PUT TO THE TEST

Andy Hudson, Greg Smith and Stuart Brashear, Dyno Nobel, USA, discuss the company's software analysis system being put to the test to help reduce vibrations during cast blasting.

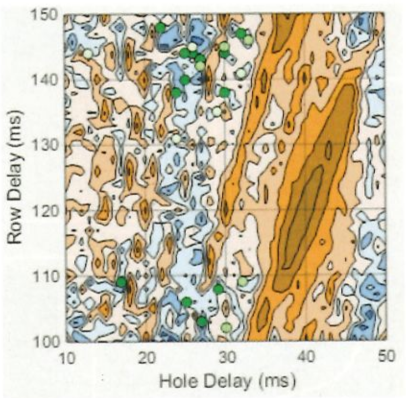
Explosives manufacturer Dyno Nobel has developed a software, DYNO 42™, that simulates the most effective delay sequences in order to produce the most efficient blasts depending on the customer's needs. The results of the programme are analysed by highly trained DynoConsult® team members. Recently at a Western opencast coal mine, a Mid-Atlantic limestone operation and a granite quarry in the Southeast US, this programme was put to the test.

Case study one

At the Western opencast coal mine, cast blasting is the blasting technique most commonly used. It is done in all dragline pits. Bench heights range from 150 – 200 ft. The geology consists of clay, shale, sand, coal rider seams and occasional rock lenses. Water conditions vary from dry to severe.

Due to the above-mentioned conditions coupled with sleep time from start of loading to blast time, highwall deterioration may occur. This poses a hazard to those working under the wall during the coal drilling, blasting and removal of materials. Damage to the highwall from blasting is often cited as a contributing factor to highwall instability. The mine was faced with a complicated situation because it needed quality casting along with vibration control.

In an effort to minimise highwall damage associated with blasting operations, vibration reduction has been sought as a means to reduce damage to the new highwall created by each cast blast.



Visual comparison of delay timing to desired results.

Before the use of DYNO 42, delay sequences were chosen based on giving good effective cast performance. No thought was given to the effect on the highwall. The impact of vibration was only addressed if there were engineered structures, such as power transformer stations or gas wells, in the area.

Previously, peak particle velocity (PPV) was typically the only vibration measurement that was considered. With DYNO 42, particle displacement can also be reviewed with respect to influence on final highwall conditions post blast.

A signature hole was shot for analysis to achieve a baseline. After shooting a signature hole, two test blasts were conducted using different methods to minimise vibration and particle displacement. One blast was derived from DYNO 42 software analysis with a priority of reducing overall vibration and displacement while still maintaining nominal cast results. The second blast was shot using progressive timing that was chosen for maximising cast with no regard to resultant vibration effects near field or far field. In order to identify the most effective timing sequence that would provide needed cast with the lowest vibration, side-by-side test shots were fired with seismographs 523 ft behind each blast for comparison.

The first shot using the DYNO 42 software had a PPV of 7.84 in./sec. with a displacement of 0.40 in. The second shot using progressive timing had a PPV of 9.84 in./sec. with a displacement of 0.52 in. There was no appreciable difference in effective cast benefit. The results of this test indicated an approximate reduction in peak particle velocity and associated particle displacement of 20%, again with no discernable impact on effective cast.

The analysis results from DYNO 42 provided the most effective cast blast for this customer. The mine and Dyno Nobel will continue to use and analyse results from DYNO 42. A quantitative study of highwall stability based on p-wave attenuation hole-to-hole is planned for future blasts.

Coal casting.

Case study two

DYNO 42 was the solution to another customer's concerns at a Mid-Atlantic limestone operation. These concerns were over the offsite impact of transient ground vibration and potential complaints associated with blasting. With the help of DynoConsult, the company used Signature Hole Analysis (SHA) for determining initiation timing for all production blasts employing electronic initiation.

Over time, as distances and vectors between production blast events and neighbouring properties change, the signature waveform employed to derive optimum timing sequences was no longer valid. As a result, transient ground vibration amplitude began to increase faster than the expected rise due to reduced distances and attenuation between blast events and seismic monitoring locations. Additionally, the frequency spectra for vibration events changed more than expected.

To ensure optimum results for the use of electronic initiation and to ensure minimum offsite impacts from blast events, it was recommended that a new series of single hole test shots be fired. The test shots are used to update the base waveform data used in conjunction with the DYNO 42 Vibration Control software to minimise vibration effects offsite.

Over a period of time, additional signature waveform data was collected from new test holes fired in close approximation to current blasting operations. This data was then used in place of the original signature data.

The use of the new signature waveform data resulted in transient ground vibration amplitude values consistent with expected results, given the distance to neighbouring structures and the past effectiveness of employing timing sequences derived by DYNO 42. Frequency spectra associated with the vibration event also showed improved distribution towards higher frequencies, minimising the potential for adverse structure response and heightened perception of blast events.

The loss of active vibration control results serve to demonstrate the need for constant vigilance and assessment of blast results. Evaluation of transient vibration is needed to determine when signature hole data, used for determining optimum hole sequencing, is no longer viable and may even be detrimental due to outdated waveform characteristics.

Case study three

The third mine where DYNO 42 software came into good use was at a granite quarry in southeast US. This quarry's current drill patterns were a 13 x 13 with 3 ft of sub-drill using a 5.75 in. blasthole. The average pounds per hole was 598. The seismograph, measuring vibration, is located within 700 ft from the blast. SHA was being used to delay shots.

In the past, previous shots in this area (670 ft) produced a PPV of 1.06 at 55.6 Htz. Knowing there were several shots left in this area to remove the bench, the PPV was too high and a solution was needed to be reached to lower vibrations in the area.

DYNO 42 was used to come up with a delay that produces the best simulated PPV and frequency. TITAN® XL 1000G with a density of 1.10 was loaded in the blasthole along with DigiShot® electronic detonators. Sub-drill was reduced from 3 ft to 1 ft, and the goal was to reduce the vibrations in the area.

Due to the change in the sub-drill and the products applied, the seismic readings were greatly reduced from a 1.06 at 55.6 Htz to .57 at 83.3 Htz.

In the future, digging will be evaluated and continued sub-drill of 1 ft with the goal of no sub-drill.

Conclusion

Vibration control is a big concern for many different mines in many different industries. The development of DYNO 42 software, in conjunction with DynoConsult experts and SHA, is providing the technology needed to help understand how to better control vibrations. This technology is giving insight into getting the highest quality blasts while addressing neighbouring communities' concerns. It is just one of many different software solutions being developed to help reduce pain points in the industry.