Comentários sobre o Desmonte de Rochas com Explosivos

Blasting result evaluation (Part 02)

Por Bruno Pimentel.

Hello my friends, as always, we start by leaving here the link to our Newsletter, so that those who are new can have access to our previous articles, as well as asking you to subscribe, because this way you will be automatically notified with each new article. Now we are also gradually translating our Newsletter into English, so we will always try to keep up with our publications fortnightly, and in the meantime we will make the previous articles available in English.

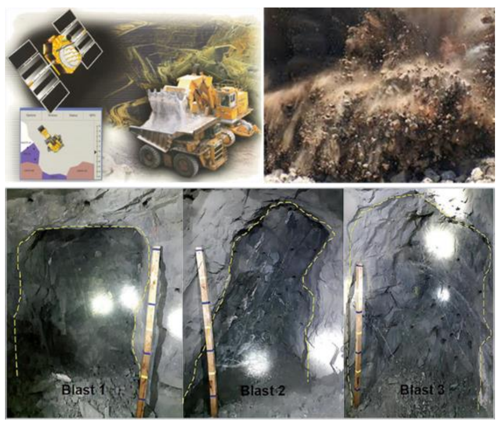
Português: https://www.linkedin.com/newsletters/desmonte-de-rocha-c-explosivo-6941709482355748864/

English: https://www.linkedin.com/newsletters/rock-blasting-6959820770344595456/

In the last article we talked about the need to know well the objectives of each blat, as they are the key to being able to make a practical and real evaluation of the results of our blast, after all, as much as there are several theoretical indications about the concept of a good blast, in practice, to evaluate our blast we need to know exactly what we wanted, because just as there are several blast techniques, there are also several different reasons to use them.

So we finish the last article with a list of the main factors or practical criteria used to evaluate most blasts, as they are usually related to the main or specific objectives that we have in the different operations. So in today's article, we will take the opportunity to make some comments on how or why to evaluate each of these points, remembering that we will try to analyze each of them as a single and separate objective, as there are numerous possibilities to relate them, and this relationship will directly impact in the balance between the objectives and in the way in which we will evaluate each one of them.

- Fragmentation
- Secondary Blasts
- Excavator productivity
- Truck filling factor
- Beneficiation Plant Performance
- Dilution
- Remaining rock massif
- Safety and Environment
- Costs

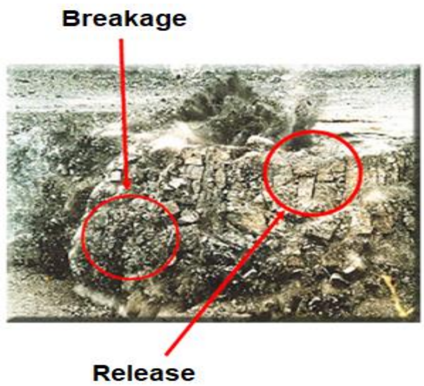


But before commenting on each of these points, something important that we commented at the end of the last article, and that we have to keep in mind as we talk about each of these points, is that the same objective can have different evaluation criteria, some quantitative and other qualitative ones, and this will be related to the specificity of the objective, and in addition, that we may have the need to always improve some of these objectives, such as fragmentation, that some processes may need it to be increasingly thin, and no matter how much we have a good result, we will always have room to improve, while other objectives can be more specific, where, for example, we can have a maximum productivity of the excavation equipment, according to its capacity, as soon as it reaches the maximum point. of this productivity, any extra effort may not bring benefits or even harm other objectives, such as the generation of unnecessary costs. So we will comment on them in general, but remembering that there may be several variations of specificity of each objective and also of the way to evaluate them, and especially the exceptional cases need to be evaluated in a specific way.

- **Fragmentation**

We can say that in all blasts fragmentation is always a primary objective, so from small blasts, such as the removal of a rock block, to large blasts, the fragmentation result is one of the main criteria used to evaluate the results of any blast. That's why we always say that fragmentation is the purpose of the blast, because regardless of the scenario, we perform blasts to break the rock, either just to remove it from the place or for its use.

So even in blasts, where we have other objectives that can have a greater weight, fragmentation will be present, because as we know, this is the primary function of the blast, which is to break the rock, so even if we don't have fragmentation as an objective main, that is, we do not have an ideal fragmentation to achieve, it will always be present, and we will evaluate it, albeit qualitatively, according to the other objectives.



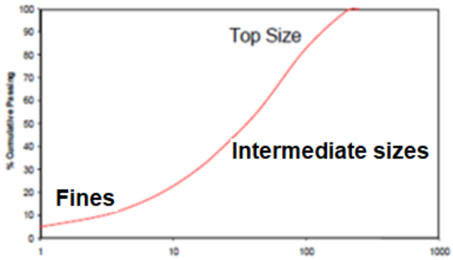
For example, we might have a blast where the objective is to remove the rock without causing damage to the surroundings, so we don't need good fragmentation, we just need to break the rock so that it can be removed from the site, so we won't evaluate a specific fragmentation for our blast, but when evaluating our ability to remove the rock from the site, this already implies that we have reached the necessary fragmentation to remove the material, and by doing this without causing damage (which is our main objective) we can say that we have a good blast, even if it doesn't maximize the energy utilization of the explosive or even if we don't have a theoretically perfect blast.

Therefore, in general, we will always be performing at least a visual qualitative analysis of the fragments of our blast, which may be based on other points, such as the ability to remove the material, or just performing a general assessment indicating whether the fragmentation is visually acceptable or not. This visual analysis is the main type of qualitative analysis that we normally perform, which we usually refer to previous blasts or the achievement of main objectives, such as the example we cited of our ability to remove material.

Qualitative analyzes are subject to the personal criteria of whoever is evaluating, so one person may think the result is good and another that it is not, we even usually use our memories of previous results, but they are easily lost in memory, and in the same way different people will have different memories. So, although we always carry out this type of analysis, even if unintentionally, it is an inaccurate parameter, but it will always be present in the evaluations. And it is important, especially psychologically speaking, because if the service requester is not visually satisfied, he can be sure that other types of analysis will not convince him so easily.

So, even if it is not the main objective, fragmentation in one way or another will always be present in the evaluations, because in addition to being the main consequence of the blast, it has an effect on all other results, so it is always a baseline analysis that we will perform to evaluate our blasts, albeit indirectly.

There are several ways to analyze fragmentation, from qualitative analysis to quantitative analysis, using several different methodologies, so to determine how we are going to analyze our blasts, we first need to determine which point or points we want to evaluate. Because with regard to fragmentation, we can analyze with a focus on several points:



- Size distribution
- Size and number of blocks
- % of fines
- Specific range of sizes
- Material to feed the plant
- Material for works and infrastructure services
- Material removal capability
- Others

Determining the focus of our evaluation will also depend on our objectives, for example, if our objective is to maximize fragmentation so that the excavator can produce more, our point of analysis will be the ideal fragmentation curve for work of that type of excavator, or we may have a goal of ensuring that all material is below a certain size, so our measurement will be based on the % material below or above that specific size.

So depending on our objective, we will determine which point or points are important to evaluate, and from there, we will choose the analysis techniques to evaluate these points, where we can have simple analysis methodologies, or we may need a more complete analysis of the whole result.

There are several techniques and methodologies that we can use to evaluate the fragmentation of our blast, which will depend on the objective, and the points that we need to evaluate. Some of them are:

- Visual qualitative analysis;
- Photo analysis;
- Production of loading and transport equipment;
- Studies of production and interruption of the primary crusher;
- Counting the large blocks present in the blasted material pile;
- Sampling;
- Others.

The simplest assessment, which is practically automatic, is the visual qualitative assessment, which, despite being very subjective, by following the history and making constant assessments, it is possible for a person to develop a good experience and assess the blasts, serving as an initial basis for comparison, and although it will never be exact and precise, it always has its level of importance.

Then, a technique that is widely used is photo analysis, where software is used to determine the fragmentation curve of the material through photographic analysis, where normally taking as a reference an object of known size, they determine the size of the other fragments of each photo. This is a very practical technique to have a quantitative analysis, but it is necessary to follow the methodology well, because small deviations can lead to large anomalies in the results.

We can say that this is one of the most used quantitative techniques to evaluate the fragmentation generated by the blasts, so we will do an exclusive article about it at some point, and it is still usually the one we use to evaluate when we have a more specific fragmentation to be evaluated, such as a specific range or an ideal granulometric curve.

It is also important to mention that there are several software available and that most of them have a very acceptable level of accuracy, but as we said, it is necessary to follow a series of criteria in order to make a good analysis.

Then we have some indirect forms of evaluation, where we can evaluate the productivity of loading, transport and material processing equipment, which serve as an indication of the suitability of fragmentation to your needs.

Another point, which is usually a great difficulty in several operations, is the amount of large fragments, and thus it is common to establish evaluation criteria for counting blocks, or for controlling the volume of secondary blasts performed.

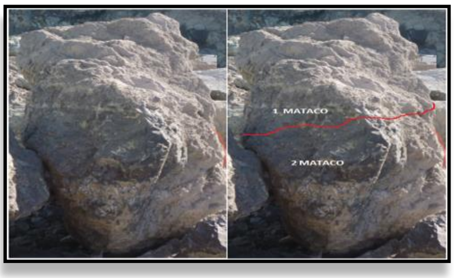
In some specific situations, analysis by sampling can be carried out, where a portion of the material is taken as a sample, and the analysis is carried out to have a real measurement of the fragmentation of the material. But due to the amount of material and the difficulty, this is usually a technique used only in specific studies, and sometimes used as a reference only to determine the accuracy of some other analysis methodology.

In addition to these, we can have a series of other forms of analysis, and every day more technologies are emerging that allow more accurate analysis, such as cameras on excavators or conveyor belts, measuring the fragmentation of the material, or even drones that perform superficial analysis of the material, but let's stop here, otherwise this point takes over the entire article.

- **Secondary Blasts**

Another factor that is widely used to evaluate blasts, and is directly related to fragmentation, especially with respect to larger sizes or blocks, is the evaluation of the need to perform secondary blasts, whether measured in volume, mass, number of blocks or even number of secondary blasts performed.

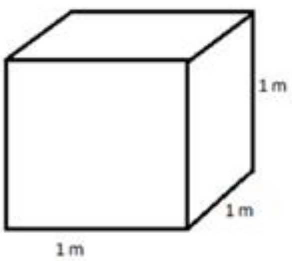
This is a very direct point of evaluation, because the existence of the need to carry out a secondary blast already directly indicates that the primary blast was not efficient. In addition, this can have a major impact on some operations, such as civil works, as a new blasting process may be necessary to solve a specific problem, or other examples are the possibility of impacting mining performance, limiting moving equipment, or even restricting access to a part of the material. So small operations can have this theme as a very strong objective, as any impact can represent a large % of loss on the operation.



This is a point that deserves a comment apart from fragmentation, because as we always say, inefficient blasts not only generate bad results, they also generate rework and costs, which is directly reflected by secondary blasts, as well as by the impacts on other activities.

Therefore, normally one of the primary goals is to avoid the need to perform secondary blasts, so it is common for many operations to measure the number of blocks that need secondary blasts, as well as the volume of irregularities present after the blast.

Theoretically, we consider as a block, the fragment that has a size greater than 80% of the maximum size supported by the equipment, so each operation can have a different size limit, which will be determined by the equipment used, where we normally use the smallest measure, between loading, transport and material processing equipment. But in practice, we can consider any large fragment that generates any kind of negative impact on operations.



In addition to the blocks, the number of floor and wall regularizations is usually also analyzed, which are measured by volume, and considered from the moment they negatively impact other activities, and therefore the need to perform secondary blasts.

For example, we can have a regularization in the corner of the wall, which does not affect anything and can be detonated together with the next blast, which in this case would not be considered, but we can have regularizations in the front, which directly impacts the locomotion of cargo equipment and transport, which requires a secondary blast, so that the material is removed and the equipment can carry out its activity.

So, as simple as the topic may seem, depending on the operation, whether small or large, if not handled properly, the need for secondary blasting can represent a major impact on the operation, that is, directly reflecting the result of primary blasting.

- **Excavator productivity**

The excavation of the material is the first activity of movement of the blasted material, as it is directly affected by the blast result, mainly the results of fragmentation and material disposition, and therefore it is normally used as a parameter for evaluating these results.

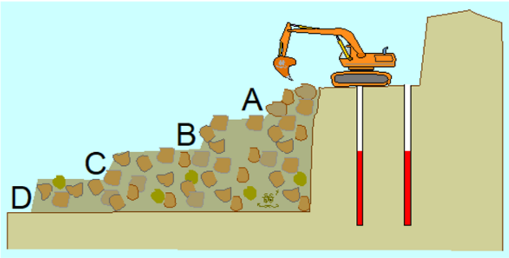
Thus, it is common to use excavator productivity as a methodology for analyzing the results of blasts, taking care to eliminate certain situations or anomalies, which may be more influenced by the operator or by the operating conditions of the equipment.

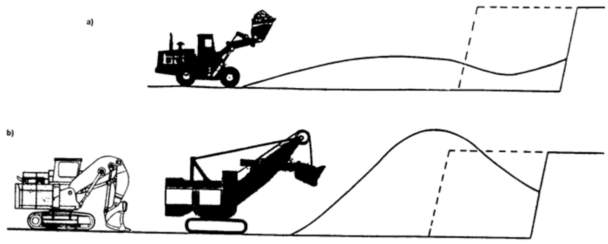
Normally, an analysis of excavator productivity is carried out by the amount of material removed per hour of operation, where the tons per hour of production are measured, and the control is done by the operational control system, when available, or by estimating the number of trucks loaded in the same period.

For a more efficient analysis and with less interference, normally when you have the data from the central control system, the maneuver and stop times of the equipment are filtered, or any other point where the equipment is not effectively producing.

As we said, the fragmentation and the characteristics of the material pile are the two main points that interfere in the productivity of the loading, and thus, in addition to evaluating the value of productivity itself, it is analyzed in a qualitative way, which of these points is contributing or impacting productivity more.

For example, the beginning and end of the stack, as well as the upper part, usually tend to have a lower productivity, requiring a more careful analysis when we are going to make comparisons between the results of different blasts, as the blasts need to have the same representation of materials.





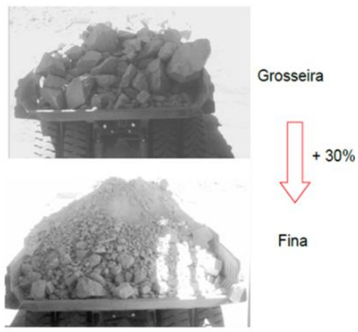
Another example is that the material can be very well fragmented, but very cohesive and compact, which will make it difficult to excavate the material, so a more detailed analysis is essential to filter or identify those points that can impact the results.

We also need to be aware of the types and capabilities of equipment, as they will require different levels of fragmentation and stack formats.

- **Truck filling factor**

Another way of evaluating blast results is through truck loading evaluation, where we can evaluate loading time and filling factor.

The loading time will depend on the excavation performance, which is directly affected by the result of our blast, in the same way that the filling factor of the trucks is affected by the granulometric distribution of our fragmentation, so together with the evaluation of productivity of excavators it is common to evaluate the loading time or the filling factor of the trucks.



As we said earlier, our blast can also affect the floor conditions of the loading area, interfering with the maneuverability, speed and wear of loading and transport equipment.

- **Beneficiation Plant Performance**

In mining operations, especially in hard rock, one of the activities that can be most impacted as a result of blasting is the beneficiation plant, as this is where there is a high cost of energy and size reduction processes.

Thus, there are several methodologies, known as “mine to mill” or “mine to plant”, that seek to optimize the blasts to guarantee great gains in the material processing steps, so on these occasions it is common to measure the blast results according to of gains or impacts the processing steps, where we can assess equipment productivity, cost reduction, energy reduction, equipment wear and tear or other points that may be affected by the blast result.

Usually the main point to optimize is the material fragmentation, as it will directly affect the crushers and mills, as well as the energy level required for the material processing.

It has been more than proven that investments in making better blasts bring great operational and economic benefits, several times greater, in the material processing stages, which are mainly a reflection of higher productivity, lower energy consumption and less wear on the equipment.

Over the last few years, we have seen an increase in this type of work and evaluation, where the direct relationship between the benefits has been proven, with increasing precision, maximizing the performance of all subsequent stages, as a result of the optimization of the blast, so later on we will also make some articles related to this topic.

Several companies have invested in consulting and training of their own teams, so that they can optimize the blast process, and thus benefit the later stages of loading, transport and material processing.

Proper fragmentation is usually one of the main goals of this work, where the fine and coarse fragmentation plots are the ones that need the most attention, where we usually need to maximize the fines, and ensure that the coarse ones will be reduced to intermediate sizes, which is why normally in line with an assessment of impacts on the beneficiation process, fragmentation is also jointly evaluated, which serves as a prediction of the expected results of the process.

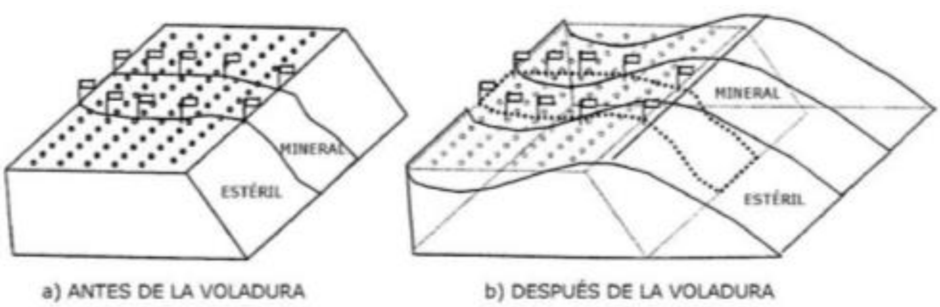
Normally in this type of methodology, the evaluation of the results of the blast is complete, where we do from indirect analysis of the productivity and efficiencies of the following activities, to a high level of control and evaluation of our blast, so that we can identify the points that need to be improved and how they affect our results.

- **Dilution**

Another point that is widely evaluated, especially in mining, is the dilution control, which consists of minimizing the mixture of ore, which is the material of interest, with the sterile, which is the material that has no economic value.

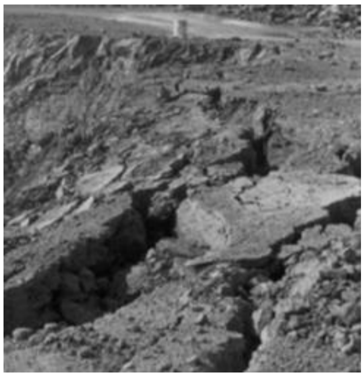
Dilution control can also be done, between materials of different content, or that have certain specific characteristics, so we can use dilution control to ensure that two different materials do not mix or that they mix as little as possible.

Mainly underground mining, dilution control is constant, either to avoid mixing of materials or to avoid over-excavations, so it is very common to establish criteria or techniques to assess the dilution of the blasts performed.

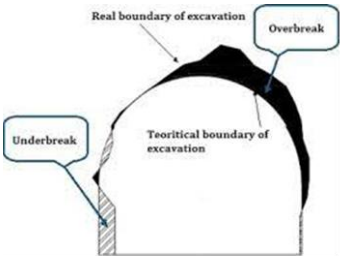


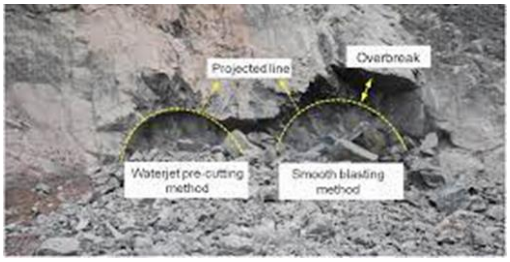
- **Remaining rock massif**

Another very common objective of most blasts is the preservation of the remaining rock, which we can usually evaluate in 4 different ways, depending on the scenario and the specific objectives of each blast.



1. Structural damage: refers to the stability of the rock body, which is normally monitored by the geotechnical team, and whose impacts may represent a monitoring point to assess the blasts.
2. Overbreaks: consists of breaking beyond the predetermined volume of rock for our blast, which implies damage to the rock, an extra volume of material to be excavated, dilution, and even underground will imply extra containment. That's why it's another item that we can monitor to determine the evaluation of the results of our blasts.
3. Underbreaks: it is linked to the secondary blasts item, as it consists of when we break less than we should, leaving a remnant of rock that should have come out, and this will generate rework, impacts other activities, loss of ore recovery, in addition to that this portion may be unstable and pose security risks.





4. Face damage: these are the effects of the current blast on the rock volume of the next blast, where we can mainly cause damage to the face of the next blast, generating fractures and preformed blocks, which will represent risks and a worse performance of the next blast.

- **Safety and Environment**

Regardless of the objectives of our blast, the basic rule will always be not to cause damage or accidents in our blasts, so all of them are always evaluated in terms of safety and damage to the environment.

There are a number of points that we can evaluate, but the main ones are:

• Damage to people and equipment

• Damage to structures and facilities

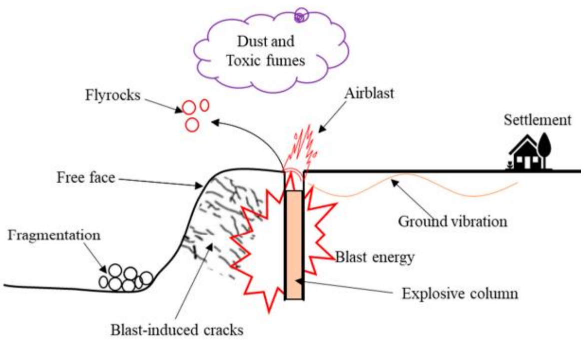
• Damage or disturb the community

• Flyrocks

• Vibrations and air wave

• Dust and toxic gases

• Others



Although our objective and evaluation criterion will always be zero damage, it is important to understand that some of these points may have acceptable safety limits, such as vibrations and airwaves, which will be generated in the blast, but must be within the legal and safety limits, previously established according to each scenario.

In some operations, normally due to the scenario in which they are found, some of these themes may have decisive proportions in the design and evaluation of blasts, such as blasts close to urban areas, where the impacts on the environment need to be much more controlled than operations in remote areas, which for example may have much higher vibration limits.

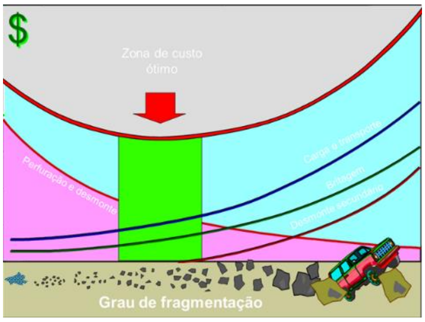
We may also have a specific situation that we need to control, either to avoid environmental impact or damage to safety, and for that we can establish specific controls to evaluate our blasts.

On this topic we commented on some examples in previous articles when we commented on clearance area and flyrock events, so if you haven't read it we recommend you do so, but we will certainly return to them in more detail on several other occasions.

- **Costs**

The last point on our list is the cost assessment of our blast, as like all activities, we want to carry out our blasts in a way that it achieves the objectives, but with the lowest possible costs.

There are usually 3 main points of view for evaluating the costs of our blast, where first we can only evaluate the costs of explosive, related to the price and amount of explosive used in each blast, we can analyze the cost of the activity itself, where normally we add the preparation, drilling and blast costs, which are the set of activities necessary to fragment the rock, or finally, we can analyze the total costs of the operation, which we can usually evaluate the costs per ton extracted, or in mining, per ton processed, involving the steps of excavation, transport and ore treatment.



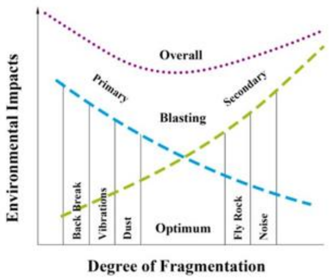
It is important to be clear that as in any activity, we need to control the unit costs of our blasts, where all companies will have budgets, which will enter as a fundamental point for the evaluations of our blasts, but it is important to always consider the impact that others results of our blast on other activities, as we can control specific costs and have much higher overall costs, or we can invest, of course in a controlled manner, in our blasts, to obtain much lower total costs.

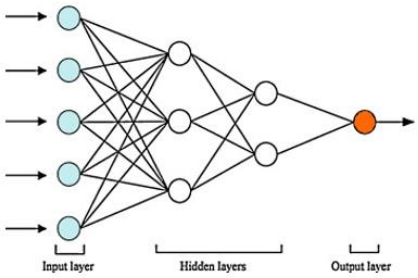
This theme is totally linked to the concepts of “mine to mill” that we talked about earlier and that we will talk about in more detail in other opportunities, but just to give a very simple example, for those who do not know the concept, we can have a scenario where we have a standard blast cost of 1 real and this gives us a percentage of fines of 5%, resulting in a final material processing cost of 100 reais, so we can control the results of our blast so that we don't have a cost greater than 1 real, but this implies a processing cost of 100 reais, or we can look for better results in our blasts, which for example may represent a cost of 10 times, that is, 10 reais, but which will deliver us 10% of fines, which reduces processing costs to 70 reais, so before we had a total cost of 101 reais with the blast within normal standards, and now investing 10 times more in the blast, we have a final cost of 80 reais, that is, even spending 10 times more on the blast our final cost dropped more than 20%.

So this is a simple example, this topic can be very long, and as we speak we will come back to it, so let's stop here, just not to extend today's article too much.

- **Equilíbrio**

As we said before, most blasts will have several different objectives and they will interact with each other, and this interaction is what should determine the design and criteria for evaluating the results, taking into account that some of the objectives may be contradictory, and therefore we need to strike a balance between them, and the more complex our blast, the more difficult it is to strike that balance.





We still need to remember that objectives or priorities can change with each blast, where for example, we can have a blast on one side of the mine that is well isolated and another one close to the offices, and although we need the same level of fragmentation, the controls will usually be much larger.

Just two comments to finish our article today, the first is that related to the issue of results evaluation we have a series of measurement techniques and equipment used to monitor rock blasting and its results, so we will talk about them in a other moments, and the second is just a report and an observation to close today's topic, of an example of the complexity that it can be to define the objectives, relate them to the existing limitations and reach the balance to evaluate our blasts:

It is very common for some operations to have specific goals, that is, costs or quantities, so for example we know an operation that had a specific power factor goal, and of course one of the main objectives for evaluating the blast was not to exceed the power factor limit, but in addition to this strict and sacred limit, the operation had several operational limitations, such as it had a single diameter and problems with the availability of drills, and there were several other limitations for varying the blast parameters, and even then, they needed to of an excellent fragmentation, so when we are going to evaluate this type of blast/scenario/operation, in addition to taking into account the objectives, we need to evaluate the existing limitations so that we can evaluate our ideal blast balance, so in these cases, our ideal blast or the evaluation criteria, must take these limitations into account, so that with them we can have a clear view of the that it is possible to do. So it is important to understand what is possible to accomplish in each scenario, because some objectives may not be achievable according to the existing limitations, and this must be clear both when designing and when evaluating the results of our blast.

That's it, for today we will stop here, probably in our next article we will start by commenting a little on the importance of quality control in our blasts.

We hope that these articles are being useful, both to contribute to the dissemination of knowledge, as well as to improve our blasts, and for that reason we are always open to suggestions, and if anyone wants to share an article or a topic that they believe will contribute, just send us a message.

Please comment and share, so that we have more and more safe and quality blasts!!

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