MODIFICATIONS TO THE WADDELL SHREDDER AS USED IN THE SOUTH AFRICAN METHOD OF DIRECT ANALYSIS OF CANE

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Abstract

The Waddell shredder, as used in the South African Sugar Industry for preparing cane samples for laboratory analysis, is examined from its original concept to its present design. The reasons for and details of, modifications are described and commented on. The design modifications are subdivided into three main sections: (1) rotor and drum (2) power transmission and (3) control. These modifications have considerably reduced maintenance costs and improved mechanical efficiency.

Introduction

A Waddell shredder is used at each factory to prepare, on average, approximately ten cane samples per hour and has been in operation for several seasons (approximately 5 700 hours at each factory in each season).

Fig. 1 shows the entire shredder as commonly used in all mills in South Africa. It consists of three basic parts: 1. drum and rotor; 2. power transmission and motor; 3. control.

1. Drum and Rotor
   1.1 The drum: Fig. 2 shows the cylindrical smooth bore drum of 450 mm diameter and 300 mm length with an opening and door of 185 mm x 285 mm.
   1.2 The rotor: Figs. 2 & 3 show the disced cylinder of 225 mm diameter with 4 hammer retaining shafts running through it. There are 14 hammers in banks of 3 and 4 per row alternately.

2. Power Transmission:
   2.1 Fig. 4 shows the pneumatic "Airchamp" clutch and brake with adoptor shaft mounted on an 11 kW motor.

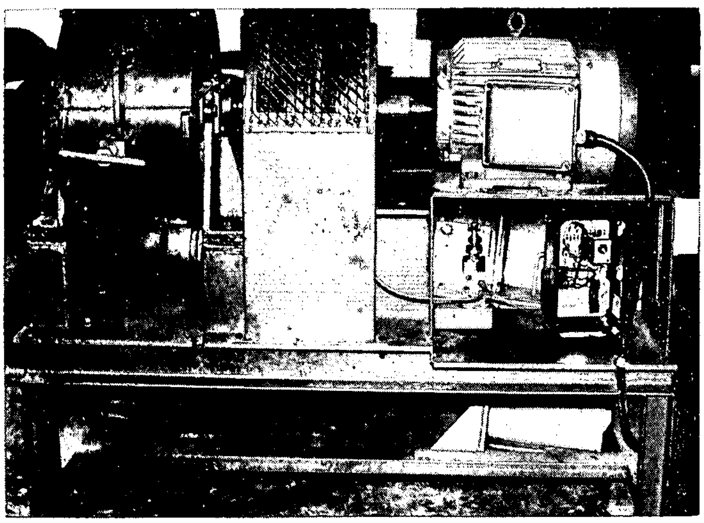


FIGURE 1

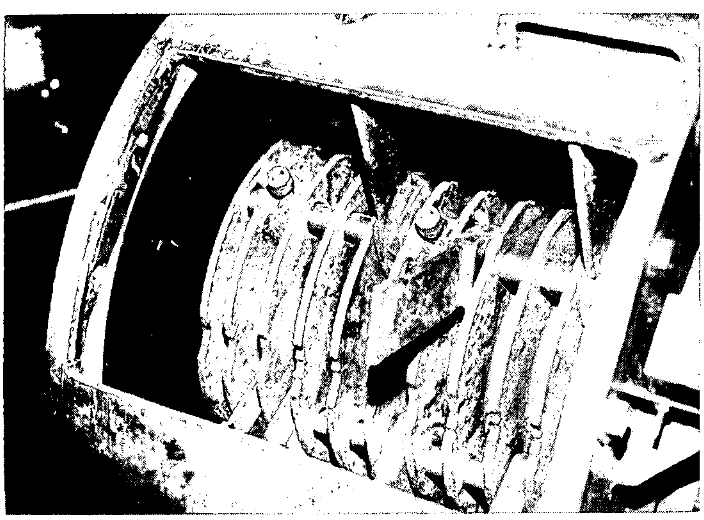


FIGURE 2

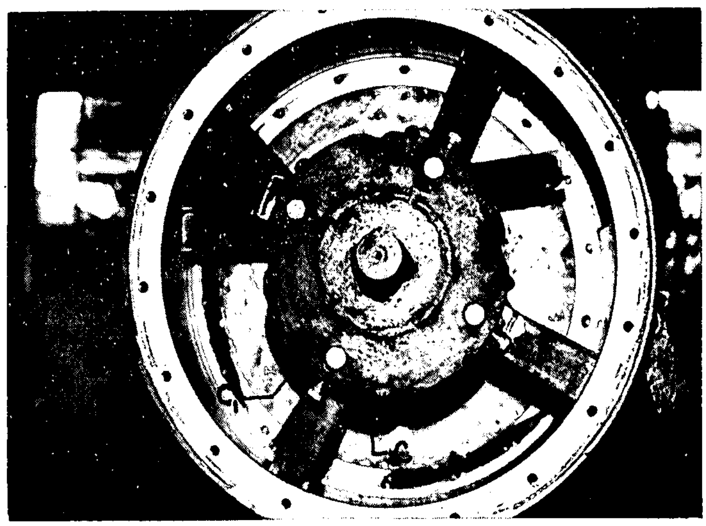


FIGURE 3

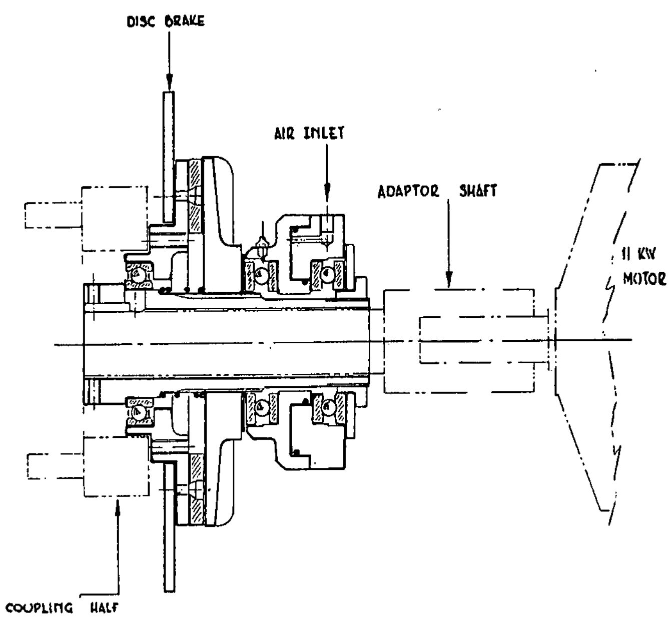


FIGURE 4

2.2 Fig. 5 shows the pneumatic "Wichita" clutch and brake mounted directly to an 11 kW motor.

2.3 Fig. 6 shows an 11kW motor driving a "Borg-Warner" 530-33 hydraulic pump through a disc type flexible coupling. The pump feeds a hydraulic motor ("Borg-Warner" 30-29) which in turn is coupled to the shredder rotor shaft via a disc type flexible coupling.

3. Control: With both the pneumatic and hydraulic transmissions, the drive is activated through a solenoid operated valve which receives its power from the control cubicle (see Fig. 7). Schematic diagram of the hydraulic system is shown in Fig. 8.

Shredder operating procedure

A cane sample of approximately 1,5 kg is fed by hand into the opening in the shredder drum. The door of the drum is closed and locked and the start button on the control cubicle is pressed. A safety interlock (see Fig. 9) prevents the running of the rotor while the door is open unless the discharge receptacle is in position. The batch shredding time is automatically controlled at 5 seconds, after which the door is opened and a specially shaped receptacle is hooked in place. The rotor is started again and the shredded cane is discharged into the receptacle.

Initial development

In the early stages of development the shredder was coupled directly to a 5,5 kW 4 pole squirrel cage motor. During the experimental work it was found that the motor could not deal with the direct on line starting under load at the required frequency. An 11 kW motor was substituted but, with the relatively short shredding time, very little motor cooling took place.

It was also necessary to introduce a braking action after the shredding in order accurately to control the actual shredding time. With the motor coupled directly to the rotor it would

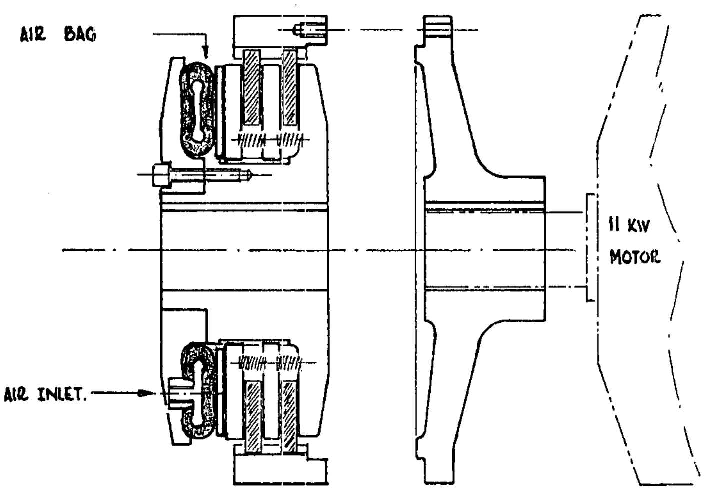
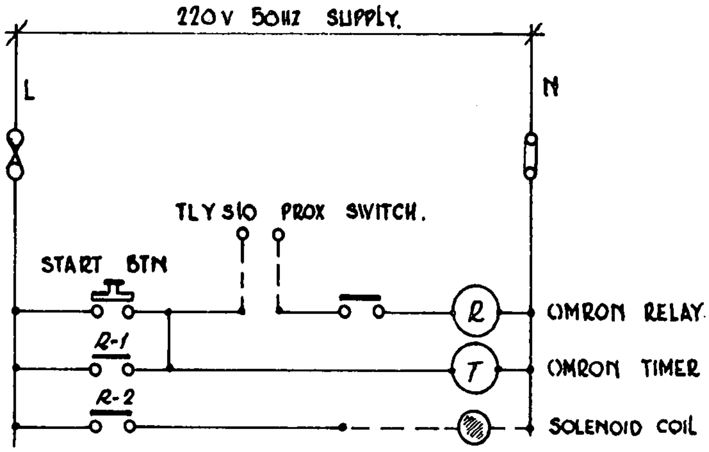


FIGURE 5



SHREDDER TIMING CONTROL

FIGURE 7

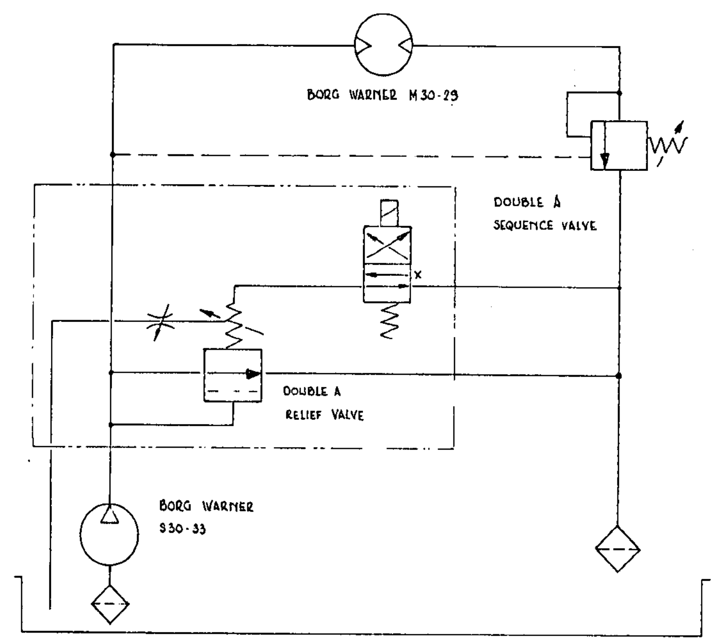


FIGURE 8

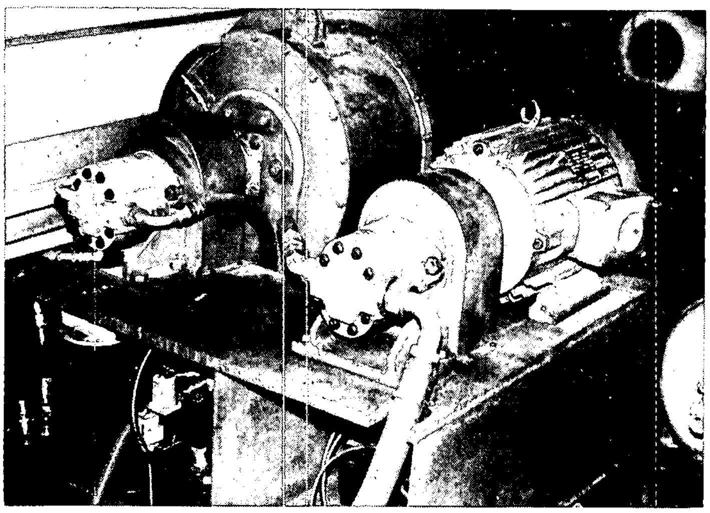


FIGURE 6

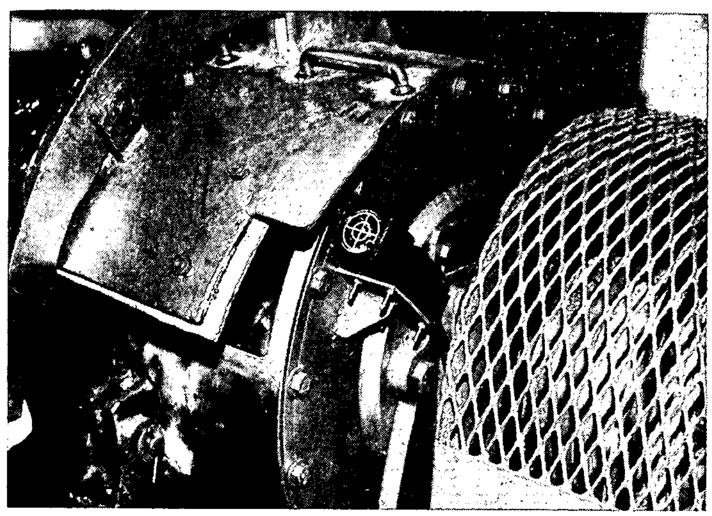


FIGURE 9

have been necessary to fit a large brake to fulfil this duty. Instead, it was decided to utilise a clutch (see Fig. 4), fitted with a disc and a suitable disc brake caliper. Both the clutch and brake were pneumatically operated through a 5 port solenoid valve (see Fig. 10) which was energised via the control system. This then was the basic machine as put into operation during the implementation of direct analysis of cane (DAC).

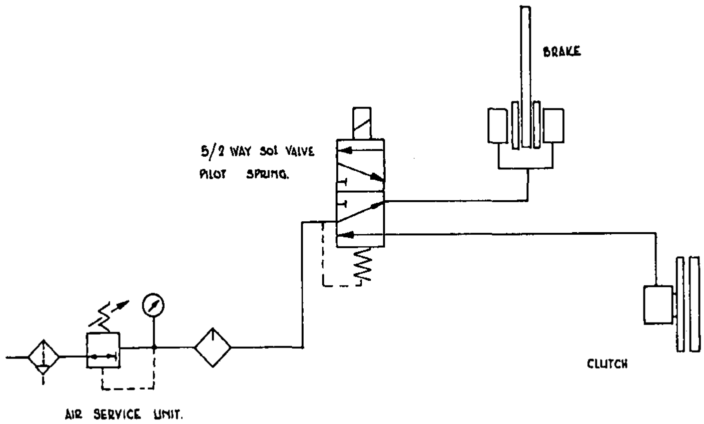


FIGURE 10

Operating problems

During operation it became apparent that the shredder would have to be modified, as breakdowns and preventive maintenance were proving to be costly and time consuming.

Problem Areas :

(*a*) *Shredder hammers:*

The shredder hammers (see Fig. 11) and their retaining shafts required frequent renewal. In some instances shafts and hammers had to be replaced after four days of operation. The main reason was the complete wearing away of the hammer bush and consequent grooving of the shaft. This led to the hammers striking the shredder drum and damaging it and hammers breaking away from the retaining shaft. This was completely impracticable.

(*b*) *Power Transmissions:*

Fig. 4 shows the clutch and brake assembly. The bearing on the left, carrying radial load, comes under dynamic load when the clutch is disengaged, and as this condition is prevalent with the operating cycle of the clutch, the life of the bearing is shortened. A seizure of the bearing caused severe damage to the clutch and also locked the clutch to the rotor yielding an unsafe condition. The clutch is mounted on an adaptor shaft, which, in turn is mounted on the motor shaft. This presented a problem whenever it was necessary to examine or change

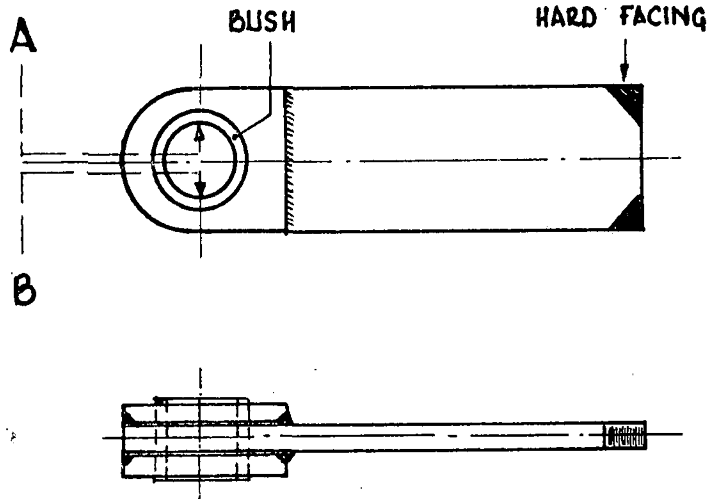


FIGURE 11

motor bearings. To remove the bearing it was necessary to heat and drive off the stub-shaft, which often caused distortion and consequent replacement of the shaft.

Misalignment of the clutch led to excessive vibration and erratic operation of the disc brake. The caliper of the disc brake also proved troublesome. After a short operational period slight wear occurred on the pads and the extended brake piston chattered and damaged the piston housings and seals thus rendering the brake ineffective.

(*c*) *Control Equipment:*

All equipment required for motor starting, pneumatic control and clutch and brake sequence control, was housed in one box. This proved unsatisfactory. An air leak, however small, caused an oil mist to be sprayed on to the electrical components, effecting maintenance in the restricted space within the cubicle was awkward. Vibration tended to dislodge various components, especially the control transformers. The shredder door interlock was of the press button limit switch type and due to the presence of moisture and shredded cane the mechanical parts of the switch frequently malfunctioned rendering the equipment unsafe and incurring high maintenance costs.

Modifications

(*a*) *Shredder hammers:*

Various combinations of hammer bush and shaft materials were tried without deviation from original dimensions.

Combinations of phosphor bronze on stainless steel, S.G. iron on stainless steel and EN 23 shafts only produced marginal improvements in hammer life; minimum service duration of hammers and shafts was extended from 4 days to 14 days.

Use of various high molecular weight polyethylenes in conjunction with stainless steel shafts, extended the hammer life to six weeks.

It was observed that wear was occurring at points A and B (see Fig. 11) and it was discovered that the hammers, during acceleration and deceleration, were impinging on the retaining bars (see points C and C1 Fig. 3) and that this lever-action was causing the damage. By removing the retaining bars the wear problem was alleviated; hammers are seldom changed within 20 weeks despite the fact that an interim decision to discontinue the use of the cane prebreaker had placed a greater burden on the task of the shredder.

(*b*) *Power Transmission:*

The "Airchamp" clutch and brake were replaced with the more suitable "Wichita" units (see Fig. 5).

The advantages of the "Wichita" clutch are :

1. The clutch does not have bearings.
2. The mounting to the electric motor is much simpler and does not require an adaptor shaft.
3. The linings are easily changed without the removing the clutch.

Disadvantages of the change to the "Wichita" clutch and brake are :

1. A rotating union is required to supply air to the hollow centre shaft onto which the clutch is fitted.
2. The "Wichita" brake is mounted externally to the machine and it tends to obstruct when hammers and shafts have to be changed.
3. Cost Factor: The "Wichita" units are expensive (R1 730 for clutch and brake as compared with R470 for the "Airchamp" equivalents).

Spares for the "Wichita" assemblies were sometimes difficult to obtain and were also costly.

It was established that the "Wichita" clutch and brake assembly would operate for an entire season without maintenance, was easy to work on and was extremely reliable, but also costly. The next step was to examine the potential of a hydraulic drive in the place of the pneumatic drive to obtain the same reliability and relatively maintenance free operation afforded by the "Wichita" assembly, but at a lower cost.

The following considerations prompted this avenue of inspection :

	Shredder Drive Air Clutch and Brake:	Hydraulic Drive:
1. Initial cost	R1 730,00	R750,00
2. Ability to vary speeds	NO	YES
3. Ability to add to drive	NO	YES
4. Spares availability	Experienced delays	Good
5. Cost of spares	Expensive	Reasonable

Three basic types of hydraulic unit were considered :

1. Piston pumps and motors.
2. Vane pumps and motors.
3. Gear pumps and motors.

Piston Units: were considered to be over sophisticated and too costly in this application.

Vane Units: although the cost factor is favourable the maximum continuous working pressure in the vicinity of 17 MPa was a disadvantage.

Gear Units: with a working pressure of 20 MPa and lowest price it afforded the best potential. It was also felt that a gear pump and motor would prove less troublesome if for any reason the oil should be contaminated (although precautions would be taken to guard against this).

A Borg-Warner gear pump and motor with the necessary valves and control equipment (see Fig. 6) were fitted to the existing shredder framework. Acceleration and braking times are controlled with the valve configuration shown in Fig. 8. Following workshop tests, the unit was installed in the Amatikulu sugar mill where, on average, 15 cane samples are prepared in each hour. The shredder operated for the entire season without breakdown or maintenance requirements. The operating oil temperature never exceeded 50°C (maximum recommended 80°C).

A salient advantage of the hydraulic drive is the smoothness with which the drive is brought into operation; the shock transmitted on start-up by the pneumatic clutch and brake is a major aggravation to maintenance.

(*c*) *Control Equipment:*

The three sections of the control equipment were separated.

The motor starter was mounted away from the shredder and a 500 volt contactor coil was used thereby eliminating the 220V supply on the starter. The timer control was mounted in a transparent enclosure, independent of the other sections. It was rubber mounted and fitted throughout with "Omron" equipment which proved to be more reliable and accurate than the original equipment.

The original press button limit switch (shredder door interlock) was replaced by a proximity sensor ("Omron" TL-YS10). This proximity sensor has proved to be most satisfactory. The enclosed unit is completely waterproof, has no moving parts, and is easy to install. The service life of the unit is far in excess of that of the limit switch; the TL-YS10 is calculated at 125 years as against 9 years for the limit switch (if it does not fail much sooner through corrosion or physical damage). The other main disadvantage of the limit switch is that it can be accidentally operated by hand. The cost of a proximity switch is R18,50 as compared with R9,50 for a limit switch.

A point to be considered is that the proximity switch will handle an AC load of up to 700 mA. This does not present a problem in this application (see Shredder control circuit MK 3).

The original limit switch was wired normally open, across the neutral link, and it took the entire load of the relay, timer and solenoid coil. The circuit was altered with the proximity switch placed in series with the MK 2P relay.

Briefly, this particular proximity switch operates as follows:

The circuit is composed of a coil, resistor capacitor, transistor and LED. The detection is based on the principle that, when the coil of an HF oscillator is approached by a metal object, the oscillator stops oscillating because of the eddy current loss, etc. It is primarily designed to detect approaching magnetic metal objects (see Fig. 12).

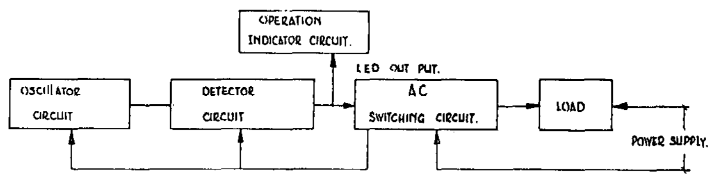


FIGURE 12

Maintenance costs: summary

Original Shredder

Component:	Component Cost per Machine:	Average Replacement Frequency:	Component Costs for 20 Shredders in a 40 week Season:
Hammers and Rods	R43,00	Weekly	R43,00 x 20 x 40 = R34,400,00
Clutch and brake lining	R32,00	2 per season	R32,00 x 20 x 2 = R1,280,00
Door limit switch	R9,50	2 per season	R9,50 x 20 x 2 = R380,00
Clutch bearing	R12,95	2 per season	R12,95 x 20 x 2 = R518,00
			R36 578,00

The foregoing takes no account of installation labour costs, nor does it include labour costs in remedying breakdowns of the control system and other mechanical damage, etc.

Modified Shredder

One hydraulic shredder was operated for a full season at the Amatikulu mill under heavy duty conditions and a second unit was tested for extended periods under amplified stress in the workshop. Throughout these periods of operation the only maintenance required was the replacement of two sets of hammers and rods and one hydraulic hose (total cost R100,00 excluding labour costs).

Acknowledgements

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