BIVITEC PERFORMANCE ON EXXARO COAL

Z. Botha[1], M. Whitter[2] and G.J. de Korte[3]

ABSTRACT

Water shortage is a reality in South Africa, especially in the Waterberg Coalfield. The increasing cost of water has a negative impact on the development of new beneficiation plants, therefore resulting in a negative impact on the economy of the country. Consequently dry, fine screening has become an option that is employed more often during the optimization or construction of beneficiation plants.

The Bivitec Screen is one of the available dry screening technologies and it is the topic of this paper. The Bivitec Screen was developed to provide true non-blinding performance. The screen utilises a floating frame mounted on rubber blocks, which has one fixed cross member followed by one floating cross member. The floating cross member stretches and releases the screening mats to provide a G-force equivalent to 50G, whereas standard screens operate at approximately 4G.

The floating screen deck is isolated from the screen body by the rubber blocks; therefore, the body is subjected to only 2G force, which equates to minimum vibration, and therefore the Bivitec screen is considered to be a very low maintenance screen. The polyurethane mats are extremely flexible with high open areas and held in place by a unique clamping method that reduces damage to mats upon removal and there is no bulky sub-frame to wear out.

This paper focuses on the performance of the Bivitec screen on South African coals, more specifically on coals from the Witbank and the Waterberg Coalfields, with regards to aperture size of the polyurethane mats, moisture content and ash yield of the feed coal. The performance of the Bivitec screen is also compared to conventional screening and to another dry screening unit, the Liwell.

At approximately 3% surface moisture the Bivitec screen shows 99% efficiency on coal from the Witbank Coalfield, whereas. the Liwell reported approximately 99% efficiency at 3% to 4% moisture when screening coal from the Waterberg Coalfield. However, as soon as the moisture increases to between 11% and 13%, the Bivitec screen efficiency declines to below 60% on Witbank coal, whereas the Liwell screen shows approximately 80% efficiency.

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Finally, the performance of the Bivitec screen is also evaluated in terms of capital investment and operational costs.

1. INTRODUCTION

The critical value chain for any mining operation, in its simplest form, consists of mining, beneficiation and loading of the final product for dispatch to Customer or port. Coal beneficiation in South Africa relies significantly on water consumption; however, the annual report by the Department of Water Affairs and Forestry (DWAF), 2007/2008, shows that only a few areas in South Africa have more than 100% of the average rainfall per year.

The Provinces of North-West, Limpopo and Gauteng have only approximately 75% of the average rainfall per year.

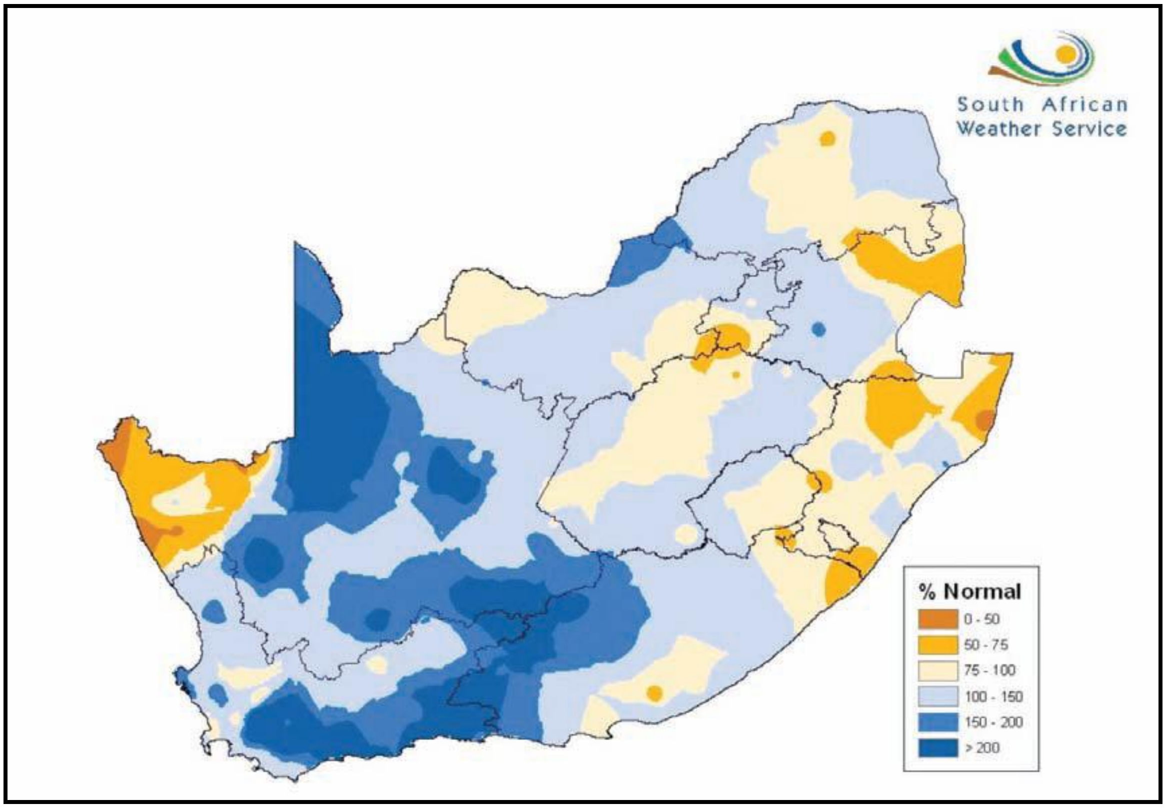

Figure 1: Rainfall in South Africa (DWAF, 2007/2008 Annual Report)

The annual report also shows that total registered water use in the country has increased by 0.6% to 17.3 billion litres in the period October 2007 to February 2008. During the same period restrictions were implemented in the North West water management area, where domestic and industrial use was restricted by an average of 30%. Restrictions were also implemented in the Limpopo water management area, where domestic and industrial use of water was limited by 70%.

Therefore water shortage is a reality in South Africa and dry beneficiation of coal becomes increasingly significant as an option requiring investigation and testing. Although not an entirely new concept in South Africa, dry beneficiation has been reported to be less efficient than the conventional wet processing technologies. Nevertheless, dry beneficiation still offers some advantages, with the obvious one being the fact that no water is consumed. If successfully implemented, the use of dry beneficiation can have a significant, positive impact on water conservation, especially in the Waterberg Coalfield, which is estimated to contain approximately 50% of South Africa's remaining coal reserves.

However, screening of fine coal at small screen apertures has always been difficult due to blinding and clogging of the screen surface and the consequent drop in screening efficiency. Recent results obtained from dry screening show that the screening of fine, damp, coal is possible, but that screening becomes less efficient at high moisture contents.

Presently Exxaro Research and Development (R&D) is involved in the testing and evaluation of two dry screening methods.

1.1 The Bivitec Screen

The Bivitec screen is manufactured by AEI (Aggregates Equipment, Inc), located in Pennsylvania. Dabmar Manufacturing (Pty) Ltd. is the custodian of this screen in South Africa.

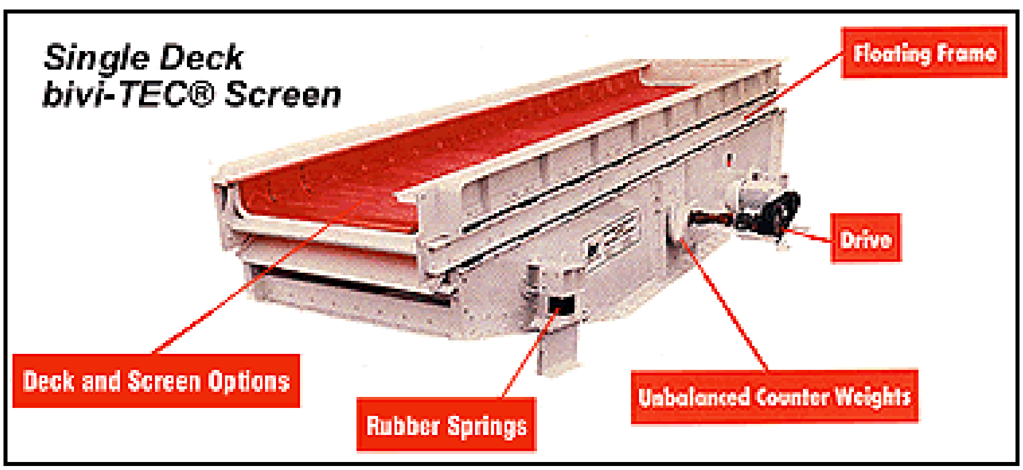

Figure 2: Bivi-TEC Screen (www.aggregatesequipment.com)

The Bivitec screen has dual-vibratory, polyurethane mats, which should eliminate blinding. Two weights, vibrating at the same frequency, move relative to each other, which tensions and relax the screen mats. The linear momentum of both vibrating movements is adjustable, resulting in open screen surfaces and optimal screening performance.

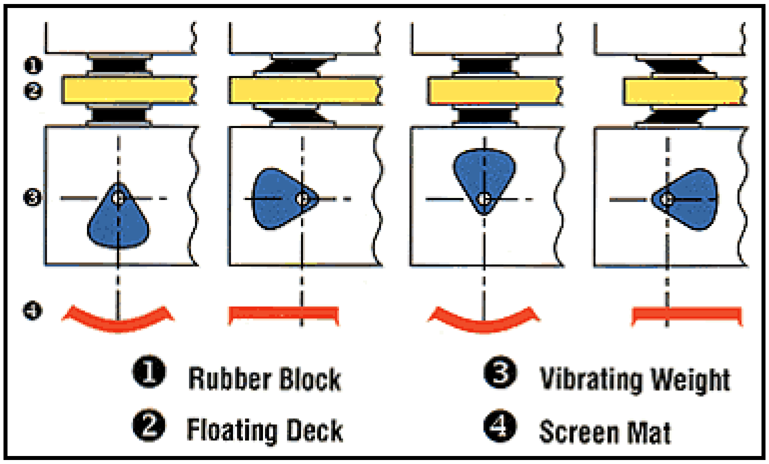

Figure 3: Operation of the Bivi-TEC Screen (www.aggregatesequipment.com)

Enhanced by resonance, one drive can produce two vibration movements. The screen box is accelerated approximately 2G while the screen mats can receive up to 50G force.

The Bivitec screen should be able to do dry screening of fine material with relatively high efficiency and it should eliminate blinding of the screen. Furthermore, due to the principle of operation, the Bivitec should be easy to maintain.

The Bivitec screen was designed to cut at 0.5mm to 50mm. The screen is available in sizes ranging from approximately 0.8m by 3m to 2.4m by 8m.

Therefore, in conclusion, the Bivitec screen was designed for dry screening, low maintenance, relatively small cut points and high efficiency. However, how does the efficiency of the Bivitec screen relate to the moisture in the coal that is being screened?

Exxaro R&D, in conjunction with CSIR, has been investigating the efficiency of the Bivitec screen at various Exxaro coal plants.

1.2 The Liwell Screen

Hein, Lehmann Canada Inc. explains that the LIWELL® (Liwell) Screen also operates on the "Flip-Flow" principle. The outer and inner screen frames move against each other in a linear motion driven from a single shaft with excenters at approximately 600 rpm. The two frames carry alternating cross beams on which the flexible screen mats are mounted (Figure 4).

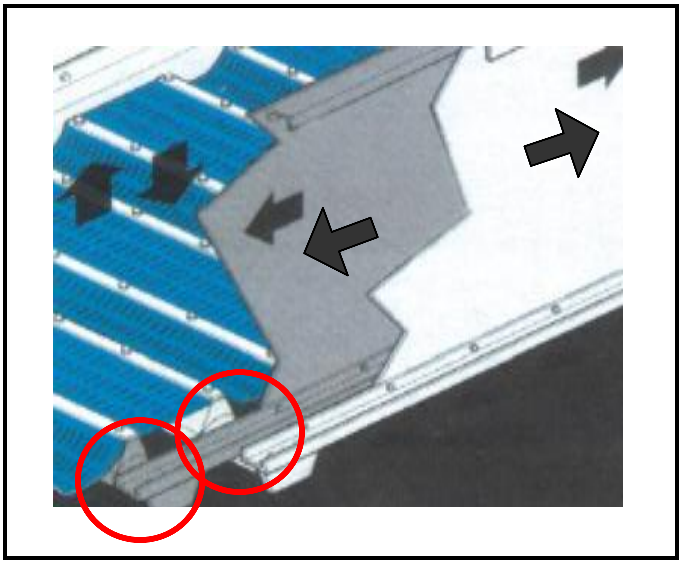

Figure 4: Operating Principle of the Liwell Screen (www.heinlehmann.ca)

The opposing action tensions and releases the special screen mats. The excenters ensure a positive movement (Figure 5), enabling the screen mats to be stretched at the end of each stroke. The change in shape of the mat and apertures and the high forces will dislodge particles before they peg. The machine itself will be subjected to between 2 and 3G, while the material being screened is exposed to acceleration of about 50G.

Conventional circular or linear motion screen machines generate significantly less force at 3G to 6G force.

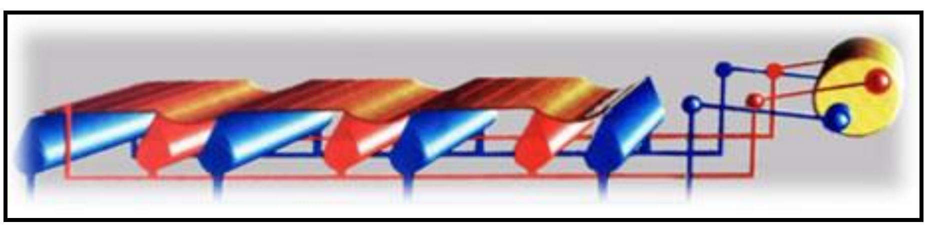

Figure 5: Operating Principle of the Liwell Screen, simplified (www.heinlehmann.ca)

Different types and designs of the Liwell screen are available, ranging from approximately 3.5m by 1.5m to 10.5 by 4m in dimension. The available surface areas range from approximately $2.5m^2$ to $26.5m^2$.

The Liwell screen should also be able to do dry screening of fine material with relatively high efficiency and it should also eliminate blinding of the screen. Hein, Lehmann Canada Inc. claims that maintenance on the Liwell is very low and guarantees continuous operation (i.e. high availability).

In conclusion, both the Bivitec and the Liwell screens were designed for dry screening, low maintenance, relatively small cut points and high efficiency.

Again, the question should be asked: how does the efficiency of the Liwell screen relate to the moisture in the coal that is being screened?

Exxaro R&D unfortunately does not have a test unit of the Liwell available, but did industrial tests in Amsterdam on currently operating Liwell screens.

Vibramech (Pty) Ltd is the custodian of the Liwell screen in South Africa and it has been indicated that the first test unit should arrive in South Africa by late 2009 or early 2010.

2. THE BIVITEC AT NEW CLYDESDALE COLLIERY

New Clydesdale Colliery installed a full-scale Bivitec screen with a feed capacity of approximately 180 to 210t/h. The screen is approximately 2.4m by 8m and weighs approximately 10.2t. The drive power is in the range of 22kW.

Figure 6: The Bivitec Screen at New Clydesdale Colliery

Tests were conducted on this screen (de Korte, 2008), which was installed in the "Module B" section of the plant. At the time of efficiency testing, Module B received feed from the Inyanda coal plant.

Feed size distributions of Seam 1 and Seam 2 coal are shown in Figure 7 and Figure 8, respectively.

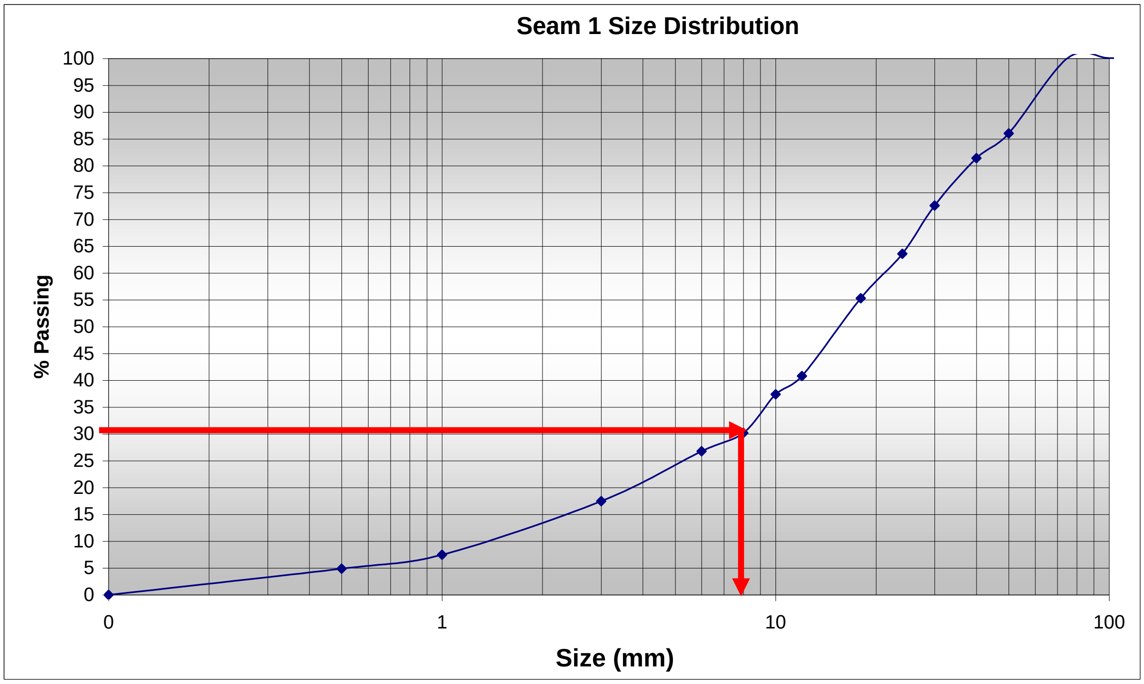

Figure 7: Inyanda Seam 1 Feed Size Distribution

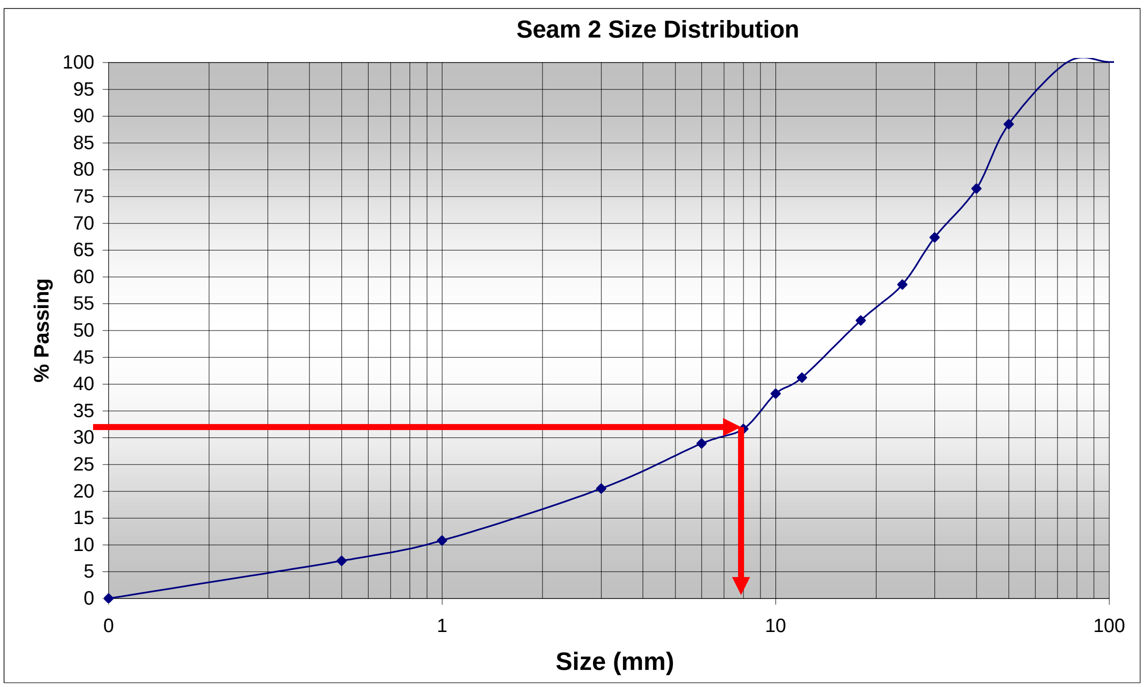

Figure 8: Inyanda Seam 2 Feed Size Distribution

The surface moisture in the feed to the Bivitec screen was found to be 3.3% and the screen cut point was at approximately 8mm.

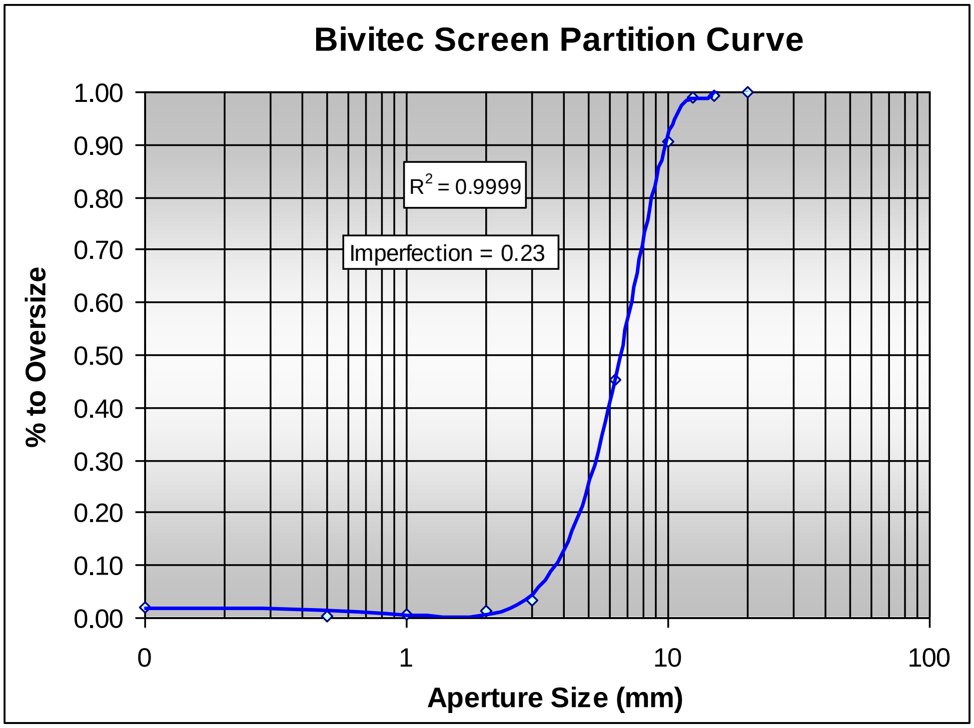

Figure 9: New Clydesdale Bivitec Screen Partition Curve

The efficiency was found to be approximately 99% with equation 1. The imperfection was calculated to be 0.23 with equation 2.

$$\text{Efficiency}_{\text{(screening at 8 mm)}} = \frac{100 \times (a-b)}{a \times (100-b)} \qquad \ldots 1$$

In the Efficiency formula, the following variables were used:

- a = % -8 mm in feed
- b = % -8 mm in screen oversize

$$\text{Imperfection} = \frac{d75 - d25}{2 \times d50} \qquad \ldots 2$$

The efficiency and imperfection values are both considered to be very good, taking into account the fact that the feed moisture was below 4% whereas the aperture was 8mm, larger than the usual 3mm or 6mm apertures.

3. THE BIVITEC AT LEEUWPAN COAL MINE

A test unit of the Bivitec screen was installed at Leeuwpan Coal Mine. The test unit has a capacity of approximately 30t/h and typical feed rates were in the order of about 25t/hr. This Bivitec screen test unit is approximately 4m by 1.05m in dimension.

Figure 10: Bivitec screen test unit at Leeuwpan Coal Mine

Recent changes in the coal market have prompted an investigation into the production of a lower grade thermal coal for Eskom. For Leeuwpan, this has prompted the need to dry screen raw coal at small (-6 mm) screen apertures. Tests have shown that the bulk of the -6 mm coal can be added to the Eskom product, if the -3 mm material could be screened out.

Therefore the test unit of the Bivitec screen was installed at Leeuwpan to assess the feasibility of screening out damp, -3mm material. Efficiency tests were conducted in 2009, using 3mm square aperture screen mats. The same tests at laboratory scale were also done by attempting to achieve surface moistures of the Leeuwpan feed coal and utilizing laboratory shaker screens (de Korte, 2009). Both sets of results are shown in Figure 11.

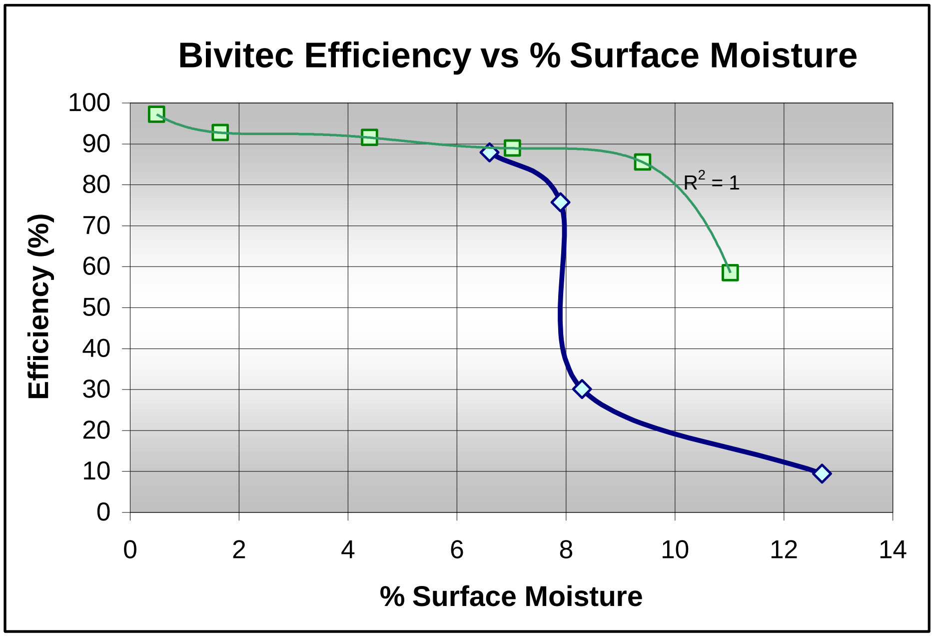

Figure 11: Leeuwpan Bivitec Screen Efficiency Curve

The New Clydesdale Bivitec tests showed approximately 99% efficiency at 3% surface moisture, which is higher than the 92.5% efficiency achieved with the laboratory screens at 3% surface moisture (Figure 11).

However, at Leeuwpan, utilizing the Bivitec, the feed coal with high moistures is screened at significantly lower efficiencies than the laboratory screens (Figure 11).

Therefore, at lower moistures, the Bivitec seems to be more efficient than normal screening methods; however, at higher moistures the Bivitec does not perform as well as normal screening methods.

It was also noted that, although the Bivitec screen does not blind while screening damp, fine coal, the fines are simply carried over with the oversize coal.

4. DRY SCREENING WITH MEDUPI COAL

4.1 Medupi Coal and the Bivitec Screen

The aim of the Bivitec test work conducted with Medupi coal was to cut efficiently at a 4mm aperture. This is a relatively small aperture and the calculated imperfection was 0.38 whereas the calculated efficiency was 87%. The feed moisture of this test was approximately 6%.

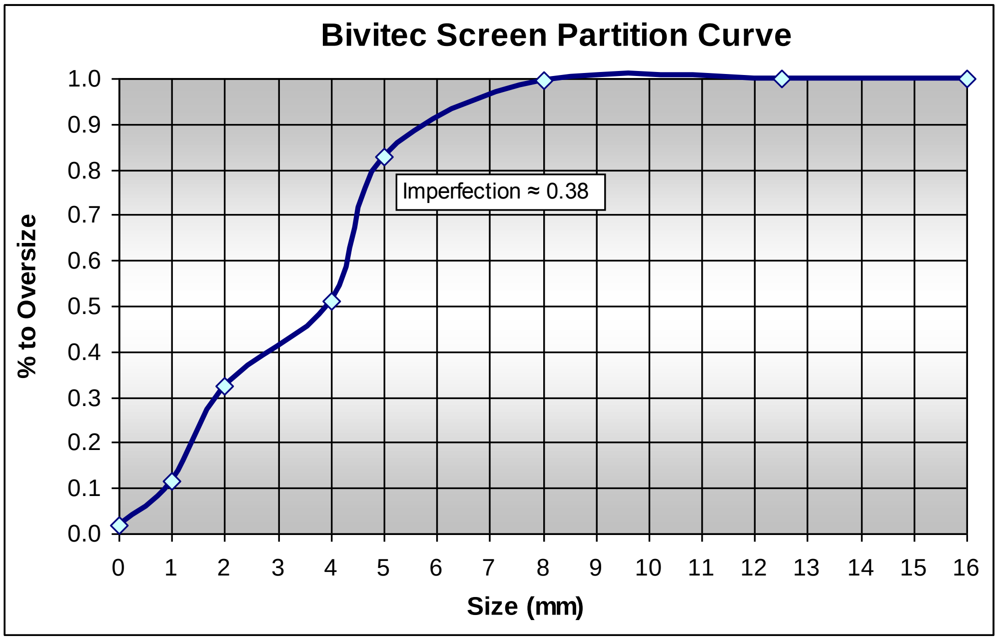

Figure 12: Medupi Bivitec Screen Partition Curve

4.2 Medupi Coal and the Liwell Screen

The Liwell tests were done at Enerco / Amsterdam. The first tests were carried out at a feed rate between 18.7t/h to 56.3t/h and average surface moisture, ranging from 3.3% to 4%. The cut point still had to be 4mm.

The efficiency was calculated to be, on average, approximately 99%. The calculated imperfections seemed to worsen with lower feed rates (Figure 13):

- 18.7t/h with an imperfection of 0.17
- 25.0t/h with an imperfection of 0.15
- 35.7t/h with an imperfection of 0.13
- 41.6t/h with an imperfection of 0.14
- 56.3t/h with an imperfection of 0.11

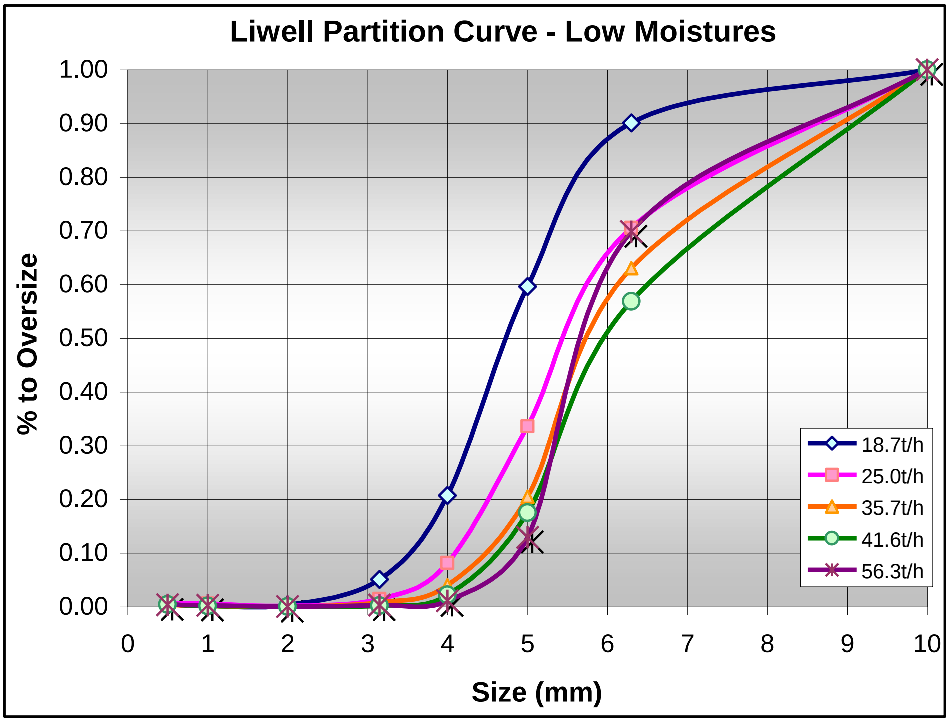

Figure 13: Medupi Liwell Partition Curve at Low Moistures

The second set of tests was done at higher moistures ranging between 6.7% and 7.1%. The calculated imperfections again seemed to be worse at lower feed rates (Figure 14):

- 7.6t/h with an imperfection of 0.23
- 22.4t/h with an imperfection of 0.18
- 34.1t/h with an imperfection of 0.16

These tests, at higher moistures, were reported to have been extremely difficult to execute. The efficiency dropped to approximately 80% and it was reported that screen mats showed some adherent particles. This could perhaps infer that, at such moistures, slightly larger apertures should be used.

It should be noted that these tests were done on an operating unit in Amsterdam. Due to the arrangement of this screen and the feed rates of each test, the screen area was not always used efficiently.

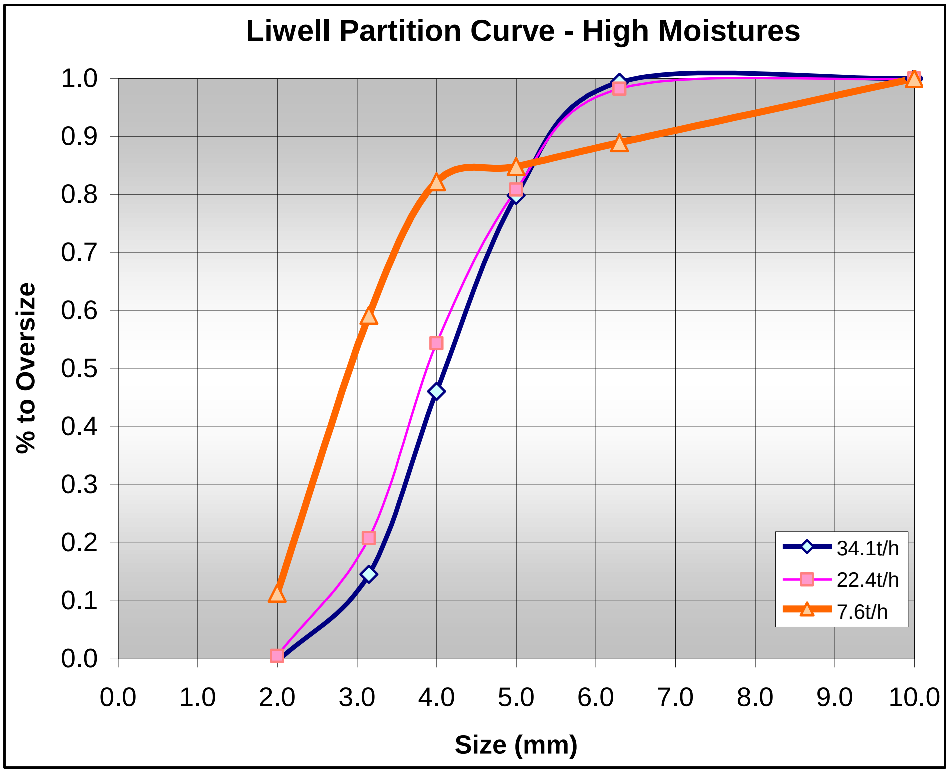

Figure 14: Medupi Liwell Partition Curve at High Moistures

Compared to the Bivitec tests done at Leeuwpan (Figure 11), those on the Liwell also show efficiencies lower than 90% when the surface moisture of the coal is higher than 8%.At surface moistures below 4%, the Liwell and the Bivitec tests reported the same efficiency of approximately 99%.

Although the Liwell screen tests show a more acceptable imperfection than the tests done on the Bivitec screen; the calculated imperfection values should be considered with the values obtained for the efficiencies and in such a case this would indicate that the wet fines adhered to larger particles and were simply carried over the Liwell screen.

5. THE BIVITEC AT EXXARO RESEARCH AND DEVELOPMENT

Dabmar Manufacturing (Pty) Ltd. manufactured the small Bivitec screen available for testing at Exxaro R&D (the same Bivitec screen test unit that was used at Leeuwpan Coal Mine).

The screen installed at Exxaro R&D has a feed rate capacity of approximately 25 to 30t/h. The screen has two screen decks: 25mm aperture (top) and a 3 mm aperture (bottom). Recently a 6 mm aperture screen mat was also made available. The Bivitec screen is 4m by 1.05m in dimension.

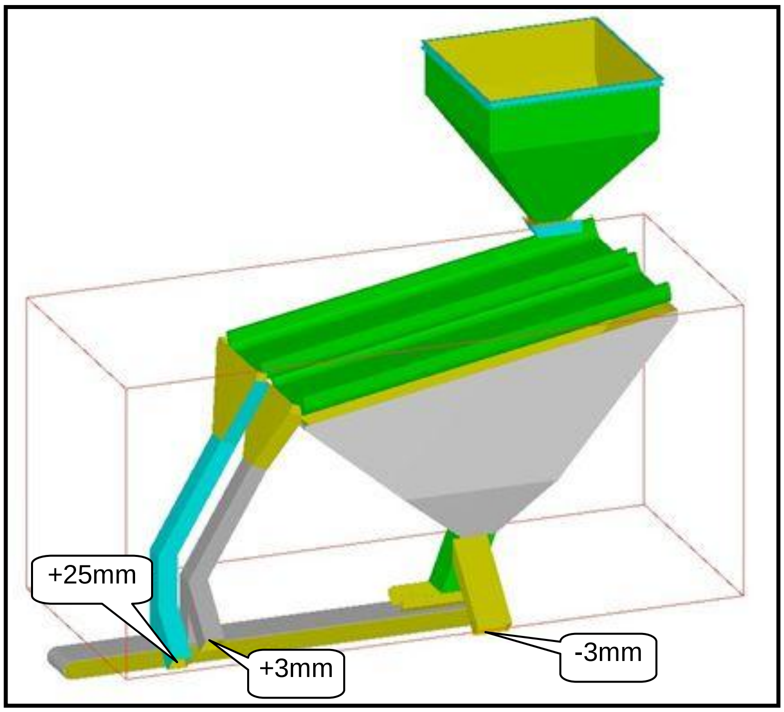

Figure 15: Diagram of the Bivitec test unit at Exxaro R&D

Exxaro is currently busy with test work on a potential colliery, in the Mpumalanga coalfields, referred to as “Belfast”. Belfast coal was tested at Exxaro R&D with surface moistures varying between 0% and 15% (Masilela, 2009). The screen mats used had an aperture of 3mm, and as was expected, the screen efficiency declined as the surface moisture increased (Figure 16).

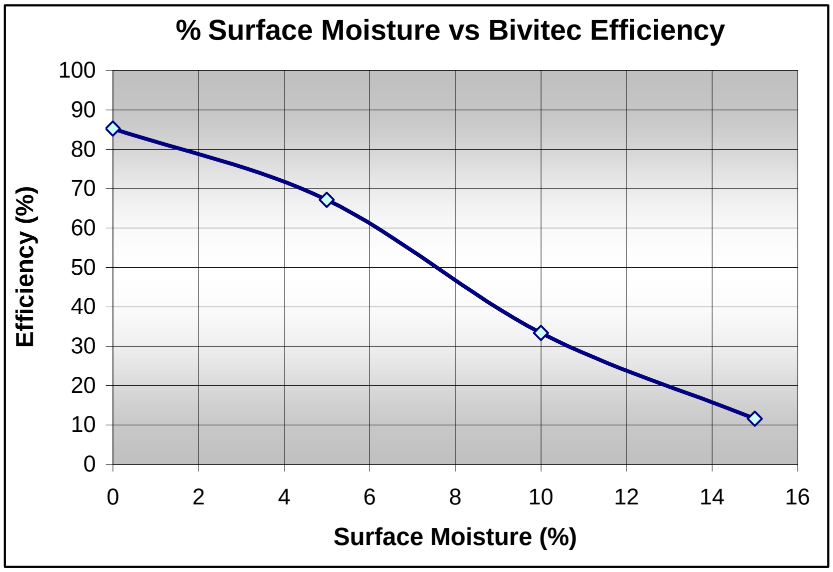

Figure 16: Belfast Bivitec tests at Exxaro R&D

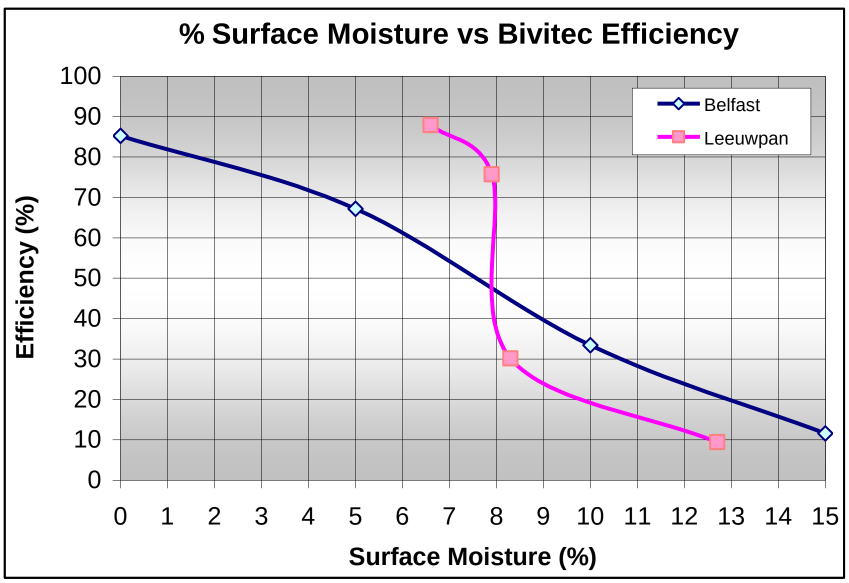

Figure 17: Comparison between tests done on the Bivitec test unit

The Bivitec tests, done at Leeuwpan Coal Mine, show a much sharper drop in efficiency with increased surface moisture than the Bivitec tests done at Exxaro R&D.

The Leeuwpan "bottom coal" may be compared to the Seam 1 and Seam 2 coal of the Witbank coalfields. However, the Leeuwpan "top coal" has not yet been compared to the Witbank coalfields. Nevertheless, the Leeuwpan "top coal" is thought to be divided into the 4 Upper and 4 Lower Seams and Seam 5, separated by shale partings. This results in the top coal varying in ash from 20% to approximately 50% (Botha, 2008). Moreover, the Leeuwpan shale in the top coal has a very challenging shape, which could make screening difficult.

Therefore it seems as if the efficiency of the Bivitec screen is also dependent on the characteristics of the feed material.

6. BIVITEC MODELLING

Exxaro R&D utilizes the LIMN software, with Microsoft Excel as a platform, to simulate plant operations. Currently Exxaro R&D is constructing a user-defined, customized model for the Bivitec screen, using the LIMN software, with Microsoft Excel as a platform, which will be audited by Dabmar Manufacturing (Pty) Ltd.

The Bivitec unit model in the simulation must be customized to adjust the efficiency of the screen as the moisture content and aperture of the screen changes and the unit model should easily predict screening efficiency during simulations of the plant. Therefore, the unit model will include the relationship between feed moisture, aperture and screening efficiency of the Bivitec screen and the simulation may be used as a mineral resource management tool for the plant to control product quality.

Furthermore Exxaro R&D seeks to quantify the financial benefits of conventional screening versus dry screening and preliminary investigations show savings in capital expenditure, as well as operational expenditure. In addition, the financial model also shows an increase in revenue for specific plants.

7. CONCLUSION

The test work on the Bivitec screen at Exxaro R&D is an on-going process. However, thus far it is clear that the Bivitec screen is more efficient than conventional screening when the surface moisture of the coal is kept below 8% - at surface moistures below 8% the screening efficiency is usually higher than 80%.

However, it is also evident that the performance of a specific Bivitec unit depends on the material type (i.e. shape of the coal and shale, and its quality), the feed size distribution and the required capacity.

With the Bivitec screen, the floating screen deck is isolated from the screen body by rubber blocks; therefore, the body is subjected to only 2G force, equating to minimum vibration, which is desirable. The polyurethane mats are extremely flexible, with high open areas and held in place by a unique clamping method that reduces damage to mats upon removal and there is no bulky sub-frame to wear out. For all these reasons, the Bivitec screen is considered to be a very low maintenance screen.

All the benefits of the use of the Bivitec screen have been simulated to show an increase in production as well as an increase in revenue.

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