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Analysis on thermal insulation effectiveness of saw dust in okra dryer

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Abstract
Thermal insulation of drying equipment plays a very important role in minimizing heat losses during drying process. This study is aimed at analyzing the performance of insulation using sawdust in a locally fabricated hot air okra dryer. The effectiveness of the insulation was analyzed mathematically by evaluating the R-Value and the heat loss through the composite wall of the drying chamber of the fabricated machine. The result showed minimal heat loss when compared to the value indicated by the un-insulated okra dryer. The study further revealed that saw dust material can be used in local dyers to reduce heat losses and cost of importing insulation materials by local industry in the country. The fabrication of saw dust insulated okra dryer can lead to job creation in both small and large scale industry.

Keywords: insulation effectiveness saw dust, heat losses, dryer

Introduction

The thermal insulation is very important in reducing heat losses through the wall of drying machine. The efficiency of the drying process will be increased and the drying time decreased by reducing the amount of heat losses in a dryer. (Abano *et al*, 2014) [1].

Lai (2017) [5] confirmed that wood saw dust can be chosen as filler material to reduce thermal conductivity in perforated bricks because they are commonly found as waste product with good potential due their lightweight, low thermal conductivity and high specific heat.

According to phonphuak (2015) [6] saw dust is a waste from the wood and timber industry which can be used as a source fuel in thermal process (biomas) and also as insulating materials. Saw dust material residue can be incorporated in clay to improve its thermal insulating capacity.

Chaurasia (1991) [3], revealed that saw dust was tested as an insulating material in the storage system and compared its performance with the fibre glass wool storage system for hot water applications under similar conditions. From this study, it has been observed that the saw dust storage system also gave good performance for retaining the solar heat hot water up to the following evening. Based on this investigation, the low cost and widely available saw dust may also be successfully employed as an insulating material.

According to sprig, (2020), there are many available raw materials which when properly processed can be converted into first class insulators. Various types of straw saw dust and similar fibrous materials are or may be converted into efficient "loose fill" insulating materials. Thermal insulation is one of the most important concept of a thermal energy storage system.it is necessary to use thermal insulating materials around thermal energy storage systems to in order to minimise heat losses from the system. Poor thermal insulation of the heat storage systems leads to high heat losses (Ayusi, 2011) [2]. In Nigeria there are many local materials available for consideration as thermal insulators.these local mmaterials are either available naturally or are obtained as industrial.wood saw dust has been used historically to insulate timber building in the us and germany.

Egware (2018) [4], adopted the use of saw dust as an insulating material to prevent heat from escape from the internal chamber to the atmospher in a locally fabricated saw dust fired oven for drying purposes.

Materials and Methods

The hot air okra dryer used for this study was locally fabricated in Yola Adamawa State. The rate of heat transfer through the composite wall of the drying chamber of the machine was evaluated mathematically based on furrier law equation of heat conduction. R-Value of each layer of the composite wall was also determined. The composite wall layers comprises 1cm thick aluminium with hot surface at 80^0 and 1.5 cm thick mild steel sheet with surface at 30^0.These two layers are interposed by a third layer of saw dust insulating material 4.5cmthick.The rate of heat transfer is derived from the following mathematical expression:

Heat transfer rate, $q=\frac{\Delta t_{overall}}{\sum R_{thermal}}$, (Raveendiran, 2008).

Where, $\Delta t_{overall} = T_1 - T_4$

$$\sum R_{thermal} = R_{Aluminium} + R_{Sawdust} + R_{Mild\ steel}$$

R-Value, $R=\frac{t}{KA}$

Where, t= wall thickness of material (m)
K=thermal conductivity coefficient $(\frac{w}{mk})$
A= Surface area of the wall (m^2)

Considering heat loss through the vertical wall (vw) of the drying chamber of the machine.

For Aluminium layer,

t_1=1cm=0.01m, k_1=230 $^{W}/_{mk}$, A_1=0.46×0.32=0.1472m^2

Sawdust layer,

t_2==0.045m, k_1=0.059 $^{W}/_{mk}$, A_1=0.46×0.32=0.1472m^2

Mild steel,

t_3=0.015m, k_1=43 $^{W}/_{mk}$, A_1=0.46×0.32=0.1472m^2

Hence we have,

$$R_{Aluminium} = \frac{t_1}{K_1A_1} = \frac{0.01}{230\times0.1472} = 0.0003\ ^{k}/_{w}$$

$$_{Sawdust} = \frac{t_2}{K_2A_2} = \frac{0.045}{0.059\times0.1472} = 5.1817\ ^{k}/_{w}$$

$$R_{Mild\ steel} = \frac{t_3}{K_3A_3} = \frac{0.015}{43\times0.1472} = 0.0024\ ^{k}/_{w},$$

Therefore, we have

$\sum R_{thermal}\ (vw) = R_{Aluminium} + R_{Sawdust} + R_{Mild\ steel}$=0.0003+5.1817+0.0024=5.184 $^{k}/_{w}$

Heat loss through the vertical wall

$$(vw), q_{vw} = \frac{T_1 - T_4}{\sum R_{thermal\ (vw_1)}} = \frac{80-30}{5.184} = \frac{50}{5.184} = 9.65\ \text{w}$$

Since the drying chamber has 2 equal vertical walls, the total heat loss through vertical wall is given by the expression:

$$q_{total(vw)} = 2q_{vw} = 2\times 9.65 = 19.29\ \text{w}$$

Considering the horizontal wall (HW) of the drying chamber, we have sum of R-value is equivalent to:

$$\sum R\ \text{HW} = \frac{t}{K_1A_1}$$

$$R_{Aluminium} = \frac{t_1}{K_{1HW}A_{1HW}} = \frac{0.01}{230\times0.207} = 0.0002\ ^{k}/_{w}$$

$$R_{Sawdust} = \frac{t_2}{K_{2HW}A_{2HW}} = \frac{0.045}{0.059\times0.207} = 3.685\ ^{k}/_{w} \quad R_{Mild\ steel} = \frac{t_3}{K_{3HW}A_{3HW}} = \frac{0.015}{43\times0.207} = 0.00169\ ^{k}/_{w}$$

Hence

$\sum R_{thermal}$ HW) $= R_{Aluminium} + R_{Sawdust} + R_{Mild\ steel}$
=0.0002+3.685+0.00169=3.687 $^{k}/_{w}$

Heat loss through the Horizontal wall (HW)

$$, q_{HW} = \frac{T_1 - T_4}{\sum R_{thermal(HW)}} = \frac{80-30}{3.687} = \frac{50}{3.687} = 13.56\text{w}$$

Since the drying chamber has 2 equal horizontal wall (HW), the total heat loss through vertical wall is given by:

$$q_{total(HW)} = 2q_{HW} = 2\times 13.56 = 27.12\ \text{w}$$

The total heat loss through the machine insulated walls, $q_{total} = q_{vw} + q_{HW} = 19.29 + 27.12 = 46.41w$

For the uninsulted drying chamber, the heat loss through the wall was analyzed as follows:

Considering the vertical wall of the drying chamber, we have the heat loss through the un-insulated vertical wall as;

$$q_{uvw} = \frac{T_1 + T_4}{\sum R_{UVW}}$$

$\sum R_{UVW} = R_{Aluminium\ wall} + R_{Mild\ steel\ wall}$, We get

$\sum R_{UVW}$ =0.0003 + 0.0024 $^{K}/_{W}$ = 0.0027$^{K}/_{W}$.

Since the two walls are equal in size, total Resistance for the un-insulated vertical wall is expressed as:

$\sum R_{total\ UVW}$ = 2($\sum R_{UVW}$) = 2× 0.0024= 0.0054$^{K}/_{W}$.

Heat loss through the vertical un-insulated wall,

$$q_{uvw} = \frac{T_1 + T_4}{\sum R_{total\ UVW}} = \frac{80-30}{0.0054} = \frac{50}{0.0054} = 9259\ \text{w}$$

Considering the horizontal wall, we get

$\sum R_{UHW} = R_{Aluminium\ wall} + R_{Mild\ steel\ wall}$ = 0.0002$^{k}/_{w}$ + 0.00169 = 0.00189$^{K}/_{W}$.

Since the two un-insulated horizontal walls are equal, the total resistance is expressed as:

$\sum R_{total\ UHW}$ = 2($\sum R_{UHW}$) = 2× 0.00189 =0.00378 $^{K}/_{W}$

Heat loss through the horizontal un-insulated wall,

$$q_{UHW} = \frac{T_1 + T_4}{\sum R_{total\ UHW}} = \frac{80-30}{0.00378} = \frac{50}{0.00378} = 13228\ \text{w}$$

Table 1: Result of thermal insulation effectiveness using saw dust material

Elements %	R-value($^{k}/_{w}$)		A(m^2)	Δ t^0(c)	Heat loss(w)
Vertical wall 1	5.184	0.1472	50	9.645	21
Vertical wall 2	5.184	0.1472	50	9.645	21
Horizontal wall 1	3.687	0.207	50	13.308	29
Horizontal wall 2	3.687	0.207	50	13.308	29
Total	17.74	0.7084		46.41	100

Table 2: Result of un-insulated Okra Dryer

Elements %	R-value($^{k}/_{w}$)		A(m^2)	Δ t^0(c)	Heat loss(w)
Vertical wall 1	0.0027	0.1472	50	9257	21
Vertical wall 2	0.0027	0.1472	50	9257	21
Horizontal wall 1	0.00189	0.207	50	13228	29
Horizontal wall 2	0.00189	0.207	50	13228	29
Total	0.00918	0.7084		44970	100

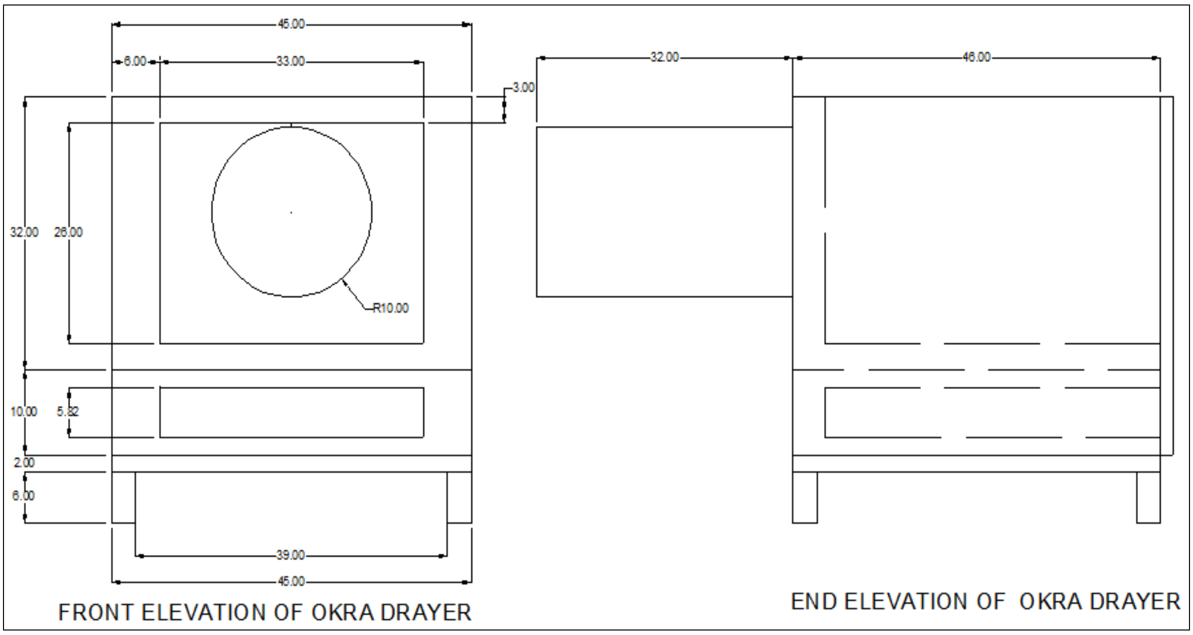

Fig 1

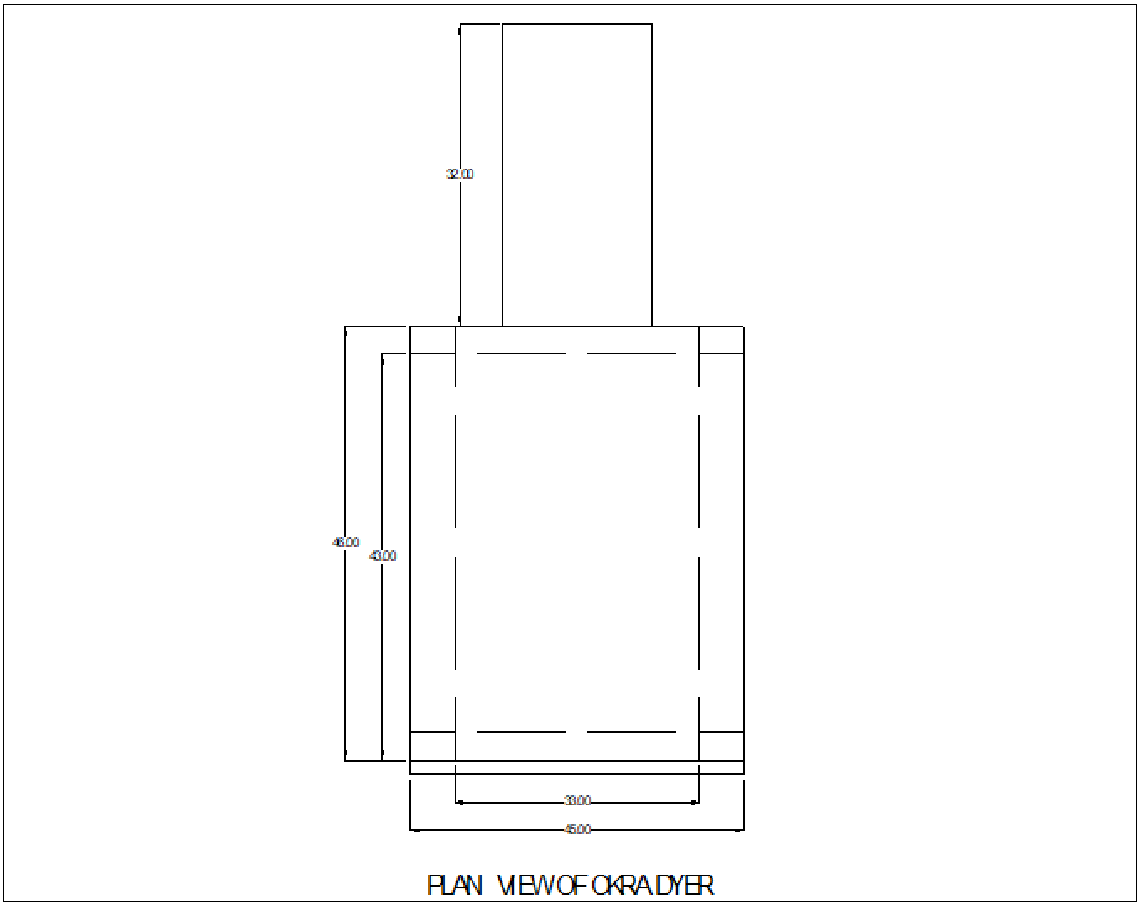

Fig 2

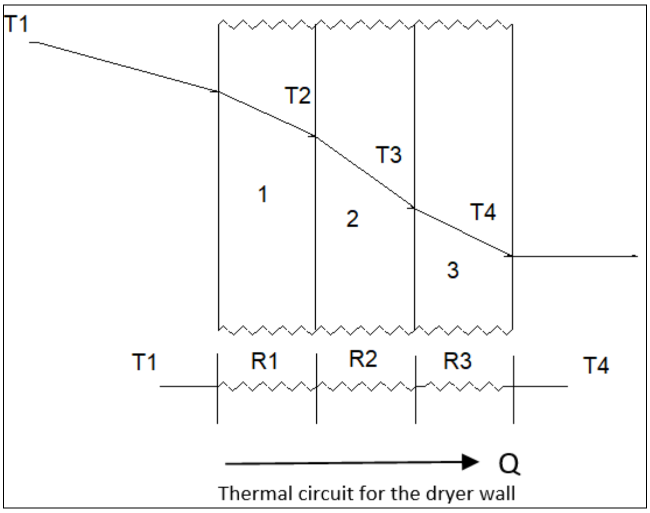

Fig 3

Result and Discussion

The result presented in table 1 above shows the values of R-Value and the heat loss calculated for the insulated okra dryer, while table 2 revealed the R-Value and the heat loss for the non-insulated okra dyer. From the result of the analysis, It was observed that the heat loss through the composite wall of insulated okra dryer is 46.41w.This shows that the saw dust material used as insulator has significantly reduces heat loss when compare to the result of heat loss 44,970w presented in table 2 for the similar non-insulated okra dryer. In this area study, therefore there is need to encourage the use of locally available insulation material to reduce heat loss in drying system.

Conclusion

In conclusion it seen that saw dust material has the capability of minimising heat loss in a locally fabricated okra dryer. This phenomenon showed that locally available material can be used as insulation material without importing them from United Kingdom. The okra dryer is a device that can create Job and also ease the process of preserving okra in urban and rural area.

References

1. Abano EE, Optimization of drying conditions for quality dried tomato slice using response surface metholog. Journal of food processing and preservation, 2014.
2. Ayugi G, Banda EJKB, Dujanga FM. Local thermal insulating materials for thermal storage.Rwanda Journal of Mathematical science, Engineering and T, series c, 2011, 23.
3. Chaudrasia PBL. Comparative study of insulating materials in solar water storage system.Division of energy management, Engineering and product, Central Arid Zone Research Institute India, 1991.
4. Egware HO, Unuareokpa OJ, Awheme O. Performance of a locally Fabricated Saw dust Fired oven for drying purposes. Journal of Applied Science, Environment and Management,2018:22:168-172.
5. Lai Mun, Abdulahi Salem, Basalem Maged. Study of Saw dust and expanded polystyrene as cavity filler material on the effect of thermal conductivity in perforated clay. Materials Science Forum, 2017, 890.
6. Phonphuak N, Chindaprasirt. Types of waste, properties, and durability of pre-forming waste-based fired masonry bricks. Efficient Masonry Bricks and Blocks, 2015, 103-127.
7. Raveendiran P. Heat and Mass Transfer Solved Problems, HMT University, 2008, 3.
8. Sprig RE. Home manufactured loose-fill insulation. Accessed on 13 april, 2020. www.http//lib.dr.iastate.edu