

SIEMENS

Industrial Solutions and Services

Haulage & Loading

Phoenix, AZ

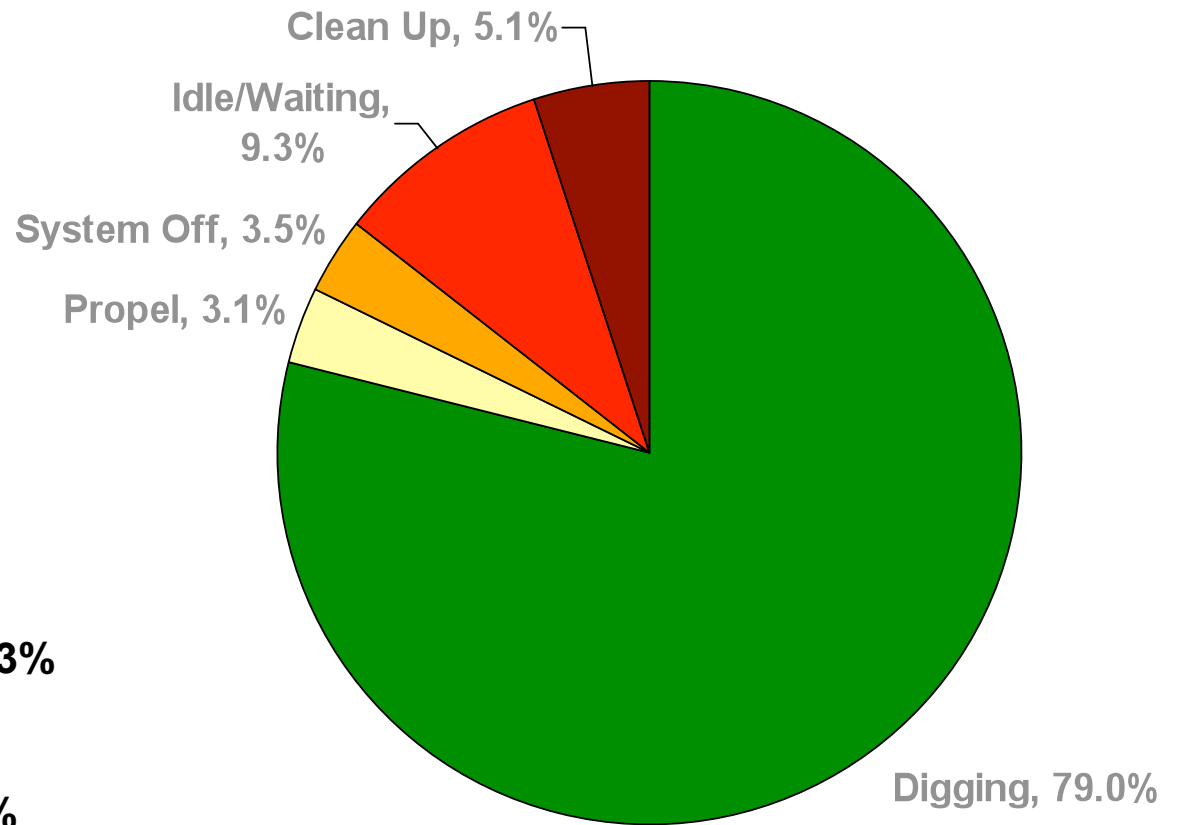
May 22, 2007

Improving Shovel Duty Cycles



Break Down of Shovel Work

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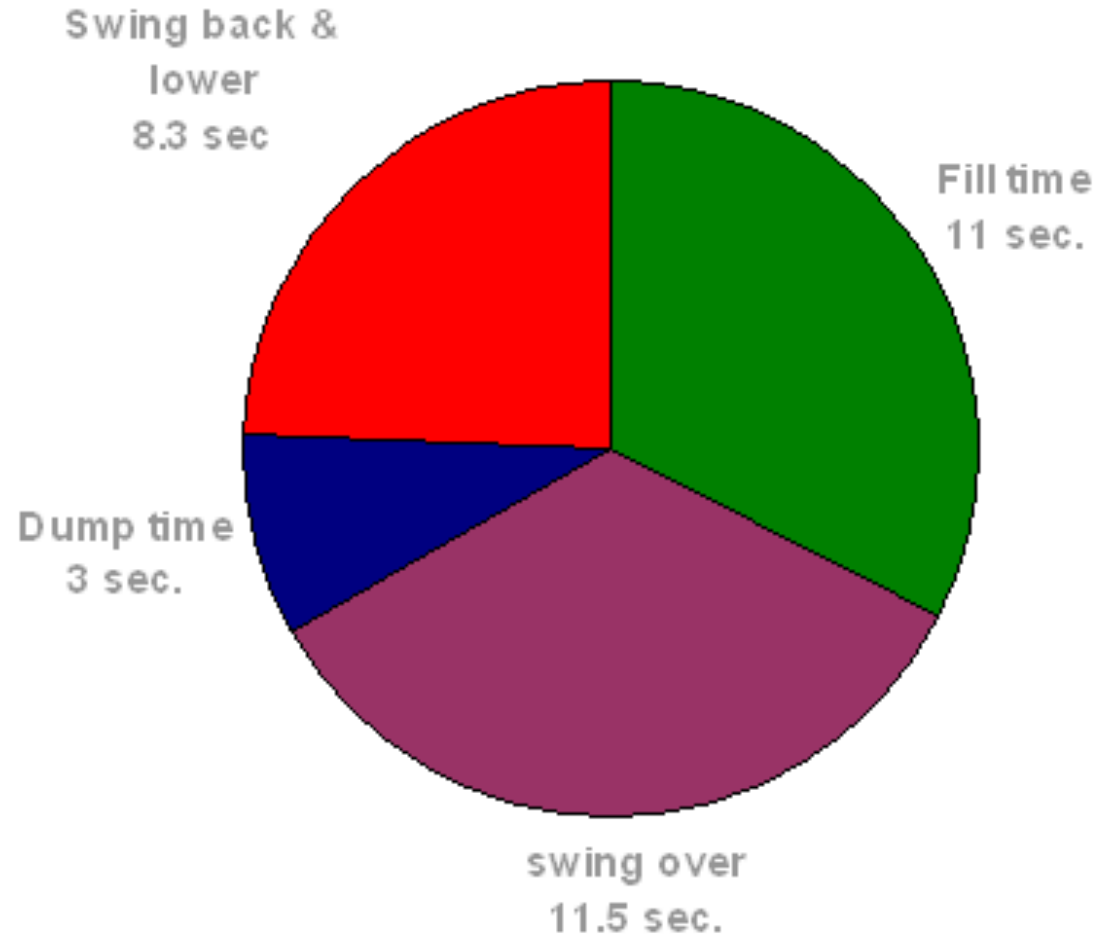


- ◆ Digging 79.0%
- ◆ Idle / Waiting 9.3%
- ◆ Clean Up 5.1%
- ◆ System Off 3.5%
- ◆ Propel 3.1%

Shovel digging / loading cycle

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- Cycle Break Down
 - ◆ Fill time: 11sec
 - ◆ Swing over: 11.5sec
 - ◆ Dump Time: 3 sec
 - ◆ Swing Back & Lower: 8.3 sec
- Total : 33.8 sec(70Deg)

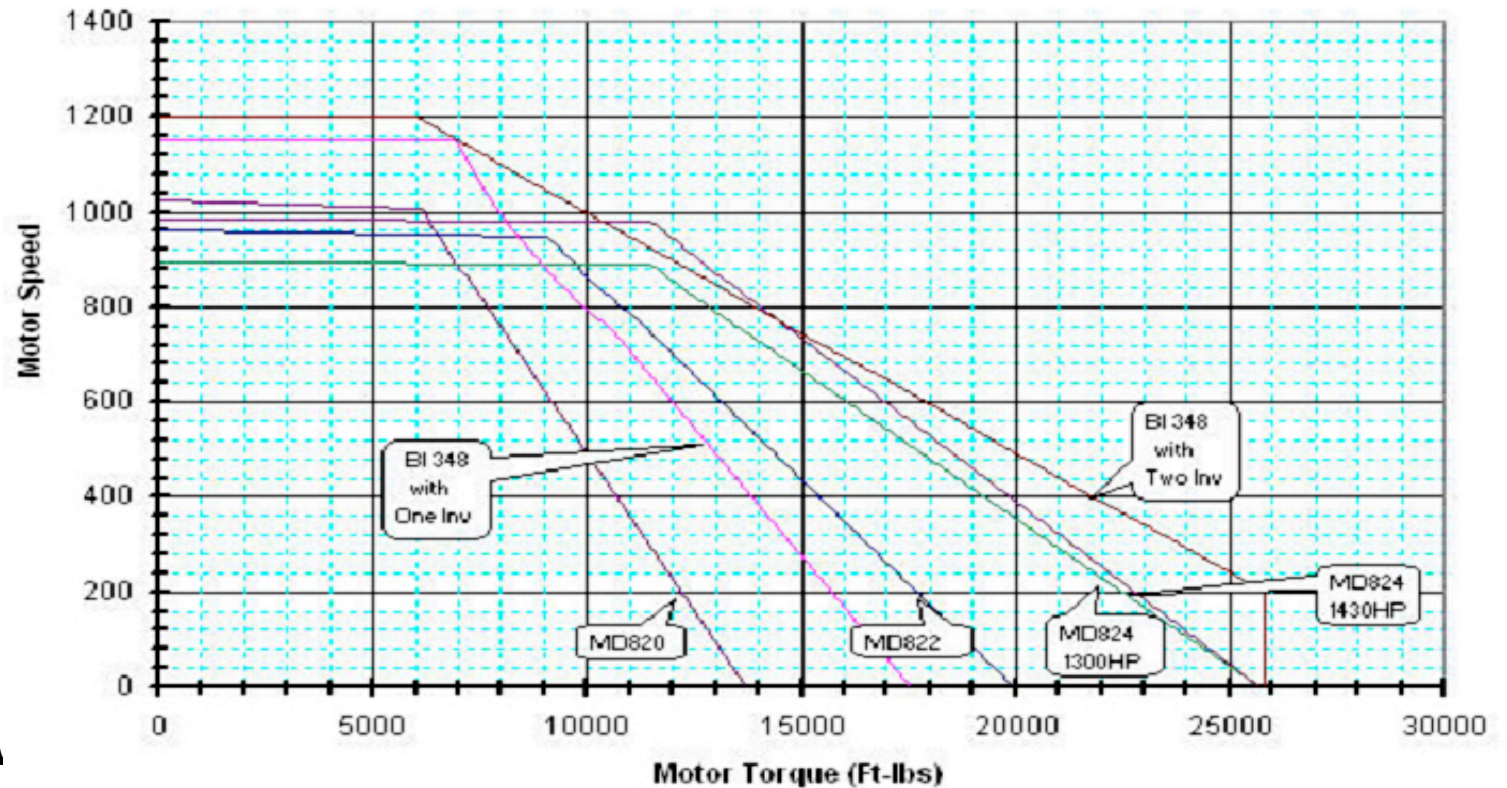


Cycle Reduction with Electrical Drive System

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- ◆ Maximize area under the speed / torque curve
- ◆ High Torque at Stall
- ◆ High Peak Power
- ◆ High Top Speed
- ◆ Estimated time savings: 2 sec / cycle, 20 min / day

DC and AC Motor Comparison Torque vs Speed



- Automatic Positioning at Dig Start Point
 - ◆ Difficult to judge the pendulum motion of the dipper and start the digging process at the right point.
 - ◆ Establish dig starting point e.g. with laser or radar / ultrasound and position control dipper to point.

 - ◆ Estimated time savings 1 sec / cycle, 10 min / day

- Automatic Hoist/Crowd coordination
 - ◆ During digging – retract before Hoist stalls and Crowd as hard as possible against bank to fill the dipper.
 - ◆ Fill the dipper to correct weight
 - ◆ Various algorithms controlling Hoist and Crowd together during digging – e.g. when Hoist speed falls off, Retract until Hoist speed picks up again or kWh / ton power profiling.
 - ◆ Develop dipper weight measurement in the bank and fill last dipper to the correct full truck load
 - ◆ Estimated time saving 2 sec / cycle, 20 min / day

- Optimized position to the bank
 - ◆ Position not too far and not too close to get the highest number of full dippers without moving again
 - ◆ Automatic movement with distance measurement to bank
 - ◆ Scan bank profile to determine correct distance, starting position and digging trajectory
- Increase Torque and HP in Propel
 - ◆ High stall torque to avoid getting “stuck”
- Minimize switchover time Hoist-Propel
- Cable Reel

- Estimated time savings 15 min / day ?

- Optimum Truck Placement
 - ◆ Allow the loaded dipper to be in correct position over truck dump body with medium Crowd extension
 - ◆ Use automatic truck positioning algorithm
 - ◆ Estimated time savings 20 min / day

- Optimize Swing to Truck
 - ◆ Use automatic swing algorithm
 - ◆ Use distance measurement
 - ◆ Use optimized acceleration / deceleration with position control
 - ◆ Reliable and controlled dipper opening

 - ◆ Estimated time savings: 2 sec / cycle, 20 min / day

- Other considerations for cycle time reduction
 - ◆ Operator training
 - ◆ Clean up process

 - ◆ Estimated time savings: 20 min / day

- Maximimize speed / torque area for high acceleration, high peak power and high top speed
- Intelligent automated digging support
- Intelligent automated spotting
- Intelligent automated swinging and loading support
- > We are working on these items and plan to introduce results at MinExpo 2008
- Operator Training
- Estimate: 2 hours 5 min time reduction per 20 hour day (10+ %)