17* international Mining Congress and Exhibition of Turkey- 1MCET2001, ©2001, ISBN 975-395-417-4

Performance of the Bigger, Faster and Smarter New Generation Electric Mining Shovels

L.B.Paterson
P&H MinePro Services, Milwaukee, Wisconsin, U.S.A.
M.Özdoğan
Ideal Makina, Ankara, Turkey

ABSTRACT: The world Mining Industry is seeing a continued movement to larger loading and hauling units in classic truck and shovel applications. The "Bigger, Faster, Smarter" equipment has provided a great opportunity to lower miner's cost per ton. However, in some cases, due to specific production requirements, established pit development or restrictions on capital, there are other available options in lowering the cost per ton. Better shovel/truck matching, and optimizing the loading activity are some considerations. This paper takes a look at the performance of the new larger loading equipment and explores the available options to keep abreast in a competitive market.

1 INTRODUCTION

"Higher productivity at a lower cost per ton", that's the common mantra we hear from the Mining Industry today. In the face of ever increasing operating costs and unpredictable commodity costs, as well as the increase in competition in an ever-shrinking Global market, many mining operations are under immense pressure to lower costs.

Many mine operators are faced with difficult decisions regarding equipment - "repair or replace?" in older operations, "what size is optimal?" in greenfield operations and "how do I become more efficient and cost effective with the equipment I already have?" The answers to these questions are further complicated by the volatile market in which we operate with a resultant myriad of choices for operators to consider.

In addition, we have seen a considerable increase in size of equipment in operation at mines with a theme of "Bigger, Faster, Smarter" for the latest offering from P&H Mining Equipment. As the equipment gets larger, some operators of existing mines with smaller and older equipment are considering "upgrading" to larger machines. Are the larger machines indeed as cost effective as the manufacturers claim them to be? And is the price tag justified?

So, the answer lies in the requirements of the operation and the prevailing economic constraints in that region.

Using examples from the P&H range, namely the 2300XPB, 2800XPB, 4100A and 4100XPB, this paper will demonstrate the effect on cost per ton of. different elements of the loading operation. Using an exclusively developed Interactive Production Costing Model, we have run countless scenarios to present the comparisons in this paper. All calculations have been done utilising the equipment to the maximum production with nominal truck presentation and typical mining conditions, and keepmg them the same for all exercises. In reality, the results will vary from mine to mine and analysis should be conducted for specific applications. What is important in the numbers that follow are their comparisons relative to each other, not the absolute value.

2 SHOVEL SIZE

It's probably most common that shovels are referred to in terms of their nominal capacity in cubic units of capacity. This is calculated using nominal material densities; nominal weights of a general-purpose dipper, and nominal fill factor. Note the excessive use of the word "nominal", dipper sizing will change according to the conditions and constraints prevailing at a specific mine. So any shovel model will ultimately be sold with a dipper size "tailored" to the operation.

"Nominal" dipper sizes for the P&H range of equipment as follows:

2300XPB - 25 m^3
2800XPB-35m^3
4100A -45 m^3
4100XPB-56m^3

Do we size a dipper for the "Rated Suspended Load" of the shovel, or do we consider truck size?

3 TRUCK MATCHING

The best match is one where the shovel, loading its maximum payload is able to fill a truck to its maximum payload in 3 or 4 even passes.

Typically the P&H shovel will be able to load a range of trucks. There is no absolute match, as mentioned before; the dipper will be tailored to give the right match. Figure 1 below illustrates the flexibility of the range; please note that truck payloads are indicated in METRIC tons:

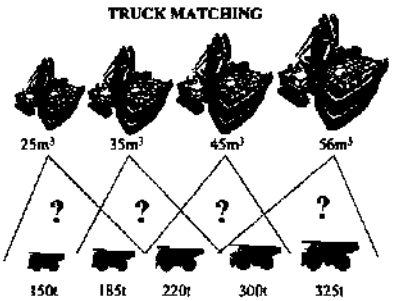
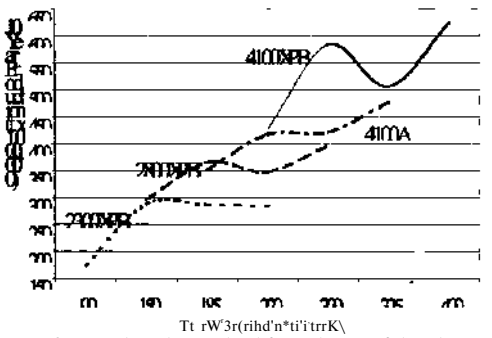


Figure 1 Truck-shovel matching

Figure 2 shows typical production levels for the shovels loading the selected range of trucks from 90t to 400t.



Tt rW'3r(rihd'n*ti'i'trrK\

Figure *2.* Typical production level for each type of shovels

This exercise does include some numbers that are not really a true match. Firstly there is currently no 400t truck, but the graph depicts what a 4100XPB would do with a truck that size. Secondly, it is geometrically not a good match for a 2800XPB to load a 300t truck, but the numbers have been included to show the trend, production would actually be lower than depicted due to the geometrical constraints. Lastly, a 90t truck has also been included for the 2300XPB, again this is a match outside of the design of the shovel, but the curve trend is more apparent with it's inclusion.

What does this graph tell us? Firstly that the larger the shovel, the chances are you will get better production from the unit. Secondly, matching trucks is far more critical in the larger range of shovels than with smaller shovels.

The assumption also stands for this exercise that trucks should ALWAYS be filled to maximum payload. In a shovel/truck operation, the costs of loading are in the region of 30% of the total system costs. With the trucks therefore the more expensive portion, it stands to reason that if any under utilization of capacity is to be incurred it should be with the shovel. As the utilization of the shovel capacity approaches 100%, mere may be merit in accepting slightly underloaded trucks, but this exercise would site be site specific and a separate exercise would have to be conducted.

One further assumption is that the number of passes to load a truck is 3 or more. To "drop" half of the payload of a truck into the bowl for the first pass İs considered detrimental to the truck operator, as well as to the truck from the perspective of its structural longevity.

Figure 3 shows the impact on loading cost/t for matching different truck sizes.

From Figure 3, you see that the cost per ton also fluctuates for each shovel type, which highlights the need for truck matching. The overall trend across the product lines is that the cost per ton produced diminishes as we move towards the "Bigger, Faster and Smarter" shovels with correctly matched trucks.

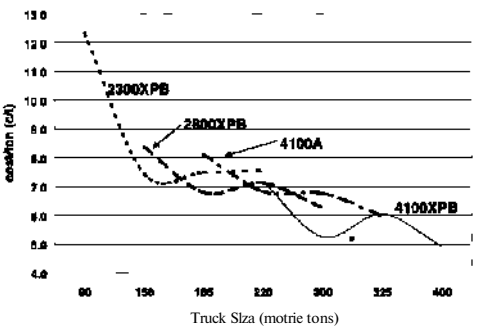


Figure 3. Unit production cost for each type of shovels.

An important element to consider is that you may not get the "ideal" match, with a resultant say, 2.8 passes required to load a truck. Some operators are

of the belief that they are able to judge 0.8 of a load, but much time is spent "getting it right" with the majority resultant that it is not. Overloaded or underloaded trucks are both detrimental to the operation. Overloading accelerates fatigue and induces premature failure, while underloading tends to be uneconomical. Figure 4 shows the effect of over or underloading trucks.

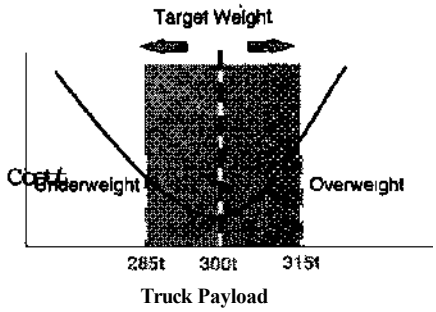


Figure 4. Typical truck cost curve.

The solution is to match the dipper to the truck and not the shovel. This ensures the best environment for the operator who then has to concentrate on efficient loading techniques, rather than exercising continuous judgement on truck fill. The next item that therefore raises a concern is the issue of productivity. All too often we as miners discuss the productivity of our equipment and use them as a basis of comparison. Unless both operations being compared are exactly the same the productivity comparison is meaningless.

4 PRODUCTIVITY

Productivity is a function of a number of factors, the major influences being:

- Truck size selection
- Blasting proficiency
- Average swing angle
- Truck presentation
- Truck Spotting time
- Operator efficiency

- *Truck Size Selection*

We have already demonstrated the effect of overall production on truck size selection. As we are becoming more proficient in understanding the conditions under which we are mining and the behavior of the material in the operation, we are able to tailor equipment for the mining operation. We have alluded to dipper sizing, and matching it to the truck. There is now a trend to tailoring the truck to the mining operation. Much work has been done in the area of truck body design and there is a shift away from a "generic" truck body. This enables operations to be optimised and to ensure that payloads are maximised for that all-important 70% of the costs of the load and haul cycle - the haul.

In order to demonstrate the effect of truck payload selection, we have run the 4100XPB model with truck selection changes. Figure 5 graphically depicts the effect on productivity.

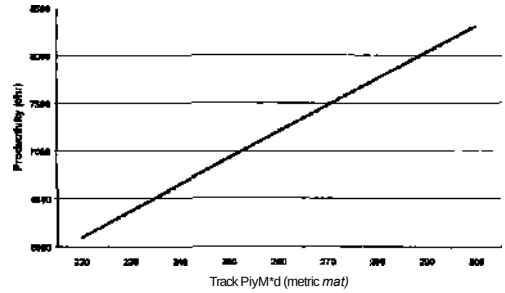


Figure 5 Effect of truck payload selection on productivity.

- Blasting Proficiency

Inefficiencies in drilling and blasting can cause substandard digging conditions resulting in either longer cycle times to fill a dipper or sub-standard dipper fills, and in some cases bodi of these conditions. To ensure that the truck is full the operator is forced to move from an optimal situation say, three-passes, to four or even five passes.

Figure 6 depicts the effect of sub-standard blasting conditions, where the operator is forced to deviate from optimal three-pass loading to a four or even a five-pass situation.

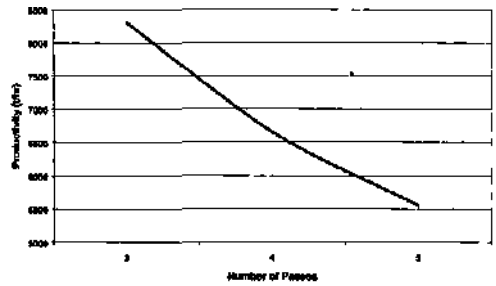


Figure 6 Effect of 3,4 or S pass loading on shovel productivity.

- Average Swing Angle

All the studies thus far have been conducted using an average swing angle of 70°. Choice of loading practice and face loading management on the part of the operator can cause the average swing angle to vary considerably. Figure 7 shows the effect of different average swing angles.

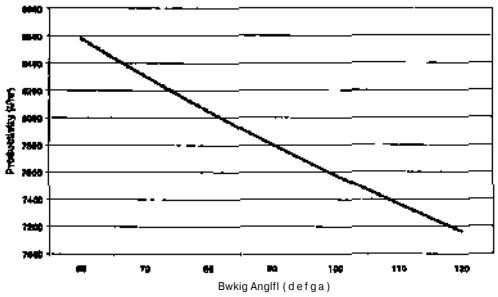


Figure 7. Effect of swing angle on shovel productivity.

- Truck Presentation

It could be debated that truck presentation does not affect productivity, since the time spent "waiting on trucks" is booked separately and not included in the calculations. This may well be the case for operations that are extremely "under trucked" and the operator *has* the time to book the waiting time. However, if the truck is İn sight of the operator, the waiting time may not be booked and somehow gets included in the loading time and therefore used İn productivity calculations.

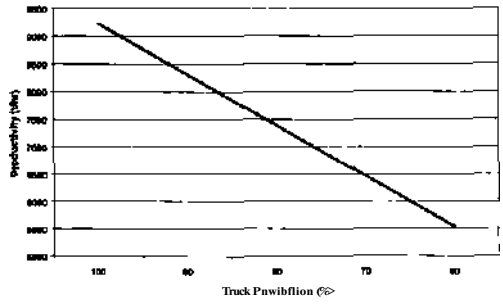


Figure 8. Effect of truck presentation on shovel productivity

These errors may also be eliminated if there is electronic monitoring of the truck fleet. For the purposes of this exercise let us assume that the operator does not differentiate this waiting time from loading time. Figure 8 looks at the effect of truck presentation. The truck presentation is presented as a percentage, i.e. 80% Truck Presentation means that the shovel will have a truck to load 80% of it's available time.

- Truck Spotting Time

Much time is lost in the truck loading cycle due to maneuvering the truck into the loading position The use of the double back-up loading method does bring this to a minimum. Some applications utilize a modified drive-by method of loading with a resultant spotting time of less than 10 seconds. Poor practices could result in Truck Spotting times of more than a minute.

Figure 9 demonstrates the effect of Truck Spotting Time on Productivity. One thing to remember is that truck spotting time is also affected by floor conditions (severe undulations) or floor cleanliness ("housekeeping" around the shovel).

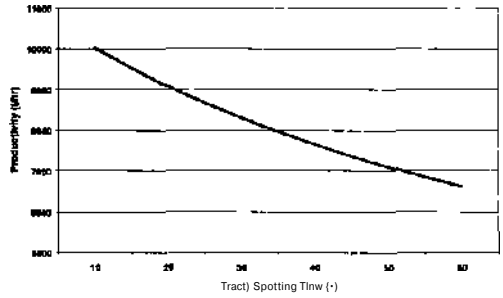


Figure 9. Effect of truck spotting time on shovel productivity

- Operator Efficiency

The operator spends 8 hours a day on the shovel and is probably the single biggest contributor to shovel efficiency. The control of digging and loading practices falls directly under the control of the operator. In essence, the shovel operator is the manager of the loading operation.

The method the operator tackles the digging face influences swing angle, time in the bank and truck positioning.

The net effect of an inefficient operator is increased shovel cycle time. Figure 10 shows the effect of increased cycle time on the loading operation.

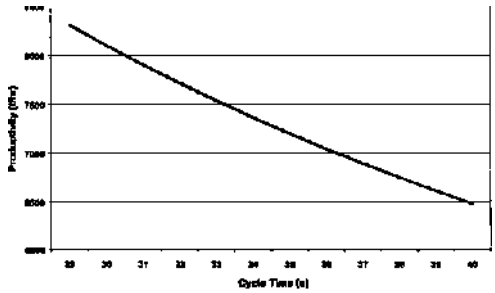


Figure 10. Effect of increase in cycle time on shovel productivity.

5 TECHNOLOGY

A large portion of this paper has concentrated on productivity - and technology is a huge contributor to the high productivities we now enjoy.

Digital controls, OptiDig, Diagnostics, Remote Communication and LoadWeigh capabilities all contribute to these productivities.

- Digital Controls

The older analog control curve has a single point where peak power, the product of bail pull and bail speed, is delivered. From Figure 11 one can see the digital peak power is delivered over a much wider range of operating points.

This capability, plus more bail pull at the slow end of the curve reduces time in the bank. The higher speed at light loads reduces time lowering an empty dipper.

Lower cycle times mean higher productivity.

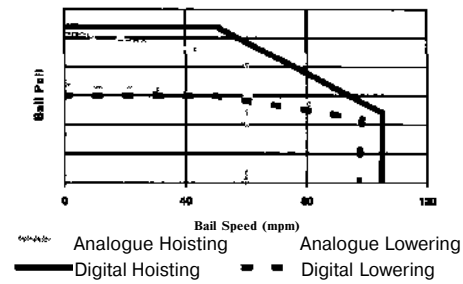


Figure 11. Bail! pull vs bail speed in analog and digital control

- Diagnostics and Remote Communications

Although probably more related to "uptime" and therefore' overall production, this is an important feature that mine operators can pursue in achieving overall shovel efficiency, and ultimately higher annual production.

A program of regular diagnostics can identify trends and highlight problems before they occur. In addition, the newer technology, associated with a network of relay stations can bring vital sign monitoring right into the maintenance offices.

Operators can also be monitored from remote locations and potentially expensive practices can be halted before their continuance can result in unnecessary downtime. Cycle time analysis can also be carried out from a distance and an education program set in place to rectify any bad habits from manifesting themselves m the operation.

- OptiDig

The digital technology also enables the new equipment to be fitted with productivity enhancing tools such as OptiDig which senses digging motion feedback and balances hoist and crowd motions to optimize power usage, regardless of material density or operator experience.

- LoadWeigh

The ability to tell with any CERTAFNTY what's in each dipper load is an extremely valuable too! for the operator. This provides a "dipper by dipper" account of the payloads loaded by the operator. From this feedback the operator is able to accurately determine what's on each truck and the system informs the operator the remaining tonnage required to make up the truck payload. So the primary use of this tool İs to tighten up load variance (see Figure 12). Of course, the operator is not entirely responsible for the efficiency of the dipper fill, blasting plays an important role in this and LoadWeigh is another tool to determine blasting effectiviry

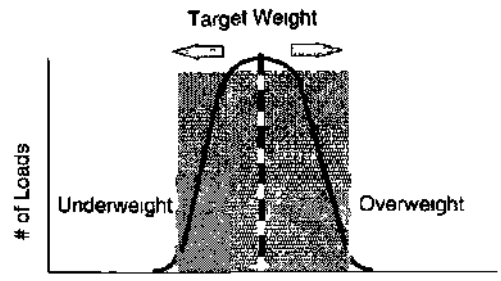


Figure 12 Tighten up load vanance.

There are many other features inherent in the shovel of today that enhance productive capability and minimize downtime. That's what makes them "Smarter".

6 WHAT ABOUT THE OLDER EQUIPMENT?

Does this mean that in order to "enjoy" the benefits of new technology that new equipment should be purchased? Absolutely not! In an ongoing effort to meet the needs of the Industry, we recognise that not all equipment has reached the end of its useful life, and that not every operation has the available capital for full machine replacements.

Every development project is conducted not only with the newer equipment in mind. Our engineers make every effort to provide the newer technology in the form of an upgrade for our older models still working in the field. This presents an economical alternative to operations to become more cost effective at the loading face, and which does have an effect on associated operations as well.

We have seen dramatic improvements in productive capability in operations that have opted for the digital upgrade. Of course, the introduction of the digital technology opens the door for the application of other upgrades such as OptiDig and LoadWeigh.

So being an owner of older equipment does not necessarily preclude one from applying the new technology.

7 SUMMARY

In this paper we have highlighted the benefits and cost effectiveness of the new "Bigger, Faster, Smarter" shovels. We understand that not every operation is suited for the larger equipment and there is definitely a benefit in going smaller, especially when one is limited regarding quantity of final product. We are sure there is still sufficient food for thought for existing operations that are just looking for improvements in efficiency, not only from an applications standpoint, but consideration of training and upgrades.

'Finally, we extend our thanks to P&H for giving us the opportunity to share some ideas on improvement of the shovel/truck operation.

Together we can move forward to produce at the lowest cost per ton.