CALCULATION OF COOLING LOAD FOR MUSHROOM CULTIVATION

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ABSTRACT

In this paper the thermal comfort condition for mushroom cultivation was studied. In addition to this the cooling load needed for bring that thermal comfort condition was calculated. Mushroom cultivation was done by so many peoples in the hot and dry climatic places. In the cold places the yield of mushroom was more compared with the cold climatic places this is due to thermal comfort condition needed for mushroom cultivation. The solution for even yield in dry and cold climatic condition is to bring the thermal comfort condition at dry places by means of a refrigeration system. To design a refrigeration system cooling load calculation is necessary. So a prototype model for refrigeration system geometry for mushroom cultivation was developed and its necessary cooling load was calculated.
Keywords: cooling load; mushroom cultivation; Refrigeration system; Thermal comfort.

INTRODUCTION

During Solar heat conversion, waste heat dissipation is a huge factor. To avoid this problem Four pilot installations between 7 kW and 90 kW nominal cooling capacity were equipped with latent heat storages between 80 kWh and 240 kWh energy content. It results in a seasonal energy efficiency ratio (SEER) for cooling up to 11.4. Furthermore simulation results under different climatic conditions indicate raising efficiency up to 64% compared to a system with solely dry re-cooling.[1] Many factors can affect the operating performances and the design of the indirect air cooling system of power plant. A study has been carried out by developing a physic mathematical model describe the thermo flow characteristics of air cooling tower for indirect air cooling system.VC ++ is used to develop a program for the indirect air-cooled tower optimization. By this program better tower structure is achieved which is used to conduct thermal analysis of the influences of ambient temperature, wind speed, and saturated exhaust flow rate on back pressure of turbine.[2] A closed loop thermal cycle with loop thermal cycle containing cylindrical heat pipes integrated within a roof-mounted circular wind tower is used to achieve internal comfort. By using inlet wind speeds varying from 1 m/s to 5 m/s, the results of the study showed that the proposed cooling system was capable of meeting the regulatory fresh air intake requirements per occupant of 10L/s. In addition, the results showed that a passive cooling capacity ranging between 6K and 15K depending on the operating configuration. [3] TPV(Thermal Photo Voltaic) systems are increased by three developments like diffused junction GaSb cell that responds out to 1.8 microns producing over 1 W/cm^2 electric given an IR emitter temperature of 1200 C. High power density along with a simple diffused junction cell makes an array cost of $0.5 per Watt possible. IR emitters and filters that put 75% of the radiant energy in the cell convertible band. Ceramic radiant tube burners that operate at up to 1250 C. Herein, we describe a 1.5 kW TPV generator / furnace incorporating these new features. This TPV generator / furnace is designed to replace the residential furnace for combined heat and power (CHP) for the home [4]. An investigation is carried out to check the potential of producing liquid spawn of an edible mushroom, Pleurotus pulmonary's (grey oyster) by submerged fermentation in a 2-L stirred-tank bioreactor under controlled conditions also to evaluate its ability to colonize rubber wood sawdust substrate for sporophore production. It contains 20 g L−1 of brown sugar, 4 g L−1 of rice bran, 4 g L−1 of malt extract, and 4 g L−1 of yeast extract (BRMY) with initial pH of 5.5 and incubated at 28◦C with agitation speed of 250 rpm and oxygen partial pressure of 30–40%. Maximum P. pulmonarius dry biomass production of 11.72 ± 5.26 g L−1 was achieved after 3 days of fermentation. It produces higher yield of sporophores compared to normal used grain spawn. [5] To recycle agro-industrial wastes into food production a new species named genus Gymnopilus is used to determine the optimal condition needed to cultivate G. pompanos, to evaluate its biological efficiency and to determine the biodegradation of substrate. Strain ICFC 748/12 produces the highest biological efficiency on Populus sawdust reaching a mean of 70.67%. G. pampeanus has a strong capacity to degrade Eucalyptus and Populus. This mushroom has the ability to decompose cellulose and to decaylignin, thus being white rot fungi [6].

CFC-12 is replaced in order to investigate behavior of R134a refrigerant. This includes performance and efficiency variations when it replaces R12 in an existing system as well as changes involved in maintaining the system charged with R134a[7]. AIRCOND a system composed of three sub systems: the heating loop, the ejector cycle and the cold storage-air handling units: heating loop is composed of a solar array of 60 square meters evacuated tube solar collectors; installed at a tilt angle of 45° and facing to south, a 3000 L tank is used as hot water storage in order to cover energy by the ejector cycle. The cold water produced by the ejector cycle then transferred in a 900L cold storage tank filled with 800L micro-encapsulated phase change material (MEPCM) for cold storage designed to meet dynamic cooling load. This study is carried out to achieve air-conditioning in Mediterranean countries. [8]

DESIGN OF PROTOTYPE FOR MUSHROOM CULTIVATION

For Mushroom cultivation, paddy straw and mushroom seeds packed in a polyethene packet, which is normally a circular shape with 20 cm diameter and 30 cm height. In the prototype for cultivation we have to design a box with four mushroom cultivation pockets. Therefore, the box size is 1-meter width 1-meter length and 2-meter height. This model was created using PRO-E software. The door is used with the gap of 50 cm*50 cm square shape. The box is made up of timber.

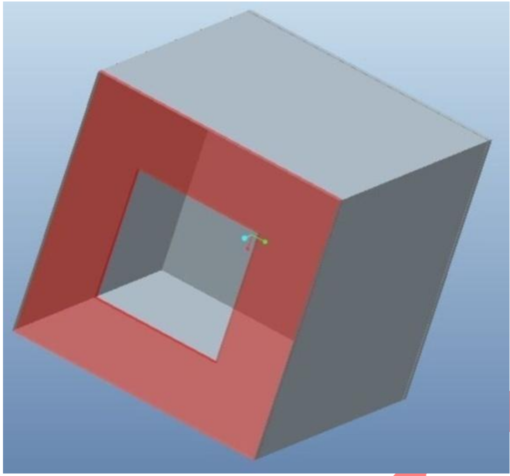

Figure 1

THERMAL COMFORT CONDITION FOR PLEUROTUS SPP.

In This paper the cooling load calculation is based on the pleurotus spp mushrooms here its thermal comfort condition is given,

R.H = 85-92%

Air Temperature = 60-64 F

CO_2 = less than 600 ppm.

Light = 2000 lux/hour

Flush Interval = 10 days

COOLING LOAD CALCULATION

Under the steady state approach which does not account the effect or effect of heat capacity of building materials. The heat balance of room air

$Q_{total} = Q_c + Q_s + Q_i + Q_v + Q_w$

INTERIOR LOADING (Q_i)

Q_i = [no of people × heat output rate] + [rated wastage of lamps × use factor ×allowance factor] + [heat evolved per kg of mushroom] × (kg of mushroom)

= [1*200] + [20*1*1.25] + [6490 kg]

Q_i = 225.15 watts

QVENTILATION

$Q_v = \rho \times V_r \times C \times \Delta T$

$V_r = N \times V / 3600$

N = 6 per hour

V = $2\ m^3$

$V_r = (6 * 2\ m^3)/3600$

$= 3.3 * 10^{-3}$

$Q_v = 1.2 * 1005 * 3.3 * 10^{-3} * 23$

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Q_v = 91.5354 watts

The door infiltration for a 0.5 m swinging door is $V_r = 0.05\ m^3/sec$

Q_{vd} = 0.05 * 1.2 * 1005 * 23

= 1386.9 watts

Q_v = 1386.9 + 91.5354

Q_v = 1478.4354

Q_S - SOLAR HEAT GAIN

The solar gain through transparent elements can be written as

$Q_s = A_s \ {}_{i=1}\Sigma^m A_i\ \delta q_i\ Z_i$

Here, m=0, there is no transparent element

Q_s = 0

$Qc = {}_{i=1}\Sigma^{Nc} A_i\ U_i\ \Delta T_i$

Here, we used wood. So a=0.

In Solar temperature and for vertical wall ΔR = 0, for vertical wall $T_{so}=T_o$

Qc for 4 vertical walls is 303.4252 watts

For 4 walls,

= 4 * 303.4252

= 1213.7008 watts

For bottom,

= 1213.7008 + 303.4252

= 1517.126

For roof,

ΔR = 63 w/m^2

T_{so} = $T_{so}+(\alpha S_T/h_o)-(\Sigma\ \Delta R/h_o)$

h_o = 34.0 w/m^2

Σ = 0.70 for brown color of top

T_{so} = T_o-((0.70*63)/34)

= 38-1.2970

T_{so} = 36.70 ^0C

$Q\ c_{roof}$ = 2m2 * 6.5962 * (36.70-15)

= 286.27508 watts

= 1517.126 + 286.27508

Q_c = 1803.40 watts

Total Cooling Load

Q_c = 1803.403 watts

Q_s = 0

Q_i = 225.15 watts

Q_r = 1478.4354 watts

$Q_{total} = Q_c + Q_s + Q_i + Q_v + Q_w$

If water is not considered and Door opening is not considered.

Q_c = 1803.403 watts
Q_s = 0
Q_i = 225.15 watts
Q_r = 91.5359 watts
Q_{total} = 2120.0884 watts
= 2.120 K watts
= 2.120 Kw/2.8
= 0.75 tons of cooling capacity required

The 0.75 tons of cooling capacity required to meet the thermal comfort condition for mushroom cultivation in dry places like Tirunelveli district.

CONCLUSIONS

Proto type of small refrigeration system geometry for mushroom cultivation was developed. And its required cooling load was developed under the environmental condition of Tirunelveli in Tamilnadu at India. This cooling load calculation is useful for those who want to make a refrigeration system for mushroom cultivation. In the future work Refrigeration system for mushroom cultivation using vapor compression and vapor absorption system will be analyzed. If use the refrigeration system for mushroom cultivation based on this cooling load, calculation will increase the yield in the dry places also.

NOMENCLATURE

f_o = outside film or surface conductance
f_i = inside film or surface conductance
A = outside area of wall
t_o = outside air temperature
t_i = inside air temperature
x = thickness of wall
K = thermal conductivity for the material of the wall
U = overall co-efficient of heat transmission of the wall
ΔT = Temp diff between inside and outside air(k)
A = Surface area m^2
U = Thermal transmittance ($w/m^{2}\cdot k$)
K = thermal conductivity
A = Surface Area
ρ = density of air (kg/m^3)
V_r = ventilation rate (m^3/sec)
C = specific heat of air (J/kg-k)
N = no of air exchanges per hour
V = volume of the room
As = mean absorbtivity of the space

Ai	=	area of the i^{th} transparent element
δq_i	=	daily average value of solar radiation
Z_i	=	transmissivity of i_{th} transparent element
M	=	no of transparent element
i	=	building element
N_c	=	no of components
T_o	=	daily average value of nearly ambient temperature(K)
a	=	absorption of the surface for solar radiation
S_T	=	daily average value of solar radiation incident of the surface (w/m_2)
h_o	=	outside heat transfer coefficient

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