It was recommended to select the above equipment to operate at maximum efficiency [1], which would result in reduction of the overall energy consumption, therefore translating into cost savings. Pump motors are significant consumers of energy in a typical concentrator plant, since they mostly operate on a continual basis, 24 hours/day. This paper details the results of analysis of efficiency of installed pump motors at one of Anglo Platinum’s concentrator plants and recommends ways to improve their efficiency.

Concentrator pump motor population

Number and type of motors

This concentrator plant has a total of 257 pump motors, which represents over 13 MW of installed power. Most units are in the range between 0,75 kW to 300 kW at 4 pole speed (230), with only a few 2 pole (23) and 6 pole speed units (4).

Most units are with B3 mounting, with some V6 and B5. From the total of 257 units, 90 units (35%) are flameproof, ranging from 0,75 kW to 15 kW and most of these (82 units) are for 380 V supply, the balance is for 525 V supply (68%).

Loading of concentrator motors

Oversized motors frequently occur in various industrial plants worldwide and are not specific to the mining industry. This phenomenon is often a consequence of various allowances, accumulated during the process of design, project management, construction, procurement and commissioning of a plant. This is best explained in the example below, where the end result is a motor that is 47% oversized than what the application requires.

To investigate this, engineering personnel at this concentrator measured and recorded average loadings of 132 units. Loadings varied from 23% to 102%, with an average loading of 55%. Distribution of measured motor loadings is shown in Fig. 3.

Usually AC motor efficiency is in direct proportion to its loading – the higher the loading, the higher is its efficiency. Therefore motor efficiency losses can be reduced by selecting the correct size motor for each application.

Motor right-sizing (standard efficiency motors)

Selection of motors and right-sizing by swapping with the existing (standard efficiency) units

To select units for right-sizing, each of the 132 measured motor loadings were tabulated with their physical location in the plant and the corresponding efficiency at that loading. Corresponding efficiencies were established by interpolating or extrapolating from the given efficiency data at 50%, 75% and 100% of loading that is available in the motor manufacturers catalogues for their range of standard efficiency motors [3]. The actual condition of the motor was not taken into account (some of the motors might have been rewound several times with the associated significant loss of efficiency).

Right-sizing analysis followed assuming the internal swap within the plant within the pool of the existing standard efficiency units. The target was set to increase individual units’ loadings to approximately 75% to 80%. Once this was complete, efficiencies were then established for new (right-sized) loadings and entered into the table. The last step was to calculate efficiency loss reductions between the two cases. Utilization of each unit was taken into account and annual energy saving was calculated, based on an average annual energy cost paid by the company (R0,16/kWh). A Pareto chart of potential energy savings illustrates this.

Adopting a minimum saving cut-off point of 12000 kWh/ annum, 53 motors were selected as suitable for right-sizing. Average loading of these 53 units was established at 48%. All selected motors are utilized 100% of time, i.e. they are in continual operation. Average efficiency for these 53 units was calculated at 91,9%.

Benefits of right-sizing with the standard efficiency motors

Total power requirement that could be reduced by right-sizing was calculated at 250 kW, which translates into annual energy savings.
saving of 2,19 million kWh or reduction of annual electricity account by over R350 000. Having in mind the large expenditure on energy, this saving is certainly not a significant amount. However, it should be borne in mind that this equipment, like any other machinery, consumes energy continuously over its entire economic life. Running cost of a plant motor is often 98,5% of the total cost vs. the acquisition cost of 1,5% [4]. Because of that and the imminent energy shortages in South Africa resulting in energy cost increases, it would be more appropriate to take a life cycle approach to energy savings.

**Life cycle energy cost reductions – standard efficiency**

Average economic life expectancy of a typical low voltage motor operating in the plant environment is assumed at 15 years [4], [5]. To be able to forecast the cost impact of motor right-sizing over its 15 years life cycle, three energy cost and inflation scenarios for South Africa were taken into consideration. The first scenario assumes the Consumer Price Index (CPI) constant at 4.5% and an average energy price increase year-on-year at CPI+1%. The second scenario assumes constant CPI at 6% and energy cost increases of CPI+2% throughout the period. The third scenario assumes CPI at 6% throughout, but with step-wise increase in energy costs between CPI+2% and CPI+6% over this period. This is illustrated in the Fig. 7.

These three scenarios were used for calculation of energy savings over the equipment expected life of 15 years. Discounting at scenarios’ forecast CPI was performed to arrive at today’s money values.

As it can be seen from Fig. 8, depending on a particular scenario, saving between R5,7 and R6,9-million could be achieved by right sizing as described.

**Motor right-sizing (high efficiency motors)**

The process of right-sizing as described above assumed that motors will be exchanged within the plant or otherwise replaced by the same efficiency units. Analysis has been performed to establish the benefits of right-sizing with high efficiency motors.

**Loadings and efficiencies**

Efficiencies were established by interpolating or extrapolating from the given efficiency data at 50%, 75% and 100% of loading that is available in a motor manufacturer’s catalogues for their range of top premium efficiency motors [3].

Since the same 53 units were analysed, the average loading remained the same, e.g. 81%. This time however, the average efficiency was calculated at 95,2%.

**Benefits of right-sizing with high efficiency motors**

Total power requirement that could be reduced by right-sizing with high efficiency motors was calculated at 317 kW, which is 27% higher than when it would be done with standard efficiency units. Assuming the current utilisation of 100%, this represents the saving of 2,78-million kWh annually, or over R444 500.

**Life cycle energy cost reductions – high efficiency**

Re-applying three scenarios as explained previously, the analysis has shown that, depending on a scenario, saving between R7,2 and R8,8-million could be achieved by replacing standard efficiency motors with the high efficiency units. This is graphically illustrated in the Fig. 9.

**High efficiency motor costs**

Budget prices obtained have shown that, in spite of the huge overseas government, regional and pan-governmental pressures during the last few years for promotion of high efficiency motors in order to reduce CO2 emissions and energy savings [6], these machines are in South Africa still on average 33% more expensive than the standard efficiency ones.

In this instance, the purchase cost of selected 53 units of standard efficiency vs. the purchase cost of right-sized 53 high efficiency units has been compared. This is illustrated in...
the following two tables. It should be borne in mind that in order to keep quoted prices confidential, non-related monetary units have been used instead of the South African Rand (ZAR). All units are of 4 pole speed, except where indicated.

It is obvious that, due to the effect of right-sizing, the purchase cost of the selected 53 units has decreased by 17.5%, in spite of higher prices of high efficiency motors.

**Way forward**

Similar analysis is planned to be conducted at all plants operating at Anglo Platinum. High efficiency motors should be considered for gradual introduction where the application is highly utilized, such as with pump motors. It is recommended that these motors should be purchased whenever the existing units fail. This would minimize the higher acquisition costs. In addition, use of Eskom’s Demand Side Management funds could also be considered to aid the introduction of high efficiency motors.

**Conclusion**

This paper has shown on the example of one Anglo Platinum concentrator plants that a significant energy and hence monetary savings could be made by conducting a plant motor loading and right-sizing analysis. Combined with an introduction of high-efficiency motors, this initiative could generate even larger return. What makes this initiative even more important is the fact that savings are to be generated throughout the equipment expected life. It also illustrates that the impact of higher cost on introduction of high efficiency motors could be minimized if combined with the right-sizing analysis.

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**References**