Experimental Optimization of Baffles Patterns Used in Prototype Model of Rotary Bagasse Dryer

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Abstract: Drying is one of the energy intensive events in most of the process industries, which consumes about 20 percentage of total energy consumption of the plant. In sugar industry the main byproduct and source of energy is bagasse. The bagasse produced after extraction of sugar cane juice from sugar cane, but bagasse comes out from mill section is having 45 to 52 percentage of moisture. This bagasse is directly feed to boiler furnace. Such high moisture contained bagasse is having low calorific value and creates many problems. In this paper, experiments were conducted on bench type rotary bagasse dryer model. The model was tested for different input parameters. The different baffles were used in rotary drum and most effective baffles were identified. In this study, it is concluded that tangential baffles are most effective and maximum reduction of moisture was achieved in this type of baffles. The rotary dryer can employ in sugar industry to dry the bagasse effectively. The introduction of rotary bagasse dryer in sugar industry leads to increase overall efficiency and productivity of sugar industry.

Index Terms - *Bagasse drying, Rotary bagasse dryer, Baffles patterns, Residence time, prototype model*

I. Introduction

1.1

Drying is one of the energy intensive event in most of the process industries, which consumes 10-20 percentage of total energy of the plant.[1,15] The bagasse produced after extraction of juice from sugar cane. The bagasse comes out from mill section is having 46 to 52 percentage of moisture [7, 10]. Drying of fibrous material like bagasse is process of removal of moisture from solid material. In most of cases, water moisture exists in the materials. The moisture present in bagasse of two forms, one is unbounded state or surface moisture which can be removed during falling period of drying [1, 2, 15]. The unbounded moisture is exist in bagasse due impinge of hot water during milling process to remove the sucrose from sugarcane and unbounded moisture naturally present in sugarcane [5]. Other form of moisture in bonded, which can removed during constant rate of drying. Bagasse is dried for ease handling, to preserve the bagasse for next season and to improve the calorific value of bagasse which simplifies the design of furnace. The quantity of bagasse requires can be reduced substantially [4, 8, 9, 14]. The bagasse is dried to bring its moisture content to a specific value before being feed to boiler furnace [6]. Rotary dryers are most commonly used in processing industries such as grain drying, cement industries and softwood drying than any other type of dryers [1, 11]. The rotary dryer can adapt to dry the bagasse, if they are correctly designed, fabricated then the high thermal efficiency can be obtained. The rotary dryer is consisting of long drum which is rotating with low speed on bearing supports. The rotary drum is incorporated with flights of different patterns. Previous researcher has studied different pattern's effects on drying rate and drying efficiency. The analysis of the effect of flights and their patterns were predicted by using Discrete Element Method (DEM) software. It was concluded that, flight shapes influences the discharging pattern of the material falling from the flight [13]. The nature of material curtain in drum's cross section is mainly depends on flight shape [16]. Tangential flights carries more material and large angular discharging range while carrying a quantity of material compared to a other flights.[13,16] The more complex flights are having higher hold up time and a larger angular discharge range. The rate of material discharge from tangential baffles is generally more than simple radial baffles. The height difference between the lifters and the bottom of the dryer in a cross-section is less as compare to radial flights.

1.2

In tangential flights, the falling length and the falling time of the particles will be increases up to a maximum value. This leads to increase the convective heat transfer, this increase the overall heat transfer co-efficient. On the other hand falling length and falling time are less in radial and angled hook shape flight. Proper selection of flights for specific applications of the dryer is need to be consider the material properties, amount of moisture present in material and cohesiveness and stickiness of material. It is good practice to use straight or single bend flights at the feed end. In the beginning the product is highly wet and sticky, hence straight flights are recommended. But double bend lifters may be adopted toward the discharge end. In this portion of dryer, the product is sufficiently dry and free flowing. This arrangement of flights in rotary drum dryer improves drying performance in many cases. This arrangement of dryer can be improve heat transfer and overall performance of the cascading dryer.

1.3

The heat transfer coefficient in direct heated rotary dryer is mainly depends on convection heat transfer from the hot gases to the wet surface of the product. The model of the rotary dryer developed for experimentation is having 5^0 inclined with horizontal surface, which promotes motion of particles in forward direction. The rotary drum accomplished with internal baffles in order to promote agitation of the solids. The bagasse enters at the high end of the dryer and hot air flowing parallel to the flow of bagasse. The experiments were carried out to find most feasible solution of bagasse rotary dryer. The important factors that influence dryer design and performances were checked. The drying is performed under different input conditions. The dryer is incorporated with different shape of baffles, which are made of mild steel and bolted inside the periphery of the drum and periodically along the drum. Baffles lift the bagasse material and cascade it into the hot air flow. The rotary dryer used in process industries are having complex shapes, but in our research work, for theoretical and experimental purposes, simple baffle shapes are used for case analysis. The baffles consist with one and two segments are used in our experiment. Several researchers studied about heat and mass transfer in rotary dryers. They emphasizes on behavior of the material bed, the material accumulated in the baffles, the material curtain patterns and the mean residence time [3, 5]. The experiment results show that the mean residence time is depends on the flight's shape. A rotary drum fitted with right-angled flights has a higher residence time than a drum fitted with radial flights and the hook shape or two segment 120^0 angle baffles. The right-angled flights (tangential baffles) are having effective discharge of bagasse across the rotating drum which improves the heat transfer co-efficient. This experimental study is conducted to investigate the influence of the baffles shape on the residence time. The baffles profiles selected are without baffles, radial baffles, right angle baffles and two segment hook shaped baffles or 120^0 angle baffles.

II. EXPERIMENTAL SETUP

2.1

The bench model of rotary bagasse dryer was design and developed in local industries. The experiments were conducted in Shree Datta Shetkari Sahkari Sugar Industry Dattnagar, Tal.-shirol, Dist-Kolhapur, India. The fresh bagasse from mill was collected and trials conducted for different input parameters.

2.2

The complete experimental setup is shown in fig. no (1). The experimental set up is consists of two blowers driven by a motor of 1 hp capacity each. The inlet valve is provided in between blower and heater which control the inlet air flow. The heater is fabricated in circular cross section and accommodated with three electrical coils each coil is having a capacity of 2 KW. The bagasse is feed from the hopper at upper end of the rotary drum. The hot air from heater enters in the rotary drum. The hot air and bagasse moves simultaneously in the drum. The rate of flow of bagasse is

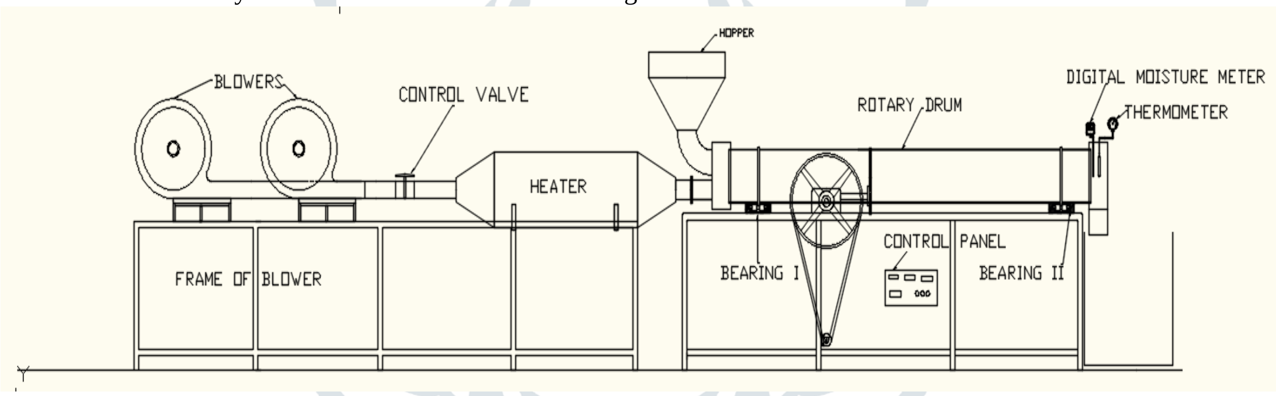

Fig. No. (1) Schematic diagram of Experimental set-up of rotary bagasse dryer.

controlled by inlet valve of bagasse, which is located below the hopper. The inlet temperature is controlled by on-off temperature controller. The velocity of hot air is measured with the help of digital anemometer. The outlet temperature is measured with pressure thermometer. The inlet and outlet moisture is measured by using digital moisture meter. The inlet and outlet humidity is measured with help of sling psycho-meter. The bagasse is feed with uniform rate through hopper. The speed of rotary drum is measured by counting the number of revolutions per minute by using stop watch.

2.3

During experiment, steady state condition was achieved; all the parameters such as inlet and outlet hot air temperatures, velocity of hot air, bagasse flow rate, inlet air humidity, outlet air humidity, speed of drum, moisture present in bagasse at inlet and outlet, inlet bagasse temperature and outlet bagasse temperature were measured.

2.4

Rotary bagasse dryer was performed under different input conditions. The inlet temperature was varied from 100^0C to 170^0C and all other parameters were measured at different inlet temperatures. In this model, experiments were conducted with three types of baffles and without baffles. The Fig.(2) shows that different patterns of baffles were used in the drum. In case of without baffles rotary drum, the movement of bagasse was caused by drag force of hot air and gravitational force. The bone drying zone is negligible and the heat transfer takes place only by conduction from drum surface to bagasse. It observed that the moisture reduction rate was comparatively less in rotary drum without baffles. The Fig.(2a) shows radial baffles, in which bagasse is lifted and suspended from different heights of drum. The curtain developed across the rotary drum is observed as shown in Fig.(3). The curtain is partially developed. The discharge of material takes place up to half of the cross section of drum. The total convective heat transfer is of moderate amount. The tangential baffles are as shown in Fig. (2c), the distribution of bagasse material across the rotary drum is more uniformed in tangential baffles (rectangular baffles). The tangential baffles develops good curtain of bagasse as shown in Fig. No.(5), therefore the bone drying time will be more and the total heat transfer co-efficient has been improved. The hook type baffles (120^0 angled baffles) are shown in Fig.(2b) They are having moderate holdup capacity and distributes the bagasse less evenly across the drum. The partial curtain of bagasse is developed in using 120^0 angled hook type baffles and shown in Fig. No. (4).

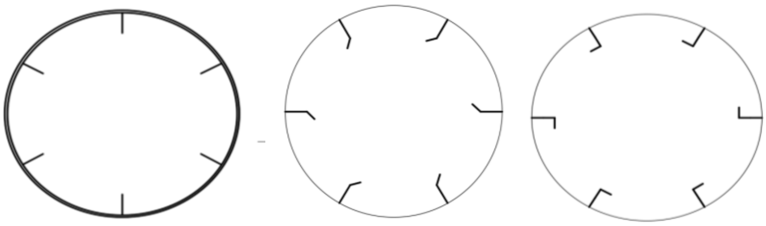

Fig.(2) a)Radial baffles (Straight baffles). B)hook type baffles(120^0 angled baffles) .c)Tangential baffles (rectangular baffles)

Fig. no. (3) Curtain developed in Radial baffles

Fig. no. (4) Curtain developed in hook shape 120^0 angled baffles

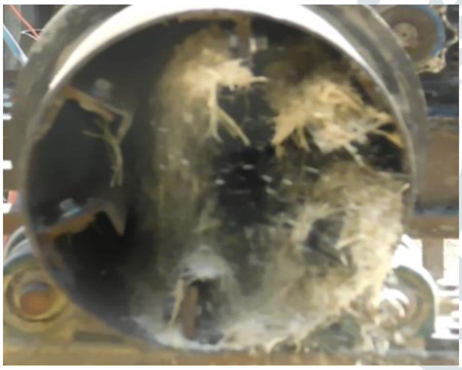

Fig. no. (5) Curtain developed in Tangential baffles.

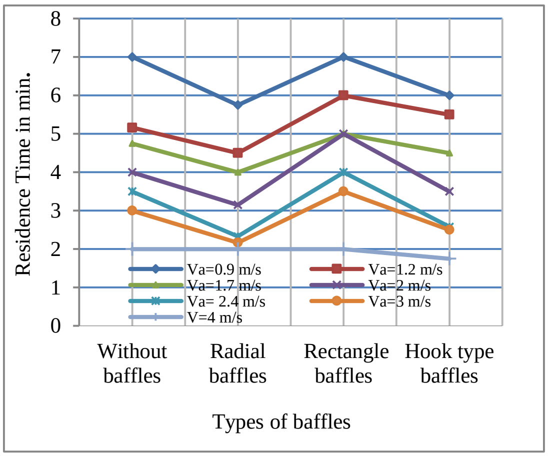

Fig. no.6 Residence time vs. types of baffles. When speed of drum=5rpm, $T_i = 140^0c$

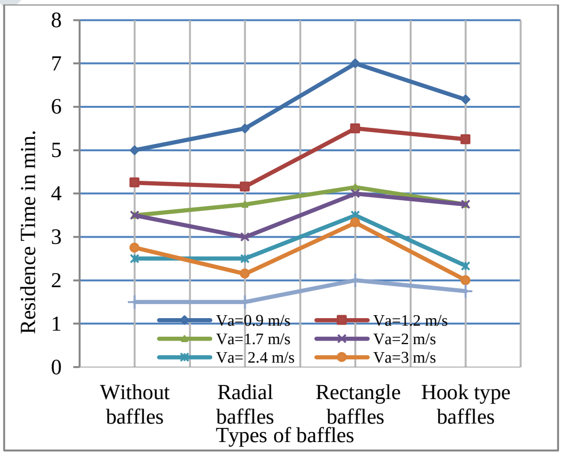

Fig. no. 7 Residence time vs. types of baffles. When speed of drum=7.5rpm, $T_i = 140^0c$

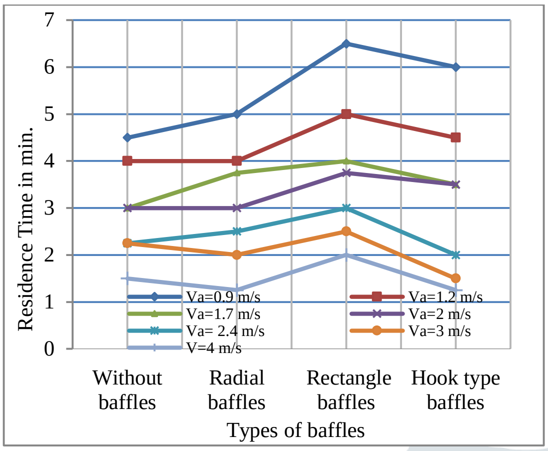

Fig. no.8. Residence time vs types of baffles.
When speed of drum=10 rpm, Ti =140^{0}c

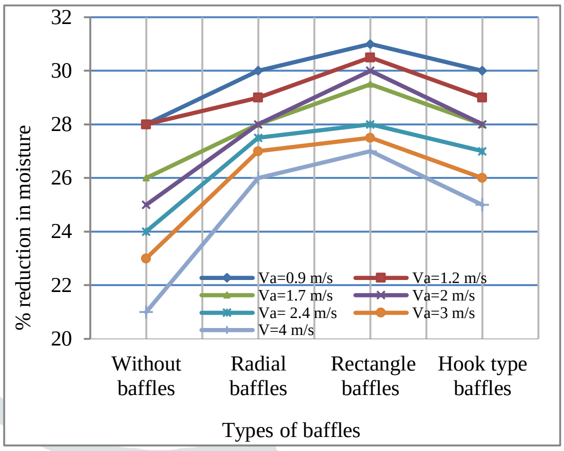

Fig.no. 9 % moisture reduction vs types of baffles.
When speed of drum=5 rpm, Ti =140^{0}c

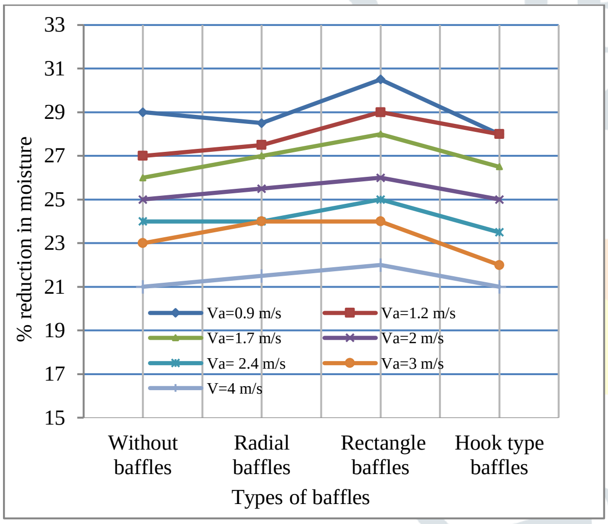

Fig. no. 10 % moisture reduction vs. types of baffles.
When speed of drum=7.5 rpm, Ti =140^{0}c

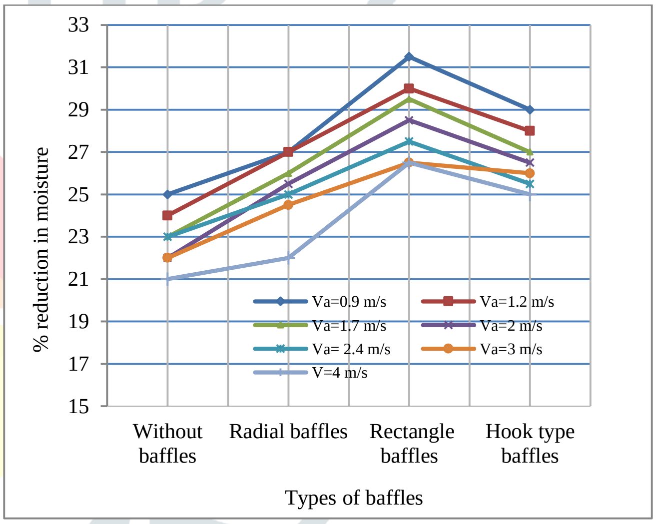

Fig.11 no. % moisture reduction vs. types of baffles.
When speed of drum=10 rpm, Ti =140^{0}c

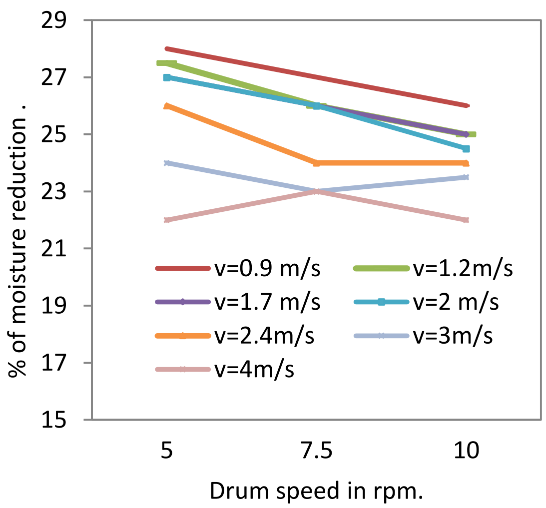

Fig. no. 12. % moisture reduction vs. Drum speed,
When T_i =130^{0}c and without baffles

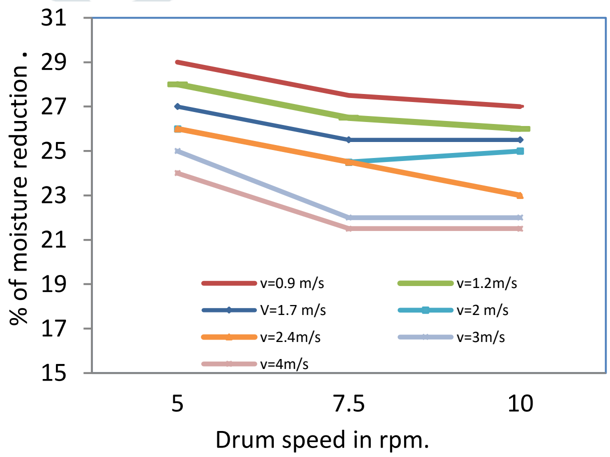

Fig. no. 13. % moisture reduction vs. Drum speed,
When T_i =130^{0}c and radial baffles

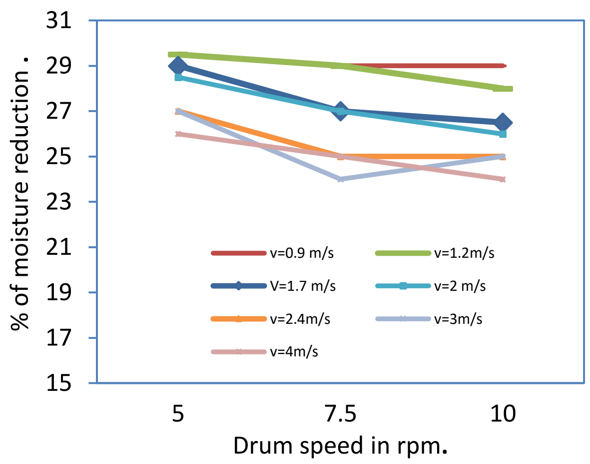

Fig. no.14. % moisture reduction vs. Drum speed, When T_i =130^{0}c and Tangential baffles.

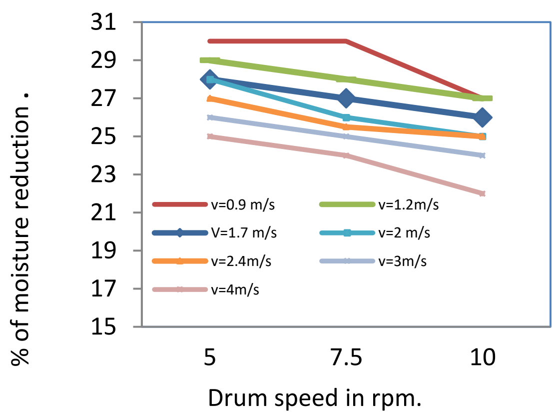

Fig. 15. no. % moisture reduction vs. Drum speed, When T_i =130^{0}c and 120^0 Angled baffles.

III. RESULT AND DISCUSSION

3.1

The results obtained from bench model are good enough to dry the bagasse; same can be employing effectively to dry the bagasse, which is used as fuel in boiler of sugar industry.

3.2

The moisture reduction is varies from 20 to 32 percentage for different parameters and different shapes of baffles.

3.3

The graphs plotted in Fig.no.6 to Fig.no.8 indicates that rotary dryer incorporate with rectangular baffles having more residential time as compare to radial and hook type baffles.

3.4

The graphs plotted in Fig.no.9 to Fig.no.11 reveal that, the rectangular baffles are more effectively removes the moisture. This type of baffles, the bagasse carrying capacity is more and it develops the uniform curtain in hot air stream. This leads to increase the bone dry zone, eventually convective heat transfer is observed more as compare to other type of baffles.

3.5

Experiments were conducted on bench model of rotary bagasse dryer at different speeds. The graphs from Fig.no.12 to Fig.no.15 shows that the more moisture reduction rate can achieved at lower speed of rotary drum.

3.6

The bagasse distribution across the rotary drum is more evenly occurs with rectangular baffles.

IV. CONCLUSION

The rotary dryer usually use to dry granular materials like soybean seed, cotton seeds, fertilizer, and in many process industries, but same can employ effectively to dry the sugar cane bagasse.

The sticky and cohesive materials are difficult to dry in rotary dryer. But in spite of sticky and cohesive nature bagasse can be dry effectively in the rotary dryer by proper design and fabrication of dryer.

The bench model developed in local industry was used to dry the bagasse. The results obtained from this model are good enough to dry the bagasse effectively. The percentage of reduction of moisture was varies from 20 to 30 at different input parameter.

REFERENCES

[1] Arun S. Mujumdar "Handbook of Industrial Drying."Fourth Edition; 2015.
[2] Ademiluyi F. T "Development of Software for Design and Construction of Rotary Dryer for Drying Ground Cassava" International Journal of Engineering and Technology Volume 6 No.8, August, 2016. PP-260-270.
[3] M. H. Lisboa, D. S. Vitorino, W. B. Delaiba, J. R. D. Finzer and M. A. S. Barrozo." A study of particle motion in rotary dryer." Brazilian Journal of Chemical Engineering. Vol. 24, No. 03, July - September, 2007, pp. 365–374.
[4] Piyali Das, Anuradda Ganesh, Pramod Wangikar "Influence of pre-treatment for deashing of sugarcane bagasse on pyrolysis products," Energy Systems Engineering, Department of Chemical Engineering, Indian Institute of Technology, Powai, Mumbai 400076, India. pp-445-457.
[5] E. Gil, L.A. Bujedo and L. Gorostiaga "Comprehensive utilization of energy in sugar factory using renewable energy sources, maximizing the power cogeneration." International Conference on Renewable Energies and Power Quality, (ICREPQ 11) Las Palmas de Gran Canaria (Spain), 13th to 15th April, 2011, pp-1-5
[6] Assefa Alena and Omprakash Sahu "Cogenerations of energy from sugar factory bagasse." American Journal of Energy Engineering, 2013; 1(2): pp-22-29.

[7] L.Praveen Raj and B. Stalin.“Optimized Design of a Bagasse Dryer System for Sugar Industry.”Bonfring International Journal of Industrial Engineering and Management Science, Vol. 6, No. 4, October 2016. pp-115-119.

[8] Leticia Fernandes de Oliveira, Jefferson Luiz Gomes Correa, Poliana Gaspar Tosato,Soraia Vilela Borges, Jose Guilherme L. F. Alves, and Bruno Elyezer Fonseca. “Sugarcane Bagasse Drying in a Cyclone: Influence of Device Geometry and Operational Parameters.” Drying Technology, 2011, vol. 29: pp-946–952.

[9] Juan H. Sosa-Arnao, Jefferson L. G. Correa, Maria A. Silva and Silvia A. Nebra. “Sugar cane bagasse drying - a review.” International Sugar Journal., July 2006, PP-1-6

[10] Sankalp Shrivastav and Ibrahim Hussain “Design of Bagasse Dryer to Recover Energy of Water Tube Boiler in a Sugar Factory.” International Journal of Science and Research (IJSR). Volume 2, Issue 8, August 2013. PP-356-358.

[11] Nadia Cairo, Gianpiero Colangelo and Giuseppe Starace. “Performance analysis of two industrial dryers (cross flow and rotary) for ligno-cellulosic biomass desiccation.” International Conference on Renewable Energies and Power Quality (ICREPQ-12) Santiago de Compostela (Spain), 28th to 30th March, 2012. PP-274-280.

[12] T. J. Afolabi , S. E. Agarry. “Mathematical Modelling and Simulation of the Mass and Heat Transfer of Batch Convective Air Drying of Tropical Fruits.” Chemical and Process Engineering Research. Vol.23, 2014. PP-9-18.

[13] Pruthviraj Savalagi and H.C.Chittappa. “Flight design for rotary bagasse dryer. “International Research Journal of Engineering and Technology (IRJET).” Vol. 04 Issue. 08. Aug -2017. PP-920-925.

[14] Ramesh A Soraganvi , Dr M. C. Navindgi and Shri. G. Suryaprakash Rao., “Technical Report to Increase the Boiler Efficiency by Installing Bagasse Drier in Bagasse Based Cogen Power Plant.” International Journal for Scientific Research & Development. Vol. 4, Issue 04, 2016. PP-1379-1382.

[15] Ian C. Kemp. “Fundamentals of Energy Analysis of Dryers.” Modern Drying Technology Volume 4: Energy Savings, First Edition. Edited by Evangelos Tsotsas and Arun S. Mujumdar. 2012. PP-1-45

[16] Richard G. Sherritt and Rod Caple, Leo A. Behie and Anil K. Mehrotra. “The Movement of Solids through Lighted Rotating Drums. Part I: Model Formulation.” The Canadian Journal of Chemical Engineering, Vol.-71. June, 1993. PP-337-346.