Loading and Hauling

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Martin Mattsson
LOADING AND HAULING

Purpose

• Increase the understanding for how a machine fleet and site can be optimized (loading and transport) in regards to productivity and costs.

Goal

• To be able to choose the most effective load and transport solution, measured in cost/ton.
AGENDA

Agenda

- Optimal loading
  - Wheel loaders
  - Excavators
- Optimal hauling
  - Articulated trucks
  - Rigid trucks
- Case study:
  - Loading and Transport
DIGGING/LOADING SOLUTIONS

Alternatives
1. Wheel loader
2. Crawler excavator, backhoe
3. Crawler excavator, face shovel
4. Massive scale mining - continuous miner, cable shovel, dragline
DIGGING/LOADING SOLUTIONS

Alternatives

1. Wheel loader
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3. Crawler excavator, face shovel
4. Massive scale mining – continuous miner, cable shovel, dragline
# DIGGING/LOADING SOLUTIONS

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Wheel Loader</th>
<th>Backhoe Excavator</th>
<th>Face Shovel</th>
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<td>YYY</td>
<td>YY</td>
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<td>YYY hammer, ripper, QC</td>
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<td><strong>Bucket selection</strong></td>
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<td>YYY</td>
<td>Y</td>
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<td><strong>Selection/Boulder handling</strong></td>
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<td><strong>Loading level</strong></td>
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<td>floor</td>
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<tr>
<td><strong>Reliability</strong></td>
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<td>YYY</td>
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</table>

**Key Rating**
- poor
- fair
- good/excellent
- exceptional
OPTIMIZE LOADING – WHEEL LOADERS
OPTIMIZE LOADING – WHEEL LOADERS

Quarry design

• Quarry Floor
  • Water removal
  • Grades/Inclinations
  • Even ground surface
• Keep the site clean from waste/equipment not in use
• If possible; Make sure that is enough space for at least two receivers of the load
OPTIMIZE LOADING – WHEEL LOADERS

Truck positioning

• Select a position as close to the material as possible
• Place the receiver of the load in the direction of travel
  • Sharp turns when truck leaves will destroy surface
  • If loading can be arranged with trucks passing without reversing capacity increases
OPTIMIZE LOADING – WHEEL LOADERS

Maintain the Roads

• Make sure the road is as smooth as possible and free from dropped gravel
• Smooth out rough routes with finer material and fill in holes
• Dropped material is wasted revenue and becomes a 2nd cost.

Volvo L350F Load & Carry 100 m
Productivity rate = 570 ton/hr

Add one stop-and-go and productivity decreases 14%
Productivity rate = 490 ton/hr
OPTIMIZE LOADING – WHEEL LOADERS

Take the Shortest Route

• Plan your transport routes so they are as short as possible.
  • Straighten out road curves.
  • Move obstacles (i.e. road signs)
  • Optimize roads in regards to inclination and length.
• Optimize placement of depots in regards to handled material.
• Consider a belt conveyor for long transports, especially if there is a large elevation change.
Uphill Grades

• Avoid sharp turns before uphill grades so that momentum is maintained and braking minimized.

• Uphill grades at the unloading area can assist deceleration without braking, and assist backup.

Use force of gravity to slow down at dump, and accelerate at re-start cycle.

Aids fuel efficiency and reduces wear on brake pads.
OPTIMIZE LOADING – WHEEL LOADERS

Volvo 350F load & carry 160 m

<table>
<thead>
<tr>
<th></th>
<th>Productivity (ton/h)</th>
<th>Fuel eff. (ton/lgal)</th>
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</thead>
<tbody>
<tr>
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<td>Straight</td>
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<td>Volvo L220F</td>
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OPTIMIZE LOADING – WHEEL LOADERS
OPTIMIZE LOADING – WHEEL LOADERS

Handling Finished Products

• Bucket selection
  • a Rehandling bucket Test – makes a real difference.

• Tire selection
  • L2 or L3 is sufficient
    Weight
    Internal friction
    Price
    Test

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OPTIMIZE LOADING – WHEEL LOADERS

Rehandling Bucket

• Optimized for fast filling - “knifes” in to material instead of crowding.
• Large fill factor (full measure) for capacity.
• Minimizes spillage or waste, for example in a load and carry.
• Rounded corners and edges reduce stuck material in the bucket and increase the life of the bucket.
• Can increase fuel efficiency up to 10%.
OPTIMIZE LOADING – WHEEL LOADERS

How much can fuel consumption be decreased per hour with a rehandling bucket compared to a General Purpose bucket?
OPTIMIZE LOADING – WHEEL LOADERS

Short Cycle Loading
Normal Operation - Crushed

Lower is Better

<table>
<thead>
<tr>
<th>Cycle Time (s)</th>
<th>Fuel Consumption (L/h)</th>
<th>Productivity (t/h)</th>
<th>Fuel Efficiency (t/L)</th>
<th>Bucket Fill Factor (%)</th>
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<td>L180F GP</td>
<td>L180F RH</td>
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<td>98%</td>
<td>107%</td>
<td>99%</td>
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</table>

Higher is Better

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OPTIMIZE LOADING – WHEEL LOADERS

Tires

L2:
- When a good grip is important.
- When driving on sand with few/no sharp stones
- Load/carry, including material handling.

L3:
- All types of load/carry applications.
- When driving on sand.

L4:
- When handling aggressive material and protection against cutting is needed. For example when handling blasted rock.

L5:
- When handling extremely aggressive material. For example in quarries and mining applications. Low travel/speed.

Increasing tread depth, also increasing weight and reducing TMPH!
OPTIMIZE LOADING – WHEEL LOADERS

Finished Material

- Right Bucket – Rehandling Bucket
- Right Tires – L2 or L3
  - Weight
  - Internal Friction
  - Price

Duplicate slide???
OPTIMIZE LOADING – WHEEL LOADERS

Rock Handling

• Right Bucket – spade nose bucket
• With or without teeth
• Right tires – L5
• Chains are sometimes used
OPTIMIZE LOADING – WHEEL LOADERS

Spade Nose Bucket

- Adapted for loading of blasted rock
- Designed for superior penetration ability
- Can be equipped with both teeth/segments and bolt on edge
OPTIMIZE LOADING – WHEEL LOADERS

Load and Carry

• Cost-effective transport from 0-650ft (200m), Why?
  • Reduce the fleet of mobile machines, less operators less traffic.
  • Lower investments
  • No/reduced need for loading ramp to hopper
OPTIMIZE LOADING – WHEEL LOADERS

Load and Carry

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OPTIMIZE LOADING – WHEEL LOADERS

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<th>Configuration</th>
<th>Length of transport 160 yard</th>
<th>Length of transport 220 yard</th>
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<td>Production</td>
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<td>0,52 $/tn</td>
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<td>Volvo L180F</td>
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<td>Volvo A35E</td>
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</table>
OPTIMIZE LOADING – WHEEL LOADERS

Load and Carry / Travel Enhancement

• A Boom Suspension system reduces bucket movement when driving on uneven surfaces.
  • Increased productivity (up to 20%)
  • Increased comfort and stability
  • Less spillage and waste
  • Less stress on axles, frames & lifting arms

Movie
OPTIMIZE LOADING – WHEEL LOADERS

Finished Material

• The right bucket can reduce fuel consumption 5%
• The right tires can also reduce fuel consumption 5%
• Overall, in 1500 h / year
  6.6 gal / h → 10,000 gal
  10% saving → 1,000 gal
  $3,000/year
SUMMARY OF LOADING – WHEEL LOADERS

Benefits of Wheel Loaders vs. Crawler Excavators

• Mobility
  • Possibility of load/carry on shorter distances (rule of thumb: up to 650ft)
  • Loading from different locations/depots for mixing material
• Utility
  • Maintain roads, clean up loading area
• With quick fit/coupler you can:
  • Do some odd or small jobs, for example clean under the conveyor belt
  • Use different buckets. The right bucket for the right purpose.
  • Easily switch to forks for block handling or material handling.
OPTIMIZATION OF LOADING – CRAWLER EXCAVATORS
SUMMARY OF LOADING – CRAWLER EXCAVATORS

Benefits of Excavators vs. Wheel Loaders

• Travel and Digging/Loading are separate modes
  • Faster load cycle times (swinging not traveling)
  • No/little undercarriage or tire wear during loading
• Handling variable material
  • Boulder handling, sorting
  • More reach
  • Better distributing of load in truck bed
• Ancillary Jobs
  • Hammer/breaker
  Quick coupler allows ripper attachment, other buckets

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OPTIMIZE LOADING – EXCAVATORS

Organized loading site

• Keep the loading site free from rocks and waste.
• Make it easy for the hauler/truck to approach/reverse for loading, thus giving a shorter and more effective loading cycle.
• 45-90 deg swing is optimal
• Use truck spotting time to pull material closer.

Give a shorter and more efficient loading cycle → Increased production
OPTIMIZE LOADING – EXCAVATORS
OPTIMIZE LOADING – EXCAVATORS

Positioning

• Load from the bench, if possible.
  • Better visibility
  • Better traffic flow
  • Better floor and pile management
  • Optimal digging forces

• Cooperation with the hauler gives a shorter, more effective loading cycle

• Make sure the excavator is placed on firm ground, don’t swing over cab

• Aim for as short swing angle as possible, minimize boom/arm movements.

What’s in it for me?
Reduce cycle time from 22 sec to 20 sec
→ Loads one more 40 ton truck/hour
→ increase revenue $150,000/year
(at $2 per ton)
OPTIMIZE LOADING – EXCAVATORS

Use the right attachment

- A variety of boom/arm/bucket combinations – choose!
  - Mass Ex (ME) = short boom & arm → big bucket but limited reach. Resale value?
  - Long arm = reach can reduce travel but hurts digging capacity, may increase cycle time.
  - Standard boom + short arm → often best truck loading. Good digging & reach for a tight cycle.
  - Quickfit/coupler – switch to breaker, ripper, grading bucket, etc. → ripper sometimes used to unstick the crusher chamber.
OPTIMIZE HAULING
HAULING SOLUTIONS

Alternatives
1. Road trucks
2. Articulated dump trucks
3. Rigid framed dump trucks
4. Mobile crusher/conveyor
## Hauling Solutions

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Articulated Truck</th>
<th>Rigid Truck</th>
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<td><strong>Power/Weight ratio</strong></td>
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<td><strong>Payload Capacity</strong></td>
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<td><strong>Gradeability</strong></td>
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<td><strong>Running Costs</strong></td>
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<td><strong>Reliability</strong></td>
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OPTIMIZE HAULING

Load Matching

• 2 minute loading optimal
  → Wheel loader 3-5 passes
  → Excavator 4-7 passes.
  3 minute loading acceptable.

• Avoid partial passes
  → extra payload rarely outweighs wasted time
  → reduced fuel efficiency
  → increased spillage issues.

One load cycle 25 sec
### OPTIMIZE LOADING – LOADER PASS MATCH

<table>
<thead>
<tr>
<th>Trucks</th>
<th>Volvo L220F</th>
<th>Volvo L350F</th>
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</tbody>
</table>

**Maximum counterweight and pin-on spade bucket size assumed.**

Matching based on payload factor (body volume assumed to suit material density).
# OPTIMIZE LOADING – EXCAVATOR PASS MATCH

<table>
<thead>
<tr>
<th>Trucks</th>
<th>Excavators **</th>
<th>Hitachi EX1200</th>
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<tr>
<td>50.0 Ton</td>
<td>11.0 Pass</td>
<td>10.0 Pass</td>
</tr>
<tr>
<td>45.4 t</td>
<td>11.0 Pass</td>
<td>10.0 Pass</td>
</tr>
<tr>
<td>60T RDT</td>
<td>13.33</td>
<td>11.43</td>
</tr>
<tr>
<td>60.0 Ton</td>
<td>14.0 Pass</td>
<td>12.0 Pass</td>
</tr>
<tr>
<td>54.4 t</td>
<td>14.0 Pass</td>
<td>12.0 Pass</td>
</tr>
<tr>
<td>70T RDT</td>
<td>15.56</td>
<td>13.33</td>
</tr>
<tr>
<td>70.0 Ton</td>
<td>16.0 Pass</td>
<td>14.0 Pass</td>
</tr>
<tr>
<td>63.5 t</td>
<td>16.0 Pass</td>
<td>14.0 Pass</td>
</tr>
</tbody>
</table>

**Maximum counterweight and pin-on Rock bucket size assumed.
Matching based on payload factor (body volume assumed to suit material density).**
Load Matching

- Load distribution is important, plan bucket placement
- Generally, an excavator can distribute the load better due to the additional reach and profile of the bucket.
- Off-balance loading is a safety threat, increases spillage, and increase tire/suspension wear.
OPTIMIZE HAULING

Plan the roads
• Unloaded machines always yield to a loaded machine.
• Consider a safe road width, ensure suitable passing points.
• Avoid repeated starts and stops as much as possible along the haul.
• Proper drainage and super-elevation in turns.
• Consistent grades, no variance:
  • 8-10% grade for rigids
  • 8-12% grade for artics

Rolling Resistance = $$$$  
Tire penetration of 4" → +5% RR  
→ reduce production 10%  
→ increase running costs 10-25%
OPTIMIZE HAULING
ADT TIRE APPLICATIONS

Earth moving Construction

Sand

Long cycle / High speed

Soft ground Flotation

Short cycle / Low speed

Soft ground Traction

L5 tires are suitable for mining applications with low speeds and very abrasive environments.

• Very good cut protection.
• Low average speeds.
• Extra Long tread life.
• Reduced comfort.

Operating in SOFT SAND requires different tire characteristics than in mud.

• Good flotation
• Shallow tread depth
• Minimal ground disturbance

E3 tires are "all around" tires suitable for close to all articulated hauler applications,

• Good self cleaning and traction.
• High average speeds.
• Long tread life.

E4 tires are suitable for work sites with rather well maintained haul roads and abrasive environments (gravel pits and quarries).

• Good cut protection.
• Good comfort.
• Extra Long tread life.

L5 tires suitable for mining applications with low speeds and very abrasive environments.

• Very good cut protection.
• Low average speeds.
• Extra Long tread life.
• Reduced comfort.

Operating in SOFT SAND requires different tire characteristics than in mud.

• Good flotation
• Shallow tread depth
• Minimal ground disturbance

Operating in HARD GROUND - ROCK CUT RESISTANCE, DURABILITY

• Low average speeds.
• Extra Long tread life.
• Reduced comfort.

Operating in UNDERGROUND

• Low average speeds.
• Extra Long tread life.
• Reduced comfort.
Wheel Loader Match Excel file from David Nus
OPTIMIZE HAULING

Tools to optimize site operation

- Site Sim (Volvo CE)
- Other tools…

- RETARDING not BRAKING
Case study

Newly opened quarry
Start: 1 jan 2010
Time span: 18 month (enddate 2011-06-30)
8h hour workday
5 days / week
44 weeks / year
(220 days)
Production

■ **Crushed material to asphalt plant**
  - The asphalt plant needs 250 000 ton gravel per year.
  - Asphalt production 6 month per year

■ **Delivery to other markets**
  - 1100 ton / day
  - 12 month per year

■ **Hard Rock for harbour construction**
  - 1400 ton / day
  - 12 month per year
Case study

- For loading and transport we are ONLY interested in the need for unloading of blasted stone.

- You should NOT consider the handling of intermediate or final material, loading on truck etc.
Case study

Alternative I:
- Excavator loads mobile cross + mobile
FALLSTUDIE

Alternative II:
- Excavator loads mobile cross, wheel loader loads material on trucks for transportation to stationary secondary cruscher and sorter
FALLSTUDIE

Alternative III:
- Wheel Loader loads Hualer. Hualer transports to fixed primary cruscher
- Length of transports from face to stationary primary cruscher, 500m
CASE STUDY

Tasks:

1. Create a production plan for the coming 18 month
2. Set the dimensions for loading
3. Use Simulation: Estimate Dollar / tonnes

Present:

1. Production plan
2. Choice of machines
3. Cost (dollar/tonnes)