



THE FUTURE OF DIAMOND LIBERATION AND RECOVERY?

A LITTLE HISTORY

● LIBERATION

- Flooring
- Stamp mills
- Scrubbing and screening
- Jaw/cone crushers
- High pressure grinding rolls

● CONCENTRATION

- Rotary pans
- Dense medium separation static cones
- Dense medium separation cyclones

● RECOVERY

- Hand sorting
- Grease belts
- X-ray machines

UNIT PROCESSES

- Autogenous milling
- Waste sorting (NIR)
- Large diamond recovery (XRT/pulsed XRF)
- Dense medium separation (DMS)
- XRT final diamond concentration
- Size frequency distribution analyses
- Quality analysis
- Secure diamond storage
- Product Protection

AUTOGENOUS MILLING

THERE ARE MANY BENEFITS TO AUTOGENOUS MILLING

- Combines many unit processes into one
 - Scrubbing
 - Secondary crushing
 - HPGR/recrush crushing
 - HPGR Disagglomeration
 - Recovery plant feed preparation
- Improved diamond liberation
- Reduces diamond breakage
- Removes circulating loads within the plant
- Generates a high percentage of fine, discard material
- Reduces downstream unit processes required capacities
- Effectively undertakes preliminary waste sorting
- Treats weathered kimberlite: easier downstream materials handling



AUTOGENOUS MILLING - IMPACT ON MINING

Autogenous milling can have a significant impact on the upstream mining processes.

- It can handle less “well shaped” material than conventional crushing
 - Therefore allows for the use of primary jaw crushers rather than the more expensive gyratory crushers or mineral sizers
- Handles fine, sticky material well
 - Mining can blast finer
 - Blasting is cheaper than crushing and milling
- Finer blasting
 - Reduces overall mine operating costs
 - Can increase diamond liberation
 - Can decrease diamond breakage

WASTE SORTING - NIR

WASTE SORTING, COMBINED WITH AUTOGENOUS MILLING, HAS MANY ADVANTAGES

Autogenous milling of kimberlite effectively concentrates waste in the mill recycle load. Historically this has been crushed, often using expensive HPGRs prior to returning to the mill feed.

Waste sorting can remove a very high percentage of the basalt and granite in this stream: potentially up to 80% of the mill recycle load.

Advantages

- Lower power consumption
- Less diamond breakage
- Lower opex
- Lower downstream unit processes capacity requirements
- Less wear and maintenance

LARGE DIAMOND RECOVERY - XRT

XRT COMBINES DIAMOND CONCENTRATION AND RECOVERY

- High capacity sorting made possible by increases in computer processing power
- Now economically viable
- Can sort from 150mm to ~6mm
- Capacities up to 150tph per machine
- Low yield: concentrate reports directly to the Sorthouse

REPLACES DMS IN THE TREATMENT OF THE +6mm MATERIAL

- Lower opex
- Lower power consumption
- Lower water consumption
- No coarse X-ray machines
- Improved security
- Less logistics: FeSi and spares



XRT TECHNOLOGY IS DEVELOPING FAST AND WILL EVENTUALLY BE ABLE TO TREAT ALL THE REQUIRED SIZE FRACTIONS DOWN TO 2mm.

THIS MEANS THE DEMISE OF DMS IN THE LARGER, WELL CAPITALISED MINES.

RECOVERY PLANT

- XRT technology will eventually remove the need for X-ray machines to recovery diamonds from the coarse DMS concentrates
- In the medium term, XRT will be applied to the Recovery Plant X-ray machines in order to improve selectivity and reduce yields
- Smaller XRT machines will become more common in order to generate a final concentrate containing up to +90% diamond
- Secure packaging systems will also become more prevalent to reduce risk

METALLURGICAL ACCOUNTING

THE DIFFICULTY OF METALLURGICAL ACCOUNTING IN DIAMOND MINES IS WELL KNOWN.

- Size frequency distribution (SFD) analysis machines will be installed to provide on line information for metallurgical accounting and process management
- On line quality sorting will be the next important unit process to be developed
- These two systems will be able to provide on line information regarding the financial performance of the mine

DIAMOND SECURITY

Diamond security must be fully integrated into the metallurgical processes

- XRT technology

 - LDS Concentrate reports directly to the Sorthouse and removes other high risk unit processes

 - “Hands-off” final sorting: +90% diamond concentrate

- SFD

 - Again a “hands-off” process

- Quality sorting

 - Removes need for direct access to diamonds on mine

- Canning

 - Secure export

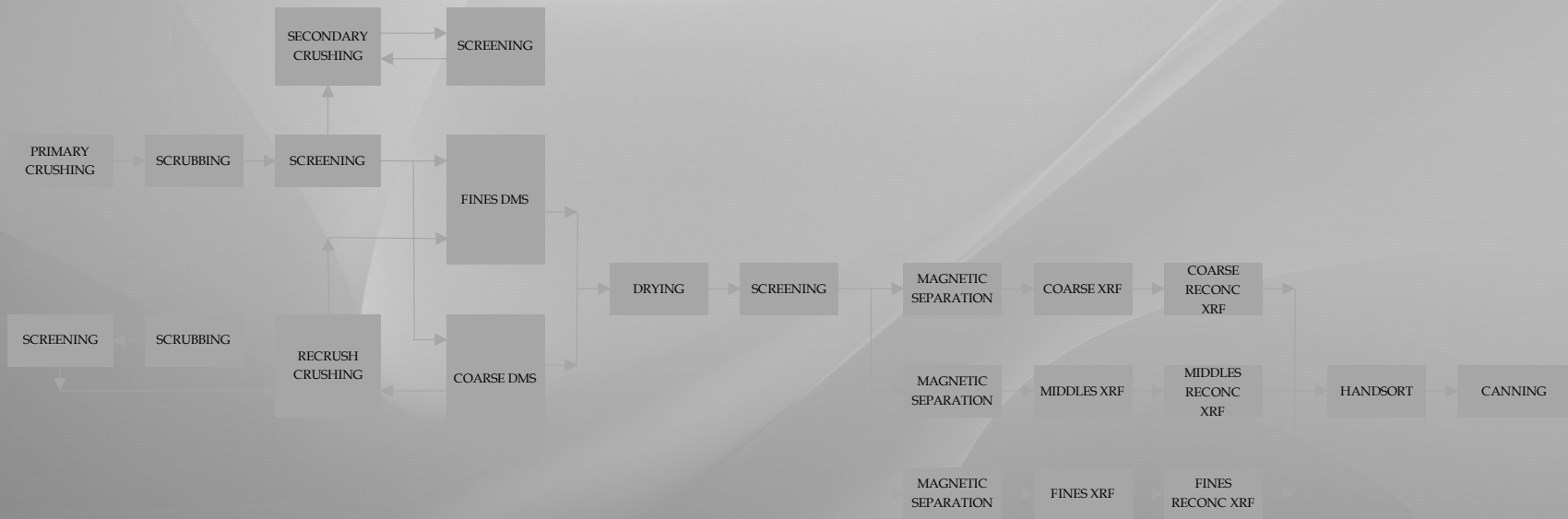
SIMPLICITY

WHERE DOES THIS ALL LEAD US?

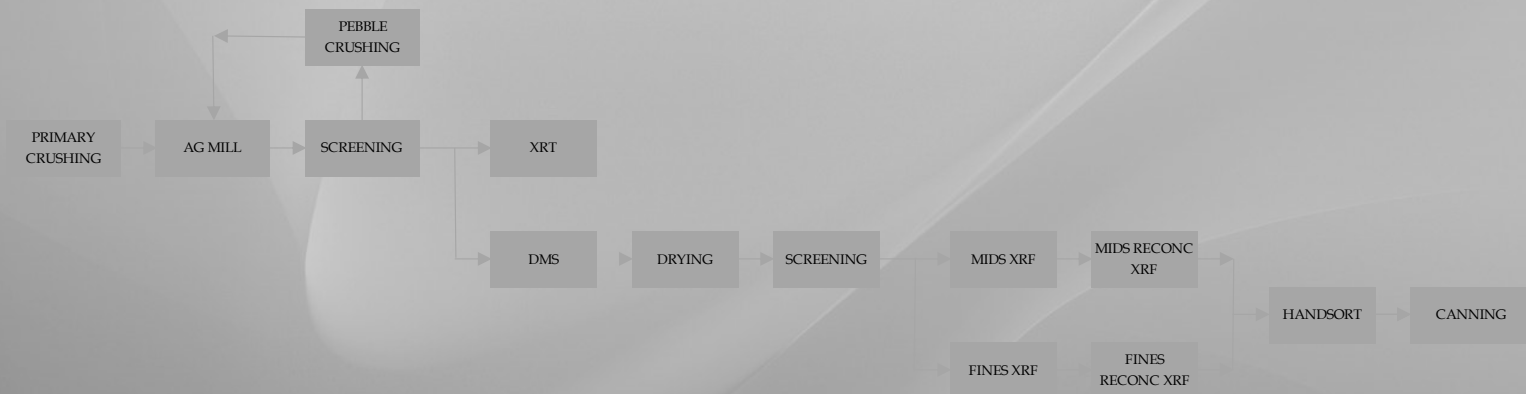
SIMPLICITY

IN DIAMOND PLANT FLOWSHEET DESIGN

CURRENT FLOWSHEET



MEDIUM TERM FLOWSHEET



FUTURE FLOWSHEET



SECURITY

THE SIMPLE FLOWSHEET HAS SIGNIFICANT IMPACTS ON DIAMOND SECURITY: A MUCH NEGLECTED CONSIDERATION IN DIAMOND PROCESS ENGINEERING DESIGN

- Less equipment
- Less maintenance
- Easier process control
- Less potential for operator interference
- Less spillage
- Less manpower
- Smaller footprint to secure

ALL OF THE ABOVE MEANS LESS OPERATIONAL ACCESS TO DIAMONDS AND HENCE LESS THEFT

SIMPLICITY RULES OK

“IF YOU CAN'T EXPLAIN IT TO A SIX YEAR OLD, YOU DON'T UNDERSTAND IT YOURSELF”: Albert Einstein

“LIKE ALL MAGNIFICENT THINGS, IT'S VERY SIMPLE”: Natalie Babbitt

“LIFE IS REALLY SIMPLE, BUT WE INSIST ON MAKING IT COMPLICATED”: Confucius

“SIMPLICITY IS THE ULTIMATE SOPHISTICATION” : Clare Boothe Luce

SIMPLICITY RULES OK

WHAT DOES SIMPLICITY GIVE US?

- Lower capex
- Lower opex
- Less manpower
- Less working capital
- Lower logistics requirements
- Quicker commissioning and ramp-up
- “Automatic” plants rather than “automated” plants
- Less unit process complexity = less circuit vulnerability
- Higher overall plant utilisation
- Easier process control
- Easier operational training
- Improved safety
- Improved security

BEST BUSINESS SOLUTION

HISTORICALLY DIAMOND PLANTS WERE DESIGNED ON THE BASIS OF PROCESS ENGINEERING EXCELLENCE. THIS FOCUSED TOO MUCH ON MAXIMUM DIAMOND LIBERATION AND RECOVERY RATHER THAN THE DEFINING THE OPTIMAL MIX OF TECHNICAL AND FINANCIAL SOLUTIONS

DIAMOND MINES AND PLANTS MUST NOW BE DESIGNED FOR
BUSINESS EXCELLENCE

TANGIBLE RESULTS NOW

PPM HAS USED THE ABOVE CONCEPTS IN A NUMBER OF DIAMOND PROJECTS: WHAT WAS ACHIEVED?

- Capex reduction of ~50% compared to conventional plant design for the same functionality
- Opex reduction of ~40%
- Project construction and commissioning: ~30% reduction in time to nameplate production levels

THE “ONE AFTER NEXT PLANT”?

WHAT WILL THE LONGER TERM FUTURE HOLD?

- **Diamonds within kimberlite detection (DWIK)**
This has been tested since the 1990's yet is still elusive
Expect some breakthroughs in the not too distant future
- **Electro pulse disaggregation (EPD)**
To liberate the diamonds detected by DWIK
It works, but can it be made economic and continuous production friendly?

WHERE NEXT?

PPM BELIEVES THAT THE PRINCIPLES OF SIMPLICITY, WHICH HAVE PROVEN TO BE SUCCESSFUL IN THE DIAMOND INDUSTRY, CAN BE APPLIED TO OTHER MINES AND COMMODITIES.

THIS IS CONSIDERED TO BE AN ESSENTIAL PART OF THE NECESSARY MOVE TOWARDS A MORE PROFITABLE GLOBAL MINING INDUSTRY, AS WELL AS A MORE ENVIRONMENTALLY FRIENDLY ONE.