NSE TECHNICAL TRANSACTIONS

ISSN 1119 - 5363

A Technical Publication of The Nigerian Society of Engineers

IN THIS ISSUE

OCTOBER - DECEMBER, 1997 VOL. 32 NO. 4

COMPARATIVE STUDIES OF TEMPERATURE FLUCTUATIONS WITHIN WOODEN AND STEEL SILOS IN IBADAN

E. B. LUCAS AND Y. MIJINYAWA
Department of Agricultural Engineering
Faculty of Technology, University of Ibaban.

ABSTRACT

Temperature fluctuations and moisture condensation within the interiors of a steel and wooden silos were determined experimentally. The steel silo is of 1mm thickness while the wooden silo is a two-layered wall panel of 12mm and 6mm thick plywood separated by 50mm air-gap. Measurements taken during the hotter months of March and April in Ibadan showed that temperature fluctuations in the steel and wooden silos were 9ºC and 7ºC respectively. Corresponding maximum temperature in the silos were 38.5ºC and 37.2ºC. While the interior of the wooden silo remained dry, the steel silo had condensed moisture droplets lining its inner walls. Since moisture condensation in a silo contributes to grain spoilage by biological agents, wooden silos are rated superior in respect of reducing this adverse feature.

KEYWORDS: Condensation, Conductivity, Comparartive, Deterioration, Fluctuation, Silo.

INTRODUCTION

Bulk storage of grain in Nigeria is usually in metal silos. Aluminium and Steel are the common silo constructional materials. These are materials of high thermal conductivity and some stored grains develop hot spots, roast and cake within these silos when ambient temperature is high.

In the tropics, diurnal temperature may be as high as 15 ºC or more during the dry seasons. Under such exposures, metal silos are subjected to wide temperature fluctuation resulting in moisture condensation on the roofs and walls. This is so even when radiation reflecting surface are employed. The condensed moisture migrates into the grain bulk and this has been identified as a major cause of increased fungal activity in stored grain. Another occurrence usually found in steel silos is the development of hot spots. Osobu (1971) and Onwuzulu (1986) reported serious incidences of hot spots and caking of grain stored in metal silos in Western Nigeria. Yaciuk et al (1975) reported the abundant growth of anthropoids and some other food grain destroying organism at elevated temperature of around 40ºc in grains stored in metal silos. Bakshi and Bhatnagar (1972), also reported the development of moisture gradient and grain spoilage in outdoor metal silos exposed to high solar radiation.

Osobu (197]) undertook a comparative study of temperature fluctuations within a metal and a double-walled concrete silo in Ibadan and observed lower temperature fluctuations in the concrete silo. He also found that the concrete had less moisture condensation within it. Ajayi (1986) observed that when the ambient environment was between 24ºC and 30ºC, temperature fluctuations within a concrete silo was from 2]ºc to 24ºC while inside a steel silo, the figures were 2]ºc to 27ºC.

Three sources of heat contribute to temperature fluctuations in a silo. These are the external heat from solar radiation which penetrates through the wall into the grain bulk, the internal heat from the metabolic activities of the grain itself and respiration of organisms within the silo. If the grain bulk is dried to a safe level of moisture content and the material is initially free of micro-organisms, the internal heat sources are negligible (Bakshi and Bhatnagar, 1972; Sinha, 1973). When the internal heat sources are negligible, the temperature within a silo enclosure depends on only the ambient condition and the thermal conductivity of the silo material. Materials for silo wall construction should preferably be of low thermal conductivity.

The objective of this work was to compare the performances of wooden and steel in respect of temperature fluctuations within the silo and the accompanying moisture condensation within the silos.

2. MATERIALS AND METHOD

Two silos, each of capacity, 7m³ were placed close to each other in the premises of the Department of Agricultural Engineering, University of Ibadan. The cold, rolled steel silo is cylindrical in shape, 2.3 metres in diameter, 1.7 metres in height and of wall thickness of 1mm (Ajayi, 1986). The second silo was wooden. It is of regular hexagonal section, each side measuring 1.2 metres, the height being 1.8 metres. It has solid wood (Mansonia altissima) frames and plywood sheathing, the plywood being of African Mahogany face and core veneers bonded with phenol-formaldehyde adhesive. The wooden silo is double-walled, being 12mm and 6mm thick respectively and with a 50-mm air-gap between the walls (Mijinyawa 1989). It has been established that comparative test on silos in respect of temperature simultation may be carried out on unloaded silos (Bakshi and Bhatnagar, 1972; Sinha, 1973). The comparative studies on the two silos were therefore carried out on empty silos. The tests were carried out around March/April when the ambient temperatures in the environment usually attain their higher values, reaching as much as 38.5°C.

Temperature readings were taken thrice daily; around 6.00 a.m.,] 2.00 noon and 6.00 p.m. In addition, readings on a maximum-and-minimum thermometer were observed daily at 6.00 p.m. Ideally, a thermal-hygrograph should be used to obtain a complete detail of temperature situation within the silo. However, the most important requirements for the work were the indications of maximum and minimum temperatures attained, as these have implications for moisture condensation within.

3. RESULT AND DISCUSSION

The result are presented in Table 1 and graphically in Figure 1. The ambient temperature were as expected minimum in the mornings and maximum around the afternoons following when solar radiation was maximum. The temperature fluctuation curve for the interior of the steel silo was practically indentical with that for the ambient, both curves overlapping on some days. The curves for the temperature flucutations in the interior of a wooden silo was quite distinct from that of the ambient.

The minimum temperatures recorded within the wooden silo were higher than the temperatures for corresponding days within the steel silo and the ambient while the maximum temperatures recorded within the wooden silo were lower than those for the ambient and steel silo.

While the thermal conductivity for steel is] 2-62 w/m°c (parrish, 1973), it is only around 0.094-0. 42 w/m°c for wood (Mijinyawa, 1989). This accounts for the wider flucutations in temperature within the interior of the steel silo compared to the wooden one. The average temperature were 7°C; 9°C and] 0°C respectively within the wooden and silos and in the environment. The delay in the attainment of maximum temperature within the interior of the wooden silo was also due to the low thermal conductivity of the wall material.

Moisture condensation within an enclosure depends on the temperature and relative humidity gradients between its internal and external surfaces. These are higher at night when ambient temperature drops. With reduced temperature fluctuations within the wooden silo, the moisture condensation therein should be at a lower level than in metal silo. This was observed during the tests, the inner walls of the wooden silo were found dry while those of the steel silo were visibly wet. A wet interior wall in a silo promotes the prolification of fungi within. The moisture condensed on the walls migrate to the adjacent grains and these are readily attacked by the fungi. In addition, there are associated insects which these fungi serve as attractants to, these further causing grain deterioration. It is therefore essential to prevent moisture condemnation on silo interior walls.

4. CONCLUSION

Silos with plywood walls performed better than steel silos in keeping down temperature fluctuation within the silo interior. This could in turn limit fungal and bacteria activities within stored grain especially when naturally durable woods are used for silo construction.

TABLE 1

TEMPERATURES AND TEMPERATURE FLUCTUATIONS WITHIN AND OUTSIDE SILOS

	Ambient Temperatures (°C)			Temperatures in Steel Silo (°C)			Temperatures in Wooden Silo (°C)		
Day	A+	B++	C+++	A+	B++	C+++	A+	B++	C+++
1.	24.0	36.0	12.0	24.8	34.5	9.7	26.0	34.0	8.0
2.	27.0	37.0	10.0	25.4	35.0	9.6	27.0	35.0	8.0
3.	25.0	35.0	10.0	26.0	36.0	10.0	27.0	32.4	5.4
4.	25.0	34.0	9.0	25.0	32.0	7.0	26.6	31.8	5.2
5.	21.80	36.0	14.2	22.0	32.0	10.0	22.0	31.0	9.0
6.	24.0	34.0	10.0	24.0	34.0	10.0	25.0	34.1	9.1
7.	26.4	37.0	10.6	29.0	38.5	9.5	28.2	37.2	9.0
8.	25.8	37.1	11.3	24.0	35.0	11.0	26.1	34.0	7.9
9.	26.1	38.0	11.9	28.1	38.0	9.9	27.4	37.1	9.7
10.	26.2	38.0	11.8	26.0	36.0	10.0	27.0	35.0	8.0
11.	25.8	36.5	10.7	26.0	36.0	10.0	26.0	35.4	9.4
12.	26.4	38.0	11.6	26.0	36.0	10.0	26.8	36.6	9.8
13.	26.2	36.8	11.6	26.0	35.0	9.0	27.0	35.0	8.0
14.	25.2	35.0	9.8	25.0	35.0	10.0	26.0	33.4	7.4
15.	25.8	37.0	11.2	24.0	36.6	12.5	27.1	35.0	7.9
16.	23.30	32.0	8.7	20.2	30.0	9.8	24.4	27.0	2.6
17.	24.0	32.0	8.0	20.3	27.0	6.7	27.1	30.5	3.4
18.	22.0	31.5	9.5	20.4	29.0	8.6	23.0	30.0	7.0
19.	24.2	33.5	9.3	20.3	29.5	9.2	24.0	29.2	5.2
20.	26.0	35.0	9.0	20.6	30.0	9.4	26.1	34.0	7.9
21.	25.3	33.5	8.2	20.4	30.0	9.6	26.0	35.0	9.0
22.	26.0	35.0	9.0	26.0	34.5	8.5	26.5	32.0	5.5
23.	25.0	36.0	11.0	26.0	35.0	9.0	26.3	35.2	8.9
24.	25.6	33.0	7.4	24.0	32.0	8.0	26.0	31.0	5.0
25.	22.0	30.0	8.0	22.0	30.0	8.0	23.0	30.1	7.1
26.	24.0	34.8	10.8	24.0	34.0	10.0	24.5	34.5	10.0
27.	26.0	36.0	10.0	24.0	33.0	9.0	27.0	32.0	6.0
28.	26.0	33.9	7.0	26.0	33.0	7.0	26.0	32.0	6.0
29.	24.0	30.2	6.2	25.5	34.0	8.5	26.0	32.6	6.6
30.	25.5	33.5	8.0	26.0	32.0	6.0	27.0	31.0	4.0
Average			10.0			9.0			7.0

A+ = Minimum temperature B++ = Maximum temperature

C+++ = Temperature fluctuation.

REFERENCES

Ajayi, D. O. 1986 Evalution of Concrete and Metal Rhumbu Storage Structure for Cob Maize. M.Sc. Dissertation in the Department of Agricultural Engineering, University of Ibadan.

Bakshi, A. S. and A. P. Bhatnagar, 1972. Temperature Studies in Grain Storage bins. Indian Journal of Agricultural Engineering 9 (2): 20 - 43.

Mijinyawa, Y. 1989. The use of wood products in the design and construction of a grain silo for the humid tropics. A Doctoral Thesis in the Department of Agricultural Engineering, University of Ibadan.

Onwuzulu, O. C. 1986. Bulk storage of grains in silos. Paper presented at the Nigeria Society of Agricultural Engineers Annual Conference, University of Ile-Ife. Sept. 1 - 5, 1986.

Osobu, A. 1971 **Structures:** Efficiency and Economics of locally produced and imported Structures. A paper presented at Ford Foundation, IITA and IAR & T Seminar on grain storage in the humid tropics. Ibadan. July 26-30 1971.

Parrish, A. 1973. Mechanical Engineer's Reference Book. Butterworth and Company Publishers, London.

Shina, R. N. 1973. Interrelations of physical, chemical and biological variables in the deterioration of stored grains. In R. N. sinha and W. E. Muir (editors) Grain Storage:- Part of a system. AVI Publishing company, New York.

Yaciuk, G; W.E. Muir and R. N. Sinha. 1975. A Simulation Model of temperatures in stored grain. Journal of Agricultural Engineering Research 1 (20): 245 - 258.

FIG. 1 : DAILY TEMPERATURE FLUCTUATIONS WITHIN AND OUTSIDE SILOS IN IBADAN