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Technical note: Evaluation of mill liners at East Driefontein Gold Plant

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SYNOPSIS

This note describes an investigation into the most cost-effective material for mill-shell liners in large-diameter pebble mills with lifter bars. This is part of a project being conducted at the gold plant of East Driefontein near Carletonville in the Transvaal.

It was found that manganese-steel and chromium-steel liners are more cost-effective than liners of cast mild steel or white iron.

SAMEVATTNG

Hierdie aantekening beskryf 'n ondersoek na die mees kostedoeltreffende materiaal vir meulrompvoerings in die geval van rolklipmeule met 'n groot diameter, met ligterstawe. Dit is deel van 'n projek wat by die goudaanleg van Oos-Driefontein naby Carletonville, Transvaal, aan die gang is.

Daar is gevind dat mangaanstaal- en chroomstaalvoerings meer kostedoeltreffend is as voerings van gegote sagtestaal of wityster.

The pebble mills at East Driefontein Gold Plant have used a combination of grid and backing-plate shell liners since the start of operations. Latterly an arrangement of alternating 100 mm and 80 mm high lifter bars was superimposed along adjacent rows of grid liners in order to improve the liner life.

The life of the grid liners increased from 230 to more than 1500 days, and the lifter bars lasted for 200 to 300 days depending upon their position along the length of the mill. Overall there was a decrease of 47 per cent in the consumption of the liner steel in the pebble-mill shell.

The mechanism of wear improvement is thought to be as follows: a portion of the pebble load is contained between the lifter bars, forming a false lining that protects the grid liner primarily from attrition wear; there is less slip over the liner, and there may also be less impact wear owing to this false lining.

Comparisons between two identical mills showed that a mill fitted with the lifter bars produced 7,8 per cent more material smaller than 75 μm per kilowatt-day, drew 9,6 per cent less power, and experienced a decline of 2,6 per cent in the tonnage of minus 75 μm material produced, than a mill without lifter bars[1].

It was desirable to regain some of the power draught and the production of minus 75 μm material while still maintaining the lower liner costs. A project was therefore initiated on the use of a liner configuration consisting of a solid 50 mm steel liner of various alloys together with a lifter bar.

Objectives

The objectives of the project were as follows:

(1) to determine the most cost-effective material for mill-shell liners in large-diameter pebble mills with lifter bars,
(2) to determine the frequency with which lifter bars should be renewed so as to maximize the life of the shell liners,
(3) to increase the effective diameter inside the mill and thereby regain some or all of the loss in power draught that had resulted from the installation of lifter bars,
(4) to reduce downtime by reducing the frequency of relining and to streamline the task of relining, and
(5) to find the optimum ratio of lifter-bar spacing to height with respect to throughput, power utilization, and liner consumption.

This note describes the work carried out on the first of the objectives.

Results

Four different alloys were tested for the solid shell liner using lifter bars of manganese steel. The wear profiles of the different shell liners are depicted in Figs. 1 to 4, and are virtually the same. The thicknesses of the liners were measured by use of a vernier calliper gauge.

A cost comparison on a daily basis shows that the manganese-steel and chromium-steel liners are the most cost-effective if account is taken of the shorter life of the white-iron liners (Table I).

Half of the white-iron liners had to be renewed after 286 days of running time because large pieces of the liners had cracked off at the edges. The rest of the white-iron liners ran for 438 days.

An initial life of 286 days was used for the white-iron liners in the comparative calculations, whereas at 438 days the running cost was R0,26 per day, which is identical to the cost of the chromium-steel liner.

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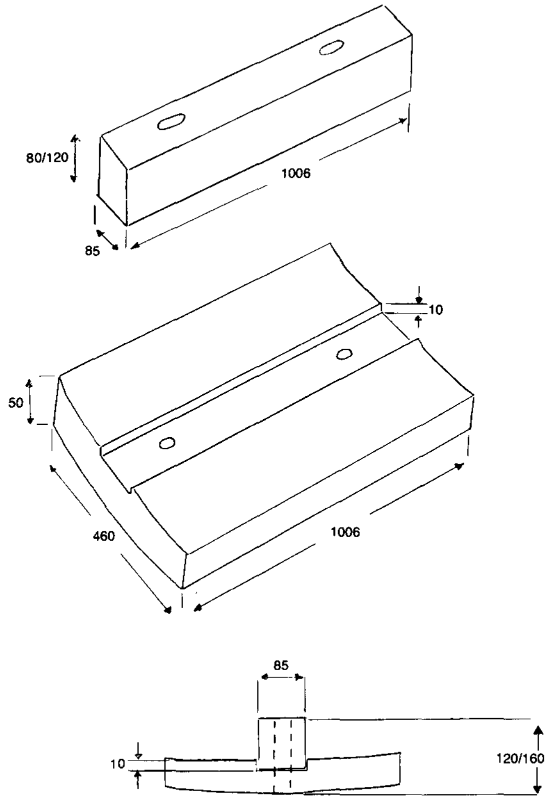

Fig. 1—Solid shell liner and lifter bar (all sizes given in millimetres)

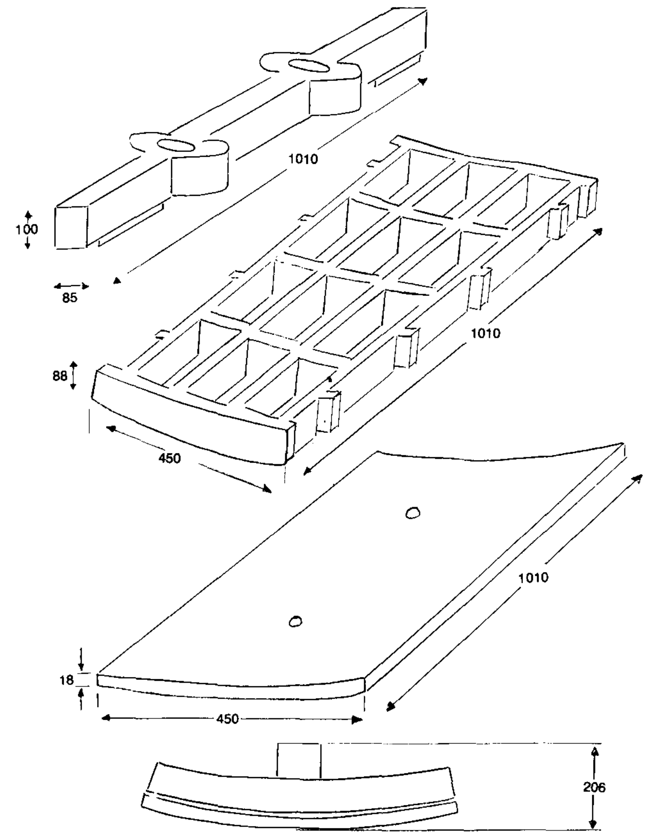

Fig. 2—Backing plate with grid liner and lifter bar (all sizes given in millimetres)

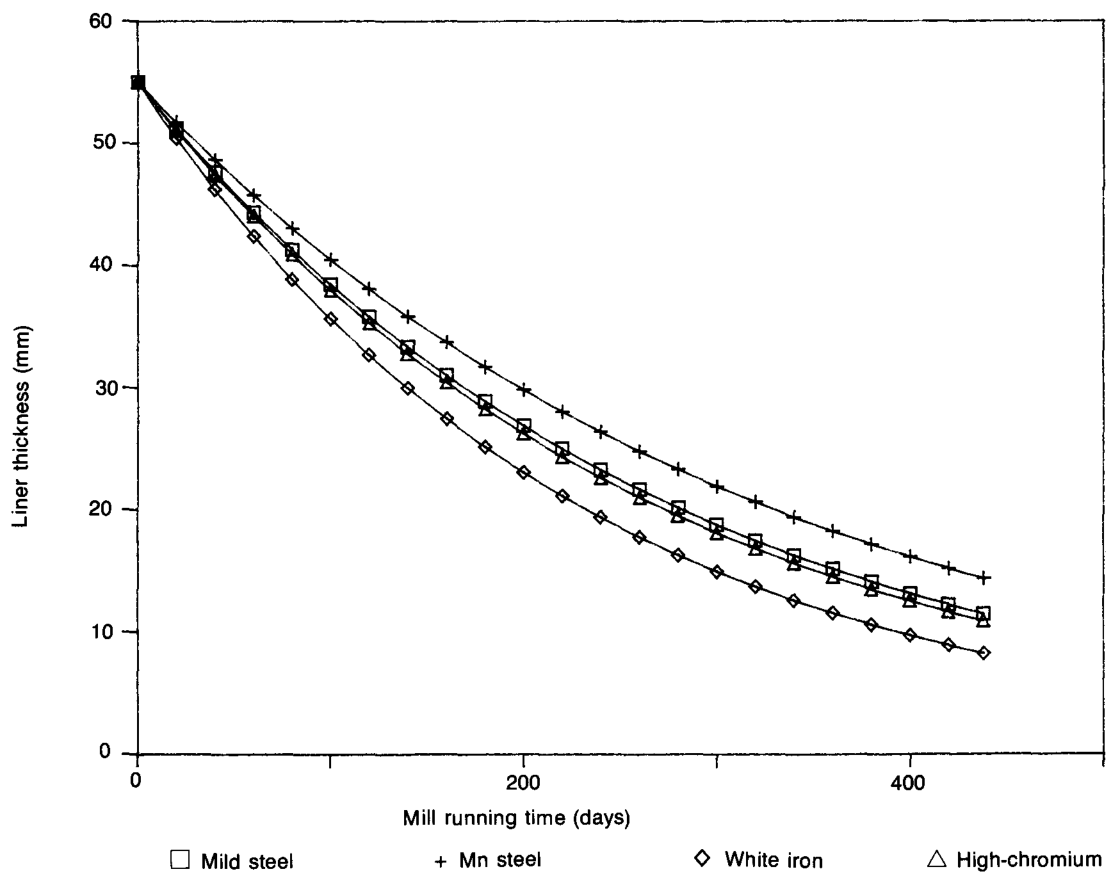

Fig. 3—Liner wear behind high lifter bars

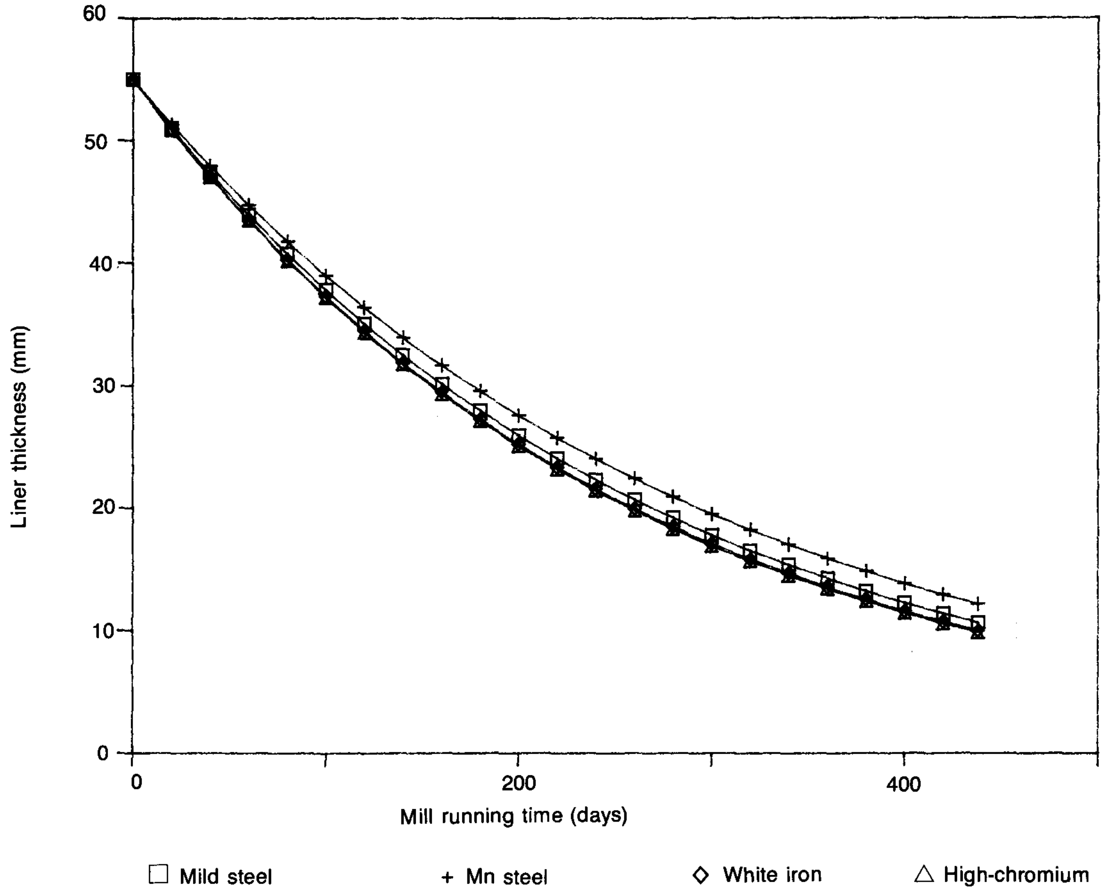

Fig. 4—Liner wear behind low lifter bars

TABLE I
COMPARISON OF MATERIALS

Material	Average mass of liner, kg		Cost of liner R	Running time d	Consumption		
	Start	End			kg/d	R/d	R/d per liner
Manganese steel	178	122	288	438	0,13	0,21	0,66
Cast mild steel	185	100	389	438	0,19	0,41	0,89
Chromium steel	178	138	498	438	0,09	0,26	1,14
White iron	170	82	221	286	0,31	0,40	0,77

Future Work

The project will continue with work on the third objective. Opposing lateral halves of one mill will be lined with manganese steel and chromium-steel solid backing plates, together with manganese-steel lifter bars, and the performance will be compared with that of a mill lined with grids and lifters.

Reference

1. Howat, D.D., and Vermeulen, L.A. Mintek, private communication, 1986.

Book news (continued)

- **Report M397**

A literature review of alloys cathodically modified with noble metals, by J.H. Potgieter. Jan. 1990. 19 pp.

Research carried out by various groups throughout the world has indicated that the corrosion resistance of chromium, stainless-steel, and titanium alloys is considerably enhanced by the addition of small amounts of noble metals, particularly the platinum-group metals (PGMs), in the form of either bulk alloying or surface alloying. This technique, which is known as cathodic modification, results in the spontaneous passivation of the alloy, especially in reducing acid media.

Additions of 0,1 to 0,4 per cent PGMs increase the corrosion resistance of chromium in sulphuric acid solutions by several orders of magnitude. In the case of ferritic stainless steels, the effect of cathodic additions is enhanced in alloys containing more than 25 per cent chromium, and the improvement of corrosion resistance is greater in sulphuric acid than in hydrochloric acid. If the alloy contains molybdenum as well as a PGM, a synergistic beneficial effect is obtained.

The effect of cathodic modification of austenitic stainless steels is not as dramatic as it is in the case of ferritic stainless steels. Little is known about the effects of PGMs on the corrosion behaviour of duplex stainless steels.

A large increase in the corrosion resistance of titanium alloys is obtained by the addition of palladium. A commercial titanium–palladium alloy that is especially suited to reducing conditions has been developed in the USSR.

- **Report M399**

The separation and determination, by atomic-absorption spectrophotometry, of trace elements in high-purity platinum and palladium materials, by R.V.D. Robért and S.M. Graham. Dec. 1989. 13 pp.

A description is given of the separation procedures that allow the measurement, by atomic-absorption spectrophotometry (AAS), of trace impurities, including other noble metals and base metals, in high-purity platinum or palladium materials.

The report describes in detail the procedure for the separation of platinum from palladium when either element is present as the major constituent in the sample material. The separation procedure involves extraction of the palladium as the dimethylglyoxime complex into chloroform. The mean recoveries of platinum and palladium, after separation and measurement by AAS, are better than 95 per cent, with relative standard deviations ranging between 1,2 and 3,2 per cent.

- **Report M400**

Spectrographic determination of impurities in high-purity tantalum oxide and niobium oxide, by S.T.G. Anderson and G.M. Russell. Feb. 1990. 12 pp.

This report describes the development of spectrographic methods by d.c. arc excitation and carrier distillation for the determination of impurities in tantalum and niobium oxides.

Iron, silicon, aluminium, titanium, calcium, silver, tin, magnesium, and manganese can be determined in tantalum oxide and niobium oxide in concentrations ranging from 3 to 300 p.p.m. Niobium can be determined in tantalum oxide in concentrations ranging from 10 to 300 p.p.m. Tantalum cannot be determined in niobium oxide, and tungsten cannot be determined in either matrix, as a result of the absence of sensitive lines in the spectra of these elements. Relative standard deviations are in the region of 0,18 for tantalum oxide samples, and 0,13 for niobium oxide samples.

A detailed laboratory method is included.

2. Recent publications

- *Oil shales of the world: Their origin, occurrence and exploitation,* by Paul L. Russell. New York, Pergamon Press, 1990. 736 pp. US$ 95.00.

This book gives a detailed record of the many oil-shale deposits of the world, and documents the varied attempts to utilize these resources. It provides a historical account from earliest times when the use of the oil shales started in about 800 AD, and traces the development of oils and lubricants during the Industrial Revolution to the present day. It describes the operation and fabrication of retorting and processing equipment, and takes into account mining methods, production, current usage, and future plans. The origin of oil shales is discussed, together with the geology, location, and extent of the known reserves in 49 countries. The book would be useful to government agencies, universities, energy companies, and all professionals involved in geology, resources, energy, mining, the environment, and the history of oil shales.

- *Annotated bibliographies of mineral deposits in Europe, including selected deposits in the USSR,* by J.D. Ridge. New York, Pergamon Press. Part 1, 1983, 785 pp. US$ 195.00. Part 2, 1990, 500 pp., US$ 120.00. Parts 1 and 2 US$ 250.00.

This two volume set provides a source from which ore geologists can readily obtain selected but comprehensive bibliographies of the major ore deposits of Europe and the Asiatic portion of the USSR. Part 1 covers northern Europe including examples from the USSR in both Europe and Asia, and Part 2 deals with central and southern Europe. The set is a reference work for undergraduate or graduate courses in economic or ore geology, and for any student of ore-deposit geology either in university or engaged in exploration geology.

- *Underground mining methods and technology,* edited by A.B. Szwilski and M.J. Richards. Amsterdam, Elsevier Science Publishers, 1987. 427 pp. Dfl. 240.00.

This book contains the proceedings of the International Symposium on Underground Mining Methods and Technology, which was held in Nottingham in 1986.

- *Reclamation, treatment and utilization of coal mining wastes,* edited by A.K.M. Rainbow. Amsterdam, Elsevier Science Publishers, 1987. 668 pp. Dfl. 295.00.

This volume contains the proceedings of the Second International Conference on the Reclamation, Treatment and Utilization of Coal Mining Wastes, which was held in Nottingham in 1987.