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A novel method for analyzing grain facility heat treatment data☆

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Abstract

Use of elevated temperatures ($\geqslant 50^\circ C$) in food processing facilities for management of stored-product insects is a viable alternative to fumigation with methyl bromide. Effectiveness of heat treatment in controlling insects is determined by attainment of uniform temperatures between 50°C and 60°C. A unique surface area method was proposed and developed to assess the effectiveness of heat distribution. The pilot flour mill at Kansas State University, Manhattan, KS, was heated with natural gas (positive pressure) and electric (neutral pressure) heaters in June and August 1999, respectively. The proposed surface area method compared the two different heating systems and successfully quantified the under- and over-heated sections of the treated rooms at any given time during the treatments. A two-parameter nonlinear log-logistic equation was used to describe and predict the general trend in the floor surface area that is under 50°C as a function of treatment time, and percentage of floor surface area as a function of maximum floor temperature. With electric heating, time delays for temperature increase were considerably shorter than with gas heating. However, electric heating resulted in substantial amounts of under-heated floor areas ($T < 50^\circ$C) throughout the facility at the end of the heat treatment. The methods provided here, especially when coupled with the contour maps of temperature, can be used to design and evaluate heat treatment strategies in grain and food processing facilities.

Keywords: Heat treatment; Temperature distribution; Modeling; Nonlinear regression; Stored-product insects

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☆ Names are necessary to report factually on available data; however, the USDA neither guarantees nor warrants the standard of the product, and the use of the name by the USDA implies no approval of the product to the exclusion of others that may also be suitable.

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1. Introduction

Eliminating or reducing the population of insects in grain processing and storage facilities is a formidable task. Methyl bromide, a space fumigant routinely used for disinfestations of food processing facilities, is to be phased out by 2005 in developed nations because of its stratospheric ozone-depleting effect (Makhijani and Gurney, 1995; Fields and White, 2001); therefore, alternatives to replace methyl bromide are urgently needed.

Use of extreme temperatures or heat treatment has long been recognized as an effective control measure for insects associated with food processing facilities such as flour mills (Dean, 1911, 1913; Fields, 1992). During heat treatment, the entire facility or portions of it is heated to 50°–60°C and these temperatures are held for 24–36 h (Imholte and Imholte-Tauscher, 1999). The 24–36 h heat treatment period is necessary for the heat to penetrate equipment and wall voids to kill insects harboring inside. However, to kill exposed insects, exposure at $T > 50$°C for less than 12 h is sufficient (Fields, 1992; Dowdy, 1999; Roesli et al., 2003). Heat treatment does not require toxic chemicals or chemical pesticides; therefore, workers are better protected and there are no regulatory or chemical barriers (Heaps, 1988). Temperatures necessary to kill many species of stored-product insects have been reported and are attainable at most food processing facilities with gas, electric, or steam heaters (Fields, 1992; Dowdy and Fields, 2002; Mahroof et al., 2003a,b; Roesli et al., 2003). Heat treatment to control stored-product insects was widely used at the turn of the 20th century but later avoided due to equipment and structural damage (Heaps, 1994; Heaps and Black, 1994). Most modern food and grain buildings can withstand temperatures of 50°–60°C for extended periods of time. Caution should still be exercised, to prevent damage to heat-sensitive equipment. Ideally heat treatment should be done according to need, not on a calendar basis, and must be worked into a facility's master plan of sanitation for pest control along with housekeeping and competent inspections (Heaps, 1996; Sheppard, 1998).

In this study, a new method was developed to evaluate and compare the performance of two heat treatment systems (natural gas heating versus electric heating) at different floors of a pilot grain facility. Specific objectives were: (1) to develop a new method for evaluating heat treatments based on analysis of (a) percentages of floor surface areas that were less than 50°C as the treatments progress, and (b) percentages of floor surface areas that do not reach 50°C at the end of the treatments; (2) to correlate the percentage of floor surface area to maximum floor temperature; and (3) to investigate temperature distributions across the heat-treated rooms with use of contour plots.

2. Materials and methods

The pilot flour mill and cleaning house of the first, second, third, and fourth floors of the Department of Grain Science and Industry, Kansas State University (Manhattan, KS) were heat treated. Dimensions of the first floor of the mill were 24 m × 21 m × 4 m. Dimensions of the second, third, and fourth floor of the mill were 17 m × 12 m × 4 m. Treatments were performed at two different dates in 1999, June 25–27 with gas heaters and August 4–6 with electric heaters. Minimum, maximum and average ambient outside temperatures during the days of the heat treatments for June were 18°C, 32.2°C, and 25.1°C, respectively. Minimum, maximum and average ambient outside temperatures during the days of the heat treatments for August were 18.3°C, 33.3°C, and 25.8°C, respectively.

Gas heaters under the commercial name TempAir® (Patent number 6,141,901, Rupp Industries Inc., Burnsville, MN) were used during the June treatment. The heaters were placed outside the building, and the heated air was delivered inside the building, creating a positive pressure, through flexible nylon ducts with a diameter of 50.8 cm. The nylon ducts had circular openings of 10 cm diameter. The units used were: three THP-550 units, each producing 579,902 kJ; and one THP-1400 unit, producing 1,480,299 kJ. The air flow rate of a THP-550 heater was 85 m^3/min and that of a THP-1400 heater was 227 m^3/min. Ducts from the THP-550 unit (one duct per unit) were placed in the basement and on the first floor. Both ducts from the THP-1400 unit also were placed on the first floor. Two Bayley® fans (Rupp Industries Inc., Burnsville, MN) were placed on each floor to facilitate air circulation. Each fan had motor power of 1.5 hp, fan blade diameter of 78 cm, and airflow of 391 cm^3/min (Roesli et al., 2003).

Electric heaters under the commercial name TecHeat® System (Aggreko Inc., Fenton, MO) were used during the August treatment. The electric heaters were placed within the facility with power and monitoring cables running to a control trailer outside. This system heated air within the building rather than ducting any additional air into the structure thus maintaining a neutral pressure within the building relative to the other system tested. One heater, producing 289,951 kJ/h power, was placed on each floor of the flour mill and cleaning house. An Aerovent propeller fan (Plymouth, MN), was used on each floor. Each fan had a blade diameter of 63 cm, and airflow of 179 cm^3/min at 25.4 mm water gauge static pressure, and rotated at a speed of 1,750 rpm.

Temperatures were measured and recorded at the floor level of the flour mill and cleaning houses using HOBO® temperature/relative humidity data loggers (Onset Computer Corporation, Bourne, MA). HOBO®s were distributed at several locations in the cleaning house and flour mill in a loose grid fashion, using 16–22 per floor, in each room. To equally compare temperature distribution and heating dynamics during the two heat treatments, temperature loggers were placed in the same places each time and temperatures were recorded at 10-min intervals.

In order to calculate the percentage surface area that had not reached 50°C, first a grid map of the surface at a given time was generated with Surfer software (Golden Software Incorporated, Golden, CO) by using the X, Y, Z coordinates of each HOBO® data logger along with the corresponding temperatures. This was performed for all flour mill and cleaning house floors that were studied. The temperature criterion of 50°C was specified in order to compute the negative and positive planar areas on the generated maps. The negative planar area represents the projection of the map where the temperature of the surface area was $<50^\circ C$. The positive planar area represents projection of the map areas where the temperature of the surface area $\geqslant 50^\circ C$. The total planar area was the sum of negative and positive planar areas. The percentage surface area under 50°C was calculated by taking the ratio of the negative planar area to the total planar area. Hence, the plots of percentage surface area $<50^\circ C$ as a function of duration of heat treatment were generated. The contour maps of maximum floor temperature for each cleaning house and flour mill were also generated with the same software.

A nonlinear regression analysis was performed on the computed percentage surface area that had not reached 50°C. PROC NLIN procedure in SAS (SAS Institute, 1995) was used. The Marquardt iterative algorithm, one of the five methods available for PROC NLIN, was chosen to regress the residuals onto the partial derivatives of the model with respect to the parameters, until the estimates converged. The Marquardt algorithm was favored over the other iterative methods since the parameters were highly correlated (UCLA Academic Technology Services, 2003). Good agreement between predicted and observed values was further analyzed by examining the standardized residuals.

3. Results and discussion

In preparation for the nonlinear regression, an appropriate functional equation was determined. Values of the percentage surface area were normalized to a 0 to 1 scale. The normalization allowed comparisons of calculated percentage surface area values and modeling results, independent of initial and final values. Normalized values were converted back after nonlinear curve fitting. The following formula was used for normalization:

$$A_{norm} = \frac{A(t) - A_i}{A_f - A_i} \tag{1}$$

where A_{norm} is the nondimensional area under 50°C, $A(t)$ is the percentage of the area under 50°C at time t, A_i is the percentage of the area under 50°C at the beginning of heat treatment, and A_f is the percentage of the area under 50°C at the end of heat treatment.

The plots of time versus percentage surface area under 50°C showed a sigmoidal form. The plots of temperature versus percentage surface area followed the same trend. A log-logistic equation was used to represent both cases (South Carolina DHEC, 2001):

$$\text{Percentage Surface Area} = \frac{1}{1 + e^{-b\left(\left(\log_{10} temperature\right) - c\right)}} \tag{2}$$

where b and c are model parameters.

The F-test for goodness-of-fit showed that the model was highly significant ($P < 0.001$). Ratios of parameter estimates to standard errors indicated values of t for parameter estimates were significant at the $\alpha = 0.05$ level. The coefficient of determination, R^2, is not readily defined for nonlinear regression. A measure corresponding approximately to R^2 in the nonlinear case can be calculated from the analysis of variance (SAS Institute, 1995):

$$\text{Pseudo}R^2 = 1 - \left(\frac{SSR}{SST}\right) \tag{3}$$

where SSR is the residual sum of squares and SST is the total corrected sum of squares of the model.

The standardized residuals were examined for each floor of the flour mill and the cleaning house. Since the majority of the standardized residuals fall within ± 2 standard deviation range, the error terms were considered normal. There were no outliers. However, a slight positive serial correlation appeared after examining the standardized residuals versus predicted values of the percentage surface area. Although such correlations will not cause bias in parameter estimates, they may increase the variances of estimates.

Modeling of time-temperature data from heat treatment of local grain facilities were reported by some researchers. Mahroof et al. (2003b) and Subramanyam et al. (2003) recorded temperature data at two different locations, mostly wall corners, on each flour mill and cleaning house and performed curve fitting with a three-parameter regression model. Roesli et al. (2003) used only one HOBO® per floor and performed curve fitting by using the same equation. Since temperatures were recorded at no more than two locations per room, such time-temperature plots fall short of sufficiently representing the entire treated rooms, nor do they offer any explanation of temperature distributions across the floor. However, the proposed surface area approach by using time–temperature data which were acquired at numerous locations per floor, provides quantification of under- and over-heated floor surface areas. This type of technique has not been previously reported in the literature.

The temperature profile in a heat-treated area is influenced by a number of factors: type and intensity of heating system, placement of heat sources, number of fans to facilitate air movement, placement of fans, dimensions of the room, equipment present in the room, outside ambient temperature, structure of the building, and number of vents. It is a challenge to establish a heating system that will maintain perfectly balanced heat distribution throughout all floors. Certain sections of the treated areas may become exposed to undesirably extreme temperatures, while some sections remain under-heated ($T < 50^\circ C$). It is in these under-heated areas that insects may survive and avoid the lethal effects of temperature. It is also important that sufficient heat penetrates inside equipment to ensure insect mortality. The main concern with over-heating is the risk of damage to delicate equipment.

Time–temperature relationships play an important role in effective heat treatment for insect management. As a rule, the higher the temperature, the lower the exposure time for insect mortality. Mahroof et al. (2003a) reported that it is preferable to use temperatures of 50°C and higher during heat treatments because at these temperatures, eggs, older instars, pupae, and adults of *Tribolium castaneum* (Herbst) are highly susceptible to heat. However, young (neonate) larvae of *T. castaneum* are relatively heat tolerant, requiring 7.2 h for 99% mortality at 50°C, whereas the other stages required 1.8 h at 50°C.

Natural gas heating and electric heating created different heating patterns. Gas heating tended to be consistently slower at the beginning of each treatment, exhibiting no change in the percentage of treated areas ($T > 50^\circ C$) for several hours after the onset of heating (time delay). The time delays, also called lag times, of the two systems are compared in Fig. 1. The lag time was defined as the amount of time elapsed between the onset of the heat treatment until any floor HOBO® data loggers had detected a temperature reading of 50°C or higher. Lag times for each cleaning house or flour mill were extracted separately. In general, lag times for the electric heating system were considerably shorter than those of gas heating, except for cleaning houses on floors 2 and 3, which were in the 22–23 h range. Both systems revealed comparable speeds of heating for mill floor 2, approximately 6 h. Time delay could be an important issue from the standpoint of cost-effectiveness of the heat treatment, if the heating system also requires more time for sufficient heat treatment to ensure adequate insect mortality. As can be seen from Fig. 2, shorter lag times did not necessarily correspond to effective treatment. With the exception of cleaning house floor 1, fewer under-heated areas were observed with the gas heating system. In mill floors 3 and 4, gas heating exhibited more than twice the lag times of electric heating, although at the end of the treatments, more than 99% of the floor surfaces reached $T > 50^\circ C$ with gas heating, unlike that achieved with electric heating. Therefore, the primary concern must be the quantification and identification of under-heated areas ($T < 50^\circ C$) at the end of each treatment. The proposed surface area approach, coupled with contour plots of temperature, helps achieve this goal. All

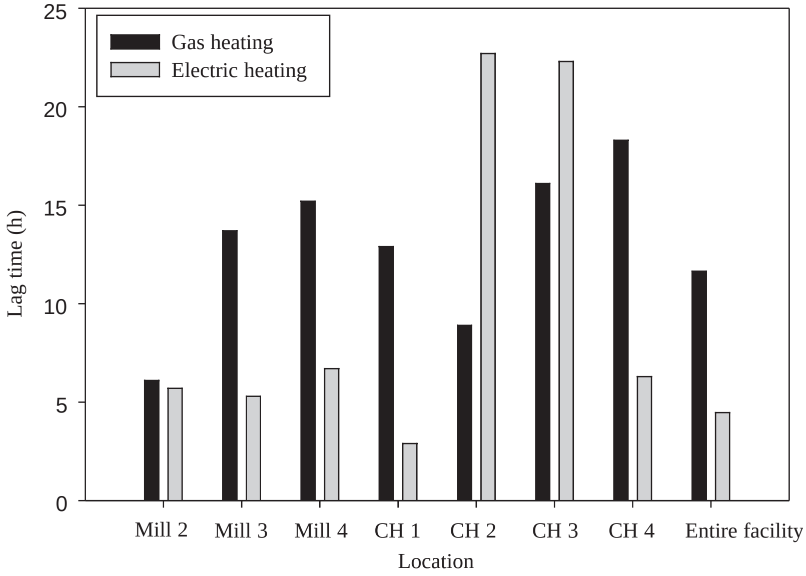


Fig. 1. Lag times during heat treatment for gas heating and electric heating as a function of location within the facility (CH = cleaning house; numbers refer to floor level).

data sets of percentage floor surface area under 50°C versus duration of treatment followed a log-logistic equation (Eq. (2)). Pseudo-R^2 values ranged from 0.896 to 0.999 (Table 1). By using Fig. 2, the percentage floor surface area that has not yet reached 50°C as a function of duration of heat treatment can be determined.

All data sets for percentage floor surface area versus maximum floor temperature followed the same log-logistic model. Pseudo-R^2 values ranged from 0.967 to 0.999 (Table 2). Percentage surface area-maximum temperature plots have a practical use in quantification of areas that are under-heated or over-heated. For example, for cleaning house 1, floor area exposed to $T > 60^\circ C$ was 0% with gas heating and 13% with the electric heating system; the under-heated areas ($T < 50^\circ C$) were 48% with gas heating and 24% with electric heating (Fig. 3).

Maximum temperature distribution varied substantially throughout the treated rooms (Fig. 4). Under-heated areas were detected at every floor with electric heating, with cleaning house floor 1 having the most $T < 50^\circ C$ floor surfaces. These under-heated areas were mostly detected at the corners or along the walls. In general, considering the entire facility, electric heating resulted in more under-treated areas ($T < 50^\circ C$) than gas heating. On the other hand, almost half of cleaning house floor 1 never reached the target temperature of 50°C with the gas heating system. Conversely, the section of mill floor 2 facing west reached temperatures over 80°C with gas heating, which may carry the risk of heat damage.

Considering the entire facility, the energy requirement of gas heating was less than that of electric heating (Tables 3 and 4). However, for a complete economical overview other expenses such as the cost of equipment rental and set up, labor, quality assurance, and maintenance should be taken into account and evaluated for each treatment.

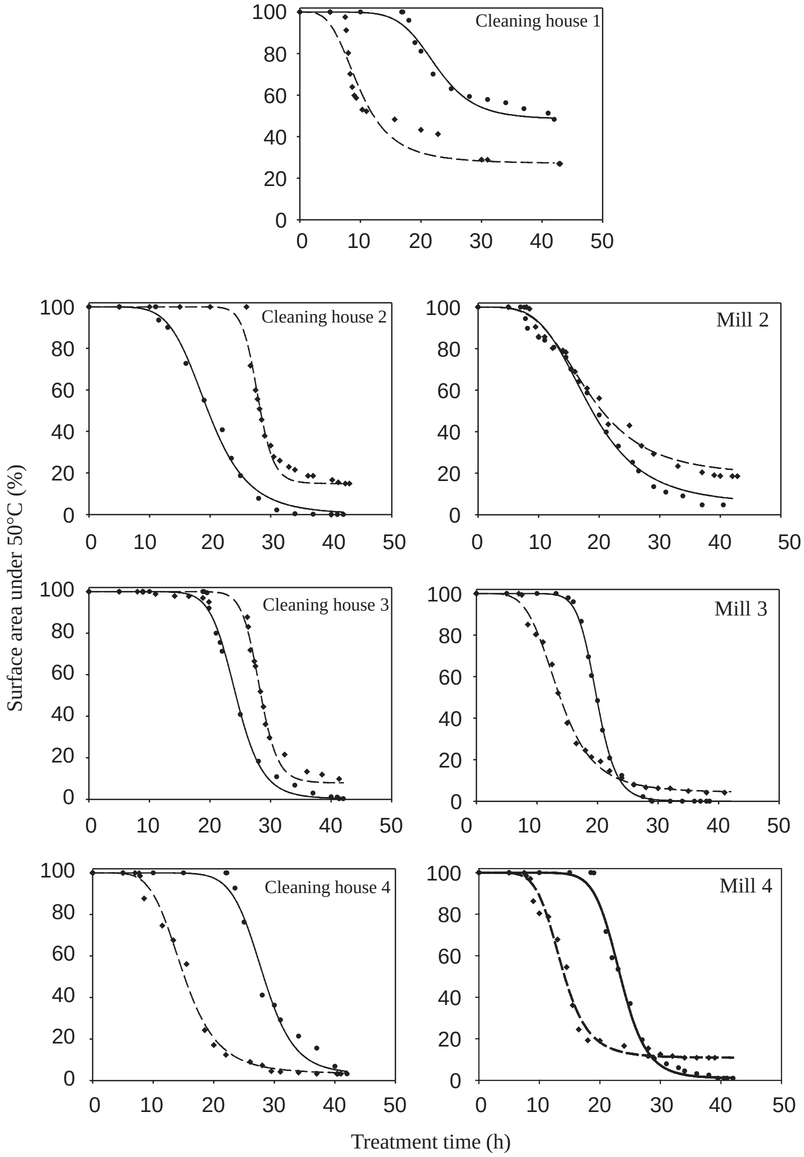


Fig. 2. Floor surface area (%) under 50°C at any given time during heat treatment of the facility. (●) Gas heating data; (◆) Electric heating data; (——) Predicted gas; (– – –) Predicted electric.

It is important to provide sufficient heat throughout the treated rooms for effective disinfestation. Uniform heat distribution is desirable to avoid under- and over-heated areas. Temperature monitoring is a valuable tool to identify such areas. Redirecting heat from fast-heating areas to cooler areas will facilitate homogenous heating. This can be accomplished by fans and strategic placement of ducts with gas heating or by portable heaters with electric heating.

Table 1
Parameter estimates for Eq. (2)—surface area under 50°C versus treatment time

	Gas heating			Electric heating		
Location	*b*	*c*	Pseudo-R^2	*b*	*c*	Pseudo-R^2
Mill building 2	9.45	−11.95	0.990	8.78	−11.05	0.989
Mill building 3	28.31	−36.74	0.999	10.98	−12.44	0.996
Mill building 4	24.66	−33.74	0.993	14.44	−16.39	0.990
Cleaning house 1	16.37	−22.12	0.965	8.27	−8.21	0.896
Cleaning house 2	13.51	−17.47	0.995	49.16	−71.04	0.983
Cleaning house 3	25.68	−35.57	0.994	44.07	−63.90	0.993
Cleaning house 4	24.72	−35.80	0.986	12.13	−14.26	0.994
Entire facility	15.85	−21.43	0.999	7.68	−9.50	0.986

Table 2
Parameter estimates for Eq. (2)—surface area versus maximum floor temperature

	Gas heating			Electric heating		
Location	*b*	*c*	Pseudo-R^2	*b*	*c*	Pseudo-R^2
Mill building 2	−26.12	45.67	0.986	−58.60	102.3	0.999
Mill building 3	−188.9	333.9	0.991	−125.4	218.0	0.992
Mill building 4	−173.9	304.6	0.991	−51.83	89.56	0.974
Cleaning house 1	−42.82	72.26	0.987	−41.64	72.34	0.989
Cleaning house 2	−58.99	104.0	0.994	−64.11	112.2	0.990
Cleaning house 3	−134.0	235.3	0.967	−144.3	250.9	0.979
Cleaning house 4	−224.2	389.8	0.968	−113.7	197.7	0.997

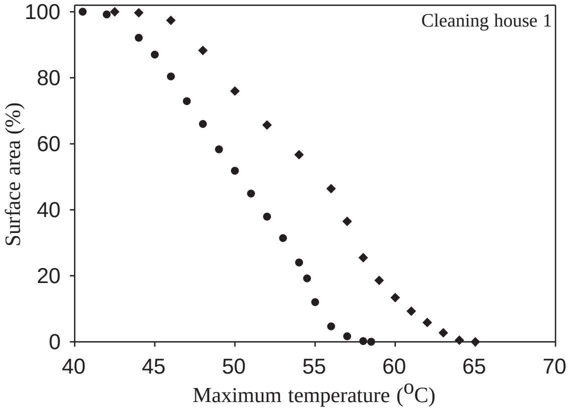
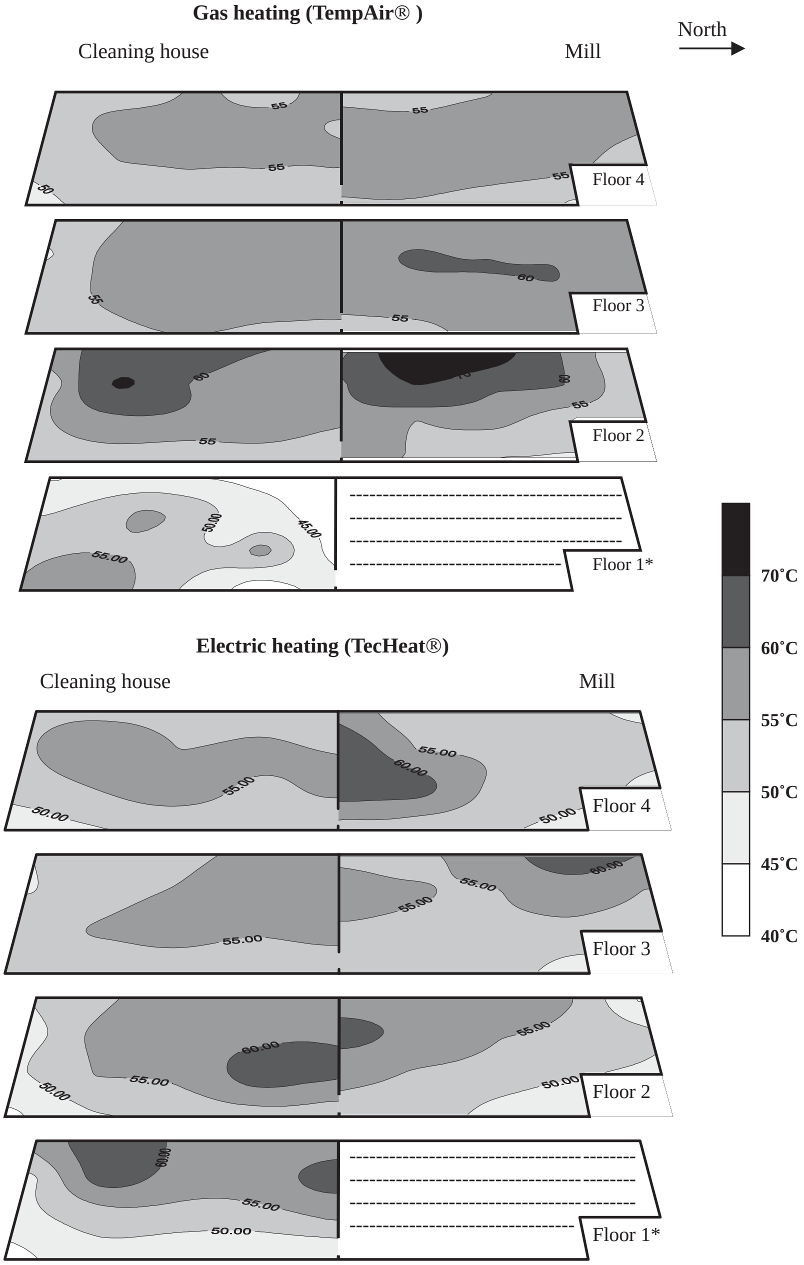


Fig. 3. Relationship between floor surface area (%) and maximum floor temperature. (●) Gas heating; (◆) Electric heating systems in cleaning house 1.



*Flour Mill floor 1 was not studied.

Fig. 4. Contour plots of maximum temperature distribution during heat treatments in the cleaning house and flour mill floors.

Efficient use of heat may also minimize the energy required for heat treatment. Considering that heat treatment in this particular facility is conducted at least three times per year, heat conservation may add up to save considerable amounts of energy, time, and money.

Table 3
Energy requirement for gas heating system

Heater model	DEC[a] (kW/day)	DEC[a] cost/day[c] ($)	DGC[b] dkt/day	DGC[b] cost/day[c] ($)	Total cost/day ($)
THP-1400	88.3	5.30	33.6	168	173.3
THP-550	43.0	2.58	13.2	66	68.58
Entire facility[d]	217.3	13.04	73.2	366	379.04

[a] DEC: Daily Electric Consumption.

[b] DGC: Daily Gas Consumption.

[c] Cost/day calculation was based on cost of electricity of $0.06/kW and cost of natural gas of $5/dkt.

[d] One THP-1400 and three THP-550 units were used for the entire facility.

Table 4
Energy requirement for electric heating system

Capacity/heater (kJ/h)	Number of heaters	Cost/day[a] ($)
289,951	7	812

[a] Cost/day calculation was based on cost of electricity of $0.06/kW.

4. Conclusion

A new technique to analyze the heat treatment data of grain facilities has been developed. The basis of this method was to compute the percentage of floor surface areas of each cleaning house and floor mill that has not reached the target temperature of 50°C throughout the heat treatment. This approach quantifies not only the under-heated areas of the heat-treated rooms at any given time during the heating process but also the time delays to reach to 50°C. Identification of the under- and over-heated areas was achieved with contour plots of each room. The quantification and identification of maximum floor temperature were also established.

A two-parameter log-logistic equation successfully described the percentage surface area-time and percentage surface area-maximum temperature. The drawback of this model is that the parameter estimates are limited to the experimental conditions. Nevertheless, the surface area method coupled with the contour maps of temperature provided insight to heating as a means for stored-product insect management and also proved to be effective in comparing different heating systems and different sections of the facility during heat treatments. This approach may also aid in designing or modifying future heat treatments in food processing facilities.

The electric heating system resulted in considerably shorter time delays than gas heating to reach the target temperature of 50°C. Gas heating yielded fewer under-heated surface areas across the facility. Cleaning house floor 1 was identified as the section of the facility that demonstrated the highest percentage of under-heated area with both systems. This was the only floor in the study resting directly on earth, hence resulting in higher heat loss through the floor. Redistribution of heat from hotter to cooler areas should be targeted regardless of the heating system chosen.

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References

Dean, D.A., 1911. Heat as a means of controlling mill insects. Journal of Economic Entomology 4, 142–158.

Dean, D.A., 1913. Further data on heat as a means of controlling mill insects. Journal of Economic Entomology 6, 40–53.

Dowdy, A.K., 1999. Mortality of red flour beetle, *Tribolium castaneum* (Coleoptera: Tenebrionidae) exposed to high temperature and diatomaceous earth combinations. Journal of Stored Products Research 35, 175–182.

Dowdy, A.K., Fields, P.G., 2002. Heat combined with diatomaceous earth to control the confused flour beetle (Coleoptera: Tenebrionidae) in a flour mill. Journal of Stored Products Research 38, 11–22.

Fields, P.G., 1992. The control of stored-product insects and mites with extreme temperatures. Journal of Stored Products Research 28, 89–118.

Fields, P.G., White, N.D.G., 2001. Alternatives to methyl bromide treatments for stored-product and quarantine insects. Annual Review of Entomology 47, 331–359.

Heaps, J., 1988. Turn on the heat to control insects. Dairy and Food Sanitation 8, 416–418.

Heaps, J., 1994. Temperature-controlled insect elimination. Association of Operative Millers Bulletin December, 6467–6476.

Heaps, J., 1996. Heat for stored-product insects. IPM Practitioner, May/June, pp.18-19.

Heaps, J., Black, T., 1994. Using portable rented electric heaters to generate heat and control stored product insects. Association of Operative Millers Bulletin, July 6408-6410.

Imholte, T.J., Imholte-Tauscher, T., 1999. Engineering for Food Safety and Sanitation. Technical Institute of Food Safety, Woodinville, Washington, DC.

Mahroof, R., Subramanyam, B., Throne, J.E., Menon, A., 2003a. Time-mortality relationships for *Tribolium castaneum* (Coleoptera: Tenebrionidae) life stages exposed to elevated temperatures. Journal of Economic Entomology 96, 1344–1351.

Mahroof, R., Subramanyam, B., Eustace, D., 2003b. Temperature and relative humidity profiles during heat treatment of mills and its efficacy against *Tribolium castaneum* (Herbst) life stages. Journal of Stored Products Research 39, 555–569.

Makhijani, A., Gurney, K.R., 1995. Mending the Ozone Hole: Science, Technology and Policy. MIT Press, MA.

Roesli, R., Subramanyam, B., Fairchild, F.J., Behnke, K., 2003. Trap catches of stored-product insects before and after heat treatment in a pilot feed mill. Journal of Stored Products Research 39, 521–540.

SAS Institute, 1995. SAS/STAT User's Guide, Cary, NC.

Sheppard, K., 1998. Heat sterilization. In: Mueller, D.K. (Ed.), Stored Product Protection. Insects Limited, Inc., Westfield, IN, pp. 175–196.

South Carolina Dept. of Health, Environmental Control, 2001. Options for data analysis of whole effluent toxicity testing required by NPDES permits. Bureau of Water. September issue.

Subramanyam, B., Mahroof, R., Roesli, R., 2003. Management of red floor beetles using elevated temperatures. Association of Operative Millers Bulletin. February, pp. 7899-7907.

UCLA Academic Technology Services. SAS Library. Nonlinear Regression in SAS. 2003. http://www.ats.ucla.edu/stat/SAS/library/SASNLin_os.htm.