# Pilot scale evaluation of mine water (MW) as a cooling medium

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## Abstract

Sasol One abstracts large volumes of water from various sources, such as the Zuikerbosch & Vaal River for various applications including make-up to the cooling water systems. In an attempt to evaluate the use of underground MW as an alternative cooling medium, two pilot-scale cooling towers (CTs) were used. Data of five runs (3 weeks each) at different linear flow velocities (LFVs) and cycles of concentration (COC) were obtained. A prescribed chemical treatment program from a local supplier was also evaluated. Mild steel corrosion coupons and heat exchanger tubes were used to monitor the fouling, scaling and corrosion rates. An experimental design program was followed to determine the layout of the different experimental runs.

The respective indices indicate the presence of low scaling and corrosion rates in the CTs which correspond well with that obtained from the analyses of the coupons and heat exchanger tubes (1.5 to 11.0 mg/dm$^2$/d and 0.04 to 0.21 mm/y, respectively). In addition, the fouling rates (2.8 to 27 mg/dm$^2$/d) obtained during the five runs indicate the presence of sessile bacteria in the system. According to the supplier, the total cost of the chemical treatment program used during the pilot-scale test work is comparable to the current cost for the commercial cooling systems at Sasol One.

It is evident from the results obtained during this study that the use of underground MW as a cooling medium is a viable option. However, the work conducted in this study was only a first effort and it is possible that the high levels of sulphate (up to 966 mg/ℓ) in the make-up water could result in concrete corrosion, which could have a detrimental effect on the integrity of the cooling tower structures. In addition, the variability in the MW quality, which was not considered during the experimental period, could be problematic since it will complicate the chemical treatment of this water in a full scale cooling tower system.

## Introduction

Sasol One abstracts large volumes of water from various sources, such as the Zuikerbosch & Vaal River for various applications including make-up to the cooling water systems. The underground mine water is of a poor quality since it contains high concentrations of salts. Possible uses for this water were investigated by the Water and Environmental Technology (WET R&D) e.g. the use of this water as cooling water.

An experimental design program was followed to determine the layout of the different experimental runs. This was done in collaboration with the Chemstat group (Process Development) at Sasol Technology, R&D. The statistical analyses of the data were done by means of analyses of variance and regression methods to investigate the individual and interaction effects of the factors (cycles of concentration, COC, and linear flow velocity, LFV) on the responses (fouling, scaling and corrosion rates). The rationale for using an experimental design program to determine the variables (LFV and COC) is beneficial since it limited the amount of experimental runs required for reliable results en by doing so, reduced the time required for the test work. It is important to note that the variability of the MW quality was not taken into consideration during this study.

The results obtained during this study were statistically analysed and used to compare the degree of fouling, scaling and corrosion during different runs. The efficiency of a prescribed chemical program recommended by Buckman Laboratories was also evaluated during this study. In addition, the supplier also determined the cost of the chemical treatment program used.

## Experimental procedure

This research was conducted as a result of a previous study conducted on laboratory scale CTs for the evaluation of the use of MW as a cooling medium, which resulted in promising results (Raijmakers, et al, 2001).

Two pilot-scale CTs were operated using a prescribed chemical treatment program from a local supplier and MW was used as make-up to the cooling towers. This study includes data of five respective runs at different LFVs and COCs. Each run was executed over a period of three weeks.

Determination of the COC was based on potassium, chloride and conductivity analyses and controlled by means of a blow down system.

The pH of the recirculation water was adjusted to maintain a pH of 8.2 to achieve optimal performance of the control chemicals used in the various tests. Sodium hydroxide and hydrochloric acid were used for pH adjustment to optimise the effectiveness of the treatment program. Mild steel corrosion coupons and heat exchanger tubes were used to monitor the fouling, scaling and corrosion rates.

The experimental conditions of the CTs:

| | |
|---|---|
| CT Inlet Temperature: | 40-45 °C |
| CT Outlet Temperature: | 32-35 °C |
| Delta T: | 8-10 °C |
| System volume: | 100 ℓ (excluding COC) |

The operational conditions for the experimental design program for the different runs are summarised below:

| Respective runs | LFV in HE* tubes (m/s) | LFV in CR** (m/s) | Recirculation flow rate (ℓ/h) | COC |
|---|---|---|---|---|
| 1 | 1 | 0.9 | 600 | 6 |
| 2 | 0.7 | 0.56 | 400 | 4 |
| 3 | 1 | 0.9 | 600 | 2 |
| 4 | 0.35 | 0.22 | 200 | 6 |
| 5 | 0.35 | 0.22 | 200 | 2 |

*HE = heat exchanger **CR = coupon rack

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