

Technical paper for submission to SAIMM for presentation at “Heavy Minerals Conference 2003” Capetown, October 2003.

THE APPLICATION OF NEW DESIGN CONCEPTS IN HIGH TENSION ELECTROSTATIC SEPARATION TO THE PROCESSING OF MINERAL SANDS CONCENTRATES

M. Germain¹, T. Lawson², D.K.Henderson³ and D.M. MacHunter⁴

November 2002

1. Project Metallurgist, Roche Mining (MT)
2. Operations Manager, Roche Mining (MT)
3. Business Development Manager – Australasia, Roche Mining (MT)
4. Principal Technologist, Roche Mining (MT)

Roche Mining (MT)
11 Elysium Road
Carrara
Queensland 4211
AUSTRALIA

Tel. +61 7 5569 1300
Fax. +61 7 5525 3810
E-mail. sales@roche.com.au

The application of new design concepts in high tension electrostatic separation to the processing of mineral sands concentrates.

M. Germain, T Lawson, D Henderson, D MacHunter

Abstract

The development and commercialisation of new generation high tension electrostatic separators has provided a basis for simplifying mineral separation plant circuitry.

The inclusion of new design features including insulated plate electrodes that have resulted in significantly improved separation efficiencies in electrostatic separators are described. The increase in separation efficiency has resulted in a reduction in the number of treatment stages required to produce final high grade mineral products. Comparative performance data on different feed types are presented.

A comparison between mineral separation plant flowsheets using both conventional and new generation high tension electrostatic separation technology is presented. A 55% reduction in the number of installed electrostatic separators and a 36% reduction in plant area was achieved through the use of this new electrostatic separation technology.

Introduction

Traditional mineral sand dry mill electrostatic separation circuits use combinations of High Tension Roll (HTR) and Electrostatic Plate (ESP) machines to separate electrically conducting minerals from non-conducting minerals. These circuits normally generate partially separated “middling” streams of conductor and non-conductor particles that are recirculated to some earlier stage in the circuit. At equilibrium, the amount of this recirculated material can be greater than the amount of introduced fresh feed. This phenomenon can cause significant restrictions to plant throughput.

Recent improvements in electrostatic separation technology are described. These improvements indicate that these large recirculated streams are the result of the inefficiency of the traditional HTR and ESP separation stages.

The combined effect of relatively high rotational speed of the rolls within high tension roll machines and the mass of the coarser non-conductor particles causes them to be thrown from the roll into the conductor stream. Also, the relatively low mass of the finer conductor particles cause them to be pinned to the roll and not thrown and hence a significant percentage of these fine conductor particles mis-report to the non-conductor fraction. Traditional electrostatic circuit designs have relied on the complimentary performance of HTR and ESP separators in the treatment of wide feed size distributions to address these issues.

Concerns over high plant recirculating loads due to the adverse effect of a wide particle size distribution on separation efficiency has motivated continuing research by technology providers into the design of machines capable of effectively treating streams containing these wide size distribution.

Development of Enhanced Electrostatic Separators

Electrostatic equipment has been used by the mineral sands industry for over 30 years to effect a separation of titanium minerals from zircon and quartz. Developments through this period centered on changes such as dust control, safety and control improvements but little fundamental change occurred to the separation technology.

In 1985, a “rolling plate” device consisting of an electrostatic plate separator with the plate replaced by a roll was investigated¹. An electrostatic plate machine has also been tested with a range of electrode types including standard plate electrodes fitted with insulating coverings¹.

Research undertaken under the auspices of the “Australian Minerals Industry Research Association” (AMIRA)² included modelling and fundamental evaluation of the physical principles at play in the conventional electrostatic separation devices to gain an insight into the optimisation of this technology. During this phase, work was conducted on a thin steel belt running between two rollers (Figure 1). The aim was to determine the effect of extended decay time on machine performance. This testwork produced some promising results and led to an assessment of large diameter rolls in an attempt to achieve the same increase in decay time with an item that was simpler to manufacture and operate. The results of this work were mixed with no particular roll size showing consistent performance gains.

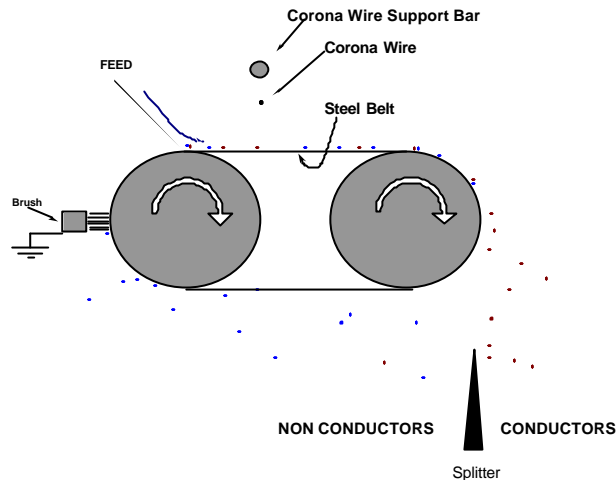


Figure 1. Prototype electrostatic separator incorporating an electrically conducting belt.

During this period, development progressed on a tribostatic separator that used an insulated electrode to prevent material attracted to it from losing its charge on contact and then misreporting¹. Research into the use of an insulated plate electrode in a conventional HTR separator has also been investigated¹ resulting in a number of new generation HTR separators including the Carrara HTR Separator (figure 2).

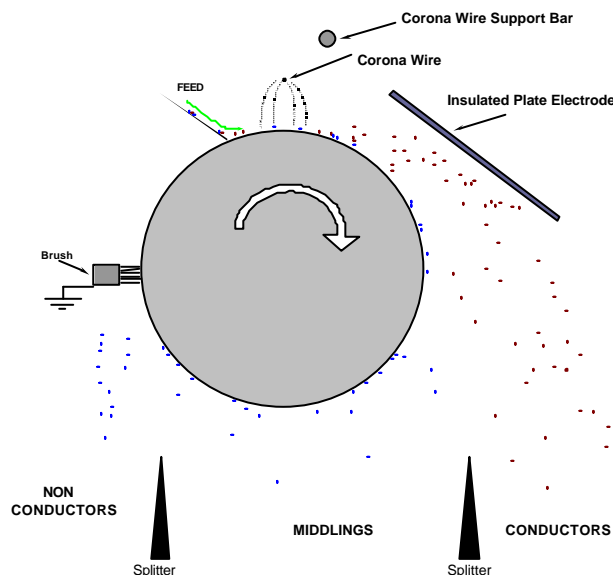


Figure 2. Layout of a single “Carrara” High Tension Roll Separator stage.

Enhanced Metallurgical Performance

The development of these new generation HTR separators using an insulated plate electrode at a controlled distance from the roll surface has increased separator efficiency and enabled the effect of

particle size to be significantly reduced¹. It is hypothesised that the improvement in separation performance through the inclusion of an insulated plate electrode is the result of the insulated plate inducing an opposite charge on the surface of the roll and thus influences the electrical discharging of the particles after they have passed under the corona wire. Under this scenario it is thought that the fine conductors are very quickly discharged and reversed in polarity enabling them to be attracted toward the plate rather than relying on the throwing action of the roll rotation. Conversely, non-conducting particles would find a stronger attraction to the roll and be carried further around the roll.

Testwork has demonstrated that the physical spread between the trajectory of the conductor and non-conductor stream is greater in the Carrara separator than in conventional HTR separators as is the quality of both the conductor and non-conductor products.

Separation Efficiency Improvement

Laboratory testwork was undertaken to quantify the separation performance of the Carrara (Mk 6) HTR separator and a conventional Reichert Mk5 HTR separator. Figures 3 and 4 show the conductor grade-recovery curves for a mineral sands rougher separation on feedstocks with 30% and 70% conductors respectively. These tests were performed on laboratory scale separators.

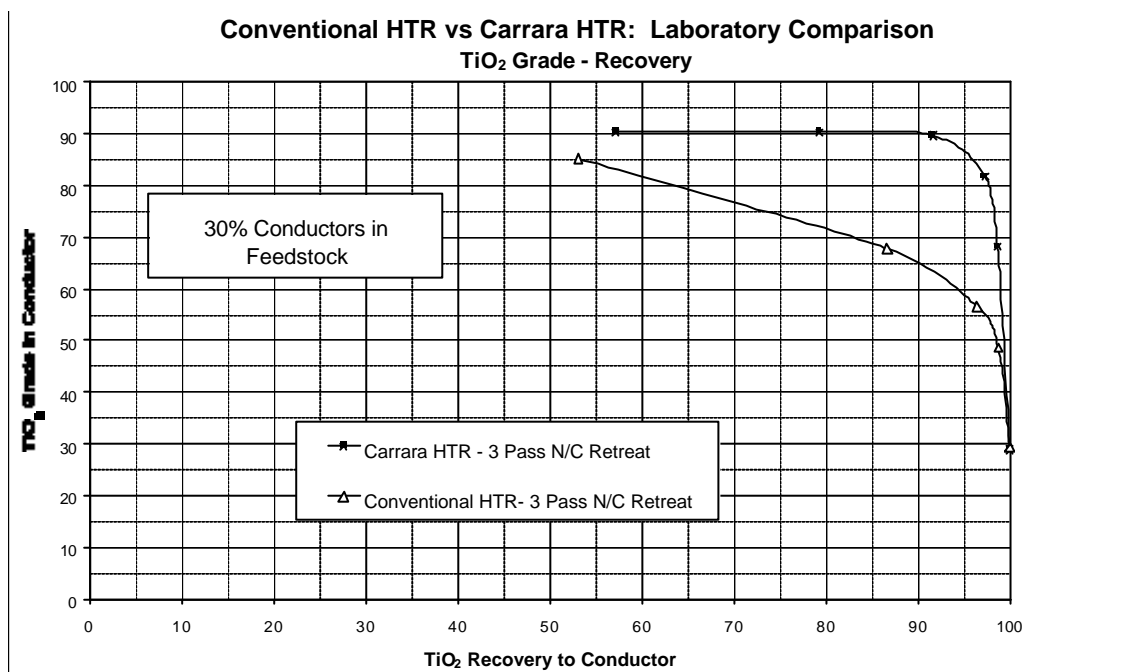


Figure 3. Comparison of TiO₂ Grade-Recovery - Conventional HTR Vs Carrara (Mk6) HTR 30% conductors in the feed.

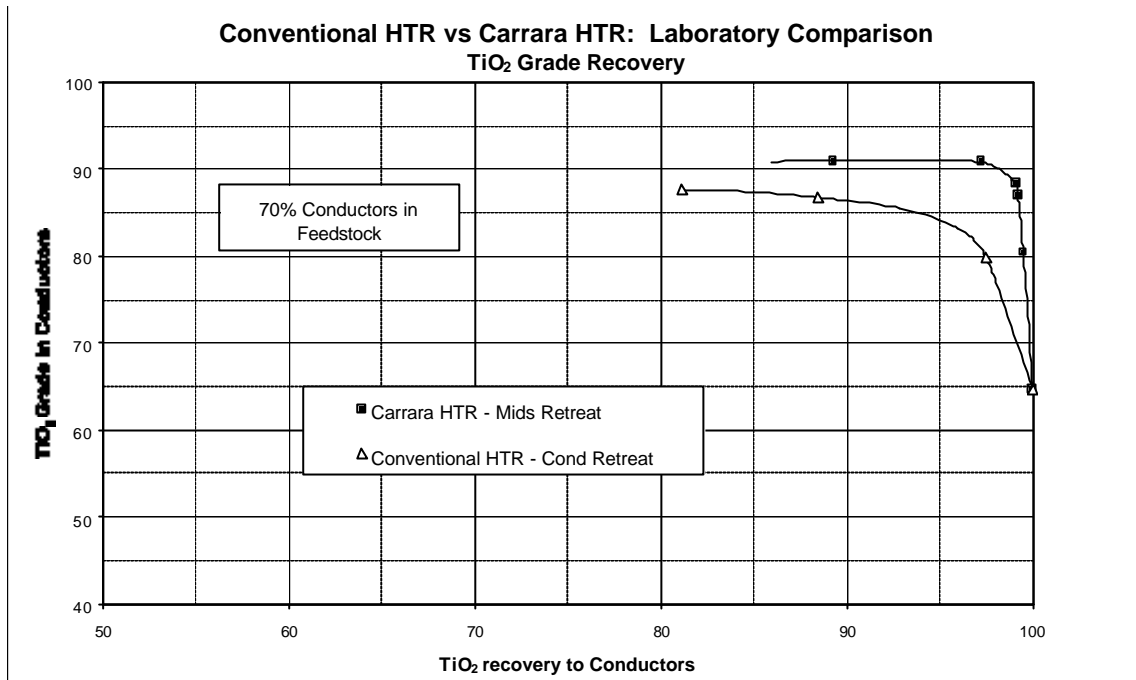


Figure 4. Comparison of TiO₂ Grade-Recovery - Conventional HTR Vs Carrara (Mk6) HTR 70% conductors in the feed.

The sharper point of inflection in the Carrara separator curves and the consistently higher values of both grade and recovery demonstrate that more efficient separation has been achieved with this unit on both feedstocks. The performance gain with the 70% conductor feedstock appears to be less significant, however, this is more a function of the HTR separator performance being higher with the feedstock with higher conductor content. Indeed, the overall shape and position of the two Carrara separator curves are very similar, indicating a very consistent performance on both feedstocks. This consistency of performance across changes in feed type should prove advantageous in a production environment.

The data presented in Figures 3 & 4 were derived from a laboratory test programme that utilised a single stage separator in which products were re-treated to simulate a three stage machine. Single stage laboratory test conditions can be very tightly controlled, often producing results that are significantly better than multiple pass plant scale equipment. A separation performed on a pilot scale three stage Carrara (Mk 6) HTR unit, with a feedstock containing 60% conductors, was subsequently repeated on the single stage laboratory unit. The results are compared in Figure 5.

Laboratory Carrara HTR vs Pilot 3 Stage Carrara HTR
Rougher Separation: Grade - Recovery

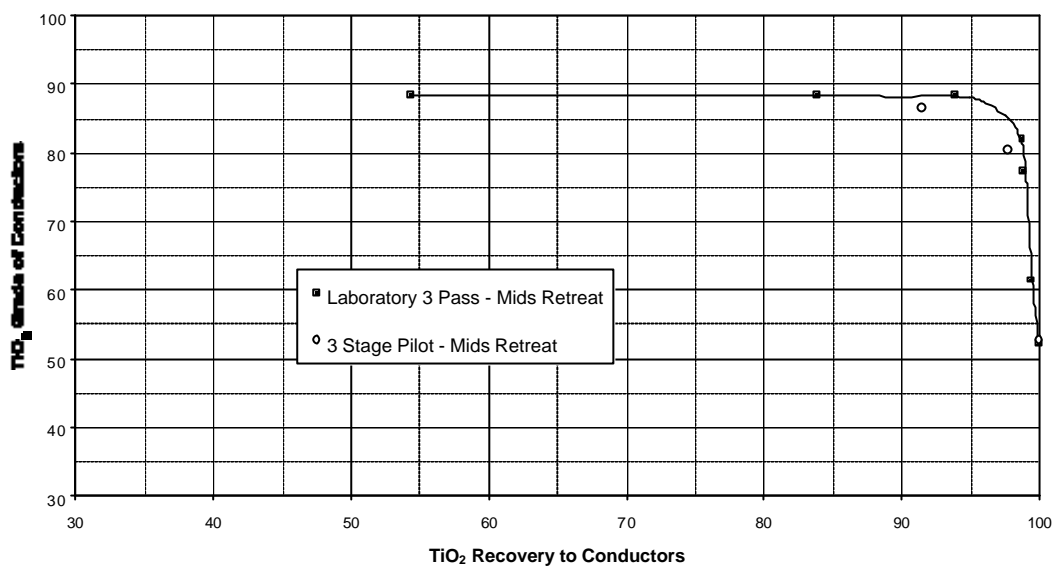


Figure 5. Comparison of TiO₂ Grade-Recovery – 3 Stage Pilot Carrara (Mk6) HTR vs 3 passes on a Laboratory Carrara (Mk6) HTR, 60% conductors in the feed.

The operation of the three stage unit was not fully optimised, including some variations in inter-stage feed temperatures and thus some reduction in efficiency was expected. Nevertheless, the plotted points from the three stage unit can be seen to lie very close to the laboratory grade recovery curve.

In-plant comparison data between a conventional three stage HTR separator and a two stage Carrara (Mk 6) HTR separator are presented in Figure 6. The data are plotted as efficiency for the separation between TiO₂ (present as ilmenite and rutile - conductors), and Al₂O₃ (predominantly present as staurolite – non-conductor).

$$\text{Efficiency} = \frac{(\text{TiO}_2 \text{ recovery to conductor fraction} + \text{Al}_2\text{O}_3 \text{ recovery to non-conductor fraction})}{2}$$

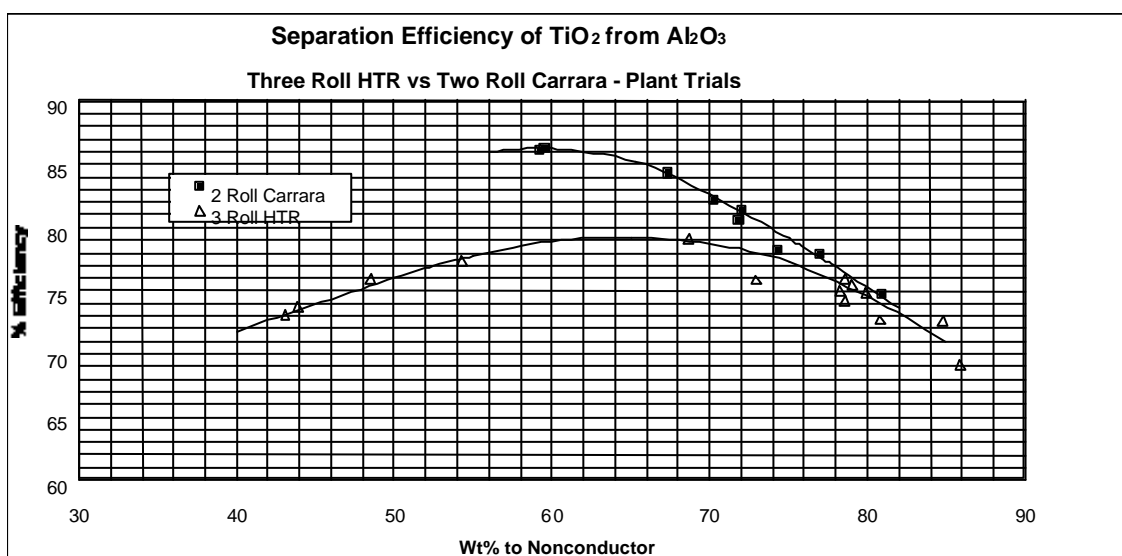


Figure 6. Separation Efficiency TiO₂ from Al₂O₃ – 2 Stage Carrara (Mk6) HTR vs 3 Stage HTR.

These data indicate that at a peak separation efficiency of >85% the two-stage Carrara (MK6) HTR machine out performs the conventional three-stage HTR machine with a peak separation efficiency of 79%. Use of a three stage Carrara (mk6) HTR separator is expected to further increase the efficiency of that unit.

Flowsheet and Plant Implications

The use of these new generation HTR separators in mineral sands separation plants is being investigated by a number of mineral sands producers. The full impact of the potential of this technology on a mineral separation plant can be determined by comparing a full scale plant based on conventional HTR technology to a full scale plant based on new generation technology, both treating the same feed material. While this may never be possible, it is possible to compare such plants at a design stage.

The development of Bemax's Gingko project proposed for the Murray Basin region in Australia spanned the development of these new generation HTR separators such that the bankable feasibility study (BFS) for this project was based on metallurgical testwork and plant design using conventional electrostatic separation technology while the subsequent definitive engineering design phase for this project investigated the use of new generation electrostatic separation technology.

The number of processing stages for these two designs are compared below:

Circuit	Number of electrostatic processing stages			
	Conventional		Carrara	
	HTR	ESP	Carrara HTR	ESP
Ilmenite	1	2	2	
Leucoxene			3	
Rutile	5	6	5	2
Zircon	3	6	4	1
Total	9	14	14	3

It should be noted that an additional circuit, the leucoxene circuit, was introduced in the DEDP. The total number of electrostatic processing stages, and taking into account the introduction of the additional leucoxene circuit, was reduced from 23 to 17 representing a 26% reduction in the number of electrostatic stages required.

The difference in the two flowsheets is further highlighted when the reduction in the number of processing units required for the two options is considered. These data are tabulated below:

Circuit	Number of processing units			
	Conventional		Carrara	
	HTR	ESP	Carrara HTR	ESP
Ilmenite	5	7	8	
Leucoxene			5	
Rutile	23	19	11	2
Zircon	7	12	6	1
Total	35	38	30	3

The total number of electrostatic separators was reduced from 73 to 33 representing a 55% reduction in the number of separators required when utilising the improved HTR technology. Additionally, the requirement for ancillary equipment was reduced, e.g. the number of bucket elevators required should be reduced from 32 to 25.

The reduction in the number of stages and physical units has also been reflected in a significant reduction in the building size requirement. Layouts of the two options indicate that the dry milling circuits that will incorporate the new generation machines will require some 1330 m² of space compared to some 2080 m² of space for the conventional circuits i.e. a reduction in plant floor space of some 36%.

With the range of economic and operational benefits outlined above the future of this new technology is assured. All processing flowsheet development projects being undertaken by Roche Mining (MT) for new mineral separation plant will incorporate the use of this new technology.

Conclusions

The use of new generation HTR separators has been shown to have a significant effect on reducing the complexity and size of mineral sands separation plants. This technology is being thoroughly evaluated by both existing and potential minerals sands producers worldwide and the number of new generation HTR separators installed in existing plants is steadily increasing. Given the increased separation efficiency of this new technology it is likely that all new mineral sands dry treatment plants will now be designed based on utilising this technology.

References

1. Internal Roche Mining (MT) Research and Development,
2. Australian Minerals Industry Research Association Research Project P255