Effectiveness of High Speed Rail Grinding on Metal Removal and Grinding Productivity

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ABSTRACT

The emergence of a new generation of rail grinding trains with high speed rail grinding capabilities has increased the ability of railroads to maintain and profile the rail with a minimum disruption to rail operations and at reduced cost. Specifically, the ability to grind rail in a single high speed pass in the range of 12-14+ mph allows for faster grinding and shorter work windows, making it more appropriate for maintenance of high density rail lines. It also improves the utilization of the grinding trains and the effectiveness of the rail grinding operation in rail profile and surface condition maintenance.

This paper presents the results of four years of metal removal measurements using state of the art high speed production grinders on a major Class 1 railroad and examines the effect of grinding speed on metal removal for a range of grinding conditions. The study addresses the full range of grinding speeds from traditional speeds in the 6 to 8 mph range to high speed 12 to 14 (and even 16) mph grinding speeds obtained from the new generation grinders. In addition the relationship between speed, grinding pattern, and metal removal is examined.

In addition, the paper addresses the issue of grinding productivity and associated grinding cost as a function of grinding speed and utilization. This includes the sensitivity of daily grinding productivity to grinding speed, track time and utilization, and the associated impact on miles worked per day and finished cost per mile ground.
INTRODUCTION

The value of rail grinding has been well established over the past three decades in controlling rail defects, extending the service life of rails, and reducing overall maintenance of way costs [1, 2, and 3]. The result is that rail grinding is well established as a key part of any track maintenance program. However, rail grinding, with its relatively low speeds of operation, traditionally in the 2 to 8 mph range, requires significant track occupancy time, which increases its cost and impact, particularly on high density main line tracks, where it is needed the most.

The emergence of a new generation of rail grinding trains with high speed rail grinding capabilities has increased the ability of railroads to maintain and profile the rail with a minimum disruption to rail operations and associated train delay costs. Specifically, the ability to grind rail in a single high speed pass in the range of 12-14+ mph allows for faster grinding and shorter work windows, making it more appropriate for maintenance of high density rail lines. With the improved control systems of this modern generations of rail grinding equipment, not only have speed capabilities increased dramatically, but also the ability to fine tune the metal removal by controlling the grinding speed of the equipment. Thus fast, controlled grinding passes allow for light maintenance grinding, with metal removal of the order of 0.002" to 0.006" per pass. This fast, light, single pass grinding improves the utilization of the grinding trains and the effectiveness of the rail grinding operation in rail profile and surface condition maintenance [1].

Grinding speed represents one of the key control parameters in determining the type of grind, its extent (depth), and its quality [1, 4]. Grinding at a speed beyond the capability of the equipment will result in a non-uniform finish, with “chatter,” surface blemishes, and uneven metal removal. Increasing the forward speed of the grinding train generally results in a decrease in metal removal. That is because the grinding wheel spends fewer rotations over a given location on the rail head. Thus for example, a 3,600 rpm grinding wheel, moving forward at a speed of 4 mph will apply approximately 30 cutting revolutions on each yard of rail. If the
forward speed was doubled, to 8 mph, the same yard of rail will receive only 15 cutting revolutions of the same grinding wheel and at 12 mph, it receives 10 cutting revolutions of the grinding wheel. Thus the total number of cuts decreases, with a corresponding decrease in the amount of metal removed during the passage of the grinding motor. In addition, the distance between grinding “marks” will increase with speed, corresponding to the increased distance traveled by the grinding train during each rotation of the wheel.

This relationship, however, is not always linear since there are nonlinear effects associated with increased/decreased efficiencies of cut (as a function of motor type, horsepower, stone used, etc.), with the grinding stone-rail interaction effects (which vary as a function of speed, grinder design, system dynamic characteristics or stone selection), and with other characteristics of the grinding system, the rail surface, and the system’s local dynamic response characteristics [1, 4].

The overall relationship between metal removal and speed, illustrated in Fig. 1 shows the reduction in metal removal as a function of increased forward speed of the train. While there is some variation in metal removal as a function of speed, illustrated by the band width of the curve in this figure, speed does represent an effective means of controlling the amount of metal removed for each pass. This effect forms the basis of modern high-speed maintenance grinding that uses a single, high-speed, light-metal-removal pass (applied at frequent intervals) to control the profile of the rail and prevent the development of fatigue damage.
HIGH-SPEED GRINDING

As noted previously, the ability to grind rail at increased speeds represents one of the major developments of the last two decades in the area of rail-grinding equipment and technology. This has been accomplished through the introduction of a new generation of sophisticated control systems together with specially designed high-speed buggies. This increase in grinding speed has been quite dramatic, going from the 4 to 8 mph grinders of the 1980s to the modern 10 to 14+ mph grinders. In fact, the newest generation of rail-grinding equipment has demonstrated the ability to grind at speeds of up to 18 mph [1, 4] on a limited basis\(^1\) and production grinding in the 14+ mph range, though 10 to 12 mph remains as the more common top production speed range.

By allowing for a high pass grinding pass, which removes a carefully control amount of metal, rail grinders can optimize their rail maintenance operations, removing small amounts of surface damaged metal and restoring profiles, on an ongoing preventive maintenance basis. This is the basic concept of preventive grinding, with shallow, fast and frequent grinding passes used to control the rail profile, the wheel/rail interface, and the development of rail defects [1, 5].

\(^1\) On a limited or spot basis under “ideal” grinding conditions
Furthermore, by performing this activity at higher and higher speeds, railroads can schedule these preventive grinding passes on a more frequent basis, minimizing disruption to traffic and train schedules. This comes at a time of increasing railroad traffic and corresponding increases in the utilization of the track, with track access becoming a premium on high-density main line—thus the need for high-speed, high-productivity maintenance activities, such as high-speed rail-grinding become even more important. This is even of greater concern for higher speed passenger rail systems where schedules are tight and track maintenance windows are very limited.

This increase in grinding technology has also been matched by improved measurement technologies allowing for the careful monitoring of both metal removal and profiles. This new measurement technology allows for the measurement of metal removal down to 0.001 inches and allows for careful monitoring of metal removal as a function of speed, pattern, and even grinding trains. Recent measurements on a major Class 1 railroads over the four year period 2007-2010, allowed for the development of this needed metal removal vs. speed and pattern data. Note: This work was performed using two new generation high productivity grinding trains; each with 96 30 Hp grinding motors and a total grinding power of 2880 Hp².

Figures 2A and 2B illustrate how this metal removal data is obtained. By performing a careful overlay of the profile data (Figure 2A); the actual metal removal data can be obtained for each position across the rail head.

² Harsco Rail RMS-9 and RMS-10 Rail Grinders working on major US railroad during the period 2007-2010
FIGURE 2A: Rail profile overlays; before and after grinding

FIGURE 2B: Metal removal as a function of rail head position (#16 pattern)

It is important to note, that these metal removal curves are a function of several key variables [1] to include:

- Grinding horsepower
  - Number and size (power) of grinding motors
- Grinding speed
- Grinding pattern
- Grinding equipment design
- Grinding stone technology

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• Condition of rail being ground

Thus, changing patterns, which changes the distribution of grinding motors across the rail head, will result in a different metal removal signature, as shown in Figure 3 as compared to Figure 2B. Figures 4A and 4B show the grinding pattern differences clearly, with pattern 16 having [Figures 4A and 2A] a significantly larger number of grinding motors on the gauge corner and less grinding motors on the field side of the rail head, than pattern 10 [Figures 4B and 3]. The result is greater metal removal on the gage side and less metal removal on the field side for pattern 16.

FIGURE 3: Metal removal as a function of rail head position (#10 pattern)
It should be noted from Figures 2B and 3 that the depth of metal removal varies across the rail head, as a function of the grinding motor concentration associated with a given grinding pattern. Thus, the location of maximum metal removal varies, e.g. in Figure 2B, the maximum metal removal point occurs approximately 1.2 inches to the gauge side of the center of the rail head and is of the order of 0.020 in (0.5mm). Another commonly used measure of the metal removal is the area of the difference curve which corresponds to the area of metal removal across the rail head (i.e., the area under the curve in Figure 2B). Thus, metal removal performance can
be defined either in terms of a maximum point on the railhead (which varies from pattern to pattern) or as an area under the railhead.

Grinding speed is another key metal removal factor, which allows for changing of metal removal for a given grinding train, as it moves down the track and the metal removal needs vary from site to site. By taking metal removal measurements at a range of grinding speeds it is possible to define a metal removal vs. speed curve such as presented in Figures 5A and 5B for metal removal area and maximum depth respectively. As can be seen in these Figures, the metal removal clearly decreases with increasing speed in the manner previously illustrated in Figure1 for the speed range of 7 to 12 mph.

FIGURE 5A: Area of Metal Removal vs. Speed (Fixed grinding pattern)
Noting that the metal removal is dependant on such key parameters as total grinding horsepower and grinding pattern as well as speed, it is possible to develop grinding effectiveness curves for a given class of rail grinders, for a given set of patterns or combined similar patterns [6].

Figures 6A and 6B illustrate such a curve which presents the effectiveness of high speed grinding as performed by such a new generation 2880 Hp high productivity grinding train. Figure 6A shows maximum depth of metal removal vs. speed in the range 8 to 14 mph (13 to 23 kph) for two different grinding patterns. Figure 6B shows total cross-sectional area of metal removal vs. speed in the range 8 to 14 mph (13 to 23 kph) likewise for the same two grinding patterns. Note average and upper bound curves are superimposed onto the actual data points to more clearly illustrate the speed dependency behavior.

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3 Harsco Rail RMS-10 Rail Grinder working on major US railroad during the period 2007-2010
FIGURE 6A: Max depth of metal removal vs. Grinding Speed

RMS 10 Speed-Max Depth Comparison

Speed (mph)

Max Depth (in)

Patt 7
Patt 13
Average (7 & 13)
Ubound

FIGURE 6B: Area (cross-sectional) of metal removal vs. Grinding Speed

Speed-Area Removed Comparison

Speed (mph)

Area (in^2)

Patt 7
Patt 13
Average (7 & 13)
Ubound
As can be seen in these Figures, the range of metal removal depth clearly varies with speed, as shown in Figure 4A, with a range metal removal of almost 0.016 to 0.036 in at 8 mph decreasing to 0.008 to 0.024 in 14 mph.

The metal removal area shows a similar behavior in Figure 6B.

Figure 7 presents the metal removal vs. speed curves for the full range of grinding patterns, to include top, gage and field side patterns. As can be seen in this Figure, the range of metal removal at any given speed is significantly greater (e.g. 0.15 to 0.070 in at 8 mph). However, the overall metal vs. speed removal curve retains the same overall decreasing shape (dropping to 0.010 to 0.040 in 14 mph).

**FIGURE 7: Max depth of metal removal vs. Grinding Speed: All Grinding**
One Pass Grinding, Speed, and Grinding Productivity

Traditional defect removal grinding involved significant levels of metal removal usually associated with slow speeds and or multiple passes [1, 5]. However, as noted previously, the use of preventive maintenance grinding⁴ to control the condition of the rail surface, reduced the need for aggressive metal removal and increased the importance (and use) of single high-speed light grinding passes. This use of high-speed grinding allows for the performance of these light grinding passes rapidly, with a minimum of interruption of normal train operations. Furthermore, these high-speed light grinding passes, allow for extremely high productivity. For example, if the grinding speed is 8 mph and there are 4 hours of available on-track “spark time,” then over 30 miles of track can be ground. If the speed is increased to 12 mph, then almost 50 miles of track can be ground. These values are of even greater impact when it is realized that less than a decade ago 10 mile days were considered exceptionally productive grinding days.

When doing one-pass grinding on a production basis, speed is a key means of controlling the amount of metal removed per pass. In this operating scenario, it is essential that the correct amount of metal be removed. Inadequate or insufficient metal removal, due to too high a grinding speed, will allow a defect to remain in place, while excessive metal removal, due to too slow a grinding speed, will result in the removal of “good” rail metal, negating the benefits of grinding in extending rail life and increasing the real “cost” of rail-grinding [1]. By properly matching the speed of the grinder to the required amount of metal to be removed, the grinding activity is at its most efficient and cost effective level of performance.

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⁴ Preventive maintenance grinding is the grinding approach in which frequent shallow (light) grinding passes are used to remove any rail surface damage before they develop into defects and to maintain an optimum profile on the rail head.
In addition to increasing the productivity of the grinding train, high-speed grinding also allows for increased track time. This is because dispatchers are able to fit high-speed grinders, working at 12 to 14 mph, into work blocks much more effectively than slow speed grinders. At the higher speeds, the grinding train can more easily fit into the schedule of the line, without delaying trains or disrupting operations.

The potential increase in productivity is dramatic, as illustrated in Figure 8. When the railroad provides “exceptionally” good track time (corresponding to a utilization level of 75 percent, i.e., the machine is able to work 75 percent of the day or 9 hours out of a 12-hour work day) a high-speed grinding machine can, in a continuous grinding mode\(^5\), grind over 100 miles in a 12-hour work day. This requires the operation of the grinder at the high end of the speed spectrum (12+ mph) and the track time to keep the machine in full-speed operation. This is usually not practical on the busy main line of a railroad. However, even with reduced track time, such as at the 50% utilization level, high speed grinding allows the railroad to obtain 50 to 60 miles of continuous (one-pass) grinding in a single day. Lower utilization and lower grinding speeds has a corresponding and direct impact on this productivity.

**FIGURE 8: Effect of Speed on Grinding Productivity**

\(^5\) Continuous grinding mode is an out-of-face grinding where curves and tangents are ground sequentially and continuously.

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These production levels can, in turn, be translated into a cost of rail grinding. Using a grinding contractor cost of $24,000 per 12-hour day (note this cost can vary significantly based on the form and structure of the grinding contract; see [1]) the corresponding cost per pass-mile of grinding can vary from more than $1,200 per pass-mile to less than $200 per pass-mile. This relationship is illustrated in Figure 9 which shows that at the high-speed, high utilization levels of operation, the effective cost of grinding a mile of rail can be less than $200. At the more average speed and utilization levels, the cost per mile is of the order of $400 to $650 per mile, while poor track time and low speed\textsuperscript{6} will increase the cost to the $750 to $1200+ per mile range.

**FIGURE 9: Effect of Speed on Grinding Cost (per mile)**

The factors that directly effect the utilization of the grinder and the associated cost of grinding include: *track time*, *equipment availability* (including downtime and stone changes), *grinding speed*, and *type of grinding*.

It can thus be seen that optimizing the key grinding characteristics, and in particularly the speed of grinding to match the requirements of the rail line will result in not only the most cost effective grinding maintenance activity but also the most effective utilization of limited track maintenance windows. In the case of high speed rail lines, the use of modern, state of the art, high speed rail grinding trains, operating at speeds of the order of 12-14 mph will allow the rail

\textsuperscript{6} Lower speeds will result in increased metal removal so for high metal removal applications, the cost increase will not be as dramatic as shown above [1].
operators to maintain the surface condition of the rails (and associated condition of the track itself) with minimum disruption to train service and operating schedules.
REFERENCES


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FIGURES

FIGURE 1 Metal Removal vs. Grinding Speed [4]
FIGURE 2A Rail profile overlays; before and after grinding
FIGURE 2B Metal removal as a function of rail head position (#16 pattern
FIGURE 3 Metal removal as a function of rail head position (#10 pattern)
FIGURE 4A Grinding pattern 16
FIGURE 4A Grinding pattern 10
FIGURE 5A Area of Metal Removal vs. Speed (Fixed grinding pattern)
FIGURE 5B Maximum Depth of Metal Removal vs. Speed (Fixed grinding pattern)
FIGURE 6A Max depth of metal removal vs. Grinding Speed
FIGURE 6B Area (cross-sectional) of metal removal vs. Grinding Speed
FIGURE 7 Max depth of metal removal vs. Grinding Speed: All Grinding
FIGURE 8 Effect of Speed on Grinding Productivity
FIGURE 9 Effect of Speed on Grinding Cost (per mile)
Effectiveness of High Speed Rail Grinding on Metal Removal and Grinding Productivity

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Traditional Rail Grinding

• Value of rail grinding has been well established over past three decades
  – Effective in controlling rail defects
  – Extending the service life of rails
  – Reducing overall maintenance of way costs

• Rail grinding is well established as a key part of any track maintenance program.

• Traditional rail grinding has relatively low speeds of operation
  – 2 to 10 mph range
  – Requires significant track occupancy time
    • Significant delays on high density main line tracks
High Speed Rail Grinding

- New generation of high production rail grinding trains have high speed rail grinding capabilities
  - Grind rail in range of 12-14+ mph
    - Single pass continuous grinding
    - Production grinding at 10 to 12 mph
  - Allows for single pass high speed maintenance grinding
  - Allows railroads to maintain and profile rail with minimum disruption to operations
    - Reduces train delay costs
    - High productivity
  - Effective for maintenance of high density rail lines
Improved Grinding Effectiveness

• New generation high speed rail grinding systems
  – Improved control systems
  – Improved bogie designs
  – Improved grinding stones
  – Reduced high speed “chatter”

• Ability to fine tune the metal removal by controlling grinding speed
  – High-speed maintenance grinding metal removal of 0.002" to 0.006" per pass
Effect of Higher Speed Grinding on Metal Removal

- Grinding speed represents key control parameters for depth and quality of grinding
- Increasing forward speed of grinding train results in decrease in metal removal
  - Each grinding wheel spends fewer rotations over a given location on rail head
  - 3,600 rpm grinding wheel at 4 mph applies 10 cutting revolutions/rail foot
  - At 8 mph, same foot of rail receives 5 cutting revolutions
  - At 12 mph, it receives 3 cutting revolutions of grinding wheel
  - Total number of cuts decreases with speed
    - Corresponding decrease in metal removed
  - Distance between grinding “marks” will increase with speed
    - Increased distance traveled by grinding train during each wheel rotation
Metal Removal Relationship

• Relationship is not always linear; nonlinear effects associated with:
  – Increased/decreased efficiencies of cut
    • Function of motor type, horsepower, stone used, etc.
  – Grinding stone-rail interaction effects
    • Vary as a function of speed, grinder design, system dynamic characteristics and stone composition
    • Local dynamic response characteristics
  – Condition of the rail surface
  – Other characteristics of grinding system
• Grinding at a speed beyond capability of equipment results in non-uniform finish, surface blemishes, and uneven metal removal
Metal Removal vs. Wheel and Motor Parameters

Metal Removal Rate vs. Wheel Wear Rate for Different Grades at Constant Power
Metal Removal vs. Grinding Speed

The graph shows the relationship between metal removal (mm) and speed (kilometers per hour). As the speed increases, the metal removal decreases linearly.
Effective HIGH-SPEED Grinding

- New generation of high speed grinding trains
  - Sophisticated control systems together with specially designed high-speed buggies
- Grind at speeds of 10 to 14+ mph grinders
  - Ability to grind at speeds of up to 18 mph on a limited basis
  - Production grinding in 10 to 12+ mph
    - Continuous one-pass maintenance grinding
- Designed for preventive grinding
  - Shallow, fast and frequent grinding passes used to control the rail profile, wheel/rail interface, and development of rail defects
    - Able to optimize rail maintenance operations by removing small amounts of surface damaged metal and restoring profiles
    - Ongoing preventive maintenance
    - Reduced disruption to traffic and train schedules allows for more frequent scheduling of preventive grinding passes
Improved Measurement Capability

• Improved grinding technology matched by improved measurement technologies
  – Measurement of metal removal down to order of 0.001 inches
  – Allows for careful monitoring of metal removal and profiles
    • Function of speed, pattern, and grinding trains

• Study of metal removal measurements on a major Class 1 railroads over the four year period 2007-2010
  – Two new generation high productivity grinding trains; each with 96 30 Hp grinding motors and a total grinding power of 2880 Hp

• Allowed for development of actual metal removal vs. speed and pattern data
  – Overlay of pre- and post-grind profiles
  – Metal removal obtained for each position across rail head
2880 Hp (96 Stone) Production Rail Grinder
Rail profile overlays; before and after grinding

RMS 9 - Patt 16 @ 12
Profile Overlay

Pre
Post
Metal removal as a function of rail head position (#16 pattern)
Metal removal as a function of rail head position (#10 pattern)
Metal Removal Parameters

Metal removal is function of several key variables:

- **Grinding horsepower**
  - Number and size (power) of grinding motors
- **Grinding speed**
- **Grinding pattern**
- **Grinding equipment design**
- **Grinding stone technology**
- **Condition of rail being ground**
Metal Removal vs. Grinding Patterns

• Grinding pattern represents a distribution of grinding motors across rail head
• Different patterns will result in different metal removal “signatures”
  – A ‘gauge” pattern has significantly larger number of grinding motors on gauge corner and less motors on field side of rail head
  – A “top” pattern has significantly larger number of grinding motors on top center of rail head
  – A “corner” pattern has larger number of grinding motors on gauge and field corners of rail head
Metal Removal Across Rail Head

- Metal removal can be measured as depth of metal removed at each point of rail head
  - Difference in metal removal (depth) across rail head
  - Maximum metal removal point varies with pattern
    - #16 gauge corner pattern has maximum metal removal point approximately 1.2 inches to gauge side of center of rail head
    - Of the order of 0.020 in (0.5mm)
- Metal removal can be measured as “area” of metal removal across the rail head
  - Difference in area between pre- and post-grind profiles
- Metal removal measurements at a range of grinding speeds defines metal removal vs. speed curve
  - Metal removal area
  - Maximum depth
Area of Metal Removal vs. Speed (Fixed grinding pattern)
Maximum Depth of Metal Removal vs. Speed (Fixed grinding pattern)

RMS 9, Pattern 25

- Max Depth
- Average

mph

in
Grinding Effectiveness Curves

- Function of total grinding horsepower, grinding pattern and speed
- Can be developed for given class of rail grinders
  - For defined set of patterns or combined similar patterns
- Study developed grinding effectiveness curves for high speed grinding
  - As performed by new generation 2880 Hp high productivity grinding train
- Maximum depth of metal removal vs. speed
  - Speed range 8 to 14 mph (13 to 23 kph)
  - For different and similar grinding patterns
- Total cross-sectional area of metal removal vs. speed
- Average and upper bound curves are superimposed onto actual data points
Max depth of metal removal vs. Grinding Speed

RMS 10 Speed-Max Depth Comparison

RMS 10

Max Depth (in)

Speed (mph)

- Patt 7
- Patt 13
- Average (7 & 13)
- Ubound
Area (cross-sectional) of metal removal vs. Grinding Speed

Speed-Area Removed Comparison
RMS 10

Area (in^2)

Patt 7
Patt 13
Average (7 & 13)
Ubound
Metal Removal vs. Speed Results

- Range of metal removal depth clearly varies with speed
  - 0.016 - 0.036” at 8 mph decreasing to 0.008 - 0.024” at 14 mph
- Metal removal area shows a similar behavior
- Similar overall behavior for full range of grinding patterns
  - To include top, gage and field side patterns
  - Range of metal removal at any given speed is significantly greater
    - 0.15 - 0.070” at 8 mph
  - Overall metal vs. speed removal curve retains the same overall decreasing shape
    - 0.010 - 0.040” at 14 mph
Max Depth of Metal Removal vs. Grinding Speed
All Grinding Patterns

Speed - Max Depth Comparison (Grinding Band)
RMS 9

Max Depth (in)

Speed (mph)
Metal Removal vs. Speed Results

Full Range of Grinding Patterns

• To include top, gage and field side patterns
• Range of metal removal at any given speed is significantly greater
  – 0.15 - 0.070” at 8 mph
• Overall metal vs. speed removal curve retains the same overall decreasing shape
  – 0.010 - 0.040” at 14 mph
Speed Control of Metal Removal

Production one-pass “maintenance” grinding uses speed to control metal removed per pass

• Necessary to insure correct amount of metal is removed
  – Insufficient metal removal will allow defect to remain in place
  – Excessive metal removal-removal of “good” rail-increases overall costs

• Necessary to match speed of grinder to required metal to be removed

High-speed grinding also allows for increased track time

• Dispatchers can fit high-speed grinders into schedule of line, without delaying trains or disrupting operations
High Speed Grinding Productivity

High-speed grinding has potential for extremely high productivity

- At grinding speed of 8 mph and 4 hours “spark time” over 30 miles of track can be ground
- At 14 mph almost 60 miles of track can be ground
- Traditional grinding has daily productivity of order of 10 mile
- Key is available track time
  - Improves with higher grinding train speeds
Effect of Speed on Grinding Productivity

Miles Ground Per Day
Based on a 12 Hours Day

- 50% Utilization
- 75% Utilization
Effect of Speed on Grinding Productivity

• If railroad provides “exceptionally” good track time
  – Utilization level of 75%
  – 9 hours out of a 12-hour work day
• High-speed grinding machine can grind over 100 miles in a 12-hour work day
  – Continuous “out-of-face” grinding mode
  – 12+ mph grinding speed
• Usually not practical on the busy main line of a railroad
Effect of Speed on Grinding Productivity

• If railroad provides “good” track time
  – Utilization level of 50%
  – 6 hours out of a 12-hour work day
• High-speed grinding machine can grind 50-60 miles in a 12-hour work day
  – Continuous “out-of-face grinding mode
  – 10 mph grinding speed
• Lower utilization and lower grinding speeds have corresponding impact
  – Can drop to 25 miles per day or less
Cost of Grinding

• Production levels can be translated into a cost of rail grinding
• Based on grinding contractor cost of $24,000 per 12-hour day
  – This cost can vary significantly based on form and structure of grinding contract
• Corresponding cost per pass-mile of grinding can vary from more than $1,200 per pass-mile to less than $200 per pass-mile
  – For high-speed, high utilization levels of operation, effective cost of grinding is less than $200 per mile
  – For average speed and utilization levels, cost per mile is of the order of $400 to $650 per mile
  – For poor track time and low speed cost of $750 to $1200+ per mile
• Note: low speed used if significantly more metal removal is required
  – May be necessary for defect removal or aggressive profiling
Effect of Speed on Grinding Cost (per mile)

Cost of Grinding vs. Speed

- 50% Utilization
- 75% Utilization
Summary

• Rail grinding is an important part of rail and track maintenance program.
• Modern high-speed maintenance grinding uses a single, high-speed, light-metal-removal pass to control surface and profile of rail.
  – Uses speed to control metal removed per pass.
• Grinding technology capable of production grinding of 10 to 14 mph.
• Metal removal dependent on total grinding horsepower, grinding pattern, and speed.
  – Grinding effectiveness curves (vs. speed) developed for specific rail grinders and patterns.
  – Extensive field tests confirm variation (decrease) in metal removal with increasing speed.
• High-speed grinding has potential for extremely high productivity and corresponding reduced cost per mile of grinding.
• Optimizing grinding speed to match requirements of rail line will result in cost effective grinding and effective utilization of limited track maintenance windows.