International Journal of Innovation and Scientific Research
ISSN 2351-8014 Vol. 4 No. 2 Jul. 2014, pp. 153-157

http://www.ijisr.issr-journals.org/

Design and Development of Fluidized Bed Dryer for Domestic Purposes

Hanoc George Varghese, Mohd Saad Ahamed, and Dr. M.Sreekanth

School of Mechanical and Building Sciences,
Vellore Institute of Technology University,
Chennai, Tamil Nadu, India

ABSTRACT: Efficient drying of cereals, pulses and pellets in rural India has always been hindered in rainy seasons and during cloudy days. This can lead to wastage of agricultural products during storage in both farms and individual homes. We present the method of designing a Fluidized Bed Dryer for drying purposes. This simple and efficient system based on the fluidization process has been designed in SolidWorks software. The design has been thermally analyzed using Ansys. Stress analysis and flow simulation has also been carried out using Ansys. Our studies showed that the design can withstand the working conditions and hence a compact working model of the design was fabricated. Further tests and experiments can be conducted on the fabricated model for other uses including polishing and smoothening of rough particles for industry. We conclude that the design can effectively be used in for drying purpose both at domestic and industrial scale.

KEYWORDS: Fluidization, Ansys, SolidWorks, Drying, Fabrication

1 INTRODUCTION

Fluidized bed technology has been used in industrial dryers for the drying of wet solid particles [1]. Industrial drying operations require a high rate of heat and mass transfer and a high rate of solid transport to or from the dryer. The main advantages of fluidized bed technology in drying application are large contact surface area between solids and gas, high thermal inertia of solids, good degree of solids mixing, and rapid transfer of heat and moisture between solids and gas that shortens drying time considerably without damaging heat sensitive materials. In addition, fluidized solid particles can be easily transported into and out of the dryer by gravity (much like a liquid) and transported elsewhere by pneumatic conveying with less mechanical equipment. Fluidized-bed drying has found many applications in chemical, metallurgical and pharmaceutical industries [1, 2].

In a country like India where grains like cereals are harvested seasonally and consumed continuously; need to be stored properly from insects, pests, mold, and fungus formation [3]. The situation can worsen during rainy seasons and high humid conditions. Cooling the grain by ambient air aeration (even in tropical climates) solar cooling' or refrigerated aeration offers many benefits including slowing insect population growth rates, reducing pesticide usage and preserving grain quality. Drying grams, such as paddy rice, to a moisture content of 14% is essential to prevent destructive mold growth and to maintain germination and milling qualities [4-9]

Heating grains to 55°C for 15 min is lethal to all stages of insect, fungus development; while at 65°C death is almost instantaneous [10]. Adequate management of insects and molds that attack and destroy harvested grain has always received less attention [11]. We present a model (design) for domestic heating of grains, cereals to prevent the mold and fungus formation in humid and wet conditions. Fluidized Bed technology has been used to achieve the same.

Corresponding Author: Hanoc George Varghese (hanocg.varghese@gmail.com)

2 DESIGN OF FLUIDIZED BED DRYER [FBD]

The design has been made keeping in mind various parameters including mobility, compactness, efficiency of heat transfer and volume. The model was made in SolidWorks 2012 software and has been analyzed in Ansys 14. The whole structure is supported by tripod stand. It consists of the following parts as shown in the figures,

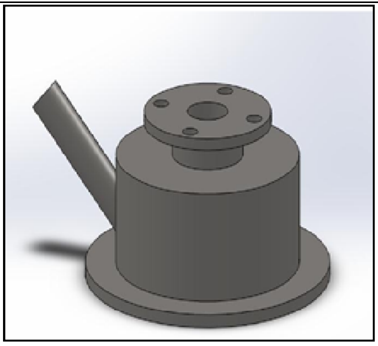	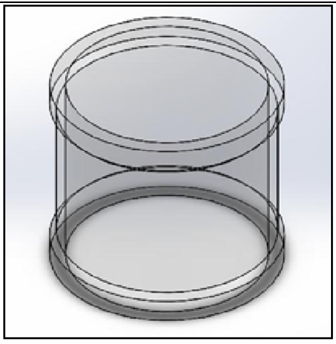	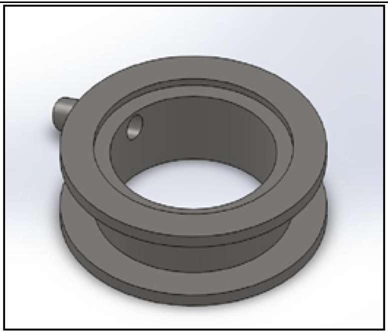
Fig. 1. Upper chamber (Pellet Inlet)	***Fig. 2. Borosilicate Glass chamber***	***Fig. 3. Middle Chamber***
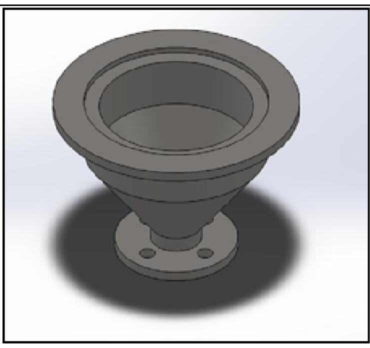	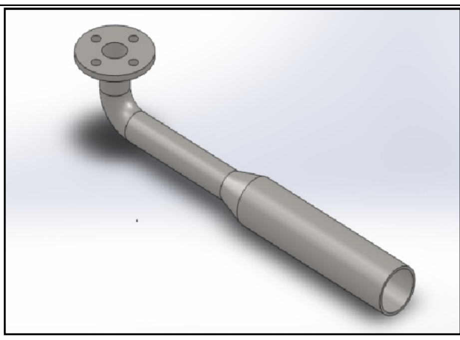	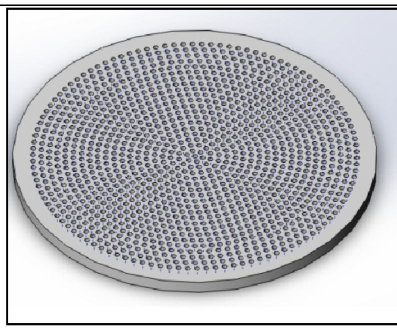
Fig. 4. Lower Plenum	***Fig. 5. Air inlet tube with flange***	***Fig. 6. Teflon Distributer Plate***

Other necessary parts include the Tubular Heater (Heat source), Asbestos and Rubber gaskets (to prevent the outflow of hot air to the atmosphere), Dimmer stat (to vary the current to the tubular heater), stainless steel mesh (to hold the sand pellet mixture), Valves (for inlet and outlet) and Air Blower (provide the inlet air).

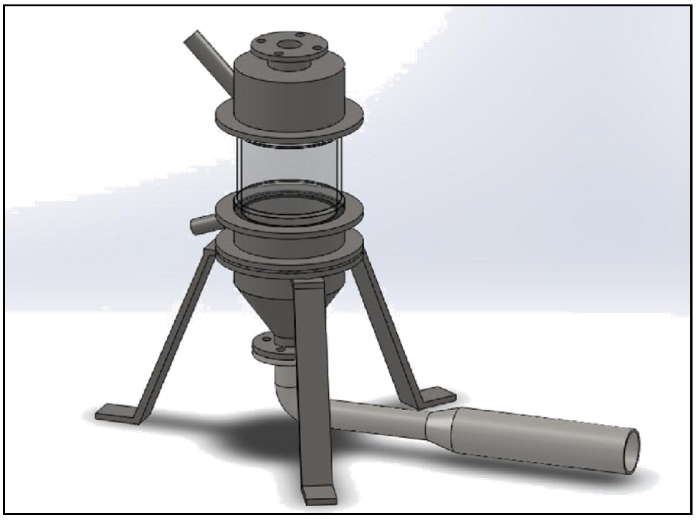

Fig. 7. Final model assembly.

3 OPERATION/WORKING

Cleansed and clear fine sand (0.05 mm to 1 mm) is used to produce the effect of fluidization. The pellets (like cereals, grains) are mixed along with the sand and are poured into the chamber through the pellet inlet. Tubular heater fixed inside the air inlet tube provides the required amount of heating (by varying the current) and the hot air is made to flow into the chamber with the help of an air blower. Hot air is then distributed evenly before entering the chamber by Teflon distributor plate. This evenly distributed hot air mixes with the mixture of sand and pellet to cause the fluidization. A suspended state of solid fluid mixture is formed and effectively dries the pellets. Sand has a high heat retaining capacity which augments the process of drying effectively. The pellet sand mixture is then removed from the outlet and can be separated out using a simple sieve.

4 ANALYSIS IN ANSYS

A temperature close to 383K (above boiling point of water) has to be reached to remove the moisture content and effectively aid the drying process. Temperature analysis with different flow velocity was done to find out the optimal flow velocity to reach close to 373K in the chamber.

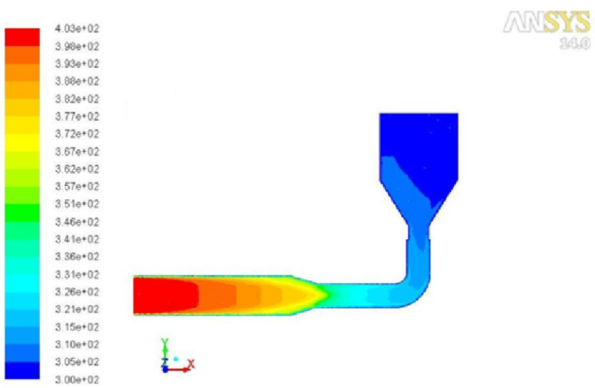

Figure 8: Temperature variation at velocity = 2 m/sec

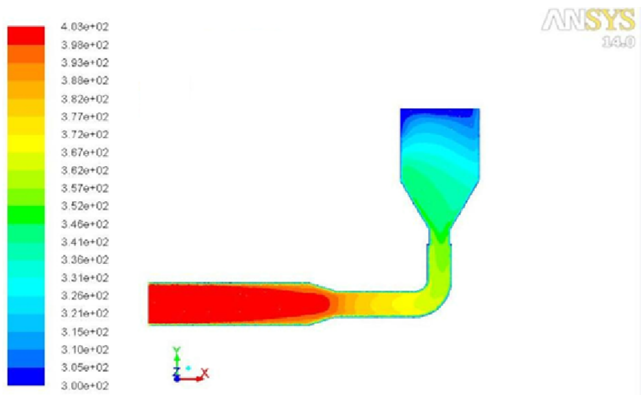

Figure 9: Temperature variation at velocity = 8 m/sec

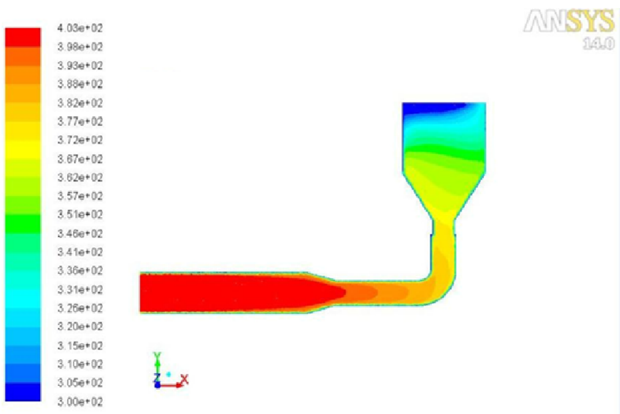

Figure 10: Temperature variation at velocity = 15 m/sec

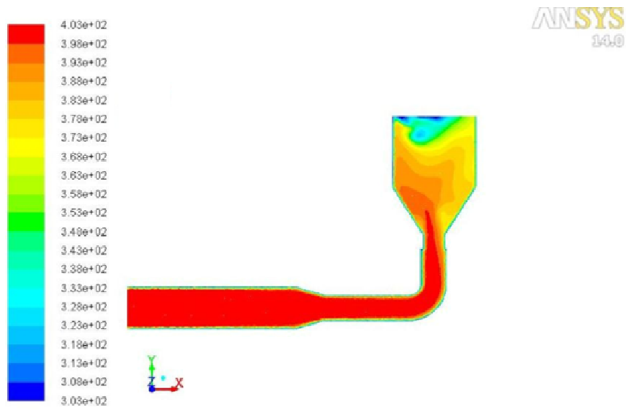

Figure 11: Temperature variation at velocity = 20 m/sec

We can see from Figure 8 that the heat is not effectively transferred from the inlet to the chamber region. Temperature of only 305K is reached as against 383K which is the target temperature. Keeping the current constant, the flow velocity is slowly increased to 8 m/sec, 15 m/sec, 20 m/sec and it can be observed that the target temperature of 388K. It can be concluded from the temperature analysis that a flow velocity of 20 m/sec is required to attain the target temperature of 388K for effective drying of pellets and remove the moisture content completely.

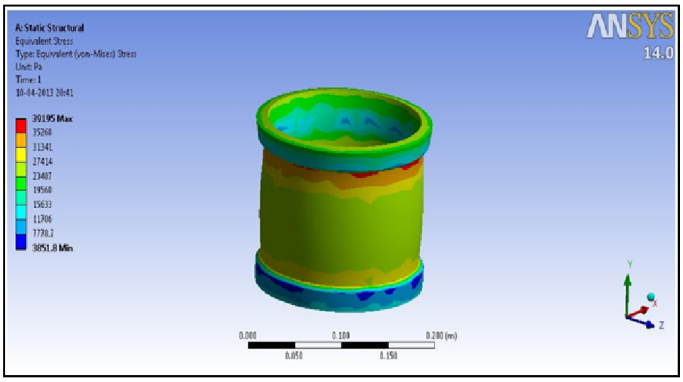

Figure 12: stresses induced in the glass structure

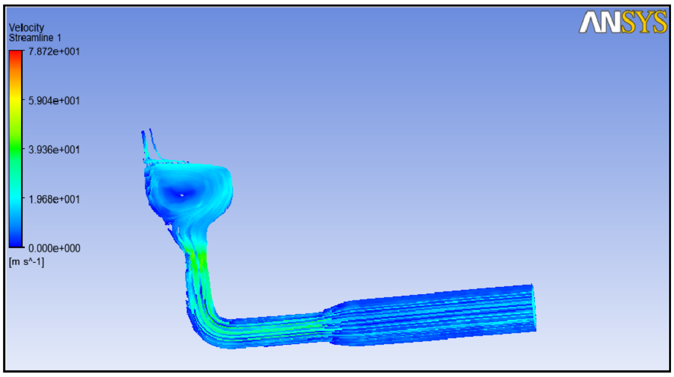

Figure 13: Flow happening in the Fluidised Bed Dryer

Force of 101.27N due to weight of the upper chamber acts on the glass structure and the stresses induced in it are shown in Figure 12. The maximum stress induced is 39 KPa on the borosilicate glass structure which is in the accepted limits and safe design criteria. It can be clearly seen from Figure 13 that flow is streamlined till the start of plenum from the air inlet and then it turns turbulent as the flow whirls in the plenum section due to mesh plate (acts as obstruction) to the flow with holes of diameter 2.5mm which allows only the air to pass through the mesh plate.

5 REMARKS AND CONCLUSION

The design satisfied the purpose of drying pellets effectively and an optimum temperature of 388K was reached at a flow velocity of 20 m/sec. The flow can be provided by either by an air blower or air compressor. The hardware model of the fluidised bed dryer was made for testing and analysing the effectiveness of drying and was found successful meeting the needs.

Figure 14: Hardware Model

The hardware model (Figure 14) is now been tested for its other uses including polishing and smoothening of particles for small scale industry usage. Further development to the design includes the attachment of sensors and control systems for exact measurement of various parameters of temperature, pressure and velocity which will help in conducting more tests and experiments.

REFERENCES

[1] Fluidized Bed Dryers — Recent Advances, Wan Ramli Wan Daud; Department of Chemical and Process Engineering, Faculty of Engineering, University Kebangsaan Malaysia, 43600 UKM Bangi, Malaysia.

[2] Heat and mass transfer during drying of a bed of shrinking particles – Simulation for carrot cubes dried in a spout-fluidized-bed drier; Ireneusz Bialobrzewski , Magdalena Zielinska, Arun S. Mujumdar; Department of Agri-Food Process Engineering, University of Warmia and Mazury, Heweliusza 14, 10-718 Olsztyn, Poland, Department of Mechanical Engineering and Engineering Science Program, National University of Singapore, Singapore.

[3] The Thermodynamic Performance of a Continuous-flow Fluidized Bed Grain Disinfestor and Drier;G. R. THORPE.

[4] Nour/Jantan, D. G. M.; Chek, T. I.; Rukunudin, I. H.; Ahdulla, R.; Sahim, S. Aerated bulk storage of padi in vertical concrete silos. Regional grains post-harvest workshop, Jakarta, 3-6 May 1983

[5] Thorpe, G. R. The aeration of wheat in the climate of North India. Bulletin of Grain Technology 1980. 18(l): 3-9

[6] Thorpe, G. R. A solar cooling system for bulk stored food grains. Agricultural Engineering Australia 1981, 10(l): 14-19

[7] Elder, W. B.; Ghaly, T. F.; Thorpe, G. R. Grain refrigeration trials in Australia. International Symposium on Practical Aspects of Controlled Atmosphere in Fumigation in Grain Storages. Perth, 1 l-15 April 1983

[8] Thorpe, G. R.; Elder, W. B. The use of mechanical refrigeration to improve the storage of pesticide treated grain. International Journal of Refrigeration 1980, 3: 99-106

[9] Ghaly, T. F. Refrigerated aeration trials of stored wheat: insect control and quality changes. Proceedings 26th Annual Conference, The Royal Australian Chemical Institute Cereal Chemistry Division, Broadbeach, Queensland, 1976.

[10] Stored Grain Losses Due to Insects and Molds and the Importance of Proper Grain Management; Phillip Harein, University of Minnesota, Richard Meronuck, University of Minnesota.