Designing of Domestic Grain Dryer

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***Abstract*— In this paper intent to develop the concept of the calculation using the domestic grain dryer. This is use to remove the moisture content from grain. The drying is achieved by allowing the heat toward the seed from heater. The results are expected to shows a good response in removing the initial moisture content from 14% to 8% from the grains without altering their nutrition values.**

***Keywords* — Design, Domestic Grain Dryer, Solar Power, Grain Drying, Agriculture Engineering.**

I. INTRODUCTION

Drying is the process of removing the moisture content from the grains of the crops after they have been harvested. Also we can say that, Drying is presses to maintain the quality of grain during storage to prevent the growth of bacteria and fungi and the development of insects and mites[3]. That's why the drying is most important after harvesting grains usually contain about 25 to 30% moisture content which is not ideal to store them. Because the safe moisture content for cereal grains is usually 12 to 14% on wet basis[6]. During the post-harvest procedure, an average of 10% of the crop is wasted.[7]

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II. LITERATURE REVIEW

Mohanaj P. Chandrasekar

From this paper we get to know that the The drier with heat storage material enables to take care of consistent air temperature inside the drier. The inclusion of warmth storage material also increases the drying time by about 4h per day. The chili was dried from initial moisture content 72.8% to the ultimate moisture content about 9.2% and 9.7% (wet basis) in the bottom and top trays respectively. They concluded that, forced convection solar drier is more suitable for producing high quality dried chilli for small holders. Thermal efficiency of the solar drier was estimated to be about 21% with specific moisture extraction rate of about0.87 kg/kW h [2]

Grain drying - Dr. Kenneth j. Hellevang:

This paper has helped us to understand about the amount of moisture content required in grain drying . It also helped us to understand about the moisture content required in order to store grain for both long term and short term period. For long term it should be around 9 months and for short period of time it should be around 6 month. [3]

Selecting Fans and Determining Airflow for Grain Drying and Storage: William F. Wilcke (University of Minnesota) and R. Vance Morey (University of Minnesota) - From this paper, we have studied different factors affecting while selection of fan and determining airflow for grain drying. This paper describe the airflow requirements for grains drying, airflow resistance offered by grain depending on grain depth and its estimation using u-tube manometer. It also gives information about what should be floors and duct arrangements and the air inlet and exhaust opening required for dryer. The part of types of fans and estimation of fan power requirement is also covered [5].

III .CALCULATION CONSIDERATION

Considering soya bean as a sample for this design,

1. Initial moisture content of soya beans = 14%
2. Initial temperature of air = 23 0c
3. Initial relative humidity of air = 81 %
4. Equilibrium moisture content at initial stage = 17.8 (From Figure 3.1) As the EMC is much more than the safe moisture content of soya bean.
5. From market survey, it has been observed that expected final moisture content is 8% .
6. So adding heat with rise of temperature = 10 0c
7. From psychrometeric chart on drawing the process of sensible heating. We can find out relative humidity of final state.
8. So final temperature of air = 330c
9. Final relative humidity of air = 45 %
10. Equilibrium moisture content at final stage = 7.8 (Approx.8)

Which matches the desired moisture content

IV. CALCULATION

The main factor or component to which has performed an important role in order to remove moisture form grain are:

1. Design of heater
2. Design of Fan
3. Insulation of drying chamber

Design of Heater :

Volume of grains per tray = 0.6×0.6×0.08 = 0.0288 m3
Total volume of grains = Number of trays × volume per tray = 3 × 0.0288 = 0.0864 m3
Total mass of soybean = bulk density × volume
= 55.7 kg (approx. 56 kg)

Estimation of excess amount of water:

Amount of water must be removed = initial weight- final weight = 3.65kg of water
Quantity of heat required to remove moisture content = m× Cp × ΔT
Power = 0.0848 KW = 84.8 W
Power = (sec) 0.1 = 152.643/t , Drying time = 1526.43 sec = 25.44 min (approx 26 min)

Design of Fan:

ma × Cpa × ΔT = 0.1 KW
Discharge obtained to cubic foot per min = 8.68×10-3 m3 = 17.65cfm (approx.18-20)
Velocity of air through grain: Air flow rate/Cabinet area (cfm/ft2)
Velocity = 17.65/4.687 = 3.765 cfm/ ft2
Total depth of grains = 3×0.2625 = 0.787 ft.
Static pressure loss due to resistance to air flow by grains = Total depth of grains × Static pressure per foot = 0.0787 inch of water.
Static pressure loss due to resistance to air flow by grains (h1) = 1.5×0.0787 = 0.118
hw = (ρa × h2) / ρw
h2 = 4.047×10-4 inches of water
Loss due to sudden enlargement = { (U1) 2 / 2g } × { 1- (A1 / A2)}
h3 = [1.8982/ (2×9.81)] × [1-(3.99×10-3/0.4356)] = 0.1819 m of air
hw = (ρa × h2) / ρw
h3=0.1819 ×1.146/1000
= 2.084×10-4 m of water.
h3 = 2.084 × 10^{-4} m of water
Total static pressure = h1+h2+h3
= 0.1186 inches of water (approx. - 0.12)
Fan horse power = (Air flow × total static pressure)/ (6320 × Fan efficiency)
Fan horse power = (18×0.12)/ (6320×0.75) = 4.5568×10-4 HP = **0.**34W
2. Required static pressure (in inch of water) = 0.12

Insulation of the drying chamber:

Quantity of heat per sec = 100 W (from previous calculations)
10% of the quantity of heat produced/ sec =10 W (3)
Quantity of heat lost per unit area = Ks× (T1-T2)/X1
= Kg× (T2-T3)/X2 (4)
=Km× (T3-T4)/X3
10 = {[45/0.003] × [306-T2]}
q = Km× (T3-T4)/X3
10 = 50× (T3-296)/0.003
10=0.03× (305.99-296.006)/X2
X2=0.0299 m=2.9 cm
Glass wool 3cm thick should be used as the insulating material to achieve a minimal heat loss of 10% from the drying chamber.

V. **DIAGRAM AND LABELLING:**

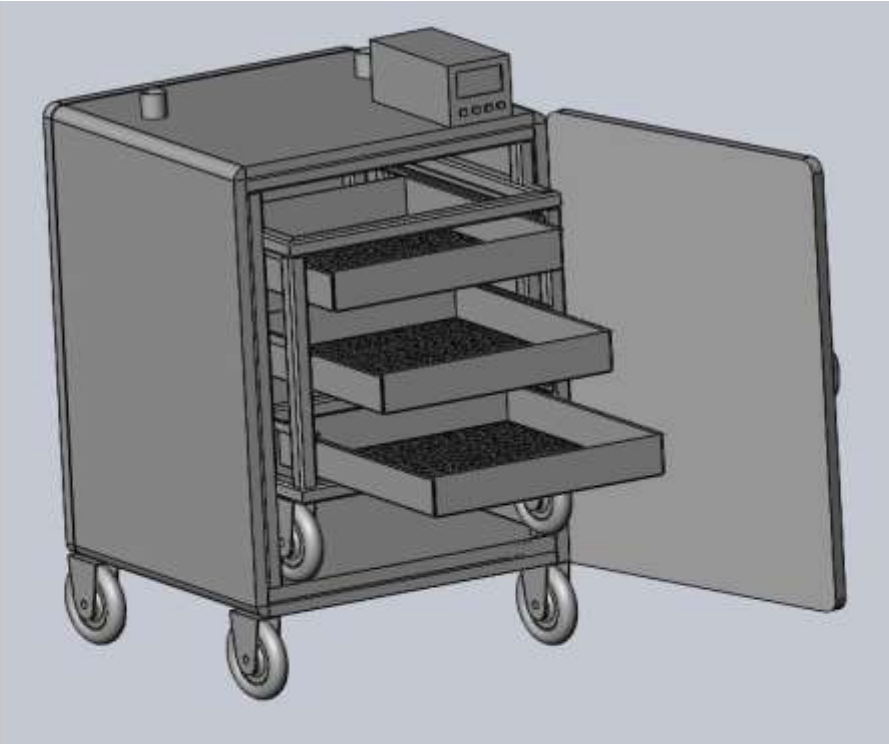

Figure 1: 3d View of Solar dryer

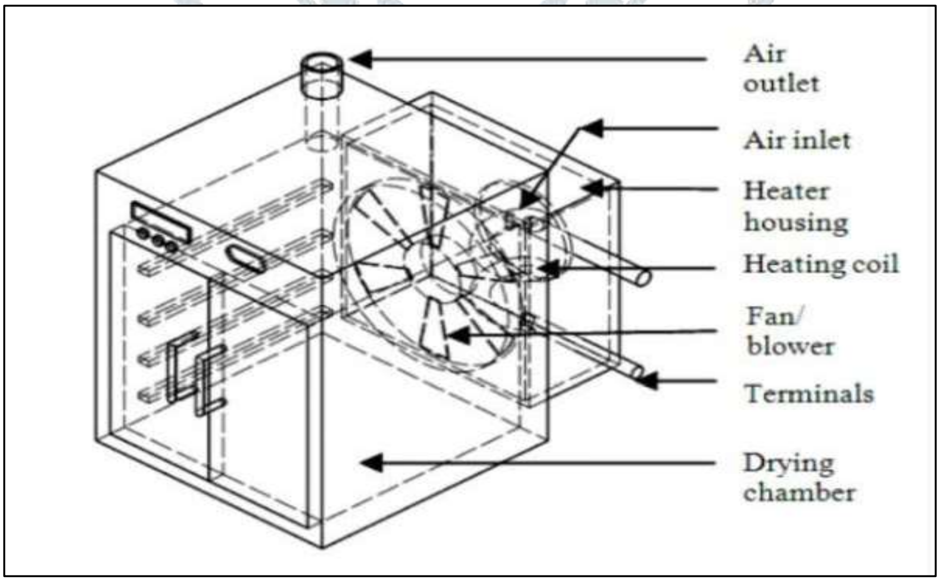

Figure 2: Wireframe model of Solar Dryer

VI.EXPECTED OUTCOME

1] It is expected to achieve the desired moisture content. In our consideration we have used soya bean as a sample. Desired moisture content level for soyabean is 8% so that grain will not be spoiled by excessive moisture content.

2] The dryer suppose to be maintaining desired relative humidity and air temperature. The required relative humidity and air temperature in this case is 33^0C and 45%.

3] The drying is expected to be uniform throughout all trays.

VII.Conclusion

1] The heater supplies the right quantity of heat and incorporates a fan which supplies the right quantity of air needed to distribute this heat evenly to all grains in the drying chamber.

2] The design of dryer has been done by considering it for small scale farming where the the amount of grain to be dried is not much .

REFERENCES:

1. Waewsak, J.; Chindaruksa, S.; and Punlek, C.A “mathematical modeling study of hot air drying for some agricultural products”. Thammasat Int. J. Sci. Technol. 11(1): 14-20. 2006
2. M. Mohanraj And P. Chandrasekar, “Performance Of A Forced Convection Solar Drier Integrated With Gravel As Heat Storage Material For Chili Drying”, Journal Of Engineering Science And Technology Vol. 4, No.3, \2009
3. Dr. Kenneth J. Hellevang, “Grain Drying” .Extension Agriculture Engineer, 2013.
4. K.D.Ganvir, “Design and Development of Grain Dryer” ,International Research Journal of Engineering and Technology (IRJET),Volume: 07 Issue: 03 | Mar 2020.
5. Wilcke, William F. and Morey, R. Vance, "Selecting Fans and Determining Airflow for Grain Drying and Storage”. Proceedings of the Integrated Crop Management Conference.18, 1993
6. Bala, B.K., “Drying and storage of Cereal Grains. Science Publishers Inc. New Hamsphire”, USA,1997
7. https://extension.uga.edu/publications/detail.html?number=B873&title=Grain%20and%20Soybean%20Drying%20on%20Georgia%20Farms.
8. Holman, J.P., “Heat transfer”. 9th Ed., McGraw Hill, NEW York,1998
9. Akinola, O.A.; Akinyemi, A.A.; and Bolaji, B.O. Evaluation of traditional and solar fish drying systems towards enhancing fish storage and preservation in Nigeria. J. Fish. Int., Pakistan 1(3-4): 44-9. 2006.
10. Wehrspann, J. May 1998,Sizing up graindryers cited by Penton Business Media, Inc. September, 2010