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Changes in Drilling Performance and Dust Suppression with the Use of a Water Separator Sub

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CHANGES IN DRILLING PERFORMANCE AND DUST SUPPRESSION WITH THE USE OF A WATER SEPARATOR SUB

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ABSTRACT: Drill and blast is a key excavation process in open pit mining systems. Rock fragmentation due to drilling results in the production of fine dust particles that can be detrimental to the environment. There are different methods to manage the dust make often based on some form of "wet" drilling which can cause further issues. The water separator sub is a device aimed at overcoming some of these issues. This paper outlines a study undertaken of the effect of a water separator sub on drill performance and dust suppression. The study involved collecting dust measurements through a real time dust monitor, and analysing drill performance data from a mine site, in particular drill penetration rate data and bit life.

INTRODUCTION

Depending on the type of rock being drilled, drilling can be a source of harmful dust that is detrimental to human health (Kalestone Environmental, 2011). Current dust suppression techniques have pitfalls in terms of productivity, health and safety and environmental sustainability.

The water separator sub shown in Figure 1 is a device that replaces the bit sub in the drill string. It is designed so the combination of water and compressed air that is directed down through the centre of the drill string takes a sudden sharp turn before the drill bit. Due to the higher inertia of water particles, the water is unable to negotiate the turn and is physically separated from the air (USBM, 1988). The air continues its flow and makes it way through the U-turn flowing through slots to the bit. The water accumulates in a small reservoir and the air pressure forces it to be ejected out of weep holes located above the bit as a fine spray as shown in Figure 2 (NIOSH, 2012). The compressed air that exits the drill bit forces the fragmented drill cuttings up the hole and then mixes it with the water spray carrying the wetted material to the surface (Listak and Reed, 2007).

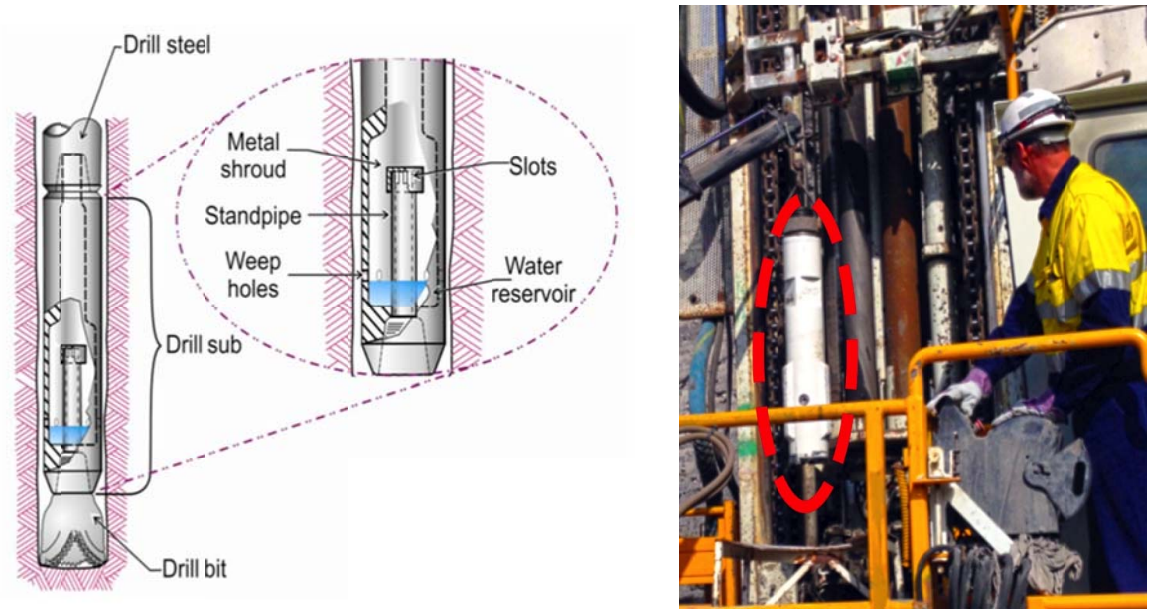

Figure 1: Schematic of water separator sub in a blasthole (NIOSH, 2012) (left) and, installation of the sub (right)

The water separator sub has the potential to utilise the advantages of wet drilling in terms of dust suppression. This contributes to sustainability of the mining industry by allowing drilling operations to occur, without posing a threat to human health and the environment. Minimising dust also benefits a mining operation's social license to operate. Dust can be irritating and worrying to surrounding

communities, even if the particular dust particles are not harmful. It can result in complaints and resistance from communities to any future development or extension of operations. Dust can also be extremely problematic for visibility. It can cause operations to be halted, resulting in lost production. Suppressing dust at drilling operations will help reduce dust make at a mine site and contribute to ensuring production is maintained.

Figure 2: Water spray from weep holes in side of the sub above the drill bit

The water separator sub also has the potential to lower drill bit costs. Preventing water from coming into contact with the drill bit can extend bit life by preventing corrosion and premature bit wear that is associated with standard wet drilling. If drill bit life is extended, bits do not need to be replaced as often reducing downtime and therefore lowering costs. This contributes to sustainability as companies are always looking for ways to lower operating costs in order to mine economically in deep pits and in tough markets.

METHODOLOGY

The project involved a field study at an openpit coalmine operating in the Hunter Valley of Australia. Data related to bit life and penetration rate and, measurements of dust levels were analysed over a period of several months before and after a water separator sub was installed.

RESULTS

Dust levels

Dust monitoring was conducted to compare the effect of wet drilling on dust suppression with and without use of the water separation over a six-day period. A Dust Trak II Aerosol Monitor mounted on the surface near to the drillhole collar as shown in Figure 3 was used in the study. The unit utilises a light-scattering laser photometer to provide real-time aerosol mass readings every 30 seconds and reports the instantaneous dust concentration in air in units of mg/m^3. Figure 4 shows a plot comparing the dust readings for the same time period for the three days before and after sub installation that indicates there were more instances of high peaks readings before sub installation.

Figure 3: Dust monitor in use during drilling operations

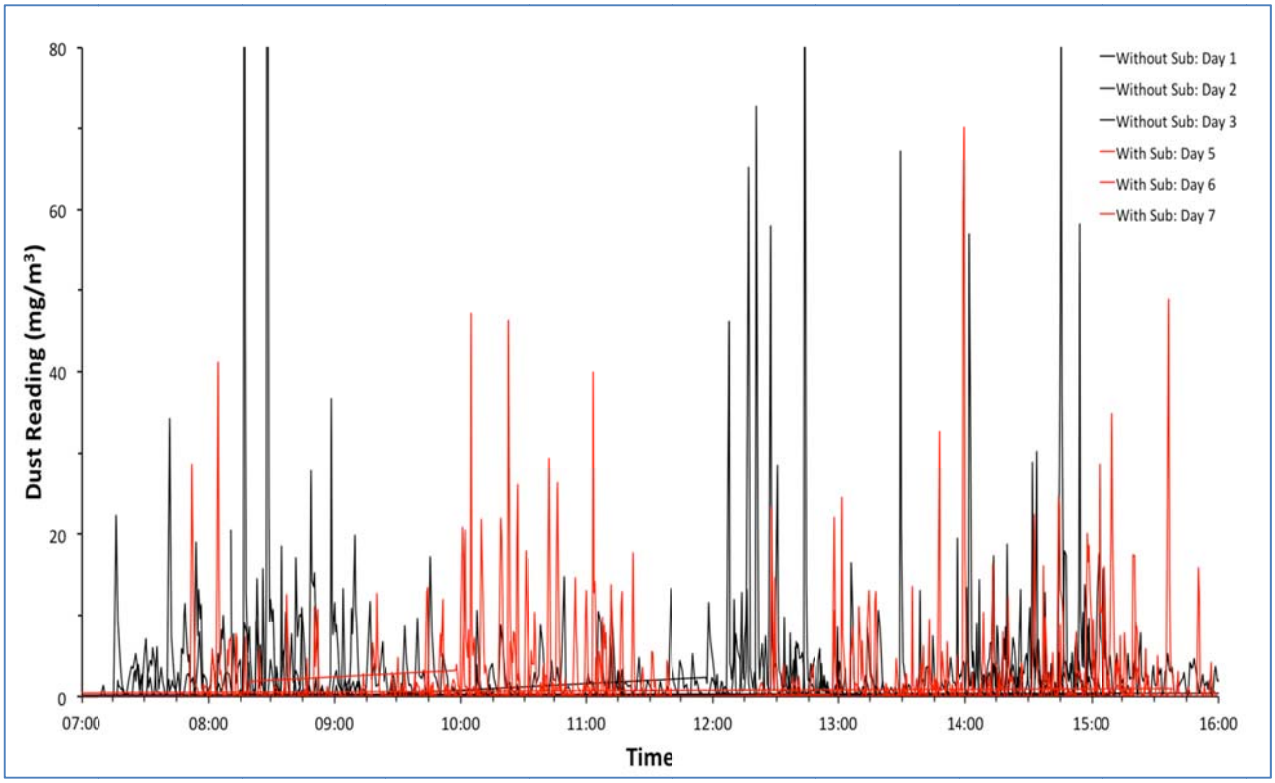

Figure 4: Variation in dust readings before and after sub installation

Table 1 shows a summary of the mean and maximum readings on each day of monitoring. While use of the water separator sub in wet drilling resulted in a slight reduction in the mean daily dust readings of 12%, there was a near halving in the maximum daily dust readings.

Table 1: Comparison of dust readings over a six-day period

		Dust reading (mg/m³)	
	Day	*mean*	*maximum*
no water separator	1	1.99	65.3
	2	4.24	159.0
	3	2.08	98.6
	mean	**2.77**	**107.6**
water separator installed	5	3.65	70.3
	6	1.16	49.1
	7	2.48	35.0
	mean	**2.43**	**51.5**

On Day 4, dust monitoring commenced at 8:00 am with wet drilling prior to installation of the water separation and continued until the water separator was installed at approximately 9:30 am. Dust monitoring then continued until 3:30 pm, utilising water separated wet drilling. There was a noticeable reduction in the dust levels after the sub installation with more consistent and fewer peaks in dust make post installation as shown in Figure 5.The results in Table 2 compare the mean, minimum and maximum readings before and after the sub was installed.

The significance of this data set is that it applies to the same set of conditions in terms of rock type, drill machine, drill bit, operator and weather conditions. As the data indicates there was a reduction in the mean reading by 0.81 mg/m^3 or 25%, the minimum reading decreased by 0.027 mg/m^3 or 47%, and the maximum reading decreased significantly by 17.9 mg/m^3 or 37%. This shows that on this day with all other variables being the same, use of the water separatorsub increased the effectiveness of wet drilling in reducing dust make.

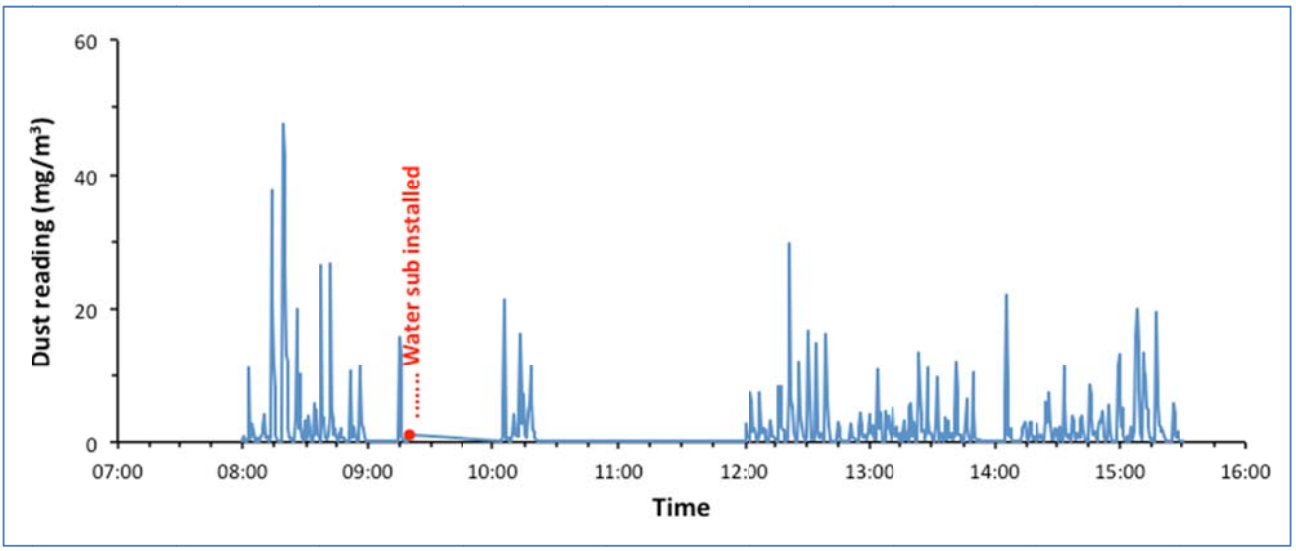

Figure 5: Variation in dust readings before and after sub installation on Day 4

Table 2: Effect of water separator installation on dust make

	Dust reading (mg/m³)		
	mean	*minimum*	*maximum*
before installation	3.19	0.057	47.6
after installation	2.38	0.03	29.7
percentage change	25%	47%	37%

Dust monitoring limitations

While it was planned to maintain similar conditions with the water separator sub during the study, in reality a number of changes occurred and differences in operating conditions that may have impacted on the measurements.

First, the drill rig used in the study was fitted with a dust curtain and collection system. It was observed that there were differences between drill operators in the use of this system.

Second, the water flow rate was not fixed but varied by the operator depending on the ground conditions and the amount of visible dust present.

Third, the drill rig was moved between drill sites after three days into the study. It was initially planned that the drill rig would remain in the same location for the duration of testing, however due to scheduling changes, drilling was completed prematurely and the rig relocated. This is likely to have introduced differences in geological ground conditions. This factor does not apply to the data in Table 2.Finally, weather conditions such as temperature, wind and humidity can also affect the amount of dust generation. Dry, hot and windy days will see an increase in the amount of dust present in the air. It was observed during the period of study that drilling operations occurred on fine, sunny days with minimal wind. Even so any small gust of wind may have affected the readings depending on the location of the dust monitor and wind direction. For example, if a wind gust was in the direction of the dust monitor it may have temporarily resulted in a higher measurement, conversely if the wind gust was away from the dust monitor it would have reduced the dust measurement.

Drill penetration rate

The mean daily drill penetration rate per shift was analysed over a nine month period prior to installation of the water separator sub and six months post installation. Histograms of the respective performance are shown in Figure 6 and various statistics summarised in Table 3. A comparison of the results for both cases shows there were reductions of 10.4% and 8.8% in the median and mean penetration rates respectively. The use of the water separator sub had been expected to increased penetration rate by

removing water from the point of rock breakage, however the data indicates the opposite seemed to have occurred.

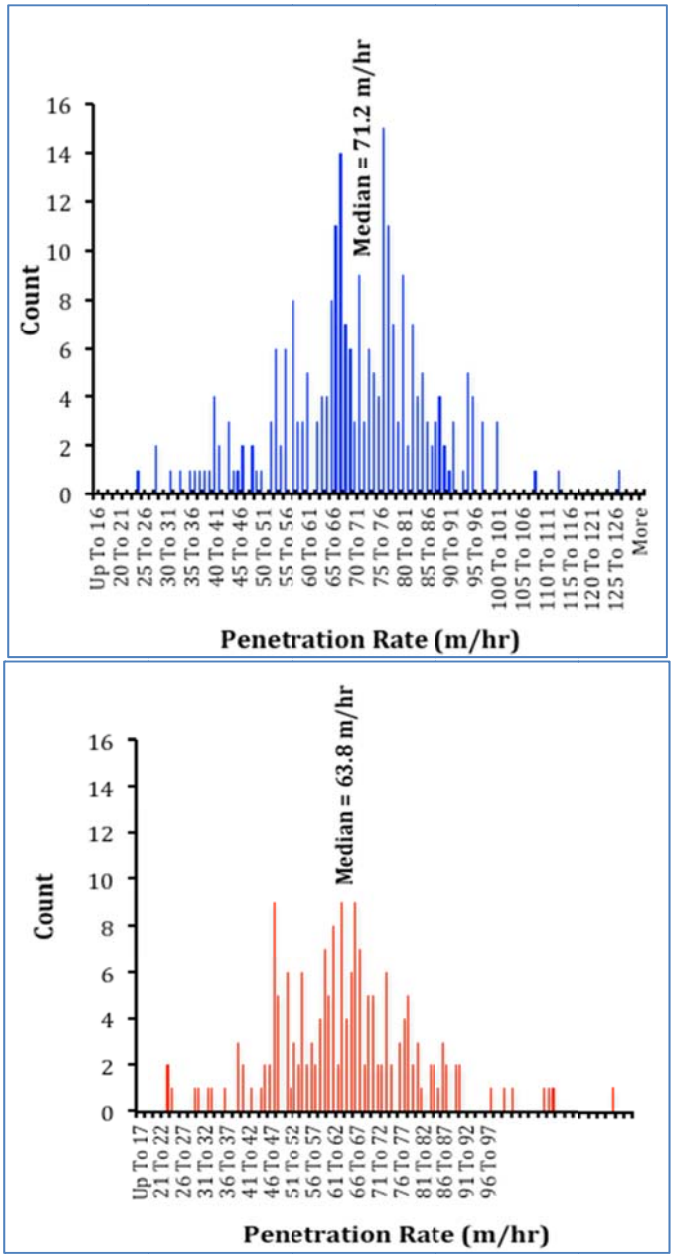

Figure 6: Mean daily drill penetration rate before sub installation (left) and after sub installation (right)

Table 3: Comparison of the drill bit penetration rate before and after sub installation

	Daily penetration rate (m/hr)		
	median	*mean*	*s.d.*
before installation	71.2	70.4	16.9
after installation	63.8	64.2	16.4
percentage change	10.4%	8.8%	–

Penetration rate data limitations

A problem in analysing penetration rate data is that it is reliant on operator efficiency. Each operator's experience and drilling performance will influence penetration rates. This factor could have accounted for

some variance in the results. On the other hand, considering the size of the two data sets, this is less likely to be a contributing factor. Nevertheless during the period of study, a number of new drillers were employed and, due to the large number of operators at the mine as well as the number of drill rigs, there may have been differences in the actual operators between the two periods.

Another issue is variation in ground conditions. Numerous drill sites can result in variations in the material properties of the overburden material. Factors such as strength, hardness and abrasivity of the rock and moisture content all present the potential to alter penetration rates.

Drill bit life

Bit life was examined over similar periods as penetration rate before and after installation of the water separator sub. The data analysed for drill bit life was based on the metres drilled per bit from the time a bit was first mounted to being dismounted. This was chosen as simply measuring the period during which a bit was used and does not take into account time delays for crib breaks or maintenance, nor does it consider lower penetration rates due to harder rock beds. Table 4 shows a comparison of the mean, minimum and maximum metres drilled per bit before and after sub installation. The mean bit life was found to have increased significantly by 58% after the water separator sub was installed. The improvements in the minimum and maximum values were 78% and 71% respectively.

Table 4: Comparison of the drill bit life before and after water sub installation

	Number of bits	*Bit life (m/bit)*		
		mean	*minimum*	*maximum*
before installation	13	13,326	6,743	26,230
after installation	8	21,060	12,039	44,854
percentage change		58%	78%	71%

Drill bit life limitations

A limitation on the reliability of the data is the variation in ground conditions. As is the case for penetration rate, drilling operations would have occurred between locations in the pit resulting in different drilling conditions with changes in rock strength, hardness and abrasivity.

Another factor that may have impacted on bit life is the operator decisions on what constitutes a worn-out drill bit. Although there are strict guidelines on what constitutes a worn bit, if a bit was used past its optimum point then it would have skewed the results towards appearing to have improved drill bit life and conversely if changed too early.

CONCLUSION

The impact of a water separator sub was examined in terms of changes in dust make, drill penetration rate and drill bit life. Water is injected into the compressed air line that is used to bail rock fragments from the bit face in order to reduce the amount of fine dust produced at the drillhole collar. Over a three-day period both before and after installation of the sub, there was little significant change in the measured dust levels. As the drill rig was moved before and after installation this may have consequently resulted in changes in drilling conditions and may have masked any improvements. Interestingly, a 25% reduction in dust make was measured post installation on the actual day the sub was installed. It is recommended that a further study be undertaken over a much longer time period to confirm the impact on dust levels.

The average daily drill bit penetration rate and bit life were analysed over a nine-month period before installation of the sub and a six-month period after installation. It was found that there was a reduction in the median and mean penetration rates by 10.4% and 8.8% respectively. Conversely, the sub had a marked beneficial effect of increasing bit life over the period studied of 25%.

Overall, while installation of the water separator sub was not found to have had any significant impact in the measured dust levels on the surface near the drillhole collar, it had a slight detrimental impact on penetration rate while it had led to a significant improvement in extending bit life.

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