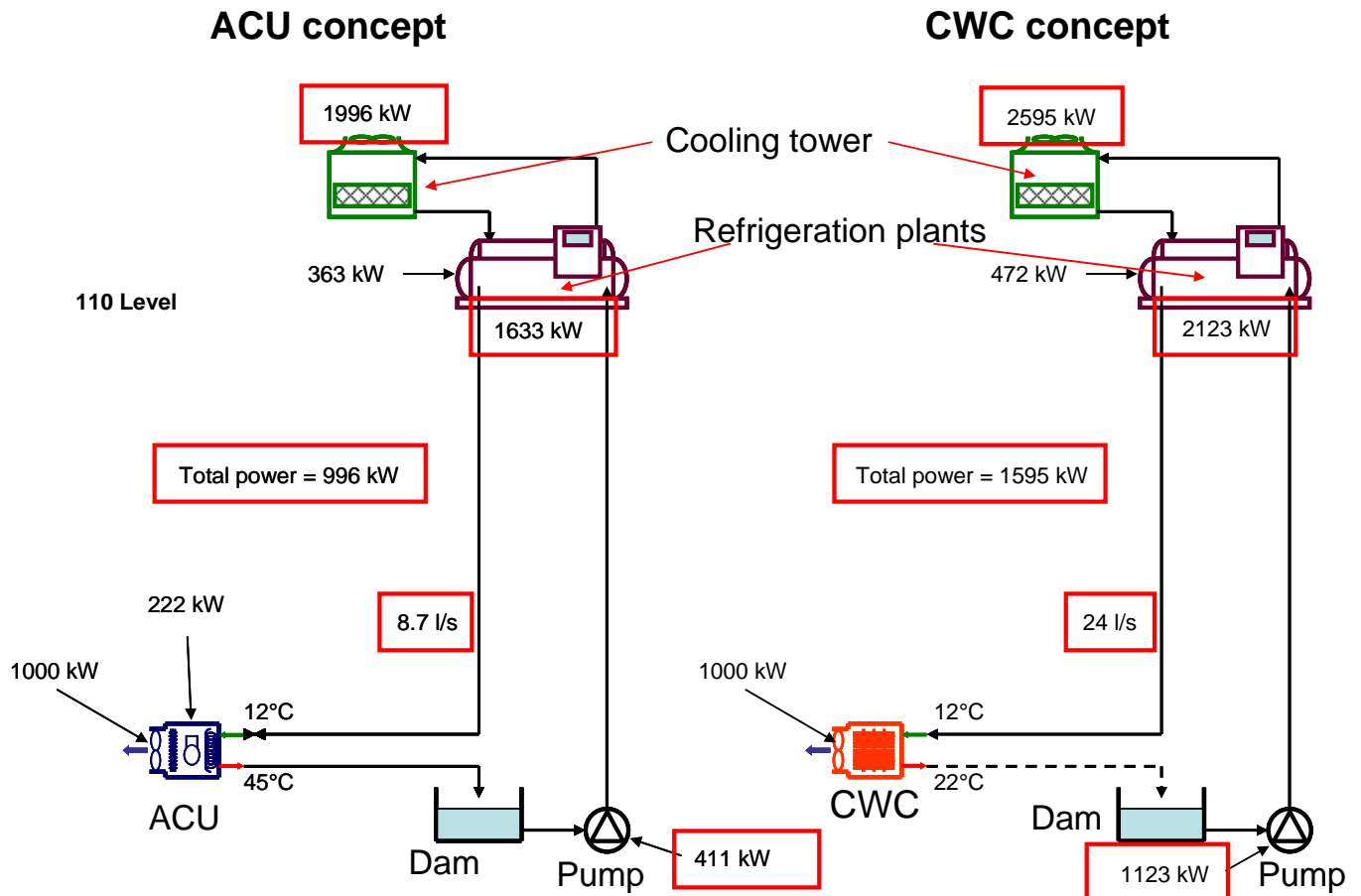
Solution

Flownex allowed the system designer/engineer to take into account the chilled water temperature increase due to the change in depth and heat transfer from the warm ambient conditions inside the mine. A Flownex network for each client's specific CWC installation could be created quickly. It was then possible to accurately model the heat transfer, pressure change and power consumption throughout the system and also optimise the system by using the Flownex designer feature.

The Flownex model allowed the system engineer to make detailed calculations of what the influence of the addition or omission of surface cooling towers and chillers would be on the power consumption of the proposed system incorporating ACU's. This can be used to select the most economically viable system layout for different client requirements and existing infrastructure.

Results

The two concepts (ACU vs. CWC) shown below were compared in Flownex. The existing performance of installed CWC could be simulated and accurately predicted in Flownex.



Then the advantages of the ACU in terms of mass flow rate, cooling tower and refrigeration plant requirements, pump sizes and total power required were highlighted in the comparison.

The results of a power requirement study performed for i) a mine without any cooling, ii) one with ACU cooling and only a cooling tower and iii) one with ACU cooling and both a cooling tower and surface refrigeration plant, highlights the lower power requirements involved in using the ACU concept.

<i>Item</i>	<i>Existing layout</i>	<i>ACUs with surface cooling tower</i>	<i>ACUs with surface refrigeration plant and associated condenser cooling tower</i>
<i>ACUs cooling capacity [kW_T]</i>	-	800	800
<i>Refrigeration plant cooling capacity [kW_T]</i>	-	-	936
<i>Cooling tower capacity [kW_T]</i>	-	730	1135
<i>ACUs compressor power requirement [kW_E]</i>	-	178	178
<i>Refrigeration plant compressor power requirement [kW_E]</i>	-	-	199
<i>Cooling tower fan power requirement [kW_E]</i>	-	25	25
<i>Pumping power requirement [kW_E]</i>	806	1308	1016
<i>Total power requirement [kW_E]</i>	806	1511	1418
<i>Delta total power requirement [kW_E]</i>	-	+705	+612

It could be proven that the ACU concept offers a cost-effective and energy-efficient solution for application in deep mine cooling below 2 km (1.2 miles). M-Tech was able to prove the feasibility of the new ACU technology to clients through accurate simulation of the existing setup and the customizable proposed alternative. These simulations also enabled the qualitative and quantitative illustration of the advantages of the new ACU concept in terms of capital and running cost savings. A case study to compare the costs of existing cooling units to the ACU showed that for the exact same cooling power the ACU uses around 1 MW (3.4 MBtu/hour) compared to 1,7MW (3.4 MBtu/hour) used by a conventional CWC. This provides the mines with a potential saving of 700 kWh (2388.4 MBtu). With the current average electrical cost in the mining industry a saving of almost R 1 Million (\$139000) per ACU unit can be made over a single year.

Additionally Flownex can be used to determine the excess energy in the flow simulation due to the water drop. It could then be evaluated whether the capital investment of a water turbine to utilize this available energy would be worthwhile for a specific scenario. Different scenarios can then be effectively evaluated and Flownex provides the means to select the optimum solution from both a technical and cost perspective.

Quotes

“Thanks to Flownex we have a very effective means to show the advantages and impact of the ACU concept to the mining industry. Flownex provided fast and accurate solutions of CWC and ACU’s. The simulation results were used to evaluate the business case of ACU’s when it is implemented at depths in excess of 2km. This knowledge optimised the product delivered and gave us an edge over our competitors.”

- **Dr. Martin v Eldik**, Divisional Manager: Heat Pumps, M-Tech Industrial (2008)