Reducing Blasthole Drill Carbon Footprint

Using Intelligent Compressor Control

SANDVIK

Environment, Health & Safety
always first

- Safety first everywhere for our equipment in use and in our own organization
- Our aim is to achieve zero work related injuries and illness

EHS leadership from all employees

Risk based EHS management systems

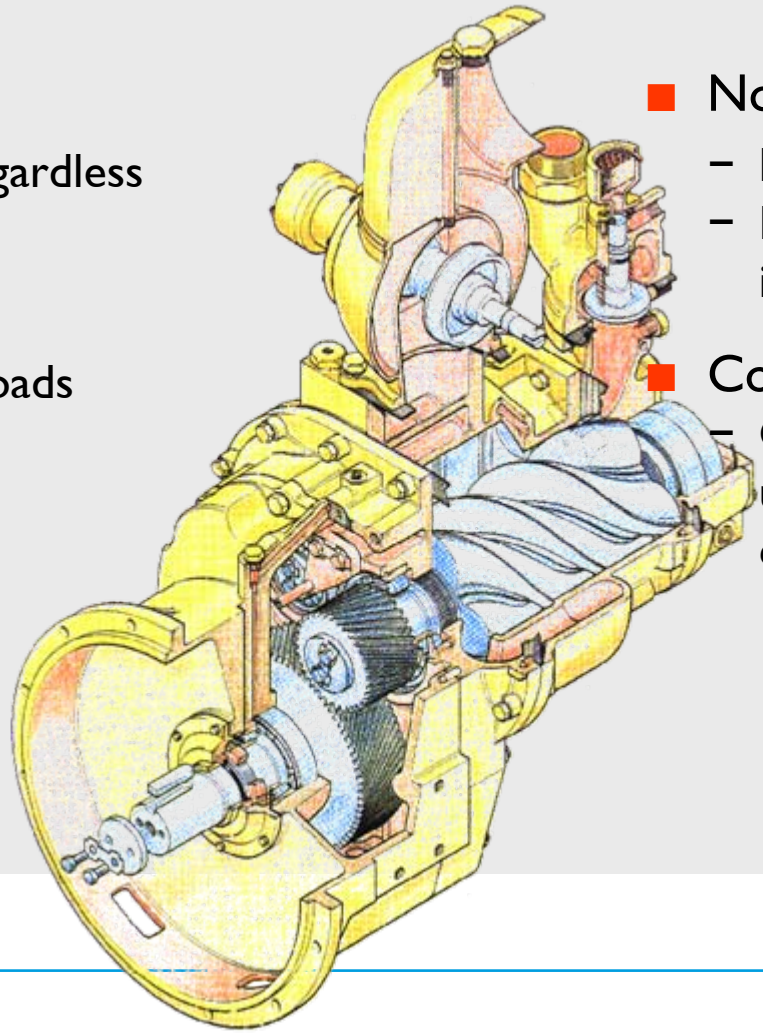
Certification to OSHA 18001 & ISO 14001

Sustainable and continuous improvement

Status quo. . .
wasted air

TODAY

- When drilling
  - Maximum volume regardless of drilling condition
- When not drilling
  - Maximum pressure loads engine for no benefit



WHY?

- No compressor clutch
  - Power robbing
  - Inherently high-service item
- Compressor lubrication
  - Oil in the receiver air tank used to lubricate the compressor bearings

Case study
Drayton Coal Mine

- Sandvik DR460 blasthole drill retrofitted with CMS
  - Machine 18 months old
  - 229 mm (9”) hole size
  - 194 mm (7 5/8”) pipe size
  - Engine CAT C27, 638 kW (855 hp)
  - Compressor 56,6 m^3/min (2000 SCMF)
  - Nominal uphole velocity 81 m/s (16 000 ft/min)
- 2000+ hours of CMS operation

Anglo American site
Drayton Coal in the
Hunter Valley NSW

Challenging site conditions

- Drayton coal has a complex strata structure ranging from soft clay tertiary deposits that become easily saturated, conglomerate layers, oxidised coal, silt stone to a hard diorite intrusion that intersects the strata. The geology is quite faulted and folded

Key results
Drayton Coal Mine

- **Engine load factor when drilling**
  - Reduced from 78% to 53%
- **Net fuel savings**
  - Saving 44,9 l/hr (11.9 US gal/hr) or 800-900 l/day (211-238 US gal/day)
- **Reduced CO_2 emissions**
  - Estimated to be 8000 tonnes/year (8800 tons/year)
- **Re-rated engine to Class C from Class B**
  - Potentially doubles life between rebuilds (from 1,2 to 1,6 million liter to rebuild)
- **Extended service interval**
  - Changing to "on condition" rather than scheduled

Estimated fuel saving for this machine: 300 000 liter @ AUD 0.75/l = AUD 225K operating at 6700 hours/year

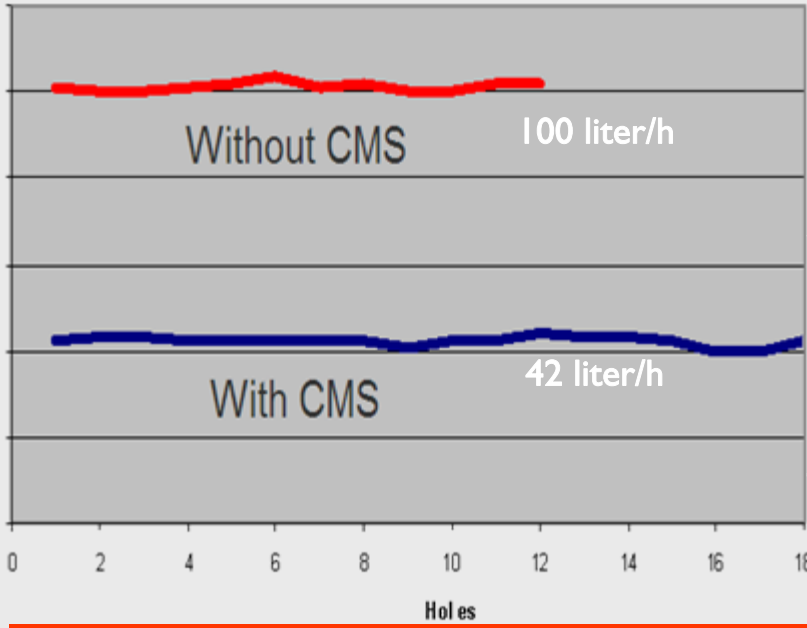
Functionality
at start-up

- WITHOUT CMS
  - Starter motor cranks both engine and compressor
  - Compressor produces air immediately and builds to full pressure, stalling the engine.
  - Engine start-up can be very difficult and require "bleeding" the receiver tank before trying again … and again
- WITH CMS
  - Intelligent starting process minimizes start-up compressor load
  - Compressor produces *no* air until engine reaches idling speed (1190 rpm)
  - Builds 3,5 bar (50 psig) pressure in receiver tank
  - Activates evacuation pump and off-loads compressor
  - Air/oil mix in receiver tank lubricates compressor without parasitic load

Ideal for cold weather or any difficult start-up conditions

CMS functionality
when *not* drilling

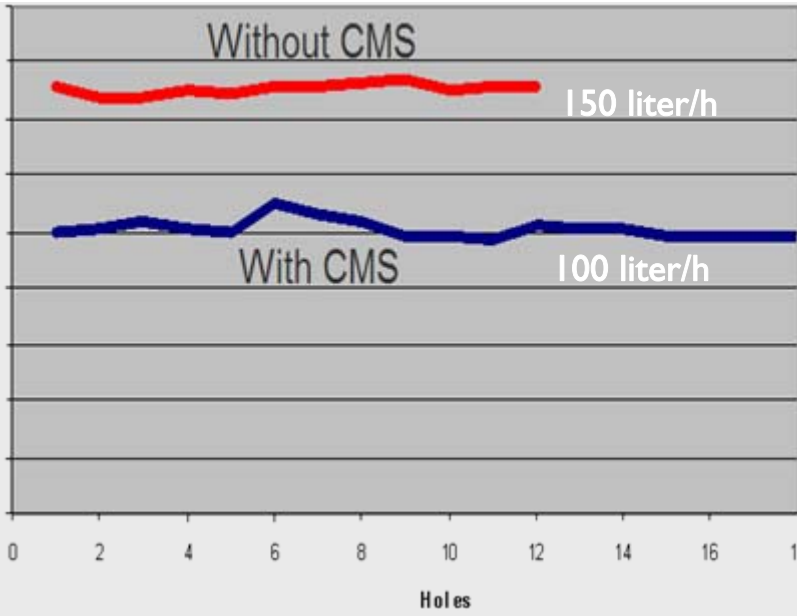
- **Isolates receiver tank**
  - Check-valve isolates pressure in tank from main compressor
- **Cuts off air intake**
  - Closes air intake valve to main compressor
- **Creates vacuum in main compressor**
  - Hydraulically driven evacuation pump extracts all air from main compressor
  - "No-load" eliminates cooling needs of main compressor
  - Stored air/oil mix in receiver tank continues to lubricate compressor bearings
- **Saves fuel**
  - Dramatically saves fuel when idling, tramming, setting up, or adding/racking pipe
- **Cool shut-down**
  - Allows engine to cool off quickly before shut-down
  - Reduces turbo charger failure from hot shut down



58% fuel reduction on DR460 at Drayton Mine

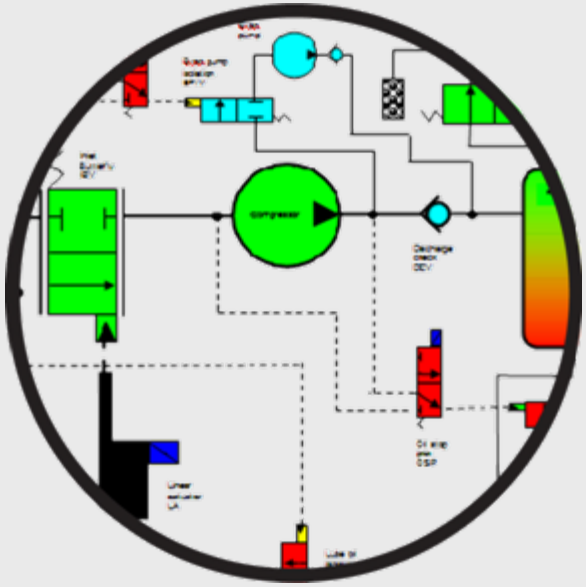
CMS functionality
when drilling

- **Opens compressor intake and outlet**
  - System produces compressed air in seconds
  - Instantaneous flushing delivered by air stored in receiver tank
- **Precise air volume delivery**
  - CMS system opens butterfly intake valve to the exact correct angle
  - Compressor delivers the pre-determined correct amount of flushing air
- **Anti bit/hole blocking feature**
  - Multiple sensors track air pressure
  - Butterfly valve dynamically controlled
  - Air volume automatically increases and decreases in response to back pressure



33% fuel reduction on DR460 at Drayton Mine

PLC
functionalities



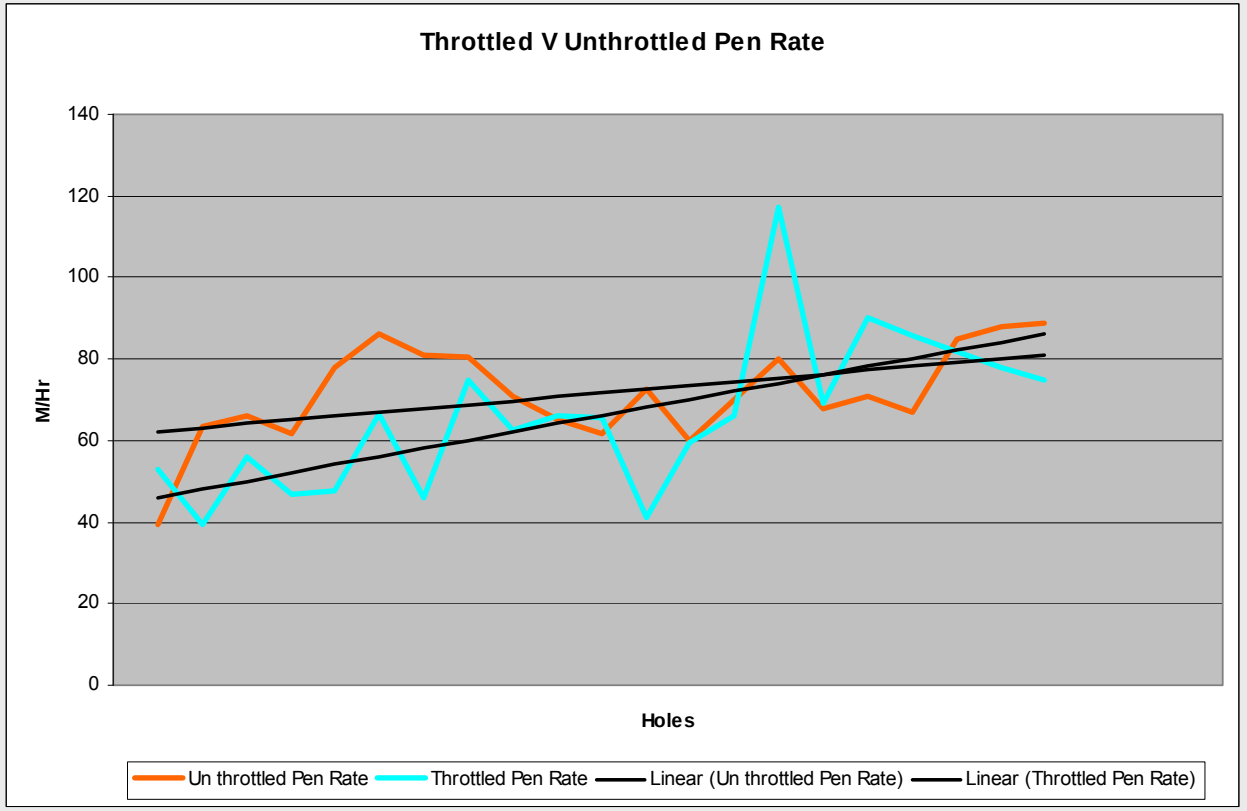
- **Fully automated**
  - Allows continuous optimization without operator interjection
- **Infinitely adjustable**
  - Always adjusts air intake valve settings to allow the optimized flow
- **Stability (no "hunting")**
  - Matches air supply with demand
- **Instantaneous reaction**
  - Alters air volume based on multiple feedback from system pressure sensors
- **Provides continuous feedback to operator on down-hole conditions (how CMS is responding)**

Determining optimum
up-hole velocity

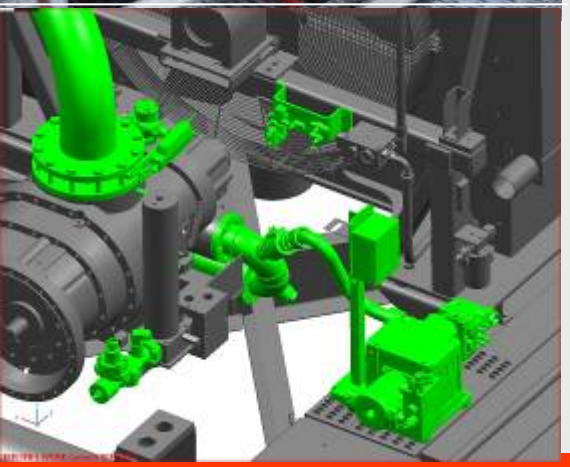
- **Purposes of flushing air**
  - Keeping the drilling face clean
  - Cooling the rotary bit bearings
  - Bailing rock cuttings to the surface
  - Clearing water, clay, and unconsolidated material
- **Is more air always better?**
  - *NO*. 2,8 bar (40 psi) pressure on the rotary bit is enough. The nozzles on the rotary bits can be replaced to function correctly.
  - *NO*. 20 to 40 m/s (4000 to 8000 ft/min) is normally enough. If this keeps the hole clean, higher velocity is a waste.
- **Anti-blocking protection**
  - The optimum operation is to use a "low" nominal flow for standard conditions
  - Extra air capacity is an "insurance" against getting stuck
  - Critical to this functionality is automation and response time

Impact on
penetration rate

- No loss
  - Training required
  - Works best without operator interference
- Sufficient flushing to maintain a clean hole
- Drayton record for meters drilled in 12 hour shift broken a number of times using CMS
  - >1000 meter



Retrofit
installation



Main components not including wiring and hosing

- Machine audit
- Custom engineered system
- Control module
  - Graphical User Interface (GUI)
  - PLC with software
  - Digital data bus
- Compressor inlet and actuator
- Evacuation pump and motor
- New piping, valves and hosing
- Certified installation
- Operator and maintenance training

Engineered solution

- **CMS not an off-the-shelf "product"**
  - A custom engineering project for each drill
  - Various iterations of engines, compressors, valves, and machine layouts
- **Managed introduction**
  - Currently available for D90KS and DR460 drills
  - Initial installations in Australia
  - Availability roll-out for other models and regions in 2011

Compressor Management System (CMS)

- **Benefits of reduced engine load are**
  - Easier starting
  - No hot shut down
  - Reduced fuel consumption (up to 40%)
  - Reduced carbon foot print (8000 t/yr)
  - Increased service interval
  - Longer component life
- **Additional CMS benefits**
  - Reduces drill bit and drill pipe wear
  - Minimizes dust and noise
  - Less infrastructure (fuel/water trucks)

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