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DESIGN AND DEVELOPMENT OF HUMIDIFICATION CHAMBER FOR SOAKING OF PADDY

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Abstract: Parboiling of paddy is a very old technique and practiced in many parts of the world. It involves soaking, steaming and drying. Here, in this study we concentrated on soaking of paddy, soaking of paddy requires several liters of water and after the soaking process was finished the resulting water was full of phenolic compounds and rich in COD and BOD levels, due to this the surrounding areas of the rice mills gets polluted and it is also a severe environmental concern. So in this study we made an attempt to reduce the usage of water compared to conventional techniques and also to prevent the effluent by developing a humidification chamber.
Keywords: Parboiling, Effluent and Humidification.

INTRODUCTION

There are several studies carried on parboiling of paddy using different equipments. Rice mills processing paddy after parboiling will discharge large quantities soak water as an effluent and this effluent is an environmental concern (N. Ramalingam & S. Anthoni Raj; 1996). Paddy soaked for 2-3 days in conventional rice mills which follow the traditional cold-soaking and double steaming methods. There are development of off-flavours during soaking of paddy due to fermentative changes and the water discharged in land and sewers is a public health nuisance(Charlton, 1923).


Figure 1: Soaking of paddy   Figure 2: Contamination due to effluent

The total aerobic bacteria, staphylococci, lactic acid bacteria and yeast in soak water were in smaller numbers in household, double steaming, hot soaking and pressure-parboiling waters

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than in soak water of traditional cold-soaking, this is due to prolonged soaking of paddy for higher periods (Naga-mani,1986). The soak water also contains sugars, amino acids, phenolic compounds and the level of these compounds varied with the type of method (Anthoni Raj & Singaravadivael, 1986). There are higher levels of reducing sugars, total sugars and also higher amount of organic carbon in the soak water coming from the hot soaking process.

The continuous discharge of soak water in and around rice mills will not only make the sickness of soil but also affects the growth of natural flora. And it was also stated that the amount of phenolic compounds present in soak water are very high than the prescribed standards (ISI, 1981). The modern ricemills adopting hot soaking method discharge large quantities of soak water in to the environment having high COD values.

As there are lot of environmental affects due to the effluent produced during soaking of paddy, a study was under taken at IICPT, Thanjavur to eradicate effluent in soaking process by designing and developing a new technique for soaking of paddy which produce zero effluent. The ultimate aim of this study is to overcome all the above mentioned factors and to come up with a good solution to modern parboiling rice mills.

Rice mills process several tonnes of paddy per day. For parboiling they require large quantities of water and more than half of this water becoming as effluent. According to polllutin control board the effluents coming from the industries must be treated and it incurs additional cost. It must not be discharged into rivers and ponds as it was contaminated. There will be lot of insects and pests due to stagnet water in the surrounding of rice mills (N. Ramalingam & S. Anthoniraj, 1995). So this study elimates the soak water by using humid air for under going the soaking process in parboiling.

MATERIALS AND METHODS

Design of humidification chamber: There was an thin layer dryer at IICPT, Thanjavur, the heating section of the dryer was replaced with humidification chamber. The humidification chamber was designed and fabricated at IICPT workshop.

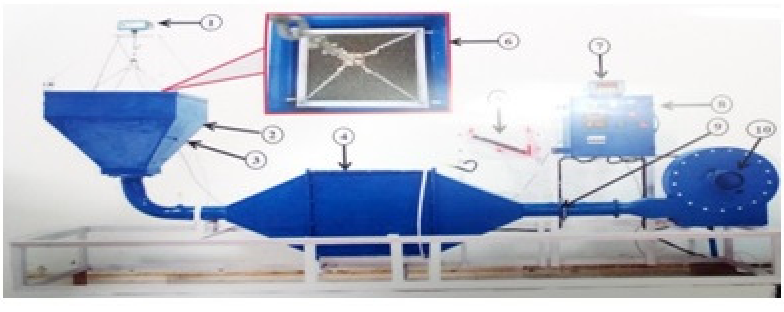


Figure 3: Existing thin layer dryer at IICPT

The heating section in the dryer was replaced by humidification chamber. The designs of the dryer were given below.

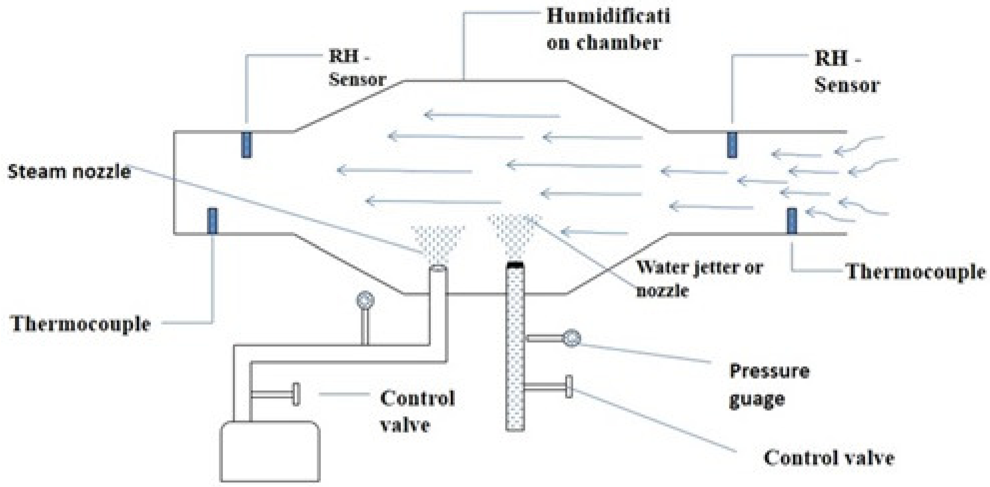


Figure 4: Design of humidification chamber

Description of the equipment: There was a blower provided to suck the ambient air through the suction valve and the air is passed over the heating section, such that the becomes heated. The heated air is passed through the water jet coming from the nozzle such that the hot air and water particles mixes, where it becomes as humidified air. The humidified air is passed on to the sample kept in sample tray and finally studied for moisture absorption kinetics or soaking. The different paramaters like temperature, relative humidity, velocity of air, water flow rate and pressure were measured and monitered.

Auto Cad design of chamber

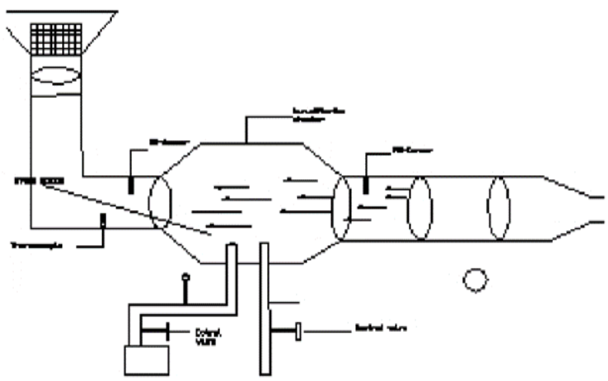


Figure 5: Auto Cad design of the chamber

Diffrerent components of humidification chamber

Blower and suction valve: The required air with required velocities was provided by the blower. The air at different velocities was obtained by adjusting the suction valve. The blower used was a centrifugal blower with 900 cfm capacity with 2HP continuous rated 3-phase motor was fixed as the requirements.

Heating section: The heating section was one of the most important component of the humidification chamber, the air coming from the blower was passed through the heaters where it gets heated. Here we used six heater coils each having a power 0.5KW. The length of the coil was 45cm and width was 5cm. The maximum temperatute of the heating section generated by heating coils was 76°C. The design of the heating section as follows.

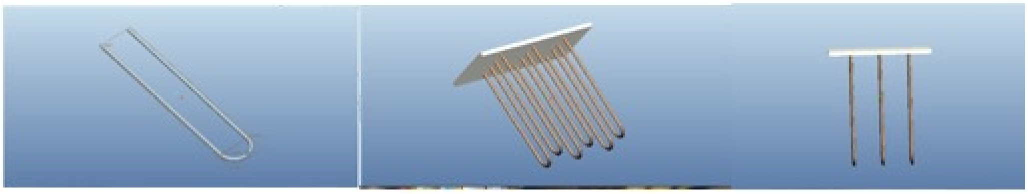


Figure 6: Different sectional views of the heating section developed in Pro e

Nozzle: The purpose of nozzle here was to pass water as a mist, such that the particles of the water thoroughly mixes with the air coming from the heater to give humidified air.

Flow meter: The flow of water through the nozzle was controlled by using a flow meter. The flow meter delivers water at a rate of 1 L/hr to 10 L/hr, water can be delivered at desired flow rates by the rotation of valve.

Figure 7: Nozzle

Figure 8: Flow meter

Sample tray: The sample tray consists of a perforated sheet on which paddy is scattered in a thin layer. The humid air passes through the perforations and the paddy is studied for moisture absorption or soaking. The humidified air which was coming through the pipe flows as single stream line. For spreading this humid air uniformly the bottom of the conical section was attached with three perforated sheets such that the air after passing the perforated sheets will become uniform before it reaches to sample.

Different measuring systems involved in the study

Temperature measurement: The temperature of the ambient air, the temperature of the heated air and the temperature of the humidified air i.e, mixture of hot air and water were measured using ‘K’ type thermocouples(-200°C to +1260°C) connected to data logger (Model DT80).

Air flow rate measurement: There was an circular orifice plate of 3mm thickness. The orifice was tightly held between two flanges and D-D/2 pressure tapping system was followed for measuring the pressure difference. The entire set up was intalled between blower and heating section.

U- tube manometer: The manometer was filled with methyl bromide having specific gravity of 0.826. The pressure was read as mm of water guage pressure.

Velocity of air through orifice: The pressure difference is measured by using u- tube manometer. The velocity of air through the orifice was calculated using the following formula (Geankoplis, 1993)

$$V_0 = \frac{C_0}{\sqrt{1-\left(D_0/D_1\right)^4}}\sqrt{\frac{2(P_1-P_2)}{\rho}}$$

V_0= velocity of air through the orifice(m/s), C_0= dimensionless orifice coefficient
D_0= diameter of the orifice(cm), D_1= innner diameter of the pipe, P_1-P_2= pressure difference, ρ= density of air(kg/m^3).

Hot wire anemometer: The velocity of the air was also measured using hot wire anemometer of AM-4204 model. There is a super large LCD display which will display the velocity of air in m/s, km/h, ft/min, knots, mile/h. In this study the velocity was measured in m/s. There are two sensors one is for velocity and the other is for measuring temperature. Tiny glass bead thermistor sensor for velocity and precision thermistor sensor for measuring temperature. The range of velocity is 0.2m/s to 20m/s and the maximum temperature upto which we can use the anemometer was 50°C.

Figure: 9 Hot wire anemometer Figure: 10 Measuring Probe

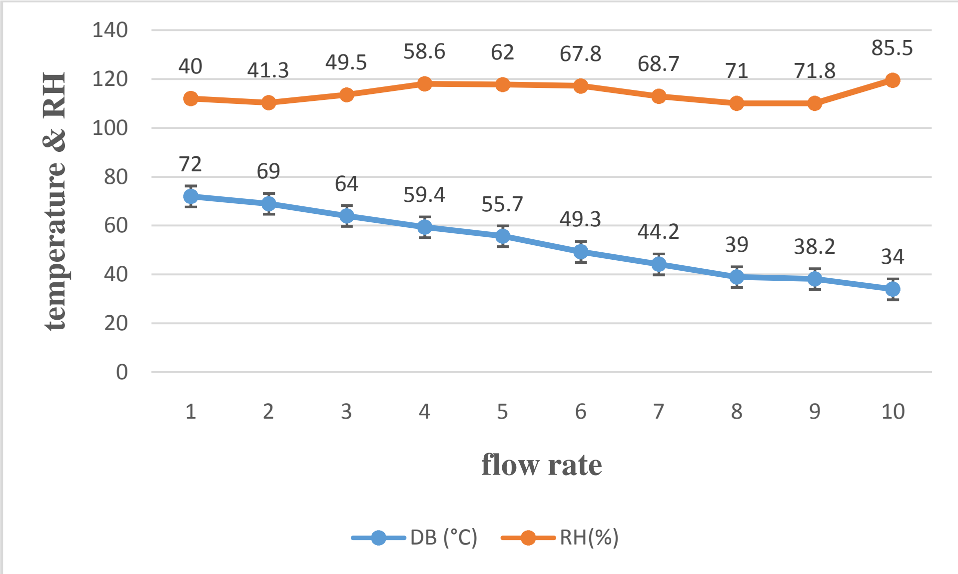
Dry bulb and wet bulb temperature measurement: Dry bulb temperature is the temperature of the air which was measured using a thermometer. Wet bulb temperature is the temperature measured by keeping a piece of wet cloth to the thermometer (K M SAHAY & K K SINGH). Here, in this study the dry bulb temperature of the mixture (air & water) was measured using a thermometer and the wet bulb temperatutre was measured by keeping wet cotton to the thermometer.

Humidity and RH measurement: Psychrometric chart gives different properties of moist air like wet bulb, dry bulb, dew point, humidity, relative humidity, specific volume and enthalpy. If any of the two properties of the air were known then the remaining properties can be located on the chart (K M SAHAY & K K SINGH). Here we know the dry bulb and wet temperatures of the moist air, by using these two properties, the humidity and RH were determined by using psychrometric chart.

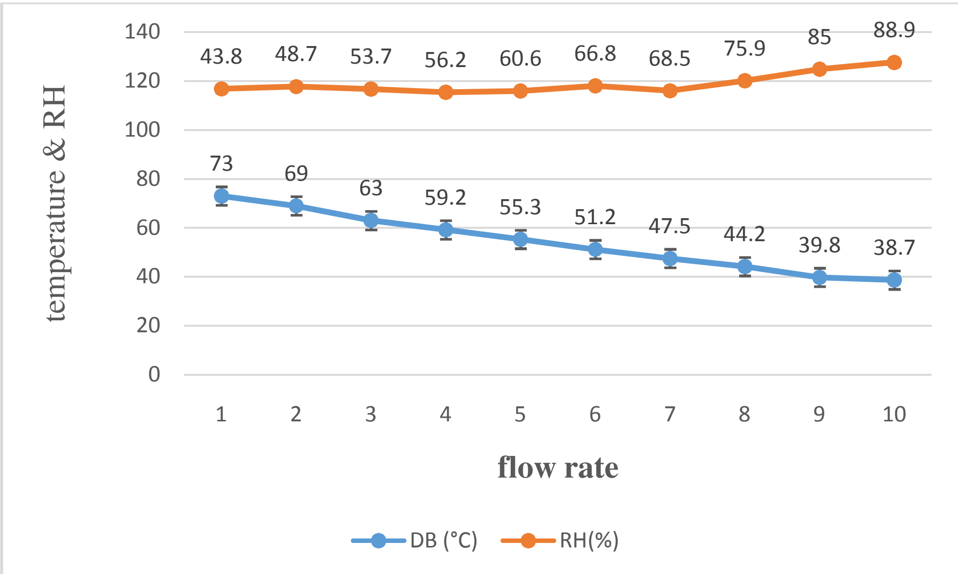
RESULTS AND DISCUSSIONS

The design and development of the humidification chamber had successfully completed and the chamber is evaluated for maximum relative humidity under different velocities(velocity of air) and flow rates (water flow rate). The velocity of the air was changed according to the position of the suction valve. The suction valve was kept at four different positions(1/4th, 1/2nd, 3/4th and fully opened inorder to have four different velocities(2.8m/s, 3.50m/s, 4.6m/s and 6.4m/s).

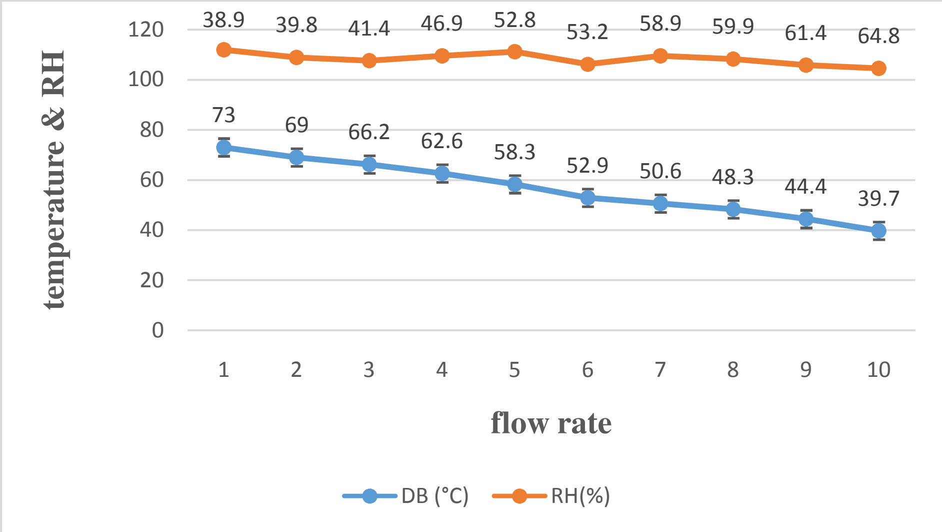
Valve position at fully opened, velocity 6.40m/s and flow rate 1 to 10L/hr: The plot between flow rate, temperature and RH is shown as follows, as the water flow rate from the nozzle increases at rate of 1 liter per hour to 10 liters per hour the dry bulb temperature of the mixture goes on decreasing from 72°C to 34°C and it was also observed that the relative humidity of the humidified air (air and water mixture) goes on increasing with the increase in flow rate. The maximum relative humidity observed 85.5% at maximum flow rate of 10 liters per hour. The position of the valve at the its maximum gives an air velocity of 6.40m/s(max. air velocity attained during the study)



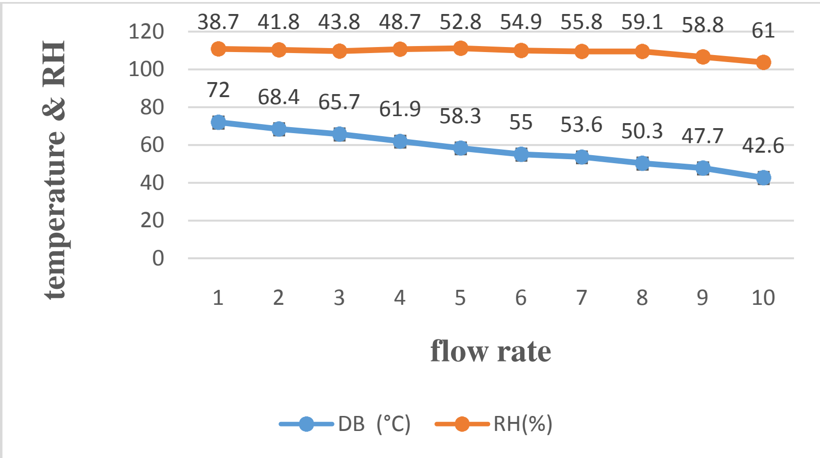
Valve position at 3/4th, velocity 4.60m/s and flow rate 1 to 10L/hr: For obtaining good relative humidity values the position of valve was gradually changed in order to have different velocities. The following plot shows the variation of dry bulb and RH with change in water flow rate. The position of the suction valve was changed from fully opened to three fourth such that the velocity read by the hot wire anemometer was 4.60m/s. from the plot the dry bulb temperature of the humidified air dcreases from 73°C to 38.70°C and the maximum relative humidity observed was 88.90%.



Valve position at 1/2nd, velocity 3.50m/s and flow rate 1 to 10L/hr: The position of the valve was changed from three fourth to half and the velocity read by the anemometer was 3.50m/s. As the flow rate increases from left to right in the plot i.e from 1 liter per hour to 10 liters per hours the temperature decreases from 73°C to 38.70°C and the relative humidity values were very low, the maximum value observed was 64.80%



Valve position at 1/4th, velocity 2.80m/s and flow rate 1 to 10L/hr: The valve position was changed from half to one fourth i.e the minimum valve position and the velocity read by the anemometer was 2.80m/s(minimum velocity). As the water flow rate increases from 1 liter per hour to 10 liters per hour the dry bulb temperature decreases from 72°C to 42.60°C, the relative humidity values observed were very low and the maximum relative humidity was 61.00%



Conclusion: A humidification chamber was succesfully designed and developed for humidification of paddy, for higher velocities and higher flow rates there were good relative humidity values like 88.50% at 6.80m/s velocity and 10 liter per hour flow rate and very good relative humidity values were obtained at a velocity of 4.60m/s they were 85% RH at 9 liter per hour flow rate and 88.90% RH at 10 liters per hour flow rate. So in the entire study the maximum RH observed was 88.90% at a flow rate of 10 liters per hour and at a velocity of

4.60m/s, with this values the paddy can be humidified(soaked) during parboiling such that there is no flowing effluent.

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