ENERGY SAVING REPORT FOR NORTHAM

FRIDGE PLANT NO 5 SET POINT CONTROL

BY USING THE SMARTCOOL™ TECHNOLOGY

TILT COOL TECH

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1. BACKGROUND

1.1. BACKGROUND TO THE SMARTCOOL™ TEST

The refrigeration system of a deep level mine in the northern part of South Africa was used to test the Smartcool™ Technology. The test was done from July to September 2010. Data was gathered when the system was running without and with the Smartcool™ technology. The test periods were as follows:

Winter Test

1. Normal Control : 16 – 29 Jul 2010
2. Smartcool™ Control : 03 – 14 Aug 2010
3. Normal Control : 15 – 26 Aug 2010
4. Smartcool™ Control : 27 Aug – 09 Sep 2010

Summer Test

5. Smartcool™ Control : 24 Sep - 25 Oct 2010
6. Normal Control : 26 Oct – 10 Nov 2010

It was decided to test Smartcool™ on a York centrifugal chiller, with refrigerant R134A, controlled by a Siemens S7 PLC. A picture of the chiller and its name plate can be seen Figure 1 below.

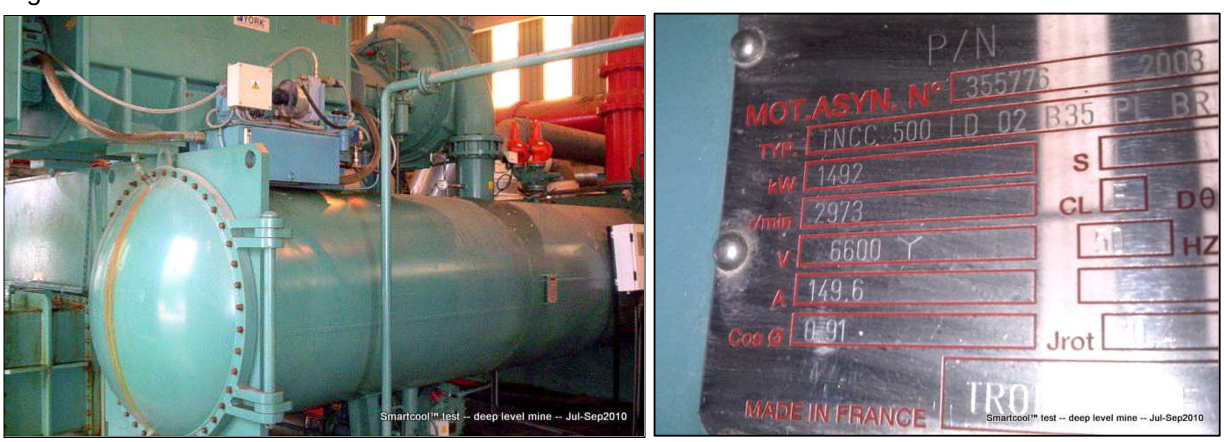

Figure 1: Picture of the York refrigerant machine where test was done, with nameplate.

1.2. REFRIGERATION SYSTEM LAYOUT

The mine uses water to cool the underground mining conditions and operations. This water is cooled in the refrigeration system which consists of six York and two Sulzer 7 MW refrigeration systems on surface. Five of these units run continuously. In peak summer conditions this is increased to six or seven machines, with the balance available as standby capacity. The plant runs each day at 98% availability. The refrigerant used in units 1, 2, 7 and 8 is R134A and in units 3, 4, 5 and 6 is R22. Also, part of the refrigeration system are the hot water storage tanks, Pre-Cooling Towers, Bulk Air Coolers, eight (8) refrigeration machines and chill water storage tanks on surface. See the schematic layout of the refrigeration system in Figure 2.

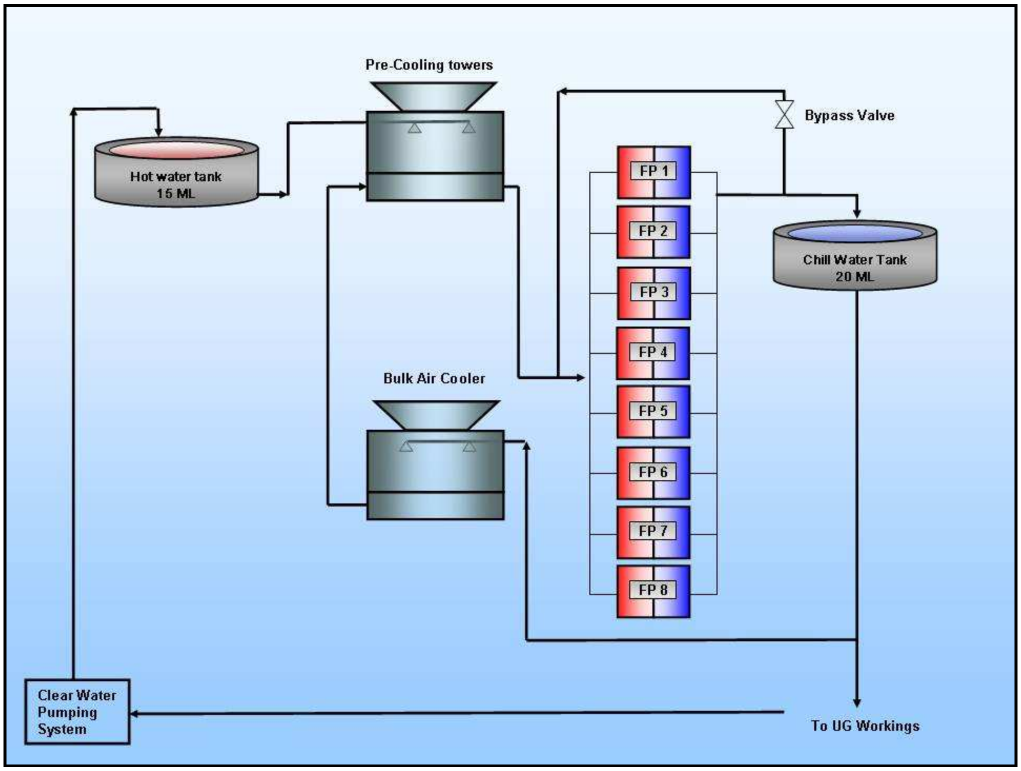

Figure 2: Simplified schematic layout of the refrigeration system of the mine.

From the clear water pumping system, water enters the hot storage tank at ± 30℃. The hot water is then pumped through Pre-Cooling Towers for pre-cooling. In the Pre-Cooling Tower sumps the pre-cooled water and return water from the Bulk Air Coolers are mixed. From the Pre-Cooling Tower sumps the water are pumped to the refrigeration plant where it is chilled.

The refrigeration plant consists of eight (8) refrigeration machines each operating with a cooling capacity of 5800 kW. The average operating evaporator flow of each machine is 190 l/s. The average inlet and outlet water temperatures of the machines are 12.8 ºC and 4.7 ºC respectively. The machines operate at an average Coefficient of Performance (COP) of 4.7 throughout the year.

When needed, some of the chilled water is bypassed back to the inlet of the plant to keep the outlet temperature of the refrigeration plant at the desired constant value.

The chilled water is stored in the four chilled water storage tanks, with a combined capacity of 20 ML, from which it is distributed to either to the Bulk Air Coolers or back to underground mining operations.

A summary of the water flow, temperature and performances for the different seasons of year can be seen in Table 1.

DESCRIPTION	SUMMER	INTERMEDIATE	WINTER
Evaporator flow	1080 l/s	820 l/s	680 l/s
Inlet water temperature	13.4 ºC	12.6 ºC	12.2 ºC
Outlet water temperature	4.7 ºC	4.7 ºC	4.7 ºC
Coefficient of performance	4.4	4.9	4.9
Bypass flow	270 l/s	55 l/s	17 l/s
Bulk air cooler flow	480 l/s	430 l/s	335 l/s
Flow to mine workings	330 l/s	335 l/s	328 l/s

Table 1: Summary of flow and temperature performances of the Refrigeration plant at the mine.

Note: Summer: January, February, November, December,
Intermediate: March, April, May, September, October,
Winter: June, July, August.

2. HOW ELECTRICITY SAVINGS ARE ACHIEVED WITH SMARTCOOL™

Ordinary centrifugal chillers control the load of the compressor to keep the evaporator outlet temperature constant at a pre-defined set point. The Smartcool™ technology aims to reduce the electrical energy consumption of a chiller machine by also monitoring and focussing on the efficiency at which the centrifugal compressor is actually operating.

Smartcool™ aims to improve the Coefficient of Performance (COP) of the centrifugal machine by taking into account the rate of heat removal achieved by the machine under different operating conditions. Knowing the machines exact performance under varying conditions Smartcool™ will unload and load the machine accordingly to optimise the rate of cooling achieved vs electrical energy consumed.

Once the Smartcool™ technology controller is installed the controller will “self learn” the chiller machines characteristics to automatically control the compressor at its optimum efficiency. The controller will automatically adapt to varying environmental conditions to ensure that the maximum energy savings are achieved at all times.
The Smartcool™ controller do not override a chiller machines existing controls but will do its working within the machines existing control parameters. The safety of the chiller machine will never be compromised by installing the Smartcool™ controller.

Smartcool™ is installed apart from the PLC control system. All the interlocks are programmed inside the PLC. Smartcool™ sends a 4-20mA signal to the PLC that controls the set point of the evaporator outlet temperature. Below, in Figure 3 is a picture of Smartcool™ control panel at machine no. 05.

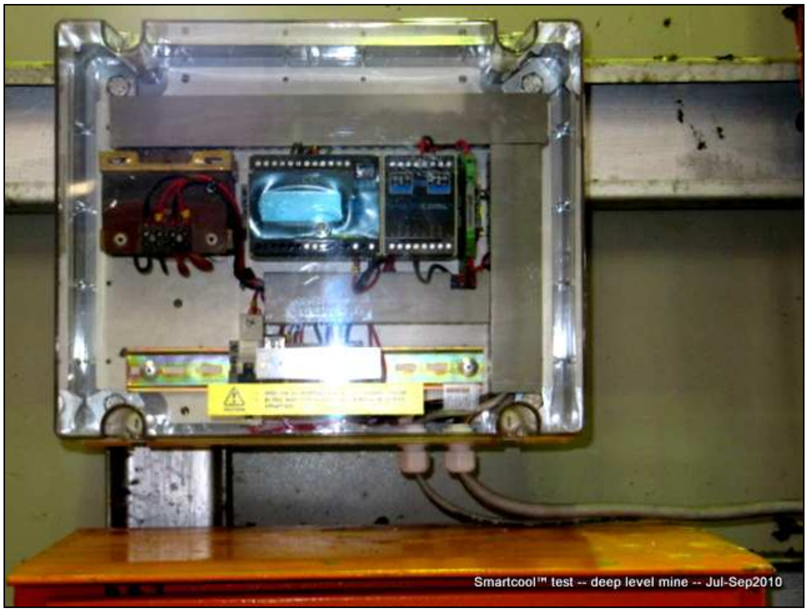

Figure 3: Picture of Smartcool™control panel.

3. SMARTCOOL™ RESULTS

3.1. TEMPERATURE CHANGE

Smartcool™ was installed on refrigeration machine no 5. The evaporator out temperature was measured. During the winter test period when the Smartcool™ was not controlling the average temperature was 4.18 ºC. During the winter Smartcool™ test periods the average temperature was measured as 4.52 ºC. During the summer test period when the Smartcool™ was not controlling the average temperature was 4.50 ºC. During the summer Smartcool™ test period the average temperature was measured as 4.63 ºC.

In Figure 4, the graph shows how the evaporator outlet temperature during Smartcool™ operation changes. In Figure 5 the graph shows the evaporator temperature set point changed by Smartcool™ and the evaporator out temperature.

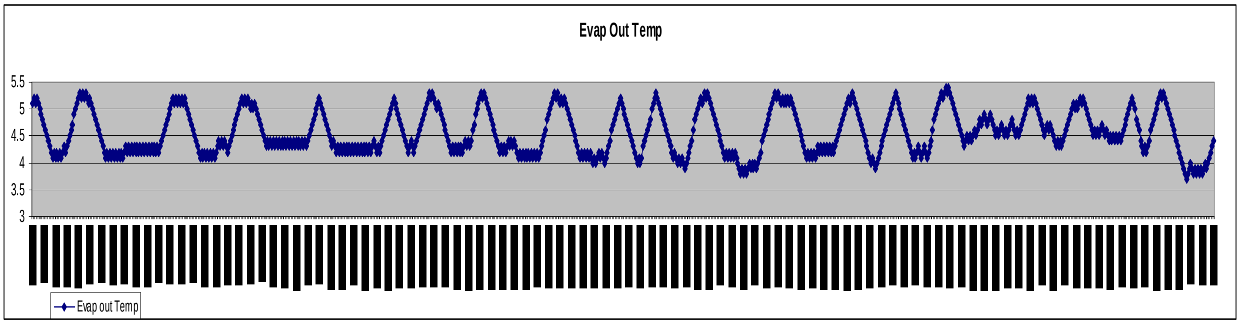

Figure 4: Graph indicating the evaporator outlet temperature during Smartcool™control.

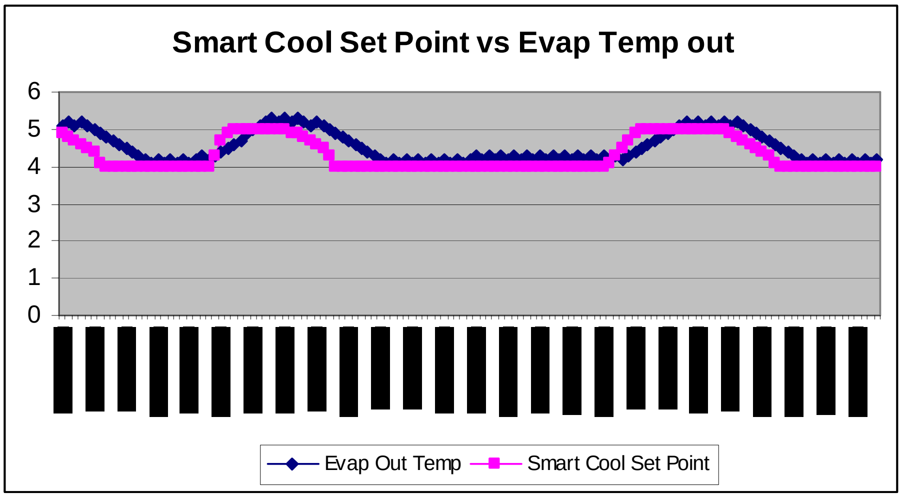

Figure 5: Graph indicating the evaporator outlet temperature and set point supplied by Smartcool™control.

3.2. ELECTRICITY CHANGE

A power logger was installed on the incomer of machine 05. In the table below the electricity consumption with and without Smartcool™ can be seen.

During the winter test period the average electricity consumption on the compressor of machine no. 05 without Smartcool™ was 1 286 kW and with Smartcool™ 1 184 kW. The reduction is 102 kW, which equates to an 7.9% reduction in electricity consumed.

During the summer test period the average electricity consumption on the compressor of machine no. 05 without Smartcool™ was 1 393 kW and with Smartcool™ 1 290 kW. The reduction is 103 kW, which equates to an 7.4% reduction in electricity consumed.

The electricity and temperature can be seen in the Table 2 below.

Control Mode	Period	Avg. Power (kW)	Avg. Evap. Out Temp. (ºC)
Winter Test			
Normal Ctrl	16 – 29 Jul 2010	1,275	No data logged
Smartcool™	03 – 14 Aug 2010	1,157	4.53
Normal Ctrl	15 – 26 Aug 2010	1,297	4.18
Smartcool™	27 Aug – 09 Sep 2010	1,212	4.51
Avg. Normal Ctrl		1,286	4.18
Avg. Smartcool™ Ctrl		1,184	4.52
Difference for No.5		102	0.34
Summer Test			
Smartcool™	24 Sep – 25 Oct 2010	1,290	4.63
Normal Ctrl	26 Oct – 10 Nov 2010	1,393	4.50
Difference for No.5		103	0.13

Table 2: Summary average power consumed by compressor and temperature with and without Smartcool™ control.

4. CONCLUSION

Smartcool™ was tested on one of the refrigeration machines at a mine in the northern part of South Africa. The machine was a York centrifugal chiller, with refrigerant R134A, controlled by a Siemens S7 PLC. The winter and summer tests were performed from July to November 2010 with periods when Smartcool™ was controlling the evaporator outlet temperature set point and periods without Smartcool™ control. Data of the evaporator outlet temperature and the electricity consumed by the compressor were compared for the two cases.

During the winter test it was seen that when Smartcool™ controlled the evaporator outlet set point temperature, the average temperature increased from 4.18 ºC to 4.52 ºC. A rise of 0.34 ºC. The electricity consumed by the compressor reduced with 7.9%, or 102 kW when Smartcool™ was in control.

During the summer test it was seen that when Smartcool™ controlled the evaporator outlet set point temperature, the average temperature increased from 4.50 ºC to 4.63 ºC. A rise of 0.13 ºC. The electricity consumed by the compressor reduced with 7.4%, or 103 kW when Smartcool™ was in control.