The Role of Blast Operations in Metal Mining

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Abstract

A recent forum of mine operators revealed a continuing strong interest in alternative methods of freeing rock. A Rand Corporation report lists a continuous mechanical machine that would replace drilling and blasting as a priority for mine operators. Meanwhile, mounting evidence documents a dramatic cost benefit in processing where increased blast energy is available. The reasons for this dichotomy may be due to a number of factors.

Blast avoidance is based on several factors that include:

1) Management structures
2) Risks to personnel and equipment
3) Environmental concerns
4) Desire for continuous operations
5) Lack of blasting expertise at decision-making levels
6) Lack of measuring devices

Non-blasting methods may have a role where rock weakening and the generation of fines is not desired. In metal mines, however, ore is typically ground to as fine as 500 mesh in the concentration process.

Given the high energy requirements in ore processing and energy concerns in the U.S., this issue has broad implications. It appears that mine operators are more focused on issues such as blast complaints and liability concerns. Manufacturers and users of explosives should improve their efforts in pointing out these advantages.

Introduction

Previous work by the author and a host of researchers worldwide has confirmed that enormous unrealized cost and productivity improvements remain available to metal producers. Since metal mines blast rock that is subsequently milled to as fine as 500 mesh, some operations have documented cost reductions in the tens of millions of dollars annually through total flowsheet optimization, often referred to as drill-to-mill optimization.

Summary of Rand Report

The following excerpts are from a Rand Corporation report that has been published under the title: "New Forces at Work in Mining: Industry Views of Critical Technologies" (Peterson, 2001). The remarks are self-explanatory and offer some bright spots, but overall, a chilling picture of the challenge facing those who aspire to optimize blast designs with respect to ultimate rock use.
"The majority of the participants were drawn from the executive ranks of the mining industry; they include chief executive officers, presidents, chief operating officers, and vice presidents."

Cited Trends:

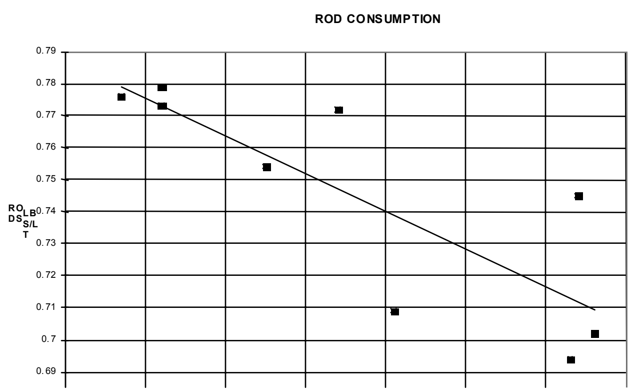
1) "…continuing trend away from the use of cartridge products in favor of bulk products"

2) "The integration of IT is also improving blast optimization capabilities through in-field measurement and reporting of loading information and blast results such as particle size, heave, and distribution."

3)"…outsourcing of blasting-related services, ranging from consulting on safety to providing comprehensive packages priced according to the volume of "shot rock" on the ground or ore processed. As a result of these blast-optimization efforts, the volume of blast agents per unit of shot rock is slowly decreasing."

"Given their centrality to the mining process, most unit-ops machinery and equipment were cited as critical technologies by participants. However, industry representatives tended to devote attention primarily to the latter phases: materials loading, hauling, and processing. Drilling and blasting technologies were rarely cited by operating-company representatives as critical."

Figure 1



"According to technology suppliers, drilling- and blasting-related technologies are rapidly evolving and are offering mining companies important new capabilities. Nevertheless, operating-company representatives rarely identified drilling and blasting technologies as critical during the RAND discussions. For one supplier in particular, this disparity in perceptions appeared to preclude important productivity-enhancing opportunities."

"When considering blasting technologies, operating companies tend to be highly cost-conscious, which mitigates opportunities to develop value-added or innovative products."

"The need to find an alternative to blasting to reduce percussive noise at in-town locations.…The key constraint in developing such technology, an executive noted, is raising the compressive strength of head wear materials enough to cut consistently and economically through the range of rock found in a mine. Other challenges are the mitigation of noise and dust generation.'

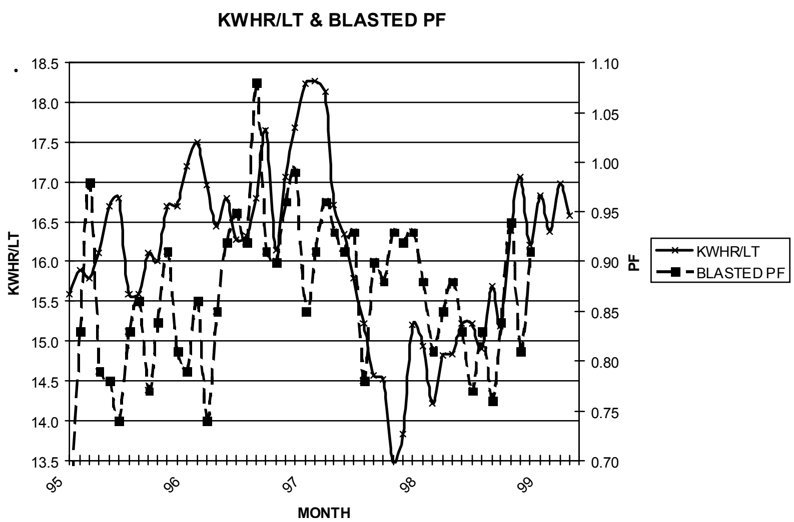


Figure 2 SAG Power v Powder factor

Recent evidence of downstream benefits of finer fragmentation

The author has offered examples of the benefits of higher powder factors based mostly on conventional (rod and ball) milling. (Eloranta, 1995 & 2000) Figure 1 shows that grinding media consumption in rod mills is affected by powder factor. Autogenous and semiautogenous (SAG/AG) mills clearly have different feed requirements. Larger fragments in SAG/AG mills perform the task of introduced grinding media in conventional milling. Therefore powder factors are generally kept lower in these operations. However, figure 2 shows beneficial trends for SAG milling. Power consumption for this iron ore application inversely rises and falls with powder factor.

Management structures

The technical aspects of drill to mill optimization pale in comparison to the managerial obstacles imposed by departmental structuring. Re-engineering, visioning and numerous other restructuring templates have not overcome inter-departmental hurdles in many companies. Whether the topic is next year's budget or grade control; mine versus plant acrimony exists at the expense of optimization. Even departments within the mine are pitted against one another.

The Soviet model

Western researchers have sometimes questioned Soviet research, noting the absence of a meaningful economic system that resulted in questionable allocation of resources. A closer look at the underlying assumptions for the allocation of budgets in US operations reveals similar weaknesses. The ‘currency’ exchanged between mine and plant is not based on real economics in many instances. Clearly, rule-of-thumb selection of drill size and bench height does not result in optimized flowsheets. Once these parameters are set at the outset of mining, they become a fixed limitation for the blast engineer. A look at a simple example of how the appropriate powder factor is determined is revealing. The ISEE Blaster’s Handbook says, “(Powder factor) can vary from 0.25 lbs/ton (0.12 kg/tonne) to as high as 1.0 lbs/ton (0.49 kg/tonne) depending on the formation and the end use of the rock being blasted. In general, most rock is blasted between 0.5 lbs/ton and 0.65 lbs/ton (0.25-0.32 kg/tonne.”

Ash (1963) and many others have forwarded excellent ‘initial layout’ criteria. There now exists a view that the resulting designs approximate optimum blasting. However, they are, by and large, empirical relationships that have produced *acceptable* fragmentation in a variety of applications. This is not to say that most operations would not see fragmentation improvements by adhering to Ash criteria. In the selection of powder factor, Ash could represent a minimum value for acceptable downstream performance.

Systems that lead to improvement

For metal producers to move towards optimized operations, there are at least 3 paradigms that come to mind. They are:

1) Team Concept
2) Renaissance man
3) Customer/ Supplier relationship

The team concept has been broadly applied to all types of businesses in the past decade. The core concept behind the team concept involves the notion of altruism, where individual recognition submits to the success of the team. Key requirements of this concept include: a definition of who the team includes and how the individuals are motivated to ‘buy in’ to the project.

The Renaissance man concept requires just what it says, a gifted leader with the insight usually only possessed by many knowledgeable, experienced individuals. This individual is able to comprehend, in detail, the key components of an entire operation. Such people exist today, despite the growing complexity of modern technology.
The customer/supplier relationship has been expanded recently to include functions within a single operation. When in-house functions apply techniques that suppliers have developed, such as ‘value-added’ services and customer satisfaction initiatives; system improvements have been documented.

Given these models, why haven’t we seen more progress on total flowsheet optimization? The problems seem to center on the following:

1) Failure to get team members to buy in to the concept. The general manager must go beyond approving the team concept; he must be a champion for its success.

2) Failure to broadly define the team. If separate teams are working on mine optimization and a second team is working on mill optimization; overall optimization may not occur.
3) The customer/supplier model fails for several reasons:
   a) Departments acting as suppliers fail to get to know their customers real needs.
   b) Departments acting as customers may not wish to let the supplier department in on internal problems or secrets.
   c) The customer/supplier relationship requires that other suppliers and other customers actually exist. Unless a company plans to outsource functions normally done internally, this becomes an exercise only.
4) The problem with relying on the Renaissance man model lies in the scarcity of individuals with the required interpersonal and technical talent.

Various views of adequate blasting

Drill and blast is a fundamental process in surface mining. The success or failure of D&B methods cast a long shadow over the balance of the operation. However, in the actual day-to-day management of affairs, D&B is sometimes viewed as an obstacle in the effort to dump ore into the crusher. The smooth operation of haulage is hampered by drill patterns cutting off roads, areas of poor fragmentation, blast clearing delays plus interruptions of power and de-watering. Mine managers are often faced with complaints from neighbors and regulatory agencies concerning blasting.

For these reasons and others, the Rand forum of mine operators revealed a continuing strong interest in alternative methods of freeing rock. A priority for mining executives is the development of a continuous mechanical machine that would replace drilling and blasting.

A troubling development involves the ever-increasing size of mining equipment. Quoting from the ISEE Blaster's Handbook, “”Large loading and crushing equipment is designed to handle a large volume of material. It is a frequent misconception that burdens and spacings can be increased because large loading equipment has been acquired.”

Some metal miners say that if pieces are small enough to pass through the shovel bucket, it is good enough.

Mick Lownds has observed that most operations blast to satisfy a single constraint. That is; they have one particular problem, such as eliminating toe, which dictates the overall blasting effort. The other blast results come along as a consequence of the one parameter that causes critical problems. I think this is an accurate characterization of many operations.

Several years ago, a blasting consultant with vast international experience was invited to speak to the local SME section on blasting. In his talk he stressed the fundamental importance of fragmentation. I was encouraged to see that following his slide show, he was surrounded by a number of mine managers. However, when I joined the conversation, I discovered that the interest was in a slide he had shown of a new type of loader-mounted breaker hammer available for secondary breakage.

Don't cut my budget

At a metal mine familiar to the author, the general manager listened carefully to the drill-to-mill approach. He was not fully convinced, but suggested that the mine and mill manager work out a budget for the next year, wherein the savings in milling costs would reduce the mill managers budget while the mine manager's budget increased. Given the long history of budgeting battles between the two, no agreement was ever reached. Realistically, no one wants their budget cut while the other guy gets an increase.

Poor Blasting Practices

The main reason that mine managers are not focused on the opportunities that lie ahead in blasting, is that they are busy with the problems that go hand in hand with poor blast results. When discussions of blasting come up; they typically involve things like:

1) Shortage of blasted inventory
2) Airblast or seismic complaints from neighbors or regulators
3) Flyrock damage to equipment or facilities
4) Tight bank, blocky or oversize material
5) Misfires
6) High D&B costs
7) Failure to pull grade

As long as these issues dominate, any hope of total process optimization is lost. A clear vision of improved blasting must precede actual improvements on the ground. If not, the uncontrollable factors of open pit mining, such as geology and weather, will overcome strategic efforts and reduce managers to seeking shortsighted tactics to maintain production.

Summary and Conclusions

The blasting community finds itself in an unusual position. Here we have an unprecedented array of measuring devices generating more data than ever thought possible. We are in the midst of a revolution in blast design that will allow blasters to design shots, not on empirical formulas, but instead, on the needs of the customer. Whether the ore goes to impactors, crushers or leach pads; or if it ground by conventional mills or SAG/AG mills, blasts can be tuned to an operation's specific needs. At a recent symposium on SAG mills, the question was posed, "What is the optimum feed for SAG milling and how would we recognize it when we had it?" A great deal of communication between blasters and ore processors will be required to interpret the large body of data now being generated. It is clear that upper management of mining companies is not aware of the opportunities available through better fragmentation. This misperception will likely persist as long as blasting problems continue to dominate optimization discussions.

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