# Economics of Abrasive Selection for Shipyard Use

By James D. Hansink
GMA Garnet Pty Ltd
Australia

Keeping up with the changes in abrasive requirements for use in shipyards is a bit like trying to ride a bicycle on an ice skating rink. You make progress slowly, and you are likely to fall flat on your face from time to time.

Some people often describe shipbuilding as if it were a single industry with simple problems common to all participants. In the automobile industry, a few large firms do essentially the same thing in several different countries. In shipbuilding, however, a huge number of facilities carry out activities ranging from construction of the largest bulk carriers to maintenance and repair of the smallest coastal fishing vessel or private pleasure craft. It is a grave mistake to try and characterise shipbuilding as a single industry.

Abrasive selection in shipyards is often driven by these differences in size and mission, and economics is often dictated by outside influences. The market might be divided along the following lines.

- Newbuilding vs. maintenance activities are perhaps the most basic difference.
- Size of the shipyard is important. Large facilities often have different and very special requirements not present at small yards.
- Local environmental requirements are becoming the single most important criteria in defining abrasive use, because costs associated with environmental control and compliance can far exceed the cost of abrasive.

No doubt there are other criteria, but this article presents a brief overview of the shipyard market for blast cleaning abrasives and suggests a simple means to estimate the true cost of surface preparation.

## The Cost Factor

Perhaps the most important criteria for abrasive selection is cost—either the real cost of the abrasive or the perceived cost of the value of the abrasive relative to its cost per tonne. A clear understanding of the true cost of abrasives and of surface preparation is critical to the success of a painting programme at any shipyard.

In all too many cases, however, the facility owner has no real understanding of the true cost of either the abrasive supply or the full cost of surface preparation. It is far too easy to assume that the yard should buy the cheapest material it can find when, in fact, there are other factors in the total cost besides cost per tonne.

In other cases, the facility manager may have more important or more pressing matters facing him than abrasive selection, and so he misses the opportunity to significantly increase his economic returns and to minimise undesirable environmental impacts that can result from using less expensive abrasive media.

The cost of surface preparation and the unit cost of abrasive are not the same thing.

$$\frac{(A \times B) + C + D}{X} + E = \text{Total Cost}$$

A = Abrasive cost ($/tonne)
B = Consumption rate (kg/hr/nozzle)
C = Labour cost ($/hr)
D = Equipment cost ($/hr)
E = Environmental cost
X = Productivity ($m^2$/hr)

*Fig. 1: Full cost formula*

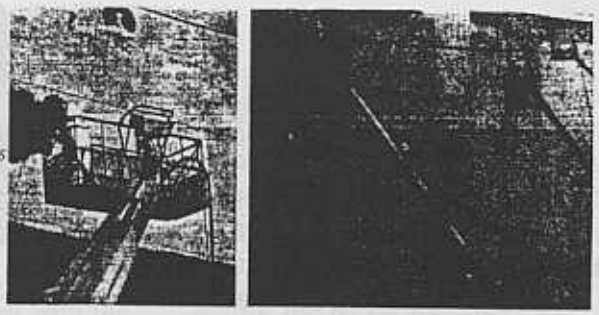
The full cost of abrasive blast cleaning in a shipyard is the sum of the costs of material, labour, and equipment, as well as related environmental or management costs adjusted by the productivity of the tools used. The cost of the abrasive—one of the "tools" of abrasive blasting—is only a small part of the total cost, which is tied to the cost of producing the abrasive, delivering it to the user, and a number of other factors. However, the productivity gain in using a high quality product or material usually offsets the difference in price. It's like the difference between buying a low cost axe or an expensive power saw. Which makes the most sense if you have a hundred trees to cut down?

## Other Factors

What other factors influence the total cost of blasting in a shipyard? Since blasting is a labour-intensive activity, the labour costs for both blasters and their supervisors must be included. In many cases, this is the largest single expense.

Equipment costs—the costs of owning capital equipment as well as the costs of replacing expendable items such as nozzles—should be counted. The productivity of these items must be weighed, of course, because the cheapest abrasive available is of no value at all if it fails to adequately prepare a surface for coating.

Costs related to environmental controls and regulations, especially the costs of dust control and waste management, are a growing factor in the blasting business. Certainly they should be included. Waste management is becoming the most important part of the cost picture in some areas, and it will only continue to grow in the future.



*Low dust conditions with a blaster using garnet (right) compared with high dust levels resulting from blasters using coal slag (far right) Photos courtesy of GMA Garnet Pty Ltd.*

## Cost Formula

The formula in Figure 1 shows that total cost is the sum of all these factors, and the economics of abrasive selection depends on the level of each one.

The most important element of cost is productivity, which is reflected in the efficiency with which the various factors—material, labour, and equipment—are used.

**Table 1: Cost Comparison**

| | Garnet | Slag |
|---|---|---|
| Test Area ($m^2$) | 4.6 | 4.5 |
| Time (min) | 11.8 | 18.5 |
| Consumption (kg/hr) | 400 | 790 |
| Efficiency (kg/$m^2$) | 17.1 | 54.1 |
| Cleaning rate ($m^2$/hr) | 24.1 | 15.1 |
| Cost ($/metric tonne) | 330 | 72 |
| Direct cost ($/$m^2$) | 9.75 | 9.87 |
| Cleanup @ $50/tonne ($/$m^2$) | 0.92 | 2.90 |
| Disposal @ $100/tonne ($/$m^2$) | 1.85 | 5.81 |
| Total Cost ($/$m^2$) | 12.52 | 18.58 |

(U.S. figures)

Small changes in productivity have large effects on the total cost.

Environmental costs are often assumed to be constant regardless of the abrasive chosen. This is simply not true. For example, an abrasive media that cleans a surface twice as efficiently as another abrasive not only allows the user to purchase only half as much abrasive to do the job but also requires the disposal of only half as much waste, which certainly impacts the environmental costs of the project. The formula should always include estimates for the cost of adequate dust control, material handling and disposal, and any other indirect expense that is likely to occur.

If the abrasive is to be recycled three or four times—as is common with some garnet media—then allowance for the small added costs of labour and equipment should also be made.

## What Affects Productivity?

Since productivity of the assets and dust control are the key elements in determining total cost of blasting in a shipyard, it is important to understand what affects these factors.

The nature of the abrasive grain—its size, shape, and most important its mass—determine how efficiently the abrasive will work on the steel.

In addition, the type of steel surface, its location, and the complexity of its configuration must be considered. A deeply pitted, rusted surface will clean differently than a new steel plate covered with light mill scale. Likewise, a large, flat hull surface generally will clean much faster than the compartmentalised interior of a ballast tank.

Other factors to consider in determining productivity are site ventilation and operator skill. Both can have a dramatic effect on productivity and, therefore, on total cost. In addition to the possible health risks, poor ventilation can cause even the most skilled operators to

use excessive amounts of time (labour costs) and abrasive (material costs), because when visibility is low and they cannot see well, they tend to overblast. Use of unskilled operators can result in the same problems. On the other hand, the quicker that dust and spent abrasive can be removed, the quicker the painting can be done, and the better the productivity will be.

Dust control is a function of the abrasive being used—some media are less prone to breakdown than others—and the conditions at the site. A yard employing 20 blasters is going to have a different dust problem than one using only one or two blasters, as shown in the photographs on page 25. Also, a poorly supervised or unskilled operator will tend to create excessive dust and waste material regardless of the abrasive media being used. An additional factor in dust control is the type of coating being removed. Some coatings are more brittle than others and, therefore, create more

*Garnet grains as seen through a macro lens*
*Photo courtesy of GMA Garnet (Europe) GmbH*

**By Joseph Periera**
**Abdulla Industrial Engineering Co.**
**Jubail, Saudi Arabia**

# Which Abrasive:

What is more important for the life of coatings—the paint system or the abrasive used for surface preparation?

No matter which paint system is used, surface cleanliness is a major factor in determining the life of the coating. In the Middle East, the trend in abrasive blast cleaning—a fundamental means of preparing industrial and marine surfaces—has moved from the use of sand to slag and currently to garnet abrasive.

Following is a brief comparison of costs and other factors for all three materials from company trials carried out in January.

**Table 1: Cost Comparison of Coal Slag, Sand, and Garnet** (Blasted surface: new steel, light rust)

| | Coal Slag | Sand | Garnet |
|---|---|---|---|
| Abrasive consumed | 50 kg | 50 kg | 50 kg |
| Size | 0.25–1.45 mm | 0.1–2 mm | 0.2–0.6 mm |
| Hardness (Moh) | 6.7 | 6.4 | 8 |
| Specific gravity | 2 | 2 | 4 |
| Blast standard | Sa 2½ | Sa 2½ | Sa 3 |
| Area blasted | 1.27 $m^2$ | 0.73 $m^2$ | 2.75 $m^2$ |
| Time taken | 5 min | 2.5 min | 9 min |
| Air pressure (nozzle) | 85 psi | 85 psi | 85 psi |
| Dusting | high | very high | very low |
| Profile | 52 microns | 38 microns | 65 microns |
| Production rate | 15 $m^2$/hr | 17.5 $m^2$/hr | 18.33 $m^2$/hr |
| Flow rate (kg/h) | 600 | 1,219 | 333 |
| Price per tonne | $160 | $15 | $300 |
| Disposal cost | $25 | $10 | $10 |
| Cost of equipment & labour/hour | $50 | $50 | $50 |

**Cost Analysis**

Cost per square metre = $\frac{\text{flow rate (price per tonne + disposal cost) + cost of equipment and labour}}{\text{production rate}}$

A. Coal slag: $\frac{0.600 \times (160 + 25) + 50}{15} = \$10.73/m^2$

B. Sand: $\frac{1.219 \times (15 + 10) + 50}{17.5} = \$4.60/m^2$

C. Garnet: $\frac{0.333 \times (300 + 10) + 50}{18.33} = \$8.35/m^2$

## Sand

Sand is rarely used these days in the Middle East. Although it is inexpensive, it produces high levels of dust and contains high levels of contaminants such as chloride. It generally does not produce as good a profile as other abrasives. More importantly, its use is banned in most industrial countries due to its connection with silicosis, a lung disease caused by inhaling dust that contains silica, which is found in high levels in sand.

## Slag

Industrial waste slags, such as those made from copper, platinum, coal, and nickel, all generate high levels of dust. Because of their size, they are relatively inefficient at removing rust from surface pits, and the sharp, angular slag particles can leave inclusions on surfaces. They can produce a nonuniform anchor pattern with excessive peaks, which can lead to pinpoint rusting.

Although silica is not a problem with slags, they have the potential to leach dangerous chemicals such as arsenic, cadmium, and lead into the environment if they are not disposed correctly. Consequently, proper disposal can be costly.

## Garnet

Natural mineral sands (as

dust particles, as will removal of a three-coat system compared with removal of a single coat.

### In Conclusion: An Example

Table 1 on page 25 illustrates the actual experience of one shipyard in evaluating a high-cost material—an almandine garnet—against a less expensive coal slag. In this case, the shipyard owner did not attempt to recycle the abrasive, and disposal costs were considered minimal.

Note that productivity—the amount of material and time necessary to clean one square metre—was significantly reduced with the use of the high-cost media. That's the message here: cost per tonne of abrasive should be only a small part of the shipyard's decision.

As new technologies and environmental requirements are imposed on shipyards, compliance and cost control will increase in importance. However, significant savings can be realised simply by using the existing tools more efficiently and by taking care to accurately measure the costs involved.

# Sand, Slag, or Garnet?

opposed to the silica sands discussed above) include Australian garnet and its Indian counterpart. Garnet has a uniform particle size of about 30–60 mesh, and so it produces a uniform anchor pattern. Garnet cleans very fast and easily produces a white metal (Sa 3) finish. Unlike sand and slag, it is often recycled multiple times, thereby reducing disposal costs. Garnet contains no silica or heavy metals. It has low chloride, leaves no inclusions on the surface, and produces low levels of dust. Because of its small particle sizes, it is very effective at cleaning surface pits.

For maximum efficiency, nozzle pressure should be 6.75 bar (100 psi) or more, and the air flow capacity of the supply should be a minimum of 350 CFM (165 L/s) for a No. 7 (10 mm orifice) nozzle.

The essence of blasting economics is speed, which is achieved by the correct combination of particle size, density, air pressure, and nozzle size. Finer, denser particles are the fastest, and garnet has this advantage, with a high density (4.1 kg/L) and small size (300–600 microns).

Table 1 on page 26 shows comparative costs for garnet, coal slag, and sand using typical field results. The cost analysis illustrates that despite the fact that garnet is nearly twice as expensive as coal slag ($300/tonne vs. $160/tonne), it produced a savings of 22% in the total cleaning cost per square metre.

After the garnet was blasted, it was collected, sieved, weighed, and recycled three times. Table 2 above shows the data for each of these uses. The figures illustrate that after being recycled three times, the average cost of garnet is almost the same as the one-time use of sand, the least expensive of the three media.

**Table 2: Cost Comparison of Recycled Garnet** (Blasted surface: new steel, light rust)

| | I Use | II Use | III Use | IV Use |
|---|---|---|---|---|
| Abrasive consumed | 50 kg | 45 kg | 40 kg | 36 kg |
| Blast standard | Sa 2½–3 | Sa 2½ | Sa 3 | Sa 3 |
| Area blasted | 2.75 $m^2$ | 2 $m^2$ | 1.7 $m^2$ | 1.7 $m^2$ |
| Time taken | 9 min | 7 min | 6.5 min | 6.5 min |
| Air pressure (nozzle) | 85 psi | 85 psi | 85 psi | 85 psi |
| Profile | 65 microns | 67 microns | 58 microns | 54 microns |
| Production rate | 18.35 $m^2$/hr | 17.14 $m^2$/hr | 13.84 $m^2$/hr | 13.84 $m^2$/hr |
| Flow rate (kg/hr) | 333 | 385 | 369 | 332 |
| Price per tonne | $300 | 0 (recycled) | 0 (recycled) | 0 (recycled) |
| Disposal cost | $10 | $10 | $10 | $10 |
| Cost of equipment and labour | $50 | $50 | $50 | $50 |

**Cost Analysis**

Cost per square metre = $\frac{\text{flow rate (price per tonne + disposal cost) + cost of equipment and labour}}{\text{production rate}}$

| | cost/$m^2$: | |
|---|---|---|
| I Use (new) | | = $8.35/$m^2$ |
| II Use (recycled): | $\frac{0.385\ (0 + 10) + 50}{17.14}$ | = $3.14/$m^2$ |
| III Use: | $\frac{0.369\ (0 + 10) + 50}{13.84}$ | = $3.88/$m^2$ |
| IV Use: | $\frac{0.332\ (0 + 10) + 50}{13.84}$ | = $3.85/$m^2$ |
| Average: | | = $4.80/$m^2$ |
| Saving: slag vs garnet recycled 4 times | $\frac{10.73 - 4.80}{4.80}$ | = 125% |

Saving: sand vs garnet recycled 4 times is almost same cost.