Yield Optimization and Improvements by Cut-to-Weight Practice

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• Equipment Overview
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A Brief History

Nucor Steel, Auburn
Weighing System

• **Justification** - Target of 1% annual yield improvement
• **Installation** - 1999
• **Upgrade** - 2005 / 2007
Equipment Overview
Weighing System Equipment Targets

• Must be designed and built to provide extended operation with the minimum of maintenance

• Each weigh pod should be an individual weighing unit.

• Both manual and automatic modes of operation are needed

• Components should be oversized
Weigh Pod
Weighing Systems

Basic Requirements

• Direct lift with hydraulic cylinder
• Canister designed for quick change
• Quick-connect stainless steel braided hoses
• Flex joint technology
• Enclosed, pressurized canister system
• Water cooled load cell mounting plates
Weigh Pod Cutaway
Weighing Systems

Basic Requirements

• High “live load to dead load” ratio
• Load cell calibration “on the fly”
• Manual or PLC controlled operation
• Reliability
• Low maintenance
• Accuracy of 1/10 of 1%
Typical Operation

- Sensor tells PLC that cut billet is in position
- Signal sent to PLC to weigh billet
- Billet is weighed
- Displayed weight is compared to Set Point weight
- PLC adjusts set point (SP) of billet length measuring unit
- Next cut is adjusted to new SP
- Operator has a digital display for each billet weight
- Operator can print out activity report summarizing individual billet weights, or sum of all billets and combined weights
Operator’s Screen
List of Users
CCR Weighing Systems

• CMC Steel, South Carolina
  - billets
• Gerdau Ameristeel, Cambridge & Manitoba
  - billets, blooms
• Hamilton Specialty Bar, Hamilton
  - billets
• Hyundai Steel, Incheon, Korea
  - beam blanks
• Nucor Steel, Auburn
  - billets
• Rocky Mountain Steel Mills
  - 12.25” rounds
• SDI Columbia City
  - Jumbo beams
Weighing System at Nucor Steel Auburn
Nucor Steel, Auburn
The Process

• Billet Length is measured by a scanner or encoder
• When Billet Length = Billet Length Set Point (SP), the torch cuts
• The billet is weighed
• The new length set point is calculated before the next billet is cut
Why Weigh Billets?

- The temperature of the tundish, casting speed & mold condition all affect the thickness off the billet shell.
- The thinner the shell, the more the billet may bulge.
- The higher the billet density, the heavier the billet is for the same length.
- The following chart shows the variance in billet weight for a fixed length.
Billet Weight Adjustment

• **Billet Weight Error (BWE) = SP – PV**
  (therefore a negative (-) error is a heavy billet)

• **Billet Density (lbs/inch) = Actual Weight / Length SP**
  (A three-Billet Rolling Average is Used)

• **Length Correction (In) = Weight Error (lbs.) / Avg. Density (lbs. /in.)**

• The Length Correction is added to the next billet to be cut
Example

- Weight SP = 5162 lbs,
- Length SP = 469.65,
- Density = 11 lbs/in

- Next Billet Weight = 5172 lbs
  Weight Error = 5162 – 5172 = -10 lbs
  Length Correction = -10 lbs / 11 lb/in
  = 0.909in

  Next Billet Length = 469.65 - 0.909 = 468.74in

- The weight correction results in less variation in weight throughout the heat
# Cut by Length

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<th>Minimum</th>
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How the Adjustment Works

• Verify the billet weight is real (> 500 lbs.)
• Zone Control

Zone 1 – No adjustment needed within 1/10 of 1%
Zone 2 – Adjust per formula (+/-) 1%
Zone 3 - Reduced adjustment per formula (+/-) 0.7% to 1%
Zone 4 - No adjustment – operator alarmed

• A separate formula is used for first 2-3 billets of a new heat
Additional Feedback

Additional feedback supplied by:

• Gerdau Ameristeel

• CMC Steel

• Hyundai Steel
Additional Feedback
Cut by Length
Giveaway 61lbs / billet Yield Loss 1.38%

Cut By Length – Encoders

Standard Deviation = 34.1 pounds
Mean = 4491 pounds
Target = 4430 pounds
Giveaway = 61 pounds per billet
= 1.38% Yield

Data from longest continual run at single cut length used to calculate statistics

Sequence number

Measured Weight – Ref. Weight
### Additional Feedback

**Cut by Weight**

Giveaway 12lbs / billet **Yield Loss 0.26%**

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**Data from longest continual run at single cut length used to calculate statistics**

- Standard Deviation = 15.9
- Mean = 4508.8 pounds
- Target = 4497 pounds
- Giveaway = 11.8 pounds per billet
  - = 0.26% Yield
Additional feedback
Distribution Comparison

Cut by Length

Cut by Weight

Highest Overweight  296lb,
Lowest Underweight 282lb,
Mean giveaway  80lbs / billet

Yield loss 1.86%

Highest Overweight   61lb
Lowest Underweight  27lb,
Mean giveaway 12lbs / billet

Yield Loss 0.26%

Net +1.6%
Additional Feedback
Cut by Weight
(Long Run) Giveaway 5 lbs / billet Yield Loss 0.11%

All Strands -- Grade 560, 4497 Ordered Weight

Standard Deviation = 11.5 pounds
Mean = 4502 pounds
Target = 4497 pounds
Giveaway = 5 pounds
= 0.11% Yield

Long run at one cut length demonstrates best possible performance under ideal conditions.
Not an indicator of long-term performance.
Benefits of Billet Weighing

Melt Shop
• Less chance of ongoing operator error
• Real time feedback on every billet
• Energy savings
• Liquid to cast product yield optimized = $$$

Rolling Mill
• Consistent billet weights supplied to the Mill
• Scheduled mults / yield on Mill optimized
• Energy savings
• Shorts minimized, no steel given away = $$$
Yield

Minimum of 1% improvement in Plant Yield
Value - $1.0 million / year

With

• No additional cost or equipment
• Gains in throughput
• Savings in energy
• Logistical improvements
Future Considerations

Implementation of Predictive Adjustments based on Casting Conditions

- Temperature change
- Ladle change
- Flying nozzle change
Nucor Steel
and
CCR Technologies Inc.

Wish to

THANK YOU