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THE IMPACT OF LIMESTONE FRAGMENTATION ON RAW MIX PRODUCTION IN CEMENT INDUSTRY

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ABSTRACT – Raw mix design is one of crucial point in production of clinker. Cement industry use limestone, marl, clay in particular percent to provide the best quality in production of clinker. The quality of the material must be in line with the quality targets. Fragmentation is important element, because affect pre-blending design, economic norm from blasting to crusher. Blasting is an operation which affects all subsequent operations and costs. The Kuz-Ram model is possibly the most widely used approach to estimating fragmentation from blasting, and renewed interest in the field of blast control has brought increased focus on the model.

Keywords: Blasting, Fragmentation, Crusher, Kuz-Ram, Raw Mix.

INTRODUCTION

Optimum blasting just does not happen. It requires suitable planning, good blast design, accurate drilling, the correct choice of explosives and initiation system and methods, adequate supervision and considerable attention to detail. The primary purpose of blasting is to fragment rock, and there are significant rewards for delivering a fragmentation size range that is not only well suited to the mining system it feeds but also minimizes unsaleable fractions and enhances the value of what can be used in production. Over the past decades, significant progress has been made in the development for blast design and blast fragmentation size prediction. Rock fragmentation depends on many variables such as rock mass properties, site geology, in situ fracturing and blasting parameters and as such has no complete theoretical solution for its prediction. Empirical models for the estimation of size distribution of rock fragments have been developed such as those based on the Kuz–Ram fragmentation model. This method is able to predict the entire fragmentation size distribution, taking into account intact and joints rock properties, the type and properties of explosives and the drilling pattern. Element like fragmentation can affect electrical, diesel and explosives consumption. Marl in this case is not included, there is no blasting in marl quarry.

EXPERIMENTAL

Calculation started with finding particular size of limestone for hammer crusher type FLS EV 200x200 (Table 1). Optimal input sizes of limestone should satisfy the capacity of

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the crusher, mixing ratios for pre-blending, output size that affects the capacity of the mill, as well as economic norms.

Table 1 Hammer crusher FLS EV 200x200, manufacturer characteristics

Hammer crusher	Inlet roller			Hammer rotor		Max. feed size		Weight
Type	Nos.	Peripheral speed (m/s)	Speed (rpm)	Peripheral speed (m/s)	Speed (rpm)	Max. size (mm)	Max. weight (kg)	Total weight (ton)
EV 200x200	1	1	19	30-39	290-375	1,400	2,000	95

The requirement of the ball mill, in order to satisfy the capacity is that the size of the material be around 30mm. In relation to the requirements of the mill, and in order to satisfy the capacity of the crusher, the optimal size of the input on the crusher can be calculated:

$$Dopt = \frac{Di - Do}{2} \qquad (1)$$

Di = 1.4 (m) - Input size;
Do = 0.03 (m) - Output size;
Dopt = 0.685 ± 0.1 ≈ 0.5-0.7 (m).

The primary assumption of empirical fragmentation modelling is that increased energy levels result in reduced fragmentation across the whole range of sizes, from oversize to fines. This is generally valid, but not necessarily applicable to real situations. Some of the other factors that may override the expected relationship include:

- Rock properties and structure (variation, relationship to drilling pattern, dominance of jointing);
- Blast dimensions (number of holes per row and number of rows);
- Bench dimensions (bench height versus stemming and subdrilling);
- Timing between holes, and precision of the timing;
- Detonation behaviour, in particular detonation velocity (VoD);
- Decking with air, water and stemming;
- Edge effects from the six borders of the blast, each conditioned by previous blasting or geological influences.

Table 2 show different input parameters for drilling and blasting by years.

Table 2 Drilling and blasting parameters

Parameters	2016.	2017.
Diameter of drill hole	90 mm	90 mm
Burden	3 m	2.6 m
Sub-drill	1.5m	1.5 m
Distance between rows	5 m	3 m
Distance between holes	5 m	4 m
Slope of the blasting hole	70°	70°
Stemming	3 m	2.5 m

RESULTS AND DISCUSSION

The major changes to the Kuz-Ram model, was developed as a result of the introduction of electronic delay detonators (EDs), since these have patiently transformed fragmentation. Both the effect of assigned timing and the effect of timing scatter are accommodated (Cunningham, 2005). The equation set includes changes in the uniformity and mean fragment size equations, which is as follows:

$$X_{50} = AA_T K^{-0.8} Q^{\frac{1}{6}} \left(\frac{115}{RWS}\right)^{\frac{19}{20}} C(A) \quad (2)$$

Where, A_t is timing factor, which is multiplier, and incorporates the effect of interhole delay on fragmentation, C(A) a correction factor for the rock factor, n_s is the uniformity factor governed by the scatter ratio. As with the rock factor A, it can happen that the uniformity index is just not what the algorithm suggests, in which case correction factor C(n) is provided to overlay the inputs and enable estimation of the effects of changes from a common base.

$$n = n_s \sqrt{(2 - \frac{30B}{d})} \sqrt{(\frac{1+S/B}{2})} (1 - \frac{W}{B}) (\frac{L}{H})^{0.3} \mathrm{C(n)} \quad (3)$$

Where, B is burden (m), d is the hole diameter (mm), S is the spacing (m), W is the standard deviation of drilling accuracy (m), L is the total length of drilled hole (m), H is the bench height (m), C(n) is a correction factor for the uniformity index.

For data input, there is graphics for two years, 2016. (Figure 1) and 2017. (Figure 2) which show different size of material relative to percent passing by Kuz-Ram model based on drilling and blasting parameters for 2016. and 2017.

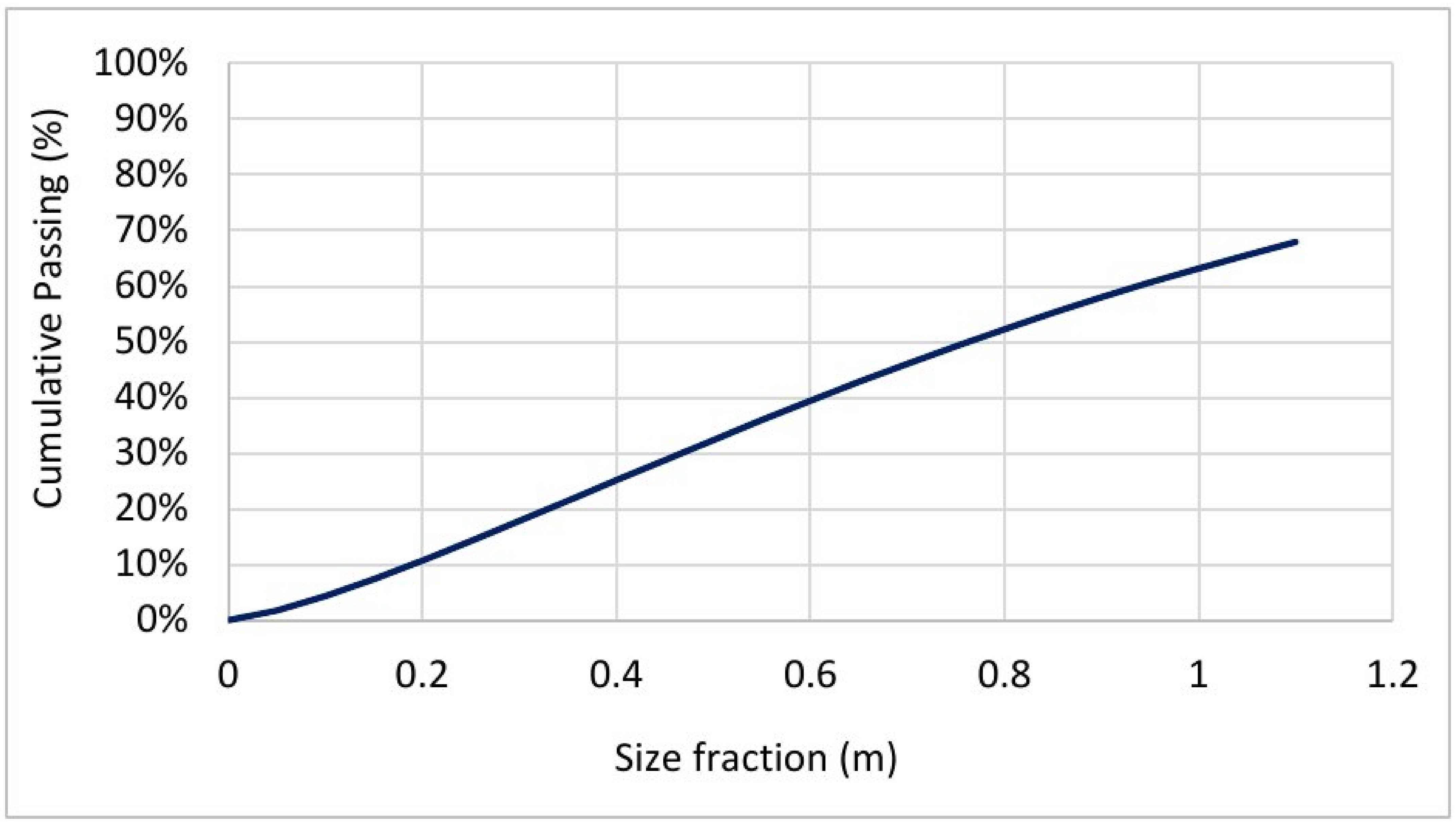

Figure 1 Kuz-Ram model base on drilling and blasting parameters for 2016

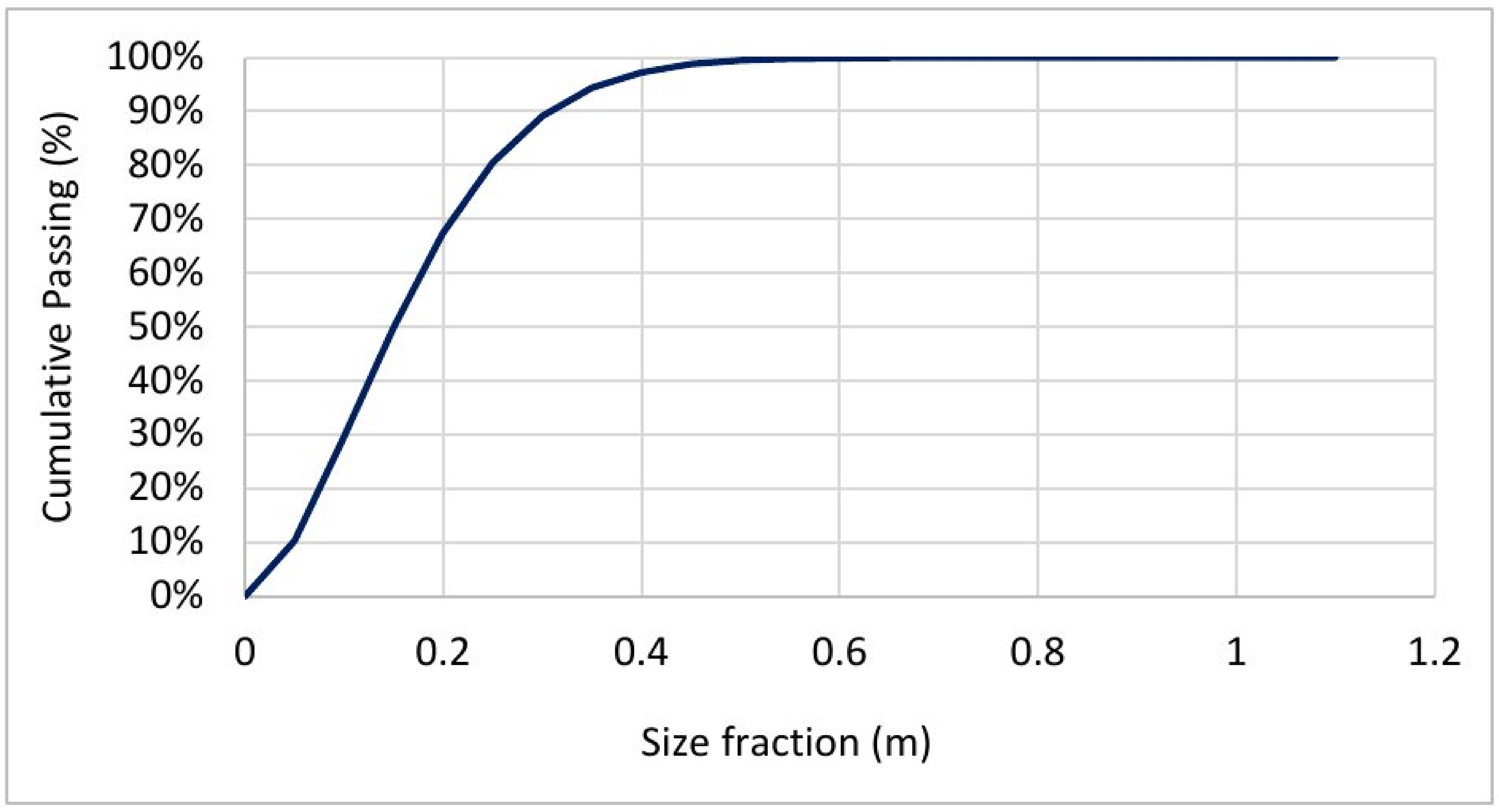

Figure 2 Kuz-Ram model base on drilling and blasting parameters for 2017

Predicted fragmentation base on Kuz-Ram model show different (Table 3) between percent passing of good materials which is affected from drilling and blasting parameters.

Table 3 Predicted fragmentation base on Kuz-Ram model

Percent	2016.	2017.
Oversize	20.7 %	10.9 %
In range	68.6 %	88.4 %
Undersize	10.7 %	0.7 %

Along with the results of the Kuz-Ram model, the consumption of electricity on the crusher can be predicted according to the formula by Kick:

$$E = Ck\ log\ \frac{Di}{Do} \tag{4}$$

E - Electrical energy (Kwh/t);
Ck = 10 * Wi - cons. of proportionality;
Wi = 12.77 Kwh/t (empirical value for limestone);
Di - Diameter of input material;
Do - Diameter of output material.

Applied Kick formula for electrical consumption on optimal and max. size of fragmentation give result (Table 4).

Table 4 Consumption of electrical power by Kick formula

Kick formula	Max. size (1.4 m)	Optimal size (0.8 m)
Electrical consumption	85.45 kWh	54.39 kWh

According to different sizes of fragmentation, differences in electricity power consumption can be seen as well as economic justification of using more explosives for drilling and blasting parameters from 2017. (Table 5).

Table 5 Electrical power consumption on hammer crusher

Year	2016.	2017.
Consumption of explosives (t)	82421	90757
Limestone production (t)	590176	632702
Electrical power (kWh)	385800	403500
Total (kWh/t)	0.56	0.49
Secondary blasting (times)	18	3

The benefit of increasing the consumption of explosives, and reducing fragmentation is the consumption of diesel and better utilization of machanization (Table 6). Machine can give more production, better cycle with less working hours and diesel consumption.

Table 6 Diesel consumption of different mechanization in quarry

Mechanization	Loader Caterpillar 988		Bulldozer Caterpillar D9R	Drilling rig AtlasCopco Roc F6	
Year	Fuel consumption (l)	Working hour (h)	Fuel consumption (l)	Working hour (h)	Drilled meter (m)
2016.	64151	2001	15785	1216	17340
2017.	63804	2106	9675	954	18563

When optimal fragmentation is good, it can avoid safety problems:

- Inequality on the lower part of banch;
- Irregular upper edges of the bench;
- Generating excessive mass on the edge of the bench;
- Increased number of boulders;
- Genarating cracks on bench;
- The distribution of materials in the truck basket.

CONCLUSION

Being an empirical model, which infers finer fragmentation from higher energy input, it is more about guidance rather than accuracy. The results obtained remain a starting point to give an overview of what is expected of an adjustment to a preexisting blast design. It can also serve as a basis for evaluating different designs, investigating the effect of changing certain variables and predicting the size distribution to be produced by the design. Results from calculated is near real value, so usage of Kuz-Ram model give positive benefits and good prediction what to expect. Safety and economically benefits are is another good indicator of the use of model and empiricism. The most important function of Kuz-Ram is to guide the blasting engineer in thinking through the effect of various parameters when attempting to improve blasting effects, leading to the final product, which is clinker in the cement industry.

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