STATUTORY DECLARATION

Statutory Declarations Act 1959

IN THE MATTER of Australian Patent Application No. 2015203343 in the name of Hofmann Engineering Pty Ltd

- and -

IN THE MATTER of an Opposition thereto by Metso Sweden AB

I, Michael John Daniel, of 32 Lagoon Crescent, Bellbowrie, QLD 4070, Australia, make the following declaration under the *Statuftory Declarations Act 1959:*

Education and Experience

1. I am currently a consultant in the mining industry and the principal of my own company, CMD Consultancy Pty Ltd.

2. In 1988, I was awarded a Bachelor of Science in extractive metallurgy from the University of the Witwatersrand in Johannesburg, South Africa.

3. In 2003, I was awarded a Master of Science from the University of Queensland for research relating to High Pressure Grinding Rollers (HPGRs) and culminating in my Master's thesis entitled "HPGR model verification and scale-up".

4. In 2007, I was awarded a Doctor of Philosophy from the University of Queensland for research again relating to HPGRs and culminating in my PhD thesis entitled "Energy Efficient Mineral Liberation Using HPGR Technology".

5. I am a member of the Engineering Council of South Africa (ECSA) and I am a registered professional engineer (Pr. Eng.).

6. I have during the course of my career attended numerous conferences and presented papers on the subject of HPGRs, including:

   - Daniel, M.J., 2006b, *Measurement of electrical energy consumed during a Bond ball mill locked cycle test*, XXIII IMPC, 3-8 September 2006, Istanbul, Turkey.
   - Daniel, M.J.; Lane, G.; McLean, E. (2010), *Efficiency, economics, energy and emissions - emerging criteria for comminution circuit decision making*, XXV IMPC, 6-11 September 2010, Brisbane, Australia.

- Daniel M. J, (2016), *The modelling of scrubbers and AG mills and when to use them*, XXVIII Proceedings of the International Minerals Processing Congress (IMPC), September 2016, Quebec City, Quebec, Canada.
- Daniel, M. J. (2008), *Summary of Research Outcomes of an Amira P9N HPGR Project that Incorporated Mineralogical, Analysis, Particle Weakening and Micro-cracked, HPGR Products,* 2009, Proceedings of the V International Mineral Processing Seminar, November 2008, Santiago, Chile.
- Daniel, M. & Bailey, C. (2009), *Uses and Benefits of Laboratory-Scale HPGR Tests*, Procemin 09, 2009, Proceedings of the VI International Mineral Processing Seminar, Ed Amelunxen, Kracht and Kuyvenhoven, November 2009, Santiago, Chile.
- Morley, C. and Daniel, M.J. (2009), *HPGR Flowsheets – the Next Generation*, Procemin 09, 2009, Proceedings of the VI International Mineral Processing Seminar, Ed Amelunxen, Kracht and Kuyvenhoven, November 2009, Santiago, Chile.
- Lane, G, Daniel, M., Dunne, R, Morrell, S and Maxton, D, 2009, *HPGR application in Australia – status and future directions*, Procemin 2009, Proceedings of the VI International Mineral Processing Seminar, Ed Amelunxen, Kracht and Kuyvenhoven, November 2009, Santiago, Chile, pp 179.
- Shi, F., Lambert, S., Daniel, M.J., 2006, *Measurement of the effect of HPGR treating platinum ores*, SAG 2006, 23-27 September 2006, Vancouver, Canada.
- Kirsch, S. and Daniel, M. J. (2009), *The Optimisation of Semi-Autogenous and Ball Mill Based Circuits for Mineral Processing by Means of Versatile and Efficient High Pressure Grinding Roll Technology*, In the Proceedings Tenth Mill Operators' Conference 2009, 12-14 October 2009, Adelaide, Australia.
- Daniel, M.J., 2006a, *The researcher who rummaged through Bond's toolbox,* Second international JKMRC student conference, 7-8 March 2006, Brisbane, Australia.
- Daniel, M.J., 2005, *Particle bed compression comminution using a piston-die to predict the performance of a HPGR*, Randol Perth Forum, August 21-24, 2005, Perth, Australia.
- Daniel, M and Lane, G, 2008, Energy efficiency processes and measurement: Ausenco's perspective, Energy Efficiency in Mining & Minerals Increasing Energy Efficiency: Measure, Assess & Audit, 24–25 September, 2008.

- Daniel, M.J. and Morley, C. (2010), *Can diamonds go all the way with HPGR?*, The Southern African Institute of Mining and Metallurgy, Conference proceedings *"Diamonds – Source to Use 2010"* March, 2010, Gaborone, Botswana, pp 201-214.
- Daniel, M. J. (2007), *Triple pass HPGR circuit concept, CSRP '07 Delivering Sustainable Solutions to the Minerals and Metals Industries*., Produced by Centre for Sustainable Resource Processing, 26 Dick Perry Avenue, Kensington, Western Australia, 6152, Australia, 1st annual conference, 21 November 2007, Melbourne, Australia.

7. Of note, in September 2017, my previous paper published in 2009 with co-author S. Kirsch and entitled *"The Optimisation of Semi-Autogenous and Ball Mill Based Circuits for Mineral Processing by Means of Versatile and Efficient High Pressure Grinding Roll Technology"* has been recognised as a landmark paper and is to be re-published in a special edition of the MetPlant 2017 conference proceedings.

8. I have also had my research in HPGRs published in peer reviewed journals, including:

   - Daniel, M. J. & Morrell, S. (2004), *HPGR Model Verification and Scale-Up*, Elsevier, *Minerals Engineering* 17 (2004) 1149-1161, May (2004).

9. From 1988 to 1990, I completed my national service in South Africa.

10. From 1990 to 1992, I was employed by the Anglo American Corporation of South Africa Limited as a Senior Plant Metallurgist.

11. As a Senior Plant Metallurgist, I was responsible for sulphuric plant operations, including: managing monthly and quarterly cost and production reports; completing metallurgical tests to determine optimised plant operating conditions; metallurgical tasks during annual plant shutdowns; and proposing modifications of processes to achieve improved performances at reduced costs.

12. From 1992 to 1994, I took personal leave for travel.

13. From 1994 to 2000, I was employed by De Beers Consolidated Mines (Pty) Ltd in various roles.

14. Initially, I was employed as a Task Manager of Acid Unit Processes.

15. From 1996 to 1998, I was employed as a Senior Project Manager responsible for operations and senior process engineer.

16. From 1998 to 2000, I was employed as a Principal Project Manager (Equipment Specific Optimised Process).

17. As a Principal Project Manager, I was responsible for: developing an understanding of integrated process knowledge (through modelling, simulation and optimisation) covering the complete diamond mining value chain; up-front metallurgical process design and interfaces associated with development of new or existing ore reserves; developing methodology for the treatment of new ore bodies, including characterisation of drill cones and products with an objective of minimising capital costs and mine development time frames; developing a methodology entitled “Mine to Mill” an integrated concept in which plant processes are simulated and optimised so as to maximise profit over revenue ratios; and developing database information management, simulation and modelling tools for the evaluation of steady state and dynamic process conditions.

18. In 2000, I emigrated from South Africa to Australia and commenced my studies as outlined above in paragraphs 3 and 4.

19. From 2006 to 2008, I was employed by the University of Queensland as a Senior Research Fellow.

20. As a Senior Research Fellow, I was responsible for: initiating and completing several comminution projects including: the use of emerging technologies for researching energy efficiency in comminution; developing processes for sustainable resource processing having a reduced environmental impact; developing new methods for measuring energy consumption in comminution processes; developing an understanding of energy dynamics within comminution circuit designs; adapting test work programs to evaluate and confirm decision making processes in new plant designs; high level analysis of ore characterisation test data and procedures; and analysis and completion of existing comminution circuit surveys for plant optimisation.

21. In 2007 and during my time as a Senior Research Fellow, I established my company CMD Consulting Pty Ltd.

22. Since establishing my company, I have been actively involved in the design and optimisation of various comminution circuits around the world and have extensive experience in the design and application of HPGR technology.

23. My company’s clients have included: Barrick Gold; Anglo American; AngloGold Ashanti; Randgold; Newmont; Newcrest; BHP; Rio-Tinto; Xstrata/Glencore; Straits Resources;

Vale; Cliffs resources; Vedanta; CBH Resources; Boteti Mining; Donhad; Magotteux; and Northern Minerals.

24. My company has been engaged by vendors such as CITIC-HIC, Polysius and Metso.

25. My company has also completed work for companies including Iron Road, SRK and Selfrag, and engineering companies such as Jacobs, Ausenco, Fluor, GR Engineering, Mintrex, Minovo and WorleyParsons.

26. From 2008 to 2012, I was engaged through my company as a process consultant for Ausenco during which I was involved in many studies including the following:

- *Detour Lake study* - responsible for comminution circuit process simulations and HPGR test work review;
- *Eyre Iron study* - responsible for comminution circuit process simulations and HPGR test work review;
- *Reko Diq study* - responsible for comminution circuit process simulations and HPGR test work review;
- *Malartic study (internal Ausenco)* - responsible for comminution circuit process simulations and test work review;
- *NewGold Blackwater study* - responsible for comminution circuit process simulations and test work review;
- *Teck's QBII study* - responsible for comminution circuit process simulations test work review;
- *Mt Todd Comminution Circuit ToS including HPGR, SAG, convention crushing. May 2011, Part of the review and design team of the comminution circuit of Vista Gold's 12 Mt/y Mt Todd prefeasibility study in Western Australia*;
- *Cerro Casale study* - responsible for comminution circuit process simulations and HPGR test work review;
- *Cadia East Project* - responsible for comminution circuit process design for the 12 or 12 Mtpa Cadia East standalone plant, and the Marsden 10-20 Mtpa low cost concentrator. Both studies involve the evaluation of conventional SABC circuit against HPGR technology;

- *Cadia East Expansion* - part of the comminution circuit process design team for the 20 Mtpa Cadia East Brownfield expansion. This included the installation of an HPGR ahead of the existing SAG Mill;
- *Gosowong Gold Project* - provided input into the proposed installation of fine grinding equipment;
- *Dumont Comminution Circuit ToS including HPGR, SAG, crushing and roller mills January 2011* - part of the review and design team of the comminution circuit of Royal Nickel's 50 kt/d Dumont study in Canada;
- *Relincho comminution circuit peer review, November 2011* - I was responsible for a peer review of the comminution circuit of Teck's Relincho operation in Chile;
- *Maaden, Ad Duwayhi Gold Project* - SABC circuit design note;
- *Maaden Comminution Circuit design using SABC, February 2012* - part of the review and design team of the comminution circuit;
- *Caracoles Comminution Circuit External Peer Review and HPGR vs SAF ToS, March 2012* - part of the review team of the comminution circuit of Antofagasta's 100kt/d Telegrapho study in Chile;
- *Andacollo Comminution Circuit External Peer Review, November 2011* - responsible for peer review of the comminution circuit of Teck's Andacollo operation in Chile;
- *Fusion Comminution Circuit review and ToS including HPGR, SAB, ABC, June 2012* - completed a review of the comminution circuit of Eyre's iron's 19 Mt/y conceptual study in South Australia; and
- *Cadia East Expansion forecast simulations, April/May 2012* - completed the comminution circuit throughput forecast for the commissioned 20 Mt/y Cadia East Brownfield expansion.

27. As a result of my education and experience as set out in paragraphs 2 to 26 above, I believe I have extensive experience in the application of HPGR technology in the minerals industry.

Instructions

28. I understand that IP Gateway Patent and Trade Mark Attorneys Pty Ltd ("IP Gateway") act on behalf of Metso Sweden AB ("Metso"). I am instructed by IP Gateway that Hofmann Engineering Pty Ltd ("Hofmann") is the applicant of Australian Patent

Application No. 2015203343 B2 (“AU2015203343”), the granting of which has been opposed by Metso. IP Gateway has instructed me that AU2015203343 claims a priority date of 7 September 2010.

29. Initially, I was asked by IP Gateway to provide comments regarding the general field of HPGRs, including a general background and summary of developments in this field. My respective comments are set out in paragraphs 45 to 119 below. IP Gateway then provided me with an extract from AU2015203343 and asked that I provide comments regarding the subject matter discussed in the extract. Now produced and shown to me and marked **Exhibit MJD-1** is a copy of the extract provided to me. My respective comments are set out in paragraphs 120 to 139 below. In addressing the general field of HPGRs and the subject matter discussed in the extract from AU2015203343, I was asked by IP Gateway to limit my comments to information known to me prior to 7 September 2010.

30. After providing my comments in paragraphs 120 to 139 below, IP Gateway then provided me with a copy of US Patent Publication No. 2007/0215733 A1 (US 2007/0215733 A1), published 20 September 2007, and asked that I provide comments in relation to the edge protection system disclosed in the publication. Now produced and shown to me and marked **Exhibit MJD-2** is a copy of US 2007/0215733 A1. My respective comments are set out in paragraphs 140 to 146 below.

31. After providing my comments in paragraphs 140 to 146 below, IP Gateway then provided me with a copy of US Patent Publication No. 2005/0061901 A1 (US 2005/0061901 A1), published 24 March 2005, and asked that I provide comments in relation to the grinding rollers disclosed in the publication. Now produced and shown to me and marked **Exhibit MJD-3** is a copy of US 2005/0061901 A1. My respective comments are set out in paragraphs 147 to 151 below.

32. After providing my comments in paragraphs 147 to 151 below, IP Gateway then provided me with a copy of an English translation of International (PCT) Publication No. WO 90/06178 A1 (WO 90/06178 A1), published 14 June 1990, and asked that I provide comments in relation to the high-pressure roller presses disclosed in the publication. Now produced and shown to me and marked **Exhibit MJD-4** is a copy of the English translation of WO 90/06178 A1. My respective comments are set out in paragraphs 152 to 155 below.

33. After providing my comments in paragraphs 152 to 155 below, IP Gateway then provided me with a copy of US Patent No. 5,253,816 A (US 5,253,816 A), published 19 October

1993, and asked that I provide comments in relation to the high-pressure roller system disclosed in the publication. Now produced and shown to me and marked **Exhibit MJD-5** is a copy of US 5,253,816 A. My respective comments are set out in paragraphs 156 to 161 below.

34. After providing my comments in paragraphs 156 to 161 below, IP Gateway then provided me with a copy of International (PCT) Publication No. WO 2009/013276 A1 (WO 2009/013276 A1), published 29 January 2009, and asked that I provide comments in relation to the roller press for grinding particular matter disclosed in the publication. Now produced and shown to me and marked **Exhibit MJD-6** is a copy of WO 2009/013276 A1. My respective comments are set out in paragraphs 162 to 167 below.

35. After providing my comments in paragraphs 162 to 167 below, IP Gateway then provided me with a copy of an English translation of German Patent Application/Patent No. 40 37 816A1 (DE 40 37 816A1), published 4 June 1992, and asked that I provide comments in relation to the roller press disclosed in the publication. Now produced and shown to me and marked **Exhibit MJD-7** is a copy of the English translation of DE 40 37 816A1. My respective comments are set out in paragraphs 168 to 172 below.

36. After providing my comments in paragraphs 168 to 172 below, IP Gateway then provided me with a copy of an English translation of German Patent Application/Patent No. 44 00 797A1 (DE 44 00 797A1), published 20 July 1995, and asked that I provide comments in relation to the grinding roller disclosed in the publication. Now produced and shown to me and marked **Exhibit MJD-8** is a copy of the English translation of DE 44 00 797A1. My respective comments are set out in paragraphs 173 to 181 below.

37. After providing my comments in paragraphs 173 to 181 below, IP Gateway then provided me with a copy of an English translation of German Patent Application/Patent No. 26 43 307A1 (DE 26 43 307A1), published 30 March 1978, and asked that I provide comments in relation to the crushing mills disclosed in the publication. Now produced and shown to me and marked **Exhibit MJD-9** is a copy of the English translation of DE 26 43 307A1. My respective comments are set out in paragraphs 182 to 185 below.

38. After providing my comments in paragraphs 182 to 185 below, IP Gateway then provided me with a copy of an English translation of Belgian Patent Application/Patent No. 1013969A3 (BE1013969A3), published 14 January 2003, and asked that I provide comments in relation to the grinding roller disclosed in the publication. Now produced and shown to me and marked **Exhibit MJD-10** is a copy of the English translation of BE1013969A3. My respective comments are set out in paragraphs 186 to 190 below.

39. After providing my comments in paragraphs 186 to 190 below, IP Gateway then provided me with a full copy of AU2015203343 and asked that I provide comments regarding my understanding of the edge protection system disclosed in the document. Now produced and shown to me and marked **Exhibit MJD-11** is a copy of AU2015203343. My respective comments are set out in paragraphs 191 to 209 below.

40. In addition to the documents referred to in paragraphs 29 to 39 above, IP Gateway has also provided me with a copy of the Federal Court of Australia practice note GPN-EXPT entitled "Expert Evidence Practice Notes (GPN-EXPT)" issued on 25 October 2016 (the Practice Note). Now produced and shown to me and marked **Exhibit MJD-12** is a copy of the Practice Note. I have read and understood the Practice Note and believe I have complied with all relevant obligations set out in the Practice Note in making this declaration.

41. During the course of my career, I confirm that I have had dealings with Metso and other HPGR manufacturers. I was professionally engaged by Metso as a consultant to provide information on the design of comminution circuits. I also personally know some of the inventors of AU2015203343.

42. Despite the above, I confirm that I am not permanently engaged to provide services to Metso or Hofmann. Other than as disclosed above and by reason of my engagement to provide evidence in this opposition, I have no relationship with, or commercial or financial interest in, Metso or Hofmann.

Sources of Information

43. Over the past 17 years, there are a number of sources of information which I regularly consult in relation to HPGR technologies. These sources of information include the Internet, patent documents, conference papers, peer reviewed journals and publicly available documents.

44. Another source of information is a library of books, articles and notes I have gathered and maintained over the years.

General Comments on HPGRs and Edge Protection Systems

45. During the 1970s, Dr.-Ing Klaus Schönert ("Schönert") studied the breakage of rocks and other solids when subjected to very high pressure.

46. In 1982, Schönert was awarded a US patent on a high pressure roll crusher for the fine and very fine comminution of brittle solids, and a few years later he published several papers in which industrial uses of HPGRs were discussed (see, e.g., Schönert, K. 1988. A first survey of grinding with high compression roller mills. *International Journal of Mineral Processing* 22:401-412). These rolls soon became widely used in the cement industry largely because of their low power consumption.

47. In my opinion, the use of HPGR technology is not entirely a new invention as is the perception. In fact, the rolls design concept originates from earlier roller press technology that was widely used in the briquetting of fine materials into lumps. This is shown by example in the roller presses that were manufactured by Wilhelm Köppern (now Köppern Group; "Köppern") from as early as 1918 (see Figure 1, below).

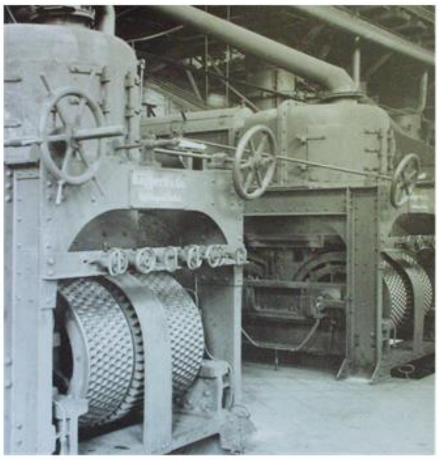

Figure 1 – A photograph of roller presses manufactured by Köppern in 1918

48. Existing designs of roller presses have since been modified to employ the concept of the so-called inter-particle crushing under continuous operating conditions. In fact, it is the concept of subjecting a bed of particles to a pressure greater than 50 MPa for the purpose of comminution that originated in the 1982 patent of Schönert.

49. Schönert's general remarks in his fundamental study of comminution processes was that in any comminution process the particles are broken by contact forces, which deform the particle and cause a stress field. As the stress level meets the criteria either of yielding or fracturing, then the particle will be deformed inelastically or broken, respectively. The number of contact forces depends on the mode of stressing being either in single particle mode or multiple particles (see, e.g., Schönert, K. 1988. A first survey of grinding with high compression roller mills. *International Journal of Mineral Processing* 22:401–412).

50. Schönert states that comminution devices such as crushers, mills and HPGRs all stress the material by compression and shear. Both single particle and bed particle stressing experiments were conducted as part of his fundamental research and Schönert concluded that inter-particle bed breakage has a lower efficiency than single particle stressing. Schönert further states that the efficiency may drop by as much as a factor of two to three depending on the conditions relating to the number of contact forces.

51. Schönert also mentions that even though the inter-particle process is less efficient than single particle stressing, he found that when a bed of particles is compressed and comminuted, the result is that the material is comminuted more efficiently than in a ball mill. Schönert accordingly concluded that the main reason for this is the fact that the controlled transport and stressing feature in HPGR results in a high proportion of available energy being used solely for the purpose of stressing the material.

52. In conventional mills, the material transport and stressing inside the active volumes of the mill between the balls occurs randomly. This often allows particles to move out of position resulting in unproductive collisions between grinding media or the media and the liner wall within the mill. This mode of energy input is inherently wasteful because of the hit-and-miss nature of the process.

53. For practical applications of the particle bed compression principle, Schönert suggested the use of two rolls mounted in a strong frame and fed in such a way that a particle bed is formed between the rolls under high pressure (> 50 MPa) as shown in Figure 2 below (source: Farahmand, A, Ehrentraut, G,1997, Erzmetall, No. 3/March 1997, p 201-210).

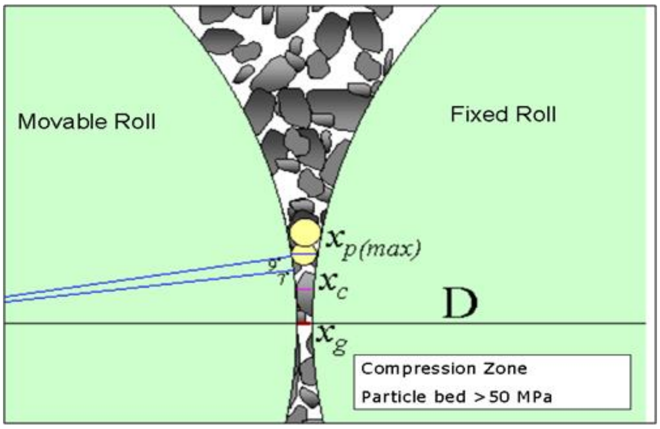

Figure 2 – A schematic demonstrating the principles of the HPGR comminution process.

54. HPGR manufacturers Kloeckner Humboldt Wedag Deutz AG (KHD), Polysius AG ("Polysius" now ThyssenKrupp) and Köppern obtained rights to Schönert's patented technology and further developed the idea based on their own technology of briquetting

machines. This eventually resulted in the modern-day version of the HPGR as shown in Figure 3 below (source: Alsmann, L.;1996, *KHD Humboldt Wedag, New roller press series characterised by enhanced reliability*, Aufbereitungs -Technik/Mineral Processing, Nr.6, June 1996, pp 259-268; and Farahmand, A, Ehrentraut, G,1997, Erzmetall, No. 3/March 1997, p 201-210.)

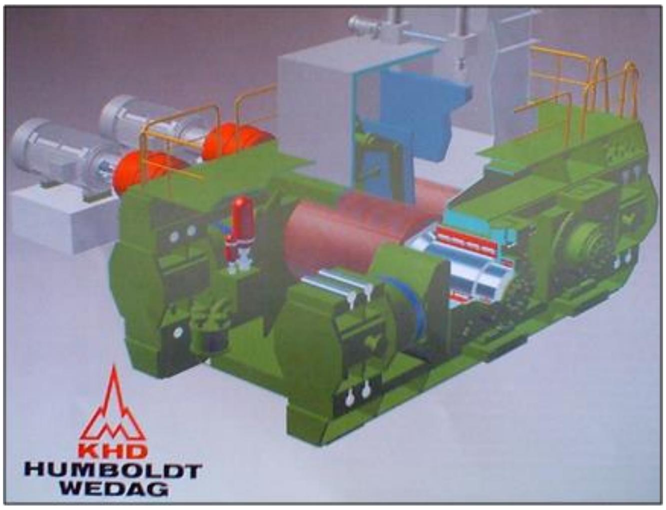

Figure 3 – A schematic of a modern HPGR assembly

55. Between 2002 and 2010, there was a large number of trade off studies on HPGR completed. Ironically, this ultimately culminated in a publication entitled *"Not another HPGR trade off study"* by P. Ameluxen and D. Medows in Minerals and Metallurgical processing, February 2011.

56. Major HPGR circuits that were approved against conventional SAG milling and ball milling include (see Figure 4):

- Cerro Verde I and II, Peru (2006);
- Boddington, Western Australia (2009);
- Anglo Platinum Mogalakwene (2008);
- Salobo, Brazil;
- Sierra Gorda, Chile;
- Gindalbie, Western Australia;
- Tropicana, Western Australia;
- Windimurra, Western Australia; and
- Morenci, Arizona, USA.

Figure 4 – HPGR installations by Polysius between 2006 and 2009 (source: Burchardt, E (2013) ICRA Workshop).

57. The various components or features of HPGRs are protected by a vast number of patents. These patents are meant, in my view, to provide the owner with a competitive edge over other competing manufacturers. In my opinion, the various patents have retarded the development of HPGR technology as a whole and often confuse clients as to the real benefits of HPGR as opposed to other less patented alternatives.

58. I now provide the following brief timeline of important events relating to HPGR development:

- In about 1982, Schönert is granted a first patent for the comminution of mineral ores and other materials under high compressive forces (> than 50 MPa). This patent is a German patent but corresponding overseas patents are also granted.

- From about 1982 to about 1996, various patented designs are granted for mechanical improvements to HPGR design. These designs include roll surface designs. Much of the process data behind these patented designs stem from the Cyprus Sierrita trials, which will be discussed later.

- In about 1992, KHD filed a patent application for their stud lining design. This stud lining design is ground breaking since the original Schönert 1982 patent. The tungsten carbide studs provide for an autogenous build-up of crushed ore at the base of the roll surface. This concept, provided the studs are inserted into a solid roll "tyre", extends the life of the HPGR roll wear surface ten-fold.

- From about 1990 to about 1994, trials are conducted of various KHD installations at the De Beers diamond mines. During this period, Rio Tinto also installed segmented rolls produced by Polysius at the Argyle diamond mine.

- In about 2000, the Argyle diamond mine installed a re-crush KHD stud lined HPGR unit for the first time in the diamond industry. I analysed the performance of stud liners over smooth liners during the completion of my Masters at the University of

Queensland (see paragraph 3, above). Data from the Argyle diamond mine, the De Beers' Premier Mine and BHP's (the trading entity of BHP Billiton Limited and BHP Billiton plc) Ekati Diamond Mine were studied.

- From about 1994 to about 1996, the first trials with a Polysius 24/17 HPGR unit were conducted in which it was tested at a hard rock copper mine in the US called Cyprus Sierrita.
- From about 1999 to about 2003, KHD obtained patent rights in its stud lining design concept for HPGRs (the "KHD stud lining concept").
- In about 2000, Köppern developed and sought patent protection for its wear protection system called Hexadur™.
- Shortly thereafter, various patent applications were filed by Polysius, KHD and others for various geometric edge protection systems.
- For example, Polysius developed and sought protection for an edge protection system that consisted of geometric specific specialised edge (square tile) stud inserts of similar materials to those used for the studs already fitted across the face of HPGR rolls. This, in my opinion, represents a key development in HPGR technology and can certainly be considered an extension or improvement over the original KHD stud lining concept.
- For example, KHD developed and sought protection for an edge protection system that consisted of geometric side bolt-on components formed from a composite hard material and also geometric specific specialised edge stud inserts of similar materials to those used for the studs already fitted across the face of HPGR rolls. Again, this, in my opinion, represents a key development in HPGR technology and can be considered an extension or improvement over the original KHD stud lining concept.

59. The various wear protection systems that have recently been developed for HPGRs are extensive and not surprising as they embody the success of the HPGR concept in its entirety.

60. The successful KHD stud lining concept stems from the stud pattern, stud diameter and stud protrusion from the base metal to accumulate the build-up of crushed ore in the zones between the studs to provide a self-replacing natural wear protection surface.

61. The patents protecting the KHD stud lining concept protected KHD and Polysius from competitor developments. However, the expiry of the original Schönert HPGR patents

and stud lining patents resulted in the filing of many improvement patents filed by several new-comers to HPGR manufacturing. For example, patent applications were filed relating to roll surface wear protection systems and extensions of this, namely edge protection systems.

62. In my view, the new roll surface patented designs can be considered either:

(a) an attachment device or engineered component that consists of composite wear resistant materials. The attachment devices are typically similar to the attachment of studs or via a bolt-on mechanism, similar to the recent Köppern system; or

(b) an extension or improvement of the KHD stud lining concept since the stud liners at the edges are exposed to alternative processes that influence wear rates of HPGR rolls at the edges. In my opinion, these processes do not relate to the design of an edge protection system *per se*, but rather the nature or conditions under which the rolls are operated, namely:

(i) edge effect is caused as a result of the wear of the cheek plates, which allows for edge material to bypass the gap between the rotating HPGR rolls, allowing for the material to make contact with the side of the rolls (i.e., roll edge);

(ii) the HPGR unit is not choke fed resulting in the operating gap collapsing and creating resultant lateral stresses on the studs. This condition is known to be the cause of stud breakage, which can occur at any position across a roll surface including the edges that are prone to hard non-magnetic tramp metal such as stainless steel balls, copper rods, bolts etc.; and/or

(iii) the stud patterns at the edge of the rolls terminates resulting in a poor build-up of the all-important autogenous wear protection layer (the basis of the KHD stud lining concept).

Schönert and the original HPGR "process" patent

63. Schönert studied at the University of Karlsruhe, where he used single-particle compression breakage to study comminution. His studies included early studies of HPGRs.

64. In 1968, he became the head of the University's comminution group.

65. Schönert's research at various universities led to the patenting of the HPGR comminution process and not the mechanical device as such in 1982 (see Figure 5 below for an extract of an account from Schönert).

ROLLER MILLS | 93

- Increasing pressure decreases in principle the comminution efficiency of interparticle breakage but raises the production of ready material, by which the recirculation is reduced.
- The recirculation determines the size of mill, classifier, and transport equipments and, by that, the investment costs. Increasing pressure increases wear.
- The comminution costs result from investment, energy expenditure, and wear. An economical optimization of a high-pressure comminution has to consider all three facts.

My patent (Schonert 1982) claims the high-pressure comminution process, not the high-pressure roller mill. In my understanding, only the idea to stress a particle bed by a pressure much higher than usual, and not to be afraid about agglomeration, is the essential point of the novel comminution method. One should remember the general principle that any agglomeration worsens the comminution effect and should be avoided. Contrary to that, in a high-pressure roller mill, the material is more or less briquetted. This argument was always essential for winning the big patent cases in Germany, the United States, and Denmark.

Figure 5 – An extract from "The History of Grinding" by Alban J. Lynch, and Chester A. Rowland, SME publication, 2005, pp 93

Who uses HPGR?

66. The great majority of the 500+ HPGR units in operation globally are in the cement sector and are too numerous to identify individually.

67. Since their introduction in the mid-1980s, HPGRs have been widely used in the diamond and iron ore sectors where they are now considered commonplace.

68. In the hard rock sector (typically copper and gold ores), the first application was a full-scale 15-month trial at Cyprus Sierrita in about 1995/96.

69. More recently, HPGR was selected as the preferred technology for the Cerro Verde copper/molybdenum project in Peru (commissioned November 2006) and the Boddington gold/copper project in Western Australia (March 2009).

What happened at Cyprus Sierrita? I heard that it was a failure.

70. While Cyprus Sierrita was widely considered to have been unsuccessful as it did not lead to a commercial sale, the fact that the comminution performance of the machine was impressive is not in dispute (see, e.g., Thompsen, L., *Operational performance of grinding rolls at Cyprus Sierrita*, Comminution Practices 1996, Chapter 15; and Thompsen, L., Patzelt, N. and Knecht, J., *High-pressure grinding for copper at Cyprus Sierrita*, Minerals Engineering 23–26, September 1996).

71. The difficulties experienced related to the behaviour of the wear surfaces, and many valuable lessons were learnt from this operation about the precautions necessary in circuit design and unit operation for the protection of the studded roll surfaces and the successful application of HPGR technology (see, e.g., Morley, C., *The Case for High Pressure Grinding Rolls*, Proceedings Randol Innovative Metallurgy Forum, Perth, Australia, 2005, (Randol International Ltd, Golden, Colorado). pp 15–30 “Morley 2005”).

72. Bearing in mind that this was (and was always intended to be) a trial, it could be argued that it was in fact a success, as the outcome now forms a large part of the foundation of current HPGR machine and circuit design practice.

What were the findings from the Cyprus Sierrita trial? What are the rules for hard rock applications?

73. The major issues related predominantly to the protection of the wear surfaces and can be summarised as follows (see Morley 2005 for a detailed discussion):

- feed must be unsegregated and presented uniformly across a roll width;
- tramp metal management must be highly efficient and the system designed so that tramp metal removal does not entail the stopping of feed to the HPGR;
- feed top size should not exceed the operating gap between rolls;
- for highly competent ores, very high operating pressures should be avoided;
- continuous stud lined tyres (see Figure 6, below) are preferred to segments (see Figure 7, below) as accelerated wear occurs at segment boundaries;
- early experiments with stud linings did not include edge protection (see Figure 8, below); and
- tyre surface protection advancements included, welded on hard-facing, chevron hard facing, studs and Hexadur®.

74. Roll edge protection and cheek plate design are now well developed and this method of protection is generally preferred to edge bypass rock-boxes, although the alternative is still considered in some specialised applications. By way of explanation, cheek plates are assemblies that are attached to the sides of the rolls to prevent feed material from passing rolls without being subjected to the comminution process. My detailed comments regarding cheek plates are presented later in relation to paragraphs 93 to 102.

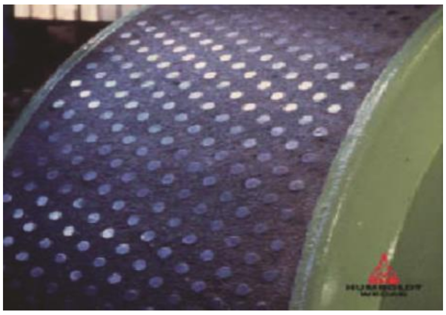

Figure 6 – A photograph of a state of the art KHD (now Weir) HPGR with stud liner protection and welded edges (circa 2000).

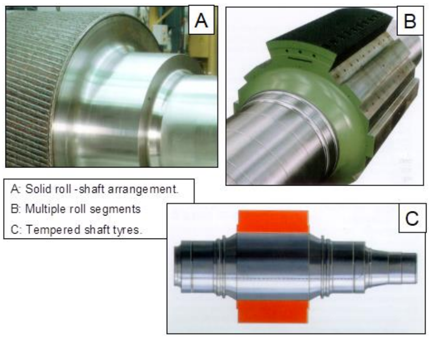

Figure 7 – Photographs of typical full-scale roll designs including: (A) solid roll/shaft; (B) multiple roll segments; (C) tempered shaft tyres.

Figure 8 – A photograph of an early model HPGR from Weir/KHD without edge protection.

HPGR Assembly Components

75. The HPGR technology was developed over an extended period from the late 1980s through the 1990s. Energy efficiency became very topical early in 2000, which prompted a lot of research into HPGRs. This led to company sponsorship towards further developments, and in fact led to the sponsoring of my Master degree and Doctorate (see paragraphs 3 and 4 above).

76. There are a number of mechanical components that form the technology. Many of these components were improved by KHD and Polysius in order to attain a competitive advantage. The all-important "HPGR process" patent of Schönert kept many major

equipment competitors away from German manufacturers Polysius and KHD, who obtained early rights to exploit the Schönert HPGR patent.

77. The components generally consist of the following features:

(i) a frame;

(ii) roller shafts;

(iii) bearings and bearing housing design, namely cylindrical bearing versus spherical bearing and anti-rolls skewing in the design; and

(iv) tyres/rolls, namely:

- segmented Ni-hard bolt-on segments;
- solid “smooth-tyre” single shrink on segment;
- hard-faced or “smooth-tyre”; and/or
- stud-lined.

78. Arguably, it was the development of the stud lining concept that was the most important breakthrough that allowed this technology to compete with conventional milling by semi-autogenous grinding (“SAG”) mill technology.

79. The revolutionary game changing stud lining concept promoted an autogenous rock layer that protected the ductile base surface of the roll. Very hard wear resistant materials such as tungsten carbide studs or pin inserts protect the roll surface and promote the build-up of the required autogenous rock wear protection layer.

80. HPGR operational problems include roll skewing. Roll bearing design therefore plays an important function in ensuring that a roll surface remains functional enabling the build-up of the autogenous rock layer. KHD have cylindrical bearings whereas Polysius use spherical bearings. Smaller HPGRs are equipped with conventional heavy self-aligning roller bearings. For example, The Weir Group PLC (“Weir”; formerly KHD) uses rubber thrust bearings that feature an inlaid rubber sheet. The inlaid rubber sheet functions like a highly viscous liquid to ensure optimal load introduction.

81. Another important feature is the combination of polished chromium plates and PTFE-faced sliding plates that can easily be replaced when worn without disassembly of the rollers and do not require additional maintenance. They are mounted between the bearing housings and the top/bottom frame as well as to the external guide mechanism of the bearings for axial fixing of the press rolls.

82. The issue of the edge wear problem emerged as early as 2002, which was soon after a number of successful trials using stud lined rolls. The Argyle diamond mine had some of the first Polysius HPGR designs that were fitted with segmented rolls. These are still in operation today with the segments being replaced regularly and manufactured locally in Perth.

83. KHD entered the Australian market in about 2001 with the installation of the first studded rolls in a re-crush application at Argyle diamond mine as presented in Figure 9, below.

Figure 9 – A photograph of the Weir/KHD HPGR roll designs without edge protection from the Argyle diamond mine.

84. The edge wear problem then emerged with evidence presented in the minerals engineering journal (see, e.g., Maxton, D., Firsch, S. and van der Meer, F., 2005, *KHD Humboldt Wedag high pressure grinding rolls developments for minerals applications*, Randol Innovative Metallurgy Forum, Perth, Australia, August 21-24) and reproduced in Figure 10, below.

Figure 10 – A photograph showing edge wear on new Weir/KHD roll designs.

85. In an effort to break into the hard rock comminution market, the HPGR manufacturers began developing wear surfaces that could remain in service significantly longer than those constructed out of hard faced compounds and Ni-hard alloys. Information about the studded tyre design - developed by KHD - filtered into Australia during the late 1990s. At that point, there were no operating facilities using the new hard metal (tungsten carbide).

HPGR designs and surface characteristics

86. There are probably as many engineering challenges associated with HPGR (e.g. rolls design, surface characteristics and hydraulics) as there are process challenges. Both need to be continuously and simultaneously developed.

87. The roll designs currently consist of three different types and may be used along with a series of different roll surfaces, depending on the application. The roll designs may be a solid roll/shaft arrangement or multiple roll segments or tyres secured through a tempered shaft as previously shown in Figure 7 above. There are many variations of roll surfaces, which may be smooth, welded, profiled, or studded as shown in Figure 11, below.

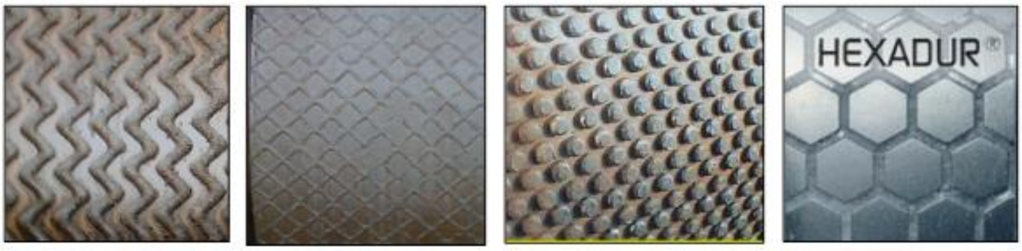

Figure 11 – Photographs of typical full-scale HPGR surface characteristics, including from left to right chevron, welded, studded and Hexadur®

Stud liner concept

88. One of the most important subjects in HPGR grinding is the wear of the roll surface. To date, most applications in the cement industry utilise hard-faced smooth rolls, frequently with a hard-facing welded rim pattern on the surface for a better surface grip.

89. In the case of minerals, such a surface necessitates high maintenance efforts - often requiring frequent re-welding of the roll surface. For this reason, KHD developed and sought patent protection for the studded roll surface in the late 1990s. These rolls with surface protection provide a longer wear life due to more wear resistant studs and the embedding of an autogenous wear layer of crushed rock/ore. This autogenous wear layer is formed by the ore packing itself between the studs on the rolls. This way the roll surface is coated and protected from the direct wear of the mineral rock.

90. The autogenous surface generally prevents larger rocks from directly impinging on the roll surface, and provides a shield from the abrasive movement of material parallel to the roll surface. The wear thus becomes principally that of the hard metal tungsten carbide stud inserts, which are highly wear resistant (see Figure 12, below).

Figure 12 – A photograph of a Weir/KHD HPGR with a studded surface and edge protection.

91. The various stud lining designs have ultimately distinguished the various HPGR suppliers since 2000. However, since about 2012, there has been an increase in the development of new designs together with new manufacturers in the international minerals market, namely, Metso, Köppern, FLSmidth & Co. A/S (FLSmidth) and Citic-Heavy Industries Co. Ltd (Citic-Hic).

92. The typical service life of a set of rolls depends on the application and the size of the rolls. The service life generally ranges from 4,000 to 36,000 hours. In hard rock, gold and copper applications the service life is limited to about 6,000 to 8,000 hours using 40-45 mm stud inserts. This timeframe is comparable to the service life of a set of SAG mill liners and lifters. Typical HPGR service life for various ore types are provided below:

- Iron ore (pellet feed) 14,000-36,000 hours;
- Iron ore (coarse) 6,000-17,000 hours;
- Gold ore (coarse) 4,000-6,000 hours;
- Kimberlite rock (coarse) 4,000-7,000 hours; and
- Phosphate ore (coarse) 6,000-12,000 hours.

Cheek plate and edge effect design

93. The significance of the feeding device in HPGR operations is frequently underrated. The method of material feeding has an important influence on steady and vibration free HPGR operation. Depending on the specific material to be processed, the feeding device can be equipped with a regulating gate and given the most appropriate wear-protection lining.

94. The cheek plates of a feeding device are mounted on opposite sides and are vertically and horizontally adjustable. The pair of cheek plates form an integral part of a feeding device (see Figure 13, below).

95. The cheek plates ensure that only a minimum of un-pressed feed is allowed to flow past. The plates are mounted in a manner which enables them to give way upon skewing of the movable HPGR roll. In such a scenario, the cheek plate returns to its original position

by means of a pre-loaded spring assembly once the parallel position of the movable HPGR roll relative to the fixed HPGR roll is restored.

Figure 13 – Photographs showing cheek plates that protect the roll edges from side wear.

96. The cheek plate is of split design to be capable of separately changing the bottom part of the cheek plate, which is subjected to maximum wear. This is a further contribution to lower the cost of wear.

97. The first few years of operation were problematic with the main issues revolving around the tyres and cheek plates. In fact, the first set of solid Ni-hard tyres supplied by Krupp Polysius failed after six hours in service - the tyre on the fixed roll cracked causing a catastrophic failure.

98. The second set of solid Ni-hard tyres did not fail but they wore out in only 10 days. The time required to swap out the solid tyres was approximately 20 days. As a result of this and the relatively short wear life of the tyres, the decision was made by Argyle Diamonds to move towards a bolt-on Ni-hard segment design.

99. Over a number of years, various wear materials have been tested on the new segment design ranging from hard facing compounds to Ni-hard alloys. To date, the segment manufacturing process has been optimised to the point where the Ni-hard (V) segments last approximately six weeks and treat in the order of 475,000 t, wearing down 150 mm (in radius) before an exchange is required. The time required for the segment exchange has been reduced to 25-30 hours.

100. As a result of the initial issues encountered with the tyre surface and the subsequent developments made to prolong the service life, the utilisation of the HPRG circuit steadily increased from 42% in 1991 to 76% in 2002.

101. The much shorter exchange time related to a change to a bolt-on segmented design, which made a large contribution to the increase in circuit utilisation. One of the other

issues encountered was excessive wear at the cheek plates and lost production resulting from frequent cheek plate liner and tip replacements (see Figure 14, below). This issue was serious enough to force a removal of the cheek plates and their replacement with a customised bypass rock box design at the roller edges.

Figure 14 – Photographs (a) to (c) show the various types of cheek plate designed by manufacturers.

102. The change from cheek plates to the rock box design caused a loss in comminution efficiency due to edge material bypassing the roller gap. This in turn caused an acceleration of differential wear encountered between the central zone of the roller gap and the edge zone. The reduced wear rate experienced at the edges with the rock box design caused an unacceptable bath tub profile which required the edges to be constantly ground (on-line) in order to achieve a satisfactory wear profile across the roll surface. The requirement for grinding added to the operating expense of the HPRG circuit but increased utilisation, arising from removal of the need to replace the cheek plate wear components, more than compensated for the additional operating cost and lower comminution efficiency (see Figure 15, below).

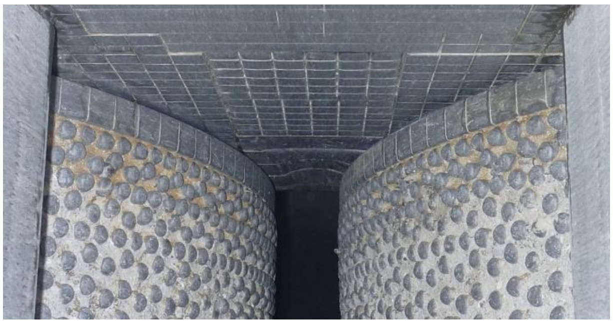

Figure 15 – A photograph showing the assembly of the cheek plates in position against the HPGR rolls with edge protection.

Edge Protection Systems

103. Figure 16, below, shows the KHD stud and edge protection system. I understand the system is covered by two different patent families.

104. The first family covers the studs, which provide for the build-up of an autogenous rock layer against the base of the metal that holds the hard brittle wear resistant tungsten carbide pins.

105. The second family covers the geometrically unique edge wear protection component. These components are inserted into the base of the roll assembly much like the stud pins. They are usually fastened with Loctite.

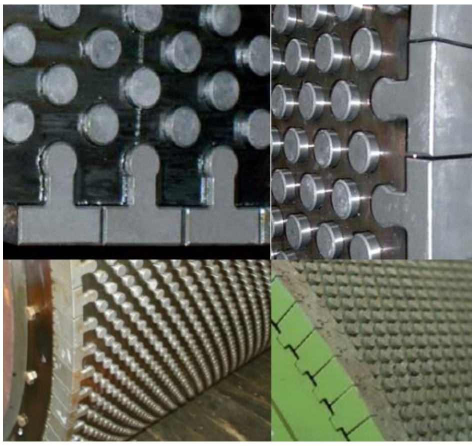

Figure 16 – A collage of photographs showing the stud and edge protection system of a Weir/KHD HPGR.

Roll surface repairs and refurbishments

106. Without adequate stud repairs and maintenance (see Figure 17, below), the HPGR rolls may be subject to accelerated wear rates and what is known in the industry as “washouts”. Washouts occur when the studs are damaged by oversized rock and tramp metal (see Figure 18, below).

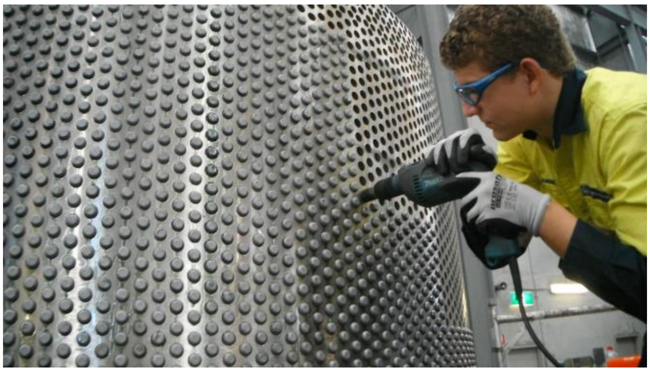

Figure 17 – A photograph showing stud re-lining and maintenance being performed by hand.

Figure 18 – A photograph showing Polysius HPGR with “washout” in the form of severe edge wear.

107. The KHD stud insert design relates to “pins” of certain specified diameters and lengths. The base end is chamfered so as not to develop stress concentration points.

108. It is my understanding that Polysius use the KHD stud inserts under a royalty agreement with KHD. Polysius, however, have devised their own design of a roll surface protection and also at the edges of the roll (see Figure 19, below).

Figure 19 –A photograph of the Polysius surface and edge design.

109. Stud “hardness” specification along the full width of the rolls has also become a critical issue relating to even wear across the surface and the prevention of the formation of the so-called “bath-tub” wear effect.

HPGR Manufacturers

110. There are currently six recognised manufacturers of HPGR machines. These are:

- ThyssenKrupp (TK) (previously Polysius - a subsidiary company of TK);
- Weir Minerals (WM); (previously KHD);
- Köppern;
- Citic-HIC;
- Metso; and

- FLSmidth (acquired technology from dissolved company Alpine).

111. The first three German HPGR manufacturers (TK, WM and Köppern) were bound by the original Schönert patent that protected the process of comminution (crushing and grinding) of materials.

112. Initial trials in the early 1990s by two German manufacturers (Polysius and KHD) were plagued with wear problems relating to the treatment of very hard and abrasive mineral ores.

113. Later, the technology performance was based on the performance of the various wear protection systems. In this regard, KHD invented roll stud and edge protection systems. It is my understanding that these systems were permitted to be used under commercial agreements between Polysius and KHD. It is also my understanding that Köppern was for many years not permitted to use stud lining system patented technology.

114. It is also my understanding that the stud patent expired in recent years and opened up the stud lining market. For example, Köppern was quick to enter the stud lining market followed closely by Metso with a new edge and cheek plate design. The body of the rolls, however, were stud lined. Citic-HIC, based in China, used their own form of wear protection systems for many years.

115. The fundamental differences between the original three HPGR manufacturers can be summarised as follows:

- ThyssenKrupp/Polysius:
  - favours a high aspect ratio design, i.e., large diameter, small width; and
  - use of studs for wear protection on rolls surface;
- Weir/KHD:
  - favours a low aspect ratio, i.e., small diameter, large width; and
  - use of studs for wear protection on rolls surface; and
- Köppern:
  - favours a low aspect ratio, i.e., small diameter, large width; and
  - use of studs and Hexadur® wear protection linings.

116. I provide the following Figures 20 to 23 illustrating some of the designs of the various HPGR manufacturers. I note that Hofmann is not a manufacturer of HPGR systems but rather a manufacturer of mechanical components of HPGR systems.

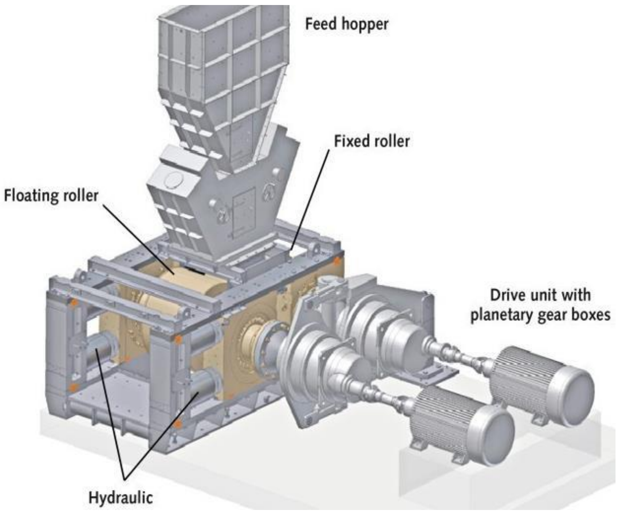

Figure 20 – A diagram showing the ThyssenKrupp design with specialised feed hopper to promote choke feed.

Figure 21 – A photograph showing a Weir/KHD HPGR design

Figure 22 – A photograph showing the Citic-HIC HPGR roll designs with Nitrogen hydraulic spring system

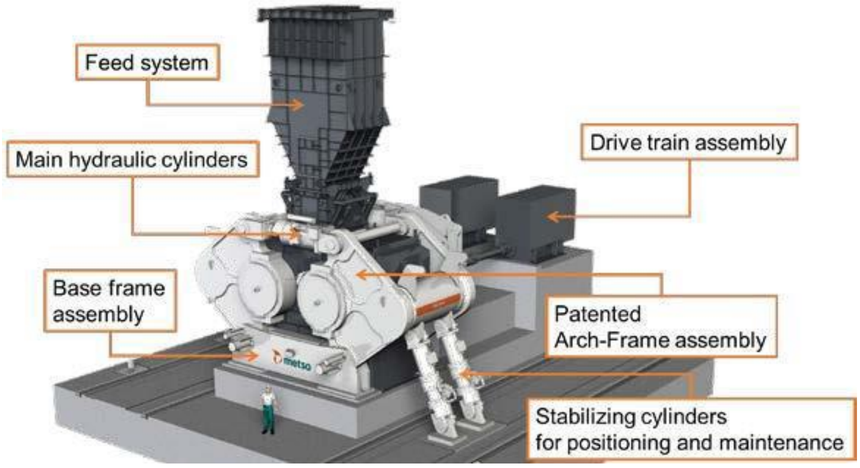

Figure 23 – A diagram showing the HPGR design of the Metso HRC™ system (source: Herman et al. 2015, "Building the world's largest HPGR – the HRC™ 3000 at the Morenci Metcalf Concentrator" SAG Conference, Vancouver).

117. Metso, upon entering the HPGR market in about 2012, have improved HPGR technology. Their HPGR system, referred to as the HRC™, includes (see Figure 24, below):

- anti-skewing Metso arch-frame;
- tungsten carbide studded tires HPGR flanges;
- feed hopper with guide plates to direct the feed into the crushing zone;
- hydraulic cylinders can be adjusted to provide the optimal crushing force;
- variable speed drive train suitable to run between 110% to 30% full speed; and
- dust enclosure to provide a dust and noise barrier, and protection of the main bearings.

118. The benefits of these new features include:

- increased circuit efficiency and capacity - flanges direct material to the crushing zone thereby maximising the amount of ore crushed. In a closed circuit pilot scale operation, this amounted to over a 20% increase in circuit capacity and over a 10% decrease in circuit specific energy;
- improved availability - the arch-frame eliminates downtime associated with skewing;
- increased reliability - the anti-skewing arch-frame prevents bearings from being damaged due to misalignment;
- reduced operating costs - energy efficiency, longevity of wear components including the studded tires and no use of grinding media all contribute to low operating costs; and

- flexible operating parameters - speed and pressure can be adjusted for changing ore conditions and downstream circuit demands.

Figure 24 – A diagram showing the flange assembly of the Metso HRC® HPRG (diagram sourced from: Herman et al. 2015, "Building the world's largest HPGR – the HRC™ 3000 at the Morenci Metcalf Concentrator" SAG Conference, Vancouver).

119. While I appreciate that some of my aforementioned comments encompass subject matter falling after the date specified in paragraph 29, I have nevertheless included the comments to fully detail the developments in the HPGR field. Indeed, in some instances, my comments may refer to publications published after the date but that encompass developments falling before the date and are therefore, in my opinion, worth mentioning.

Extract of AU2015203343

120. I have read and understood the extract of AU2015203343 provided to me by IP Gateway.

121. The extract of AU2015203343 discusses in general terms the covering of an HPGR roller surface with inserts to promote the accumulation of an autogenous layer of ore to reduce wear. The extract also discusses the problem of roll edge wear and several prior art solutions.

122. The edge effect wear problem emerged as early as 2002, soon after several initial successful industrial trials using the new stud lining technology of KHD. At the time, KHD and Polysius were the key players for HPGR applications in the minerals industry.

123. KHD developed the stud lining concept that involved the formation of an autogenous layer of crushed material that packed at the base of the roll metal and was contained by the slightly protruding studs (see Figure 25, below; source: Alsmann, L., 1996, KHD Humboldt Wedag, *New roller press series characterised by enhanced reliability*, Aufbereitungs -Technik/Mineral Processing, Nr.6, June 1996, pp 259-268).

124. The stud lining concept represented a major breakthrough and improvement in HPGR technology following the Polysius Cyprus Sierrita trials (discussed in paragraphs 70 to 74 above). HPGR pilot plant test work conducted in Germany looked into the properties of the material being crushed and whether this influenced the formation of this autogenous layer on the roll surface. The test work found that brittle dry materials did not facilitate in the formation of this important autogenous layer. Likewise, the test work found that material that is too moist (i.e., contained more than 5-6% moisture) is not suitable for HPGR processing.

125. In the extract, it stated on line 20 of page 1 that: *"This layer provides protection to the outer face of the roller and typically remains in place during the grinding action"*. This is the key to the prolonged service life of HPGR rolls and hence it is very important to first test the material being crushed to determine if it is in fact suitable for HPGR processing by enabling the formation of this protective autogenous layer. It could be argued that the hardness/strength performance and spacing of the tungsten carbide pins is equally important. This statement is made on the basis that early trials of stud lining resulted in some of the studs at the centre of the roll face failing and causing initial *"washouts"* (see right side panel of Figure 26, below) and ultimately the entire failure of the rolls (see left side panel of Figure 26, below) after just half the predicted roll wear life.

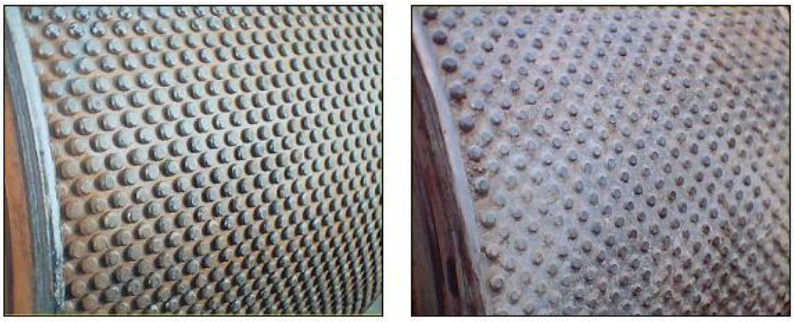

Figure 25 – Photographs showing the autogenous layer of ore that forms between the protruding studs (source Alsmann, 1996)

126. The stud breakages were caused by either poor materials specifications or oversized rocks that were larger than the operating gap between the rolls. Schönert's initial feed size "ruling" was that feed particles should be less than 2.0 to 1.75 times the operating gap (Xg) (see Figure 27, below).

Figure 26 – Photographs showing HPGR roll "washout" as a result of poor inspection and stud maintenance (source: Koski, S., et al., 2011. Cerro Verde concentrator - four years operating HPGRs, SAG 2011. Department of Mining Engineering, University of British Columbia, Vancouver, B. C., Canada; and Burchardt, E, Patzelt, N., Knecht, J. and Klymowski, R.,;(2011), HPGR's in Minerals : What do existing operations tell us for the future?, Paper #108, SAG 2011. Department of Mining Engineering, University of British Columbia, Vancouver, B. C., Canada.Burchardt, E (2013) HPGRs in Hard Rock Mining, Mining Magazine).

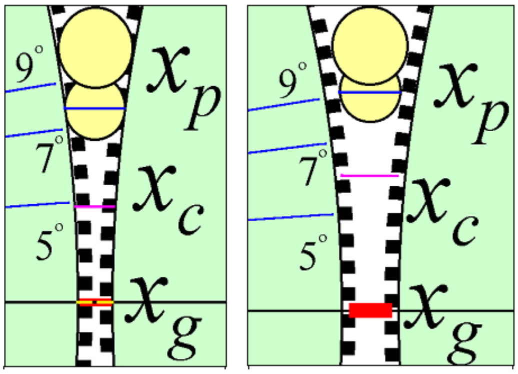

Figure 27 – A diagram showing how the gap between HPGR may vary and change the nipping characteristics between the rolls.

127. This feed size "ruling" quickly changed to a top size equal or less than the operating gap. This then eliminated the so-called pre-crusher zone (see Figure 28, below) of all HPGR operations at the time. The largest common diameter rolls at the time were about 2.4 m which resulted in an operating gap of approximately 70-75 mm. This limited the application to a degree, but was necessary in hard rock operations such as copper applications at Cerro Verde and gold applications at Boddington. For example, the early HPGR processes of Schönert were configured to all take place within the small compression zone (see Figure 28).

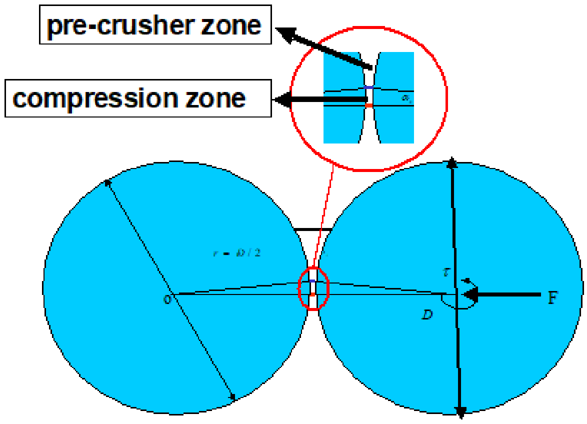

Figure 28 – A diagram showing the relative size of the compression zone within a HPGR.

128. The stud protection layer was the breakthrough that HPGR technology required. After KHD, Polysius soon followed with their studs known as “fat-boys”.

129. Edge wear problems began to then emerge and both KHD and Polysius developed their own edge protection systems. Both companies developed mechanical/geometrical-based edge protection systems that enabled them to each retain their clients and replacement parts. Competitors to KHD and Polysius were largely kept away as a result of stud liner patents.

130. The cause of the edge wear problem originated from two fronts. The first front being that at the edge of the rolls, the compressed bed is subjected to the atmosphere and does not experience the overall surrounding compressive forces that would otherwise originate in the centre of the rolls.

131. The second front being breakage at the edge of the rolls (termed the “edge effect” zone) is different to that at the centre and conforms more to that experienced in a conventional rolls crusher. This so-called "edge effect" is what defines the proportion of relatively coarse particles usually seen in HPGR products. Its existence has been explained by the pressure gradient across the width of the roll and the zero confinement of the ore at the edges of the rolls where cheek-plates are sometimes provided.

132. The edge effect is within the compression zone area as seen in Figure 29, below. Referring to Figure 29, a plan view of the rolls reveals the location of the edge effect zone, the blue shaded zones are not subjected to the same breakage forces and pressures. Hence, larger particles exit the HPGR largely un-broken. This, in turn, limits the ability of the HPGR to retain or build up an autogenous layer in these areas. The effect is compounded by the positioning of the last row of studs across the width of the

rolls and no autogenous layer is built up. This is clearly visible in the right side panel of Figure 26 in which the edge row of studs are clearly exposed.

133. This explanation provided herein demonstrates that the edge effect problem is an artefact of the process and the inability of the studs at the end of the rolls to accumulate and be protected by the autogenous wear layer. The stud liner patent of KHD was, therefore, the most advanced roll wear protection system and prolonged KHD and Polysius' dominance in HPGR technology development up until 2012.

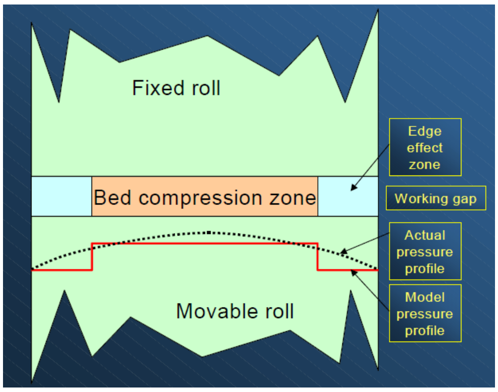

Figure 29 – A diagram showing a plan view of the compression and edge effect zones in an HPGR system.

135. In 2008, Köppern, an established provider of the roller press (HPGR), entered into the minerals industry (previously restricted to KHD and Polysius) with their machines fitted with a Hexadur® roll surface (see Figure 30, below). The Hexadur® surface was a failure at a gold mine installation at Bendigo, and also at One-steel's Whyalla iron ore concentrator. Köppern was then positioned to develop stud liners in time for when the stud liner patent expired.

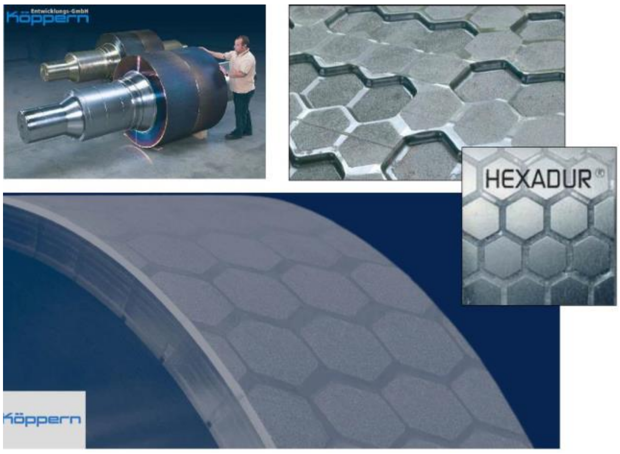

Figure 30 – Diagrams illustrating KHD's Hexadur® roll surface developed to decrease surface wear.

136. As indicated in the previous paragraph, it is my understanding that in 2012, the KHD stud liner patent expired or ceased at least in Australia. This allowed other comminution

vendors to enter the niche HPGR market, such as, e.g., Citic-HIC, Metso and FLSmidth. KHD (now Weir) and Polysius (now ThyssenKrupp) arguably had a 35 year lead in HPGR development and experience. Citic-HIC claimed to have 25 years of experience gained in China.

137. At about this time, the edge protection systems of KHD and Polysius were well in place. The edge protection systems as described in their respective patents are specific to each manufacturer's specification. Neither KHD nor Polysius disputed their designs. As indicated above, each had edge protection systems having unique geometrical designs that ensured that suppliers of the replacement parts conformed with their respective patents. The edge protection systems of both KHD and Polysius consisted of inserts. In contrast, the current (2012-2017) edge protection systems of Metso and FLSmidth consist of bolt-on annular rings.

138. It is my view that the edge protection systems are a secondary or tertiary issue when compared with the overall high-level "HPGR process patent of the past" and stud liner invention that involved the accumulation of an autogenous wear protection layer on the surface of the rolls.

139. An emerging weakness of insert design based edge protection systems is that if the tiles or edge segments are damaged and left to operate undetected, washout wear emerges as shown in the right-side panel of Figure 26, above. Stud breakage is a more serious problem as the washouts may originate in the centre of the roll surface (see left-side panel of Figure 26, above).

US 2007/0215733 A1

140. I have read and understood the content of US 2007/0215733 A1 in the name of Splinter *et al.* which describes a grinding roller. I understand that US 2007/0215733 A1 was published on 20 September 2007.

141. The document is entitled "Grinding roller for the pressure communication of granular material". This title is vague and implies the whole roller body. I believe the title includes an error with the term "communication", which I believe should read "comminution".

142. The figures of the document present concepts that clearly show the mechanical insert of the KHD edge protection design (see Figure 31, below). Figure 2 (reproduced below on left hand side of Figure 31) illustrates an edge protection system that resembles the Polysius edge protection system (see Figure 19, above). KHD presented their patented

stud protection as STUD-PLUS™ technology. This was marketed as a comprehensive stud liner protection system and not specifically as a separate edge protection system (see Figure 32, below).

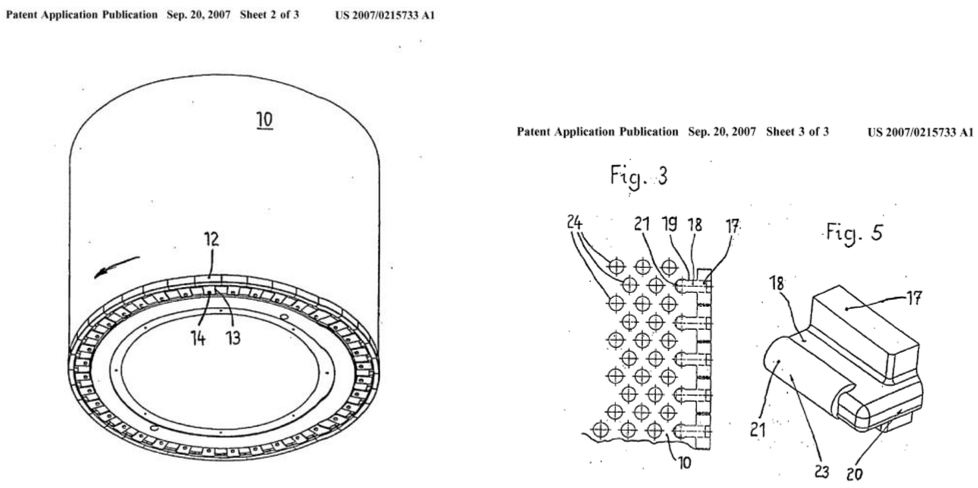

Figure 31 – A copy of Figure 2 from US 2007/0215733 A1

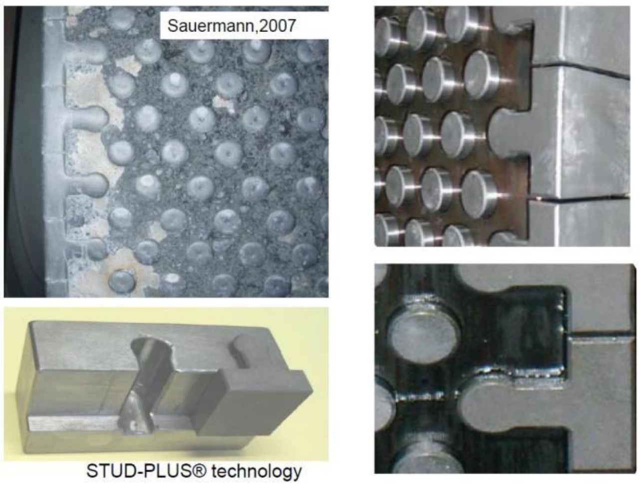

Figure 32 – Photographs showing KHD's promoted edge protection system.

143. US 2007/0215733 A1 comes after a previous publication (i.e., Maxton, D., Firsch, S. and van der Meer, F., 2005, *KHD Humboldt Wedag high pressure grinding rolls developments for minerals applications*, Randol Innovative Metallurgy Forum, Perth, Australia, August 21-24) that commented that edge wear on studded rollers was an emerging problem. In my view, edge wear (see Figure 33) was not the key problem but rather roll wear in general was a more serious problem.

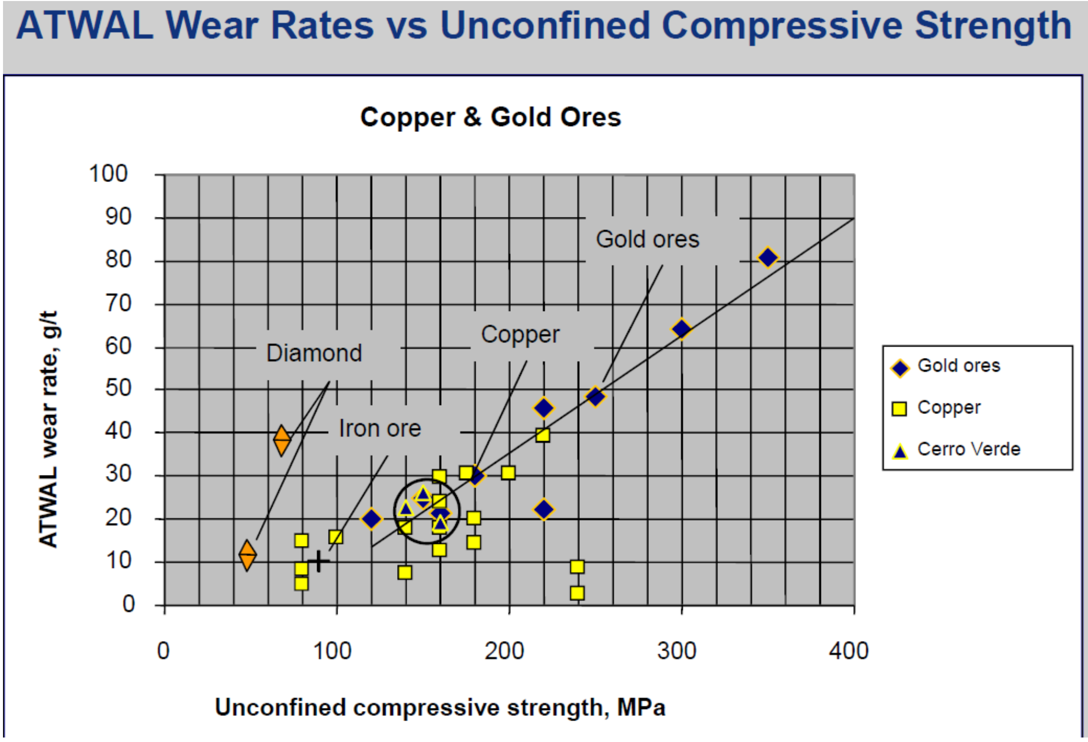

Figure 33 – A material wear rate plot against material confined compressive strength (source: Klymowsky, R. 2008. HPGR Technology present and Future, Procemin).

144. Studded rolls were a solution to the treatment of very competent and abrasive ores. A material wear rate (ATWAL TEST) was plotted against material confined compressive strength (see Figure 33, above). Prior to the stud liner technology, HPGRs were fitted with smooth rolls, welded chevrons, etc. At that time, about 2002, there was a lot of discussion and publications about process benefits of using studded rolls over smooth rolls.

145. The copper and gold ores presented much higher wear rates than platinum, iron ore and diamond applications.

146. The diamond industry was particularly concerned as it regarded that the “studs/teeth” would damage the diamonds. Other perception in the industry included the perception that it was the studs that actually provided for the crushing mechanism.

US 2005/0061901 A1

147. I have read and understood the content of US 2005/0061901 A1 in the name of Burchardt *et al.*, which describes a grinding roll. I understand that US 2005/0061901 A1 was published on 24 March 2005.

148. This document is entitled “Grinding roll”. Again, this title is vague and implies the whole roller body.

149. The figures of the document present concepts that clearly show the mechanical inserts of the Polysius design (see Figure 34 and Figure 35, below). Figures 2 and 4 of the document show an edge protection system that resembles the Polysius edge protection system consisting of a specialised stud insert.

Figure 34 – a photograph showing the roller studded surface and an exposed edge rim without the tiles.

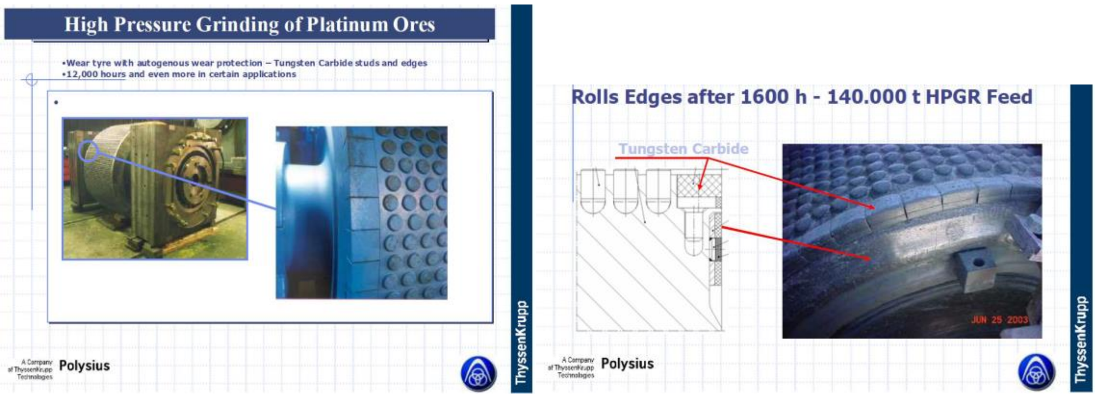

Figure 35 – Diagrams/photographs showing the Polysius HPGR roller studded surface and edge assembly.

150. This document came soon before a publication by Rene Klymowsky at Procemin 2008 entitled *"HPGR Technology present and Future"* that mentioned the need for edge wear on studded rollers as it was clearly an emerging problem at their inaugural copper mine Cerro Verde which employed four large 24/17 HPGR units.

151. These units suffered extensive wear issues relation to cheek plates, edge protection and stud breakage and wash-outs.

WO 90/06178 A1

152. I have read and understood the content of what I am advised is an English translation of WO 90/06178 A1 in the name of Kloeckner Humboldt Deutz AG (KHD), which describes a non-wearing cover for the surfaces of roller presses. I understand that WO 90/06178 A1 was published on 14 June 1990.

153. This document appears to disclose an early edge protection design of KHD. It is likely that this edge protection design was developed when hard-facing technology was considered the only way of protecting wear surfaces. This design predates the development of the stud lining concept.

154. The document discloses a weld-on edge protection system for rollers that experienced edge wear. The disclosed system is likely to have drawn concerns about its reliability. In particular, users would have likely looked to alternative technology than risk the technical problems associated with the subject system.

155. It is my view that the HPGR technology development was retarded globally by restrictive patents that limited HPGR development to just two German manufacturers for more than 20 years. Upon expiry of the restrictive patents, a myriad of patents on small components that make up HPGR have emerged and, in my view, these now present a risk to the further development and adoption of HPGR technology within the minerals industry.

US 5,253,816 A

156. I have read and understood the content of US 5,253,816 A in the name of Krupp Polysius AG, which describes a crushing roller. I understand that US 5,253,816 A was published on 19 October 1993.

157. This document discloses an early HPGR rolls shaft and segment protection system of Polysius. It is likely that this system was developed when high wearing segmented section were the only way of protecting a wear surface. This is similar to the Argyle diamond mine primary application that has very coarse rocks in the feed.

158. The roll surfaces are reported to wear at a rate of 8 mm per day. The rolls diameter would see up to 200 mm of steel surface removed, leaving the segments to be replaced every 4-6 weeks (about 600-800 operating hours). This represented a significant cost and equipment downtime.

159. The current stud technology is designed to last for about 5,000-12,000 hours. Availability is known to be about 88% whereas SAG technology offers about 94% availability. SAG mill liners are replaced every 4-6 months. HPGR roll replacements are thus competitive in terms of cost and downtime.

160. In my view, segmented roll technology is outdated and not suitable for hard rock applications (see Figure 7, above) and was last trialled in the Cyprus Sierrita application in about 1994 to about 1996.

161. That being said, the segmented technology could still be used for the treatment of non-abrasive relatively soft/brittle materials, such as, e.g., slags and cement clinker, cement clinker being a dry process.

WO 2009/013276 A1

162. I have read and understand the content of WO 2009/013276 A1 in the name of FLSmidth A/S, which describes a roller press with annular disc. I understand that this document was published on 29 January 2009.

163. This document discloses a very different concept to the concepts disclosed in documents US 2007/0215733 A1 and US 2005/0061901 A1 discussed above. The disclosed annular disc is of a bolt-on design that is meant to replace cheek plate technology.

164. The roller press disclosed is, in my opinion, very novel and potentially a ground-breaking concept in the advancement of HPGR technology. To my knowledge, limited data is published on the results of this roller press.

165. It is my view that this disclosed annular disc is also of a geometric nature if classified as an edge protection system of the roll surface as this is the function of the attachment. The annular disc, however, is different as it effectively provides a rotating cheek plate that is less prone to wear. The traditional cheek plates of Polysius, KHD and Köppern are all stationary components relative to the rotating rolls and, therefore, prone to higher wear rates. Cheek plates are a consumable to HPGR operations and a set of manufacturers' wear components typically comes at a significant cost.

166. It is my view that this document discloses an innovation that is meant to be an improvement on the cheek plate designs of Polysius, Köppern and KHD. Metso appear to have adopted a similar annular disc concept.

167. I have not seen such a device operating within the industry. However, it may well have been trialled during experimental trials.

DE 40 37 816A1

168. I have read and understood the content of what I am advised is an English translation of DE 40 37 816A1 in the name of Kloeckner Humboldt Deutz AG (KHD), which describes milling rollers. I understand that the document was published on 4 June 1992.

169. This document, as entitled, discloses an annular ring mounted at roller ends. The document discloses a system that is a very different concept to the cheek plate designs of KHD, Köppern and Polysius (see Figure 14). In my view, the disclosure of the document does not specifically relate to the problem of edge wear in rolls but rather provides an alternative mechanism to the commonly used cheek plate.

170. Cheek plate design has varied significantly over the years (see Figures 13 and 14, above) as have the feed presentation hoppers above the HPGR unit (see Figures 20 and 23, above). HPGR units require a choke feed, and the "open" area towards the ends of the roll surface requires either cheek plates or a mechanism as presented in this document to function efficiently.

171. In my view, this document discloses a mechanism that is arguably quite similar to the mechanism presented in WO 2009/013276 A1, and similar to the edge/cheek plate mechanisms in the Metso design (see Figure 24, above).

172. To my knowledge, the spring loaded mechanism disclosed in this document that is provided as an alternative to cheek plates has never really been commercially developed by KHD.

DE 44 00 797A1

173. I have read and understood the content of what I am advised is an English translation of DE 44 00 797A1 in the name of Krupp Polysius AG, which describes a grinding tool. I understand that the document was published on 20 July 1995.

174. This document, entitled "Grinding tool for roller mill", relates, in my opinion, to "experimental" attempts to improve the wear/service life of the original segmented rolls or rolls with hard faced welding. This could be viewed as a variant of the stud lining concept previously discussed. However, in this variant, the "stud" segments extend across the entire face of the rolls like "cross-bars". The base of the bars have an interlocking mechanism and enable the manufacturer to protect the geometry as well as the materials of the hard facing. This design may have been tested at Cyprus Sierrita as a replacement for one of the segments. However, there is very little publically available data and much of the knowledge of the trials is restricted to only employees.

175. The experimental HPGR unit at Cyprus Sierrita had many segments in which many surface designs and materials were tested. In the end, the inserted stud lining protection was the most successful mechanism of prolonging surface wear. As previously

mentioned, this is predominantly due to the "autogenous" layer of fine "rock" materials that compacts in-between the studs and provides an "ongoing wear replacement surface".

176. The experiments at Cyprus Sierrita for copper ores and also for diamond kimberlite ore in the preceding years 1988 to 1994 saw HPGRs or HPRC (high pressure rolls crushers) being incrementally developed before finalising with the current tyre and stud liner systems.

177. All of the diamond related work was extremely secretive at the time. KHD had installed units at the Premier diamond mine for testing. These units were 2.8 m in diameter and 0.45 m wide. The aim of these rollers/crushers was to liberate large diamonds without breaking the high valued gems.

178. This resulted in De Beers at the time abandoning KHD and moving forward with technology development with Polysius. This is still the case to this day, as I understand.

179. As such the results of the Cyprus Sierrita trials are largely protected and not in the public domain. This secretive approach followed by both technology manufacturers arguably retarded the overall development of HPGR technology as the industry was not told about it, nor its benefits.

180. Only through independent research efforts of the CSIRO in the late 1990s and industry support in the AMIRA P9 projects did the benefits of the technology become more known and widespread.

181. In my view, the mechanism/system disclosed in the document did not result in any commercially successful wear resistant roll surface.

DE 26 43 307A1

182. I have read and understood the content of what I am advised is an English translation of DE 26 43 307A1 in the name of Willy Rueschhoff GmbH & CO KG, which describes a roller. I understand that the document was published on 30 March 1978.

183. This document arguably discloses one of the first designs for a superior roll wearing system. The documents discloses the use of inserts that are geometrically arranged so as, in my opinion, to secure ongoing consumable wear parts supply.

184. It is my view that the concept did not become a commercial success.

185. I note that the disclosed wear protection system includes lateral inserts having a geometric design.

BE1013969A3

186. I have read and understood the content of what I am advised is an English translation of BE1013969A3 in the name of Magotteaux Int., which describes a grinding roller. I understand that the document was published on 14 January 2003.

187. In my view, the concept disclosed by this document is extremely interesting at least because, to my knowledge, Magotteaux Int. do not manufacture HPGR or roller presses. My understanding is that Magotteaux Int. provide wear resistant materials within the minerals beneficiation processes, mainly grinding balls to my knowledge forged and of high chrome, etc.

188. The diagrams disclosed in this document are not clear and I do not fully understand how the disclosed edge mechanism functions. However, it does appear to have the function of a bolt-on section but the body is not replaceable. The design appears to incorporate a complex geometrical system of sleeves and pins, which, if in place, would, in my view, prevent competitors from offering similar components to their clients.

189. It is possible that Magotteaux Int. have developed these wear parts for roller press technology within the coal and clinker industries.

190. To my knowledge, many of the early patented developments in HPGR were specifically limited to the treatment of mineral ores, such as, e.g., copper, gold, lead zinc, iron ore, etc. It is my understanding that industrial materials, such as, e.g., coal, clinker, slags and cement, were covered under separate patents, and possibly under conditions that were not as competitive as in the minerals industry. For example, one of the earlier developers of HPGR, Alpine, was granted a license to exploit the Schönert HPGR patent and develop HPGRs in the USA for the purpose of non-mineral ores. Alpine is no longer an operating company and has since been acquired by FLSmidth.

FULL SPECIFICATION OF AU2015203343

191. After providing the comments set out above, IP Gateway then provided me with a copy of the full specification of AU2015203343, which I have read and understood.

192. Page 1 and most of page 2 of AU2015203343 are the same as the extract of AU2015203343 discussed above.

193. It is my view that the AU2015203343 disclosure for the improvement of the studded surface is a major improvement over US 2007/0215733 A1. In my opinion, in AU2015203343, the components are more rigid and sturdy as shown in Figure 18 of AU2015203343 (reproduced below as Figure 39) and have a well-engineered bolt-on system in particular because of a leading pin labelled 451 in the figure to ensure adequate fastening.

194. In my opinion, AU2015203343 presents a legitimate solution to the edge wear problem by offering a replaceable edge segment that is held in place using unique geometrically-shaped components of the disclosed edge protection system as shown below in Figure 39. In my view, the shape of the components represent an improvement on the shape of the components of the KHD and Polysius systems. It is also my view that the intention behind the shaped components is as a means of retaining clients with ongoing service and replacement part supply.

195. The edge protection system, in my view, is intended as an extension/improvement over the stud liner roll surface design. The original KHD stud liner concept relied upon the formation of the autogenous layer of crushed rock between the tungsten carbide stud inserts to serve as a continuous barrier to protect the base of the roller metal from physical wear. Accordingly, the KHD system does not rely on the design of the studs as such to define the system.

196. In my view, the KHD stud liner concept is, in turn, an extension of the Schönert HPGR patent. As previously discussed, the Schönert HPGR patent is a process patent that was granted to, in my view, the already existing concept of a mechanical device with two counter-rotating rollers, one fixed into a frame whiles the other is free to move under a controlled hydraulic system.

197. The Schönert HPGR patent was an unusual patent as it covered the process of compression of brittle materials under high compression forces. The feed material is subjected to bed breakage or inter-particle crushing and, to my knowledge, must exceed 50 MPA. The measurement of this pressure limit is not clearly defined and it would be difficult to determine in practice.

198. In practice, the Schönert HPGR patent disclosed a process condition whereby the feed material is subjected to very high press forces that result in a “briquetted” product that sometimes resulted in compacted materials that resembled a product similar to the feed. However, the resulting material was sufficiency damaged internally. Subsequent milling

and de-agglomeration of the compacted flake materials provided an overall process that was more energy efficient that the conventional crushing and milling processes.

199. It is my view that most so-called HPGRs treating hard abrasive rock do not experience bed compression forces that exceed 50 MPA. According to my understanding, this technically renders the currently available roller press devices the same as conventional roll crushers rather than an HPGR as initially covered by the Schönert HPGR patent.

200. In my view, the so-called improvement of the studded roll wear surface by means of an edge protection system is not the purpose or intent of the AU2015203343 disclosure. Neither, in my view, is the side bolt-on attachment method. Specifically, the intent of the AU2015203343 disclosure is, in my opinion, the shape and design of the components that would enable Hofmann to control the manufacture of these components and thereby prevent competitors from fabricating the same components and underselling them.

201. By way of example, Cerro Verde, Sierra Gorda and Boddington all use multiple Polysius 24/17 HPGRs. The concentrators cost in the region of $2-4 billion with each of the HPGR units costing approximately $10-15 million each. Typically, the cheek plates cost about $60,000-80,000, and I would assume that edge protection components would cost a similar amount if not less. These large projects are, therefore, at risk of getting embroiled in potential legal issues relating to component attachments for HPGR assemblies. This, in turn, may result in undue technical and economic risks to the projects.

202. I am aware that the components of AU2015203343 look very similar conceptually to the components of US 2007/0215733 A1. This is not, in my view, the intent or purpose of AU2015203343. It would be unreasonable to view the studs or the edge protection tiles/studs to be the subject or intent of AU2015203343.

203. Many have argued that the original Schönert HPGR patent should never have been allowed in the first place. Similar mineral industry “process” patents have been proposed since 1982 most of which, according to my understanding, have been rejected or simply viewed as being un-patentable. A recent example of this that comes to mind is the claim to patent ball mill processing by allowing a mixture (75/25) of both balls and pebble rocks as the grinding media within the ball mills. This idea is not patentable, in my opinion, since ball mills in operation at the time routinely used a mixture of balls and an unknown quantity of pebble rocks that was virtually impossible to measure and account for, hence rendering any patent, if allowed, unenforceable. The dimensions of these balls are not measured within the industry, and hence, such a patent, if allowed, would, in my opinion, initially conflict with the operating conditions of existing ball mills.

204. In my opinion, the side-bolt-on edge protection system of US 2007/0215733 A1 ("the KHD patent"; see Figure 36, below) and the edge protection system of AU2015203343 (see Figure 37, below) are also similar in concept. However, it is my view that the intent of AU2015203343 is to secure protection for the geometric shape and design of the components to prevent "cloning" of the components by competitors.

205. Other similar features between the US 2007/0215733 A1 and the AU2015203343 edge protection systems are shown in Figure 38 and Figure 39, below.

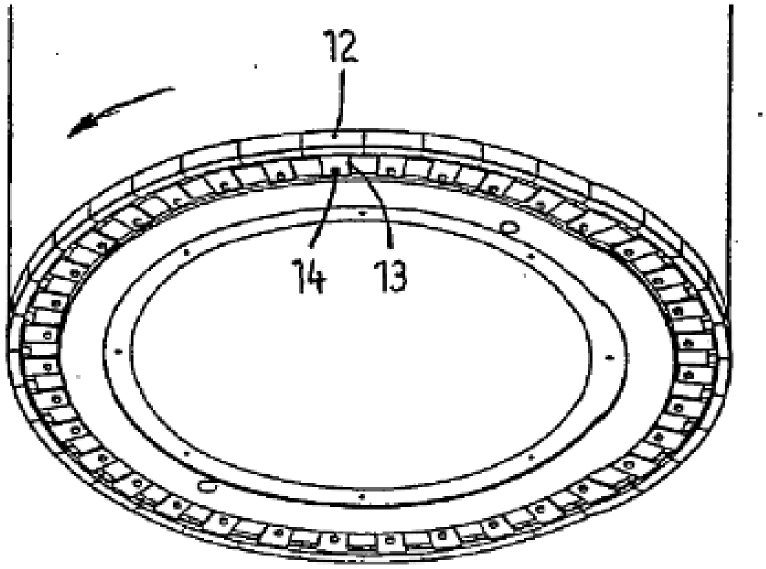

Figure 36 – Figure 2 from US 2007/0215733 A1 showing the KHD edge protection system.

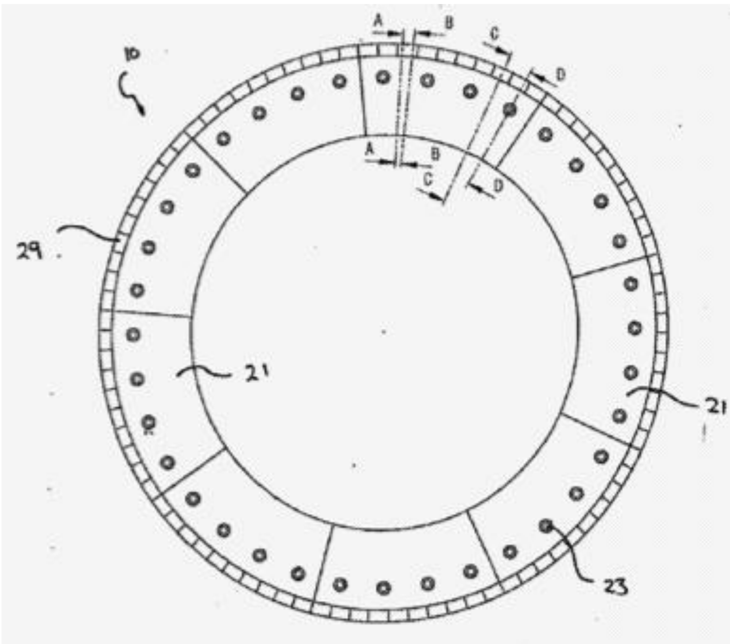

Figure 37 – Figure 1 from AU2015203343 showing a side view of the edge protection system.

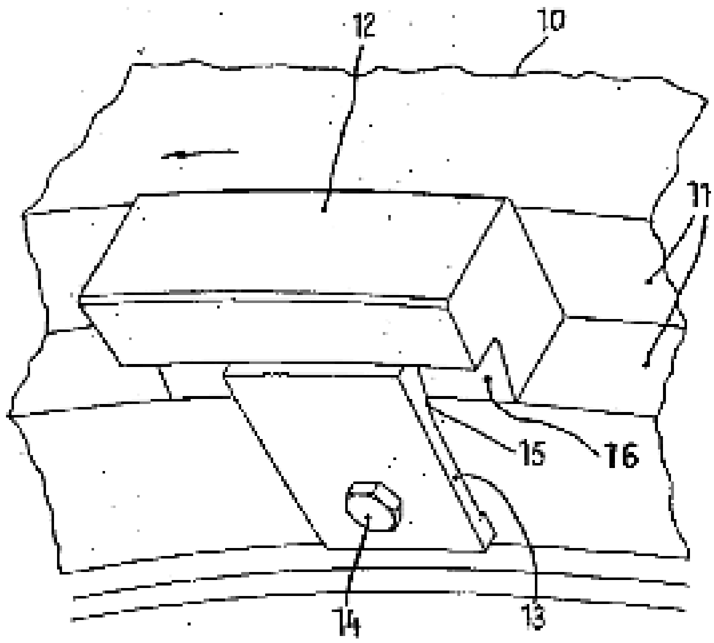

Figure 38 – Figure 1 from US 2007/0215733 A1 showing the bolt-on KHD edge protection system.

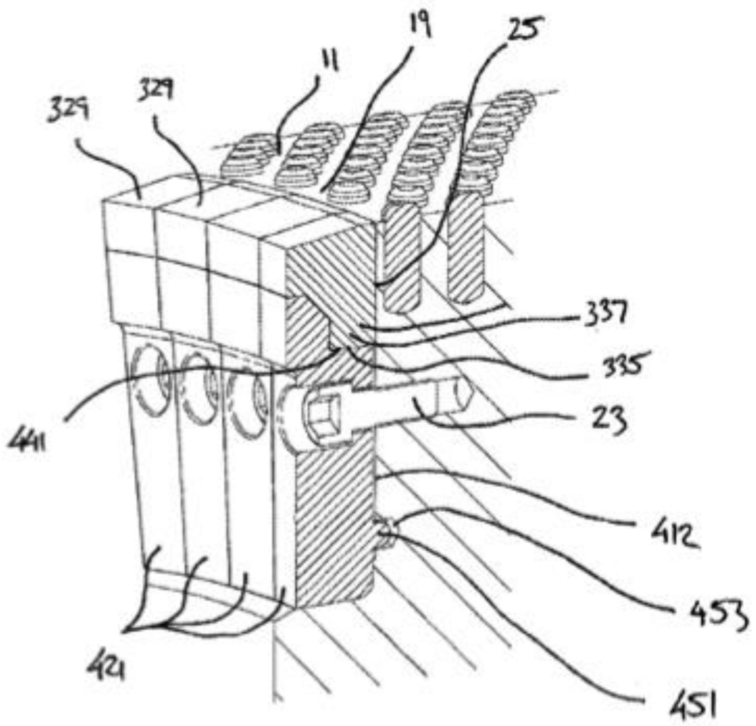

Figure 39 – Figure 18 from AU2015203343 showing the bolt-on edge protection system.

206. Likewise, Figures 40 and 41 below show similar features between the Polysius (i.e., US 2005/0061901 A1) and the AU2015203343 edge protection systems.

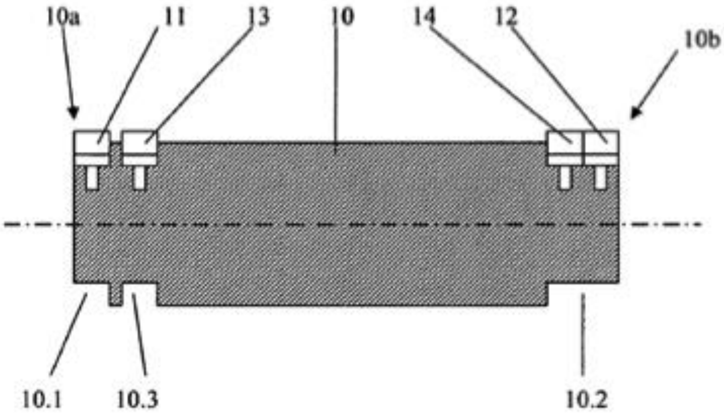

Figure 40 – Figure 2 from US 2005/0061901 A1 showing a cross-sectional schematic of the Polysius HPGR roll with edge protection system.

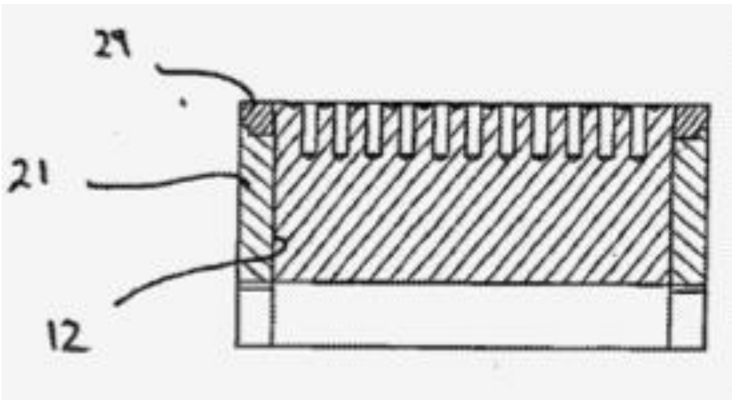

Figure 41 – Figure 4 from AU2015203343 showing a cross-sectional side view of an HPGR roll with the Hofmann edge protection assembly.

207. In particular, Figures 40 and 41 above, in my view, show that the function of the various edge protection components is to prolong the wear surfaces of HPGR rolls in their entirety.

208. Of note, the KHD annular ring disclosed in DE 40 37 816A1 appears to provide a replacement device (on the side of a roll surface). In my view, this compares with the edge protection system of AU2015203343. However, it is my view that the intended duty of each system is different.

209. Lastly, Köppern and Citic-HIC also have edge protection systems. Köppern have a side mounted bolt-on design as shown in Figure 42. Citic-HIC, in contrast, have an annular disc side edge protection system as shown in Figure 43.

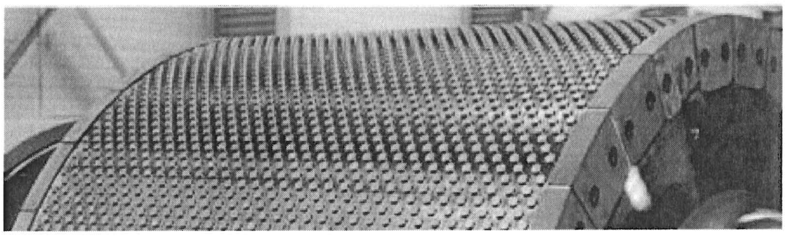

Figure 42 – A photograph showing the Köppern side mounted bolt-on edge protection system.

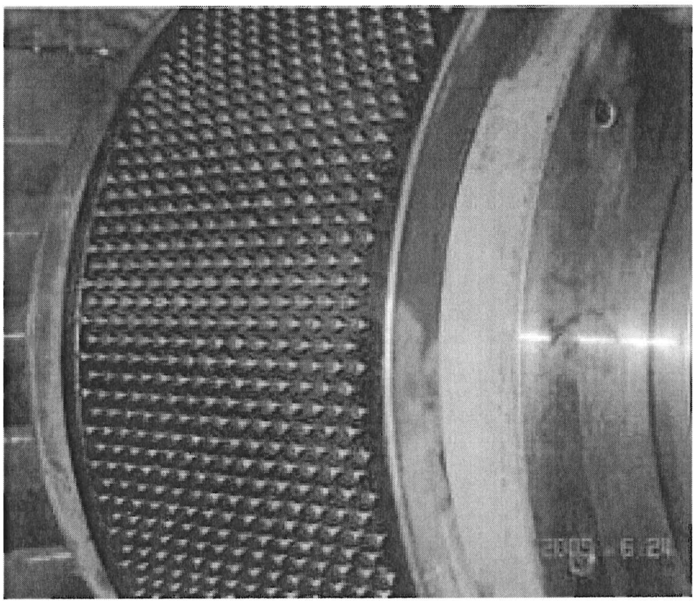

Figure 43 – A photograph showing the Citic-HIC annular disc side mounted bolt-on edge protection system.

I understand that a person who intentionally makes a false statement in a statutory declaration is guilty of an offence under section 11 of the *Statutory Declarations Act 1959*, and I believe that the statements in this declaration are true in every particular.

Declared at Springwood on this 22nd day of September 2017.

....

Before me,

....

John Daniel King-Scott, a registered patent attorney, of 3360 Pacific Highway, Springwood, Qld 4127, Australia

Note 1 A person who intentionally makes a false statement in a statutory declaration is guilty of an offence, the punishment for which is imprisonment for a term of 4 years — see section 11 of the *Statutory Declarations Act 1959*.

Note 2 Chapter 2 of the *Criminal Code* applies to all offences against the *Statutory Declarations Act 1959* — see section 5A of the *Statutory Declarations Act 1959*.