HOT AIR

Green Alternative for Structural Fumigation

Processing Plants, Warehouses & Storage Structures

42nd Annual Latin America Region Conference & Expo
February 5-7, 2019
Bogota, Columbia

Dr. Raj Hulasare
Scientist & Product Manager,
Temp Air, INC.
Burnsville, MN, USA
Structural Fumigation

- Phosphine - Insect resistance, Corrosion
- Methyl Bromide - Ozone depletion
- Sulfuryl Fluoride - Residues? Dosage?
- Contact Insecticides - Fogging, Aerosols/ULV - Penetration?
In 1762 – France: 69°C/ 156°F for 3 d, moth
Heat treatment of Mills

>100 Years Ago . . .

1913 - Kansas, Mid-West USA, Southern Canada
In Kansas the heating of more than twenty mills has absolutely proven that no stage of insect, even in the most inaccessible places, could withstand the heat.....February, 1913
Drivers - Heat Treatment (HT)?

- Consumer Preference
  - Pesticide-free Products
- Eco-Friendly Technology
  - Montreal Protocol
  - US Clean Air Act
- Insect Resistance
  - Higher dosage, Life stages?

Green IPM
Heat - Advantages

SAFE  EFFECTIVE  CO-FRIENDLY

- Non Chemical
- People-Safe
- Kills all life stages
- No ozone depletion
- No Toxicity or Corrosion issues
- No evacuation of People
- No Sealing
- Spot Treatments
Temperature Effects on Insects

Targeted temp. spectrum
120 - 140°F (50-60°C)

Temperature (°C) vs. Temperature (°F)

-30
-20
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140

DEATH IN MINUTES
DEATH IN A DAY
SLOWER GROWTH
MAXIMUM GROWTH
SLOWER GROWTH
DEATH IN WEEKS OR MONTHS
DEATH IN DAYS, OR MONTHS IF ACCLIMATED
DEATH IN MINUTES

Source: P. Fields, AAFC, Canada
Efficacy to Control Pests

- MBr – Methyl bromide
- PH₃ - Phosphine
- SF (Profume)
- CO₂ – Carbon dioxide
- O₃ - Ozone

Efficacy – function of temperature
Heat & Insect Death

- **High temperature** -
  - Death by Dehydration (low RH)/desiccation

- **Above 50 °C / 120 °F**
  - Cell membranes “melt”
  - Enzyme destruction
  - Change in salt balance
  - Protein coagulation
Heat Treatment

Insects – lethal threshold temperatures

HT Process

High Temperature
[50 - 60°C /(120 -140°F)]

Low Humidity (≤ 25%)
(Desiccation/Dehydration)

Ambient temperature
Heat treatment concept: Raising the ambient air temperature of the complete facility, or a part of it, to 122-140°F (50-60°C), and maintaining these temperatures for at least 24 hours or less depending on application.
Process
Positive Pressurization – Forced ambient air (Patented Process)

- Positive pressure
  - Good air distribution
  - Hot air is pushed into corners, cracks and crevices
- Calculated and controlled infiltration - air changes
- Lower relative humidity

US & Canadian Patents
Re-circulating Inside Air

- Negative pressure
- Poor air circulation
- Uncontrolled infiltration
  - No air changes

Low temperature zones
  (cold spots)
Real-time Wireless Temperature Monitoring

Untreated Area (Office)

Receiver

Heater

Heater

Heater

Treated Area

Temperature transmitters

Heater
Effective Heat Treatment

Manage airflow for Uniform Temperature Profile

Monitor Temperatures throughout heated area

Real-time Wireless Temperature Monitoring System

Pockets

HOT

Damage Potential

COLD

Insect Survival

Real-time adjustment

Documentation for QC

Worker Safety & Savings
Start of the Heat Treatment

Fig. 1: Real-time Temperature Profile

Temperature (°C)

Start 24 hour hold-time

(60°C)

(50°C)

(40°C)

(38°C)

(27°C)

Tx: 49 sensor in office on 5th floor

START

12:30 hr


(27°C)
End of the Heat Treatment

Fig. 2: Real-time Temperature Profile
Steps in Heat Treatment

Visit & Feasibility

Engineering, Equipment & Estimate

Setup, HT, Document & Review

Equipment mobilization
Heat Treatment Checklist

- **Before**: cleaning, drive belts, product removal, sprinkler heads, sensitive eqpmt etc.
- **During**: Intrusive, temperature points/frequency, fans and/or duct movement for airflow and heat distribution
- **After**: cool down, insect bioassays, inspection etc.
Sanitation is the key

Important as heat does not penetrate products well.
Apply a residual pesticide such as cyfluthrin (Tempo) or diatomaceous earth
Exponential Growth of Insect Populations
The graph depicts the population growth of *S. oryzae* at different moisture contents (14%) and temperatures (18 °C, 25 °C, 29 °C) over a 2-month period. The x-axis represents the month, ranging from 0 to 2, while the y-axis shows the number of insects, ranging from 0 to 50,000. The graph indicates a significant increase in insect population as the temperature increases, with the highest population observed at 29 °C.
S. oryzae 14% mc

- **18 °C**
- **25 °C**
- **29 °C**

Number of Insects

Month

- 0
- 1
- 2
- 3

- 0
- 100
- 150,000
- 1,000,000

- 1e+5
- 2e+5
- 3e+5
- 4e+5
- 5e+5
- 6e+5
- 7e+5
- 8e+5
- 9e+5
- 1e+6
- 1e+6
Heat versus Fumigants
<table>
<thead>
<tr>
<th>Insect stage</th>
<th>Sanitation level</th>
<th>Treatment</th>
<th>% Mean (SE) mortality</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults</td>
<td>2 cm</td>
<td>MB</td>
<td>100a</td>
<td>69.90</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SF</td>
<td>100a</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat</td>
<td>90.1 (1.2)b</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SF</td>
<td>100</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MB</td>
<td>100</td>
<td>98.7 (1.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Heat</td>
<td>95.4 (2.9)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MB</td>
<td>100</td>
<td>2.56</td>
<td>0.1568</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SF</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat</td>
<td>95.4 (2.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MB</td>
<td>100</td>
<td>0.60</td>
<td>0.5787</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SF</td>
<td>98.7 (1.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat</td>
<td>97.3 (2.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pupae</td>
<td>2 cm</td>
<td>MB</td>
<td>100</td>
<td>99.8 (0.1)a</td>
<td>8.62</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SF</td>
<td>100</td>
<td>99.8 (0.0)a</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat</td>
<td>96.1 (1.3)b</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MB</td>
<td>99.9 (0.1)</td>
<td>1.73</td>
<td>0.2552</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SF</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat</td>
<td>98.2 (1.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large larvae</td>
<td>2 cm</td>
<td>MB</td>
<td>100a</td>
<td>8.62</td>
<td>0.0172</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SF</td>
<td>100a</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat</td>
<td>96.1 (1.3)b</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MB</td>
<td>99.9 (0.1)</td>
<td>1.73</td>
<td>0.2552</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SF</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat</td>
<td>98.2 (1.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small larvae</td>
<td>2 cm</td>
<td>MB</td>
<td>100a</td>
<td>5.39</td>
<td>0.0457</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SF</td>
<td>100a</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat</td>
<td>93.5 (2.8)b</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MB</td>
<td>99.9 (0.1)</td>
<td>1.02</td>
<td>0.4145</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SF</td>
<td>92.3 (7.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat</td>
<td>99.3 (0.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggs</td>
<td>2 cm</td>
<td>MB</td>
<td>99.9 (0.1)</td>
<td>1.25</td>
<td>0.3523</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SF</td>
<td>88.7 (10.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat</td>
<td>99.8 (0.1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

K-State Study (2009-2010)

n = 3/trt

Trt time=24 h for all
Heat Treatment of Bins & Silos

Proactive - Preventative
&
Reactive - Response
Bins & Silos

- Pre-loading or Pre-harvest HT
  - On-farm bins
  - Elevators storages
  - Processing facilities
  - Organic processing plants

- Bin/Silo types
  - Concrete
  - Metal
    - GI bins
    - Tanks
HT of bins and silos

Hopper bottom

Flat bottom
Bin/Silo Heat treatment

Empty Metal Silo - India
Advantages of HT of Bins/Silos

- Shorter treatment times (4 to 12 hours)
- Bins/Silos in facilities
  - Treated in rotation without shut-down
- No retrofitting – existing transition, bin-entry
- On farm or warehouses – no extensive sealing or evacuation
On Site Images

Heater Placement on multiple floors

Heater Placement under rolling shutter
Heater Placement & Layout

Heater Partially inside Packaging Plant

Duct & Fan Layout - Packaging
Detecting hidden infestations

Overhead electrical junction box

10,000s of adults, larvae, pupae!!
Partial/Spot heat treatment Mill extension in a warehouse

A temporary Plastic Sheet OR
Fumigation cover – No Sealing

Philippines – July 2018
Partial/Spot heat treatment in a warehouse
Sprinkler heads and opening the machines
Temperature Profile, Beetles, & Rats!!!!
Christmas Heat treatment
December – Snowing!

Outside temperature: 26-30°F / -1 to -3°C
Flour Mill, Celaya, Mexico

High temperature duct through the ‘well’ of Stairwell to six floors of the mill
Flour Mills in Philippines

Dead beetles, cockroaches
Heat Treatment - Durum Mill, Canada (Sept 22-23, 2018)

Sifters with screens removed
Concrete floor
Concrete floor & wall

Hole in the duct
Conclusions

- Heat kills all life stages of insects
- **Good method to locate insect problems in industrial plants**
- Repeat customers = efficacy of heat
- Viable alternative to methyl bromide
- Economies of scale - will make it more affordable
Spread of Heat Treatment

- **North America**
  - USA, Canada and Mexico

- **Europe**
  - Greece, Romania

- **Asia**
  - India, Philippines
THERMAL REMEDIATION
Industrial Applications

- Food Processing
- Rice Mills
- Flour Mills
- Pet Food
- Corn Mills
- Cereal Processing
- Bakeries
- Warehouses

- Baby Food Plants
- Wood Packaging
- Tobacco Companies

Organic processing plants/storages
Entire structure or spot treatment
Heat Treatment: Patented Scientific Process

It’s more of an Art – **HOW** you apply it