Galvanizing Furnace Heating Technology

13’–1½”
Principles of Heating Galvanizing Kettles
Part 1: Principles for extending kettle life
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\[ T_A = \text{Alloy Temp} \]
\[ T_{Zn} = \text{Zinc Temp} \]

\[ q_k \]
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Required Total Heat Input

31,700,000 BTU/ft²

9,510 BTU/ft²/hr
Σwt = 0.08 inch

6,340 BTU/ft²/hr
Σwt = 0.07 inch

3,170 BTU/ft²/hr
Σwt = 0.05 inch
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- 2,550 F
- 1,300 F
- 500 feet/second
- 85 feet/second

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$\Delta T \approx 180$ F

Reference data:
Kettle 49' x 6' x 8' deep
Total heat input 9,000,000 BTU/hour
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Principles of Heating Galvanising Kettles

Part 2: Principles for efficiency
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Reference data:
Kettle 41’ x 5’ x 10’ deep. Production average 9 ton/hr
Total heat input 6,000,000 BTU/hour. Fuel: natural gas
Ventilated fume enclosure
CO ppm typ.

$\lambda = 1.0 \rightarrow 10 \text{ gas : 1 air}$
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η %

6340 12,680 19,020 25,360 31,700 38,040

\( \frac{Q_b}{A_k} \) BTU/hr*ft^2

\( \lambda = 1.1 \)

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Burner Output Regulation
Part 1: High-Low Regulation
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Q

Q_{Hi}

Q_{Lo}

eg 10 mins

t

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Graph showing the relationship between variables:
- Q (heating rate)
- Q_{Hi} (high heating rate)
- Q_{Lo} (low heating rate)
- T_{Zn} (temperature of zinc)
- 840F (temperature in Fahrenheit)

The diagram illustrates the heating process in a galvanizing furnace, with temperature changes over time (t).
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Burner Output Regulation
Part 3: Pulse fired regulation
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Q_{Hi} \quad Q_{Lo} \quad t

Q_{AVERAGE} \quad t

Q_{AVERAGE} \quad t

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- $Q_B$ vs. $t$
- $T_G$ vs. $t$
- $T_A$ vs. $t$
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\[ Q \]

\[ Q_{\text{Hi}} \]

\[ Q_{\text{Lo}} \]

\[ t \]

\[ \tau_p \]

\[ \tau_{\text{Hi}} \]
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\[ r_H(t) \]

\[ r_p(t) \]

\[ Q_{Hi} \]

\[ Q_{Lo} \]

\[ t \]
Burner Output Regulation

Part 4: Pulse fired + Turbo regulation
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\[ M_w \uparrow \Rightarrow \Delta T \uparrow \quad M_{Zn} \uparrow \Rightarrow \Delta T \downarrow \]
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\[ \Delta T \]

\[ T_{Zn} \]

\[ \Delta T_X, \Delta T_Y \]

\[ t \]
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$T_{Zn}$

$T_R$

$\Delta T$

$Q_B$

$T_R$

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\[ T_{R,A} < T_c \quad \checkmark \]
\[ T_{R,B} > T_c \quad \times \]
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\[ Q_+ \approx \frac{\Delta T_{\text{max}} \times M_{\text{Zn}} \times C_{\text{Zn}}}{T_{\text{R min}}} \]

\[ T_{\text{Zn}} = T_{\text{C}} \]

\[ \Delta T_{\text{max}} \]

\[ M_{\text{Zn}} \]
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\[ T_{Zn} = \frac{Q_+}{M_{Zn}} + T_{R \; avg} \]

\[ \Delta T_{avg} \]
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\[ \sum M_{W, \text{DAY}} \]

\[ \sum M_{W, \text{DAY}} \]

\[ M_w \]

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\[ Q_{\text{red}} \]

\[ T_{\text{Zn}} \]

\[ \Delta T_{\text{avg}} \]

\[ \Delta T_{\text{critical}} \]

\( t \)
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\[ T_{Zn} \]

\[ Q \]

\[ \Delta T_{critical} \]

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Reference data:

Kettle internal dimensions: 41’ long x 5’ wide x 10’ deep

Production
Average: 11 tons/hour (22,000 lb/hr)
Maximum: 17.6 tons/hour (35,200 lb/hr)
for estimated 10% of working & standby time
4 dips per hour

Operating times
Production: 4,000 hours/year
Standby and zinc melting: 600 hours/year
Unused and covered: 4,160 hours/year

Solid zinc added outside working times
Ventilated enclosure during working times

Maximum burner heat output: 8,128,126 BTU/hr
Fuel: Natural gas
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<table>
<thead>
<tr>
<th>Production Rate 11 ton/hr</th>
<th>Standard System</th>
<th>System with Turbo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burner high output</td>
<td>8,128,126 BTU/hr (constant)</td>
<td>5,669,197 BTU/hr (reduced)</td>
</tr>
<tr>
<td>% time at production rate</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>Recovery time</td>
<td>9.4 mins</td>
<td>15 mins</td>
</tr>
<tr>
<td>Cycle Time</td>
<td>15 mins</td>
<td>15 mins</td>
</tr>
<tr>
<td>Predicted max. kettle heat transfer rate for recovery</td>
<td>12,045 BTU/ft²</td>
<td>8,876 BTU/ft²</td>
</tr>
<tr>
<td>Kettle steel loss rate for time at this production rate</td>
<td>0.126 inch/year</td>
<td>0.098 inch/year</td>
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</tbody>
</table>

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<tr>
<th>Production Rate 17.6 ton/hr</th>
<th>Standard System</th>
<th>System with Turbo</th>
</tr>
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<tr>
<td>Burner high output</td>
<td>8,059,823 BTU/hr</td>
<td>8,059,823 BTU/hr</td>
</tr>
<tr>
<td>% time at production rate</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Kettle steel loss rate for time at this production rate</td>
<td>0.019 inch/year</td>
<td>0.019 inch/year</td>
</tr>
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<tr>
<th>Combined Production</th>
<th>Standard System</th>
<th>System with Turbo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kettle steel loss rate</td>
<td>0.145 inch/year</td>
<td>0.118 inch/year (19% reduction)</td>
</tr>
</tbody>
</table>
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