Downstream Costs and their relationship to blasting

by

Jack Eloranta

J Eloranta & Associates

8 June, 1999

Introduction

The purpose of this paper is to review the pertinent literature concerning the relationship between blasting and downstream handling and processing costs. The 9 listed studies are examined and reviewed. The proliferation of papers on this subject attest to the widespread interest in this long debated issue. So significant, it transcends not only drilling and blasting, but also mining, crushing and grinding. This subject is not a novelty that will simply pass away. It will ,instead, become the pole star that guides mines to optimized equipment selection and energy usage.

Kanchibotla

This work, done at JKMRC in Queensland, Australia, modeled blasting crushing and grinding at an open-pit, gold mine. Powder factors varied from .58 kg/m^3 to .96 kg/m^3. The attached graph shows the SAG mill electrical consumption for three blast designs.

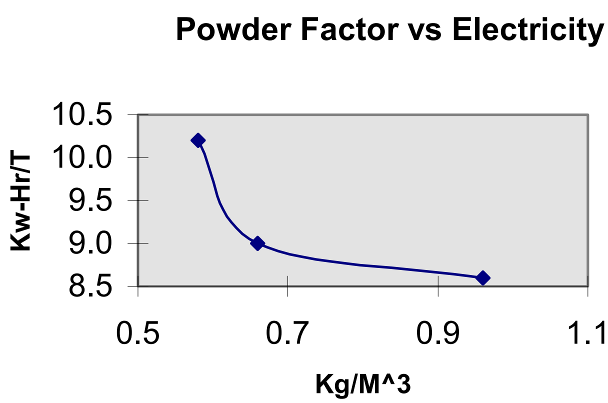


Figure 1 (Kanchibotla, 1998)

As powder factor rose from .58 to .66; there was a12% drop in kWh/t for grinding. (Fig. 1) However, a much larger powder factor increase, to .96 kg/m^3, netted only a small improvement. The higher powder factor resulted in fine material that flowed freely through the crusher which saw the savings instead of the mill. If the setting of the crusher was adjusted downward; the slope of the curve would remain steep.

Furstenau

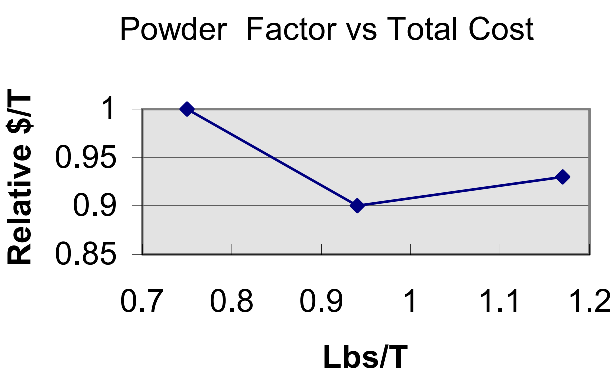


Figure 2

Full-scale blasting plus lab grinding and crushing tests were done on consolidated limestone. Blast effort was increased by 25% by increasing charge length and by 56% decreasing burden and spacing. (Fig. 2) A single particle roll mill and a small-scale ball mill were used for sample testing. A 10% overall savings was seen in total mining and processing with the longer powder column. A 7% savings was achieved with closer spacing and burden.

It appears that the powder factor was at .75 lbs/T in the reference area, .94 lbs/T in the increased column length zone and 1.17 in the reduced burden and spacing test. An optimum point may be inferred in the vicinity of .94 lbs/T, however, since there is latitude to increase column length; the highest powder factor could have been attained with less drilling.

McCarter

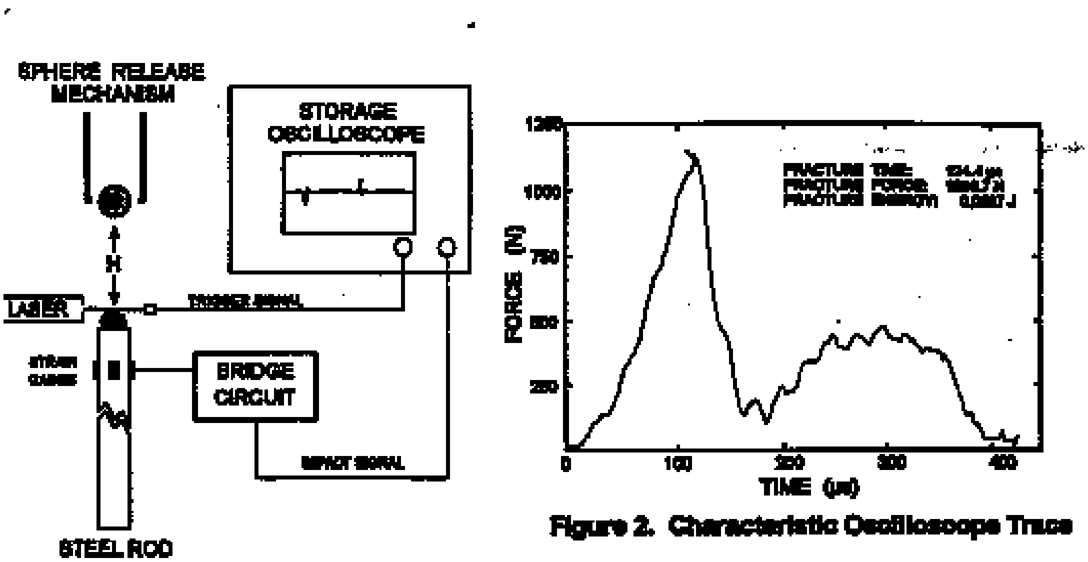


Figure 3 (McCarter, 1996)

This work employs a load cell device (UFLC) to measure the mean specific fracture energy (MSFE) of pairs of samples: one exposed to blasting, one not. Of the 7 rock types tested, 5 showed pre-conditioning benefits from blasting. Succinct statistics are provided. A casual statistical comparison indicates a 19% difference in MSFE from blasting.

Nielsen

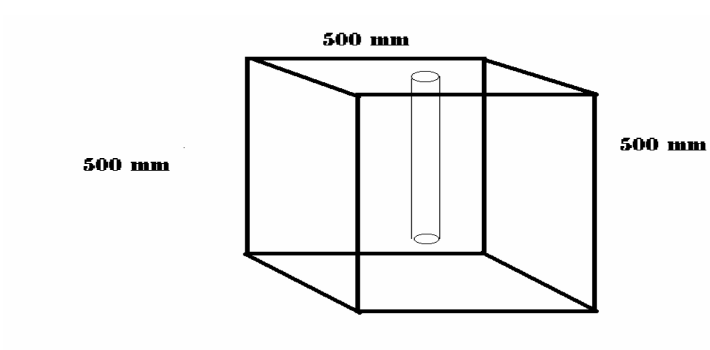


Figure 4 (Nielsen, 1995)

This work at the University of Trondheim in Norway involves grinding pairs of blasted samples; one from next to the blasthole and one from farther away. Variables included: rock type, blasting agent and grinding time. Samples were saw cut to 500 mm by 500 mm by 500 mm cubes which were drilled and shot. Fragments were collected and sorted into near-borehole and edge pieces. Samples were crushed to -8 mm and identical distributions were synthesized to feed a 250 mm ball mill. Bond work indices were calculated from these tests. Blast pre-conditioning reduced work indices to 36% to 88% of reference samples.

Mertz

Translation from Russian of work done at the GOK open cast experiment are difficult to interpret, but provide some tantalizing insights. Blast energy was varied from .8 kg/m^3 (.56lb/T) up to as high as 20kg/m^3 (14.0 lbs/T). Findings were published up to 5.5 kg/m^3 (3.9 lbs/T).

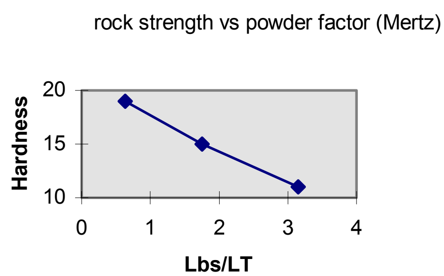


Figure 5 (Mertz)

Power consumption in crushing fell by 40% when the powder factor rose from .56 lbs/T to 3.15 lbs/T. Magnetic separation was used to recovery magnetite in the operation studied. The liberation of the ore was also improved due to micro-cracks between mineral boundaries formed during blasting.

MacKenzie

Alan S. MacKenzie did this ground-breaking work at the Lac Jeannine Mine in Quebec. Broad in scope and based on five years of operational data, his work forms the basis of many current investigations. Grinding costs are not considered, however.

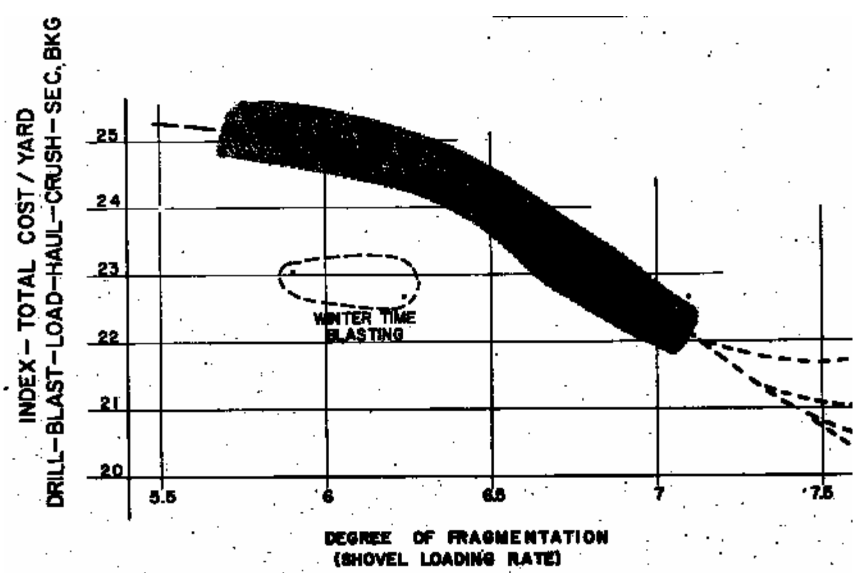


Figure 6 (MacKenzie, 1966)

Eloranta

Operating speeds and costs from more than five years of iron ore mining and processing in Minnesota are presented. Regressions are plotted to eliminate variables including ore grade and weather.

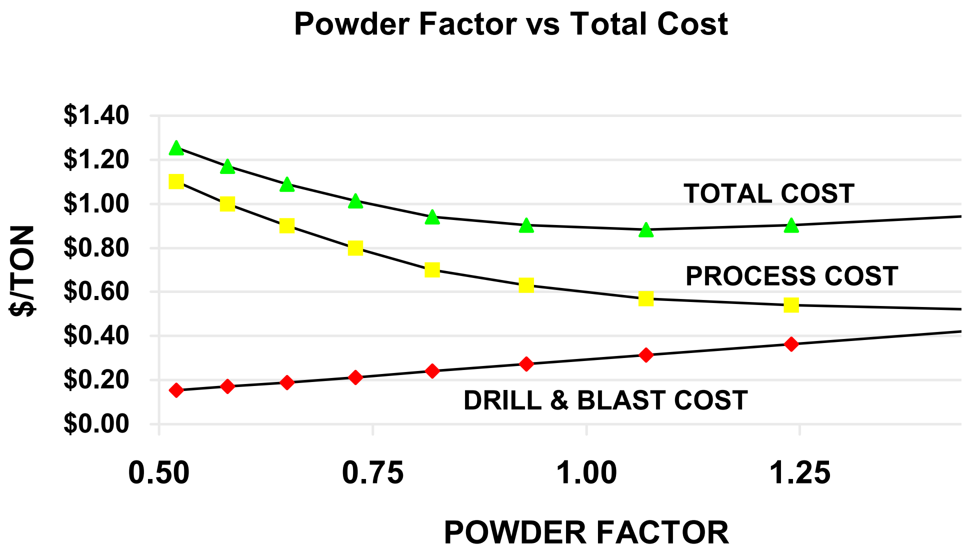


Figure 7

Total costs are compared to drill and blast costs and projected to higher powder factors.

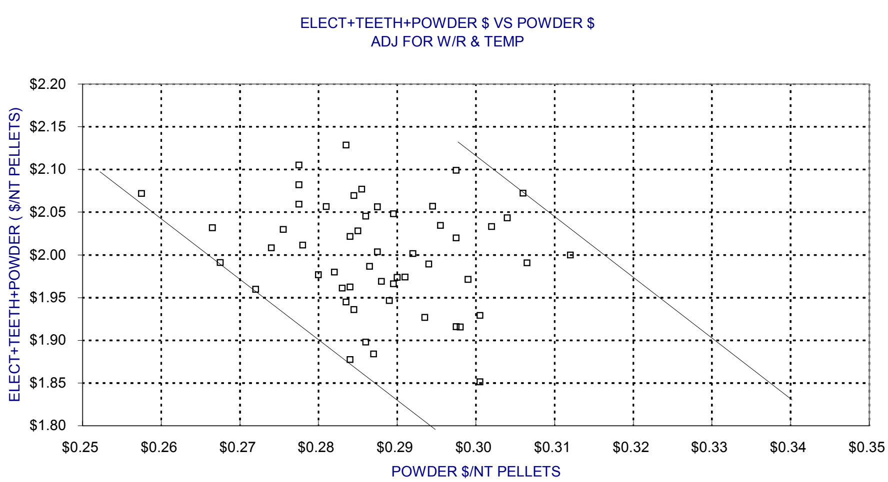


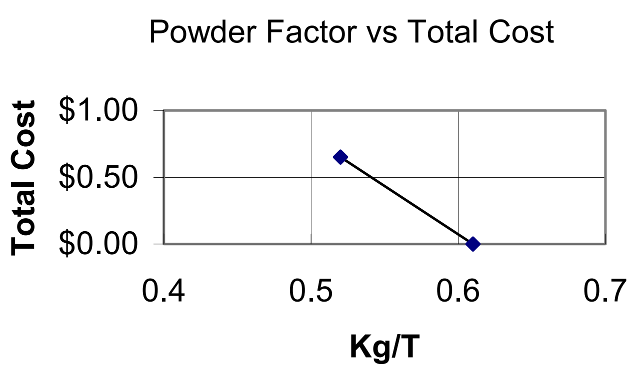
Figure 8

The assumption underlying the upper and lower envelopes is that an inverse relationship *does* exist between blasting and downstream costs and that the purpose of the plot is to shed light on the slope of that line. The broad scatter is due to seasonal changes, geological variations and large purchases in one month. Validation will require higher powder factor tests in the lower right portion of the data.

Kojovic

Very extensive studies were conducted at Mt. Coot-tha quarry in Brisbane, Queensland, Australia. With assistance from JKMRC, much more work was done than is summarized here. Changes in blast design were done by adjusting the burden and spacing alone. Powder factor went from .52 kg/m^3 to .61 kg/m^3. Some of the reported improvements were: a 25% increase in loading and handling productivity, saving $.40/T and a savings in crushing of $.30/T. Total savings were$.70/T less $.05/T due to increased blasting cost; for a net savings of $.65/T.

Figure 9
(Kojovic,1995)



Revnivtsev

This summary highlights but a few of the topics covered. Revnivtsev touches on many facet of mining and processing. He refers to studies which indicate the following:

- An optimum powder factor of about 2 kg/m^3
- “Selective disintegration’ whereby blast energy preferential breaks along mineral boundaries aiding liberation.
- ‘Healing’ of micro-cracks wherein rock regains strength following blasting

This summary highlights but a few of the topics covered.

Conclusions

Table 1 summarizes the results of the authors. It is clear that none have found an upper limit to powder factor. The apparent minimum in Furstenau’s data should be re-examined with an eye toward less drilling but a longer powder column.

Author	PF Range	Reduction	Parameter
Kanchibotla	.58 to .66	12%	Kwh/T
Furstenau	1.07 to 1.30	10%	Total Cost
McCarter	N/A	19%	MSFE
Niesen	N/A	12% - 64%	Kwh/T
Mertz	.8 to 3.9	40%	Kwh/T
MacKenzie	N/A	N/A	Mine/Crush
Eloranta	.7 to 1.07	15%	Total Cost
Kojovic	.52 to .61	($.65/T savings)	Total Cost

Table 1 Summary