“The Effects of Variable Extrusion Moisture on Extrusion, Drying, and Fired Physical Properties of a Shale Body and How Extrusions Aids Can Effect the Properties”

Harold B. Newman
Pine Hall Brick
Topics to be Discussed

- Variable Moisture Content-Factors
- Green Strength Properties
- Drying Shrinkage Properties
- Cold Water Absorption Properties
- Body Additives
  - Soda Ash
  - Lignosulfonate
Ground Material Moisture Content
2008-2011

19%

10%
Research Project

- Proportion Batches of Shale Variable Moisture Contents
- Mix for Constant Time Period
- Extrude Lab Test Bars-Good Vacuum
- Test Bars For Green Strength
- Test Bars for Drying Properties
- Fire Bars and Test for Shrinkage and Absorption Properties
Add to Mixer
Add Controlled Amounts of Water
Constant Mixing Time  5 Min
Discharge Mixed Material
Check Consistency
Maintain Good Vacuum
Extrude Bars with Good Vacuum
Extruded Column
Cut Sample Bars for Testing
Test Bars

- Green weight
- Dry weight
- Column hardness
- Green strength
Testing Green Strength
Record the Data
Recording the Sample Weight
Determine Moisture Content
Shale Mix Body Additions
Green Strength Vs Extrusion Moisture Sensitivity
21-24 % Linear Regression Lines

- Shale Mix: $y = -11x + 290$, $R^2 = 0.9934$
- Soda Ash Mix: $y = -12.2x + 305.5$, $R^2 = 0.9976$
- Lignosulfonate Mix: $y = -4.4x + 128$, $R^2 = 0.9132$
SHALE MIX BODY ADDITIONS
GREEN STRENGTH
21 % AND 24 % EXTRUSION MOISTURE

<table>
<thead>
<tr>
<th></th>
<th>21% Moisture</th>
<th>24% Moisture</th>
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<tbody>
<tr>
<td>SHALE</td>
<td>60</td>
<td>27</td>
</tr>
<tr>
<td>.25% AA</td>
<td>34</td>
<td>21</td>
</tr>
<tr>
<td>.2% S ASH</td>
<td>50</td>
<td>13</td>
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</tbody>
</table>
Shale Body
Dry Shrinkage Vs Moisture Content

Moisture Content

Percent Shrinkage

Soda Ash
Ligno
Shale

Moisture Content

18 18.5 19 19.5 20 20.5 21 21.5 22 22.5 23 23.5 24 24.5 25 25.5 26
SHALE MIX BODY ADDITIONS
PERCENT DRY SHRINKAGE
21% AND 24% EXTRUSION MOISTURE

<table>
<thead>
<tr>
<th></th>
<th>21% Moisture</th>
<th>.25% AA</th>
<th>.2% S ASH</th>
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</thead>
<tbody>
<tr>
<td>SHALE</td>
<td>2.9</td>
<td>3.46</td>
<td>3.85</td>
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<tr>
<td>.25% AA</td>
<td>4.4</td>
<td>4.8</td>
<td>4.7</td>
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<tr>
<td>.2% S ASH</td>
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21% Moisture

24% Moisture
SHALE MIX BODY ADDITIONS
DRY STRENGTH
21 % AND 24 % EXTRUSION MOISTURE

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<tr>
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<th>24 % Moisture</th>
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<tbody>
<tr>
<td>SHALE</td>
<td>230</td>
<td>180</td>
</tr>
<tr>
<td>.25 % Lig</td>
<td>275</td>
<td>280</td>
</tr>
<tr>
<td>.2% S ASH</td>
<td>335</td>
<td>280</td>
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Shale Body
Cold Water Absorption Vs Extrusion Moisture

Moisture Content

Shale
Lignosulfonate
Soda Ash
SHALE MIX BODY ADDITIONS
24 HR COLD WATER ABSORPTION
21 % AND 24 % EXTRUSION MOISTURE

PERCENT ABSORPTION

<table>
<thead>
<tr>
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<th>24 % Moisture</th>
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</thead>
<tbody>
<tr>
<td>SHALE</td>
<td>6</td>
<td>7.75</td>
</tr>
<tr>
<td>.25 % Lig</td>
<td>5.7</td>
<td>7.25</td>
</tr>
<tr>
<td>.2 % S ASH</td>
<td>6</td>
<td>6.9</td>
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</tbody>
</table>
PLANT STUDY

Old Plant
Hand Hack
Tumbled Line
16 Wide Kiln
Monitor Plant Conditions

- Moisture of Ground Dirt
- Moisture of Dirt Fed to Pug Mill
- Manual Water Addition Rate-Die Oil Pressure
- Production Rate
- Vacuum Level
- Green Brick Moisture
- Green Strength-Penetrometer
- Additive Feed Rate
PLANT DATA
DIRT FEED MOISTURE 3-4-09 TO 5-7-09

Percent Moisture

19%

11%

Samples
PLANT DATA
MANUAL WATER ADDITION RATE
GALLONS / MIN 3-4-09 TO 3-13-09

GALLONS / MIN


15 Gal

4 Gal
PLANT DATA
EXTRUDED BRICK MOISTURE
3-4-09 TO 5-7-09

PERCENT MOISTURE

SAMPLES
PLANT DATA
PENETROMETER READINGS
3-4-09 TO 5-7-09

COLUMN HARDNESS

SAMPLE SETS

0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0

1 7 13 19 25 31 37 43 49 55 61 67 73 79 85 91 97 103 109 115 121 127 133 139 145

5.5
2.0
THINGS OUT OF CONTROL
PLANT TEST
CONTROLLED MOISTURE CONTENT TEST
GREEN STRENGTH VS MOISTURE CONTENT

GREEN STRENGTH VS PERCENT MOISTURE CONTENT
PLANT DATA
VARIED MOISTURE CONTENT
GREEN STRENGTH VS PENETROMETER
PLANT TESTS
CONTROLLED EXTRUSION MOISTURE
GREEN STRENGTH VS EXTRUDER AMPS

![Graph showing the relationship between green strength and extruder amps. The x-axis represents amps ranging from 300 to 600, and the y-axis represents pounds ranging from 50 to 210. The graph shows an upward trend, indicating that as the amps increase, the green strength also increases.](image-url)
Action Taken

• Installed a Moisture Control System—In House
• Monitor Incoming Dirt Feed Rate and Moisture Content
• Control Water Addition and Additive Feed Rate Based on Incoming Dirt Feed Rate
• Eliminated Manual Water Feed Adjustments
• Control Moisture Feed Rate Based on Automatic Continuous Penetrometer Readings
RESULTS

• Got Control of Extrusion Process
  Moisture Addition Rate
  Additive Feed Rate
  Production Rate
• Set Target Penetrometer Reading at 3.9
• Improved Green Brick Quality
• Improved Brick Hack Quality
• Allowed Control of Drying Process

• Increased Recovery Rate by 5-7 %
Potential Value
6 % Increase in Recovery

- 40 Million Brick Production
- 2.4 Million Extra Brick to Sell
- Market Value $225 / M
- Increased Revenue $540,000

- 75 Million Brick Production
- 4.5 Million Extra Brick to Sell
- Market Value $225 / M
- Increased Revenue $1,012,500
Message to Sales

“We Got Extra Brick”
“You Need to Sell Them”