Selection of Powder Factor in Large-Diameter Blast Holes

by
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1995

Abstract

This paper documents the relationship between material handling and processing costs compared to blasting cost. The old adage, "The cheapest crushing is done in the pit", appears accurate in this case study. Comparison of the accumulated cost of: powder, selected wear materials and electricity; indicate a strong, inverse correlation with powder factor (lbs powder/long ton of rock). In this case, the increased powder cost is more than offset by electrical savings alone. Measurable, overall costs decline while shovel and crusher productivity rise by about 5% when powder factor rises by 15%. These trends were previously masked by the effects of: weather, ore grade fluctuations and accounting practices.

Figure 1

INTRODUCTION

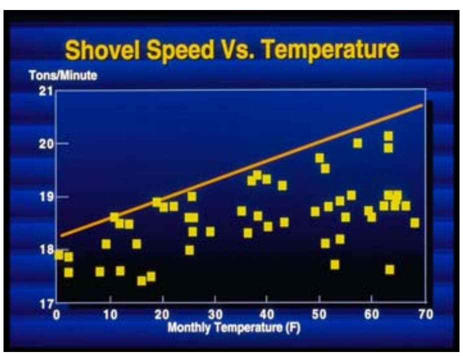

Figure 2

In metal mines where ore is reduced to a small size for concentration, excessive fines from blasting are not generally considered a problem. In these operations, powder factor selection should recognize downstream costs in both the mine and mill. Improved fragmentation accomplished in blasting not only reduces the workload in crushing and grinding but also improves loading rates and reduces maintenance in the mine. The cost of bulk blasting agents has remained roughly the same over the past decade (fig. 1) while drill bits, shovel wear parts, crusher liners, labor and electricity have risen. Even if blast designs were optimized in the past, today's cost picture requires a re-evaluation. Any discussion of blast optimization must consider mining and milling costs.

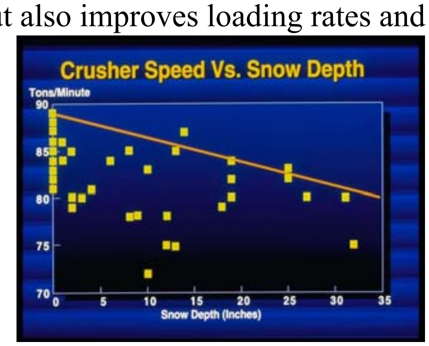

Figure 3

FILTERING NOISE FROM THE DATA

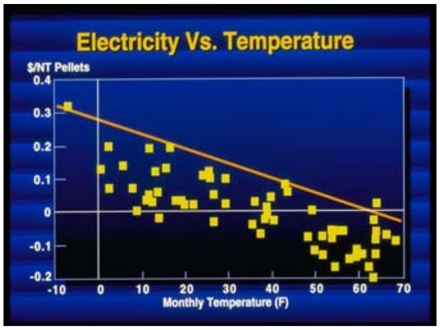

Figure 4

Since looking at 'the big picture' is the essence of optimization, it becomes necessary to identify and isolate those factors other than blasting that effect overall costs. If this is accomplished, then accounting monthly cost numbers can make engineering sense. This is an important distinction since grouping of cost by accounting areas of responsibility may not necessarily be appropriate for engineering analysis.

The following parameters were factored out:

- The lag between blasting and ore loading. Blasted rock does not all get loaded in the month it gets shot.
- The powder factor for waste rock was separated from the ore powder factor.
- Winter operations in Northern Minnesota experience higher costs and lower productivity. Shovel loading rates drop between 5 and 10 percent during winter operations.(fig 2) The primary crusher is hampered by low ambient temperatures and deep snow.(fig 3) The rock strength may actually increase due to low temperatures. The mine and plant electrical costs rise and fall along a quite predictable line from winter to summer.(fig. 4)
- Higher weight recovery ore makes all areas look better since less ore is needed to produce the same amount of concentrate. Ore grade affects total electrical cost.(fig 5)

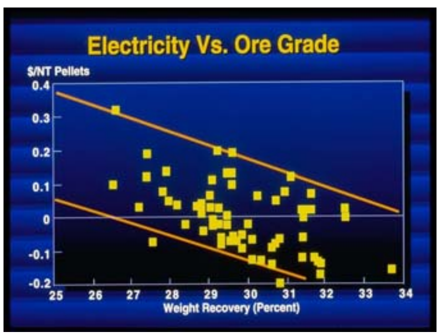

Figure 5

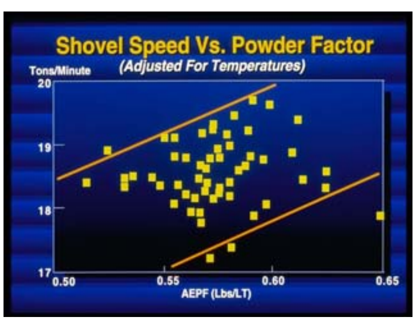

Figure 6

POWDER FACTOR EFFECTS ON COST AND PRODUCTIVITY

The next step is to apply seasonal and ore grade corrections to monthly productivity and cost results. Shovel speeds show a positive relationship to powder factor.(fig. 6) The upper and lower envelopes bracket a range of speeds representing a range of ore types and

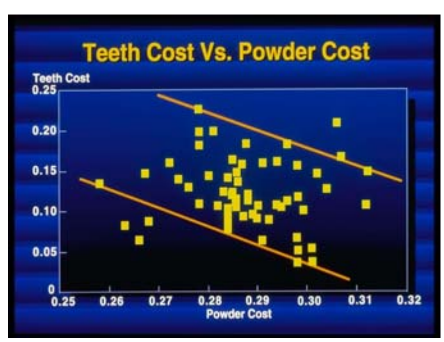

Figure 7

loading circumstances. The maintenance cost of the shovels is affected by powder factor. The cost of shovel teeth plus wear materials on buckets improves with higher powder expenditures.(fig. 7)

The effect on the primary crusher is to increase through-put as powder factor rises.(fig. 8) The last step in tracking powder factor is in the secondary and tertiary grinding and in milling. These processes consume the bulk of the electricity in the comminution of ore. With the effects of ore grade and ambient temperature regressed out, the cost of electricity drops when more is spent on blasting.(fig. 9)

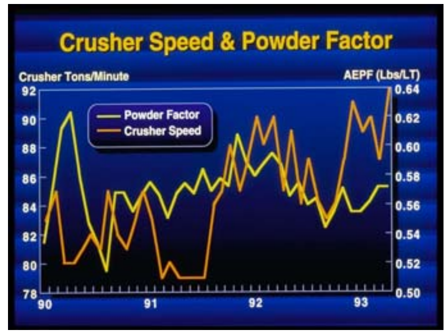

Figure 8

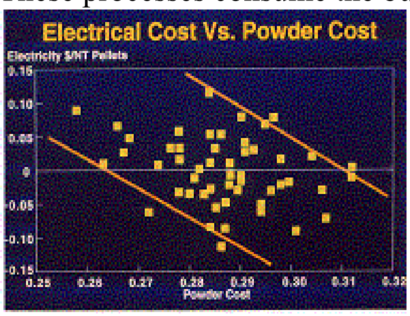

Figure 9

TOTAL COST COMPARISON

The accumulated cost of shovel teeth, powder and electricity shows the effects of under-blasting in the mine.(fig. 10)

The slope of the lower envelope may indicate up to a 3 to 1 cost payback on increasing the powder factor. The argument for a higher powder factor becomes even more compelling if the productivity of shovels and crushers are also considered.

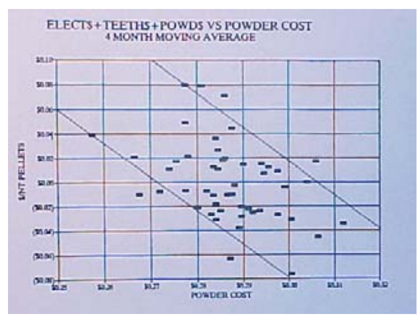

Figure 10

ANALYSIS

The first question one must ask is, 'Can the slope of the envelopes of the productivity and cost be believed'? The scatter in all of the plots is significant. In fact, the scatter should be no surprise to those familiar with iron ore. Where oxidation has softened areas to the consistency of clay; there is a stark contrast to rock that has +60,000 psi compressive strength. For confirmation of these trends one can look at work which has already established, if not already measured, the general shapes of the curves relating blasting to downstream costs. MacKenzie's work (fig. 11). almost 30 years ago(1965) was also done in iron ore. The slopes for

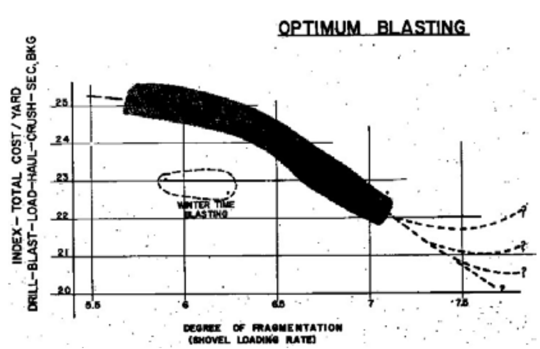

Figure 11

loading, hauling and crushing are in agreement with Minntac data The cost curves proposed by Gold(1987) also lend credibility to the argument for higher powder factors (fig. 12). Indihar(1991) reported a 30 percent increase in life of primary crusher concaves and a 100 percent increase in mantle life due to blast improvements.

CONCLUSIONS

The broad range of downstream costs for the same powder factor indicate that further study is necessary. However, the upper and lower envelopes of the data agree with theoretical modeling indicating the benefits of higher powder factors. If the trends described in this paper prove true, the following implications are of interest:

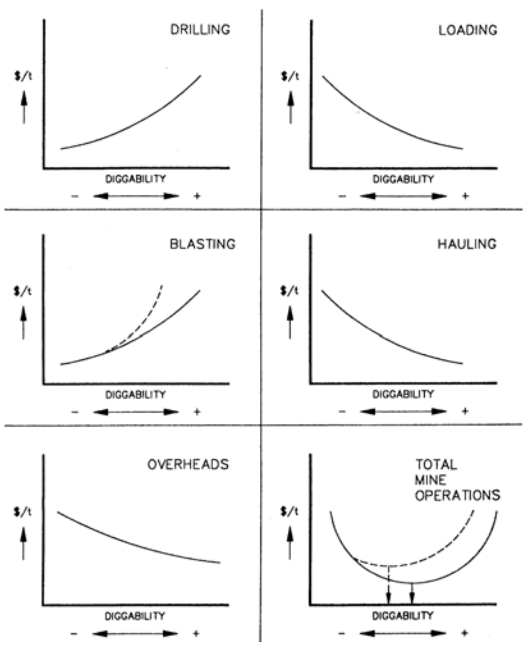

Figure 12

- Gassing blasting agents to achieve lower densities may not be not desirable.
- Anfo may not be a desirable product due to its low density.
- Higher powder factor has the benefit of no increased capital cost for higher productivity of mining and crushing equipment.
- Better stemming material or devices become more important if powder is brought higher in the hole.
- Higher crushing rates could increase crushing capacity or allow tighter close side settings which would, in turn, pass savings on to the grinding circuits.
- This approach could help optimize usage of electrical and explosive energy.

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