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Scraper winch pull force investigation

D. JANICIJEVIC
Anglo Platinum Limited, Johannesburg,

This paper describes the process of scraper winch pull force measurement and shows the results of the actual winch pull force in extreme stall situations as well as during the face and gulley cleaning. It was found that by slowing down the motor and causing it to slip, torque up to 3.5 times higher than the nominal can be developed, resulting in the same increase of winch pull force. On the other hand, measurements of the actual force needed for cleaning of the face and the gully have shown that the currently used winches are too powerful. The extra torque that can be developed by the already too powerful winch motor poses a significant danger and necessitates the implementation of measures that will eliminate this risk.

Scraper winches in operation

The scraping of ore and moving it to the ore pass at all Anglo Platinum conventional mining operations is done by using 37 kW and 55 kW double drum single speed electric scraper winches.

A 37 kW winch and one scoop are used for cleaning the face, whereas the material in the ASG and centre gulley is moved by a 55 kW scraper winch with two scoops in tandem.

Winch specifications

There are many different versions of scraper winch machines in everyday use, but models derived from the old Joy-Sullivan design are the most common. This design has two drums and an electric motor in an in-line arrangement. The motor drives the pull drum via a gearbox. The change of direction of the pull is done by applying a breaking force via clutch pads onto the surface of drums. Table I shows operating parameters of both commonly used winches. The pull force and velocity vary with the effective drum diameter. These parameters are continually changing with the change of the amount of rope wound on the drum. When the rope velocity is the highest, the pull force is the lowest and vice versa.

Winch stall and AC motor behaviour

Scraper winches are powered by low voltage squirrel-cage alternating current electric motors. These machines are purposely designed and built to operate at larger slip angles, due to the variable loading that they experience during the cleaning/ore scraping process.

This is in contrast to the relatively stationary operating regimes of conventional motors that are used to power various pump or fan applications. This is illustrated in Figure 1, where the conventional motors would permanently operate at or close to point 1 on the torque curve.

Table I
Operating parameters of winches[1]

	SLF230	JCF212
Power (kW)	37	55
Speed (rpm)	1440	960
Rope velocity (m/s)	0.90–1.40	0.76–1.35
Pull force (kN)	23–35	39–69

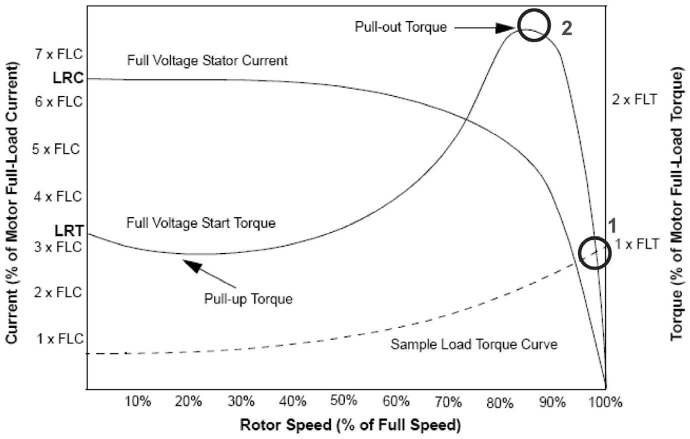

Figure 1. AC Motor operating curves [2]

The winch motors operating point is, however, dependent on the load, constantly moving between points 1 and 2 on the torque curve. This means that, in extreme situations and for a relatively small amount of slip, the motor torque far exceeds the torque at its full load.

This is experienced and interpreted by a winch driver as 'the winch having sufficient power to pull the scoop' even when it is jammed somewhere or gets hooked onto the uneven footwall.

Gold Fields test

In an attempt to experimentally determine the winch pull forces delivered by 37 kW and 55 kW winches, Gold Fields, together with COMRO and two suppliers conducted tests in May 1993[3]. Two winches were rigged up in the workshop of one of the suppliers as per the sketch in the Figure 2, with the load cell fitted in line with the rope.

Both winches were then subjected to breaking (stopping the pull drum) and the resulting pull force was measured. The profile of measured winch force changes was recorded on an analogue recorder. The measurement system was calibrated with the accuracy of the measurement system found to be within 5%[4]. In conjunction with force measurements, during the test the currents that were drawn by the motors were also recorded.

The measurement results are shown in the Table II.

The Gold Fields report concludes that measured winch pull forces are substantially higher than those quoted by the manufacturer (113 kN to 170 kN vs. 35 kN and 193 kN to 228 kN vs. 69 kN). It was then recommended that users check their standard practices to ensure that ancillary equipment such as snatch blocks, pulleys, rope and anchors, has adequate strength.

Rope strength

Since a stalled winch can provide a much higher pull force than it is designed for, it is important to compare it with the strength of the other components of the system, especially the scraper rope. The following Table III indicates the strengths of various commonly used rope constructions and diameters.

It is obvious that in extreme situations, winch pull forces could be higher than the braking strengths of both commonly used scraper rope constructions in both diameters. Effectively, this means that the safety factor of the winch-rope system may become less than 1 when a scoop gets jammed or hooked onto the footwall.

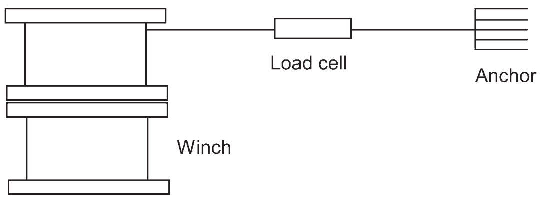

Figure 2. Gold Fields pull test arrangement [3]

Table II
Gold Fields pull force measurement results[3]

Motor power (kW)	Measured pull force (kN)	Current drawn (A)
37	113–170	> 340
55	193–228	> 500

Anglo Platinum test

To assess the extent of risk of the scraper rope breaking during real operating conditions and understand the amount of force actually required for cleaning, Anglo Platinum decided to measure the pull force.

Measurements were made during cleaning of the UG2 ore in the face of the panel 2-West of the 26 X/C on the 12 level at RPM's Townlands shaft[6].

A purposely designed load cell with an off-the-shelf Australian-made T-Tec data logger was attached to the scraper scoop and a number of measurements were logged during several cleaning cycles (movement of the scoop from the top to the bottom of the panel).

The rigging was then changed to straighten the scoop direction and several other face cleaning cycles were performed.

The final measurement was made when the load cell was attached to the front of the first tandem scoop in an advanced strike gulley (ASG). Several pull force measurements of cleaning cycles in the gulley were then made.

Load cell with the data logging device

The design is essentially a hydraulic cylinder with precise machined inside dimensions, filled with the hydraulic fluid. Figure 3 shows the drawing of the load cell design and Figure 4 is the photo of its appearance.

The pull force is acting on a cylinder piston, producing the fluid pressure, which is measured with an analogue piezo-electric pressure transducer, positioned in the control box welded to the cylinder.

The analogue pressure signal is then fed to the built-in analogue to digital converter, which feeds the digital information into a battery powered data logger memory. The rugged enclosure was made of fabricated steel with a

Table III
Breaking strength of scraper ropes[5]

Rope diameter	Breaking force (kN)	
	6 x 7 rope	6 x 6 rope
16 mm	141	126
19 mm	196	175

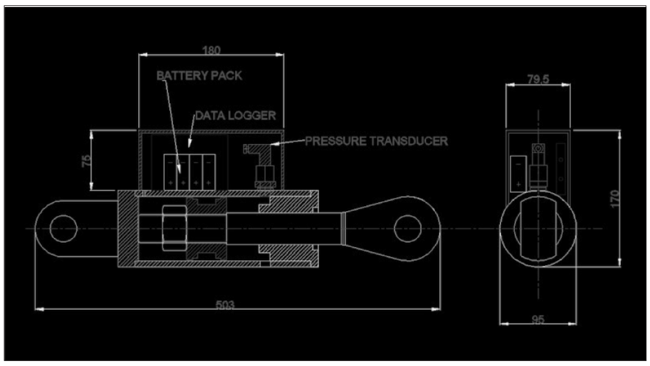

Figure 3. Drawing of the load cell

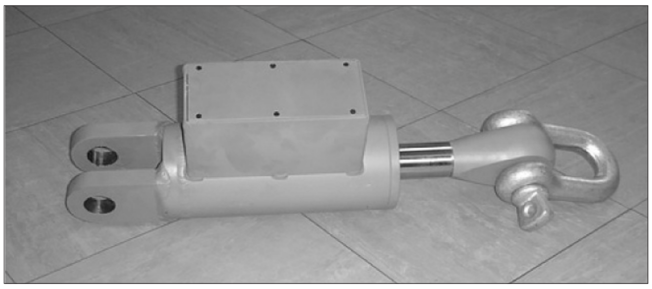

Figure 4. Photo of the load cell

Figure 5. Attaching the device to the scoop

Figure 6. The device is ready for measurements

sealed steel lid, aimed at sustaining moisture and occasional water splashes. Components inside the box were wrapped in a bubble wrap, cushioning them from possible impact during operation. The frequency of load sampling was chosen as 1 Hz (one force measurement per second). The mass of the complete assembly is approximately 20 kg.

Face cleaning force measurements

The Figures 5 to 8 illustrate the conditions during measurements.

Face cleaning pull forces

Figure 9 shows the pull forces measured during the first part of the cleaning of the face.

Figure 7. Device withstood harsh conditions

Figure 8. Often being submerged in the water and mud

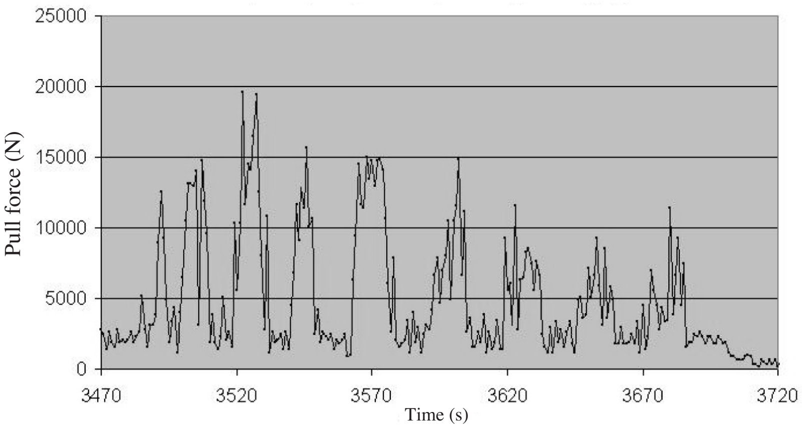

Figure 9. Measured pull force of 37 kW winch during face cleaning

From Figure 9, it is evident that during the scraping of material from the face, the pull force peaked at close to 20 kN and in most instances was reaching 15 kN.

The available pull force of a new 37 kW SLF230 scraper winch varies between 23 kN and 35 kN (depending whether the pull drum is full or empty of rope — see Table I). After the rigging was changed to accommodate scraping closer to the blasting barricades, the next set of measurements was obtained (see Figure 10).

Once again, the pull force peaked at just over 17.5 kN, significantly below the full capacity of the SLF 230 37 kW scraper winch.

The forces during the retrieval of the empty scoop ranged from 1.5 kN to 3.5 kN.

This force is used to overcome the friction of dragging the mass of the empty scoop, as well as the inertia of the whole system (mass of rope, rolling and sliding resistance of the rope over the snatch block sheave and plates, inertia of snatch blocks, some friction along the rope path and the mass of the load cell device).

ASG cleaning

Finally, the graph in Figure 11 illustrates the shape of the JC 212 55 kW ASG winch pull force that was measured while pulling two T25 hoe box scraper scoops in the ASG.

Four cleaning movements and three scoop retrieval movements were recorded. The cleaning movement durations lasted between 112 and 120 seconds, whereas retrieval movements lasted between 76 and 79 seconds.

The pull forces seldom exceeded 30 kN, whereas one peak at 40 kN was recorded during the second cleaning cycle. This peak lasted less than a second. The required pull force is gradually increased during the movement down the gulley, due to the scoop collecting more material along the way. The return movement forces were similar to those measured during the face cleaning operation and were between 1 kN and 4.5 kN.

Concluding discussion

Under certain circumstances, scraper winches that are used during face and gulley scraping have the potential to develop much higher pull forces than the rigging system, in particular the rope, can withstand.

On the other hand, it was found that the required pull forces measured during actual face and gulley scraping are lower than what the scraper winches can provide. This creates an unsafe situation, which may or already have resulted in an injury or even a fatality.

It is therefore necessary to make an attempt to either limit the winch motor torque and/or use less powerful winch motors.

Due to the slow reaction time of conventional motor overload and thermal overload devices, these are not effective methods of torque limiting. Therefore, downsizing of motor power would be the immediate recommended course of action.

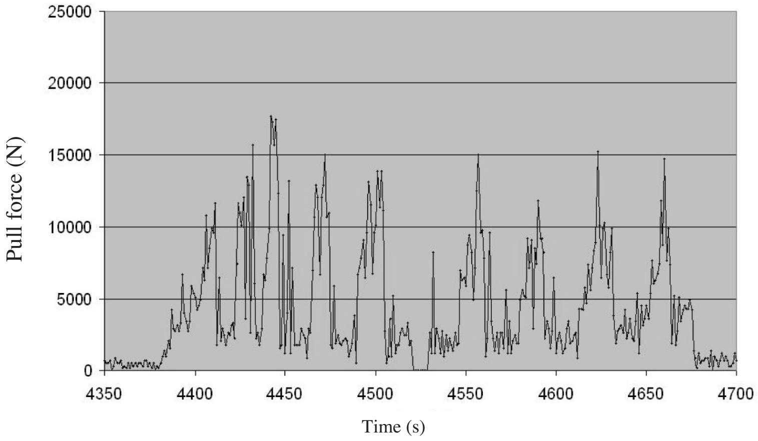

Figure 10. Second set of measured data during the face cleaning

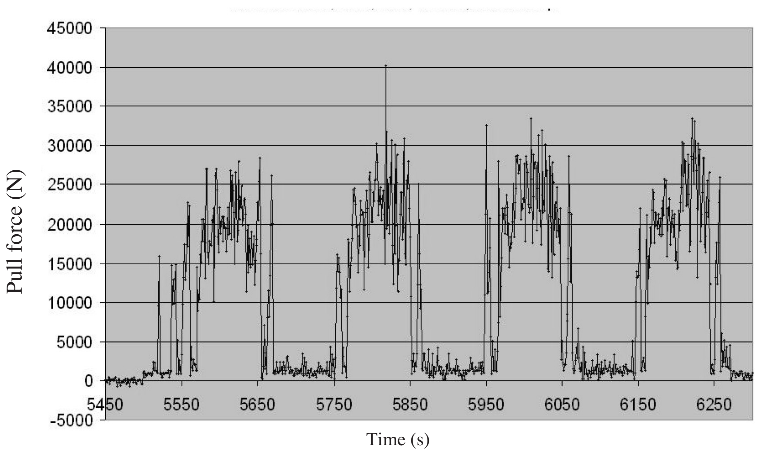

Figure 11. Pull force while cleaning the ASG with two scoops in tandem

In the longer term, the introduction of hydrostatic power or variable speed drives into scraper winch designs should be considered and evaluated. Concurrently, the development and implementation of extra low profile remotely controlled dozers should be prioritized and pursued. This would in the longer term lead to complete replacement of current scraper winches fleet.

In addition, further studies would have to be conducted to establish the pull force strength of wedged anchors used for attachments of snatch blocks. This would further the knowledge about the rigging system and help to experimentally establish its weakest component.

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References

1. EXDIN ENGINEERING. Scraper Winch Catalogue.
2. PAREKH, R. AC Induction Motors Fundamentals, Microchip AN877 Brochure, 2003.
3. KRUGER, L.V. Test report: Winch Rope Pull Test at Exdin Engineering, Test conducted by Gold Fields and Comro, 14 May 1993.
4. BARNARDO, A. Pull Test on Taylor 55 kW Winch, Calibration Report, Exdin Engineering. 1991.
5. HAGGIE RAND, Scraper Rope Catalogue
6. JANICIJEVIC, D. Scraper Winch Pull Force Measurement at Townlands, Anglo Platinum Test Report, 19 February 2008.

Dragan Janicijevic

Technology Manager: New Mining Technology, Anglo Platinum

Since 1985 Dragan has been trained and working as a research, development, design and test engineer in the automotive industry (Ricardo Consulting Engineers in Sussex, England; the IC Engines Institute in Belgrade, Yugoslavia, and in the R&D department of BMW in Munich, Germany). In 1991 he emigrated to SA and until 1996 he was employed as a product development engineer in the automotive industry (Metair Corporation in Nigel; Automotive division of Murray and Roberts in Wadeville). He then moved to managerial roles in engineering and QA field in the polymer processing industry (Techno Plastics in Edenvale) and was there until 2001. After two years of contracting and consulting in the automotive, mineral processing and mining industries in Germany and SA (DAMS, Xybanetix Consuting and MAC Consulting), he joined Anglo Platinum's Supply Chain in 2003. From 2006 he has been in the current position of technology manager in the New Mining Technology department. Dragan has published and presented several papers on engineering technology and energy efficiency topics.